The safety impact of lowering the BAC limit for drivers in Canada

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The initial review of the scientific literature described in this report was conducted in preparation for our submission to the House of Commons Standing Committee on Justice and Human Rights in 1999 on the proposed changes to the impaired driving sections of the *Criminal Code of Canada*. It has been updated to include research published since that time to ensure the report is contemporary. Support for the preparation of this report was provided by the Traffic Injury Research Foundation.

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Executive Summary

For more than sixty years, blood alcohol concentration (BAC) limits have been used to define impaired driving (DWI) offences in terms of the amount of alcohol in the driver's blood, breath or other bodily fluid. Defining DWI offences in terms of BAC has served to simplify the process of identifying and convicting offenders. The ultimate purpose in doing so, however, has been to reduce alcohol-related deaths and injuries. In this context, the selection of the most appropriate and effective BAC limit has often been a contentious and inherently political issue.

The debate surrounding the appropriate BAC limit continues today. Indeed, the interest and concern that prompted the preparation of this report relates to the debate over whether Canada should lower the BAC limit in the *Criminal Code of Canada* from 80 mg/dL to 50 mg/dL. Canada has had a BAC limit of 80 mg/dL in the *Criminal Code* since 1969.

Canada is, however, somewhat unique internationally in that all provinces, except Quebec, have a lower BAC limit of 50 mg/dL (40 mg/dL in Saskatchewan) which authorizes police to issue 12- or 24-hour suspensions to drivers with BACs that exceed this limit. In this context, if a 50 mg/dL BAC limit were introduced in the *Criminal Code,* it would not reduce the threshold BAC at which sanctions can occur for most drinking drivers in Canada. It would primarily serve to lower the limit at which criminal sanctions are imposed.

Nevertheless, there have been repeated calls over the past two decades to lower the BAC limit in the *Criminal Code* from 80 mg/dL to 50 mg/dL. Each time this has been considered, it has been rejected, most recently in 1999. Nevertheless, legislators and interest groups return to the issue of a lower BAC limit, partly because of its apparent simplicity, straightforward rationale, and perceived effectiveness.

The primary purpose of this report is to contribute to the ongoing discussion about lower BAC limits through an assessment of the potential safety impact of a change in the BAC

limit. The intent is to provide policymakers and other interested parties with a critical review of the existing evidence on the impact of lowering the legal BAC limit. The goal is to provide a thorough and objective assessment of the existing evidence and to consider the extent to which re-defining criminal impaired driving behaviour by lowering the BAC limit in the *Criminal Code of Canada* might reasonably be expected to reduce the magnitude of the alcohol-crash problem in Canada.

The main body of the report provides a critical review of research studies that have evaluated the traffic safety impact of a reduction of the BAC limit. Our primary interest was in studies that evaluated the impact of a change in the BAC limit from 80 mg/dL to 50 mg/dL, since this is the issue being considered in Canada. However, because of their relevance to the general issue of reducing the BAC limit, studies that examined other changes to BAC limits – i.e., from 100 to 80 mg/dL and 50 to 20 mg/dL – were also reviewed. The studies reviewed were evaluations of changes in BAC limits in the United States, Sweden, and Australia.

As noted above, in conducting the review, it was evident that none of the changes in BAC laws in these countries were necessarily similar to what would occur in Canada because there is nothing comparable to moving the existing 50 mg/dL limit from highway traffic law to criminal law. Nevertheless, it is important and informative to examine the experience of other jurisdictions as a means to assess the potential safety impact of changes in BAC limits.

As in any critical review of the literature, it is also recognized that no study is without shortcomings of some sort. The evaluation of road safety policies and programs can be challenging and often limited by the type and quality of data available, the researcher's ability to exercise control over and/or account for extraneous events, and the difficulty in obtaining adequate comparison groups. Although this is a reality of applied research, such factors impact its validity and consequently the conclusions that can be derived from it.

Many – in fact, most – of the studies we examined interpreted the findings as showing a beneficial impact from lowering the BAC limit. However, a critical review of these studies revealed that many are limited by weak research designs, dependent measures with

incomplete, indirect or no information about alcohol involvement in crashes, and/or overstated conclusions. The evidence is further compromised by the coincident introduction of other laws and programs targeted at drinking and driving. The presence of other coincident laws and programs is a source of confounding that makes it difficult to determine which measure caused the change in alcohol-related collisions, or what weight to assign the contribution of various measures. Our critical review of such studies provides a less optimistic view of the impact of lowering the BAC limit than is contained in the conclusions of those studies.

Even methodologically rigorous studies reveal inconsistent findings – some showed a beneficial impact, some found mixed results, and others have reported no beneficial effects.

In conclusion, our review of the evaluation literature failed to provide strong, consistent and unqualified support for lowering BAC limits. At best, the results are mixed and the methodological weaknesses in the studies raise questions about the robustness and veracity of the evidence.

1.0 Introduction

For more than sixty years, blood alcohol concentration (BAC) limits have been used to define impaired driving (DWI)[1] offences in terms of the amount of alcohol in the driver's blood, breath or other bodily fluid. In many jurisdictions, incorporating a BAC limit in law has served to define what is often referred to as a *per se* offence – statutes that define drinking-driving offences in terms of the driver's BAC. In essence, *per se* laws are intended to render the results of chemical tests of alcohol content irrefutable evidence of an offence. Hence, it is not necessary to prove the offence on the basis of physical or mental impairment or impaired driving behaviour. Nonetheless, *per se* laws define offences that are implicitly impaired driving offences and are rationalized and justified on this basis.

Defining DWI offences in terms of BAC has undoubtedly served to simplify the process of identifying and convicting offenders. The ultimate purpose in doing so, however, was to help control the alcohol-crash problem. In this context, the selection of a BAC limit has often been a contentious and inherently political issue. The value chosen is often the result of a compromise among the desire for a limit that serves to control impaired driving and the resultant crashes, the political and practical problems associated with enforcing that limit, legal concerns about culpability and the risk of harm, as well as the public acceptance of the limit.

The debate surrounding the appropriate BAC limit continues today. Indeed, the interest and concern that prompted the preparation of this report relates to the debate over whether Canada should lower the BAC limit in the *Criminal Code of Canada* from 80 mg/dL to 50 mg/dL[2].

[1] In this report, the acronym DWI refers to offences that involve the operation of a motor vehicle after consuming alcohol. Depending on the jurisdiction, such offences may include impaired operation, driving under the influence, and/or driving with a BAC in excess of the statutory limit. It may also include the offence of refusing to provide a blood or breath sample.

[2] Throughout this report, BAC is reported in mg of alcohol per 100 ml of blood, often abbreviated mg/dL or mg%. A BAC of 80 mg/dL is equivalent to .08%; 100 mg/dL is equal to .10%.

1.1 Background

In 1983, the Department of Justice contracted with the Traffic Injury Research Foundation (TIRF) to prepare a background document on possible revisions to the drinking and driving sections of the *Criminal Code of Canada*, including lowering the BAC limit from 80 mg/dL to 50 mg/dL. That report included a comprehensive review of the experimental and epidemiologic literature on alcohol and driving (Donelson and Beirness 1985).

The report concluded that the state of the scientific evidence did not support a change in the statutory BAC limit for all drivers. Consistent with these conclusions, the amendments to the *Criminal Code* introduced in 1985 did not include a lower BAC limit.

Since then, substantial declines have occurred in the alcohol-crash problem in Canada (Beirness et al. 1994; Simpson et al. 1997). These changes have been well-documented and much heralded. However, the downward trend came to an abrupt halt in the early part of the 1990s and has only recently re-emerged – albeit at a much slower pace. As a consequence, stakeholders have begun searching for new measures that would effect further reductions and reinstate a more pronounced downward trend.

In this context, considerable attention has been focussed on the so-called "hard core" offenders – individuals who repeatedly drive after drinking with very high BACs and who seem relatively resistant to traditional countermeasures. This group has captured attention because they represent only a small proportion of all drivers but account for a substantial proportion of alcohol-related serious injury and fatal crashes. Research using data from both the United States and Canada has demonstrated that drivers with BACs in excess of 150 mg/dL comprise the largest proportion of all fatally injured drinking drivers (Beirness, Simpson and Mayhew 1998; Simpson and Mayhew 1991; Simpson, Mayhew and Beirness 1996; Williams and Wells 1993).

A variety of programs and policies for dealing efficiently and effectively with this group of high-risk drinking drivers has been developed and implemented in a number of jurisdictions – e.g., mandatory assessment and treatment, vehicle impoundment, alcohol

ignition interlocks. Many of these programs have proven effective (e.g., Beirness et al. 1997; Voas et al. 1999; Wells-Parker et al. 1995) and, should they become widespread, hold considerable potential to have a substantial impact on the problem.

Legislative initiatives have not been restricted to those directed at hard core offenders. One measure for addressing the drinking driving problem in general that has received considerable attention in the past decade is lowering the statutory BAC limit for drivers.

As noted above, this has been a recurring issue in Canada. Recently, it has been a major issue in the United States. The National Highway Traffic Safety Administration (NHTSA) has actively encouraged states to lower the BAC *per se* limit from 100 mg/dL to 80 mg/dL and offered financial incentives for doing so. Twenty-nine states have already lowered their limit. More are expected to do so with passage of the Transportation Appropriations Bill in October 2000 that financially penalizes states for not implementing a BAC limit of 80 mg/dL. In the United Kingdom, the government has been engaged in a debate about lowering the BAC limit from 80 mg/dL to 50 mg/dL for several years. The debate in the UK actually arose as part of a broader initiative to harmonize BAC limits within the European Union. Such harmonization around a limit of 50 mg/dL became even more challenging when, several years ago, Sweden lowered its BAC limit from 50 mg/dL to 20 mg/dL[3]. Of some interest, the U.K. recently decided not to follow the prevailing practice in the European Union and has opted to retain a limit of 80 mg/dL. The issue of BAC limits has also been considered in Australia, where all states and territories now have a limit of 50 mg/dL.

In Canada, the issue of lowering the *Criminal Code* BAC limit from 80 mg/dL to 50 mg/dL was raised again in October 1997 as a potential means for dealing with the alcohol-crash problem. The House of Commons Standing Committee on Justice and Human Rights was charged with responsibility for reviewing the drinking-driving sections of the *Criminal Code of Canada*. Among the issues for consideration was the possible lowering of the BAC limit for drivers from 80 mg/dL to 50 mg/dL. In preparing our

[3] The Swedish limit is actually 20 mg/g which is equivalent to 21 mg/dL (Jones 1996).

submission to the Committee, we undertook a critical review of the scientific evidence on the effectiveness of lowering the BAC limit. This review provided the genesis and foundation for the present report, which has been expanded since then to encompass the rapidly growing number of publications on the topic.

The House of Commons Committee held public hearings to obtain views and gather evidence on ways to deal with impaired driving. It tabled its recommendations in May 1999 and, on the issue of BAC limits, concluded that the BAC limit of 80 mg/dL should not be lowered (Standing Committee on Justice and Human Rights 1999).

In summary, many jurisdictions have decided to lower their existing BAC limit. Canada and others have decided not to do so. These decisions have, of course, been driven by many factors. A central, but by no means exclusive, consideration has been scientific evidence concerning the extent to which lowering the BAC limit has significantly reduced the alcohol-crash problem. Given the relevance of this issue to Canada as well as to other jurisdictions, this report critically examines the scientific evidence.

1.2 Purpose

The primary purpose of this report is to assess the potential safety impact of lowering the BAC limit, particularly for drivers in Canada. The intent is to provide policymakers and other interested parties with a critical review of the existing evidence on the impact of lowering the legal BAC limit and, where available, an examination and/or re-analysis of the relevant data. Our goal is to provide a thorough, balanced and objective review of the existing evidence and to consider the extent to which re-defining criminal impaired driving behaviour by lowering the BAC limit in the *Criminal Code* might reasonably be expected to reduce the magnitude of the alcohol-crash problem in Canada.

Although the Standing Committee on Justice and Human Rights has issued its report recommending the *Criminal Code* BAC limit not be lowered from 80 mg/dL to 50 mg/dL, it is inevitable that the issue will arise again – not only in Canada but in other countries as well. And, it has. MADD Canada has been pursuing a major national campaign urging the Government of Canada to adopt a package of initiatives, a prominent

component of which is lowering the BAC limit in the *Criminal Code* from 80 mg/dL to 50 mg/dL.

As jurisdictions persist in their efforts to reduce the magnitude of the alcohol-crash problem, lower BAC limits for drivers will be a recurring theme. The intent of this report is to contribute constructively to the ongoing debate by providing an objective appraisal of the scientific evidence on the impact of lowering the BAC limit.

1.3 Scope of the Report

It should be noted that the purpose of this report is not to determine the most appropriate BAC limit for drivers. Hence, it does not include a review of the experimental literature on the effects of alcohol. Nor does it review the epidemiological literature on the relative risk of crash involvement at various BACs. Rather, the purpose is specifically to examine the impact of lowering the BAC limit on alcohol-related crashes.

Within the Canadian context, lowering the *Criminal Code* BAC limit refers to a change from the current limit of 80 mg/dL to 50 mg/dL. Accordingly, our review initially focussed on those studies that examined a lowering of the BAC limit from 80 mg/dL to 50 mg/dL. However, the recent experience of several U.S. states in lowering their BAC limit from 100 mg/dL to 80 mg/dL prompted a number of evaluation studies on the impact of this change. Given that many of the issues surrounding a lowering of the BAC limit are common to all such changes, it was deemed appropriate to include in our review studies of the effectiveness of lower BAC limits, regardless of the numerical value of the limit.

This review excludes studies on the impact of lower BAC limits for young or new drivers, commercial operators, and other specific groups. Although we acknowledge that these studies may provide examples of lowering BAC limits, such laws are only applicable to a specific subset of drivers. The specificity of the target group as well as the social/environmental circumstances surrounding the implementation of these laws (e.g., it is often illegal for young people to purchase alcohol) prevent generalization of the findings to the population of all drivers. Such studies have limited relevance to the present issue. Therefore, in the interests of clarity and focus, it was decided to restrict

the review to studies that have examined the impact of lowering the BAC limit for the general population of drivers.

The report is divided into the following major sections:

Section 2, *History of BAC Limits*, provides a context for the report by tracking the history of BAC limits in law as a means to control the alcohol-crash problem;

Section 3, *A Critical Review of the Evidence,* provides a comprehensive and critical review of studies from around the world on the impact of lowering the BAC limit;

Section 4, *Discussion*, presents a summary of other reviews of the evidence as well as discussion of the implications of a lower BAC limit in the *Criminal Code of Canada*.

Section 5, *Conclusions,* provides a statement concerning the potential impact of a lower BAC limit in the Criminal Code.

2.0 History of BAC Limits

Defining alcohol-impaired driving offences in terms of BAC dates back over 60 years. The significance of such laws can, however, be best appreciated in the context of the evolution of legal efforts to deal with the impaired driving problem. This section provides a brief history of impaired driving laws and examines the incorporation of BAC limits into law.

2.1 Classical Laws

When the potential seriousness of the problem of alcohol-impaired drivers was first recognized, criminal and motor vehicle laws formed the foundation of efforts to reduce the alcohol-crash problem. In fact, legal efforts to control the problem of drivers impaired by alcohol predates the advent of the private motor vehicle. In 1872, England passed what is regarded as one of the first laws against drunken driving. It read, in part, as follows:

> *Every person… who is drunk while in charge on any highway or other public place of any carriage, horse, cattle, or steam engine may be apprehended, and shall be liable to a penalty not exceeding forty shillings, or in the discretion of the court of imprisonment… for any term not exceeding one month.*

Enactment and later refinement of drinking-driving laws proceeded slowly during the first half of the 20th century. This paralleled, in part, the slow growth in the use of private motor vehicles as well as the relatively poor state of information about the extent to which alcohol contributed to motor vehicle crashes. Nevertheless, recognizing the apparent danger of operating a motor vehicle after consuming alcohol, legislators in many countries around the world passed what Ross (1984) termed “classical” laws, which prohibited driving “while intoxicated by alcohol”, “under the influence of alcohol”, or simply “while drunk”. These so-called “classical” laws reflected the popular and legal views of the problem that centered on the grossly intoxicated driver and were aimed at behaviour that was clearly blameworthy.

The limitation of classical laws proscribing impaired driving was their failure to provide a definition of “intoxication” or “drunk” or “under the influence”, leaving it to the discretion of the courts. Although serving to signal the danger and seriousness of drunken driving, the somewhat vague concept of intoxication undoubtedly made the apprehension and prosecution of offenders difficult. For example, in some jurisdictions a medical examination of suspects was sometimes required to support observations of police officers and other witnesses at the time of the alleged offence. However, the clinical assessment of suspects proved insensitive and unreliable. According to Goldberg and Havard (1968), suspects were often able to “pull themselves together” to pass the clinical tests only to have to be assisted from the police station once the “crisis” of the examination was over and the symptoms of intoxication re-asserted themselves.

In summary, classical laws were society’s initial effort to acknowledge and control the hazards associated with the operation of a motor vehicle while under the influence of alcohol. As with other dangerous behaviours, governments enacted laws prohibiting driving after consuming “too much” alcohol – i.e., while “drunk” or “intoxicated”. Such laws proved largely unworkable and did little – if anything – to deter the behaviour and reduce the incidence of alcohol-related motor vehicle crashes (Ross 1982).

2.2 Presumptive BAC Limits

The development of a relatively simple chemical test for alcohol in blood, urine, and especially breath, was a major milestone in legal efforts to identify and control impaired driving behaviour. Based on the pioneering work of Widmark in the 1930s, it became possible to determine the amount of alcohol in a driver’s body at a particular point in time. The historical and present-day importance of this development for drinking-driving countermeasures cannot be overemphasized. The ability to measure the concentration of alcohol in samples of blood or breath from drivers suspected of violating impaired driving laws revolutionized the legal approach for dealing with drinking drivers.

The widespread acceptance of evidence from chemical tests of BAC served two purposes. First, the chemical test provided objective information on the amount of alcohol in the blood and, therefore, the amount affecting the person’s behaviour.

Second, it provided evidence that the courts could use to help verify that the impaired behaviour displayed by the individual was, in fact, the result of alcohol consumption.

In many countries, including Canada, the results of chemical tests for alcohol were used by the police and accepted by the courts long before BAC limits were enshrined in law. To a large extent, it was the acceptance by the police and the courts of the scientific validity and reliability of such tests that facilitated their inclusion in drinking-driving legislation. The path leading to a chemical test law, and the nature of the law that resulted, depended on the legal traditions, constitution, public sentiment, and political inclination within each country.

Changes in the United States provide an example of how BAC tests were introduced into law as a means to provide corroborating or presumptive evidence of impairment by alcohol. In 1938, the National Safety Council's committee on Tests for Intoxication (now called the Committee on Alcohol and Other Drugs) and a special Committee to Study Problems of Motor Vehicle Accidents, formed by the American Medical Association, established standards for interpreting "under the influence" in terms of BAC. These standards stated that BACs less than 50 mg/dL indicated no influence of alcohol; between 50 mg/dL and 150 mg/dL alcohol influence was accepted as present but courts were advised to consider behaviour and the circumstances of arrest; and BACs over 150 mg/dL were definitive evidence of impairment (National Safety Council 1986).

A year after these guidelines were introduced, they were incorporated into drinking-driving legislation in Maine and Indiana. Over the next thirty years most states developed impaired driving legislation consistent with the recommendations of the National Safety Council Committee. By that time, however, the National Safety Council had recommended that the presumptive BAC limit be lowered from 150 mg/dL to 100 mg/dL.

In 1967, the Secretary of Transportation issued a call for all states to specify chemical test procedures for determining BAC, to enact implied consent laws (as a means to compel drivers to provide blood or breath samples for analysis), and to define "intoxicated" or "under the influence" in terms of a BAC limit not greater than 100 mg/dL.

At the time, all but a handful of states had a presumptive BAC limit of 150 mg/dL -- ten set 100 mg/dL as the limit and Utah specified a limit of 80 mg/dL.

By 1978, all states had chemical test laws with a presumptive BAC limit of 100 mg/dL. The exceptions were Utah and Idaho, where the limit was set at 80 mg/dL. Despite the apparent benefits of chemical test laws and BAC limits for the adjudication of offenders, the alcohol-crash problem continued at an alarming level.

As early as 1970, the National Highway Safety Bureau began a campaign urging states to adopt laws that made it illegal to drive with BACs exceeding a specified value, *per se*. In the early 1980s when the alcohol-crash problem engendered widespread public outrage, the National Highway Traffic Safety Administration (NHTSA) included *per se* laws in a comprehensive package of tactics for dealing with the problem. This approach to impaired driving legislation was becoming more widespread throughout the world and is discussed in more detail in the next section.

2.3 *Per Se* Laws

Under *per se* laws, a conviction requires the prosecution to prove two elements of the offence: (1) that the accused was driving or had care or control of a motor vehicle; and (2) that at the time, the person had a BAC that exceeded the statutory limit[4].

The importance of laws defining drinking-driving offences in terms of the amount of alcohol found in the driver's blood, breath or urine was that such laws removed the exclusive reliance on subjective judgments and interpretations of "intoxication" in determining whether or not an offence had occurred. In the United States, where BAC was first introduced into legislation in the form of presumptive limits, the results of chemical tests were used to corroborate evidence of impairment or intoxication. A conviction for impaired driving still required that a police officer or other expert provide testimony pertaining to the extent to which the individual's behaviour was presumed to be adversely affected by alcohol.

[4] The exact wording and specifications of the law in any jurisdiction may vary. The intent here is to illustrate that, compared to presumptive laws, the alcohol element of the *per se* offence is relatively simple and straightforward.

In 1936, Norway became the first country to introduce a *per se* statute, setting 50 mg/dL as the limit above which the operation of a motor vehicle was an offence. Sweden followed with a *per se* limit of 80 mg/dL five years later. The early adoption of such statutes by these countries were key components in what became known as the "Scandinavian approach" to dealing with drinking and driving (Ross 1984)[5].

The tremendous interest generated by the "Scandinavian" *per se* laws was a consequence of their perceived effectiveness in deterring drinking drivers. It should be noted, however, that *per se* laws were only one element in the Scandinavian efforts to reduce drinking and driving. Both Norway and Sweden had taken a strong stand against drinking and driving and mandated imprisonment as a sanction for an offence even before *per se* laws were enacted. Interestingly, in a series of papers and books, Ross criticized and cast doubt on claims of the effectiveness of the Scandinavian approach (Ross 1975; 1981; 1984; Ross et al. 1984). Nevertheless, many countries followed the precedent set by Norway and introduced *per se* statutes, thereby defining drinking-driving offences in terms of BAC.

In 1941, five years after Norway passed the first *per se* law, Sweden followed suit. Swedish legislators decided on a two-tiered *per se* statute with limits of 80 mg/dL and 150 mg/dL. The higher limit corresponded to "drunken driving" or "driving while intoxicated" and was associated with greater penalties (including incarceration) than the lesser offence of driving with a BAC between 80 mg/dL and 150 mg/dL. The 80 mg/dL limit was lowered to 50 mg/dL in 1957 and to 20 mg/dL in 1990.

Following the initial introduction of *per se* laws in Norway and Sweden in the 1940s, it was more than twenty-five years before such laws were adopted elsewhere. One of the first and most influential adoptions of the *per se* approach was in Great Britain. The *British Road Safety Act* of 1967 established a *per se* limit of 80 mg/dL. In the debate leading up to the passage of the law, the results of the landmark Grand Rapids Study (Borkenstein et al. 1964) proved highly influential. This study documented the extent of increased crash risk associated with increasing BACs. The results were used to justify

[5] Although typically referred to as the "Scandinavian approach", Finland and Denmark did not enact *per se* laws until the mid-1970s.

the setting of the *per se* limit at 80 mg/dL as this was the level at which the risk of crash involvement for the average driver increased significantly above that of a non-drinking driver.

The *British Road Safety Act* of 1967 also provided the basis for the first large-scale evaluation of the effectiveness of such legislation in deterring drinking and driving (Dempster 1969). The apparent success of the British law is credited with having stimulated consideration and subsequent adoption of *per se* statutes around the world (Ross 1984). The fact that the initial reductions in drinking and driving in Britain proved to be temporary was apparently lost in the ensuing deliberations in other countries (Ross 1973).

The issue of BAC limits in the U.K. was revisited in 1974 and again in 1981. Each time, the proposal to lower the limit (to 50 mg/dL in 1974 and 60 mg/dL in 1981) was rejected by the study committee. For the past two years, the U.K. has once again been engaged in the debate over whether to lower the BAC limit to 50 mg/dL, this time primarily to harmonize with other EU countries. And, once again the U.K. decided (early in 2002) to retain a BAC limit of 80 mg/dL.

In the years following the *British Road Safety Act*, many other countries, including Germany, France, the Netherlands, Ireland, Australia, New Zealand, and Canada enacted *per se* statutes with limits of either 80 mg/dL or 50 mg/dL. The United States was relatively slow to adopt *per se* laws. In fact, one state – Massachusetts – does not yet have a *per se* BAC limit. Nevertheless, *per se* statutes have become widely accepted as the standard legislative approach for dealing with DWI offences.

It should be noted that in addition to obvious differences in the BAC value specified in *per se* laws, they vary in other important ways across jurisdictions. For example, in some jurisdictions *per se* violations are considered traffic offences; in others, they are criminal offences. The penalties range from a licence suspension, lasting a few hours, to imprisonment. And, the conditions that must be met to justify obtaining a blood or breath test can vary from requiring substantial behavioural evidence of alcohol impairment, to testing at random without any suspicion that the driver had consumed

alcohol. These are important considerations that can have a tremendous influence on the enforcement, deterrent value, and effectiveness of *per se* laws.

2.4 BAC Limits in Canada

Because the primary purpose of this report concerns the potential impact of a lower criminal BAC limit in Canada, it is instructive to examine the history of chemical testing and BAC laws in Canada in greater detail.

The first law proscribing the operation of a motor vehicle while intoxicated appeared in the *Criminal Code of Canada* in 1921. The law stated that "everyone who, while intoxicated, drives any motor vehicle or automobile" was guilty of an offence. As was the case with most "classical" laws, it did not provide a definition of "intoxication", leaving it to the discretion of the courts. Subsequent modifications to the statutes further refined the offence to include broader concepts of intoxication in the use of the motor vehicle but none of the revisions attempted to assist the courts by defining what was meant by intoxication.

In 1951, a new offence of operating a motor vehicle while one's ability was impaired by alcohol or a drug was added. Although this served to establish two levels of the offence, there was still no definition of either intoxication or impairment.

The 1951 amendments also allowed the results of blood, breath or urine tests to be introduced as evidence but did not require drivers to submit to providing samples. According to Lucas and Charlebois (1978), breath testing was first introduced in Canada during the mid-1950s. The first reported case of the courts accepting breath test evidence as corroboration of observed signs of intoxication occurred in Vancouver, British Columbia, in 1953.

The Breathalyzer, developed by Professor Robert Borkenstein in 1954, was put into service by the Ontario Provincial Police in 1956 and by the RCMP in 1958. By the mid-1960s, the use of the Breathalyzer had spread throughout Canada and its acceptance by the police and the courts paved the way for the so-called "Breathalyzer law" in 1969.

In 1966, the House of Commons Standing Committee on Justice and Legal Affairs began its consideration of the proposed "Breathalyzer law" – more than three and a half years before it was finally enacted. The purpose of the bill was to introduce compulsory breath testing and to establish a BAC limit above which it would be an offence to operate a motor vehicle – i.e., a *per se* law.

The selection of a BAC limit, mandatory breath testing, the accuracy of breath tests, and the very concept of a *per se* law were all important issues in the debate. Testimony was presented by numerous individuals and organizations, including the Canadian Medical Association, the Canadian Bar Association and the Canadian Highway Safety Council. Scientific evidence from both experimental and epidemiologic research (including results from the Grand Rapids study by Borkenstein et al., [1964]), recommendations from respected professionals, and the precedent of the *British Road Safety Act* of 1967 all appear to have contributed substantially to the deliberations.

A consensus was finally reached and the *Criminal Law Amendment Act* was proclaimed on December 1, 1969. This legislation established a *per se* BAC limit of 80 mg/dL and made breath tests compulsory. Failure or refusal to provide a sample was an offence equivalent to that of driving with a BAC in excess of 80 mg/dL. The legislation also repealed "driving while intoxicated" but "impaired driving" remained. Of interest, it is no defence for a person charged with impaired driving to claim that their BAC was not over 80 mg/dL. Conversely, it is no defence for a person charged with driving over 80 mg/dL to claim that there were no signs of impairment.

The *Criminal Code of Canada* was amended seven years later to harmonize the penalties for the three drinking-driving offences (i.e., impaired driving, driving with a BAC in excess of 80 mg/dL, and refusal to provide a sample) and to allow *per se* offences to be prosecuted by indictment (i.e., as a more serious offence with more severe penalties). In addition, the legislation allowed approved screening devices to be used by the police at the roadside to determine the extent of alcohol consumption by drivers. Refusal to provide a breath sample for screening was deemed an offence equivalent to impaired driving.

By that time, the province of British Columbia had already introduced roadside screening and set an important precedent through a provincial law. In effect, they introduced a lower BAC limit by providing police officers with the authority to issue short-term (i.e. 24-hour) administrative driving prohibitions for drivers with BACs of 50 mg/dL or more.

Following British Columbia's lead, other provinces also introduced administrative, short-term roadside suspensions for drivers who had been drinking but not at a level that would warrant criminal charges. New Brunswick, Ontario and Manitoba set suspensions of 24 hours, 12 hours, and 6 hours, respectively, for drivers with BACs of at least 50 mg/dL or who registered a "Warn" on an approved screening device. Saskatchewan adopted a 24-hour suspension for driver with BACs of at least 60 mg/dL (subsequently reduced to 40 mg/dL). Presently, Quebec is the only province in Canada without an administrative roadside suspension law.

These short-term administrative "roadside" suspensions ostensibly re-set the *per se* limit in the affected jurisdictions. Although no provincial offence charges are laid and formal records are not always kept, the short-term suspensions provide swift and certain punishment for persons driving with a BAC that exceeds the provincial limit but lower than the *per se* limit specified in the *Criminal Code*. The procedure is relatively simple and is carried out by police officers at the side of the road. If necessary and deemed warranted by the officer, the vehicle is towed and the driver is responsible for the towing and storage fees. Recent amendments to roadside suspension laws in some provinces (e.g., Newfoundland, Manitoba, Saskatchewan) have introduced licence reinstatement fees and requirements for assessment and treatment following repeated short-term suspensions.

In this context, it should be noted that for most drivers in Canada, changing the BAC in the *Criminal Code* would not reduce the threshold BAC at which sanctions first occur for drivers. Other than Quebec, all provinces currently have a BAC limit of 50 mg/dL (40 mg/dL in Saskatchewan). Changing the BAC limit in the *Criminal Code* would not strictly speaking lower the BAC limit but rather serve to lower the limit at which criminal sanctions are first imposed.

Despite the existing 50 mg/dL limit in most provinces, the issue of lowering the BAC limit in the *Criminal Code* continues to surface. It was raised in the early 1980s as part of the government's planned revisions to the drinking and driving sections of the *Criminal Code*. At that time, the Department of Justice Canada commissioned TIRF to study the issue (Donelson and Beirness 1985). Based in part on the findings and recommendations contained in that report, Parliament did not include a lower BAC limit in the 1985 legislation.

In 1997, the government considered changes to the *Criminal Code*. Included was a proposal to lower the BAC limit – i.e., a reduction from 80 mg/dL to 50 mg/dL. As stated previously, this was one of the proposals considered and rejected by the Standing Committee on Justice and Human Rights (1999) but it was once again raised on the political and public agenda by MADD Canada beginning in 2001.

The purpose of the present report is to contribute to this ongoing discussion through a critical review of the scientific evidence on the effect of lower BAC limits and a scholarly assessment of the extent to which a change in the *per se* limit specified in the *Criminal Code* would have an impact on the alcohol-crash problem in Canada.

2.5 The Post-*Per Se* Period

Per se laws are widely believed to be an effective measure for addressing the impaired driving problem. By creating an objective and quantifiable standard, *per se* laws eliminate the need to rely on subjective evidence of the degree to which the behaviour of the accused is believed to be affected by alcohol. The prosecution and sanctioning of impaired drivers was expected to become more effective and efficient[6]. Within the conceptual framework of deterrence, *per se* laws were expected to increase the certainty of punishment by simplifying the adjudication process.

[6] Recent developments would lead some to question if this efficiency was achieved. Defence counsel have become adept at challenging the breath test device and the technician's procedure as well as raising evidence to the contrary to displace the presumption that the BAC at the time of testing was the result at the time of the alleged offence. These challenges have, in some circumstances, unduly complicated the adjudication procedure.

As evidenced by the results of the evaluation of the *British Road Safety Act*, *per se* laws do not necessarily generate sustained general deterrence. The temporary reduction in alcohol-involved crashes following the introduction of the *per se* limit in Britain appears to have been the result of a perceived increase in the probability of being arrested for, and convicted of, an impaired driving offence (Ross 1973; 1984). However, when motorists realized that the probability of arrest was considerably less than perceived, the beneficial effects began to dissipate.

A similar effect was found following the introduction of the "Breathalyzer" law in Canada in 1969. In an examination of all fatal crashes, Carr et al. (1975) reported a 6.3% decrease in the first year the 80 mg/dL limit was in effect (1970). However, in 1971, fatalities increased by 8.6%, surpassing the level prior to the legislation. The results of blood alcohol test data from three provinces showed a small *increase* in the number of fatally injured drivers with relatively low BACs (i.e., less than 100 mg/dL) in single vehicle crashes and no change in the number with BACs of 100 mg/dL and greater. If, indeed, there was an effect of the *per se* law in Canada, it was extremely short-lived. These findings and conclusions were replicated by TIRF scientists several years later (Warren et al. 1977).

Per se laws did not prove a panacea for reducing impaired driving or reducing the alcohol-crash problem. In fact, in many jurisdictions (including Canada) the problem continued unabated. Hence, in the years following the introduction of *per se* laws, many jurisdictions began implementing other measures to support or enhance drinking-driving legislation. To a large extent, such measures concentrated on increasing the detection and apprehension of offenders – e.g., sobriety checkpoints, preliminary breath testing, and random breath testing. Administrative licence revocation has also proven to be a popular – and effective – measure. Recent efforts have also focussed on programs for "hard core" offenders – e.g., mandatory assessment and treatment programs, vehicle impoundment, and alcohol ignition interlocks.

Amidst the development and implementation of all these other programs, interest groups and legislators repeatedly return to the issue of the BAC limit, partly because of its apparent simplicity, straightforward rationale and perceived effectiveness. As a result, many jurisdictions have lowered, or are considering lowering, the *per se* BAC limit in an

effort to further reduce the alcohol-crash problem. The remainder of this report examines the potential impact of lower BAC limits through a review of the research evidence, an analysis of relevant data, and a discussion of the issues.

3.0 Critical Review of the Evidence

Initiatives to lower BAC limits are invariably founded on the belief that a lower limit will serve to reduce the magnitude of the alcohol-crash problem. Although numerous hypotheses can be tendered as to what might occur as a result of a lower BAC limit, such speculation is largely unnecessary because many jurisdictions have already lowered the BAC limit and their experience can be examined to determine the nature and extent of the safety impact. Given the importance of the issue, and as a means to provide the best possible advice to policy makers and other interested parties, it is useful to review critically all studies that have evaluated the impact of a reduction in the BAC limit. This section provides such a review.

In reviewing the evaluation literature on BAC limits, it is recognized that no study is without shortcomings. The evaluation of road safety policies and programs can be challenging and often limited by the type and quality of data available, the researcher's inability to exercise control over and/or account for extraneous events, and the difficulty in obtaining adequate comparison groups. Although this is a reality of applied research, such factors impact its validity and consequently the conclusions that can be derived from it.

In conducting a thorough and critical review of the existing evaluation research, the objective was to determine the strength of the evidence. This involved identifying potential confounding factors (controllable or otherwise) and assessing the extent to which they may have influenced the results and/or compromised the validity of the conclusions. The purpose of doing so was to provide an independent and objective assessment of the strength of the available scientific evidence on the impact of lowering the BAC limit.

The review of the relatively small number of evaluation studies is organized according to the value of the BAC limit changed (i.e., from 100 mg/dL to 80 mg/dL; 80 mg/dL to 50

mg/dL; 50 mg/dL to 20 mg/dL) and the country in which the change occurred. For each study, the first step was to examine the nature of the existing law and any other coincident changes in drinking-driving laws or procedures that might have confounded the interpretation of the results. The study methodology, the type and sources of data used, as well as the results were then critically reviewed. The authors' conclusions were then examined in light of the strength of the research design, the veracity of the data, and threats to validity.

3.1 A Change from 100 mg/dL to 80 mg/dL

From an international perspective, *per se* laws were slow to arrive in the United States. Although by 1968 all states had presumptive BAC limits, the change to *per se* laws proceeded incrementally, state by state, over the next thirty years. With all but one state (Massachusetts[7]) now having a statutory *per se* limit, the National Highway Traffic Safety Administration (NHTSA) has been actively encouraging individual states to lower the standard from 100 mg/dL to 80 mg/dL. In October 2000, the Transportation Appropriations Bill was signed into law. This bill requires states to enact a *per se* limit of 80 mg/dL by 2004 or have 2% of certain highway construction funds withheld. The penalty increases to 8% by 2007.

As states began to lower the *per se* limit, an opportunity was created for examining the impact of the change. This section examines studies conducted to determine the impact of lowering the BAC limit from 100 mg/dL to 80 mg/dL in the United States.

3.1.1 The first five states

In December 1994, NHTSA released a brief report on their preliminary assessment of the impact of lowering the *per se* BAC limit from 100 mg/dL to 80 mg/dL in the first five states to introduce the lower limit (Johnson and Fell 1995; Johnson and Walz 1994). The lower limit was introduced in Utah[8] in August 1983; in Oregon in November 1983; in

[7] Massachusetts has a *per se* limit of 80 mg/dL for Administrative Licence Revocation but does not have a *per se* limit defining DWI offences.

[8] Utah had a presumptive limit of 80 mg/dL prior to 1983.

Maine in August 1988; in California in January 1990; and, in Vermont in July 1991. The evaluation was conducted in 1993, so each of the study states had a limit of 80 mg/dL for at least two years prior to the assessment.

The authors acknowledged that this study was a preliminary assessment, so it did not take into account the potential confounding impact of any other legislative changes that may have occurred at about the same time as the lower *per se* limit was introduced. In this context, all five states had administrative licence revocation (ALR) laws[9], three of which were implemented within a year of the introduction of the 80 mg/dL BAC limit. This is important from an interpretation point of view. Research has shown that ALR laws are associated with a decrease in alcohol-related collisions (Ross and Gilliland 1991) and reduced DWI recidivism (Stewart et al. 1989). Given that the implementation of these laws was coincident with the change in BAC limit in the states being studied, it is critical that the research design take this into consideration and endeavour to control for and/or partial out the independent effects of the two initiatives.

Data from the Fatality Analysis Reporting System (FARS) on drivers age 21 and over, who were involved in alcohol-related fatal crashes, were examined in comparable periods before and after the implementation of the lower BAC limit in each state. An attempt was made to use at least two years of data before and after the change. In the case of Oregon and Utah, the lack of reliable estimates of alcohol-related fatal crashes prior to 1982 reduced the number of months of data for analysis. For Vermont, the analysis was limited to 17 months of data after the change in the legal limit because the most recent year of data available from FARS was for 1992. In these three states, where a full two years of data were not available, the data were selected to match comparable seasons in the before and after periods. This resulted in a non-continuous data series – i.e., several months of data were excluded from the series immediately prior to or following the implementation of the lower limit.

Six different measures of driver alcohol involvement were examined in each state:

[9] Administrative license revocation (ALR) laws (also referred to as Administrative *per se)* provide for the immediate suspension of the licence (typically for a 90-day period) for any driver who has a BAC in excess of the statutory limit or refuses to provide a breath sample for analysis.

(1) any alcohol involvement (BAC ≥ 10 mg/dL);

(2) intoxicated (BAC ≥ 100 mg/dL);

(3) police reported driver alcohol involvement;

(4) single vehicle nighttime (SVN) driver involvement;

(5) single vehicle nighttime male (SVNM) driver involvement; and,

(6) estimated alcohol involvement (police reported, positive BAC, and/or alcohol violation).

The first two are direct, objective measures of alcohol involvement and typically provide the most valid assessment of the magnitude of the problem. The validity of these measures is, however, dependent upon the rate of testing for alcohol among drivers killed in crashes. With the exception of a few years in specific states, each of the five states had a testing rate that exceeded 80% – a rate generally deemed acceptable.

The third measure, police-reported alcohol involvement, is often used as an index of alcohol involvement although it tends to underestimate the problem. The fourth and fifth indices are surrogate measures of alcohol involvement commonly used in the traffic safety field. Surrogate measures of alcohol involvement are often used when no direct measure is available. They involve the selection of cases from specific times, places and/or circumstances (e.g., single vehicle, nighttime) known to have a high percentage of alcohol involvement. The final measure is a combination of indices that appears to be intended to take advantage of all possible sources of information so as to obtain the best possible indicator of the magnitude of the alcohol (fatal) crash problem.

For comparison, the six measures were also calculated for the rest of the nation, excluding the five states with a *per se* limit of 80 mg/dL. However, these data were not presented in the report.

The analytic approach was a simple pre-post comparison using the percentage change in each of the six measures for each of the five states. This yielded 30 separate comparisons. Nine of these thirty comparisons showed statistically significant reductions, at the liberal $p<.10$ level, associated with the introduction of the lower BAC limit. Only five of the nine reductions reached significance at the more stringent $p<.05$ level and ranged from a 4% reduction in drivers with a BAC over 100 mg/dL in California, to a 40% decrease in estimated alcohol involvement in Vermont. However, it is

noteworthy that the vast majority (21) of the measures showed no change associated with the lower limit, so the results are inconclusive at best.

The authors recognized and acknowledged some of the limitations of their study -- e.g., no other factors (such as ALR) were accounted for in the analysis, the time period examined was limited, and there were no direct comparisons with a control group. Indeed, their conclusions were appropriately guarded and cautious, emphasizing the fact that the findings were preliminary and further analysis was required.

3.1.2 The five state follow-up study

A subsequent study of the experience of lower BAC limits in the first five states was conducted by Hingson et al. (1996). This study reported that, following the introduction of the lower BAC limit, there was a 16% reduction in the proportion of crashes involving a fatally injured driver whose BAC was 80 mg/dL or higher. Moreover, the study reported an 18% reduction in crashes involving a fatally injured driver whose BAC was 150 mg/dL or higher. The authors used these figures to project a decrease of 500 to 600 deaths per year if all states lowered their BAC limit to 80 mg/dL.

The Hingson et al. study improved upon the design of the study by Johnson and Walz (1994) by examining data over a longer period of time and using control groups – each of the five states that changed the BAC limit was paired with a nearby state that retained a 100 mg/dL limit. The selection of an appropriate "control" state is both important and difficult. It is important because it serves as a reference against which any changes in the state that lowered the limit can be compared. It is difficult because the control state ideally should be similar to the change state on as many relevant variables as possible, with the exception of the variable being studied – in this case the BAC limit. Relevant variables are those factors that could affect the dependent measures – i.e., alcohol-related crashes.

In this context, the change states and comparison states in the Hingson et al. study differed not only in the BAC limit but in other important ways as well – most notably in terms of *per se* and administrative license revocation (ALR) laws. All of the states that lowered the BAC limit had existing criminal *per se* BAC laws in effect prior to the study.

Only two comparison states (i.e., Texas and New Hampshire[10]) had such laws. Idaho and Washington introduced *per se* laws during the study period.

In addition, all five change states had ALR laws during the study period. Three of these were introduced within one year of the introduction of the lower BAC limit. New Hampshire was the only comparison state to have an ALR law during the study. The point is that the change states and comparisons states differed not only in terms of the variable being studied (BAC limit) but in terms of other variables that are known to affect alcohol-related crashes. Technically speaking, the influence of important sources of confounding was not controlled.

Comparisons were made using the maximum (and equal) number of available pre- and post-law years. The time period for analysis varied from eight years before and after the change (e.g., Oregon and Utah) to two years (Vermont). Table 1 shows the change states, the date of the BAC limit change, the comparison states, and the periods over which data were examined.

Table 1: Critical Dates in the Comparison of the First Five States to Lower the BAC Limit with Selected Comparison States

Change State	*Date of change*	*Comparison State*	*Data Window*
Utah	August 1983	Idaho	Aug 75 – July 91*****
Oregon	November 1983	Washington	Nov 75 – Oct 91*****
Maine	August 1988	Massachusetts	Aug 83 – July 93*****
California	January 1990	Texas	Jan 86 – Dec 93
Vermont	July 1991	New Hampshire	July 89 – June 93*****

*****These dates differ from those reported by Hingson et al. (1996) because there appears to be an error in their paper. In four out of five cases, the time period reported in the Hingson et al. paper does not produce the equal number of pre- and post-law years as stated on page 1297. For example, the article states that Utah was compared with Idaho from August 1976 to July 1991. This period results in seven years prior to the change in the BAC limit in Utah (i.e., August 1983) and eight years following the change. The data used in the analysis reported here correspond to a period beginning in August 1975, which provides eight years before and after the BAC limit change. By adjusting the start date of the data window, we were able to replicate the data reported by Hingson et al. to within a few cases for every state except Vermont.

[10] The Hingson et al. article states that the two states were Texas and Vermont. This is clearly an error as Vermont was one of the states that changed the BAC limit.

The study used a simple pre-post design with comparison groups. The difference in the proportion of fatally injured drivers with BACs at or above 80 mg/dL in each state following the implementation of the lower BAC limit was compared with the proportion in the selected comparison state. The proportions of drivers with BACs at or above 150 mg/dL were also compared.

Meta-analytic methods were used to combine the results from all five states. Comparisons revealed a combined significant reduction of 16% in driver fatalities with BACs at or above 80 mg/dL after the BAC limit was lowered, compared to states that did not lower the BAC limit. Three of the five states had significant reductions (Oregon, Utah and California) in driver fatalities with BACs over 80 mg/dL; two states showed no effect.

In Utah, the reported 22% reduction is somewhat curious. In fact, Utah actually experienced an 11% *increase* in driver fatalities with BACs at or above 80 mg/dL following the introduction of the lower BAC limit. However, the increase in alcohol-related fatal crashes in Utah was considered a "positive" impact because the increase was considerably smaller than the 43% increase in the comparison state of Idaho. Hence, the "benefit" ascribed to the lower BAC limit in Utah is actually a smaller increase in alcohol-related fatalities than the substantial (and somewhat unusual) increase that occurred in Idaho over the same period of time.

Similar overall findings were reported when the analysis was restricted to driver fatalities with BACs at or above 150 mg/dL – an aggregate reduction of 18% was reported. Significant decreases were found in three states – Oregon, Maine and California – but the variability across states was substantial, ranging from a 23% decrease in Maine to a 23% *increase* in Vermont.

The results reported by Hingson et al. appear to corroborate the results from the same five states reported in the earlier, preliminary evaluation by Johnson and Walz (1994). There are, however, discrepancies in individual state results between the two studies that raise questions about the veracity and robustness of the effect.

In particular, Johnson and Walz reported large statistically significant decreases in Vermont and Utah immediately after the 80 mg/dL legislation; Hingson et al. reported *increases* in both these states. To some extent, the apparent discrepancies can be attributed to differences in time periods and analytic methods. Nevertheless, if the impact of the lower limit was strong and consistent, it would be expected to withstand the tests of time and method. At the very least, the variability of the results makes it difficult to predict with any certainty whether or not a given state would experience a beneficial effect of reducing the BAC limit.

Another limitation of the study was the use of a simple pre-post design. This design not only fails to control for the effects of pre-existing trends, it actually capitalizes on the unprecedented downward trend in alcohol-related fatalities that occurred during the 1980s. The authors claim they did "control for both the long-term downward trend in total fatal crashes from 1980 to 1993 and changes in exogenous variables that might influence the total number of fatal crashes" (p.1298) through the use of proportions rather than the absolute number of crashes. Although proportions do allow for direct comparisons of alcohol involvement in states with different numbers of driver fatalities, they do not control for trends, or for the influence of exogenous variables. Collapsing the data from the years prior to the lower limit to form a single point estimate eliminates the possibility of controlling for trends.

The study by Hingson et al. received considerable prominence in media reports and promotional material from NHTSA. Particular attention was given to a statement in the abstract of the paper which notes that if all states lowered the legal BAC limit to 80 mg/dL, at least 500 to 600 fewer fatal crashes would occur annually. Interestingly, this statement appears only in the abstract of the paper. The body of the paper is somewhat more cautious in its conclusions than the abstract. For example, the authors acknowledge that the study did not account for the impact of other drinking-driving legislation, particularly ALR. In fact, the conclusion in the report states "…the results of this study suggest that 0.08% laws, particularly in combination with administrative licence revocation, reduce the proportion of…" alcohol-involved fatal crashes.

The point about the coincident effect of ALR is an important one. ALR has been shown to have a significant impact on alcohol-related fatalities in and of itself (Stewart et al.

1989; Ross and Gilliland 1991). In the Hingson et al. study, not only was the influence of ALR not accounted for in the states that lowered the BAC limit, there was almost complete confounding of ALR with the lower limit. That is, all the lower BAC limit states had an ALR law and only one of the comparison states did[11]. This confounding, which was not controlled for the Hingson et al. study, makes it impossible to conclude that the observed changes in alcohol-related crashes were attributable to the lower BAC limit and not ALR.

The presence of ALR in the change states, particularly when introduced in close temporal proximity to the lower BAC limit, weakens the validity of any attempt to attribute observed changes in alcohol-related fatalities solely to the impact of the lower BAC limit. The fact that only one of the comparison states had an ALR law and only two had *per se* laws raises concerns about the comparability of the control states.

In addition to the bias introduced in the study by the presence of other laws (e.g., ALR), the authors acknowledged that states that lowered the BAC limit may have also been more concerned about the alcohol-crash problem and have undertaken a variety of programs to deal with the issue. The fact that all five states that lowered the BAC limit also had ALR laws attests to the legislative commitment. Public information and awareness campaigns, enforcement programs and community initiatives may also have been considerably more prevalent in the five change states before, as well as after, the change in the BAC limit. The potential impact of these types of measures could have been substantial.

The selection of comparison states is also a difficult issue as mentioned earlier. For example, although Vermont and New Hampshire appear to be a reasonable pairing because they are both small, largely rural New England states, they differ in important ways. For example, they are different in the way they deal with the impaired driving problem (e.g., sobriety checkpoints are prohibited in New Hampshire) and with traffic safety in general (e.g., New Hampshire is the only state without a mandatory seat belt law for all drivers). Although geographic proximity may serve as a proxy for socio-cultural factors, it does not necessarily do so in all cases.

[11] New Hampshire introduced ALR on January 1 1993 – 6 months before the end of the study period.

The issue of the appropriateness of comparison states is by no means trivial. Indeed, Scopatz (1998) demonstrated that the results of the Hingson et al. study were entirely dependent upon the comparison states selected. Using a different set of comparison states, Scopatz demonstrated that the overall impact of the lower BAC limit was not statistically significant. In fact, simply changing the comparison state for California from Texas to Arizona, or to a combination of Michigan, Ohio and Pennsylvania changed the observed reductions in alcohol-related driver fatalities from 10% to 4%. This serves to illustrate the variable nature of the results and, at the very least, renders national forecasts about the number of lives that would be saved with a lower BAC limit highly suspect.

The re-analysis by Scopatz (1998) prompted us to re-examine the data as well. The first step was to attempt to replicate the numbers presented by Hingson et al. (1996). This task was complicated by a discrepancy between the description of the method and the dates provided in the published paper (see Note to Table 1). Once the correct time periods were determined, we were able to replicate the numbers reported by Hingson et al. to within a few cases.[12] We then selected an alternative comparison state for each of the five change states. In addition, we created a composite of eight states with good alcohol testing rates to use as a general comparison for each state. The time periods over which data were examined were the same as those specified previously in Table 1. It should be noted that our selection of comparison states is no more or less valid than that used by Hingson et al. (1996). The comparison is presented as an illustration only.

The results of our re-analysis of the data are shown in Table 2. This is a busy table so we step through its components column by column. The first column lists the states that lowered their BAC limit (bold type) as well as the comparison states. The comparison state listed as "(a)" is the one selected by Hingson et al.; the one listed as "(b)" is the state we selected. As well, we used a composite of eight states with good testing rates for comparison (listed as "c").

[12] The exception was Vermont, where we found a higher number of fatally injured drivers with BACs over 80 mg/dL than did Hingson et al. This results in a 19% reduction in the years following the introduction of the lower limit rather than 1% increase reported by Hingson et al. This reduction remains considerably lower than that in the comparison state. Hence, the conclusion does not change.

Table 2: Proportion of Fatal Crashes with a Fatally Injured Driver with BAC ≥80 mg/dL Before and After the Introduction of the Lower Limit in Five Original "Change" States and Comparison States

State	Proportion Before Law (n)	Proportion After Law (n)	Percent change (RR)	Ratio of RRs (95% CI)
Oregon	0.289 (1288/4463)	0.252 (1051/4168)	-13% (0.87)	
(a) Washington	0.283 (1751/6184)	0.293 (1580/5390)	+4% (1.04)	0.84 (0.79, 0.90)*
(b) Wyoming	0.250 (395/1582)	0.295 (290/983)	+18% (1.18)	0.74 (0.69, 0.79)*
(c) 8 states	0.242 (9618/39804)	0.245 (8227/33576)	+1% (1.01)	0.86 (0.80, 0.92)*
Utah	0.142 (319/2252)	0.158 (329/2085)	+11% (1.11)	
(a) Idaho	0.151 (311/2057)	0.215 (382/1773)	+43% (1.43)	0.78 (0.68, 0.90)*
(b) Arizona	0.141 (864/6107)	0.159 (1016/6374)	+13% (1.13)	0.99 (0.86 1.14)
(c) 8 states	0.239 (9561/40055)	0.246 (8299/33747)	+3% (1.03)	1.08 (0.94 1.25)
Maine	0.256 (262/1025)	0.219 (207/944)	-14% (0.86)	
(a) Massachusetts	0.225 (729/3245)	0.208 (562/2699)	-7% (0.93)	0.93 (0.79 1.09)
(b) Connecticut	0.299 (631/2110)	0.256 (426/1665)	-14% (0.86)	1.00 (0.85 1.18)
(c) 8 states	0.251 (5318/21163)	0.233 (4633/19849)	-7% (0.93)	0.92 (0.79 1.08)
California	0.221 (4278/19370)	0.200 (3257/16288)	-9% (0.91)	
(a) Texas	0.198 (2366/11937)	0.213 (2340/10975)	+8% (1.08)	0.84 (0.81, 0.88)*
(b) New York	0.157 (1288/8210)	0.126 (902/7157)	-20% (0.80)	1.13 (1.08 1.17)
(c) 8 states	0.246 (4266/17368)	0.228 (3475/15254)	-7% (0.93)	0.98 (0.94 1.02)
Vermont	0.339 (63/186)	0.273 (51/187)	-19% (0.81)	
(a) New Hampshire	0.239 (67/280)	0.152 (34/223)	-36% (0.64)	1.26 (0.93 1.72)
(b) Connecticut	0.279 (194/695)	0.232 (131/564)	-17% (0.83)	0.97 (0.71 1.32)
(c) 8 states	0.232 (1925/8281)	0.229 (1674/7303)	-1% (0.99)	0.82 (0.60 1.11)

(a) original comparison states
(b) alternative comparison state
(c) composite 8-state comparison (Delaware, Hawaii, Illinois, Minnesota, Montana, Nebraska, New Jersey, Wisconsin)

*indicates a statistically significant reduction in the change state relative to the comparison

The second column gives the proportion of crashes involving fatally injured drivers with BACs over 80 mg/dL in the period prior to the lower limit (see Table 1 for dates). The figures in parenthesis are the numbers used to compute the proportion – i.e., the number of fatally injured drivers with BACs over 80 mg/dL and the number of fatal crashes. To illustrate, in Oregon, prior to the change in the BAC limit 1,288 of the 4,463 fatal crashes involved a fatally injured driver with a BAC that exceeded 80 mg/dL. The third column shows the comparable proportion (and numbers) in each state in the period after the BAC limit was lowered.

The fourth column lists the percent change in the proportions from pre to post periods. It also shows, in parenthesis, the relative risk (RR) – this is simply the ratio of the

proportion of “alcohol-involved fatal crashes” after the change in BAC limit to the proportion prior to the change.

The final column shows the ratio of relative risk in the change state to that in the comparison state (and the 95% confidence intervals). This ratio indicates the degree to which alcohol-related fatal crashes increased or decreased in the state that lowered its BAC limit, relative to that in the selected comparison states. For example, in the data for Oregon a ratio of .84 indicates that after the BAC limit was lowered, alcohol-involved fatal crashes in Oregon were 84% as common as in the comparison state. A confidence interval that includes the value 1.0 indicates that the observed change is not statistically significant, or could have occurred by chance.

An alternative way to deal with these ratios is to subtract the ratio of relative risks from 1.0 and multiply by 100, which provides the percent change in alcohol-involved fatalities. The percent change in alcohol-involved fatal crashes following the lowering of the BAC limit is (1-Ratio of RRs) x 100. For example, compared to Washington, Oregon experienced a 16% reduction in alcohol-involved fatal crashes – i.e., (1 - .84) x 100=16.

The state identified as “(a)” represents the original comparison state used by Hingson et al. This constitutes our replication of the Hingson et al. paper. The findings are virtually identical to those reported by Hingson et al. – i.e., three states (Oregon, Utah and California) showed a significant reduction in alcohol-involved fatal crashes following the introduction of the lower BAC limit, relative to that in the comparison state; no effect was observed in the other two states (Maine and Vermont).

However, using different comparison states (identified as “b” in the table), produced substantially different results. In this case, only one state – Oregon – showed a significant decrease in alcohol-involved driver fatalities following introduction of the lower BAC limit.

Decreases in the other four states did not differ from those in the comparison states. In fact, the decrease in New York (the comparison state) was actually larger than that in California (the change state). This comparison leads to the conclusion that there was a

significant *increase* in drinking driver fatalities in California, following the introduction of the lower BAC limit.

Our final comparison involved a composite of eight states that did not change their BAC limit over the period examined and had a high rate of testing for alcohol among fatally injured drivers. The combined comparison is identified as row "c" in the table. Using this group of eight states, again only Oregon revealed a significant reduction in driver fatalities following the introduction of the lower BAC limit. None of the other four states showed a significant reduction, relative to that in the group of eight other states.

This re-analysis of the data from the first five states to lower the BAC limit to 80 mg/dL illustrates that simply using a different set of comparison states alters the results and the conclusions substantially and questions the robustness of the findings reported by Hingson et al.

In conclusion, although the Hingson et al. study has been widely promoted to encourage other states to adopt a lower BAC limit, the results of the study are not sufficiently compelling to form the basis for policy, without further replication using a stronger research design.

3.1.3 California

California lowered the legal *per se* limit from 100 mg/dL to 80 mg/dL on January 1,1990. Six months later, ALR was introduced. California was one of the initial five states to lower the BAC limit to 80 mg/dL and, accordingly, was included in the two studies reviewed in the previous sections. Both of these studies claimed that California experienced a significant decrease in alcohol-related crashes as a consequence of the lower BAC limit. Neither of these studies, however, considered the potential impact of the ALR law that was introduced only six months after the BAC limit was lowered, nor did they control for the effects of existing trends.

Two other studies have examined the effects of the lower BAC limit and ALR in California in detail – one conducted by Research and Evaluation Associates (1991) for

NHTSA and the other conducted by Patrice Rogers (1995) for the California Department of Motor Vehicles. This section provides a critical review of both studies.

The Research and Evaluation Associates study. The primary purpose of this study was to assess the short-term effects of lowering the BAC limit in California from 100 mg/dL to 80 mg/dL. The effect of the ALR law was of secondary concern but, as described below, it was an important factor.

Although the lower BAC limit and the ALR law were implemented six months apart, considerable overlap occurred in the public discussion of the two laws. The ALR law was actually passed before the lower BAC limit came into effect and the publicity surrounding ALR was coincident with the introduction of the lower BAC limit. Hence, general awareness of the two laws and their potential deterrent effects were intimately related.

It is also important to note that preliminary screening devices were obtained by the California Highway Patrol in 1990. They were the first to acquire and use such equipment in the enforcement of DWI in California. These devices allowed police officers to obtain a preliminary assessment of a driver's BAC quickly and easily. A positive result could be used as a basis to proceed with further testing and/or an arrest. Enthusiasm and use of these devices by the police was reported to be high.

The Research and Evaluation Associates study had four objectives:

1. to determine how groups responsible for the implementation of the new laws altered their activities;
2. to assess the impact on self-reported drinking-driving behaviour, attitudes and practices;
3. to assess the impact on the number of alcohol-related traffic deaths; and,
4. to assess the impact on other measures of drinking and driving behaviour, such as arrests and crashes.

A variety of research methods was used to address these objectives: interviews with key informants and stakeholders; a public survey; time series analysis of fatal crashes from the FARS database; and, analyses of other available data such as state traffic crash and arrest data. Most of the analyses were focussed on four counties deemed to be

representative of the entire state – Alameda, Los Angeles, Fresno, and Shasta/Tehama. The exceptions were the analyses of FARS data and other crash data that were available statewide.

Key Informant Survey. The findings from the interviews with key agencies were based largely on perceptions and opinions. Nevertheless, the insights into how the laws were implemented were valuable. In general, the police indicated that the lower BAC limit created no major change to their policies and procedures. They indicated that the law made it easier to arrest drivers with lower BACs but the average BAC among arrested drivers remained in excess of 150 mg/dL -- the lower BAC limit was viewed as irrelevant for most DWI arrests.

The reduction in the BAC limit was reported to have had little impact on policies and procedures in the court system. Prosecutors believed the lower BAC limit made it easier for them to file charges at lower BACs. Judges indicated that the average BAC among offenders was still well over 100 mg/dL. They also expressed some concern that expert witnesses, who were often called to testify about the impairing effects of alcohol, were less confident in their testimony of the effects of alcohol at 80 mg/dL.

Many informants indicated that the lower BAC limit was “mere legislative tinkering”. The courts and police agencies felt that their limited resources should be channeled into getting high-BAC drivers off the road. Others felt the limit should be even lower. Most felt the lower limit was beneficial and that the greatest asset was its deterrent value. It was, however, viewed as having had no deterrent effect on chronic offenders.

Public Opinion Survey. The public opinion survey consisted of a self-completed questionnaire distributed at the Department of Motor Vehicle offices in the four selected counties. The 1,600 respondents were not necessarily representative of the California population. Just over half of the respondents (56%) knew the legal limit was 80 mg/dL; 48% knew about ALR. Only 25%, however, knew about both laws. Half of all respondents (51%) indicated that they were less likely to drive after drinking since the end of 1989 (when the BAC limit was lowered) but only 4% specifically cited the lower BAC limit as the reason for the change; 47% reported no change in their behaviour and 2% actually said they were more likely to drive after drinking.

Analysis of Fatal Crashes. The main component in the impact evaluation was an analysis of the number of alcohol-related fatalities as recorded in the FARS for the entire state as well for each of the four selected counties for the period four years prior to the introduction of the lower BAC limit and one year following – i.e., from January 1986 through December 1990. Time series models were fit to the data with intervention components corresponding to the introduction of the lower BAC limit and the introduction of ALR six months later. This technique involves examining the data statistically for the presence of long-term trends and cycles and then determining whether these changed at the time the intervention (i.e., a new law) was introduced. The intervention parameter can be examined to determine the magnitude and significance of any change in the series corresponding to the intervention. Unemployment rates and vehicle miles traveled were used as covariates in the analyses.

There were limitations to the analytic approach. Four years of data prior to the intervention is marginally adequate to model the series and with only twelve months of data following the introduction of the lower BAC limit and six months following the introduction on ALR, the results are limited to short-term effects.

The analysis of the statewide data revealed a statistically significant 12% decrease in alcohol-related fatalities associated with the implementation of the lower BAC limit. No change was found following the introduction of ALR. No statistically significant changes were evident in any of the four specific counties examined.

Other Data Analyses. Data on the number of arrests for DWI as well as police-reported alcohol-related crashes were also analyzed. The California Highway Patrol reported 15.5% more arrests but there was no change in the overall number of police-reported alcohol-related crashes following the lowering of the BAC limit. Interestingly, in two of the selected counties, there were significant *increases* in police-reported alcohol-related crashes corresponding to the lowering of the BAC limit. Because these data are based on subjective judgments of investigating officers and not necessarily on objective tests of alcohol use, these latter findings could easily have been the result of increased vigilance and subsequent reporting of alcohol involvement as a result of the new BAC limit.

Conclusion. The results indicate that the lower BAC limit was associated with a 12% reduction in alcohol-related fatalities. However, the results are based on only one year of data following the introduction of the lower BAC limit and, hence, must be interpreted with caution. In particular, the fact that California introduced ALR during this brief follow-up period should not be overlooked. The short period of time between the implementation of the two legislative measures and the intermingling of the publicity surrounding the two laws made it impossible to determine the distinct and separate effects of the lower BAC limit and ALR.

Indeed, the authors acknowledged that the observed reduction in alcohol-related fatalities could have been a function of both the lower BAC limit and ALR. At best, the results suggest a short-term impact; the more prudent would say they are inconclusive. The significant increase in DWI arrests along with the increase in police-reported alcohol involvement in crashes suggest there was greater enforcement, or at least increased vigilance, on the part of the police following the change in the BAC limit. The introduction of preliminary screening devices may also have contributed to increased police activity in this area.

In conclusion, there remain questions as to whether the observed decrease in alcohol-related fatal crashes was due to the lower BAC limit, ARL, increased enforcement, or some combination.

The Rogers study. A subsequent evaluation of the introduction of the lower BAC limit and ALR in California was conducted for the California Department of Motor Vehicles by Rogers (1995). Monthly data on alcohol-related traffic crashes were examined from January 1985 through December 1993 using time series analysis. This provided 60 months prior to, and 48 months after, the introduction of the 80 mg/dL BAC limit (i.e., January 1990) and 66 months prior to, and 42 months after, the introduction of ALR. The length of the series before and after the new laws was adequate to model the series and determine the impact of the interventions.

The author acknowledged that the close temporal proximity of the two laws created a sensitivity problem in detecting intervention effects that were uniquely attributable to either law. It was not possible to disentangle the effects of the two laws. In fact, Rogers

stated that the introduction of ALR may have served to sensitize drivers to the lower BAC limit, resulting in a synergistic effect of the two laws. Hence, it was considered best to regard the two laws as being interrelated rather than as two separate interventions with unique effects.

The traffic crash data were obtained from the California Statewide Integrated Traffic Records System. The data file contained counts of all traffic crashes reported by law enforcement agencies throughout the state. Alcohol involvement in crashes was primarily determined from police reports. These alcohol-involvement data are less valid than those determined by actual chemical tests for alcohol because police typically underestimate the extent of alcohol use by drivers involved in crashes. Property damage crashes were excluded from consideration because of underreporting and a low incidence of alcohol involvement. Crashes involving pedestrians or bicyclists were also excluded.

Four major categories of crashes were examined:

- Police-reported had been drinking (HBD) crashes;
- Nighttime crashes (i.e., those occurring between 8 p.m. and 3:59 a.m.);
- Single vehicle nighttime crashes involving a male driver (SVNM); and,
- Bar closing hour crashes (i.e., those occurring between 2 and 3 a.m.).

For each category of crashes, three subsets, based on severity, were examined – fatal crashes only, fatals plus severe injury crashes, and fatals plus all injury crashes. This created a total of 12 dependent measures for analysis.

Each dependent measure was paired with an appropriate low- or non-alcohol involved control series. The purpose of these control series was to account for extraneous sources of variance that would affect all types of crashes, not just those involving alcohol. The control series consisted of non-HBD crashes, daytime crashes (i.e., 6 a.m. to 1:59 p.m.), multiple vehicle daytime crashes, and daytime crashes between 10 and 11 a.m. In addition, four other variables believed to have an influence on traffic crash rates were examined as potential covariates – the number of licensed drivers, monthly sales of gasoline, personal income, and seasonally adjusted monthly unemployment rates.

Time series models including two intervention components – one corresponding to the introduction of the lower BAC limit, the other corresponding to the introduction of ALR – were fitted to each dependent variable series. Three types of intervention effects were examined – abrupt temporary change, gradual permanent change, and abrupt permanent change. Covariates were included in the models where appropriate.

The results revealed limited evidence of reductions in alcohol-involved crashes associated with both the lower BAC limit and ALR. Of the 12 dependent measures subjected to time series analysis, only 4 showed any effect of the lower BAC limit – two of these were significant at $p<.10$, one only approached the .10 level of significance, and one reached the .05 level of statistical significance. The latter result was, however, weakened substantially by the fact that it was no longer significant when gasoline sales were added to the model.

None of the direct measures of alcohol-related crash involvement (i.e., HBD) showed any evidence of an effect of the lower BAC limit. Of the measures that revealed an effect, the largest (i.e. 16.5%) was found in fatal and severe injury crashes in the bar closing hour series – a measure most likely to be highly related to alcohol-involvement.

Six of the 12 measures showed significant effects of ALR. These findings were generally stronger and more consistent than those associated with the lower BAC limit.

The author concluded that "the preponderance of nonsignificant results in these analyses serves to underscore the somewhat marginal nature of the effects" (p 80). To a large extent, the long-term decline in alcohol-related crashes over the previous decade effectively obscured any positive impact that these two measures may have had. Indeed, the author stated:

> "there is no compelling reason to believe that the small magnitude interventions assessed here would actually produce measurable long term reductions independent of the greater social forces apparently underlying the overwhelming downward trend persisting throughout most of these series" (p 80).

In other words, whatever factors were responsible for the general reduction in crashes -- particularly alcohol-involved crashes – they were more powerful than the effect of either the lower BAC limit or ALR.

The fact that ALR was introduced only six months after the lower BAC limit suggests that the impact of the two laws may not have been independent. Any delayed effect of the lower BAC limit would have been confounded with ALR. In addition, it could be that public awareness of the lower BAC limit was enhanced by the introduction of ALR, creating a synergistic or interactive effect between the two laws. In any event, the close temporal proximity of the two laws renders it virtually impossible to identify the unique independent effect of either one alone.

3.1.4 The next six states

During 1993 and 1994, six additional states lowered the BAC limit from 100 mg/dL to 80 mg/dL -- Kansas, North Carolina, Florida, New Mexico, New Hampshire, and Virginia. The impact of the lower BAC limit in these six states was examined by Hingson et al. (2000) using essentially the same methods as in their previous evaluation of the lower BAC limit in the first five states (Hingson et al. 1996). This method is subject to many of the same criticisms as those raised in the review of the previous study of the original five states.

As a group, the states that lowered the BAC limit experienced a 26.1% reduction in the proportion of drinking drivers involved fatal crashes (i.e., BAC of 100 mg/dL or higher). However, there was also an average decrease of 20.2% in the comparison states. This yields a net reduction of 5.9% in the states that lowered the BAC limit. Similarly, the states that lowered their limit experienced a 21.4% decrease in the proportion of fatal crashes involving a driver or pedestrian with BACs of 100 mg/dL and higher, compared to a 16.0% decrease in comparison states – this yields a net decrease of 5.4%.
Each of the six states that lowered the BAC limit experienced a larger decrease in alcohol-related fatal crashes than the corresponding comparison state but none of these individual state reductions was statistically significant. Only the aggregate reduction was.

As was the case in the earlier study examining the impact of the 80 mg/dL limit in the first five states, the simple pre-post method used in the present study fails to account for pre-existing trends in the data. In fact, the longer the pre- and post-law series, the greater the influence of a pre-existing downward trend. In addition, although this study isolated those four states that already had ALR, this approach does not completely account for the potentially significant joint effects of ALR and the lower BAC limit. In this context, two of the control states had ALR and two did not. Hence, the comparison is not the most appropriate one to help disentangle the effects of the two laws.

In conclusion, many of the same criticisms raised in reference to the earlier Hingson et al. (1996) study of the first five states to lower the BAC limit can be applied to this study as well. The most problematic are the use of a simple pre-post design, which fails to account for the long-term downward trend in alcohol-involved fatal crashes, and the confounding with ALR.

Nevertheless, the consistency of the findings in the individual states and the overall significant effect of the aggregate data suggest that the lower BAC limit, when combined with ALR, may have a beneficial impact on alcohol-related fatal crashes.

3.1.5 North Carolina

The state of North Carolina provided an opportunity to examine the impact of the introduction of a lower BAC limit without the direct confounding influence of the introduction of ALR because ALR had been in place in North Carolina since 1983 while the legal BAC limit was not lowered from 100 mg/dL to 80 mg/dL until October 1, 1993.

Foss et al. (1998; 2001) used structural time series modeling techniques to determine the effect of the 80 mg/dL law in North Carolina. A variety of outcome measures was examined, including:

- police-reported alcohol involvement in crashes, obtained from the North Carolina Traffic Crash file – all crashes, fatal crashes, and injury crashes – from 1991 through 1996;

- police-reported alcohol involvement in all crashes and fatal plus severe injury crashes occurring at night (i.e., 8 p.m. to 4 a.m.);
- the percent of fatally injured drivers with BACs ≥ 100 mg/dL in North Carolina and eleven other states with good alcohol testing rates, obtained from FARS;
- six measures of alcohol-involvement among drivers in fatal crashes (BAC≥10 mg/dL; BAC≥100 mg/dL; police-reported alcohol involvement; single vehicle nighttime [SVN]; single vehicle nighttime male [SVNM]; and estimated alcohol involvement) for North Carolina and 37 other states that did not change the legal BAC limit; and,
- the average BAC among fatally injured drivers (with BACs >100 mg/dL).

The first set of time series analyses examined potential changes in the level and trend of police-reported alcohol involvement in all crashes in North Carolina from 1991 through 1996. These analyses failed to reveal any significant impact of the lower BAC limit for any of the measures – crashes of all severity involving alcohol; crashes of all severity involving alcohol occurring at night; alcohol-involved fatal plus injury crashes; and alcohol involved fatal plus injury crashes occurring at night. It was noted, however, that over the period examined, alcohol-related fatal crashes had decreased 36% but most of this change occurred *prior* to the introduction of the lower BAC limit.

Data on fatally injured drivers with BACs of 100 mg/dL and greater were examined from 1990 through 1996 for North Carolina and eleven other states[13] that had good rates of testing for alcohol. The selection of the eleven states can be criticized for the inclusion of three states (Oregon, Hawaii, and New Mexico) that had a BAC limit of 80 mg/dL during the study period. This would bias the analysis against finding an effect of the lower limit in North Carolina because the difference between North Carolina and the comparison states would, theoretically, be compressed if the lower limit effectively reduced alcohol-related collisions in the comparison states.

The authors acknowledged this potential problem but noted that only New Mexico, which lowered its BAC limit in 1993, could be an issue. However, the number of cases from that state was relatively small and would not likely have altered the results. Hawaii's law only applied to the final few months of the time series period. Oregon had a limit of 80

[13] The eleven states were: Colorado, Connecticut, Hawaii, Illinois, Massachusetts, Montana, New Mexico, Oregon, Rhode Island, Washington and Wisconsin.

mg/dL over the entire study period. Because the limit did not change during the study period, the inclusion of Oregon as part of the eleven-state aggregate should not have posed a major problem for the interpretation of the findings.

Both the series for North Carolina and that for the eleven-state aggregate showed a general downward trend. The series failed to show a significant reduction associated with the lower BAC limit in North Carolina. Examining alcohol-related driver fatalities in North Carolina as a proportion of alcohol-related driver fatalities in the comparison states also failed to reveal a significant effect of the change in the BAC limit.

The final set of analyses examined six indicators of alcohol involvement in fatal crashes in North Carolina compared to 37 other states that did not lower their BAC limit to 80 mg/dL at any point during the period 1991 through 1996. The six indicators of alcohol involvement in fatal crashes were:

- any alcohol involvement by a driver (BAC ≥ 10 mg/dL);
- driver alcohol ≥ 100 mg/dL;
- police-reported alcohol involvement;
- single vehicle nighttime crashes (SVN);
- single vehicle nighttime crashes involving a male driver (SVNM); and,
- estimated alcohol involvement (police report, previous alcohol citation, measured BAC).

These six measures were the same as those used by Johnson and Walz (1994) in the initial study of the effects of the lower BAC limit in five states (described earlier). The same statistical procedure as that employed by Hingson et al. (1996) was used to examine the data – i.e., the ratio of relative risks of alcohol involvement comparing the simple pre-post change in North Carolina to the other 37 states.

All six measures showed a decrease both in North Carolina and the 37-state aggregate following the introduction of the lower BAC limit in North Carolina. For two measures (police-reported alcohol involvement and estimated alcohol involvement) the decrease in North Carolina was significantly greater than in the comparison states. However, the apparent effect was considered an artifact of the grouping of several months of data

before the law change. In both cases, restricting the period of analysis to 24 months before and after the change in the legal BAC limit caused the effect to disappear.

In summary, the analysis of a variety of indicators revealed no significant decreases in alcohol-involved crashes in North Carolina that could unambiguously be attributed to the introduction of a lower BAC limit. Although decreases were noted in several measures, to a large extent the greatest portion of the decrease occurred *prior* to the introduction of the 80 mg/dL limit. As a result, any potential impact of the lower limit may have been obscured by the strong pre-existing downward trend in alcohol-related crashes. The authors concluded that the lower BAC limit was not a sufficiently strong intervention to change the behaviour of the target population.

In explaining the apparent lack of impact of the lower BAC limit in North Carolina, Foss et al. suggested that the proportion of the drinking-driving population that such a law would reasonably be expected to affect might have already changed their behaviour in response to the countermeasure programs of the previous decade. Those drinking drivers who had not changed their behaviour may have consisted of a recalcitrant minority – including hard core offenders – who typically didn't comply with the existing BAC limit and would have been unresponsive to a change in that limit. In support of this position, the authors noted that the average BAC of fatally injured drivers in North Carolina remained at approximately 210 mg/dL following the change in the BAC limit.

3.1.6 Illinois

Illinois lowered the per se BAC limit to 80 mg/dL in July 1997. Voas et al. (2000) examined the effect of the law on public awareness and support for the law, the criminal justice system and the number of drinking drivers involved in crashes. Six months prior to the change in the BAC limit two other changes to existing laws were implemented that could have had an impact on alcohol-involved crashes. First, the court supervision sanction, which allowed offenders to avoid mandatory penalties and conviction, was altered such that it could be used by an offender only once in a lifetime rather than once every ten years. Second, medical personnel were allowed -- and encouraged -- to report the results of blood tests on drivers being treated for injuries sustained in road crashes.

ALR had been in place in Illinois since 1986 so its implementation was not a direct confounding factor.

To examine the impact of the law on alcohol-involved fatal crashes, the researchers used data from the FARS on the BACs of drivers involved in fatal crashes from 1988 through 1999 for Illinois and a group of five comparison states that did not lower the per se BAC limit (Indiana, Iowa, Kentucky, Missouri, and Wisconsin). Drivers involved in fatal crashes were divided into three groups – i.e., BAC=0, positive BAC but less than 100 mg/dL, and BAC of 100 mg/dL or over – based on the NHTSA imputation procedure used to assign a BAC to every driver in a fatal crash for whom a blood alcohol test result was not available.

The first step in the analysis was a simple pre-post comparison of the data from 1996 – the last full year prior to the implementation of the lower BAC limit – with that from 1998 – the first full year after the limit was lowered. This revealed a 22% decrease in the number of drivers involved in fatal crashes with positive BACs below 100 mg/dL and a 9% decrease in the number of drivers with BACs of 100 mg/dL or higher. Neither decrease was statistically significant.

A time series intervention model was applied to the monthly number of alcohol-positive drivers involved in fatal crashes for the years 1988 through 1998. The trend for non-drinking drivers over the same period of time was used as a covariate in the analysis to reduce the influence of factors related to the overall number of fatal crashes. The results revealed a significant decrease of 13.7% in alcohol-positive driver fatalities relative to non-drinking driver fatalities ($p=.04$) in the first 18 months following the implementation of the lower BAC limit. A similar analysis in the set of comparison states showed a non-significant increase of 2.5% over the same period of time.

These results indicate a significant reduction in the number of drinking drivers involved in fatal crashes in Illinois following the introduction of the lower BAC limit. The group of surrounding states that did not reduce the BAC limit did not experience a similar decrease. The authors indicated that the magnitude of the reduction in Illinois (13.7%) was somewhat higher than that reported in other states and that the size of the effect was likely to wane in subsequent years. The authors also acknowledged that two other

laws implemented at about the same time as the lower BAC limit (i.e., limits of court supervision and reporting of alcohol tests results by hospitals) may have accounted for a portion of the observed decrease.

3.1.7 Comprehensive studies

In April 1999, NHTSA released two comprehensive studies dealing with lower BAC limits: one examining the specific impact of lower BAC limits (Apsler et al. 1999); the other examining the relationship between a number of alcohol safety laws and alcohol-involved crashes (Voas and Tippetts 1999).

Apsler, Char, Harding and Klein (1999). The first of these studies (Apsler et al. 1999) examined the effect of lower BAC limits on alcohol-involved traffic fatalities as well as alcohol consumption in eleven states. In examining consumption, three years of data after the change in the legal limit were deemed necessary for analysis, thus limiting the number of states with sufficient data to five. Annual data on beer sales from these states were plotted from 1977 through to the year of the change in the legal limit. These were then compared with the trends during the period following the change. The national trend in beer sales was plotted for comparison.

The method of analysis was limited to visual inspection of the trends – no statistical tests were applied to the data. In two of five states (i.e., California and Vermont) there appeared to be a reduction in beer consumption associated with the introduction of the lower BAC limit. Reductions were apparent in two other states but the visual effect was weaker.

The authors suggested that the lower BAC limit was responsible for these apparent reductions in beer consumption. They argued that the lower limit caused drinkers to reduce their consumption either to ensure they remained below the limit or to lessen their chances of arrest. No statistical analyses were presented to support this conclusion.

To examine the effect of lower BAC limits on crashes, time series methods were applied to data from eleven states that had lowered the BAC limit from 100 mg/dL to 80 mg/dL – the states are shown in the first column of Table 3. The authors examined three measures of alcohol-involved fatalities: the number of fatalities in crashes in which any driver had a positive (i.e., ≥ 10 mg/dL) BAC; the number of fatalities in crashes in which any driver had a BAC of 100 mg/dL or greater; and, the ratio of fatalities in crashes with a driver BAC over 100 mg/dL to fatalities in crashes with drivers who had a BAC of zero. Separate analyses were conducted to determine the impact of the lower BAC limit and ALR in each state except those in which the two laws were implemented within one year of each other (i.e., California, Utah, Oregon, Virginia).

A summary of the results are presented in Table 3. The numbers in each cell are the t-values of the intervention parameters from the time series analyses. Statistically significant decreases in alcohol-involved fatalities, (which were reported by the authors) as well as significant increases in non-alcohol involved fatalities (which were not reported by the authors), are shown by the directional arrows.

Only 2 of 11 states – Vermont and Florida – revealed a significant decrease in alcohol-involved fatalities associated with lower BAC limits. However, as shown in the final column of the table, if the change in alcohol-involved fatalities is compared to the change in non-alcohol involved fatalities, five states had a significant decrease. This raises an important issue – the increase in non-alcohol involved fatalities. Six of the 11 states showed a significant *increase* in fatalities with a zero BAC associated with the introduction of a lower BAC limit. This means that the decrease in the ratios reported by Apsler et al. was more a function of the increase in the number of non-alcohol involved fatalities (i.e., the denominator) than the decrease in alcohol-involved fatalities (i.e., the numerator).

The significant increases in non-alcohol involved fatalities coincident with the introduction of the lower BAC limit, is indeed perplexing. It is even more so when it is recognized that the increases in non-alcohol involved fatalities were more prominent than the decreases in alcohol involved fatalities. In fact, as noted above, such increases were found in more than half of the states examined (i.e., 6 of 11). These changes are

Table 3: Summary of the Effect of Lower BAC Limits in Eleven States on Fatalities According to Driver BAC

State	BAC			Ratio
	Zero	≥10 mg/dL	≥100 mg/dL	≥100 mg/dL/zero
Utah	-- 0.86*	-- -0.66	-- -0.81	-- -1.39
Oregon	-- -0.16	↑ ***1.72***	-- 1.18	-- 1.35
Maine	-- 1.07	-- -0.50	-- -0.46	-- 0.56
California	-- 1.33	-- -0.56	-- -0.78	-- -1.10
Vermont	↑ ***1.83***	↓ ***-2.21***	↓ ***-2.01***	↓ ***-2.10***
Kansas	↑ ***2.59***	-- -1.12	-- -0.32	↓ ***-2.14***
North Carolina	↑ ***3.80***	-- -0.82	-- -1.01	↓ ***-1.80***
Florida	↑ ***4.74***	↓ ***-3.53***	↓ ***-3.66***	↓ ***-4.64***
New Hampshire	-- -0.79	-- 0.47	-- 0.32	-- 0.43
New Mexico	↑ ***2.57***	 -0.80	 -1.05	↓ ***-3.72***
Virginia	↑ ***1.79***	-- -0.93	-- -0.90	-- -1.49
Total Significant Effects	6 increase	1 increase, 2 decrease	2 decrease	5 decrease

* Numbers in the table are the t-value for the intervention parameter (α = .10, two-tailed)

↑ represents significant increase -- reflects no change

↓ represents significant decrease

not merely part of an existing trend in fatalities resulting from increases in the driver population. Such trends, if they did exist, would be accounted for in the analysis. The observed effect on non-alcohol involved fatalities represents a significant change in the level of such crashes coincident with the introduction of the new, lower BAC limit. Why this occurred needs to be examined. The rationale for lower BAC limits certainly does not suggest it would precipitate an increase in fatalities that do not involve a drinking driver.

Every state that experienced a decrease in alcohol-involved fatalities had ALR in effect. In addition, two of the four states that introduced a lower BAC limit and ALR within a year of each other showed a significant positive effect when both laws were modeled as a single intervention. This would suggest that, by itself, a lower BAC limit had little impact on alcohol-involved fatalities. The authors suggested, however, that lower BAC limits, when combined with ALR, have a synergistic effect on other components of the drunk-driving system, keeping the issue alive in the minds of the general public and energizing the efforts of the enforcement, judicial and licensing communities.

Voas and Tippetts (1999). As noted previously, many of the studies that have examined the safety impact of lower BAC limits have been criticized on the basis of their failure to account for the influence of other alcohol-safety laws (most notably ALR), and other factors that could influence longer-term trends in alcohol-related crashes. A recent study by Voas and Tippetts (1999) attempted to address these concerns.

Voas and Tippetts (1999) examined the effectiveness of three major alcohol-safety laws in the United States – ALR, 100 mg/dL illegal *per se*, and 80 mg/dL *per se*. Rather than selecting a group of comparison states, they used a weighted regression model to examine changes in the proportion of drinking drivers in all 50 states and the District of Columbia from 1982 through 1997. This alternative approach allowed the authors to include in the model other factors thought to influence alcohol-related fatal crash rates – i.e., alcohol consumption, seat belt laws, urban/rural distribution of population, unemployment rate, and season. A time trend variable was also included to account for the systematic decrease in alcohol-related fatalities occurring over the period examined that could be attributed to other unspecified factors.

Two dependent measures were derived from FARS for use in the analysis: the first was a ratio of the number of drivers in fatal crashes with a BAC greater than zero but less than 100 mg/dL to the number of drivers in fatal crashes with a zero BAC; the second was a comparable ratio using drivers in crashes with a BAC of 100 mg/dL and over.

The independent variables – those corresponding to the three major drinking-driving laws (ALR, 100 mg/dL *per se*, and 80 mg/dL *per se*) – and the covariates – those related to alcohol-involved fatal crashes (e.g., beer consumption, unemployment, seat belt laws) – were entered into a weighted least squares regression model. The weighting procedure placed greater emphasis on the experience of larger states. For example, California was assigned a weight of 2.5, whereas North Dakota was assigned a weight of 0.25. Also included in the model were a general trend factor to account for unmeasured variables that may have contributed to a decline in alcohol-related fatalities, and a set of factors to account for pre-existing differences in alcohol-related crashes between those states that subsequently did or did not pass major drinking-driving legislation over the sixteen-year period examined in the study.

The results revealed a significant negative relationship between the presence of each of the three laws – ALR, 100 mg/dL *per se*, and 80 mg/dL *per se* – and the ratio of drinking to non-drinking drivers involved in fatal crashes. This indicates that states with these laws had lower rates of drinking drivers involved in fatal crashes. In particular, ALR was associated with a 12.8% lower ratio of drivers in fatal crashes with BACs of 100 mg/dL and over. States with 80 mg/dL BAC had an 8.0% lower ratio of impaired (100 mg/dL BAC and over) to sober driver fatalities.

Voas and Tippetts admitted that the magnitude of these effects was difficult to interpret because they were percentages of ratios. In addition, a decrease in the ratio could have occurred as a result of a decrease in the numerator (i.e., a reduction in alcohol-related fatalities), an increase in the denominator (i.e., an increase in non-alcohol related fatalities), or some combination of the two. As evidenced in the previously discussed study by Apsler et al. (1999), the reduction in the ratio of drinking to non-drinking driver fatalities in many states was largely attributable to an increase in non-drinking driver fatalities.

The model also included a factor representing possible pre-existing differences in alcohol-related crashes between states that eventually passed lower BAC limits and those that did not. This factor was intended to account for the possibility that states with lower numbers of alcohol-involved crashes were more committed to solving the drinking-driving problem and were, therefore, more likely to pass alcohol safety legislation. For both low and high BAC drivers in fatal crashes, this factor was significant, indicating that states which eventually passed lower BAC limit laws had lower rates of alcohol-involved crashes before the legislation was passed than those states that did not enact lower BAC limits. This relationship was in addition to that noted for the law itself.

The fact that states implementing lower BAC limits had lower rates of alcohol-involved crashes than other states, prior to enacting lower BAC limits, suggests that they were more aggressive in their overall efforts to reduce impaired driving. This "enthusiastic" approach to reducing impaired driving may have contributed to both the passing of the law and ensuring its enforcement. Hingson et al. (1996) noted this possibility as well. This suggests that the benefits of lower BAC limits may be attributable, at least in part, to a more general commitment by states to drinking-driving countermeasure programs.

In conclusion, this study attempted to isolate the impact of three specific drinking-driving laws – ALR, 100 mg/dL *per se*, and 80 mg/dL *per se* – after controlling for the influence of a variety of other factors believed to affect the incidence of alcohol-related road fatalities. Although all three types of laws were reported to have an impact on alcohol-related crash rates, the authors acknowledged that the validity of the approach relies on the extent to which all significant predictors of alcohol-related crashes have been accounted for in the model. In this context, the authors admitted that potentially important factors such as changing attitudes and norms surrounding drinking and driving, increased activism, greater use of sobriety checkpoints, and extensive media coverage of the issue were not modeled. These factors are, however, often intimately connected to the passage of new laws – as either cause or effect – and are not easily separated. All of these factors may well have contributed greatly to the passage of drinking-driving laws and the overall reduction in alcohol-related crashes that occurred over the period of time examined.

The authors also urged caution in the interpretation of the results. They noted that the long-term downward trend in alcohol-related crashes was not the result of any one law or policy but was influenced by a number of factors. They concluded that the three laws examined in their study – ALR, 100 mg/dL *per se*, and 80 mg/dL *per se* – each contributed to this trend.

Comprehensive Studies: Conclusion. These latter two studies represent the most comprehensive examinations to date of the effect of the 80 mg/dL limit in the United States. Both studies examined data from FARS over a long period of time but subjected it to different selection criteria and different analytic methods.

One study found the introduction of lower BAC limits was associated with a reduction in alcohol-involved fatalities in only 2 of 11 states. To emphasize this point by putting it another way, significant decreases were not found in 9 of the 11 states that introduced a lower limit. The study also found a decrease in five states, if the change in alcohol involved fatalities was compared to the change in non-alcohol involved fatalities. However, this effect was attributable more to an increase in non-alcohol involved fatalities than to a decrease in alcohol involved ones.

The other study reported that the lower BAC limit was associated with an 8% decrease in the ratio of drinking to non-drinking driver fatalities. This latter study also found that other legal measures (i.e., ALR and 100 mg/dL *per se* laws) were also associated with reductions in alcohol-involved fatalities.

3.1.8 Conclusion

The studies reviewed in this section provide varied results on the effects of lowering the BAC limit from 100 mg/dL to 80 mg/dL. Some studies found significant benefits; others found no significant impact. Even among those that found a beneficial effect, a re-analyses of the data demonstrated how weak the effect was. And in other studies, the presence of a pre-existing downward trend in alcohol-related crashes as well as the presence of other drinking-driving countermeasures introduced at or near the time of the lowering of the BAC limit make it difficult to interpret what caused the decline. A somewhat generous interpretation of the findings might conclude that lowering the limit

from 100 mg/dL to 80 mg/dL, when combined with ALR, may have a small, beneficial impact on alcohol-related fatal crashes. The effect, however, does not appear to be robust and is difficult to demonstrate in individual states. At best, as many of the reports concluded, a lower BAC limit may have been but one factor that contributed to the continuing downward trend in alcohol-related crashes in the United States.

3.2 A Change from 80 mg/dL to 50 mg/dL

This section reviews studies evaluating the impact of a change in the BAC limit from 80 mg/dL to 50 mg/dL. Most of these studies were conducted in Sweden and Australia. Also included is a study evaluating the impact of the introduction of a 12-hour administrative suspension for drivers with a BAC of 50 mg/dL or greater in the province of Ontario.

3.2.1 Sweden

As noted previously in this report, Sweden was one of the first countries to incorporate chemical tests for alcohol into drinking-driving legislation. Blood tests were introduced in 1934 and a *per se* law setting 80 mg/dL as the limit was passed in 1941. There was also a higher tier of 150 mg/dL, which carried with it mandatory incarceration.

The *per se* limit of 80 mg/dL was reduced to 50 mg/dL in 1957 and convicted offenders were required to spend a month in jail. In 1990, the *per se* limit was reduced to 20 mg/dL. However, mandatory jail sentences were abandoned and random testing was introduced. (The recent change from 50 mg/dL to 20 mg/dL is considered in section 3.3).

At the Sixth International Conference on Alcohol, Drugs and Traffic Safety in 1974, Larry Ross presented an evaluation of the drinking-driving laws in Sweden and Great Britain (Ross 1975). To a large extent, this paper was intended to expose what Ross labelled the “myth” of the Scandinavian approach to drinking-driving legislation. After presenting the results from his earlier evaluation of the impact of the *British Road Safety Act* of 1967 (i.e., the introduction of the *per se* law), Ross went on to illustrate that a similar

effect, however temporary, could not be detected as a result of the introduction of the *per se* law in Sweden. In the course of examining the Swedish situation, Ross almost inadvertently provided an evaluation of the impact of lowering of the *per se* limit from 80 mg/dL to 50 mg/dL in 1957.

Ross examined several data series, including: the number of fatal road accidents; fatal road accidents per 10,000 registered vehicles; non-fatal crashes; persons injured; persons killed; and fatalities in "non-collision"[14] traffic accidents in Sweden. The length of the time series depended on the data element being examined but generally spanned decades. Ross pointed out that data systems pertaining to automobiles were poorly developed prior to 1935. In addition, gasoline rationing and the ban on nearly all civilian traffic during the Second World War presented difficulties in interpreting the series prior to the 1950s. These problems, however, should not have interfered with the interpretation of data pertaining to the impact of the changing of the *per se* limit from 80 mg/dL to 50 mg/dL in 1957. Of greater concern is the fact that none of the data series isolated crashes involving alcohol.

The analyses failed to detect any impact of the 1957 change in the *per se* limit. In fact, in all but one instance, the level of each data series actually continued to increase in the years following the change. Only the number of fatal road accidents per 10,000 licensed drivers decreased. This decrease, however, merely continued an existing trend without any evidence of an intervention effect associated with the lower BAC limit.

The closest Ross was able to get to crashes involving alcohol were three data series that could be considered surrogate measures for alcohol involvement: fatalities in "non-collision" traffic accidents; fatalities during evening hours (i.e., 4 p.m. to 4 a.m.); and fatal crashes on Saturdays and Sundays.

The only results presented were for the surrogate series on "non-collision" fatalities and they showed no evidence of an impact of the change in the *per se* limit in 1957. Ross stated that the other two series revealed a similar pattern; however, given that data were

[14] It is unclear exactly what the author meant by "non-collision" traffic accidents. We believe this might refer to single vehicle crashes.

available for only one year prior to the intervention for these series, it is unlikely that a statistical analysis was performed.

In summarizing the results, Ross stated:

> "…the failure of interrupted time series analyses to produce any evidence in favor of the deterrence hypothesis, leads to the conclusion that the international faith in the efficacy of the Scandinavian laws on drinking and driving is without firm foundation." (pp 674-675)

Ross noted that whereas the introduction of the *British Road Safety Act* showed a clearly demonstrable, albeit temporary impact on crashes, the evaluation of the Swedish laws (both the introduction of the *per se* limit in 1941 as well as its reduction in 1957) failed to reveal any evidence of an effect, temporary or long term. In attempting to account for this finding, Ross offered several hypotheses.

He suggested that the Swedish government was unable to produce a credible threat of apprehension, perceived or real. As well, he suggested that other features of Swedish society – most notably the strong Temperance Movement – may have already deterred drinking and driving behaviour to the limits possible by traditional measures. Essentially, those who could be deterred had already changed their behaviour.

The strength of this study was in its use of the interrupted time series technique to evaluate legislative changes; its major weakness was the data. The expected impact of a change in the *per se* limit would be a reduction in alcohol-related crashes, particularly those in which the driver's BAC was in excess of the stated limit. The extent to which an impact might be evident in all crashes would depend of the proportion of crashes involving a drinking driver. Even then, the impact of the change might not be detected by an examination of all crashes. For example, a decrease in the number of alcohol-involved crashes might be offset by an increase in the number of non-alcohol-involved crashes. In this case, the analysis of all crashes would fail to detect the impact on the alcohol-involved portion of the total.

Ross was also compelled to use surrogate measures of alcohol involvement. Although the research community has accepted this method (albeit often reluctantly), it suffers

from many of the same limitations as the use of data on all crashes – i.e., it provides no direct evidence of alcohol involvement. Because surrogate measures include crashes both involving and not involving alcohol, changes in the measure following an intervention could be the result of changes in the alcohol-involved component, changes in the non-alcohol-involved component, or both. Essentially, surrogates are not sufficiently sensitive to the factors that might affect drinking and driving. Nevertheless, Ross examined three surrogate measures of alcohol involved crashes (i.e., "non-collision", nighttime and weekend crashes) and found no impact.

It must also be remembered that this study pertains to a legislative change that occurred more than 40 years ago in a country with a very different social climate. In addition to cultural differences in the use of alcoholic beverages, Sweden had already taken a strong stance in legislative efforts to control the drinking-driving problem. In addition, jail terms had been mandatory for drinking-driving offences for several years. Perhaps as Ross suggested, those easily deterred had already changed their behaviour. Hence, the applicability of the results of this study to present policy decisions is limited.

3.2.2 Australia

Australia has for many years been seen as an innovator in drinking and driving countermeasures. Most notable has been the Australian commitment to random breath testing (RBT) to enforce *per se* laws. RBT allows the police to ask any driver for a breath sample at any time without cause. RBT was first introduced in the State of Victoria in June 1976 and it has since been adopted by every state and territory in Australia as well as a few other countries around the world (e.g., Sweden, France). In Canada, a police officer must have at least a reasonable suspicion that a driver has consumed alcohol in order to require a breath test. Random testing is not allowed in Canada.

Per se laws have also been a mainstay in Australia's countermeasure efforts. In 1976, Victoria became the first state to introduce a *per se* limit of 50 mg/dL; in December 1994, the Northern Territory became the last jurisdiction to adopt a *per se* BAC limit of 50 mg/dL. Several states initially introduced a *per se* limit of 80 mg/dL and subsequently

lowered it to 50 mg/dL. Some of these changes provided researchers an opportunity to evaluate the impact of the lower limit. This section reviews these studies.

New South Wales. The impact of lowering the *per se* limit in New South Wales (December 15 1980) was examined in a technical report by Smith (1987). A simple comparison of nighttime (i.e., 6 p.m. to 6 a.m.) and daytime (i.e., 6 a.m. to 6 p.m.) crashes of various types before and after the implementation of the lower limit was conducted. A variety of different types of crashes was examined: fatal, personal injury (admitted and not admitted to hospital), and property damage only. Comparisons were made with the "rest of Australia" for the number of nighttime fatal crashes and the number of crashes resulting in one or more admissions to hospital.

None of the data sources contained information specifically related to the use of alcohol by drivers involved. The comparison of nighttime to daytime crashes is a crude surrogate for alcohol involvement; one would expect a change in drinking and driving legislation to have a greater impact on nighttime than daytime crashes. This is because nighttime crashes are more likely to involve alcohol than those occurring during daytime hours. In addition, because the likelihood of alcohol involvement increases with the severity of the crash, it might also be expected that nighttime *fatal* crashes would reveal a greater change than less serious (i.e., property damage) crashes.

The number of preliminary breath tests and positive evidential test results were also examined. Although these data provide specific evidence of alcohol-involvement, they are of limited value as part of the impact evaluation. This is because police enforcement practices are neither uniform nor random; hence the data reflect the biases inherent in their procedures. A similar criticism can be applied to alcohol data from crash-involved drivers. Unless all such drivers, or a representative random sample of such drivers is tested, the results will be biased. These biases might also be subject to the influence of the introduction of the new legislation being evaluated. Hence, the value of such data should be viewed in light of these caveats.

In New South Wales, the data series was restricted to one year prior to the introduction of the lower limit and one year afterwards. One year prior to the change in BAC limit, the liquor laws were changed, allowing Sunday openings and later closing times (i.e. 11 p.m.

rather than 10 p.m.). Of greater concern is the confounding effect of a change in enforcement that took place in July 1980, just five months prior to the lowering of the BAC limit. Mandatory breath testing was introduced for all drivers involved in crashes or stopped for a four-point (i.e., serious) traffic offence. As well, the speed limit was set at 100 km/hr on July 1 1979. Prior to that date, a "derestricted system" operated in rural areas (Homel 1994).

Two years after the BAC limit was lowered, random breath testing was introduced (December 1982). Because of the substantial advance publicity prior to its introduction, it was deemed inadvisable to include the data from 1982 in the analysis. The author also noted that the "before" period ended and the "after" period began several days prior to the actual introduction of the lower limit. This small deviation should not have had a substantial influence on the results.

The authors used the "net" change in crashes as the measure of the impact of the lower BAC limit. The net change is the difference between the change in nighttime crashes and the corresponding category of daytime crashes. For example, if there was a 10% reduction in nighttime crashes and a corresponding 7% reduction in daytime crashes, the "net" change would be 3%. This is intended to control for other factors that may affect overall crash rates. The assumption is that the lower BAC limit would influence nighttime crashes more so than daytime crashes.

The introduction of the lower BAC limit was associated with net reductions of 9.7% in crashes that resulted in a hospital admission, 6.2% in injury crashes (but in which no one was admitted to hospital), and 7.2% for "towaway" (i.e., property damage) crashes. There was no significant change in fatal crashes.

Comparisons of nighttime crashes in NSW with the rest of Australia revealed no significant net reduction in nighttime fatal crashes but there was a significant 6.4% net reduction in nighttime crashes resulting in hospital admission.

Smith also examined data on breath tests in the year before and the year after the change in the *per se* limit. There was a 49.3% increase in the number of preliminary breath tests conducted by the police in the year following the introduction of the lower

limit (random breath testing was not introduced for another year – December 1982). The number of drivers who tested positive for alcohol decreased somewhat from 30.0% in the year before the BAC limit was lowered to 26.2% in the year afterwards. Although this decline might be attributed to the change in BAC limit, it could just as well be an artifact. Many more breath tests were conducted after the limit was lowered (nearly 50% more), so the likelihood of finding more negative cases increases, which would reduce the proportion who had a positive BAC.

The distribution of BACs among offenders also revealed a significant change, with a greater proportion of offenders in 1981 having lower BACs. Again, it might be tempting to accept this as evidence of the lower limit affecting drinking-driving behaviour. However, the lower BAC limit reduced the criterion for an offence as well as the threshold for pursuing a positive preliminary breath test reading with an evidentiary test. Consequently, more lower BACs would enter the system than before, even if the actual levels of alcohol among drivers on the road did not change. Simply put, the change in the distribution of BAC among *offenders* does not by itself provide evidence of a change in the distribution of alcohol among drivers on the road.

The fact that the introduction of the lower limit appears to have been coincident with a substantial increase in enforcement also confounds the interpretation of the observed reductions in crashes. The decreases in nighttime crashes in the year following the lowering of the legal limit may have been a consequence of increased enforcement and not necessarily a result of the lower limit. If indeed drivers changed their drinking-driving behaviour, it is not clear whether the change can be attributed to the increase in enforcement, the lowering of the legal limit, or both.

In addition, the extremely limited timeframe over which the data were examined – i.e., one year before and after the change – restricted the ability to attribute the reduction in crashes to the lower BAC limit. The reductions might as likely reflect a continuation of a longer trend. Although this study suggests there was an effect of the lower BAC limit in New South Wales, a variety of alternative and equally plausible explanations could account for the apparent changes.

Homel (1994), as part of a study to assess the impact of a range of road safety initiatives and drinking-driving countermeasures in New South Wales (NSW), discovered an "unexpected" but statistically significant decline in fatal crashes coincident with the introduction of the lower BAC limit. Homel considered the finding unexpected because the Traffic Authority of NSW had reported no discernible impact of the lower limit on traffic crashes. In addition, the earlier study by Smith (1987) described above found no significant effect on fatal crashes in NSW.

Homel used general linear modelling techniques to examine the impact of fourteen separate road safety initiatives. This is a powerful analytic tool that allows the impact of interventions to be modeled while the effects of other correlated factors are controlled. The other factors incorporated in the model included: day of the week, month, and holidays. The dependent measure consisted of total daily fatal crashes, undifferentiated by time of day or alcohol involvement, over the period July 1 1975 to December 31 1986.

The initial analysis examined the cumulative sum of the differences between the observed number of daily fatalities and the corresponding expected number of fatalities. The results showed the introduction of random breath testing (RBT) had a pronounced and sustained impact on the daily number of fatalities but the effect of the lower BAC limit was negligible. However, when the analysis was restricted to Saturdays, a decrease associated with the lower BAC limit was detected.

Homel concluded that the impact of the lower BAC limit was small and restricted to Saturdays. This effect, however, was greatly enhanced by the introduction of RBT two years later. Homel indicates that many people were not aware of the new lower BAC limit, and were not concerned about it until RBT was introduced. In conclusion, Homel stated:

> …without collateral evidence, such as survey data, it was not possible to conclude positively that the .05 [50 mg/dL] law *caused* the decline in fatalities. (p 153)

Homel attempted to explain the mechanism that might have been responsible for the observed reduction in fatalities on Saturday associated with the introduction of the lower BAC limit. He speculated that it could have been a direct deterrent effect for some

drivers through increased perceptions of the chances of being arrested, and an indirect effect by providing some drinkers with an excuse to limit their consumption. Homel also speculated that the reduction in fatalities must have been the result of heavier drinkers drinking less, even if they were still over the limit, because high-BAC drivers comprised such a large proportion of alcohol-related fatalities. Reduced consumption among those who typically drove with relatively moderate BACs would not be expected to have an impact on fatalities.

The evaluation of the lower BAC limit in NSW conducted by Homel provides a controlled and detailed analysis of the data. Its major weakness is the lack of data specific to alcohol involvement, which makes the interpretation of results difficult. He did find a decline in crashes associated with the lower limit but it was only evident on Saturdays. This suggests a limited and weak effect of the lower limit at best.

More recently, Henstridge et al. (1997) included information relevant to the impact of a reduction of the legal BAC limit from 80 mg/dL to 50 mg/dL in New South Wales in their report. These authors were primarily interested in evaluating the effect of RBT but included the lower BAC limit in their analyses as a possible factor mediating the effect of RBT.

As noted above, New South Wales lowered the legal BAC limit from 80 mg/dL to 50 mg/dL in December 1980, two years prior to the introduction of RBT. The authors examined the daily number of fatal and serious injury crashes from 1976 through 1992. Information on alcohol involvement in crashes was not available, so single vehicle crashes occurring during nighttime hours (SVN) were used as a surrogate measure. Multiple vehicle crashes that occurred between 9 a.m. and 3 p.m. on school days (presumably those least likely to involve alcohol) were used as a control series.

Time series models were fit to the daily crash data using numerous control variables -- e.g., season effects, daily weather patterns, economic factors, amount of driving exposure, and alcohol consumption. The change in the legal BAC limit was also examined as a possible mediating factor accounting for some of the effect that might otherwise be attributed to RBT.

The analysis revealed an initial 7% reduction in all serious crashes, an 8% reduction in fatal crashes, and an 11% reduction in SVN crashes associated with the lower BAC limit. All reductions were statistically significant. In comparison, RBT was associated with decreases of 19%, 48% and 26%, respectively.

This study appears to provide evidence of an impact of the lower BAC limit in NSW. The results complement those of Smith (1987) but conflict with those of Homel (1994). Homel reported a significant decrease in fatal crashes on Saturdays; both Smith and Henstridge reported more general decreases in nighttime crashes.

Unfortunately, none of these studies was able to restrict the analyses to crashes known to have involved a drinking driver – indirect, overall, or surrogate measures had to be used because data on alcohol involvement were not available. Hence, although the lower BAC limit in NSW appears to have had an impact, the conclusion remains tenuous in the absence of more direct data.

Queensland. The BAC limit in Queensland was lowered from 80 mg/dL to 50 mg/dL in December 1982, four years before an intensive police road check campaign (referred to as "de facto" RBT) and six years prior to the implementation of formal RBT. The period of time between the introduction of the lower BAC limit and RBT was sufficient to provide a reasonable test of the impact of the lower BAC limit, independent of the effects of RBT.

The results from an evaluation of the impact of lowering the *per se* limit in Queensland are reported by Smith in both a 1987 technical report and a 1988 journal article. Data included: numbers of nighttime and daytime fatal crashes; injury crashes resulting in hospital admission; injury crashes with no hospital admissions; and all property damage only crashes (not just towaway crashes). Data were available for a three-year period prior to the introduction of the lower limit (i.e., Jan 1/80 to Dec 31/82) and a three-year period afterwards (i.e., Jan 1/83 to Dec 31/85). The only other reported legislative change that might have had an influence on the results was a 20 mg/dL limit introduced for drivers under the age of 18 in March 1985.

To the extent possible, data from Western Australia were used as a comparison state. Data on property damage crashes were not used because of different reporting criteria that rendered the data not comparable to those from Queensland. The author notes that Western Australia introduced a 20 mg/dL BAC limit for first-year drivers in December 1982. An 80 mg/dL limit applied to all other drivers throughout the period examined.

A simple pre-post comparison of the aggregate crash data for the three years prior to and following the introduction of the lower BAC limit revealed net reductions of 11.3% for crashes which resulted in a hospital admission, 15.9% for injury crashes (but for which no one was admitted), and 11.5% for property damage crashes. There was no significant effect on the number of fatal crashes.

Further analyses compared each of the three years following the change with the average of the three years prior to the introduction of the lower limit. Although not consistent across all measures, the magnitude of the change appeared to become progressively larger in each subsequent year. Smith (1988) interpreted this as an indication of the longevity of the impact. However, using an average of the three years prior to the lower limit masks any existing trend in the data. If indeed there was a progressive year-to-year decrease in each of the years prior to the introduction of the lower limit, then the observed decreases following the lower limit might simply be a continuation of the pre-existing downward trend. Unfortunately, the data necessary to evaluate this possibility were not presented.

The possibility that the analyses used by Smith might have masked an overall downward trend in collisions that was occurring independent of the change in BAC limit gains some support from the comparison with changes in Western Australia (the "control" state). The comparison of nighttime crashes in Queensland with similar crashes in Western Australia revealed a significant reduction of 8.1% just for crashes that resulted in hospital admission – the decreases in nighttime fatal crashes and less serious injury crashes in Queensland did not differ significantly from those in Western Australia.

BAC data were available for an unspecified portion of drivers involved in crashes. An analysis of these data among drivers involved in crashes before and after the change in the *per se* limit revealed significant differences – there was a shift towards lower BACs

following the introduction of the 50 mg/dL limit. Smith (1988) interpreted this as evidence of the impact of the new *per se* limit. Examination of the data, however, render this conclusion suspect. For example, the data indicate that only about 10% of all drivers had a BAC of zero. This is extremely low, even if the analysis had been restricted to fatally injured drivers. It is apparent that not all drivers were tested for alcohol and that some selection of cases to be tested occurred. In the absence of a truly random selection process, there is a marked tendency to test only those cases in which there is some suspicion that alcohol might be involved. This is evidenced by the extremely high rate of alcohol positive cases (i.e., 90%). Given the bias in testing, the BAC data reported by Smith are of limited utility and cannot, by themselves, be considered a valid indicator of the impact of the lower BAC limit.

In his discussion of the results, Smith (1987; 1988) did consider many of the threats to the validity of the findings. The use of both within-state and out-of-state controls helped strengthen the research design. Smith also acknowledged the potential impact of increased enforcement following the introduction of the lower *per se* limit and that it was not possible to identify the unique contributions of enforcement and the lower limit to the observed decreases in crashes. Moreover, the possibility that a downward trend existed in the years preceding the new *per se* limit was not examined.

In addition, the crash data used in the main analysis did not include any information pertaining to alcohol use by the drivers involved; hence, it is not possible to determine whether the observed reductions were specific to alcohol-involved crashes, non-alcohol involved crashes, or both. The comparison of nighttime to daytime crashes provided a surrogate measure of alcohol involvement suggesting that the observed reductions were a consequence of there being fewer alcohol-related crashes.

The fact that fatal crashes in Queensland failed to reveal a significant decrease presents a problem for the interpretation of a positive impact of the lower BAC limit. Fatal crashes are most likely to involve alcohol – particularly those that occur during nighttime hours. Smith discounts the non-significant reduction in fatal crashes stating that most drivers and motorcyclists killed in Australia have very high BACs and these persons would be as likely to ignore a 50 mg/dL limit as they would a limit of 80 mg/dL. This may be true but it speaks to why the lower limit should not have an impact rather than why it should.

The impact of the reduction in the legal BAC limit in Queensland was also considered in the previously discussed report by Henstridge et al. (1997), who also looked at the impact in New South Wales. These authors were primarily interested in evaluating the impact of RBT but included the lower BAC limit in their analysis as a potential factor mediating the effect of RBT.

Daily fatal and serious crashes from 1980 through 1992 were subjected to the same rigorous time series analysis as was used with the data from New South Wales. Once again, these data were not restricted to alcohol-related crashes but included all fatal and serious crashes.

Time series models were fit to the daily crash data using numerous control variables -- e.g., season effects, daily weather patterns, economic factors, amount of driving exposure, and alcohol consumption. The change in the legal BAC limit was examined as a possible mediating factor accounting for some of the effect that might otherwise be attributed to RBT.

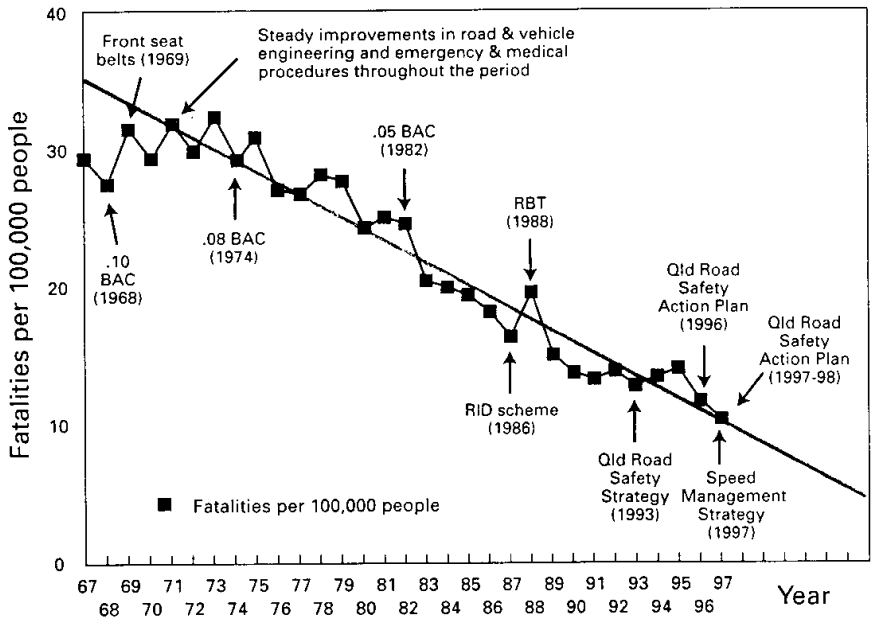
The analysis revealed a significant 18% reduction in fatal crashes and a 14% reduction in serious crashes associated with the introduction of the lower BAC limit. However, as in several other studies reviewed previously, this one did not adequately control for the overall downward trends in collisions because only two years of data available prior to the lowering of the BAC limit were available. In this context, in their Figure 6.1 (p 88) there is a noticeable drop in the number of fatal and serious crashes in Queensland at the beginning of 1983, coincident with the introduction of the lower BAC limit. However, the comparable charts for New South Wales and Western Australia (their Figures 3.1 and 5.1, respectively) show a similar decrease in crashes at the same time as that in Queensland, even though neither of the former states enacted corresponding legislation at that time. This suggests that factors other than changes in the BAC limit or at least in addition to it were causing the decline.

Summary and conclusion. Although Queensland provided an opportunity to examine the impact of the introduction of a lower BAC limit, independent of the effects of RBT, the evidence is not particularly compelling. The study by Smith (1988) suffered from a weak design and lack of information about alcohol in the crash data. In the

Henstridge et al. (1997) study, limited data were available prior to the change, so it is questionable that the observed reductions in crashes can be attributed to the lower BAC limit.

To illustrate this point, we include data from a report from Queensland Transport (1998) showing the number of road fatalities per 100,000 population from 1967 through 1997 (Figure 1). Important road safety initiatives are marked at the time of their introduction. Most striking about this figure is the pronounced downward trend in the road fatality rate beginning in the early 1970s. This has important implications for studies on the impact of lowering the BAC limit. If pre-post comparisons are restricted to a few years before and after the introduction of the 50 mg/dL limit (or the 80 mg/dL limit in 1974, or RBT in 1988) the conclusion would be that the intervention had an effect, whereas in reality the decline might be accounted for by a general downward trend in fatalities occurring as a result of other factors.

Figure 1: Annual Fatality Rate in Queensland Noting Important Road Safety Legislation (Source: Queensland Transport 1998)



South Australia. South Australia provided another opportunity to examine the impact of lowering the BAC limit, independent of the effects of RBT. The BAC limit was lowered from 80 mg/dL to 50 mg/dL on July 1 1992. RBT had been in effect since October 1981.

The impact of this law was examined by Jack McLean and his colleagues in a series of random roadside surveys conducted in Adelaide before and after the introduction of the lower *per se* limit (McLean and Kloeden 1992; McLean et al. 1995). This evaluation of the lower BAC limit in South Australia was unique in that it assessed the impact of the lower limit on the prevalence of drinking among nighttime drivers. All other evaluation studies reviewed in our report focussed almost exclusively on drivers involved in crashes. The studies by McLean are of particular value because they provide information about the behaviour that gives rise to alcohol-related crashes. Studying the impact of lower BAC limits on the behaviour that precedes alcohol-related crashes will help us understand the mechanism by which lower BAC limits may influence crashes.

The survey technique used in South Australia was to approach drivers stopped at traffic signals and request a breath sample. Sampling occurred between 10 p.m. and 3 a.m. and encompassed every day of the week (McLean et al. 1991). The same twenty intersections were used in the surveys conducted before the lower limit was introduced (February to May 1991) and afterwards (August to December 1991). Over 6,000 drivers were sampled in each survey; less than 5% refused to provide a breath sample.

Overall, after the introduction of the lower BAC limit, there was a significant reduction in the percentage of drivers who had been drinking (from 20.2% to 17.6%). Several weeks later, however, the percentage of drinking drivers had returned to a level more consistent with those found prior to the introduction of the lower limit. These results suggest that the changes in drinking and driving behaviour following the introduction of the lower BAC limit were small, and of short duration.

In their discussion, McLean and Kloeden noted that the results of previous surveys indicated there had been a steady downward trend in the proportion of drinking drivers and drivers with BACs over 50 mg/dL throughout the 1980s. Although the introduction of the lower BAC limit appeared to accelerate this decline slightly, much of the initial

reduction was not sustained. The residual reduction was 6% to 7% across all three categories of drinking drivers (i.e., all positive BACs, over 50 mg/dL, and over 80 mg/dL) but the authors point out that a reduction of this magnitude could be the result of seasonal variation – it is to be recalled that the surveys were conducted in February – May (prior to the introduction of the lower limit) and then in August – December (after the introduction of the new limit).

The roadside survey data presented by McLean and his colleagues are unique insofar as they provide a reliable and objective indicator of the prevalence of drinking-driving behaviour among late night drivers. No other study has attempted to examine the impact of a lower BAC limit on the prevalence of the behaviour that gives rise to alcohol-involved crashes – i.e., driving after drinking. If there is indeed an effect of lower BAC limits, it would be expected to be most readily demonstrated in the behaviour of drivers – not just those who happen to crash. The data presented by McLean et al. indicate that the impact on drinking drivers was of short duration. Further, data suggest that the observed reductions may very well have been part of a longer term downward trend.

A subsequent report by McLean et al. (1995) included the results of a roadside survey conducted in 1993 and also examined the BACs of fatally injured and other crash-involved drivers. The data from the 1993 roadside survey presented in the paper are limited to a single point on a graph corresponding to the percent of drivers with BACs over 80 mg/dL (just under 2%). This compares with 2.1% found in 1991 after the introduction of the lower BAC limit. No statistical analysis was performed on the data. When plotted with the data from all previous roadside surveys, the introduction of the lower BAC limit was, according to the authors, “not readily discernible from inspection of the trend line” (p 374).

Data on the percent of drivers with BACs over 80 mg/dL who were fatally injured in the area covered by the roadside surveys were also presented graphically. Because the actual number of cases per year was small (i.e. 20 to 42) and the year-to-year variability was large, three year moving averages were presented as a means to stabilize the variability. Once again, there does not appear to be a discernible change in the trend corresponding to the introduction of the lower BAC limit. Although the specific data were not presented, the authors stated that there was also no change in the percentage of

fatally injured drivers with BACs in excess of 150 mg/dL from 1986 to 1990 and from 1991 to 1994. No statistical analyses were performed. The authors concluded that it was not possible to demonstrate an impact of the reduction in the BAC limit from 80 mg/dL to 50 mg/dL on alcohol-related crashes.

An important caveat that must be attached to the research on the impact of the lower BAC limit in South Australia is the fact that the data were restricted to the city of Adelaide. The roadside surveys were conducted in the Adelaide metropolitan area and the crash data were also limited to a relatively small number of crashes occurring in Adelaide. The impact may have been different in smaller cities and rural areas where public transportation is less available and drinking establishments are further from residential areas.

The examination of data from several years prior to the introduction of the lower BAC limit was an important addition that placed the observed reductions in context. These data indicate that what might appear to have been an impact of the lower limit in a simple pre-post analysis may have been the continuation of a longer term downward trend in drinking and driving. To some extent, the introduction of the lower BAC limit may have contributed to, or helped sustain, this downward trend but it is not possible to determine if in fact it made any contribution.

Australian Capital Territory. The maximum legal BAC for driving in the Australian Capital Territory (ACT) was reduced from 80 mg/dL to 50 mg/dL on January 1 1991. The impact of this change was studied by Brooks and Zaal (1993).

The ACT is a city of approximately 300,000 residents that houses the Australian federal government. As such, it has a relatively homogeneous population of middle class civil servants. ACT has the lowest traffic fatality rate of all Australian jurisdictions (4.93 per 100,000 population) – less than half the rate for the rest of Australia (i.e., 11.26).

ACT has had random breath testing since December of 1982 and the police conduct approximately 80,000 to 90,000 tests each year. At the same time as the 50 mg/dL BAC limit was introduced, ACT also implemented a 20 mg/dL limit for learner and provisional drivers under 25 who had less than three years driving experience, for drivers of large

trucks, drivers of vehicles carrying dangerous goods, and drivers of licensed public vehicles.

The data used in the evaluation were obtained from police RBT screening tests and from evidentiary tests performed on drivers who failed the screening test, for the years 1990 and 1991. Importantly, it should be noted that the BAC data used in the report were obtained from police enforcement operations and not random surveys and are, therefore, subject to a wide range of procedural and selection biases inherent in these types of data.

The number of screening tests per month varied considerably, from 2,222 to 16,991. Data from the first 18 months (i.e., January 1990 through June 1991) did not provide any indication of a seasonal pattern that might explain the tremendous variability in the monthly number of screening tests. In 1990, there were 91,884 screening tests performed; in 1991, approximately 82,000 tests were performed.

A simple pre-post design was used to evaluate changes in the number of evidentiary breath test results per 10,000 screening tests in various BAC groups. The total number of evidential tests performed was not reported. Logit modelling was employed to examine the effect of year (i.e., the intervention effect), month, and various interactions.

The analysis revealed a significant 34% reduction in breath test results in the 150 mg/dL to 199 mg/dL BAC range and a 58% decrease in the over 200 mg/dL range. Changes in other BAC categories were not statistically significant. Very little information was available on drivers with BACs below 80 mg/dL. According to screening test data, in 1990, 363 out of every 10,000 drivers had BACs in the 50 mg/dL to 80 mg/dL range. In 1991, screening test data were not available, so the authors estimated the number of drivers in the 50 mg/dL to 80 mg/dL range by simply subtracting the number of drivers with evidentiary test results over 80 mg/dL from the total number with screening results above 50 mg/dL. This revealed only 34 of every 10,000 drivers had a BAC in the 50 mg/dL to 80 mg/dL range, which was described by the authors as “a massive reduction”. The sheer magnitude of the difference did not prompt the authors to question their estimate or the validity of the comparison.

It should be noted, however, that in 1991, all drivers with a screening test result over 50 mg/dL would have been required to provide an evidential test. Prior to the lower BAC limit, no evidential test was required of such drivers . This procedural change alone could account for the apparent decrease.

Data were also presented for drivers involved in crashes who were tested for alcohol. The results show large, significant decreases in every BAC category, from a low of 26% in the 100 mg/dL to 149 mg/dL category to a high of 46% among those with BACs over 200 mg/dL. No data were presented for drivers with positive BACs under 80 mg/dL or for those at zero. The authors state that the reported reductions are considerably larger than the overall 6% reduction in police-reported crashes over the same period.

Although the crash data appear to show profound reductions in the number of drinking drivers involved in crashes, there is not sufficient information to determine if the observed differences were caused by the introduction of a lower BAC limit. No data were presented on the total number of tested cases, the proportion of cases who were tested, or the selection criteria for testing. Given that blood testing of crash victims did not become compulsory until several years later (i.e., 1998) there was undoubtedly some selective sampling of drivers for alcohol testing. Typically, the only cases that are tested are those where there is at least a suspicion of alcohol use by the driver. The introduction of a lower BAC limit may very well have served to lower the threshold for requesting that a test be performed. In the absence of further information, it is impossible to determine if, and how, crashes were affected by a reduction in the BAC limit.

Brooks and Zaal concluded that the results provide evidence of the effect of lowering the legal BAC limit from 50 to 80 mg/dL. There are, however, two major limitations to this study. First, it used a simple pre-post design with only one year of data before and after the implementation of the lower BAC limit. Hence, the existence of a longer term downward trend cannot be ruled out as an explanation for the observed changes. (See the previous discussion of major downward trends in South Australia – Figure 1.)

Second, the study relied on BAC data reported by the police as a result of enforcement as well as data from alcohol tests performed on drivers involved in crashes. In making

comparisons, it must be assumed that the data collection procedures remained consistent from year to year. However, by definition, the lowering of the BAC limit altered police enforcement procedures. After the limit was changed, drivers who had a BAC in excess of 50 mg/dL could be required to submit to an evidentiary test. Prior to the introduction of the lower limit, only drivers with a BAC over 80 mg/dL provided evidentiary tests. In addition, and as noted previously, the selection of crash-involved drivers for alcohol testing was unlikely to have been random and may have included more drivers with low BACs in the period following the change in the BAC limit.

In conclusion, although this study has been widely cited as providing evidence of the beneficial impact of lowering the BAC limit from 80 mg/dL to 50 mg/dL, a review of the data and methods clearly show that the evidence is inconclusive. The simple pre-post design using enforcement data and BAC data from an unspecified sample of drivers involved in crashes are limitations that severely compromise the validity of the conclusions.

Canada. Canada introduced a criminal *per se* BAC limit of 80 mg/dL in 1969. The only change to the BAC limit since then has been outside the *Criminal Code of Canada* – i.e., most provinces have enacted legislation giving police the power to suspend immediately, for a brief period of time (e.g., 12 or 24 hours), the licence of any driver who registered a BAC of at least 50 mg/dL (40 mg/dL in Saskatchewan). The administrative provision is not an offence, no charges are laid and, in most cases, no official records are kept. The apparent purpose of such legislation is to provide the police officer with a means to remove the "marginally" impaired driver from the road. This type of law, in effect, lowered the BAC limit for drivers in most provinces to 50 mg/dL.

An evaluation of the lower BAC limit in Ontario, which came into effect on December 17 1981, was conducted by Vingilis et al. (1988). Under the new law, police officers were granted the authority to suspend immediately a driver's licence for a period of 12 hours if the driver registered a "Warn" (i.e., a BAC of not less than 50 mg/dL) on an approved screening device. The officer confiscated the licence and informed drivers that their driving privileges were suspended. The licence could be retrieved at the end of the

suspension at the police station. If a sober passenger was not available to take over as driver, the vehicle was towed (at the driver's expense).

The same legislation also gave police the authority to conduct random spot checks for drinking and driving. It is important to recognize that these spotchecks are not the equivalent of RBT. Whereas RBT allows the police to demand a breath sample from any driver at any time without suspicion or cause, random spotchecks only permit the stopping of drivers without cause. A breath test on an approved screening device can only be demanded if the officer has a "reasonable suspicion" the driver has consumed alcohol.

Vingilis et al. (1988) examined the incidence of alcohol use among drivers killed in crashes in Ontario between January 1979 and December 1982 – three years prior to the new law and one year following – to evaluate the impact of short-term roadside suspensions. Similar data from Manitoba and Saskatchewan were combined to form a comparison group. The data on driver BACs were obtained from the TIRF Fatality Database. The median testing rate for alcohol over the four-year period in Ontario was 93%; in Manitoba and Saskatchewan it was 89%.

Time series models were fit to each data series, including a pulse function representing an abrupt but temporary effect of the new law. The intervention component was significant in the model for the Ontario series but not for the comparison series, suggesting that the new law in Ontario had a small, short-term impact on the proportion of alcohol-related driver fatalities. Vingilis et al. (1988) were cautious in their interpretation of these findings. They acknowledged that the time series was too short to provide reliable estimates. A longer series may have revealed a different pattern of results.

It should be noted that in addition to lowering the BAC limit, this unique law was similar to administrative licence revocation (ALR) – a procedure whereby the police officer revokes the offender's driving privileges immediately upon determination that a violation has occurred. Although the sanction is not severe, the law increases the swiftness and certainty of receiving the sanction. Had there been a stronger impact of the new law, it would have been difficult to determine whether the impact was attributable to the

increase in the swiftness and certainty of the sanction, the reduction in the BAC limit itself, or both.

3.3 A Change from 50 mg/dL to 20 mg/dL

In 1990, Sweden lowered the *per se* limit for all drivers from 50 mg/dL to 20 mg/dL, thereby establishing the lowest *per se* BAC limit for all drivers in the world[15]. According to Laurell (1991), the change was preceded by a period of protracted debate and considerable parliamentary turmoil. Four of the six political parties favored a zero BAC limit and one wanted to retain the 50 mg/dL limit. The government proposed a 30 mg/dL limit. The parliamentary subcommittee on justice recommended a limit of 20 mg/dL, which was finally accepted in 1990.

At the same time, Sweden abandoned mandatory jail sentences for DWI offenders. There was a shortage of jail space and almost one-third of existing cells were occupied by DWI offenders. Hence, conditional sentences became much more commonplace, especially for offenders with low BACs. Another significant change occurred in Swedish legislation at the same time as the limit was lowered to 20 mg/dL -- i.e., a switch from blood testing to evidential breath testing (Ross and Klette 1995). This made it easier to obtain BAC readings from suspected offenders and presumably aided the arrest and prosecution of offenders.

Ross and Klette (1995) examined the impact of abandoning mandatory jail for DWI offenders in Sweden as well as in Norway, which had taken this step at the same time. However, only Sweden lowered the *per se* BAC limit at the time they abandoned mandatory jail sentences so the comparison of the two countries also afforded the opportunity to examine the effects of change in the BAC limit. Interestingly, one might expect that removing jail as a mandatory sanction for DWI would reduce deterrence and perhaps result in an increase in drinking and driving, whereas the lower BAC limit might reduce driving after drinking. Nevertheless, the confounding of the two measures renders a definitive interpretation of the results difficult.

[15] The exception is some Eastern European countries that have a zero BAC limit. It should also be noted that some jurisdictions have a zero BAC limit for young and/or new drivers.

Ross and Klette (1995) used interrupted time series analysis of monthly traffic fatalities in Sweden from 1980 through 1992. Total fatalities, daytime fatalities and nighttime fatalities were examined separately. The length of the series after the intervention (i.e., 18 months) was relatively short and the results should, therefore, be interpreted with caution. More importantly, none of the dependent measures included information specifically on alcohol involvement. The comparison of nighttime fatalities to daytime fatalities can, however, be interpreted as a surrogate for alcohol involvement.

The analyses revealed a statistically significant decrease of 15% in all traffic fatalities in Sweden associated with the change in the law in July 1990. However, this was accounted for primarily by a decline in daytime fatalities, which decreased by 16.7%. The decrease in nighttime fatalities, those most likely to be associated with alcohol consumption, was not significant.

Ross and Klette (1995) concluded that most importantly the findings showed no evidence of increased traffic fatalities coincident with the Swedish law reforms of 1990 – the authors were primarily concerned about the abandonment of mandatory jail terms for DWI offenders, which may have been expected to increase fatalities as a consequence of reduced deterrence.

The greater reduction in daytime fatalities compared to nighttime fatalities argues against the hypothesis that the lower BAC limit served to reduce alcohol-involved traffic fatalities. Although it might be argued that the anticipated decrease in fatalities associated with the lower limit was possibly mitigated by an increase associated with reduced penalties, the results from the corresponding analysis of the Norwegian data argue against this. In their paper, Ross and Klette demonstrated that the abandonment of mandatory jail for DWI offenders in Norway did not serve to increase fatalities but in fact was associated with a 22.6% decrease. The *per se* limit in Norway remained at 50 mg/dL.

In summary, the interpretation of the results from this study is clouded by the complexity of the legislative changes and the lack of a direct measure of alcohol involvement in fatalities. Although the total number of traffic fatalities decreased following the change in the BAC limit, it is unlikely that this was restricted to those involving alcohol. Nor is it

clear what was responsible for the decrease. Ross and Klette (1995) suggested that the protracted controversy over the change in the law may have enhanced awareness and served to increase overall safety-related driving behaviour.

A more recent evaluation of the impact of the lower *per se* limit in Sweden was conducted by Norström and Laurell (1997). These authors also employed interrupted time series analysis on monthly numbers of fatal crashes, single-vehicle crashes, and all traffic crashes from July 1987 through June 1996. Alcohol consumption and exposure (i.e., mileage estimated from fuel sales) were used to adjust the series for the possible influence of these factors. Once again, none of these data series contained information specific to alcohol involvement. Although single vehicle fatal crashes are typically more likely to involve alcohol, the inclusion of property damage and daytime crashes reduces the value of the measure as a surrogate of alcohol involvement.

The results revealed a statistically significant decrease of 9.7% in fatal crashes, 11% in single vehicle crashes, and 7.5% in all crashes, coincident with the introduction of a lower *per se* limit in July 1990. The strongest effect was evident in the series most strongly associated with alcohol involvement (i.e., single vehicle crashes). In a subsequent analysis, the authors indicated that about one-third of the reduction in fatal crashes during the post-intervention period could be attributed to reduced exposure among drivers aged 18 to 24 years, a group over-represented in alcohol-related crashes. The authors also alluded to an economic recession, which may have reduced driving among all drivers, not just young ones.

Norström and Laurell (1997) urged caution in the interpretation of their findings, not because of the limitations of the data sources, but because of the uncertainty of causal attributions arising from such a “quasi-experimental” design. In particular, they cited reduced exposure among young drivers as a factor that may have been responsible for a substantial proportion of the observed change in crashes that occurred about the time of the 1990 change in the *per se* limit. Moreover, the significant reductions revealed by the analyses were not specific to alcohol-involved crashes. Although a decrease in alcohol-involved crashes may have contributed to the overall reductions observed following the new legislation, other factors were likely involved as well.

In an attempt to understand the effect of the lower BAC limit on drivers, a series of population surveys examining public attitudes and self-professed behaviour was conducted in Sweden before and after the 1990 change in the *per se* limit (Aberg 1993; 1995). Immediately after the *per se* limit was lowered, Aberg (1993) reported that there was no change in self-reported drinking-driving behaviour – in 1991, 7.5% of respondents reported driving with a BAC over the limit (or after the equivalent of three glasses of wine), compared with 7.8% in 1987. The 1994 survey revealed that 6.9% of respondents reported driving after the same level of consumption. The average number of self-reported drinking-driving incidents actually increased from 0.22, to 0.30 in 1991 and to 0.40 in 1994 but none of these changes were statistically significant.

Aberg (1995) noted that although almost all drivers expressed more or less negative attitudes towards driving after drinking, attitudes became significantly less negative following the reduction in the BAC limit. In 1994, attitudes did not change. It would appear that the historically strong public support for anti-drinking and driving measures in Sweden was beginning to wane.

Aberg (1995) also reported that the proportion of drivers who had been stopped and breath tested by the police increased from 26.2% in 1991 to 40.0% in 1994 and that the perceived probability of being tested in the future had increased significantly as well. Somewhat paradoxically, the proportion of drivers who knew the legal limit decreased from 69% in 1991 to 24.8% in 1994. As well, in 1994, drivers' estimates of the number of drinks one could consume before driving actually increased from 1.7 beers to 2.0 – a level more consistent with the average estimate of 2.2 in 1987 when the *per se* limit was 50 mg/dL.

The assumption underlying lower BAC limits is that drivers will change their behaviour so as to reduce driving after drinking. This, in turn, would be expected to reduce alcohol-involved crashes. The survey results indicate that lowering the BAC limit in Sweden did not have any effect in terms of the first part of this equation – i.e., self-reported drinking and driving behaviour. The apparent lack of a change in drinking-driving behaviour was evident despite a significant increase in the proportion of drivers who have been stopped and breath tested by the police and despite a significant increase in the perceived probability of being tested in the future.

An examination of some of the attitudinal variables included in the survey uncover the reasons for the lack of a strong effect of the legislative change. Although Laurell (1991) indicated that there was strong support for the lower BAC limit evident prior to its change, Swedish driver's attitudes were significantly less negative towards drinking and driving following the change. Violations of drinking and driving laws were being perceived as less serious and less unacceptable socially. This is not to say that drivers became accepting of drinking and driving, merely that their attitudes were less negative. These findings might suggest that drivers were reacting to a law that sanctioned what had been, and continued to be, a behaviour widely believed to be associated with minimal risk.

Summary and Conclusion. The evaluations of the impact of lowering the *per se* limit in Sweden fail to provide definitive evidence of an effect on alcohol-involved crashes. Although the most recent study (Norström and Laurell 1997) found evidence of a significant reduction in crashes and fatalities associated with the legislative changes introduced in 1990, the data are not specific to alcohol-related crashes. Indeed, the authors reported that up to one-third of the observed reduction could be attributed to a decrease in driving among young drivers over the same period of time.

The results of the driver surveys conducted before and after the lowering of the *per se* limit in Sweden are interesting but should be viewed with caution. These data reveal a disturbing change in attitudes. Although drinking and driving has traditionally been seriously frowned upon in Sweden, it would appear that some erosion of this attitude has occurred. At this point, it is unclear whether this is the result of the lower BAC limit, random breath testing, or some other factor.

4.0 Discussion

Legal measures – including *per se* BAC limits -- have played a key role in societal efforts to reduce the alcohol-crash problem. As jurisdictions around the world continue to struggle with ways to deal effectively with the problem, lowering the BAC limit will undoubtedly be a recurring and contentious issue. Central to the debate over lower BAC limits is the effectiveness of this approach in reducing alcohol-involved road crashes. The primary purpose of this report was to assess the potential safety impact of lowering the BAC limit in the *Criminal Code of Canada* from 80 mg/dL to 50 mg/dL by conducting a critical review of the evidence from other jurisdictions that have lowered the BAC limit for drivers.

During the course of this study, it became evident that the proposed change in the BAC limit in Canada was unique and no jurisdiction in the world has experienced a comparable situation. Because most provinces in Canada already enforce a BAC limit of 50 mg/dL (or lower), the proposed change in the BAC limit is not simply one of changing the current 80 mg/dL limit in the *Criminal Code* to 50 mg/dL but, rather, of moving the existing 50 mg/dL limit from provincial highway traffic laws to the *Criminal Code*. To our knowledge, there is no precedent for this type of change anywhere in the world. Hence, to a large extent, the existing literature on the impact of lower BAC limits from other jurisdictions is not directly relevant to the situation in Canada. Nevertheless, it was deemed important and informative to examine the experience of other jurisdictions as a means to assess the potential safety impact of BAC limits.

In reviewing the scientific literature, it is important to recognize that social policies are rarely implemented in a manner or under conditions conducive to the conduct of a rigorous evaluation of their impact. Researchers are often in the difficult position of developing a research design that accounts for as many potentially confounding factors as possible in an attempt to isolate the impact of a particular policy, such as a lower BAC limit. The result is an array of research designs and dependent measures that cannot be readily compared. This can lead to inappropriate interpretations of the evidence and renders it difficult to draw definitive conclusions.

Many – in fact, most – of the studies we examined interpreted the findings as being supportive of lower BAC limits. However, a critical review of these studies revealed that many are limited by weak research designs, dependent measures with incomplete, indirect or no information about alcohol involvement in crashes, and/or overstated conclusions. The evidence is further compromised by the coincident introduction of other laws and programs targeted at drinking and driving – the presence of these coincidental initiatives is a source of confounding which makes it difficult to determine which countermeasure caused the change in alcohol-related collisions or what weight to assign the contribution of the various countermeasures. In sum, a critical review of the research provides a less optimistic view of the impact of lowering the BAC limit than that presented in several of the studies and even other reviews (see below).

Indeed, findings from methodologically rigorous studies have been inconsistent – some showed a beneficial impact (e.g., Voas et al. 1999), some found mixed results (e.g., Apsler et al. 1999), and others have reported no beneficial effects (e.g., Foss et al. 2001).

The observed effects may very well depend on the influence of a variety of social, cultural, and political factors that may have been operational at or about the time the lower BAC limit was introduced. For example, lower BAC limits were typically introduced during the 1980s and early 1990s at a time when most industrialized nations were experiencing large decreases in the magnitude of the alcohol-crash problem (Sweedler 1994). During this time, public concern about the problem reached unprecedented levels and drivers began changing their attitudes and behaviour. A lower BAC limit could have been one of numerous initiatives which collectively contributed to a decrease in the magnitude of the alcohol-crash problem. Providing solid evidence to support this contention has been difficult indeed. Isolating any effects of this one particular measure from the plethora of programs and policies implemented during this time presents a serious challenge to evaluation research.

Several other published reviews of the scientific evidence have raised similar issues and concerns about the strength of the evidence. These reviews differ considerably in terms of their comprehensiveness, the depth of analysis, and the level of detail. Because the issues – and, indeed, the perspective on the issues – often varies according to the

jurisdiction and the type or level of change in the BAC limit, we present a summary of the findings from these reviews according to their country of origin.

Reviews from the U.K. The first of these reviews was prepared by Andrew Clayton of the British Institute of Traffic Education Research (Clayton 1997). The purpose of the report was to review the literature on the effectiveness of drinking-driving countermeasures from around the world and to examine the potential effectiveness of introducing such measures in Britain. Lowering the BAC limit from 80 mg/dL to 50 mg/dL was among the measures considered. The review of literature included studies on the impact of introducing a *per se* limit for the first time as well as those examining a lowering of the existing limit. For the most part, the evidence from each study reviewed by Clayton was presented as it appeared in the original paper, with very little critical comment. Clayton concluded that although reducing the legal BAC limit from 80 to 50 mg/dL would appear at first glance to be a reasonable and effective means of reducing the alcohol-crash problem, the evidence from other jurisdictions, where similar measures had been adopted, was "disappointing".

In attempting to explain the apparent failure of lower BAC limits to have an impact on alcohol-related crashes, Clayton reasoned that the introduction of the lower limit and its attendant publicity was unsuccessful in convincing drivers to change their behaviour to comply with a new, lower limit. In order for lower limits to be effective, it was essential that the public be convinced that driving after consuming less alcohol was both dangerous and morally wrong.

In addition, Clayton noted that in all jurisdictions that had a limit of 50 mg/dL or lower, police had greatly enhanced powers to stop and test drivers for alcohol. Such measures were deemed essential for there to be any reasonable expectation of a beneficial impact of lower BAC limits on road safety.

Interestingly, two subsequent reports in Britain both recommended lowering the legal limit to 50 mg/dL but for different reasons. The first of these reports, prepared by the Department of the Environment, Transport and the Regions (1998), used a series of assumptions to estimate that a lower limit would save 50 lives per year. The other report, from the House of Lords Select Committee on the European Communities

(1998), stated “reducing the permitted BAC limit for drivers from 80 mg to 50 mg/100 ml in the United Kingdom would, of itself, make only a marginal long term difference to the number of road accidents involving illegal levels of alcohol” (p 25). Their recommendation to lower the BAC limit was based on the “important psychological effect” such a measure might have.

Despite the fact that the European Union has been urging a harmonized limit of 50 mg/dL, the U.K. has recently decided not to lower the limit. It is, however, likely that there will be continued pressure for a harmonized limit of 50 mg/dL in Europe.

Reviews in Canada. In a report prepared for Transport Canada, Mann et al. (1998) examined the potential impact of lowering the BAC limit in Canada from 80 to 50 mg/dL. The authors considered experimental evidence on the effects of alcohol, epidemiological evidence on the risk of crash involvement at various BACs, and the evaluation literature on the impact of lower BAC limits in other jurisdictions. A subsequent version of the report, published in the journal *Accident Analysis and Prevention* (Mann et al. 2001), deals only with the introduction of *per se* BAC limits and the lowering of BAC limits.

In the technical report, Mann et al.(1998) reviewed the existing evaluation studies on the impact of lowering the BAC limit. Although the authors acknowledged the weaknesses in the design of many of the evaluation studies as well as the potential confounding factors, they appear to have accepted the validity of the reported results at face value. Applying the stated impact of a lower limit from a study in Sweden (Norström and Laurell 1997) and a study from Queensland (Henstridge et al. 1997) to the annual number of all motor vehicle fatalities in Canada (both alcohol and non-alcohol involved), Mann et al. concluded that lowering the BAC limit to 50 mg/dL in Canada would prevent between 185 and 555 fatalities per year.

One of the studies on which the Mann et al. estimate was based was an evaluation of the change from a limit of 50 to 20 mg/dL -- a change that is not comparable to that proposed in Canada. The Australian study used by Mann et al. to set the upper limit for the estimated savings in lives was based on an evaluation of the change in the legal BAC limit from 80 to 50 mg/dL in Queensland. However, that change took place in 1982

– just as the tremendous declines in alcohol-related crashes began worldwide. Hence, the reductions attributed to the lower BAC limit may have occurred in the absence of such a change. As well, as noted in our review of this study, the effects of the change were confounded with the impact of an aggressive enforcement campaign, which started four years later, and random breath testing, which was introduced two years later.

Mann et al. qualified the estimated beneficial impact of a lower BAC limit by stating it was probably an upper limit. Such a beneficial effect was deemed possible only with increased public awareness and support and/or high-profile police enforcement initiatives. They did not discuss the possibility that such beneficial effects may have been solely attributable to these latter measures, even in the absence of a reduction in the BAC limit. In addition, the authors questioned whether the apparent beneficial impact was even replicable in Canada. In this context, the significance of the differences in social and legal climates between Canada, Sweden and Australia should not be underestimated. The importation of countermeasures from one culture to another is risky business with no guarantees of success; the importation of countermeasures based on weak evidence of success is a recipe for failure (Simpson 1990).

The subsequent published paper by Mann et al. (2001) presents a more critical review of the research literature and avoids predicting the potential number of lives saved in Canada if the *per se* BAC limit was lowered from 80 mg/dL to 50 mg/dL. Rather, the authors concluded that a review of the research presents "a promising but mixed picture of the traffic safety effects of introducing a lower" *per se* BAC limit (p 580). Although they concluded there was evidence of traffic safety benefits associated with the introduction or lowering the BAC limit, the broader social context was considered an important factor in determining whether or not traffic safety benefits would occur.

Reviews from the U.S. In the United States, in June 1997, the State of New Jersey struck a Task Force to examine new ideas and creative approaches for dealing with intoxicated drivers (New Jersey State Legislature 1998). Among the issues considered was the lowering of the statutory BAC limit from 100 mg/dL to 80 mg/dL. The Task Force heard testimony from numerous witnesses, reviewed the scientific evidence, and considered the experiences of other jurisdictions. After vigorous debate,

the Task Force concluded that a lower BAC limit would not achieve the goal of decreasing deaths and injuries resulting from impaired driving.

In reaching this conclusion, the Task Force noted that the evidence of a beneficial effect from reducing the *per se* BAC limit from 100 to 80 mg/dL was conflicting and inconclusive. In light of the lack of compelling evidence and the complexity of the issue, the Task Force considered the question of a lower BAC limit to be a policy decision that was best made by elected officials. The Task Force made no recommendation as to the adoption of a specific BAC limit.

The Transportation Equity Act for the 21st Century directed the General Accounting Office (GAO) in the U.S. to evaluate the effectiveness of laws establishing 80 mg/dL as the legal BAC limit for drivers. The evaluation consisted of a review of the policies and positions of the National Highway Traffic Safety Administration and a review of seven published studies on the effect of the lower BAC limit on alcohol-involved crashes in the United States. The report from the GAO (United States General Accounting Office 1999) was critical of many of the evaluation studies and concluded that:

> "the evidence does not conclusively establish that .08 BAC [80 mg/dL] laws by themselves result in reductions in the number and severity of crashes involving alcohol". (p 23)

The review also concluded that more recent, comprehensive studies also failed to provide conclusive evidence that lower BAC limits by themselves were responsible for reductions in fatal crashes. The Voas et al. (1999) paper provided evidence of an impact but the results from Apsler et al. (1999) were mixed. Based on this conclusion, the GAO report went on to criticize NHTSA for overstating the nature of the evidence in their campaign to have all states lower the BAC limit to 80 mg/dL.

As part of the development of a community guide for reducing the alcohol-crash problem, Shults et al. (2001) conducted a systematic review of the effectiveness of five interventions. The lowering of the BAC limit to 80 mg% from 100 mg% was one of the interventions examined. The authors included in their review nine studies that evaluated the effect of the lower BAC limits on alcohol-involved fatalities in the US. Despite the range of different dependent measures and analytic methods used in these studies, the

authors determined that the median post-law percent change in alcohol-involved fatalities was -7%, with an interquartile range of -15% to -4%.

In their Figure 2 (p 70), the authors plot the percent change in alcohol-involved fatalities following the introduction of lower BAC laws in various states. Using the tables in the Appendix to the article, it can be readily determined that of the 25 data points plotted, fourteen were not significantly different from zero. Only six of the 25 evaluations of individual states revealed statistically significant reductions in alcohol-involved fatalities following the introduction of the lower BAC limit. Contrary to the author's conclusions, this does not provide strong evidence that lower BAC laws are effective in reducing alcohol-involved fatalities.

In general, these other reviews of the research literature on the safety impact of lower BAC limits generally reflect the conclusions of the present review. Occasionally, the authors of such reviews take a different perspective on the evidence and use the positive results to support lower BAC limits. For the most part, however, independent reviews of the research conclude that the scientific literature on the effects of lower BAC limits is mixed and fails to provide consistent and compelling evidence of traffic safety benefits.

4.1 Relevance of findings from other countries

BAC limits below 80 mg/dL are not without precedent. Numerous countries – including Finland, Australia, the Netherlands, France, Belgium, Greece, Norway – have set the limit at 50 mg/dL. Sweden has a limit of 20 mg/dL. The existence of lower limits in different countries often leads to questions about the magnitude of the alcohol-crash problem in these countries in comparison with that in countries with higher BAC limits. However interesting such cross-national comparisons may be, they are not only difficult to make but also exceedingly difficult to interpret.

From a methodological perspective, the data systems on alcohol involvement in traffic crashes vary tremendously among jurisdictions. For example, whereas testing for alcohol among fatally injured drivers may be routine in some jurisdictions, it may be, at

best, sporadic in others (Stewart 2001). Cultural differences in both driving patterns and the use of alcohol can have a tremendous influence on drinking and driving as well as reactions to legislative changes. Public attitudes and values can determine the level of social censure for driving after consuming alcohol as well as support for various countermeasure initiatives. The priority afforded the enforcement of drinking and driving laws as well as the severity and immediacy of the sanctions are also key components in the overall state of the alcohol-crash problem within a jurisdiction.

In sum, there are a number of factors that can, in and of themselves, affect the magnitude of the alcohol-crash problem and, thereby, influence the validity of comparisons among jurisdictions with different BAC limits.

There is also a tendency to refer to BAC limits as if the only difference in the laws among jurisdictions was the actual BAC value specified. In fact, *not all BAC limits are created equal*. They differ in many ways. For example, in some jurisdictions, simple *per se* violations are treated as traffic offences; in others, they constitute a criminal offence. In fact, in many jurisdictions with a 50 mg/dL limit (including the provinces in Canada), it is not dealt with as a criminal offence (Paciocco 2002).

The sanctions for a violation can vary considerably as well. For example, in Belgium, a driver found to have a BAC in excess of the limit of 50 mg/dL faces a licence suspension of only three hours, while such a driver in Sweden faces much more serious sanctions. In this context, as noted earlier in our report, it is perplexing that the push for harmonization of BAC limits in the European Union has focussed exclusively on the level of the limit (50 mg/dL) and not the sanctions associated with it. Pressure to adopt the same limit in so many countries where the penalty structure is profoundly different seems curious indeed from a traffic safety perspective.

The differences in penalty structure are also evident elsewhere. In South Australia, BACs between 50 and 80 mg/dL are associated with a fine and three penalty points. In Victoria, a six month suspension is the rule. In five of the eight Australian jurisdictions, even though the numerical value of the limit is the same, the laws – and the related sanctions – can differ dramatically.

Another key factor in international (or inter-jurisdictional) comparisons is the manner and extent to which the BAC limit is enforced. In Australia, BAC limits are enforced with random breath testing. Many thousands of drivers are breath tested each year to enhance the perception of the risk of detection. As noted previously, random breath testing has been shown to have a significant effect on alcohol-related crashes.

In summary, comparisons among jurisdictions with different BAC limits can be a task fraught with spurious and misleading information. Many differences exist between countries and cultures that could have an influence on the alcohol-crash rate, independent of the value of the BAC limit for drivers. Such differences need to be accounted for when examining the impact of lower BAC limits in other counties.

4.2 Why isn't there a strong, consistent effect of lower BAC limits?

In the search for new countermeasures to reduce the alcohol-crash problem, great hopes and expectations have been placed on the potential of lower BAC limits. The fact that research has failed to demonstrate a strong, consistent effect raises the question, "Why?" Several hypotheses can be advanced to help understand why lower limits have not had the anticipated impact. It might be that the rationale for a lower limit is flawed, or that a lower limit simply does not have an impact, or that it does have an impact but this is difficult to detect, or that it does have effect but it is masked by other factors. Each of these possible explanations is examined below.

4.2.1. The rationale for a lower limit is flawed

The rationale for lower BAC limits is, to a large extent, predicated on the assumption that drinking drivers will comply with the new, lower limit by reducing the amount of alcohol they consume prior to driving, thereby lowering their risk of crash involvement. This, in turn, would lead to fewer alcohol-related crashes. There are, however, fundamental flaws in this logic.

At the very least, the rationale fails to account for the various stages between a change in the BAC limit and a reduction in alcohol-involved crashes. These stages include: knowledge of the law; understanding of the law in terms of one's own behaviour; perceptions and actual enforcement of the law; change in drinking and/or driving behaviour leading to a change in risk; and ultimately, a reduction in crashes.

As with the introduction of any new law, knowledge of the law is a critical first step leading to behaviour change. This step assumes that there will be some means by which the general public is made aware of the new BAC limit – such as widespread media coverage and/or an organized public awareness campaign -- and that a large proportion of drivers would assimilate this information. In this context, a U.S. national survey on drinking and driving conducted in 1995 found only 20% of drivers knew the BAC limit in their state (Jones and Boyle 1996). In Canada, only 25% of drivers were aware of the lower provincial BAC limit (Simpson et al. 1999). In one of the only studies to examine knowledge of the new BAC limit, Foss et al. (1998) found that only 37% of North Carolina drivers knew the correct BAC limit 17 months after it was introduced. It would appear that the first step in enhancing compliance would involve improving public knowledge of the BAC limit.

Beyond simple knowledge of the law, it is important that drivers understand what the BAC limit means and how it relates to their own drinking experiences. Beirness (1984; 1987) has argued that drinkers are extremely poor at estimating their BAC and/or the extent of their impairment and that errors of underestimation of BAC can lead to inappropriate decisions about the safety of driving. Although most people will state that it would take only two or three drinks to reach the BAC limit (Jones and Boyle 1996), they do not appear to apply that knowledge but, rather, make decisions about driving based, in part, on their own perceptions of impairment and/or intoxication.

For example, among drivers interviewed at roadside in Canada, 83% of those with BACs between 81 and 150 mg/dL believed they were not over the limit and 62% of drivers with a BAC in excess of 150 mg/dL thought they were not over the limit (Mayhew et al. 1995). In a roadside survey conducted in Minnesota, 94% of drivers who had a BAC over 100 mg/dL under-estimated their BAC (Beirness et al. 1993). These data suggest that most drivers do not understand how BAC limits relate to their own drinking and drinking-

driving behaviour. Greater understanding of alcohol, BAC, and statutory limits is essential for improved compliance.

Once drivers are aware of the lower BAC limit and know how to comply, they then must be motivated to do so. It is assumed that most drivers are law-abiding citizens who will make an effort to obey the law because they feel morally obligated to do so. It is expected that the majority of these drivers would be individuals who already do not drive after drinking or only with BACs below the existing limit. Reducing their already low risk with a lower BAC would have a minimal effect on crashes.

Others must be encouraged to comply, largely through deterrence. Effective deterrence requires a sufficient level of enforcement (and awareness of such enforcement) to create a high perceived likelihood of being arrested and sanctioned for the behaviour. Driving after drinking would be expected to change as a means to avoid the negative consequences of the behaviour.

The assumption that drivers will comply with a lower BAC limit fails, however, to recognize that drivers who comprise the largest part of the alcohol-crash problem are those who do not comply with the existing BAC limit and do not appear to be easily deterred. In both the U.S. and Canada, approximately 80% of fatally injured drinking drivers have a BAC in excess of the present limit (Mayhew et al. 1998; Simpson et al. 1996). There is no compelling reason to believe that drivers such as these would be motivated to change their behaviour in response to a lower BAC limit. If they did, the change would most likely be temporary and wane over time as drivers realized that the likelihood of being arrested was minimal.

In conclusion, the rationale for a lower BAC limit fails to make the logical connection between a lower BAC limit and a reduction in alcohol-related crashes. There is a process involved in changing drinking-driving behaviour that includes drivers becoming aware of the law, becoming motivated to comply with the law, and understanding how to comply with the new limit. There is little evidence to suggest that the introduction of a lower BAC limit has had an effect on this process; hence, there is little reason to expect a reduction in alcohol-related crashes. In addition, the rationale for a lower BAC limit fails to acknowledge the powerful influence that alcohol abuse and/or dependence has

on behaviour. People with alcohol problems account for the majority of alcohol-related crashes. Their drinking behaviour – and subsequent driving – is not easily changed. Regardless of the BAC limit, this high risk group will most likely continue to drink heavily and drive afterwards.

4.2.2. A lower BAC limit simply does not have an impact

Another possible explanation of why the research has failed to detect a strong, consistent effect of a lower limit is that lowering the legal BAC limit is simply not a potent enough intervention to have a measurable impact on alcohol-related traffic crashes. In many ways, lowering the BAC limit is a measure directed at the wrong group of drivers. To have an impact on crashes, a countermeasure must operate in such a way as to prevent drinking drivers who are most likely to crash, from driving after drinking – or at least, to prevent them from driving after consuming too much alcohol.

The majority of drivers involved in fatal alcohol-related crashes typically have BACs in excess of 150 mg/dL, well in excess of existing BAC limits. The behaviour of this group of drivers has been the most difficult to change with any type of drinking-driving countermeasure. There is certainly no reason to believe that the introduction of a lower BAC limit would somehow cause these drivers to obey the new limit when they fail to comply with the existing limit.

Undoubtedly, some drivers may be prompted to change their behaviour in response to a reduction in the BAC limit. It is anticipated that these drivers would most likely be lighter (i.e., social) drinkers whose occasional excessive consumption might have put them at risk of arrest and/or crash involvement. It was changes in the behaviour of this group that was credited with the tremendous reductions in alcohol-related crashes during the 1980s. In this context, however, those most likely to change their behaviour in response to a reduction in the BAC limit have likely already done so in response to other countermeasure programs. This leaves very little room for further change in this group – certainly not enough to result in a significant reduction in the incidence of alcohol-related crashes.

To place this in context, the average BAC of arrested drivers, injured drivers and drivers who have been killed is between 160 mg/dL and 180 mg/dL in most countries (Mayhew and Simpson 1990), regardless of the BAC limit in that country. These levels are two to three times the legal limit. It is unreasonable to expect that lowering the limit by 20 to 30 mg/dL (i.e. the equivalent of 1-2 drinks) will have a profound and lasting effect on the behaviour of a substantial number of these individuals. Even if it is effective in changing the behaviour of drivers at lower BACs, so few of them are involved in crashes (because of the relatively low risk at these levels) that the overall impact on road crashes will be nominal and difficult to detect.

Nevertheless, some studies that have evaluated the impact of lower BAC limits have reported that the beneficial effect is not limited to those in the lower BAC range covered by the new law but reductions are also evident among those with higher BACs. These findings must also be viewed in light of the methodological issues discussed previously. If there is ,indeed, an effect of lower BAC limits on drivers who typically achieve very high BACs, it will most likely dissipate when these drivers realize that in the absence of a substantial increase in enforcement the likelihood of being stopped and arrested for impaired driving remains extremely low (Ross 1973).

If, indeed, there is an effect of lower BAC limits on the behaviour of high-BAC drivers, it would be imperative to understand why this occurs. For example, if these drivers are reducing their alcohol consumption by even one or two drinks, they may be effectively reducing their risk of crash involvement, even if their BAC is still in excess of the *per se* limit. Should this be the case, an understanding of why their behaviour changed could be used to help develop ways to prompt further change and ensure that such change persists.

4.2.3 A lower limit has an impact but it is difficult to detect

It is possible that the evaluation studies conducted to date have not been methodologically sensitive enough to detect the true impact of lower BAC limits. As detailed in Section 3, the evaluation research in this area is fraught with problems. Weak research designs, and a lack of adequate controls are but two of the problems inherent to this area that compromise the validity of the findings and conclusions. In

addition, when conducting studies outside of the laboratory, researchers often have little control over a variety of factors that can affect their findings.

Most of the evaluation research in this area has examined traffic fatalities (all fatalities, alcohol-involved fatalities, or some surrogate thereof) as the dependent measure to test for effects of lower BAC limits. Fatal crashes are typically the dependent measure of choice, not only because of their social and economic severity but also because fatal crashes are more likely to involve alcohol and the scope of the investigation of such crashes provides a wealth of objective information on its involvement. Nevertheless, fatalities are relatively rare events that involve numerous causal factors and circumstances beyond the use of alcohol. Restricting the analysis to fatal crashes severely limits the scope of information about the potential impact of lower BAC limits.

The effect of lower limits on other, less severe crashes is rarely examined. To a large extent, this is a consequence of the lack of valid and reliable data on alcohol involvement in injury and property damage crashes. In addition, few studies have extended the analysis beyond crashes to the effects of lowering the BAC limit on drinking-driving behaviour, attitudes, and knowledge. Such studies would greatly enhance our understanding of whether, how, where, and for whom lower BAC limits may have an effect.

4.2.4 Effect is masked/contaminated by other factors

It was noted in the review of existing evaluation studies that the apparent reduction in crashes that occurred at about the time lower BAC limits were introduced could often be attributed to either an ongoing downward trend in alcohol-involved fatalities or the impact of other coincident programs, laws, or policies. This provides alternative explanations for the observed decreases, rendering it impossible to state conclusively that the lower BAC limit alone was responsible for any observed changes.

It is, however, possible that the introduction of a lower BAC limit may have helped sustain an ongoing downward trend in alcohol-related crashes through an interaction with other countermeasure programs such as ALR, random testing, renewed enforcement efforts, and enhanced publicity and awareness. The issue of lower limits

may also have simply helped sustain awareness and concern about the problem of drinking-driving. Unfortunately, these suggestions remain speculative because much of the research to date has not adequately controlled for the confounding effects of these other factors, so the independent and/or interactive effects of a lower BAC limit cannot be determined.

4.3 The Canadian Context

In Canada, it is an offence under the *Criminal Code* to operate or have care and control of a motor vehicle with a BAC in excess of 80 mg/dL. This law applies in every province and territory. The penalties for a conviction include a minimum fine on first offence with a possibility of imprisonment; a prohibition from driving for a minimum of 1, 2, and 3 years on first, second and subsequent offence, respectively; and a minimum period of imprisonment upon conviction for a second and subsequent offence. Convicted offenders also have a criminal record, the repercussions of which can be profound and long-lasting.

In addition, the highway traffic law in all provinces except Quebec sets the BAC limit at 50 mg/dL (40 mg/dL in Saskatchewan). The consequences for drivers with BACs at this level are not particularly severe (i.e., 12- or 24-hour immediate suspension) but they are, by all accounts, swift and certain – two key elements of effective deterrence.

It is important to recognize that changing the BAC limit in the *Criminal Code of Canada* from 80 mg/dL to 50 mg/dL would not be comparable to the process of lowering the limit as has occurred in other countries. This is because most drivers in Canada are already subject to a BAC limit of 50 mg/dL. Changing the BAC limit in the *Criminal Code* would primarily involve moving the existing 50 mg/dL limit from provincial traffic law to the *Criminal Code*.

Given that we could find no precedent for this type of change in BAC limits anywhere in the world, it is important to consider the potential implications and impacts of this unique situation.

4.3.1 Implications for drivers

Changing the BAC limit in the *Criminal Code of Canada* to 50 mg/dL would not lower the threshold BAC at which drivers would be subject to enforcement action but would in fact, serve to increase the severity of sanctions for behaviour at the same level. It is not clear that the average driver understands or appreciates the distinction between the drinking-driving provisions in highway traffic law versus those in criminal law. The subtlety of the change would most likely be of little relevance to, or beyond the comprehension of, the majority of drivers.

The net effect for convicted drivers would be an increase in the severity of sanctions imposed for essentially the same behaviour. In principle, the effective BAC limit would not change and most drivers would not have to change their behaviour to comply with the law. Granted, there may be some drivers who are currently willing to risk a short-term suspension who may decide that the threat of criminal sanctions is not worth the risk. But the key variable is not the perceived risk of sanctions but the perceived risk of apprehension. There is evidence that the perceived likelihood of arrest might be affected in the short-term but this dissipates rapidly if the actual likelihood does not (e.g., Carr et al. 1974; Ross 1973).

4.3.2 Implications for enforcement

The existing 50 mg/dL limit in provincial highway traffic law provides the police with the power to remove drinking drivers from the roadway in an efficient and effective manner. As a deterrent, these short-term suspensions provide a swift and certain sanction. It is not necessary for the police officer to undertake the formal procedures of arrest that can take in excess of two hours to complete. The driver does not have to be transported to the police station for more formal testing[16]. Nor is it necessary to complete a multitude of forms to process the criminal charge. The suspension is issued at roadside and is effective immediately.

[16] Drivers issued a 12- or 24-hour suspension on the basis of breath test conducted with an approved screening device can request that more formal testing be conducted.

Moving the 50 mg/dL BAC limit from provincial highway traffic law to the *Criminal Code* could, however, have a detrimental effect on police spotcheck programs. Using short-term suspensions, police have the ability to remove a large number of impaired drivers from the road in a brief period of time while maintaining a continued high-profile enforcement presence. With a BAC limit of 50 mg/dL in the Criminal Code, police will be restricted in their ability to issue short-term suspensions because sufficient evidence to issue a short-term suspension would also be sufficient to lay a charge under the *Criminal Code*. Because a *Criminal Code* charge necessitates the officer to take the offender to the station, it would take only a few charges to effectively shut down a police spotcheck. If even a portion of all drivers now being issued short-term suspensions in spotchecks were charged under the *Criminal Code*, the demonstrated effectiveness of spotchecks could be diminished substantially (Mercer 1999).

The ease and efficiency of short-term suspensions has resulted in police exercising their discretion in issuing short-term suspensions in lieu of criminal charges as a means to avoid the extensive time commitments associated with the processing of a charge under the *Criminal Code* (Moyer 1992; Jonah et al. 1997). A recent survey of front-line police officers confirmed the widespread practice of using short-term suspensions as a means to increase efficiency and avoid the lengthy and time-consuming procedures necessary for laying a criminal charge (Jonah et al. 1997). Although this practice would appear to create a situation whereby some offenders may avoid the sanctions associated with a criminal conviction, no study has been done to determine the extent to which this practice has either detrimental or beneficial effects on the impaired driving problem.

There is also concern about the willingness and ability of the police to enforce a *Criminal Code* limit of 50 mg/dL, if police and the public view driving with a BAC of 50 mg/dL as neither extremely risky nor morally blameworthy. In this context, not all persons are significantly impaired at a BAC of 50 mg/dL and few show overt behavioural signs of intoxication. In jurisdictions where BAC limits lower than 80 mg/dL have been introduced, police have typically been given the authority to demand a breath test of any driver at any time without cause or suspicion of alcohol use. Although random breath testing (RBT) has been shown to have an impact on drinking and driving (Homel 1988),

it is doubtful that such arbitrary testing of drivers for alcohol would be permitted by *the Canadian Charter of Rights and Freedom*s. In fact, the Standing Committee on Justice and Human Rights expressed concerns about mandatory testing without suspicion of alcohol use.

There is also concern that lowering the BAC limit to 50 mg/dL would almost double the number of drivers liable for criminal prosecution. The most recent roadside surveys of nighttime drivers conducted in Canada report 3% of drivers had BACs in excess of 80 mg/dL. Almost as many – 2.3% – had BACs between 51 and 80 mg/dL. This represents a substantial increase in the number of drivers who could be considered legally impaired under a new, lower BAC limit. In the absence of a dramatic increase in police resources to deal with the newly criminalized cohort, a lower BAC limit would result in many more drivers with illegal BACs escaping detection and prosecution because police enforcement efforts would be diluted by the processing of drivers with BACs in the 50 to 80 mg/dL range.

The impact of this situation would be greater if the likelihood of detection and prosecution were independent of BAC. This, however, would only occur through some variant of RBT. In the absence of RBT, the police are most likely to detect and pursue cases with high BACs. This is because it can be extremely difficult to detect drinking drivers. In fact, it has been demonstrated that in sobriety checkpoints the police fail to detect more than half of all drivers with BACs in excess of 80 mg/dL (Wells et al. 1997). Drivers with lower BACs (i.e., 50 to 80 mg/dL) would go largely undetected. Hence, lowering the BAC limit to 50 mg/dL would be unlikely to result in changes in the perceived and actual risk of apprehension for low BAC drivers. In the absence of a credible threat of detection and arrest, any potential changes in behaviour will most likely be short-lived.

4.3.3 Implications for the alcohol-crash problem

Mann et al. (1998) suggested that a BAC limit of 50 mg/dL could save hundreds of lives each year – between 155 and 555. The present report discounts this claim as being overly optimistic. In 1999, a total of 54 drivers with BACs between 50 and 80 mg/dL died in crashes in Canada. This accounts for about 3% of all driver fatalities. In contrast, 486

fatally injured drivers had BACs in excess of 80 mg/dL – 73% of whom had a BAC over 150 mg%. People who drive with BACs of this magnitude are not generally part of the majority of socially responsible drinkers. They consume alcohol in an abusive manner and most likely do so repeatedly; many drive afterwards. This high-risk subset of drinking drivers does not comply with existing BAC limits; there is no reason to suspect that the introduction of a lower BAC limit would have a substantial impact on this high-BAC group of drivers, and therefore on the alcohol-crash problem associated with them.

4.3.4 Implications for public support

In a national public opinion survey published in 1997, MADD Canada (Mothers Against Drunk Driving) asked if people would support lowering the BAC limit from 80 to 50 mg/dL. Overall, 73% said they would support such a move; 22% were opposed; and 5% were unsure. Strong support was also found for other measures included as part of the survey -- mandatory testing of drivers involved in serious crashes, minimum jail sentences for persons convicted of impaired driving causing death.

A national poll on road safety conducted for Transport Canada also asked about measures to reduce impaired driving (Kiar 1998). Respondents were asked to indicate their level of agreement with a series of nine measures, including greater enforcement, mandatory suspensions, vehicle seizure, and lowering the BAC limit. There was very strong support (i.e., 80% agreement) for every measure, with the exception of lowering the BAC limit. Only 60% of respondents agreed with this latter measure and 37% opposed it. Drivers with the highest level of education were least likely to support a lower BAC limit and those who drive the least were most likely to support it.

In a survey of front-line police officers conducted for Transport Canada and the Canadian Association of Chiefs of Police (Jonah et al. 1997), officers were asked about the extent to which they agreed with a variety of measures to deter impaired driving, including lowering the BAC limit in the *Criminal Code* from 80 mg/dL to 50 mg/dL. With the exception of taking simple impaired driving (i.e., no death or injury) out of the *Criminal Code*, lowering the BAC limit garnered the lowest level of support (i.e., 37%).

A national survey conducted during November and December of 1998 also examined the issue of BAC limits (Simpson et al. 1999) but used a line of questioning designed to overcome the tendency for respondents to agree with or support virtually every measure. Respondents were first asked if they thought the present BAC limit of 80 mg/dL was appropriate and should be retained. Over 60% agreed. Among the 27% who indicated it was not appropriate, 26% said it should actually be higher; 72% said it should be lower. In total, this indicates that less than 20% of Canadians felt the BAC limit of 80 mg/dL should be lowered (i.e., 72% of 27%).

For the most part, these surveys show that a lower criminal BAC limit in Canada is not one of the highest priorities among Canadians as a measure for dealing with the alcohol-crash problem. Over the past several years, the introduction and implementation of a variety of countermeasure programs, such as ALR and vehicle impoundment, have been facilitated by strong public support for measures to deal effectively with the alcohol-crash problem. Public support for any countermeasure program or policy is critical to its success.

In this context, public support has been fostered by concern about the deaths and injuries resulting from impaired driving. To a large extent, public support for drinking-driving countermeasures in the broadest sense relies on a perception that the target of such measures is blatantly irresponsible behaviour. If the public begins to perceive the criminal law as encroaching on established and common social practices that are not necessarily inherently dangerous, then support may begin to wane, eroding the tremendous social pressure against driving after drinking that appears to have been crucial to the successes of previous years.

Indeed, there is evidence that public support for drinking-driving interventions in Sweden has waned with the lowering of the BAC limit. Following the reduction in the BAC limit from 50 mg/dL to 20 mg/dL, attitudes towards driving after drinking became significantly less negative, and intentions to violate the BAC limit increased (Aberg 1995). Weakening public support has the potential to undermine existing efforts and should be avoided if at all possible. This sentiment was expressed many years ago by Professor Robert Borkenstein, creator of the Breathalyzer, who indicated that in attempts to control

the alcohol-crash problem, every effort must be made to avoid alienation of the public and to maintain the support of the social drinker (Borkenstein et al. 1963).

5.0 Conclusions

Our review of the studies that have evaluated the impact of introducing a lower BAC limit for drivers underscores the importance of a careful and critical appraisal of the evidence. Uncritical reviews that fail to identify the methodological limitations inherent in so many of the studies can lead to erroneous conclusions about the effectiveness of a lower limit. Selective citations from these studies that ignore the caveats often identified by the researchers produce a distorted picture of the strength of the evidence. Unfortunately, a number of the reviews of the evaluation research have done just that – they have taken the unqualified conclusions of the studies at face value and used this as the basis for concluding that lowering the BAC limit produces declines in alcohol-related collisions. Our conclusion is far more cautious and tenuous. We do not find compelling evidence of a consistent and strong impact.

Studies to date have used a variety of research designs, dependent measures and analytic techniques to evaluate the impact of lower BAC limit. Many have used weak research designs that fail to account for various threats to validity. A common problem is the use of a simple pre-post comparison. This design fails to control for a variety of other factors that could account for any observed changes, the most serious of which is the well-documented downward trend in alcohol-involved crashes that occurred during the 1980s. More complex designs that take such longer term trends into account have not all shown a consistent effect of a lower limit, raising questions about the reliability and robustness of the effect.

Another common design problem is the use of comparison or control jurisdictions. The use of a control group greatly strengthens the validity of the simple pre-post design but as has been demonstrated (e.g., Hingson et al. 1996, as well as our re-analysis), the results can be appreciably altered as a function of which comparison groups are used. Indeed, one set of comparison groups can produce results that show an impact of lowering the limit; the use of another, equally rational set of control groups can fail to show any effect.

Another important research design issue is the confounding created by the introduction of other drinking-driving countermeasures in close temporal proximity to changes in the BAC limit – measures such as RBT in Australia, the elimination of mandatory jail terms in Sweden and the introduction of ALR in the United States. The co-occurrence of such measures makes the interpretation of the findings difficult – separating the effects is often not possible. This has led some to conclude that the observed reductions in alcohol-related crashes were attributable to both measures (e.g., ALR and the lower limit). In some cases this more cautious and appropriate conclusion has been lost and the findings inappropriately used as evidence of an impact of a lower BAC.

Other studies have used data that were not specific to the alcohol-crash problem. The use of all serious and fatal crashes without evidence of alcohol involvement weakens the validity of the conclusion that changes were the result of a measure directed only at alcohol-related events. Evaluations of the impact of a lower BAC limit must demonstrate a direct and specific effect on alcohol-related measures. Many studies have failed to do so.

The research also indicates that a variety of factors can have a profound influence on the effects associated with a change in the BAC limit, including the social climate, the political and legal environment, prevailing social norms and customs, the presence (or absence) of supporting legislation, public acceptance of the law, and local enforcement practices. Whereas some of these factors (e.g., other coincident legislation) may be readily accounted for in the research design and analysis, others (e.g., social norms) are less easily measured.

Indeed, enforcement of the *per se* BAC limit appears to be a key factor in determining the extent of any impact of a lower BAC limit. In this context, lowering the BAC limit to 50 mg/dL presents difficulties in terms of the ability of police to detect drivers with BACs at the level. Typically, drivers with BACs in the range of 50 mg/dL to 80 mg/dL display few, if any, of the classic signs and symptoms of intoxication. Hence, enforcement of a 50 mg/dL limit is likely to be ineffective without additional measures -- such as random testing -- to help enforce the lower limit. In the absence of a credible and reliable threat of detection and arrest, there can be little expectation of an impact of a lower limit.

Decisions regarding changes in an established BAC limit are difficult and must be based on a variety of considerations. Scientific evidence of the safety impact of such a change is but one factor. The studies reviewed in this report indicate that evidence of a beneficial safety impact of lowering the BAC limit is often weak and inconsistent. Where positive results have been reported, the studies are often flawed or the results are confounded by other factors. There is little evidence that lowering the BAC limit from 80 to 50 mg/dL will, in and of itself, result in fewer alcohol related traffic deaths.

In attempting to determine the potential impact of lowering the BAC limit from 80 mg/dL to 50 mg/dL in Canada, it is important to recognize that most provinces have already set an administrative BAC limit at 50 mg/dL (40 mg/dL in Saskatchewan). Accordingly, a lower BAC limit in the *Criminal Code* would not change the threshold BAC at which sanctions first occur, only that at which criminal sanctions would apply.

The fact that introducing a lower BAC limit does not necessarily have a demonstrable impact on traffic safety should not be taken to suggest that statutory BAC limits have no value in efforts to control the alcohol-crash problem. Indeed, simply having and enforcing a *per se* BAC limit is an efficient and effective means of dealing with the problem. The actual numerical value of the limit may be of relatively little importance compared to the policies, programs and procedures that have been implemented to support it.

The function of a BAC limit may be to inform the public that the consumption of alcohol beyond a certain point is considered illegal and dangerous when combined with driving. The specific point at which driving after drinking crosses the line between acceptable and unacceptable behaviour may be of relatively little consequence. This is because the general public has only a very superficial understanding of the relationship between alcohol consumption and BAC – particularly in terms of their own behaviour. Most do not have access to facilities to measure their own BAC and, hence, must make the decision about driving based on their own subjective assessment of the extent to which alcohol has adversely affected their ability to operate a vehicle safely. Merely knowing a limit exists – and that the limit is reasonable – may be sufficient to ensure that responsible citizens will attempt to comply with the law by drinking moderately and/or making alternative transportation arrangements. Less responsible citizens – particularly

heavy drinkers – have a tendency to make very poor decisions concerning driving after drinking. They don't comply with the existing limit and are unlikely to change their behaviour in an attempt to comply with a new, lower limit. If so, a reduction in the legal BAC limit, in and of itself, would not be expected to have a substantial impact on the prevalence of impaired driving or alcohol-related crashes.

In conclusion, our critical review of the evaluation literature failed to provide strong, consistent and unqualified support for lowering BAC limits. At best, the results are mixed and the methodological weaknesses in the studies question the robustness and veracity of the evidence. In addition, our review of the literature failed to find any study in a jurisdiction that has a system of BAC limits comparable to that in Canada. Hence, the research literature could provide only indirect evidence of the potential impact in Canada of lowering the BAC limit in the *Criminal Code*.

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