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An Investigation of Missing Values of Blood Alcohol Concentration in Road Crash Databases

by

P.J. O'Connor and R.F. Trembath

AUSTRALIAN INSTITUTE OF
HEALTH & WELFARE

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An investigation of missing values of blood alcohol concentration in road crash databases

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Abstract:

In order to assess the quality of the information on alcohol involvement in road crashes and to understand the factors which determine this characteristic a study was initiated by the National Injury Surveillance Unit (NISU), as a joint funded project with the Federal Office of Road Safety (FORS), to investigate the data on blood alcohol concentration (BAC) reported in road crash databases nationally.

The following specific outputs were provided by the study:

- Identification of the factors which could influence the extent of missing values for BAC in road crash databases at national level.

- Identification of the variables most strongly associated with BAC status (known v. missing) and BAC level (≤.05 v. >.05).

- Estimation of the number and proportion of cases having BAC >.05 at national level taking into account the extent to which cases having missing values for BAC were likely to have BAC >.05.

- Provision of recommendations for reducing the level of missing values in existing databases and specification of the requirements for new databases at national level.

FOREWORD

The Road Injury Information Program was initiated in 1992 by the Australian Institute of Health & Welfare's National Injury Surveillance Unit (NISU) through a funding allocation from the then Department of Health, Housing, Local Government and Community Services. The program aims to improve national data on the incidence and severity of road injury and major trauma so as to facilitate improved monitoring and prevention.

The present report was initiated by NISU as a joint funded project with the Federal Office of Road Safety (FORS).

The study benefited from valuable comments by Dr. S. Ginpil and Mr. J. Wiley (FORS) and also the study reference group which included Dr. A.J. McLean (NHMRC Road Accident Research Unit) and Dr. M. White (S.A. Office of Road Safety).

The contribution of Mr. J. Dolinis and Mr. S. Bordeaux, in providing commentary on the statistical analysis and interpretation is gratefully acknowledged.

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EXECUTIVE SUMMARY

In order to assess the quality of the information on alcohol involvement in road crashes and to understand the factors which determine this characteristic a study was initiated by the National Injury Surveillance Unit (NISU), with joint funding by NISU and the Federal Office of Road Safety, to investigate BAC data reported in road crash databases nationally.

The main findings of the study are summarised below, organised under headings which define the outputs specified for the project.

Identification of the factors which could influence the extent of missing values for BAC in road crash databases at national level.

The qualitative and quantitative research undertaken indicated that the level of missing values for BAC could be subject to the influence of a wide range of factors including: legal requirements which varied from State to State; operational constraints such as police and hospital work loads; police, hospital and coronial procedures, including the targeting of certain drivers; case classification and data matching issues; and levels of reporting of crash involvement.

State was the variable which had the strongest relationship with BAC status (known v. missing). New South Wales had the lowest level of missing values for drivers admitted to hospital following a road crash and Western Australia and Queensland had the highest levels. Due to very high levels of missing values (greater than 74%), data on BAC distribution of drivers admitted to hospital in Tasmania, ACT, Qld and WA could be subject to very high levels of error and bias which could prevent meaningful assessment of the level of alcohol involvement in non-fatal road crashes in those States.

A review of State legislation revealed that there was no uniform national requirement for BAC testing of drivers attending or admitted to hospital following a road crash. Blood testing of drivers attending or admitted to hospital was a legal requirement in only three States and hospital policy (without a legislative requirement) in another State. In the remaining States hospital blood testing was subject to police discretion based on suspicion that a driver was affected by alcohol.

On the basis of the above factors and others discussed in the report it was considered that data on BAC based on crash reports to police could reflect factors other than the true incidence of alcohol involvement and that interpretation and use of the data in research could be highly complicated.

Identification of the variables most strongly associated with BAC status (known v. missing) and BAC level (≤.05 v. >.05).

Multivariate analysis revealed significant associations between BAC status and a number of the available independent variables: for fatalities, State, speed limit and age group; for hospital admissions, State, time of day, sex, age group, road user type, day of week and vehicle damage. For most of these variables, categories which had a low proportion of cases with missing values had a high proportion of cases with BAC >.05, which could be due to a targeting of drivers suspected to have BAC >.05.

Low to moderate significant associations between BAC level (i.e. BAC ≤.05 v. >.05) and two other variables were found for both fatalities and hospital admissions:

- Time of day was the variable most strongly associated with BAC level, with higher BAC for night-time crashes. The odds ratios (day:night) were above 6 for both fatalities and hospital admissions.
- This was followed closely by number of vehicles involved in the crash, higher BAC for single vehicle crashes. The odds ratios (single:multiple vehicle) were nearly 6 for fatalities and nearly 4 for hospital admissions.

Weak but significant associations were found between BAC level (i.e. BAC ≤.05 v. >.05) and a number of other variables: for fatalities, sex and day of week; for hospital admissions, sex, day of week, State, speed limit, road user type and age group.

The overall strength of the logistic regression models for prediction of BAC level of fatalities and hospital admissions, based on this data, was high (about 80% of cases were correctly allocated to BAC level). The outcome was similar to that achieved by Klein (1986), using discriminant analysis to estimate alcohol involvement in fatal crashes in the U.S. His model which used crash and person level variables correctly predicted level of alcohol involvement in 80% of cases, where BAC level was known. Variables found by Klein (1986) to be highly associated with alcohol involvement included many of the variables listed above, including: the hour of the day, the number of vehicles, the type of vehicle, the person's age, person's sex and weekday v. weekend.

Estimation of the number and proportion of cases having BAC >.05 at national level taking into account the extent to which cases having missing values for BAC were likely to have BAC >.05.

Using the FORS Serious Injury File for 1990, the number of serious injury (fatal and nonfatal) cases with BAC >.05 was counted. This number was referred to as the 'actual count'.

When the explanatory variables detected through logistic regression analyses were incorporated into prediction models, based on cases where BAC level was known, there being different models for fatalities and hospital admissions, and applied to the cases for which BAC was missing, the number of those cases with BAC >.05 was estimated. This number was added to the actual count to produce an estimate which was referred to as the 'actual count plus model estimate where BAC was missing'. This estimate could also be inflated to adjust for model underenumeration of cases with BAC >.05 amongst cases where BAC was known to produce an estimate which was referred to as the 'actual count plus inflated model estimate where BAC was missing'.

A summary of the outcome of the estimation procedures applied in the study is presented in the table below.

Table E1. Estimates of the number, proportion and population-based rate of alcohol involvements, where BAC was greater than .05, of drivers killed or admitted to hospital following road crashes.

Estimation method	**Fatalities**			**Hospital admissions**		
	No.	%*	Rate**	No.	%*	Rate**
Actual count (where BAC was known)	337	29	1.97	1962	15	11.50
Actual count plus model estimate where BAC was missing	376	32	2.20	3038	23	17.80
Actual count plus inflated model estimate where BAC was missing	385	33	2.26	3329	25	19.51

* Percentage based on the total number of cases (1174 fatalities and 13195 hospital admissions). Subject to rounding.
** Rate per 100,000 based on Estimated Resident Population, Australia 1990 (17,065,128). Subject to rounding.

The figures based on inclusion of model estimates should be regarded as upper limits for estimates based on police reports. There is some evidence from the qualitative and univariate quantitative research undertaken in the study that where BAC level was missing, the level could be expected to be skewed toward the low BAC category relative to cases where BAC was known, suggesting a potential for the model, based on cases where BAC was known, to overstate the figures.

However, weighing against this is the potential for substantial underenumeration through under-reporting of crashes to police. It is known that crash reports to police, which form the basis for the FORS Serious Injury File, understate the extent of serious non-fatal injury in road crashes by about 40% (O'Connor & Trembath, 1995; O'Connor and KPMG Peat Marwick 1994; FORS, 1993). If it can be assumed that the proportion of cases with BAC >.05 for hospital admissions involving drivers of motor vehicles was the same as for police-reported cases, then an estimate of the number and population-based rate of hospital separations with

BAC >.05 can be made by application of the estimate of the proportion of police-reported cases with BAC >.05 to the total number of hospital separations involving drivers of motor vehicles. As there were 15473 hospital separations involving drivers of motor vehicles in 1990, it can be calculated from the estimates presented in Table E1 that somewhere between 15% and 25% of these (2321 - 3868) could have had BAC>.05. Considering the 1990 population figure of 17,065,128, the rate of alcohol involvement, where BAC was greater than .05, of drivers admitted to hospital can be estimated to be 14 - 23 cases per 100,000 of population.

Further research into alcohol involvement in crashes not reported to police is required. Uncertainty over the reliability of estimates of alcohol involvement in road crashes, especially for non-fatal injury, indicates the need for improved data systems.

Provision of recommendations for reducing the level of missing values in existing databases and specification of the requirements for new databases at national level.

Recommendation 1
Efforts be made to reduce the level of missing values for BAC in databases on road deaths and injuries, focussing on the factors identified in this report, and that progress in this direction be monitored by appropriate State and national organisations using the databases at their disposal.

Recommendation 2
Reports quantifying the extent of involvement of alcohol in road crashes should consider the estimates produced in this report which incorporate predictions of alcohol involvement for cases having missing values for BAC in police reports.

Recommendation 3
Further research is required into alcohol involvement in crashes not reported to police.

Recommendation 4
That all States consider the introduction of compulsory blood testing of drivers admitted to hospital following road crashes, to determine BAC level.

Recommendation 5
That all States consider including the results of BAC testing in the State hospital morbidity data system and reporting them in aggregated form.

Recommendation 6
That all States consider making the results of BAC testing available at unit record level for national level analysis and reporting in aggregated form, subject to the implementation of appropriate controls to protect patient confidentiality and privacy.

Recommendation 7

That a study be undertaken to investigate statistical linkage of BAC information from hospitals with police information to determine how cases not reported to police compare with those reported to police.

1. INTRODUCTION

The involvement of alcohol in road crashes has been the subject of detailed research and public policy in Australia and in most developed countries for at least two decades. It is not the aim of the present report to review that literature or activity. Rather, the concern here is with the quality of the information on alcohol involvement in road crashes which has provided the basis for much of that research and policy. Hitherto, this matter has received little attention in Australia and in the international literature. That this is an important matter in Australia is indicated by the fact that the available information has been the basis for the development and evaluation of significant public policy.

The problem of drink driving is treated very seriously in Australia. It is one of the few countries in the world which has widespread testing of the blood alcohol concentration (BAC) of drivers, including mandatory blood testing of seriously injured drivers in some States and discretionary testing, based on police suspicion of alcohol involvement, of this class of drivers in all other States, as well as random breath testing (RBT) of drivers and discretionary breath testing of drivers, where driving under the influence of alcohol is suspected by police, in all States. Penalties for driving under the influence of alcohol or driving with a BAC level in excess of a prescribed limit are substantial. These include large fines and loss of insurance cover for any crash-involved driver where it can be shown that alcohol was a significant factor in the causation of the crash. The problem of drink driving attracts strong media attention and is the subject of substantial public and private funded media advertising.

Simpson (1993), in summing up the critical information gaps in the field of alcohol, drugs and transportation, as identified by participants at the 1992 International Symposium on Alcohol, Drugs and Transportation, reported the following:

"Much of what is known about the epidemiology of alcohol and drugs in transportation accidents comes from studies of persons (usually operators) who have been killed. Far less is known about the involvement of alcohol or drugs in collisions where someone other than the driver dies. ... Worse yet is the status of information on the presence of alcohol and drugs in transportation accidents involving non-fatal injury or only property damage. Studies in this area are virtually non-existent."

An assessment of the quality of information on the involvement of alcohol in road crashes needs to move beyond a narrow focus on fatalities and include an assessment of serious non-fatal road injury (e.g. hospital admissions).

Information about the BAC of persons involved in a road traffic crash, and other details of the crash, is stored by police, and also the Coroner's Office in the case of fatalities, for the primary purpose of assessment of crash liability. The information is also used by road safety authorities, police and others to investigate crash factors for the purpose of development of crash and injury prevention programs and policies.

In order to assess the quality of the information on alcohol involvement in road crashes and to understand the factors which determine this characteristic, a study was initiated by the National Injury Surveillance Unit (NISU), with joint funding by NISU and the Federal Office of Road Safety, to investigate BAC data reported in road crash databases nationally.

The following specific outputs were planned for the study:

- Identification of the factors which could influence the extent of missing values for BAC in road crash databases at national level.

- Identification of the variables most strongly associated with BAC status (known v. missing) and BAC level (≤.05 v. >.05).

- Estimation of the number and proportion of cases having BAC >.05 at national level taking into account the extent to which cases having missing values for BAC were likely to have BAC >.05.

- Provision of recommendations for reducing the level of missing values in existing databases and, if necessary, specification of the requirements for any new databases at national level.

The scope of the study was restricted to information on seriously injured (i.e. killed or admitted to hospital) drivers of motor vehicles involved in road traffic crashes.

2. METHODS

In order to deliver the outputs specified for the project, a mixture of methodologies was employed encompassing elements of: expert judgement, to identify hypotheses about factors that might have a bearing on the quality of information on BAC; qualitative research, to gain information on policy and procedures and to gauge the potency of explanatory factors; and quantitative analysis of crash data, to provide the basis for understanding the factors associated with high levels of missing values and high levels of BAC and to provide a model for the estimation of BAC distribution which incorporated estimates of BAC for cases having missing values on this factor.

2.1 Hypothesis Development

The first stage of the study involved the development of hypotheses about the factors that might influence the collection and reporting of BAC data in road crash data bases, for the purposes of further assessment during the qualitative and quantitative research phases of the study. The hypotheses were developed primarily through discussion with representatives of the National Injury Surveillance Unit, Federal Office of Road Safety, S.A. Office of Road Safety and the NHMRC Road Accident Research Unit (referred to in this report, collectively, as the 'study reference group'), and with reference to other studies (Klein & Burgess, 1993; Attewell & Dowse, 1992; Haworth & Rechnitzer, 1993).

The results of this stage are presented in Section 3.1

As the study reference group considered that the legislative framework was probably the most important influence on the level of missing values for BAC, information on relevant State legislation was sought from appropriate police representatives. The information was aggregated and summarised and, in order to confirm its accuracy, the police representatives were asked to verify the interpretation of the legislation.

The outcome of this is presented in Section 3.2.

2.2 Qualitative Research

The second stage of the study consisted of in-depth interviews conducted with appropriate authorities in two States to provide a description of current procedures for, and views about, the collection, analysis and reporting of information about BAC and reasons for missing values.

The States of New South Wales and Queensland were selected for the following reasons:

- They had legal requirements for BAC testing which were at opposite ends of the spectrum nationally in terms of stringency. NSW (and South Australia) had a legislative requirement for a blood sample for alcohol analysis to be taken from all motor vehicle controllers attending or admitted to hospital as a result of a road crash whereas in Queensland current traffic legislation required a blood sample for alcohol analysis to be taken from motor vehicle controllers by hospital staff only at the request of investigating police on suspicion of alcohol impairment.

- The level of missing values for BAC of the two States in the FORS Serious Injury File were dramatically different. NSW was among those States having the lowest level of missing values of all States while Queensland was among those States having the highest level of missing values.

- They had similar population-based rates of incidence of road injury (O'Connor & Trembath, 1995).

- The number of cases of road injury recorded in these States' databases was sufficient for meaningful statistical analysis of detailed breakdowns.

Twenty seven interviews were conducted in New South Wales and Queensland with senior representatives of large metropolitan hospitals, health departments, police, forensic science, the Coroner's Office, government pathologists, road safety authorities and others.

The organisational representation of those interviewed is indicated in the following table.

State	**Hospital /health dept.**	**Police**	**Coroners office/forensic or pathology service**	**Road safety authority/other**	**Total number**
New South Wales	5	3*	4	2	14
Queensland	4	3	4	2	13

* Information was also collected from 4 traffic sergeants by telephone to determine procedures at the level of metropolitan and country stations.

The interviews were conducted on a face-to-face basis in a flexible open-ended manner with follow-up by telephone, where appropriate, to clarify issues and collect additional information.

The results of the qualitative component are presented in Section 3.3.

2.3 Quantitative Analysis

The third stage of the study involved the quantitative analysis of unit record information on serious road injury to assess the relationship between a range of independent variables and both BAC status (known v. missing) and BAC level (≤.05 v. >.05). Simple univariate analysis was employed initially to provide a basic description of the relationships. This was followed up with multivariate statistical analysis to identify the variables most strongly associated with BAC status and BAC level. The multivariate analysis of BAC level was intended to provide a model that could be used to estimate BAC where missing. The study methodology did not enable the causes of the associations to be determined.

To provide a national perspective for the analysis, the Federal Office of Road Safety Serious Injury File for 1990 (FORS, 1990) was obtained.[1] The File contained data on all road crashes involving death and serious injury (i.e. hospital attendance or admission) which were reported to Police in each State. In the present study only those records which involved the death or hospital admission of a driver of a motor vehicle (including a motorcycle) were selected for study.

The variables selected for study, a subset of those available on the File, were chosen on the basis of a review of the readily available literature in the field and with reference to the views of the study reference group.

The results of the univariate analyses are presented in Section 3.4. A complete description of the methodology and results of multivariate analysis is presented in Section 3.5.

[1] An attempt was made to identify hospital unit record databases for admissions which contained the results of BAC testing for the purpose of investigating the extent of under-reporting to police of crashes involving alcohol affected drivers. No such database was identified despite wide consultation with State health authorities and trauma registries. In order to contribute to future planning of the development of improved data on BAC, Queanbeyan Hospital in NSW was funded under NISU's Road Injury Information Program to undertake a pilot study to test the feasibility of developing a database utilising hospital and police data which could enable the BAC results of all motor vehicle controllers, and their reporting of crashes to police, to be identified (Queanbeyan Hospital & Health Service, 1995). The study demonstrated that useful information could be generated at hospital level but would require tight control to ensure data accuracy. Given the short time period over which the study was undertaken statistical information from the study cannot be reliably reported.

3. RESULTS

3.1 Hypothesis Development

The factors identified through the hypothesis development process that may influence the level of missing data for BAC in road injury databases are as follows:

For fatally injured motor vehicle drivers:

1. Government pathologist or Coroners Office fails to request a blood sample for alcohol analysis.

2. Case not identified as road trauma victim.

3. Blood sample taken but not analysed.

4. Result of blood sample analysis not recorded or lost.

5. Not all information or incorrect information provided with BAC sample resulting in the failure of matching procedures.

For motor vehicle drivers admitted to hospital (includes fatalities where death occurs following hospital admission):

1. Legislative requirements, or health sector policy, for the taking of blood or breath samples from persons (driver and/or other) admitted to hospital as a result of road trauma. This was considered to be the most influential factor in whether a driver had a BAC result on a road injury database.

2. Case not identified as driver of vehicle by police and/or hospital.

3. Blood sample taken but not analysed.

4. Result of blood sample analysis not recorded or lost.

5. Not all information or incorrect information provided with BAC sample resulting in the failure of matching procedures.

6. Traffic incident not reported to police - this group will not be represented in the databases based on crash reports to police.

3.2 State Legislation

The legislative requirement for the taking of blood or breath samples by hospitals will impact upon the collection and reporting of BAC data. The current legislative requirements for the taking of blood and breath samples from persons attending or admitted to hospital following a road traffic crash are summarised in Table 1.

Table 1. Legislative requirement for the taking of blood or breath samples from persons attending or admitted to hospital following a road traffic crash

	STATE							
REQUIREMENT	NSW	VIC(a)	QLD(b)	SA	WA	TAS	NT	ACT
Hospital to take blood samples from all road trauma victims attending or admitted to hospital.	*			*			*	
Blood sample waived if:								
• Prejudicial to medical condition	*	*	*	*		*	*	*
• BAC known from other measure (e.g. breath test)		*						*
• Not driver/rider	* (c)	* (d)						*
• Consent not given		* (e)		*		*		*
Time limit after which a sample cannot be required under the legislation.	12 hrs		2 hrs	8 hrs	4 hrs	3 hrs	12 hrs to admis. + 4 hrs from admis.	2 hrs from incid. or admis.
Age below which a sample is not required under the legislation.	15 yrs	15 yrs		14 yrs			15 yrs	
Blood or breath sample taken at police request/ discretion.			*		*	*		*

(a) In Victoria there is a hospital code of practice whereby staff take blood samples for alcohol analysis from all motor vehicle drivers subject to waiver conditions. However the taking of blood is not mandatory under legislation.
(b) Legislation for mandatory blood sampling of road trauma victims was passed through the Queensland Parliament in 1974 but was not proclaimed.
(c) In New South Wales blood is also taken from pedestrians.
(d) Blood sampling of pedestrians and bicyclists may be undertaken over agreed time periods for the purposes of devising and evaluating programs.
(e) Blood sample is taken if patient is unable to give consent due to being unconscious.

Table 1 indicates that a requirement exists under legislation for hospital staff in New South Wales, South Australia and the Northern Territory to take a blood sample for alcohol analysis from all motor vehicle drivers attending or admitted to hospital as a result of a road crash. In Victoria, a blood sample or screening breath sample, is taken from all motor vehicle drivers attending or admitted to hospital as a matter of policy although this is not required under legislation.

In Victoria, Queensland, Western Australia, Tasmania and the Australian Capital Territory a request for a hospital blood or breath sample is at the discretion of police investigating the crash and generally there must be due cause for the request to be made, where driving under the influence of alcohol was suspected.

3.3 Qualitative Research

Interviews were conducted in New South Wales and Queensland to generate a description of existing procedures for, and views about, the collection, analysis and reporting of information about BAC.

3.3.1 New South Wales

Fatalities

Information about the BAC of fatally injured road crash victims in NSW is most likely to be collected as a result of blood samples taken at post-mortem or as a result of blood samples taken by hospital staff for those cases that die after presentation at the hospital.

The decision to take a blood sample for alcohol analysis is made at the discretion of the Forensic Pathologist, in the metropolitan area, or at the request of the Coroner in consultation with the Government Medical Officer, in rural areas, and depends on the circumstances of the death.

Under current policy guidelines a sample should be taken at post-mortem for alcohol analysis from all road fatalities, including nondrivers, with the following exceptions:

- the trauma victim survived for more than 24 hours from the time of the crash;
- the trauma victim was less than 14 years of age;
- the body was decomposed

Regular policy circulars are issued to all Coroners' Offices and training programs are also maintained. It was stated that it could be expected that any discretion in regard to blood sampling would be exercised in a consistent manner across all Coroners' Courts in the State.

All samples taken at post-mortem are analysed at the Division of Analytical Laboratories at Lidcombe. The laboratory maintains an electronic register which includes all Coronial cases. The information held for Coronial cases includes the name of the deceased, identification of the Coroners court that is dealing with the case, date of receipt of the sample and the sample result.

A list of Coronial cases is sent to the Road Traffic Authority on a monthly basis and sample results are matched manually against the road crash data base.

Hospital admissions

In New South Wales there is a legislative requirement for medical staff at hospital emergency departments to take a blood sample for alcohol analysis from all motor vehicle drivers who attend or are admitted for treatment as a result of road crash (subject to waiver conditions). A blood sample will be taken by medical staff from all vehicle occupants if the road user status is unclear.

Directors of Emergency Departments indicated that the main reasons why a sample would not be taken were staff forgetting to take the sample, when aware of the legal requirement, or ignorance of, or inexperience with, hospital procedures. Failure to identify a patient as a road trauma victim was also considered to be an important factor for cases of minor injury. Other factors considered to be of lesser importance were: the expiry of the statutory time limitation on the legal requirement for blood testing; and priority for medical treatment over blood sampling, including instances where blood testing would be prejudicial to the patient's medical condition.

The relative importance of these factors was stated, by the respondents, to vary between and within hospitals on the basis of patient load, staff experience and procedures. For example, it was stated that the statutory time limitations could become a more important reason for failure to take a blood sample from patients with minor injuries at times of increased casualty load. It was indicated by one respondent that waiting periods for minor cases could be longer at those times when the probability of alcohol involvement was increased i.e. Friday and Saturday night. The priority given to the legal requirement for a blood sample was also stated to vary between clinicians to some extent. It was reported that some clinicians may not request a blood sample when a patient has received a prior transfusion of blood or other fluids, because the sample would present an invalid indication of BAC at the time of the crash.

The significant features of the collection procedures for blood samples, as detailed by police, are:

- the collection and distribution process is managed by the Police Blood Sampling Unit;
- the blood sample results are recorded by police on an electronic register that is independent of police crash reports; and
- each sample is given a serial number which is used, in addition to name, for electronic matching purposes.

Reporting of BAC results by the health sector

As a component of the qualitative interview, hospital representatives were asked about their attitude to the collection and processing of blood sample results as a component of the medical record and State morbidity system. The representatives were generally interested in receiving the information and reporting it in aggregate form. Particularly interested were those who had established a trauma register, as it had relevance to the monitoring of health interventions and outcomes. However, some concern was expressed with regard to the time that it would take for the hospital to receive sample results where analysis was undertaken outside the hospital. Concerns over privacy, confidentiality and legal ramifications in regard to such sensitive information were also raised.

3.3.2 Queensland

Fatalities

In the case of road fatalities, post-mortem samples of blood for alcohol analysis are taken by Government Pathologists in urban areas and the Coroner's Office in consultation with the Government Medical Officer (GMO) in rural areas. The policy of the Coroner's Office is that samples are taken from all road fatalities regardless of road user status unless the trauma victim survives for 12 hours or more from the time of the road crash, or the deceased was less than 15 years of age. For hospital admitted cases that survive for 12 hours or more it is up to the pathologist or GMO to follow up any sample taken at the hospital.

It was stated that the high number of Coronial Courts spread across the State makes it difficult to ensure consistent procedures and that as a result a request for a blood sample for alcohol analysis may not be made in some instances, more-so in remote areas.

The results of all blood samples are analysed by the Government Chemical Laboratory which maintains an electronic register of cases which includes the name, date of death, police district and sample result.

A list of fatality records with missing data for BAC is sent each month by the Office of the Government Statistician for matching with the database of sample results maintained by the Government Chemical Laboratory. The matching process is undertaken manually and allows for variation in spelling of name.

Hospital admissions

In Queensland blood or breath sampling of crash-involved motor vehicle drivers attending or admitted to hospital following a road traffic crash is at police discretion on the basis of suspicion of alcohol involvement.

In consideration of the discretionary nature of BAC testing in Queensland, it was stated that it would be expected that higher levels of missing data for BAC will be associated with circumstances or characteristics that may be associated with a lower probability of alcohol involvement i.e. daylight hours, older age group, female sex. It was also indicated that the probability that a breath or blood sample was taken may also be related to police attendance at the accident site or hospital within the time limit prescribed under the legislation.

Discussion with hospital medical staff revealed that in instances where a blood sample has been requested by police but was not taken, the main reasons for not taking it were, in priority order: statutory limitations relating to the time delay between crash and the request for a sample; priority for managing the patient's medical condition; and failure to obtain the doctor;'s permission, noting that doctors may refuse permission to sample without providing a reason.

According to police, where police attend the crash scene or initiate an investigation after the crash and suspect the involvement of alcohol in the crash, a breath sample may not have been taken because the nature of the victim's injuries demanded that priority be given to their medical management or because the statutory time limit had expired.

Mandatory blood sampling by hospitals

As a component of the qualitative interview hospital medical staff representatives were asked their attitude to the introduction of legislation to require blood sampling of road trauma victims attending or admitted to hospital. A noteworthy comment from a number of medical officers was that legislation for mandatory blood sampling of road trauma victims was passed through the Queensland Parliament in 1974 but was not proclaimed, reportedly due to opposition from hospital medical staff at that time.

One medical officer indicated that it was his perception that blood sampling procedures had not been well accepted by medical staff in Victoria, due to the effects on workload of a requirement to sample all vehicle occupants, but appeared to be well accepted by medical staff in NSW where only vehicle controllers and pedestrians were blood tested, and that the NSW legislation would be more likely to receive support in Queensland. Concern was expressed that medical staff could be called to appear in court if blood testing became mandatory in Queensland.[2]

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[2] It is noteworthy that a dispensation exists under SA legislation preventing medical officers being called to appear in court to give evidence in relation to results of blood testing.

Reporting of BAC results by the health sector

A representative of the Queensland Department of Health suggested that whilst it would be useful to report BAC results as a component of the hospital morbidity system, the funds required to make the necessary alterations to the system may not be available.

3.3.3 Summary of results of the qualitative research

The qualitative research indicated a number of procedural and other issues that may impact upon the collection and reporting of information about the BAC of persons involved in road crash who were admitted to hospital.

In summary, the findings were as follows:

- Recording of BAC results as a part of the hospital medical record and reporting of this information in aggregated form as a part of the State hospital morbidity system was supported in principle but requires further assessment in terms of the requirements for implementation e.g. cost and confidentiality issues;

- Where BAC testing was discretionary, higher levels of missing data for BAC may be associated with circumstances or characteristics indicative of a lower probability of alcohol involvement i.e. daylight hours, older age group, female sex;

- Police attendance at the crash scene or hospital may be an important factor in determining and indicating whether or not a person is tested, particularly in States where testing is discretionary;

- Where requested by police, a blood sample is most likely not to be taken due to priority for medical treatment of the crash victim;

- Where hospital staff are required by legislation to take blood samples for alcohol analysis from road trauma victims a sample is most likely not to be taken due to staff ignorance of procedures, memory lapse or work load;

- The failure to identify a patient as a road trauma victim may also be an important factor, particularly for cases of minor injury;

- Where casualty workload is heavy the time limitations imposed by the legislation may be exceeded for minor cases due to waiting periods. This is likely to occur when the probability of alcohol involvement is greater i.e. at weekends and in the evenings;

- The use of a sample serial number for the processing of blood sample results in New South Wales provides two main points of reference for matching procedures, the person's name and the sample serial number;

- The collection of samples from hospitals by the New South Wales police ensures that the burden on hospital staff of BAC is kept to a minimum;

- The management of the blood sample collection procedures and the distribution of blood sample results by a single unit within the New South Wales police force allows for the establishment of a central register of blood sample results and related details.

3.4 Univariate Quantitative Analysis

In order to assess the relationship between a range of independent variables and BAC status (known v. missing) and BAC level (≤.05 v. >.05) univariate analysis was employed initially to provide a basic description of the data, with an emphasis on the magnitude of the relationships rather than their statistical significance. This was followed up with multivariate analyses, to assess the strength and statistical significance of the relationships for individual variables whilst controlling for the influence of other variables. This also provided a model that could be used to estimate BAC where missing. The study methodology did not enable the causes of the relationships that were found to be determined. However, some possible explanations were offered. The reader should note that other explanations may be equally or more tenable.

It can be seen from Table 2 that the overall level of missing data in the FORS Serious Injury File was substantially higher for hospital admissions than fatalities (i.e. 15.8% for fatalities and 42.3% for hospital admissions). Where a BAC level of the driver was known (i.e. in the case of 989 fatalities and 7616 hospital admissions), it was greater than .05 in 34.1% of fatalities and 25.8% of hospital admissions.

The results of more detailed analysis of BAC data on the basis of the independent variables selected for study is presented in the subsections 3.4.1 to 3.4.9. As the primary purpose of the study was to provide a national perspective, there will be only limited analysis of State differences. The reader should note that any patterns of relationships detected at national level may not necessarily apply to any individual State. The qualitative research suggested that discretionary BAC testing in some States could target drivers affected by alcohol, leading to an expected skew in the distribution of the missing cases toward the low BAC category (≤.05).

Table 2. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes, Australia 1990.

Outcome grouping	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.1 State of crash

Table 3 presents information on the extent of missing values and BAC distribution of drivers seriously injured in road traffic crashes, presented according to the State in which the crash occurred.

The variation between States in the level of missing values of BAC for fatalities was substantial, ranging from 0% to 69%. The Northern Territory and Tasmania had the smallest proportion of missing values for BAC amongst fatalities and the ACT had the highest proportion. However, the number of fatalities in these States was small. In the States having the largest number of fatalities (i.e. NSW, Vic and Qld) the percentage missing ranged from 9% to 21%. The variations detected could reflect differences in policy and procedures for BAC testing from State to State, and within State, as indicated in the qualitative research.

With respect to hospital admissions, the level of missing values of BAC varied substantially across States, with NSW having the lowest level (6%) and WA having the highest level (90%). It is readily apparent that the level of missing values was substantially lower in those States having a legislative requirement for BAC testing of drivers admitted to hospital following a road traffic crash. Where BAC testing of this class of drivers was not a legislative requirement but was a policy requirement by the health authority (i.e. in Victoria) the level of missing values was substantially higher than in the States having a legislative requirement but lower than most States not having any legislative requirement/policy requirement.

Clearly, the legal/policy framework for BAC testing has a strong bearing on the level of missing values for BAC.

Where the BAC level of the driver was known, it was greater than .05 in 34% of fatalities nationally, but that proportion varied widely across the States (22% to 80%). This variation was unlikely to reflect differential incidence.

There was more consistency in the proportion of hospital admission cases that had a BAC >.05 amongst those States (i.e. NSW, SA, NT and Vic) having a legislative/policy requirement for BAC testing of drivers attending hospital following a road traffic crash (range = 21% to 36%) than amongst those States which did not have such a requirement (range = 27% to 67%). However, the level of missing values varied widely across the States: from 6% to 43% in States having the specified legislative/policy requirement and from 74% to 90% in States which did not have such a requirement. NSW appeared to have the most accurate information on BAC level as it had a very low level of missing values (6%).

In the States where BAC testing of cases admitted to hospital was at police discretion (i.e. Tas, ACT, Qld and WA), the strong variation in the extent of cases that were greater than .05 may reflect State differences in the targeting of cases for BAC testing as well as other factors. It was unlikely to reflect a differential in the incidence in alcohol involvement in crashes, although this cannot be discounted in the present study due to the limitations of the study methods.

Table 3. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes by State, Australia 1990.

State of crash*	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities									
NT	8	30.8	18	69.2	26	100.0	0	0.0	26
Tas	32	78.0	9	22.0	41	100.0	2	4.7	43
NSW	234	65.4	124	34.6	358	100.0	36	9.1	394
Vic	173	70.3	73	29.7	246	100.0	36	12.8	282
SA	52	55.9	41	44.1	93	100.0	19	17.0	112
Qld	107	70.4	45	29.6	152	100.0	43	22.1	195
WA	45	66.2	23	33.8	68	100.0	38	35.8	106
ACT	1	20.0	4	80.0	5	100.0	11	68.8	16
Total	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions									
States having legislation for BAC testing of drivers admitted to hospital									
NSW	2953	79.1	779	20.9	3732	100.0	231	5.8	3963
SA	726	74.1	254	25.9	980	100.0	329	25.1	1309
NT	105	64.0	59	36.0	164	100.0	80	32.8	244
States where BAC testing of drivers admitted to hospital is a policy requirement									
Vic	1578	73.2	577	26.8	2155	100.0	1613	42.8	3768
States not having legislation for BAC testing of drivers admitted to hospital									
Tas	49	60.5	32	39.5	81	100.0	236	74.4	317
ACT	8	33.3	16	66.7	24	100.0	100	80.6	124
Qld	137	39.6	209	60.4	346	100.0	1767	83.6	2113
WA	98	73.1	36	26.9	134	100.0	1223	90.1	1357
Total	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

* The States are arranged in order of the extent of missing values (highest first) for fatalities and for hospital admissions are also divided into subgroups based on the legislative requirement for BAC testing.

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.2 Driver sex

Table 4 presents information on the extent of missing values and BAC distribution of drivers seriously injured in road traffic crashes, presented according to the sex of the driver.

It can be seen that the level of missing values of BAC for males and females was similar for fatalities but marginally higher for females amongst hospital admissions. Therefore the possibility of an effect on the extent of missing values for BAC at national level of differences in the application of legislation, policy or procedures for BAC testing on the basis of the sex of the driver, cannot be discounted at least for drivers admitted to hospital. The qualitative research suggested that sex differences in the level of missing values might be more marked at State level, especially between those States having a legislative/policy requirement for BAC testing of drivers admitted to hospital and those not having such legislation.

Where the BAC level of the driver was known, it was more frequently >.05 in males than in females for both fatalities and hospital admissions. For both males and females, the proportion of cases >.05 amongst fatalities was similar to the proportion >.05 amongst hospital admissions. Given the lack of any substantial difference between males and females in the level of missing values for BAC, it cannot be discounted that the sex differential in the proportion of cases >.05 could reflect true differences in alcohol involvement at national level.

Table 4. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes by sex, Australia 1990.

Driver sex	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities									
Male	486	62.2	295	37.8	781	100.0	149	16.0	930
Female	166	79.8	42	20.2	208	100.0	36	14.8	244
Total	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions									
Male	3863	69.9	1667	30.1	5530	100.0	3636	39.7	9166
Female	1791	85.9	295	14.1	2086	100.0	1939	48.2	4025
Unknown	0	0.0	0	0	0	100.0	4	100.0	4
Total	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.3 Driver age

Table 5 presents information on the extent of missing values and BAC distribution of drivers seriously injured in road traffic crashes, presented according to the age of the driver.

It can be seen that the level of missing values of BAC for each age group was similar amongst both fatalities and hospital admissions, with the exception that drivers aged 60 years or more killed in road traffic crashes had nearly double the level of missing values of the other age groups. They also had a higher level of missing values amongst hospital admissions. The high level of missing values for older drivers could reflect differences in the application of legislation, policy or procedures for BAC testing on the basis of the age of driver.

Where the BAC level of the driver was known, the proportion of cases >.05 was highest in drivers aged 26-39 years and lowest in the 60+ age group for both fatalities and hospital admissions.

The high proportion of missing values for BAC in the 60+ age group especially for fatalities could be due to a lack of targeting of older drivers as they have a low likelihood of alcohol involvement. The qualitative research suggested that where BAC testing was discretionary drivers who would be expected to have low BAC (e.g. the elderly) would be less frequently tested, resulting in high levels of missing values for BAC amongst hospital admissions in those States.

Table 5. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes by age, Australia 1990.

Driver age	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities									
≤ 25	247	63.2	144	36.8	391	100.0	59	13.1	450
26-39	166	57.4	123	42.6	289	100.0	51	15.0	340
40-59	122	66.7	61	33.3	183	100.0	32	14.9	215
≥ 60	117	92.9	9	7.1	126	100.0	43	25.4	169
Total	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions									
≤ 25	2327	71.6	925	28.4	3252	100.0	2256	41.0	5508
26-39	1566	68.5	719	31.5	2285	100.0	1603	41.2	3888
40-59	1075	81.9	238	18.1	1313	100.0	1028	43.9	2341
≥ 60	602	92.8	47	7.2	649	100.0	568	46.7	1217
Unknown	84	71.8	33	28.2	117	100.0	124	51.5	241
Total	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.4 Vehicle damage, as indicated by vehicle tow away

Table 6 presents information on the extent of missing values and BAC distribution of drivers seriously injured in road traffic crashes, presented according to vehicle damage, as indicated by vehicle tow away.

It can be seen that the level of missing values of BAC for the two vehicle damage groups was similar amongst fatalities and hospital admissions. Therefore there was no evidence of any substantial effect on the extent of missing values for BAC at national level of differences in the application of legislation, policy or procedures for BAC testing on the basis of extent of vehicle damage.

Where the BAC level of the driver was known, the proportion of cases >.05 was highest amongst fatalities where a vehicle was towed away, but there was no such pattern evident amongst hospital admissions. These results could suggest that alcohol involvement may be a more important factor in severe crashes, where vehicle damage and injury outcome were both substantial.

Of course, there could well be State differences from the patterns observed in Table 6 in response to the effects of the framework for BAC testing (i.e. legislative/policy requirements versus discretionary testing) as was suggested in the qualitative research.

Table 6. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes by vehicle damage, Australia 1990.

Vehicle damage	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities									
Vehicle towed away	587	65.2	313	34.8	900	100.0	175	16.3	1075
Vehicle not towed away	20	71.4	8	28.6	28	100.0	5	15.2	33
Unknown	45	73.8	16	26.2	61	100.0	5	7.6	66
Total	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions									
Vehicle towed away	4683	74.2	1627	25.8	6310	100.0	4336	40.7	10646
Vehicle not towed away	836	75.1	277	24.9	1113	100.0	908	44.9	2021
Unknown	135	69.9	58	30.1	193	100.0	335	63.4	528
Total	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.5 Road user type

Table 7 presents information on the extent of missing values and BAC distribution of drivers seriously injured in road traffic crashes, presented according to their road user type i.e. whether they were drivers of motor vehicles (cars, truck, buses etc.) other than motorcycles or motorcyclists.

It can be seen that the level of missing values of BAC for the two road user types was similar amongst fatalities and hospital admissions. Therefore there was no evidence of any substantial effect on the extent of missing values for BAC at national level of differences in the application of legislation, policy or procedures for BAC testing on the basis of road user type.

Where the BAC level of the driver was known, the proportion of cases >.05 was similar for the two road user types amongst fatalities, but was higher for drivers of motor vehicles other than motorcycles amongst hospital admissions. The results for hospital admissions do not necessarily reflect a higher incidence of alcohol involvement (>.05) amongst drivers compared with motorcyclists as there is a higher level of under-reporting of serious but non-fatal motorcyclist injury and some evidence of a higher level of alcohol involvement amongst cases not reported to police (see Section 4.3 for a discussion).

Of course, there could well be State differences from the patterns observed in Table 7 in response to the effects of the framework for BAC testing (i.e. legislative/policy requirements versus discretionary testing) as was suggested in the qualitative research.

Table 7. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes by road user type, Australia 1990.

Road user type	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities									
Driver of MV other than motorcycle	512	65.7	267	34.3	779	100.0	154	16.5	933
Motor cyclist	140	66.7	70	33.3	210	100.0	31	12.9	241
Total	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions									
Driver of MV other than motorcycle	4425	73.0	1640	27.0	6065	100.0	4318	41.6	10383
Motorcyclist	1229	79.2	322	20.8	1551	100.0	1261	44.8	2812
Total	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.6 Time of crash

Table 8 presents information on the extent of missing values and BAC distribution of drivers seriously injured in road traffic crashes, presented according to time of crash.

It can be seen that the level of missing values of BAC was lowest in the hours of darkness (lowest for fatalities from 6pm to 12 midnight and lowest for hospital admissions from midnight to 6am when the total number of road injury hospital admissions was also at its lowest). The relationship between a low proportion of missing cases for admissions from midnight to 6am and a low number of admissions at that time could reflect a relatively greater ability of hospital staff to undertake sampling at times of lower work load - work load being a factor raised in the qualitative research as affecting the level of missing values.

Where the BAC level of the driver was known, the proportion of cases >.05 was lowest during the daylight hours, 6am to 6pm. At those times when the proportion of missing values was highest, the proportion of cases BAC >.05 was lowest. It could be that these results reflect the incidence of alcohol involvement (>.05) at those times, targeting of the BAC testing of injured drivers toward those drivers suspected to have BAC >.05 (as was suggested in the qualitative research) or other factors.

It was noteworthy that the 'time of crash' variable had two subcategories (night-time crashes) whose proportion of cases with BAC >.05 were over 50%. This was higher than was evident for any other subcategory of any other variable presented in Section 3 which had a reasonably low level of missing values (i.e. less than 30%), with the exception of NT (see Table 3) and single vehicle crashes (see Table 10). This could indicate that time of day was relatively more strongly correlated with BAC level, a matter which was assessed more definitively in the multi-variate analysis in Section 3.4.

There could well be State differences from the patterns observed in Table 8 in response to the effects of the framework for BAC testing (i.e. legislative/policy requirements versus discretionary testing) as was suggested in the qualitative research.

Table 8. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes by time of crash, Australia 1990.

Time of crash	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities									
12pm ≤ T < 6 am	83	45.6	99	54.4	182	100.0	35	16.1	217
6 am ≤ T < 6 pm	437	85.9	72	14.1	509	100.0	107	17.4	616
6 pm ≤ T < 12 pm	129	44.2	163	55.8	292	100.0	40	12.0	332
Unknown	3	50.0	3	50.0	6	100.0	3	33.3	9
Total	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions									
12pm ≤ T < 6 am	515	44.1	652	55.9	1167	100.0	465	28.5	1632
6 am ≤ T < 6 pm	3743	91.1	365	8.9	4108	100.0	3761	47.8	7869
6 pm ≤ T < 12 pm	1345	59.4	920	40.6	2265	100.0	1278	36.1	3543
Unknown	51	67.1	25	32.9	76	100.0	75	49.7	151
Total	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.7 Day of crash

Table 9 presents information on the extent of missing values and BAC distribution of drivers seriously injured in road traffic crashes, presented according to day of crash.

It can be seen that the level of missing values of BAC for fatalities and hospital admissions was lowest for the period Friday - Sunday, although only slightly so for fatalities. Therefore the possibility of an effect on the extent of missing values for BAC at national level of differences in the application of legislation, policy or procedures for BAC testing on the basis of day of crash, cannot be discounted.

Where the BAC level of the driver was known, the proportion of cases >.05 was highest amongst both fatalities and hospital admissions on those days when the proportion of missing values was lowest i.e. Friday - Sunday. It could be that these results reflect the incidence of alcohol involvement (>.05) at those times, targeting in the BAC testing of injured drivers (as was suggested in the qualitative research) or other factors.

There could well be State differences from the patterns observed in Table 9 in response to the effects of the framework for BAC testing (i.e. legislative/policy requirements versus discretionary testing) as was suggested in the qualitative research.

Table 9. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes by day of crash, Australia 1990.

Day of crash	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities									
Monday-Thursday	366	72.8	137	27.2	503	100.0	99	16.4	602
Friday-Sunday	286	58.8	200	41.2	486	100.0	86	15.0	572
Total	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions									
Monday-Thursday	3085	82.0	678	18.0	3763	100.0	3077	45.0	6840
Friday-Sunday	2569	66.7	1284	33.3	3853	100.0	2502	39.4	6355
Total	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.8 Number of vehicles in crash

Table 10 presents information on the extent of missing values and BAC distribution of drivers seriously injured in road traffic crashes, presented according to the number of vehicles involved.

It can be seen that the level of missing values of BAC for fatalities and hospital admissions was marginally higher for single vehicle crashes. Therefore the possibility of an effect on the extent of missing values for BAC at national level of differences in the application of legislation, policy or procedures for BAC testing on the basis of day of crash, cannot be discounted.

Where the BAC level of the driver was known, the proportion of cases >.05 was highest for single vehicle crashes amongst both fatalities and hospital admissions. Indeed the proportion >.05 for single vehicle crashes was over three and a half times higher than for multiple vehicle crashes amongst fatalities, and nearly three times higher amongst hospital admissions. It could be that these results reflect the incidence of alcohol involvement (>.05) at those times, targeting in the BAC testing of injured drivers (as was suggested in the qualitative research) or other factors.

There could well be State differences from the patterns observed in Table 10 in response to the effects of the framework for BAC testing (i.e. legislative/policy requirements versus discretionary testing) as was suggested in the qualitative research.

Table 10. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes by number of vehicles in crash, Australia 1990.

Number of vehicles in crash	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities									
1	210	45.2	255	54.8	465	100.0	79	14.5	544
2+	442	84.4	82	15.6	524	100.0	106	16.8	630
Total	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions									
1	1988	59.1	1375	40.9	3363	100.0	2255	40.1	5618
2+	3666	86.2	587	13.8	4253	100.0	3324	43.9	7577
Total	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.9 Speed limit applicable to crash location

Table 11 presents information on the extent of missing values and BAC distribution of drivers seriously injured in road traffic crashes, presented according to the speed limit applicable to crash location.

It can be seen that the level of missing values of BAC for fatalities was marginally higher for crashes in the >80 kph speed zone than crashes in the lower speed zone, but this was not the case for hospital admissions. The results of the qualitative analysis indicated that, for fatalities, higher levels of missing values could occur in rural crashes due to inconsistency in procedures for BAC testing. To the extent that speed zone is a good indicator of whether the crash occurred in the urban or rural area, these results could explain the quantitative findings to some extent. The findings may also reflect an expected greater proportion of cases in rural areas which would exceed the prescribed time limits for hospital blood sampling (see Table 1) but then die in hospital and a BAC result would not then be available to the Coroner's office. It should be noted that alcohol analysis was not undertaken at post-mortem in NSW and Qld where the victim survived for more than a specified time (24 hours in NSW, 12 hours in Qld) or, in NSW, where the body was decomposed. The incidence of both of these events could be expected to be higher in rural crashes.

Where the BAC level of the driver was known, the proportion of fatalities >.05 was highest in crashes in <80 kph speed zones, where the level of missing values was lowest, although only marginally so. No such differences were evident for hospital admissions.

There could well be State differences from the patterns observed in Table 11 in response to the effects of the framework for BAC testing (i.e. legislative/policy requirements versus discretionary testing) as was suggested in the qualitative research.

Table 11. BAC status and level for seriously injured drivers of motor vehicles involved in road traffic crashes by speed limit applicable to crash location, Australia 1990.

Speed limit	BAC level where known						BAC not known		Total cases
	≤.05		>.05		Total known		Not known		
	n	% of Total known	n	% of Total known	n	% of Total known	n	% of Total cases	n
Fatalities									
≤ 80 kph	291	64.7	159	35.3	450	100.0	59	11.6	509
> 80 kph	352	67.0	173	33.0	525	100.0	115	18.0	640
Total	652	65.9	337	34.1	989	100.0	185	15.8	1174
Hospital admissions									
≤ 80 kph	3599	74.4	1241	25.6	4840	100.0	3399	41.3	8239
> 80 kph	1932	74.1	676	25.9	2608	100.0	1882	41.9	4490
Total	5654	74.2	1962	25.8	7616	100.0	5579	42.3	13195

Data Source: FORS Serious Injury File, 1990. The Serious Injury File is based on crash reports to police in which one or more persons died or was admitted to hospital as a result of a road traffic crash. Cases selected for analysis were drivers, including motorcyclists, who died or were admitted to hospital.

3.4.10 Summary of univariate quantitative analysis

A number of issues are worth highlighting based on the results presented.

- Where the BAC level of drivers seriously injured in road traffic crashes was known, it was >.05 in about one third of fatalities and one quarter of hospital admissions nationally, but varied widely across the States.
- The level of missing values of BAC for hospital admissions was substantially lower in those States having a legislative/policy requirement for the BAC testing of drivers attending hospital following a road traffic crash.
- There was more consistency in the proportion of hospital admission cases that had a BAC >.05 amongst those States (i.e. NSW, SA, NT and Vic) having a legislative/policy requirement for BAC testing of drivers attending hospital following a road traffic crash (range = 21% to 36%) than amongst those States which did not have such a requirement (range = 27% to 67%). However, the level of missing values varied widely across States: from 6% to 43% in States having the specified legislative/policy requirement and from 74% to 90% in States which did not have such a requirement. NSW appeared to have the most accurate information on BAC level as it had a very low level of missing values (6%).

- Interpretation of the univariate results regarding BAC level was complicated by high levels of missing values for some categories of the independent variables. It was noted that the results could reflect factors other than the incidence of alcohol involvement (>.05) in serious injury crashes, including the targeting of certain groups of injured drivers. It was suggested that the results found for many variables, wherein certain categories had a relatively low proportion of cases with missing values as well as a relatively high proportion of cases with BAC >.05 (and also categories having a relatively high proportion of cases with missing values and a relatively low proportion of cases with BAC >.05), could be indicative of a targeting of high BAC drivers by hospitals, police or others, a factor which was suggested in the qualitative research. Of course, where the level of missing values for any category was high, the BAC level for that category could be highly inaccurate.
- As the primary purpose of the study was to provide a national perspective, there remains the possibility of State variations from the national patterns detected. The qualitative research suggested that discretionary BAC testing in some States may be biased toward the selection of cases likely to have high BAC and could therefore be expected to result in a distribution of BAC level toward a high BAC.
- The statistical significance of the relationships between independent variables and the dependent variables (BAC status and level) was assessed by multivariate analysis (see Section 3.5).

3.5 Multivariate Quantitative Analysis

In Section 3.4, the results of univariate analysis were presented illustrating the distribution of blood alcohol concentration and missing values on the basis of a range of independent variables.

While it was informative to examine these distributions on the basis of single independent variables a multivariate approach provided two additional measures, the results of which were required by the study objectives:

- a measure of the influence (direction, strength and statistical significance) of each independent variable on the dependent variable while simultaneously controlling for the influence of other independent variables;

- a multivariate estimate of BAC, based on cases where BAC was known, which could provide the basis for estimation of BAC where missing.

This section first presents a summary of the approach to multivariate analysis adopted in this report (Section 3.5.1) which is then followed up with the results of multivariate analysis of the distribution of BAC status (known v. missing) for fatalities (Section 3.5.2) and hospital admissions (Section 3.5.3) and BAC level (≤.05 v. >.05) for fatalities (Section 3.5.4) and hospital admissions (Section 3.5.5) based on the independent variables previously considered.

Sections 3.5.4 and 3.5.5. include an assessment of the characteristics of the model in terms of predictive strength (referring to such characteristics as extent of false positives and false negatives). Sections 3.5.2. and 3.5.3 do not include such an assessment as the models for BAC status were not used for the purposes of prediction.

3.5.1 Statistical Method

3.5.1.1 Introduction

Logistic regression was considered to be the most appropriate multivariate statistical procedure as it assumes a dichotomous dependent variable and makes no assumptions regarding the distribution of the independent variables.[3]

The logistic regression model can be expressed as follows:

$$\text{Prob (event)} = \frac{1}{1+e^{-Z}}$$

where the event is BAC >.05 and Z is the linear combination

$$Z = B_0 + B_1X_1 + B_2X_2 + \ldots\ldots + B_pX_p$$

where B_0, $B_1 \ldots B_p$ are coefficients estimated from the data, X_1 to X_p are the independent variables of the study (such as State, age and sex) and *e* is the base of the natural logarithms (approximately 2.718).

Under the hypothesis that an individual coefficient is zero, the Wald statistic, W= B/SE(B) will be normally distributed. Thus, the value W provides an indication of which variables in the

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[3] While multiple linear regression could have been considered for the analysis of BAC distribution, if BAC had been treated as a continuous variable, this approach was not adopted as the distribution of BAC was not normal. Instead BAC was allocated to two categories (≤ .05 and > .05) as .05 was the legal BAC limit for vehicle controllers in most States in the year that was the subject of the data analysis (i.e. 1990) and at the time of publication of the present report was the legal limit in all States.

Other approaches to the estimation of categorical dependent variables that were considered included:

- non-iterative least squares
- discriminant function analysis.

In discussing alternative modelling approaches Hosmer and Lemeshow (1989, p20) have pointed out that discriminant function estimators are sensitive to the assumption of normality and will overstate the magnitude of association for dichotomous independent variables. They also point out (p19) that the non-iterative least squares method requires an estimate of the conditional mean of Y, given X, which is non-zero for most values of X, which cannot be assumed to be the case in the present study.

model may or may not be significant. A values less than 1.96 (P = .05) indicates that the size of the coefficient B does not significantly differ from zero (Hosmer & Lemeshow, 1989, p31).

The analytical procedure used to estimate the coefficients for the models was stepwise logistic regression using the likelihood ratio (LR) test for selecting the variable to be entered at each step. Hosmer and Lemeshow (1989, p 8-11) recommend the likelihood ratio as the most appropriate method of variable selection.

At each step in the model building process an improvement statistic was calculated. This measured the change in the quantity '-2 times the log of the likelihood' (-2LL) between each step. It tests the null hypothesis that the coefficient for the variable added at each step is zero.

For further information on the interpretation of statistics presented in this report, produced as an output from logistic regression analysis using SPSS, the interested reader is referred to Appendix 1, to the SPSS manual (Norusis, 1990) and to the book by Hosmer and Lemeshow (1989).

3.5.1.2 Indicator coding

The independent variables entered into the model were set up using an indicator coding scheme. The advantage of indicator coding is that the coefficients represent the effect of each category compared to a reference category and the exponential of the coefficient, Exp (B), represents the odds ratio for each indicator variable; that is the probability of the event occurring when the indicator is 1 over the probability of the event when the indicator is 0 while controlling for the effects of the other independent variables in the model.

Variables were coded on the basis of probability of alcohol involvement. The categories associated with an increased likelihood of a positive BAC were determined through univariate analysis. The coding scheme is presented in Table 12.

Table 12. Indicator coding scheme

Variable	Indicator category Coding = 1	Reference category Coding = 0 *
Time of day	6.00 pm to 5.59 am	All others
Day of the week	Friday to Sunday	All others
Number of vehicles	Single vehicle	All others
Crash severity	Vehicle towed away	All others
Speed limit	Speed limit > 80 kph	All others
Sex	Vehicle controller is male	All others
Age group	Vehicle controller < 40 yrs	All others
Road user	Driver of motor vehicle other than motorcycle	All others
State		
	VIC	NSW
	QLD	NSW
	SA	NSW
	WA	NSW
	TAS	NSW
	NT	NSW
	ACT	NSW

* Includes cases with missing values for the variables in question.

3.5.1.3 Multicolinearity

The contribution of individual variables to the model will be affected by the level of correlation between the independent variables. Therefore prior to undertaking the logistic regression analysis the extent of correlation amongst the independent variables was assessed. The correlations between the independent variables entered into the model are presented in Table 13. The statistic presented is Phi which is equivalent to Pearson's R for a 2 by 2 contingency table (Norusis, 1993, p210).

Table 13 Correlation between independent variables

	State*	Time of day	Day of week	No. of vehicles	Crash severity	Speed limit	Sex	Age group
State								
Time of day	-.03 to .05							
Day of week	-.01 to .02	.12						
No. of vehicles	-.08 to .04	.20	.11					
Crash severity	-.11 to .34	.04	-.01	-.03				
Speed limit	-.05 to .07	.02	-.03	-.31	.05			
Sex	-.03 to .03	.11	.07	.08	-.10	-.02		
Age group	-.02 to .04	.17	.06	.13	-.08	.01	.08	
Road user	-.01 to .02	-.05	.01	-.07	.39	.13	.29	.21

* Correlations reported for State are the range of correlations, based on 2x2 contingency tables, for individual States when compared with all other States.

The majority (92%) of the correlation coefficients were less than .3. The remaining associations were only moderate. On the basis of this result it was determined that it was unnecessary to further partition the independent variables.

3.5.1.4 Case allocation

As noted above the logistic regression model estimates the probability that each case belongs to a particular category of a categorical dependent variable. Cases were allocated to each category of the dependent variable on the basis of the estimated probability. In allocating cases to the categories of a dependent variable, on the basis of estimated probabilities, it is most common to use .5 as the cut off point (Hosmer and Lemeshow, 1989, p146).[4] Cases for which the probability of BAC >.05 was .5 or more were allocated to that category. Cases for which the probability was less than .5 were allocated to the BAC ≤.05 category. The same criterion was used to allocate cases between the known and missing categories of BAC status.

[4] The cut off point does not have to take this value however. For example, if it were more important to identify all cases with a BAC > .05 the cut-off could be lowered for example to P=.2. If however the researcher was primarily interested in investigating someone if there was a very high likelihood that they were BAC > .05 the cut off point might be raised to P = .9. In the present study P=.5 was chosen as the cut-off probability value.

3.5.2 Results of logistic regression analysis of BAC status (known v. missing) - fatalities

Table 14 Logistic regression model for BAC status - fatalities

Step No.	Variable Entered	Beta	St. error	Wald *	P (2 tailed test)	Partial Corr. (R)	Odds Ratio	95% conf. interval. (odds ratio)
1.	State**			77.6	.000	.25		
	WA	1.78	.27	42.72	.000	.20	5.92	3.47 - 10.09
	ACT	3.41	.58	34.67	.000	.18	30.36	9.75 - 94.58
	Qld	.97	.25	15.06	.001	.11	2.63	1.61 - 4.29
	SA	.64	.31	4.23	.040	.05	1.89	1.03 - 3.47
2.	Speed limit	.54	.18	9.08	.003	.08	1.72	1.21 - 2.45
3.	Age group	-.47	.17	7.31	.007	-.07	.62	.44 - .88
	Constant	-2.29	.23	101.7	.000			

* Degrees of freedom = 1 (except for 'State' variable where df = 7, noting that df = 1 for individual States)
** Individual States are listed where P is less than .05, ordered with respect to the size of R (highest first). Note that the number of cases in ACT is very small (n=16)

For fatal cases, significant relationships were found between BAC status and the following independent variables: State, speed limit and age group (see Table 14). The strongest association was for State (R = .25). The level of missing values in WA, ACT, Qld and SA was significantly different from (higher than) NSW. BAC status was nearly six times more likely to be missing in WA compared to NSW.

Weak but significant associations were found between BAC status and speed limit and age group.[5] Crashes in speed zones over 80 kph were 1.7 times more likely to have a BAC status of missing. Drivers aged 40+ years were more likely to have a BAC status of missing.

The summary statistics for the final model were as follows:

-2 Log Likelihood	921.1		
Goodness of fit	1119.2		
	Chi-square	df	P
Model chi-square	101.80	9	.000

The statistics indicate that the model was a good fit of the data.[6]

[5] The results of univariate analysis which suggested that time of day, day of crash and number of vehicles in crash may also be factors related to the level of missing values were not confirmed by the multivariate analysis, possibly due to intercorrelation amongst independent variables.

[6] This does not imply that the model has strong predictive strength. No assessment of predictive strength was undertaken as this was not part of the study objectives.

3.5.3 Results of logistic regression analysis of BAC status (known v. missing) - hospital admissions

Table 15 Logistic regression model for BAC status - hospital admissions

Step No.	Variable Entered	Beta	St. error	Wald *	P (2 tailed test)	Partial Corr. (R)	Odds Ratio	95% conf. interval. (odds ratio)
1.	State**			3453.3	.000	.44		
	Qld	4.51	.09	2427.7	.000	.37	91.0	76.06 - 108.87
	WA	5.11	.12	1957.7	.000	.33	165.1	131.70 - 207.03
	VIC	2.54	.08	1098.0	.000	.25	12.6	10.87 - 14.67
	TAS	3.83	.16	575.7	.000	.18	46.1	33.73 - 63.07
	SA	1.68	.09	316.2	.000	.13	5.4	4.47 - 6.48
	ACT	4.37	.24	325.4	.000	.13	78.8	49.06 - 126.73
	NT	2.14	.16	188.5	.000	.10	8.5	6.24 - 11.48
2.	Time of day	-.66	.05	176.0	.000	-.10	.5	.47 - .57
3.	Sex	-.41	.05	59.4	.000	-.06	.7	.60 - .74
4.	Age group	-.28	.05	27.1	.000	-.04	.7	.68 - .84
5.	Road user	-.29	.07	19.0	.000	-.03	.7	.65 - .85
6.	Day of the week	-.21	.05	20.2	.000	-.03	.8	.74 - .89
7.	Vehicle damage	-.22	.07	11.0	.001	-.02	.8	.70 - .91
	Constant	-1.59	.11	209.8	.000			

* Degrees of freedom = 1 (except for 'State' variable where df = 7, noting that df = 1 for individual States)
** Individual States are listed where P is less than .05, ordered with respect to the size of R (highest first).

For drivers admitted to hospital following a road crash, significant relationships were found between BAC status and the following independent variables (in order of strength): State, time of day, sex, age group, road user type, day of week and vehicle damage (see Table 15).

The strongest association was for State (R = .44). The level of missing values in all States was significantly different from (higher than) NSW. BAC status was about 90 times more likely to be missing in Qld compared to NSW and 165 times more likely to be missing in WA compared to NSW .

Weak but significant associations were found between BAC status and a number of other variables: time of day, sex, age group, road user type, day of week and vehicle damage. The odds ratios for these variables were between .5 and .8, indicating that the differences in BAC status were not large across subgroups of these variables.

The summary statistics for the final model were as follows:

-2 Log Likelihood	11525.5		
Goodness of fit	13462.9		
	Chi-square	df	P
Model chi-square	6450.95	13	.000

The statistics indicate that the model was a good fit of the data.[7]

3.5.4 Results of logistic regression analysis of BAC level (≤.05 v. >.05) - fatalities

Table 16 Logistic regression model for BAC level - fatalities

Step No.	Variable Entered	Beta	St error	Wald *	P (2 tailed test)	Partial Corr. (R)	Odds Ratio	95% Conf. interval (odds ratio)
1	Time of day	1.85	.17	119.6	.000	.30	6.34	4.55 - 8.82
2	Number of vehicles	1.75	.17	110.1	.000	.29	5.75	4.14 - 7.97
3	Sex	.64	.22	8.5	.004	.07	1.90	1.23 - 2.92
4	Day of the week	.45	.16	7.7	.006	.07	1.57	1.14 - 2.17
	Constant	-3.41	.26	167.3	.000			

* Degrees of freedom = 1

For fatal cases the variables that were entered into the model as significant predictors of a blood alcohol concentration greater than .05 were the time that the crash occurred (between 6.00 pm and 5.59 am), the number of vehicles involved (single vehicle), the sex of the vehicle controller (male) and the day of the week that the crash occurred (Friday, Saturday or Sunday).[8]

Vehicle controllers involved in crashes occurring at night were more than 6 times as likely to be alcohol affected when compared to controllers involved in crashes occurring during the day while vehicle controllers involved in single vehicle accidents were more than 5 times as likely to be alcohol affected when compared to vehicle controllers involved in multiple vehicle crashes.

[7] This does not imply that the model has strong predictive strength. No assessment of predictive strength was undertaken as this was not part of the study objectives.

[8] When interpreting the results it should be noted that the logistic regression procedure estimates a model that is associative in nature rather than causal. The reported odds ratios may reflect factors other than differential incidence in alcohol involvement in crashes, including the effects of selection factors in blood sampling.

The summary statistics for the final model were as follows:

-2 Log Likelihood	932.2		
Goodness of fit	924.7		
	Chi-square	df	P
Model chi-square	336.75	4	.0000

The statistics indicate that the model was a good fit of the data.

Each case where BAC was missing was allocated to the categories BAC ≤.05 and BAC>.05, on the basis of the probability value estimated by the model, using P=.05 as the cut off point. Table 15 shows the results of this estimation procedure. It also shows the way in which cases with known BAC were allocated between the categories BAC ≤.05 and BAC>.05 by the model, which facilitates an assessment of the utility of the model for the purposes of prediction of BAC level. The assessment focuses on the false positive and false negative rates and true positive and true negative rates.[9]

Table 17 Distribution of actual and predicted BAC level for fatalities, Australia 1990 (column percentages)

	Actual BAC						
	Known					Not known	Total (all cases)
Predicted BAC*	≤.05		>.05		Total known		
	n	%	n	%	n	n	n
≤.05	568	87	144	43	712	146	858
>.05	84	13	193	57	277	39	316
Total	652	100	337	100	989	185	1174

* Prediction based on logistic regression model.

Where known, BAC was correctly predicted by the model in 77% of cases. This included 193 true positive cases and 568 true negative cases. The true negative rate was high (87%) and the false positive rate was low (13%). However, the false negative rate (43%) and the true positive rate were only moderate (57%). These results demonstrate that the model was most

9 True positive rate = the proportion of cases estimated to be BAC>.05 that were truly BAC>.05.
True negative rate = the proportion of cases estimated to be BAC≤.05 that were truly BAC≤.05.
False positive rate = the proportion of cases estimated to be BAC>.05 that were truly BAC≤.05.
False negative rate = the proportion of cases estimated to be BAC≤.05 that were truly BAC>.05.

efficient in predicting true negative cases and that it would tend to underenumerate the number of cases with BAC >.05.

When the model was applied to the fatalities which had missing values for BAC (185 cases), 39 cases were estimated to be BAC >.05, representing 21% of the cases which had missing values (a lower proportion than amongst the cases where BAC was known).

However, this figure did not take any account of the pattern of actual to predicted values presented in Table 15. The number of cases truly BAC >.05 (337) was 22% higher than the predicted number of cases (277). Therefore the number of cases which had missing values for BAC which were estimated to be >.05 could be inflated by as much as 22% from 39 to 48 cases.[10]

After combining the number of cases known to be BAC >.05 (337) with the missing cases estimated to be BAC >.05 (48), the total number of cases with BAC >.05 was estimated to be as high as 385 or 33% of all fatalities. This compares with 337 cases or 34% of fatalities (where BAC was known) where the estimate for cases having missing values for BAC was excluded.

[10] Given that the qualitative and univariate quantitative research undertaken in this study suggests a lower proportion with BAC >.05 amongst cases with missing values for BAC than amongst cases with known BAC, 48 should be regarded as an upper limit, with the true value being somewhere between 39 and 48.

3.5.5 Results of logistic regression analysis of BAC level (≤.05 v. >.05) - hospital admissions

The results of the logistic regression analysis undertaken for hospital admitted cases are presented in this section.

Table 18 Logistic regression model for BAC level - hospital admissions

Step No.	Variable Entered	Beta	St. error	Wald *	P (2 tailed test)	Partial Corr. (R)	Odds Ratio	95% conf. interval. (odds ratio)
1	Time of day	1.80	.07	704.3	.000	.28	6.04	5.29 - 6.90
2.	Number of vehicles	1.30	.07	372.0	.000	.21	3.66	3.21 - 4.18
3.	State**			148.7	.000	.12		
	Qld	1.63	.14	137.4	.000	.12	5.08	3.87 - 6.67
	SA	.30	.10	9.35	.002	.03	1.35	1.11 - 1.64
	VIC	.22	.07	8.8	.003	.03	1.24	1.08 - 1.44
	NT	.58	.20	8.80	.003	.03	1.79	1.22 - 2.62
	ACT	1.13	.49	5.24	.022	.02	3.10	1.18 - 8.16
	TAS	.57	.28	4.05	.044	.02	1.77	1.01 - 3.09
4.	Sex	.84	.08	108.2	.000	.11	2.32	1.98 - 2.71
5.	Day of the week	.59	.06	85.1	.000	.10	1.80	1.59 - 2.03
6.	Speed limit	-.40	.07	33.6	.000	-.06	.67	.58 - .77
7.	Road user	.49	.08	34.8	.000	.06	1.64	1.39 - 1.93
8.	Age group	.40	.08	25.6	.000	.05	1.49	1.28 - 1.75
	Constant	-4.55	.15	977.3	.000			

* Degrees of freedom = 1 (except for 'State' variable where df = 7, noting that df = 1 for individual States)
** Individual States are listed where P is less than .05, ordered with respect to the size of R (highest first).

For the hospital admitted cases all of the independent variables were entered into the model with the exception of the crash severity (vehicle towed away).

The results of the analysis were similar to the results observed for fatal cases in that time of day and number of vehicles were most strongly associated with alcohol involvement. Vehicle controllers involved in crashes occurring at night were more than 6 times as likely to record a BAC >.05 when compared to controllers involved in crashes occurring during the day while those involved in single vehicle crashes were almost 4 times as likely to record BAC >.05 when compared to controllers involved in multiple vehicle crashes.

Weak but significant associations were found between BAC level and a number of other variables for hospital admissions: State, sex, day of week, speed limit, road user type and age group. Drivers admitted to hospital following a road crash in Queensland who were blood tested for alcohol were 5 times more likely to record BAC >.05 than such drivers in New South Wales.[11]

The statistics for the final model were as follows:

-2 Log Likelihood	6407.2		
Goodness of fit	7307.1		
	Chi-square	df	P
Model Chi-square	2283.4	14	.0000

The statistics indicate that the model is a good fit of the data.

The outcome of the allocation of cases, for which BAC was not known, to the BAC categories on the basis of the logistic regression model is presented in Table 17. It provides information about the utility of the model for the purposes of prediction of BAC level.

Table 19 Distribution of actual and predicted BAC level for hospital admissions, Australia 1990 (column percentages)

	Actual BAC						
	Known					Not known	Total (all cases)
Predicted BAC*	≤.05		>.05		Total known		
	n	%	n	%	n	n	n
≤.05	5103	90	965	49	6068	4503	10571
>.05	551	10	997	51	1548	1076	2624
Total	5654	100	1962	100	7616	5579	13195

* Prediction based on logistic regression model.

Where known, BAC was correctly predicted by the model in 80% of cases. The true negative rate was high (90%) and the false positive rate was low (10%). However, the false negative rate (49%) and the true positive rate were only moderate (51%). These results demonstrate that the model was most efficient in predicting true negatives and that it would tend to underenumerate the number of cases with BAC >.05.

[11] Again it should be noted that the results of the logistic regression procedure estimate a model that is associative in nature rather than causal. The reported odds ratios may reflect factors other than differential incidence in alcohol involvement in crashes, including the effects of targeting by police and hospitals.

When the model was applied to the hospital admissions which had missing values for BAC (5579 cases), 1076 cases were estimated to be BAC>.05, representing 19% of the cases which had missing values (a lower proportion than amongst the cases where BAC was known).

However, this figure did not take any account of the pattern of actual to predicted values presented in Table 17. The number of cases truly BAC >.05 (1962) was 27% higher than the predicted number of cases (1548). Therefore the number of cases which had missing values for BAC which were estimated to be >.05 could be inflated by as much as 27% from 1076 to 1367 cases.[12]

After combining the number of cases known to be BAC >.05 (1962) with the missing cases estimated to be BAC >.05 (1367), the total number of cases with BAC >.05 was estimated to be as high as 3329 or 25% of all hospital admissions. This compares with 1962 or 26% of hospital admissions (where BAC was known) where the estimate for cases having missing values for BAC was excluded.

[12] Given that the qualitative and univariate quantitative research undertaken in this study suggests a lower proportion with BAC >.05 amongst cases with missing values for BAC than amongst cases with known BAC, 1367 should be regarded as an upper limit, with the true value being somewhere between 1076 and 1367.

4. DISCUSSION & RECOMMENDATIONS

This study set out to contribute to an assessment of the quality of information on alcohol involvement in road crashes and to understand the factors which influence this characteristic, as well as to identify those factors that might be used to improve the information.

The discussion, which highlights some of the principal findings of the study, will be organised under the projected outputs for the study listed below.

- Identification of the factors which could influence the extent of missing values for BAC in road crash databases at national level.

- Identification of the variables most strongly associated with BAC status (known v. missing) and BAC level (≤.05 v. >.05).

- Estimation of the number and proportion of cases having BAC >.05 at national level taking into account the extent to which cases having missing values for BAC were likely to have BAC >.05.

- Provision of recommendations for reducing the level of missing values in existing databases and, if necessary, specification of the requirements for any new databases at national level.

4.1 Identification of the factors which could influence the extent of missing values for BAC in road crash databases at national level

The results of the hypothesis development stage indicated that the level of missing values for BAC could be subject to the influence of a wide range of factors including: legal requirements; operational constraints; police, hospital and coronial procedures; case classification and data matching issues; and levels of reporting of crash involvement.

The qualitative research revealed particular circumstances wherein failure to assess BAC could be expected in some cases, for example, where targeting of those expected to be BAC >.05 was employed, where police fail to attend the crash scene, where medical treatment takes priority over blood sampling, where casualty department workloads were high and where there was failure to detect a patient as a road trauma victim.

It was considered by the study reference group that principal amongst the factors which could influence the level of missing values, at least for the survivors of road injury, was the presence or absence of a legislative requirement for BAC testing. This seemed to be verified by the results of the multivariate analysis of BAC status, where State was the variable which had the strongest relationship with BAC status (known v. missing), and also in the results of the univariate analysis of BAC status by State, where very much higher levels of missing values were found in those States which have no legislative requirement for blood testing of drivers admitted to hospital. New South Wales had the lowest level of missing values for drivers admitted to hospital following a road crash and Western Australia and Queensland had the highest levels.

A review of State legislation revealed that there was no uniform national requirement for BAC testing of drivers attending or admitted to hospital following a road crash. Blood testing of drivers attending or admitted to hospital was a legal requirement in only three States and hospital policy (without a legislative requirement) in another State. In the remaining States hospital blood testing was subject to police discretion based on suspicion that a driver was affected by alcohol. In the States which had a legal requirement for hospital blood testing, the nature of the requirement varied on the basis of conditions including waiver from sampling for some classes of driver, time limits within which sampling must take place and age limits. Considering these variations it was not surprising to find that there was strong variation in the level of missing values for BAC across States which had a legal requirement for hospital-based BAC sampling.

In Victoria, where there was a health sector policy requirement for blood testing of drivers attending or admitted to hospital, the level of missing values for BAC was 43%, which was higher than for States with a legislative requirement but lower than States not having a legislative requirement. Such a high level of missing values could severely limit the utility of Victorian data on BAC which was based on police reports and hospital blood sampling. Due to very high levels of missing values (greater than 74%), data on BAC distribution of drivers admitted to hospital in Tasmania, ACT, Qld and WA could be subject to very high levels of error and bias which could prevent meaningful assessment of the level of alcohol involvement in non-fatal road crashes in those States.

Multivariate analysis revealed significant associations between BAC status and a number of the independent variables: for fatalities, State, speed limit and age group; for hospital admissions, State, time of day, sex, age group, road user type, day of week and vehicle damage (see Section 4.2 for more information). Review of the univariate statistics presented in Section 3.4 suggests that for most of these variables, categories which had a low proportion of cases with missing values had a high proportion of cases with BAC >.05, which could be due to a targeting of drivers suspected to have BAC >.05. This analysis excluded a consideration of drivers involved in crashes not reported to police (who's BAC record will not be available to police) where the available evidence, from one Australian study (Kloeden et al., 1993), suggests that there could be a bias toward high alcohol involvement amongst those cases not reported, and indeed that study appeared to understate the strength of the bias (see Section 4.3 for a discussion). As there is no system in place in any State to report routinely on the results of hospital blood sampling for BAC by demographic factors (e.g. by road user type, age and sex) such that these results can be related to the police crash reports it is not currently possible to determine definitively the influence of crash under-reporting on the quality of information on BAC based on crash reports to police.

On the basis of the factors discussed above it was considered that the data on BAC, based on crash reports to police, could reflect factors other than the true incidence of alcohol involvement and that interpretation and use of the data in research could be highly complicated.

4.2 Identification of the variables most strongly associated with BAC status (known v. missing) and BAC level (≤.05 v. >.05).

4.2.1 BAC status

Logistic regression analysis revealed low to moderate significant associations between BAC status (i.e. known v. missing) and State ($R = .25$ for fatalities and $R = .44$ for hospital admissions).

NSW had the lowest level of missing values for hospital admissions (6%) and also had a low level of missing values for fatalities (9%). The level of missing values in all other States, for hospital admissions, was significantly different from (higher than) NSW. BAC status, for hospital admissions, was about 90 times more likely to be missing in Qld compared to NSW and 165 times more likely to be missing in WA compared to NSW. Some significant differences were also apparent for fatalities i.e. WA, ACT, Qld and SA had a significantly different (higher) level of missing values from NSW.

Weak but significant associations were found between BAC status and a number of other variables: for fatalities, speed limit and age group; for hospital admissions, time of day, sex, age group, road user type, day of week and vehicle damage. Drivers killed in road crashes who had missing values for BAC status were more likely to be 40+ years of age and involved in crashes in >80 kph speed zones than drivers whose BAC was known. Drivers admitted to hospital following road crashes who had missing values for BAC status were more likely to be female, aged 40+ years, motorcyclists, involved in daytime and weekday (Monday - Thursday) crashes and crashes where the vehicle was not towed away, than drivers whoes BAC was known. These results could reflect selective omission of these drivers in BAC sampling, and demonstrate the potential for information based on BAC, where known, to be biased.

4.2.2 BAC level

Logistic regression analysis revealed low to moderate significant associations between BAC level (i.e. BAC ≤.05 v. >.05) and two other variables for both fatalities and hospital admissions:

- Time of day was the variable most strongly associated with BAC level with higher BAC for night-time crashes. The odds ratios (day:night) were above 6 for both fatalities and hospital admissions.
- This was followed closely by number of vehicles involved in the crash, higher BAC for single vehicle crashes. The odds ratios (single:multiple vehicle) being nearly 6 for fatalities and nearly 4 for hospital admissions.

Weak but significant associations were found between BAC level (i.e. BAC ≤.05 v. >.05) and sex and also day of week. Male drivers and crashes on Friday-Sunday had a higher proportion of cases with BAC >.05. The odds ratios for both fatalities and hospital admissions were about 2 for sex (male:female) and over 1.5 for day of week (Fri-Sun: Mon-Thurs).

Weak but significant associations were found between BAC level and a number of other variables for hospital admissions:

- State. All other States had a significantly higher proportion of cases with BAC >.05 than NSW. Drivers admitted to hospital following a road crash in Queensland who were blood tested for alcohol were 5 times more likely to record BAC >.05 than similar drivers in New South Wales.[13]
- Speed limit. Crashes in ≤80kph speed zones had a higher proportion of cases with BAC >.05 than crashes in >80kph speed zones (odds ratio, >80kph:≤80kph = .67).
- Road user type. Drivers of vehicles other than motorcycles had a higher proportion of cases with BAC >.05 than motorcyclists (odds ratio, drivers:motorcyclists = 1.64).
- Age group. Drivers under 40 yrs had a higher proportion of cases with BAC >.05 than drivers of 40+ yrs (odds ratio, under 40 yrs: 40+yrs = 1.49).

The overall strength of the logistic regression models for prediction of BAC level of fatalities and hospital admissions was high (about 80% of cases were correctly allocated to BAC level), although they tended to be most efficient in predicting true negatives rather than true positives. The outcome was similar to that achieved by Klein (1986), using discriminant analysis to estimate alcohol involvement in fatal crashes in the U.S. His model which used crash and person level variables correctly predicted level of alcohol involvement in 80% of cases, where BAC level was known. Variables found by Klein (1986) to be highly associated with alcohol involvement included many of the variables listed above, including: the hour of the day, the number of vehicles, the type of vehicle, the person's age, person's sex and weekday vs weekend.

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[13] The reported odds ratios may reflect factors other than differential incidence in alcohol involvement in crashes, including the effects of targeting by police and hospitals.

4.3 Estimation of the number and proportion of cases having BAC >.05 at national level taking into account the extent to which cases having missing values for BAC were likely to have BAC >.05

Where BAC level was known, it was greater than .05 in 337 fatalities (52% of fatalities where BAC was known) and 1962 hospital admissions (26% of hospital admissions where BAC was known). These actual case counts represented lower limits of the number of cases as there was reason to expect that some of the cases with missing values for BAC would in fact have a BAC >.05. When the explanatory variables detected through logistic regression analysis were incorporated into prediction models, there being different models for fatalities and hospital admissions, and applied to the cases for which BAC was missing, the number and proportion of these cases with BAC >.05 could be estimated[14] and added to the actual case count. These estimates could also be adjusted for model underenumeration of cases with BAC >.05 amongst cases where BAC was known. Table 20 summarises the outcome of the various estimation procedures, drawn from Tables 17 and 18 and associated discussion, to provide an indication of the range in the number, proportion and population-based rate of cases estimated to be BAC >.05.

Table 20 Estimates of the number, proportion and population-based rate of alcohol involvements, where BAC was greater than .05, of drivers killed or admitted to hospital following road crashes.

Estimation method	**Fatalities**			**Hospital admissions**		
	No.	%*	Rate**	No.	%*	Rate**
Actual count (where BAC was known)	337	29	1.97	1962	15	11.50
Actual count plus model estimate where BAC was missing	376	32	2.20	3038	23	17.80
Actual count plus inflated model estimate where BAC was missing	385	33	2.26	3329	25	19.51

* Percentage based on the total number of cases (1174 fatalities and 13195 hospital admissions). Subject to rounding.
** Rate per 100,000 based on Estimated Resident Population, Australia 1990 (17,065,128). Subject to rounding.

[14] This analysis excludes consideration of factors detected through the qualitative analysis reported in sections 3.4 and 3.5 which were suggestive of biases in BAC data. It must be noted that a model for prediction of BAC where missing in police data, based on relationships where BAC was known, could be invalid if there was a strong degree of bias.

It can be seen that the number, proportion and rate of fatalities with BAC >.05, based on actual count, was about 12-14% lower than based on actual count plus model, or inflated model, estimates. However, for hospital admissions the number, proportion and rate based on actual count was 55-70% lower than based on actual count plus model, or inflated model, estimates. The difference between fatalities and hospital admissions in the impact of the modelling procedures was primarily due the fact that many more cases of hospital admission had missing values for BAC.

The figures based on inclusion of model estimates should be regarded as upper limits for estimates based on police reports. There is some evidence from the qualitative and univariate quantitative research undertaken in the study that where BAC level was missing, the level could be expected to be skewed toward the low BAC category relative to cases where BAC was known, suggesting a potential for the model, based on cases where BAC was known, to overstate the figures.

However, weighing against this is the potential for substantial underenumeration through under-reporting of crashes to police. It is known that crash reports to police, which form the basis for the FORS Serious Injury File, understate the extent of serious non-fatal injury in road crashes by about 40% (O'Connor & Trembath, 1995; O'Connor and KPMG Peat Marwick 1994; FORS, 1993). If it can be assumed that the proportion of cases with BAC >.05 for hospital admissions involving drivers of motor vehicles was the same as for police-reported cases, then an estimate of the number and population-based rate of hospital separations with BAC >.05 can be made by application of the estimate of the proportion of police-reported cases with BAC >.05 to the total number of hospital separations involving drivers of motor vehicles. As there were 15473 hospital separations involving drivers of motor vehicles in 1990, it can be calculated from the estimates presented in Table 20 that somewhere between 15% and 25% of these (2321 - 3868) could have had BAC >.05. Considering the 1990 population figure of 17,065,128, the rate of alcohol involvement, where BAC was greater than .05, of drivers admitted to hospital can be estimated to be 14 - 23 cases per 100,000 of population.

It is possible that this understates the true extent of alcohol involvement. Research by the NHMRC Road Accident Research Unit (RARU) suggested that there was a link between a blood sample not being taken and the accident not being reported to police and that cases admitted to hospital which were not reported to police tended to have more positive BAC readings (Kloeden et al., 1993). Indeed the RARU study itself understated the extent of the link between failure to blood sample and non-reporting of crashes because they did not adjust their results for a lower than expected proportion of motorcyclists in the study sample, the effect of which can be shown to reduce, from their expected levels, both the extent of non-reporting of crashes to police[15] and the proportion of missing BAC values.[16] Further research into alcohol involvement in crashes not reported to police is required.

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[15] Evidence for this factor is presented in Table 40 of the FORS report 'Road crashes resulting in hospitalisation, Australia, 1990' where the extent of under-reporting to police of hospital admissions is about

Uncertainty over the reliability of estimates of alcohol involvement in road crashes, especially for non-fatal injury, indicates the need for improved data systems.

4.4 Provision of recommendations for reducing the level of missing values in existing databases and, if necessary, specification of the requirements for any new databases at national level

This report has demonstrated that data on alcohol involvement in road crashes based on crash reports to police is subject to high levels of missing values and under-reporting in many States, especially for non-fatal injury, which could severely limit the utility of such data. The potential difficulties in using data on alcohol involvement in non-fatal road injury for the purposes of evaluation can be demonstrated with the following example. Consider a scenario where high profile RBT advertising has a strong influence in causing drivers who have been drinking to adopt measures which minimise their probability of police detection, or blood sampling at hospital, when involved in a crash (e.g. by departing from the crash scene quickly, giving a false name to police or hospital or telling hospital staff that their injuries resulted from non-crash factors). Analysis of data based on crash reports to police could then appear to show that the advertising was effective in reducing drink driving because the reported level of alcohol involvement in crashes decreased whereas in truth the level could have been unchanged but be represented in an increased number of cases having missing values for BAC in police reports and in the BAC results of cases involved in crashes not reported to police. This scenario is of course hypothetical. However, it could not be disproved with currently available data.

Uncertainty over the reliability of estimates of alcohol involvement in road crashes, especially for non-fatal injury, indicates the need for improved data systems at State and national level.

Recommendation 1

Efforts be made to reduce the level of missing values for BAC in databases on road deaths and injuries, focussing on the factors identified in this report, and that progress in this direction be monitored by appropriate State and national organisations using the databases at their disposal.

50% for motorcyclists but only 10% for drivers. Table 24 of RARU's report shows a level of missing values of only 9% for their sample which had a low representation of motorcyclists.

[16] Evidence for this factor is presented in RARU's report from a comparison of data in Tables 24 and 25 on the extent of missing values, which suggests that as the percentage of motorcyclists is increased through sample selection factors, the proportion of missing values increases.

<u>Recommendation 2</u>
Reports quantifying the extent of involvement of alcohol in road crashes should consider the estimates produced in this report which incorporate predictions of alcohol involvement for cases having missing values for BAC in police reports.

<u>Recommendation 3</u>
Further research is required into alcohol involvement in crashes not reported to police.

The Association for the Advancement of Automotive Medicine (AAAM) has issued a position statement (June 10, 1993) that all adult patients injured as the result of vehicle crashes should have a blood alcohol concentration determination performed on admission to hospital and that children should also be tested if there is suspicion of alcohol involvement. Furthermore, they have emphasised that hospitals should incorporate data on BAC into their databases to facilitate research into the epidemiology and pathophysiology of injury associated with use of alcohol.

Four Australian States have legislative or policy requirements which fit with the AAAM position on hospital blood testing, at least for drivers of vehicles. Compulsory blood testing to determine the BAC of drivers admitted to hospital might be more widely supported in Australia, if the concerns of medical staff, principally about legal ramifications and workload, can be allayed. The successful operation of hospital blood sampling in four States provides evidence that the problems perceived by medical staff can be avoided. No Australian State incorporates information on BAC test results into their hospital databases.

Blood testing of all drivers admitted to hospital would provide the basis for substantially improved State and national estimates of the extent to which alcohol is involved in non-fatal road injury. Under-reporting of serious injury to police is suspected to be a source of substantial under-enumeration of the extent to which alcohol is involved in non-fatal road crashes. The qualitative research suggested that whilst hospital medical representatives were generally supportive of the reporting of BAC results in aggregated form, as it had relevance to the monitoring of health interventions and outcomes, they were concerned about issues of privacy, confidentiality and legal ramifications over the use of such sensitive information. Concern was also expressed that the funds required to make the necessary alterations to the hospital morbidity system may not be available.

<u>Recommendation 4</u>
That all States consider the introduction of compulsory blood testing of drivers admitted to hospital following road crashes to determine BAC level.

Recommendation 5

That all States consider including the results of BAC testing in the State hospital morbidity data system and reporting them in aggregated form.

Recommendation 6

That all States consider making the results of BAC testing available at unit record level for national level analysis and reporting in aggregated form, subject to the implementation of appropriate controls to protect patient confidentiality and privacy.

It has been estimated that 40 % of hospital admissions due to road crashes are not reported to police (O'Connor & Trembath, 1995; O'Connor and KPMG Peat Marwick 1994; FORS, 1993). Given that there is a suggestion that alcohol figures more highly in unreported injury than in reported injury (Kloeden et al., 1993), there is a strong need to investigate the level of BAC for drivers who do not report their injuries and crashes to police. This would require access to, and comparison of, hospital and police data on BAC results.[17]

Recommendation 7

That a study of driver injury be undertaken, involving comparison of police and hospital information on BAC test results, to determine how cases not reported to police compare with those reported to police.

[17] In order to contribute to future planning of the development of improved data on BAC, Queanbeyan Hospital in NSW was funded under NISU's Road Injury Information Program to undertake a pilot study to test the feasibility of developing a database utilising hospital and police data which could enable the BAC results of all motor vehicle controllers, and their reporting of crashes to police, to be identified (Queanbeyan Hospital & Health Service, 1995). The study demonstrated that useful information could be generated at hospital level but would require tight control to ensure data accuracy. Given the short time period over which the study was undertaken statistical information from the study cannot be reliably reported.

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Appendix 1. Information on statistics presented in the output from logistic regression analysis

1. Strength of the model

Assessment of the strength of the model can be measured in a number of ways. Relevant statistics include -2 times the log likelihood (-2LL), the goodness of fit statistic and the model Chi-square.

In interpreting the goodness of fit statistics it should be noted that the null hypotheses are quite different.

For the -2LL and the goodness of fit statistic the null hypothesis is that the model is a perfect fit. If these statistics are significant ($P<.05$) then the alternative hypothesis that the model is not a perfect fit can be accepted.

For the model Chi-square the null hypothesis is that the coefficients for all the terms in the model, except the constant, are zero. If the model is a good fit then the model chi-square will be statistically significant.

2. -2LL

The probability of the observed results given the parameter estimates is known as the likelihood. It is customary to use minus 2 times the log of the likelihood (-2LL) as a measure of how well the estimated model fits the data.

If a model fits perfectly the likelihood is 1 and the -2LL is 0. -2LL has a Chi-square distribution with N-p degrees of freedom where N is the number of cases and p is the number of parameters estimated. If the -2LL is large and significant then the null hypothesis that the model is a 'perfect' fit can be rejected.

3. Goodness of fit statistic

A goodness of fit statistic is also computed for the model which compares the observed probabilities to those predicted by the model. The goodness of fit statistic also has a Chi-square distribution with approximately N-p degrees of freedom and if the goodness of fit is large and significant the null hypothesis that the model is a good fit can be rejected.

4. Model Chi-Square

The model Chi-square is the difference between -2LL for the model with only a constant and -2LL for the model after the independent variables have been entered. The model Chi-square tests the null hypothesis that the coefficients for all the terms in the model, except the constant, are zero. This is comparable to the overall F test for regression.