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Journal of Safety Research 37 (2006) 233–243
www.nsc.org

The effectiveness of reducing illegal blood alcohol concentration (BAC) limits for driving: Evidence for lowering the limit to .05 BAC

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Received 7 January 2005; received in revised form 2 June 2005; accepted 25 July 2005
Available online 7 July 2006

Abstract

Purpose: This scientific review provides a summary of the evidence regarding the benefits of reducing the illegal blood alcohol concentration (BAC) limit for driving and providing a case for enacting a .05 BAC limit. *Results:* Fourteen independent studies in the United States indicate that lowering the illegal BAC limit from .10 to .08 has resulted in 5–16% reductions in alcohol-related crashes, fatalities, or injuries. However, the illegal limit is .05 BAC in numerous countries around the world. Several studies indicate that lowering the illegal per se limit from .08 to .05 BAC also reduces alcohol-related fatalities. Laboratory studies indicate that impairment in critical driving functions begins at low BACs and that most subjects are significantly impaired at .05 BAC. The relative risk of being involved in a fatal crash as a driver is 4 to 10 times greater for drivers with BACs between .05 and .07 compared to drivers with .00 BACs. *Summary:* There is strong evidence in the literature that lowering the BAC limit from .10 to .08 is effective, that lowering the BAC limit from .08 to .05 is effective, and that lowering the BAC limit for youth to .02 or lower is effective. These law changes serve as a general deterrent to drinking and driving and ultimately save lives. *Impact on Industry:* This critical review supports the adoption of lower illegal BAC limits for driving.

Keywords: Blood alcohol concentration (BAC) limits; .05 BAC limit; Traffic safety; Impaired driving; Fatal crashes; General deterrent; Effectiveness; Drinking drivers

1. Introduction

The international trend toward lowering BAC (blood alcohol concentration) limits has been continuing for some time now, with most industrialized nations reducing their illegal limit to a BAC of .05 or lower. The illegal limit is .05 BAC in Australia, Austria, Belgium, Bulgaria, Croatia, Denmark, Finland, France, Germany, Greece, Israel, Italy, the Netherlands, Portugal, South Africa, Spain, and Turkey. Norway, Russia, and Sweden have a limit of .02 BAC, and Poland recently adopted .03 BAC. This trend has not developed in a vacuum; a myriad of studies have indicated that lowering illegal BAC limits is in the best interest of the public. For example, laboratory studies indicate that impairment in critical driving functions begins at low BACs (Moskowitz & Fiorentino, 2000). Most subjects in laboratory studies are significantly impaired at .05 BAC regarding visual acuity, vigilance, drowsiness, psychomotor skills, and information processing, compared to their performance at .00 BAC (Moskowitz, Burns, Fiorentino, Smiley, & Zador, 2000). The relative risk of being involved in a fatal crash as a driver is 4 to 10 times greater for drivers with BACs between .05 and .07, compared to drivers with .00 BACs (Zador, Krawchuk, & Voas, 2000). A recent study by the National Highway Traffic Safety Administration (NHTSA) in the United States indicates that drivers at .05 BAC have a significantly higher relative risk (ratio of 1.38 to 1.00) of being involved in a traffic crash than drivers at .00 BAC (Compton et al., 2002). Leading medical, crash prevention, public health, and traffic safety organizations in the world support BAC limits at .05 or lower, including the World

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doi:10.1016/j.jsr.2005.07.006

Medical Association, the American and British Medical Associations, the European Commission, the European Transport Safety Council, the World Health Organization, and the American College of Emergency Physicians (Chamberlain & Solomon, 2002).

This article provides a critical review of the evidence regarding the potential benefits of enacting a .05 BAC per se limit. The first section discusses methodological issues concerning studies of this nature. The second section summarizes the evidence, including the most recent studies, for lowering the BAC limit from .10 to .08. The third section covers the available evidence for lowering the BAC limit to .05. The fourth section reviews the evidence for lowering the BAC limits for drivers younger than age 21. The last section concludes that lowering BAC limits is an effective strategy in reducing impaired-driving casualties.

2. Discussion of methodologically rigorous studies

The effectiveness of any law is highly dependent on the extent to which it is enforced and the intensity and publicity surrounding that enforcement. When an evaluation of a new impaired-driving law is conducted, it is difficult to control for changes in enforcement activities, changes in public information, changes in other laws, and changes in alcohol consumption, all of which could affect the outcome. When researchers study multiple applications of the same law, there almost always are cases where one or two of the jurisdictions will show no benefit or might even experience an increase in the problem. These exceptions to the more general finding of a benefit often will be seized by critics to use in opposing the policy. Thus, it is important to consider the preponderance of evidence provided by all the available studies.

New public health programs and policies go through several development phases before reaching full implementation throughout a country (Holder et al., 1999). For example, Canada adopted its current .08 BAC Criminal Code limit in 1969, whereas in the United States, Utah and Oregon were the first two states to lower their illegal limit from .10 to .08 per se BAC in 1983. By 1999, 18 states and the District of Columbia had lowered the illegal limit from .10 to .08 BAC. During that time, nine evaluations of .08 laws involving 11 states had been conducted in the United States. A scientific review by a committee of experts formed by the U.S. Centers for Disease Control and Prevention indicated that the median treatment effect detected by the studies they reviewed was a 7% reduction in alcohol-related fatal crashes (Shults et al., 2001). The evidence for the effectiveness of lowering the illegal BAC limit produced a consensus among highway safety advocates on the value of the .08 law. This resulted in the U.S. Congress providing a sanction that withheld a portion of a state's highway construction funds for states not adopting .08 laws by October 1, 2003.

Studies of the effects of lowering BAC limits have various research designs and methodologies. The effectiveness measure and the analysis procedure have varied from investigator to investigator. Contemporaneous changes in other laws and policies–such as the enactment of an administrative license suspension (ALS) or an administrative license revocation (ALR) law permitting officers to seize the licenses of impaired drivers at the time of arrest–were not fully considered in some of the studies. A review by the U.S. General Accounting Office (GAO, 1999) found that the .08 law was effective, but generally only when combined with an ALS/ALR law. To test the significance of an ALS/ALR law, Hingson, Heeren, and Winter (2000) compared states in which the two laws were implemented at about the same time with states where an ALS/ALR law had been in place for some time before adoption of a .08 law. They found that the .08 law made a significant difference in states where the ALS/ALR law had been in place for some years. Because of differences in effectiveness measures or analytical techniques, Foss, Stewart, and Reinfurt (1999) found no significant change because of the .08 law in North Carolina, whereas Apsler, Char, Harding, and Klein (1999) did find a significant reduction in alcohol-related crashes in North Carolina associated with the .08 BAC law. Research and Evaluation Associates (REA, 1991) reported a reduction in alcohol-related fatal crashes in California; conversely, Rogers (1995), in a later analysis, did not find a significant reduction in fatal crashes in California attributable to the .08 law but did find a reduction in nighttime injury crashes in California due to the .08 law.

Voas, Tippetts, and Fell (2000) considered the .08 BAC law as one of several alcohol safety measures in a study that included all 50 states plus the District of Columbia over a 16-year period. This study, which applied a common methodology to all the states from 1982 to 1997, found an 8% treatment effect of the .08 BAC law that was very similar to the Centers for Disease Control and Prevention (CDC; Shults et al., 2001) finding of a 7% median treatment effect. The Voas et al. (2000) study was the most comprehensive study of lower BAC limits to date and did control for many potentially confounding factors such as safety belt legislation and the economy.

A significant limitation in the interpretation of all field studies of the implementation of new laws is the varying analytical methods and criterion measures used by different investigators. With this in mind, Tippetts, Voas, Fell, and Nichols (2005) conducted identical individual analyses of 19 U.S. jurisdictions with .08 laws using a common dataset, the same effect measure, and an identical analytical procedure. This permitted a more direct comparison of the effectiveness of the .08 law in each jurisdiction where it was implemented and supported a meta-analysis of the effect sizes in each of the 19 jurisdictions to derive an overall effectiveness measure for the .08 law. The meta-analysis provided an estimate that the enactment of laws lowering the BAC limit from .10 to .08 reduced the proportion of drivers in fatal crashes who were drinking by 14.8%. Based on this reduction, had the other U.S. states adopted a .08 law in

2000, 947 lives might have been saved. Bernat, Dunsmuir, and Wagenaar (2004) examined the effects of .08 BAC laws in the same 19 jurisdictions using changes in single-vehicle nighttime (SVN) fatal crashes (when alcohol is most likely a factor) as their measure. The mixed-model regression analyses showed a significant 5.2% reduction in SVN fatal crashes associated with the .08 BAC law across all states after adjusting for ALS/ALR and trends. These methodologically rigorous studies verified that lowering the illegal BAC limit from .10 to .08 in the United States has had a significant safety impact.

3. A summary of the evidence for lowering the BAC limit from .10 to .08

At the start of the 1970s, when the first U.S. national effort at controlling alcohol-impaired driving began, even those states that based their laws on the BACs of drivers merely specified BACs at which it was "presumed" that a person was intoxicated. The presumption could be rebutted by other evidence. The presumptive levels generally were set at .15 BAC, although a few states had BAC levels of .12 or .10. Beginning in the 1970s, the U.S. Department of Transportation (DOT) used its authority under the Highway Safety Act of 1966 to encourage all states to adopt .10 BAC as the level for intoxicated or impaired driving. DOT also urged the states to enact laws that made it a violation per se to drive with a BAC of .10 or higher. From the outset of the movement to adopt .10 BAC as the national standard, there were advocates for even lower BAC levels. By 1983, this sentiment had resulted in the enactment of .08 BAC per se laws in Oregon and Utah. A strong grassroots movement started in the early 1980s that has had a significant effect on state laws, including .08 BAC laws. The most visible organization in this movement was Mothers Against Drunk Driving (MADD), founded in the United States in 1980 by a mother whose 13-year-old daughter had been killed by a hit-and-run driver with a long record of alcohol offenses. In 1986, DOT took its first formal step toward advocating a lower illegal limit by including a .08 BAC law as one of the regulatory criteria for a supplemental alcohol traffic-safety grant under the program authorized by the U.S. Congress (23 U.S.C. 408).

In 1988, NHTSA released a review of the scientific literature on the impairment of driving-related skills at low BACs, based on laboratory testing of dosed subjects (Moskowitz & Robinson, 1988). This report documented that impairment of driving-related skills starts at very low BACs. Additional states began to consider .08 BAC levels, and three more states adopted the new level: Maine in 1988, California in 1990, and Vermont in 1991. California's 1990 legislation lowered the state's per se limit from .10 to .08 BAC and established an ALR law a short time later. In 1991, NHTSA conducted a study of the effects of these new laws in California and found that the lower BAC level and the new ALR law in combination resulted in a 12% decrease in alcohol-related fatalities (REA, 1991).

Between 1992 and 1998, 10 additional states adopted .08 BAC per se laws: Kansas and North Carolina (1993); Florida, New Hampshire, New Mexico, and Virginia (1994); Alabama and Hawaii (1995); and Idaho and Illinois (1997). The movement toward a national standard for .08 BAC received renewed attention in the 105th Congress. On June 15, 2000, the Senate passed H.R. 4475 (the DOT Appropriations Bill for FY 2001) that included a general provision sponsored by Senator Lautenberg from New Jersey encouraging states to adopt .08 BAC laws by withholding a portion of a state's federal highway funds, beginning in FY 2004, for states that do not adopt .08. The final .08 BAC bill (Section 351) was adopted by Congress and signed by the President shortly after that.

3.1. Studies of the effectiveness of .08 BAC Laws

The following four early studies of the impact of lowering the BAC limit to .08 were conducted before 1999:

- A NHTSA study of the California .08 BAC law (REA, 1991).
- A NHTSA staff study of California, Maine, Oregon, Utah, and Vermont, five of the first states to enact .08 BAC laws (Johnson & Fell, 1995).
- A California Department of Motor Vehicles study of its .08 BAC and ALR laws (Rogers, 1995).
- A Boston University study of the five early states to enact .08 BAC laws (Hingson, Heeren, & Winter, 1996).

These studies controlled for many extraneous factors and provided initial evidence of the benefit of .08 BAC laws on alcohol-related crashes. One factor that was confounded in these studies was the possible interaction of .08 BAC and ALR laws enacted in close temporal proximity in some states. However, these studies provided credible evidence of the impact of the .08 law, particularly in combination with the ALR law. NHTSA recognized the need for more replications on which to base conclusions. It recognized that in the two California studies, it was difficult to isolate the effects of the .08 BAC and ALR laws, which were implemented within 6 months of each other.

In the Johnson and Fell (1995) study, it is noteworthy that of the 30 different measures used to determine effectiveness of the .08 BAC law in five states (6 measures in each state), 26 of the measures showed decreases, with 10 of the decreases showing statistical significance. Sixteen of the 20 changes in the measures that were not statistically significant were decreases. Thus, this early study showed *directional* changes that were indicative of .08 BAC having an effect. This finding was very similar to findings of the effects of ALR (Klein, 1989; Zador, Lund, Field, & Weinberg, 1988) and minimum legal drinking age of 21 in the United States (DuMouchel, Williams, & Zador, 1987).

Three additional studies of the effects of lowering the limit to .08 BAC were sponsored and released by NHTSA in early 1999:

- A study of North Carolina's .08 BAC law (Foss et al., 1999)
- A study of 11 states with .08 BAC laws (Apsler et al., 1999)
- A 50-state study of three important impaired-driving laws —ALR, .08 BAC, and zero tolerance for youth (Voas & Tippetts, 1999; see also Voas et al., 2000).

The results of these studies of the .08 BAC laws' effects provided additional evidence to support the effectiveness of .08 BAC laws. The 50-state study showed a significant (8%) reduction in the involvement of low-and high-BAC drivers in fatal crashes. The 11-state study found that .08 BAC laws were associated with reductions in alcohol-related fatalities in 7 of the 11 states studied, either alone or in conjunction with ALR laws. Also in this study, 32 of 39 outcomes directionally supported a conclusion that .08 BAC laws, when added to existing laws and programs, are associated with reductions in alcohol-related traffic fatalities. The North Carolina study found no clear effect of its .08 BAC law. However, several of the study's outcomes were directionally consistent with suggesting that the law had an effect greater than the decline in alcohol-related fatalities that began before .08 BAC was enacted.

Hingson et al. (2000) analyzed the effectiveness of .08 BAC laws in six states enacting .08 laws in 1993 and 1994. They found an overall 6% reduction in alcohol-related deaths in these six states and estimated that 400 to 500 additional lives could be saved each year if every state had had a .08 BAC law. This study took into account many of the criticisms of previous studies by the same authors. Two other studies of the effectiveness of lowering the illegal BAC limit to .08 appeared in the literature about the same time (Dee, 2001; Eisenberg, 2001). Dee used somewhat novel, panel-based evaluations of .08 laws, which in many respects addressed methodological limitations of previous studies. Fourteen states that adopted .08 BAC laws between 1982 and 1998 were analyzed and compared to the rest of the states that did not adopt .08 laws using traffic fatality rates as the key measure. Alaska, Hawaii, and the District of Columbia were excluded from the analyses. The regression analyses controlled for the potential effects of .10 BAC laws, ALR laws, dram shop laws, mandatory jail time for first DUI offenses, zero tolerance laws for youth, mandatory seat belt laws (primary and secondary enforcement, separately), raising the speed limit on interstate highways to 65 and 70 miles per hour (mph), vehicle miles traveled in the state, state unemployment rate, and state personal income per capita. A statistically significant reduction of 7.2% in traffic fatality rates was associated with the adoption of .08 BAC laws. Dee estimated that 1,200 lives could be saved annually if the additional 23 states with ALR laws also adopted .08 BAC laws.

Eisenberg (2001) conducted a baseline analysis of the effects of .08 laws similar to that of Dee (2001), but with the addition of controls for graduated driver licensing (GDL) laws and the presence of MADD in the state. Eisenberg's analysis showed that the .08 BAC limit is associated with a 5% reduction from the mean traffic fatality rate and that .10 BAC limit laws are associated with a 2.4% reduction. This estimate suggests that lowering the limit from .10 BAC to .08 BAC would garner a further reduction of 2.6% from the mean total fatal crash rate. This is a statistically significant reduction ($p < .05$).

The two latest studies of the effectiveness of .08 BAC laws were discussed in the first section (Bernat et al., 2004; Tippetts et al., 2005).

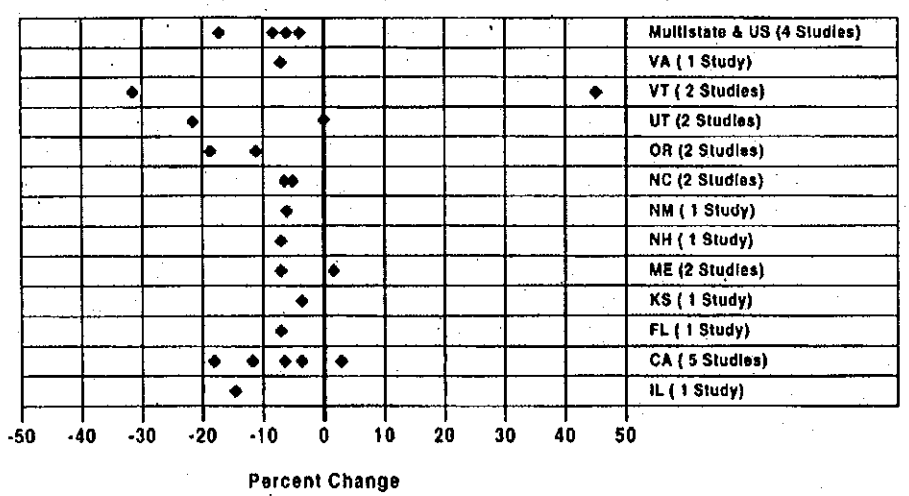

Fig. 1. Percentage of change in alcohol-involved motor vehicle fatalities following enactment of .08 laws.

3.2. Studies of impairment and crash risk at .08 BAC

A 1988 review of 177 studies clearly documented significant impairment at .08 BAC (Moskowitz & Robinson, 1988), and a 2000 review of 112 more recent studies provided even stronger evidence of impairment at .08 BAC (Moskowitz & Fiorentino, 2000). Together, these two reviews have summarized the findings of nearly 300 studies of impairment at low-BAC levels, and the findings are remarkably consistent. A comprehensive laboratory study examined driving skills among 168 subjects of both sexes and various ages and drinking histories. This study not only confirmed significant impairment in all measures of performance at a .08 BAC, but also found that impairment was present in relatively consistent levels across all age groups, sexes, and drinker types (Moskowitz et al., 2000). An epidemiological study, which compared data from a national roadside survey with data from all drivers involved in fatal crashes over a 2-year period, showed that the risk of being killed in a single-vehicle fatal crash at .08 BAC is 11 to 52 times greater than at .00 BAC. That same study indicated that the risk of dying in a single-vehicle crash at .05 BAC was 4 to 17 times that of drivers at .00 BAC (Zador et al., 2000).

3.3. Summary of .08 BAC laws

Fig. 1 (an update of Shults et al., 2001, Fig. 2) summarizes the effectiveness of .08 laws in graphic form. It shows a consistency and direction in the change in alcohol-related traffic fatalities that has occurred after .08 laws were adopted in the various states.

Table 1 summarizes all of the studies of the effectiveness of .08 BAC laws in the United States.

4. A summary of the evidence for lowering the BAC limit to .05 or less

4.1. Effectiveness of .05 BAC laws

Several countries have conducted evaluations of lowering their illegal BAC limits to .05 or less. A long-term study of the .05 BAC law in the Netherlands (adopted in 1974) concluded that it contributed to a sustained decline in the

Table 1
Studies of the effects of lowering the illegal BAC limit from .10 to .08 in the United States

Study	Results
Research and Evaluation Associates (1991) "The Effects Following the Implementation of an 0.08 BAC Limit and an Administrative Per Se Law in California."	12% reduction in alcohol-related traffic fatalities associated with the .08 and ALR laws.
Johnson and Fell (1995) "The Impact of Lowering the Illegal BAC Limit to .08 in Five States in the U.S."	Significant reductions in alcohol-related fatal crashes in 4 of 5 states ranging from 4 to 40%.
Rogers (1995) "The General Deterrent Impact of California's 0.08% BAC Limit and Administrative Per Se License Suspension Laws."	7% reduction in nighttime fatal and serious injury crashes. No significant decrease in alcohol-related fatal crashes.
Hingson et al. (1996) "Lowering State Legal Blood Alcohol Limits to 0.08 Percent: The Effect on Fatal Motor Vehicle Crashes."	16 to 18% reduction in proportion of fatal crashes involving fatally injured drivers with BACs ≥ .08 and BACs ≥ .15.
Apsler et al. (1999) "The Effects of .08 BAC Laws."	The .08 BAC law is associated with significant reductions in alcohol-related fatal crashes, alone or in conjunction with ALR, in 7 of 11 states.
Foss et al. (1999) "Evaluation of the Effects of North Carolina's 0.08% BAC Law."	No clear effect of .08 BAC law on already declining alcohol-related fatalities.
Voas et al. (2000) "The Relationship of Alcohol Safety Laws to Drinking Drivers in Fatal Crashes."	The .08 BAC laws are associated with 8% reduction in fatal crashes involving drinking drivers. If all states adopt a .08 BAC, an estimated 590 lives could be saved each year.
Hingson et al. (2000) "Effects of Recent 0.08% Legal Blood Alcohol Limits on Fatal Crash Involvement."	6% reduction in alcohol-related fatal crashes associated with .08 BAC laws in six states. If all states adopt .08 BAC, an estimated 400 to 500 lives could be saved each year.
Voas, Taylor, Kelley Baker, & Tippetts (2000) "Effectiveness of the Illinois .08 BAC Law." Also see Voas, Tippetts and Taylor (2001) "Effectiveness of the Illinois .08 Law: An Update with the 1999 FARS Data."	The .08 law reduced the number of drinking drivers in fatal crashes by 13.7% in first 12 months. Follow-up study confirmed 13.7% reduction over 30 months after .08 law adopted in 1997.
Shults et al. (2001) "Reviews of Evidence Regarding Interventions to Reduce Alcohol-Impaired Driving."	Median 7% reduction in measures of alcohol-related fatal crashes associated with .08 BAC laws. CDC strongly recommends all states adopt .08 BAC laws.
Dee (2001) "Does Setting Limits Save Lives? The Case of 0.08 BAC Laws."	Statistically significant 7.2% reduction in the traffic fatality rate associated with the adoption of .08 laws in 14 states.
Eisenberg (2001) "Evaluating the Effectiveness of a 0.08% BAC Limit and Other Policies Related to Drunk Driving."	Statistically significant reduction of 2.6% in the fatal crash rate associated with .08 BAC laws in 14 states.
Bernat et al. (2004) "Effects of Lowering the Legal BAC to 0.08 on Single-Vehicle-Nighttime Fatal Traffic Crashes in 19 Jurisdictions."	Statistically significant reduction of 5.2% in SVN fatal crashes associated with .08 law across all states.
Tippetts et al. (2005) "A Meta-Analysis of .08 BAC Laws in 19 Jurisdictions in the United States."	Statistically significant decline of 14.8% in the rate of drinking drivers in fatal crashes after the .08 laws were adopted in the 19 jurisdictions.

total number of drinking drivers involved in crashes (Noordzij, 1994). Another study from France evaluated the impact of lowering its BAC limit from .08 to .05 in 1996. Annual alcohol-related crash fatalities fell from approximately 100 before the legal change to 64 in 1997 in the province of Haute-Savoie, where the study was conducted (Mercier-Guyon, 1998).

In 1988, the illegal BAC limit was lowered from .08 to .05 in Austria. A study of the law found that there was an overall 9.4% decrease in alcohol-related crashes relative to the total number of crashes (Bartl & Esberger, 2000). However, they noted that intense media and enforcement campaigns also occurred around the time that the limit was lowered, making it nearly impossible to attribute the reductions to any one of these factors, at least in the short term. Bartl and Esberger concluded that "lowering the [il] legal BAC limit from .08% to .05% in combination with intensive police enforcement and reporting in the media leads to a positive short-term effect." This provided support for the view that a .05 BAC illegal limit, as part of a comprehensive approach to fighting impaired driving, can have beneficial effects.

Henstridge, Homel, and Mackay (1995) conducted a rigorous time-series analysis of random breath testing (RBT) and .05 BAC laws in Australia, controlling for many factors including seasonal effects, weather, economic trends, road use, alcohol consumption, and day of the week. Although the primary focus of the Australian study was the impact of RBT, the findings on the effect of .05 BAC laws were also significant. The study statistically accounted for the effect of other alcohol countermeasures to determine the specific values of the declines that were attributable directly to either RBT or the lower .05 BAC limit. The study analyzed traffic data for periods ranging from 13 to 17 years and found that those Australian states lowering their BAC limits from .08 to .05 experienced meaningful declines in alcohol-related crash measures. After Queensland, Australia, reduced their per se BAC limit to .05 in 1982, they experienced an 18% reduction in fatal collisions and a 14% reduction in serious collisions. These results were not confounded by the effects of RBT, as it was not introduced until 8 years later. Similarly, the .05 BAC limit in New South Wales was estimated to have reduced serious collisions by 7%, fatal collisions by 8%, and SVN collisions by 11%. This translated into the averting of an estimated 605 serious, 75 fatal, and 296 SVN collisions per year. Although the .05 BAC limit was introduced only 2 years before RBT in New South Wales, the authors accounted for this in their analyses and attempted to determine the crash reductions specifically attributable to each of the interventions.

Smith (1988) evaluated the effects of lowering the BAC limit in Queensland from .08 to .05 BAC. The proxy measure of changes in nighttime crashes as compared to daytime crashes was used. There was a significant 8.2% reduction in nighttime serious injury crashes (requiring hospitalization) and a 5.5% reduction in nighttime property damage crashes associated with the .05 BAC limit in the first year. Smith partially attributes some of the crash reductions in the second and third years after the adoption of .05 BAC to increased enforcement. When lowering the illegal BAC limit stimulates increased enforcement, it should be considered a benefit of the law, not a drawback, as concluded by Smith.

In South Australia, the illegal BAC limit was not lowered to .05 until 1991. Kloeden and McLean (1994) reported that the number of nighttime drivers who had been drinking was reduced by 14.1% following adoption of the law. A second study of South Australia found that the .05 BAC limit did not significantly affect the number of fatally injured drivers who were legally impaired (McLean, Kloeden, McColl, & Laslett, 1995). However, it did find that the proportion of impaired drivers at BACs of .15 or greater declined from 1991 to 1993. This last finding supports other Australian research indicating that the lower BAC limit has a substantial effect on drivers with BACs higher than .15 (Brooks & Zaal, 1992). It has been estimated that drivers with BACs higher than .15 are 244 times more likely to be involved in a fatal crash than drivers with zero BACs (Simpson, Mayhew, & Beirness, 1996). The recent study by Zador et al. (2000) found that male drivers aged 21 to 34 with BACs of .15 or higher are 573 times more likely to be killed in a single-vehicle crash than sober drivers of the same age. Thus, even though a .05 BAC limit would appear to be aimed at drivers with moderate BACs, its potential effect on the behavior of high-BAC drivers has important traffic safety implications.

Sweden's more recent lowering of its limit to .02 BAC also showed positive results. Although Sweden adopted a .05 BAC limit in the 1950s, the move to an even lower limit in 1990 further improved traffic safety. Norström and Laurell (1997) reported that in the 6 years following the introduction of the .02 BAC limit, there was a 9.7% reduction in fatal crashes, an 11% reduction in single-vehicle crashes, and a 7.5% reduction in all crashes. Norström and Laurell noted that the most significant effects occurred in fatal and single-vehicle crashes, the two categories in which alcohol is most likely to be involved. This suggests that crash reductions cannot be attributed solely to existing trends but were caused, in part, by the lower BAC limit. These results were supported by another study that estimated that the .02 BAC limit resulted in an approximate 10% decrease in fatal crashes and a 12% decrease in severe personal injury crashes (Borschos, 2000).

Table 2 summarizes the research on lowering the BAC limit to .05.

4.2. Impairment and crash risk at .05 BAC

Howat, Sleet, and Smith (1991) conducted a review of the literature from experimental and laboratory research on the impairment effects at .05 BAC. Many of the studies reviewed

Table 2
Studies of the effects of lowering the illegal BAC limit to .05

Study	Results
Noordzij (1994) "Decline in Drinking and Driving in the Netherlands."	Percentage of drivers with BACs>.05 from roadside surveys decreased from more than 15% in the years before the .05 limit to 2% in the first year and then leveled off at 12% for 10 years after the law change.
Mercier-Guyon (1998) "Lowering the BAC Limit to 0.05: Results of the French Experience."	Alcohol-related traffic crash fatalities decreased from 100 before the limit was lowered to 64 in 1997 right after the law change in the French Province where the study was conducted.
Bartl and Esberger (2000) "Effects of Lowering the Legal BAC Limit in Austria."	Found 9.4% decrease in alcohol-related crashes. "Lowering the legal BAC-limit from .08% to .05% in combination with intense police enforcement and reporting in the media leads to a positive short-term effect."
Henstridge et al. (1995) "The Long-Term Effects of Random Breath Testing in Adelaide."	Queensland experienced an 18% reduction in fatal crashes and a 14% reduction in serious crashes associated with lowering the BAC limit to .05. These results were not confounded with the effects of random breath testing. New South Wales showed an 8% reduction in fatal cases, a 7% reduction in serious crashes, and an 11% reduction in SVN crashes associated with lowering the BAC limit to .05.
Smith (1988) "Effect on Traffic Safety of Introducing a 0.05% Blood Alcohol Level in Queensland, Australia."	Significant 8.2% reduction in nighttime serious injury crashes and a 5.5% reduction in nighttime property damage crashes associated with lowering the limit from .08 to .05. Partly the result of increased enforcement.

showed statistically significant decrements in driving performance at a BAC of .05 or lower. The authors concluded that young and inexperienced drinkers appear to be at the greatest risk at .05 BAC. They recommended that setting a uniform .05 BAC statutory limit should be one measure in a comprehensive approach to reducing impaired driving including other legal, social, behavioral, and environmental strategies to deal with the problem.

Moskowitz and Fiorentino (2000) reviewed 112 scientific articles regarding the effects of alcohol on driving-related skills published between 1981 and 1997. They concluded that, by the time subjects reach .05 BAC, the majority of experimental studies examined reported significant impairment. After testing 168 drivers, Moskowitz et al. (2000) concluded that the majority of the driving population is impaired in at least some important measures at BACs as low as .02 BAC.

Two recent epidemiological studies (Compton et al., 2002; Zador et al., 2000) of the relative risk of being involved in a crash at various positive BAC levels indicate that the risk of crashing is substantially higher at .05 BAC compared to drivers at .00 BAC. Zador et al. (2000) estimated that the risk of being involved in a fatal crash for drivers at BACs as low as .02–.04 is anywhere from two times to five times higher than for drivers with BACs=.00, depending upon age and gender. That same study concluded that the risk of being killed as a driver in a single-vehicle crash is 6 to 17 times greater for drivers at BACs between .05 and .07 compared to drivers with BACs of .00, and that the risk of just being involved as a driver in a fatal crash is 4 to 10 times greater at BACs between .05 and .07 than drivers with BACs=.00. As mentioned earlier, Compton et al. (2002) concluded that the risk of being involved in any crash for drivers with BACs at .04 or higher was significant. Further, drivers with a BAC of .05 have a 38% higher risk of crashing than drivers with BACs=.00. At .06 BAC, that risk is 63% higher, and at .07 BAC, the risk is 109% higher than for drivers with BACs=.00.

5. A summary of the evidence for lowering BAC limits for youth

The United States has taken the lead in adopting lower BAC limits for underage youth. In 1984, the U.S. Congress adopted measures to sanction states that did not adopt 21 as their minimum legal drinking age. By 1988, all states had enacted such laws. Because it was illegal for those younger than 21 to drink any alcohol, it seemed logical that underage drivers should have no alcohol in their systems when they drove. In 1995, the U.S. Congress passed a law requiring states to adopt so-called zero tolerance laws for drivers younger than 21. By 1998, all states had passed laws making it illegal for any driver younger than 21 to have a positive BAC. In some states, any BAC at .02 or greater is illegal for youth; in other states, the level is set at .01 BAC or greater; in the remaining states, any BAC higher than .00 is considered illegal for drivers younger than 21. These zero tolerance laws for youth lowered the illegal BAC limits for that population and have proven to be effective in reducing the number of fatal crashes involving underage drinking drivers.

A recent study of zero tolerance laws in Florida, Maine, Oregon, and Texas was conducted by Lacey, Jones, and Wiliszowski (2000) under a NHTSA contract. Nighttime single-vehicle crashes were reduced by as much as 36% in Maine and 40% in Oregon, as little as 5% in Florida, and not at all in Texas for drivers subject to the new zero tolerance laws. Maine and Oregon, which had more experience with the law and had higher levels of enforcement and publicity, had the higher levels of effectiveness, as would be expected.

The Maryland .02 BAC law for drivers younger than 21 was evaluated by Dunlap and Associates, Inc., under a NHTSA contract with the primary objective of determining the effects of the law. The law went into effect on January 1, 1989. The number of drivers younger than 21 who were involved in crashes and "had been drinking" was collected from 1985 through 1990. An 11% decrease was found comparing the before-and-after crash data associated with

the zero tolerance law. Further, this 11% reduction was in addition to a general reduction in alcohol-involved crashes and a reduction in all crashes (alcohol and nonalcohol) involving drivers younger than 21 (Blomberg, 1992).

Hingson, Howland, Heeren, and Winter (1992) compared four states that passed zero tolerance laws before 1989 (Maine, New Mexico, North Carolina, and Wisconsin) with four nearby states that had no such law (Massachusetts, Arizona, Virginia, and Minnesota). Equal numbers of pre- and post-law years were examined in each of the four pairs of states monitoring nighttime fatal crashes involving teenage drivers in the age groups targeted by the law. Study states set different ages for the BAC law: New Mexico and North Carolina, younger than 18; Wisconsin, younger than 19; and Maine, younger than 20. As a group, the states that lowered their BAC levels for youth had significantly greater post-law reductions in nighttime fatal crashes among adolescents relative to adults (34% teens vs. 7% adults) than the comparison states (26% teens vs. 9% adults).

In a follow-up study, Hingson, Heeren, and Winter (1994) compared 12 states (North Carolina, Wisconsin, Oregon, Arizona, Maine, Maryland, Ohio, Vermont, New Mexico, California, Rhode Island, and Georgia) that lowered illegal BACs for youth before 1991 with 12 comparison states (Virginia, Minnesota, Washington, Utah, Massachusetts, Pennsylvania, Indiana, New Hampshire, Colorado, Texas, Connecticut, and Alabama). During the post-law period, the proportion of fatal crashes that involved single vehicles at night declined 16% among young drivers targeted by those laws, while it rose 1% among drivers the same age in comparison states where BAC limits were not changed. Adult crashes declined only 5% and 6% in the two groups during the post-law period. The study found that significant declines in the proportion of nighttime single-vehicle crashes among young drivers occurred only in states that lowered the underage BAC limit to .02 or lower. In other states that reduced the young driver BAC limit to .04, .05, or .06, there was no significant difference from states that did not lower the limit at all. (Note: All states have subsequently lowered their limits to .02 or lower.) The decline was only noticed for states that dropped the BAC level to .00 or .02, true zero tolerance laws rather than the mixed-message laws for youth.

Zwerling and Jones (1999) conducted a systematic review of zero tolerance laws and their effect on alcohol-related injuries and fatalities. Six studies met their strict selection criteria. All six studies showed reductions in injuries and fatalities associated with the implementation of zero tolerance laws, and in three studies, the reductions were statistically significant. The greatest reduction (22%) was reported in one study for SVN fatal crashes involving underage drivers in those states adopting zero tolerance laws. Despite some methodological difficulties cited by the authors, the six studies presented "accumulating evidence in support of the effectiveness of these laws." The total evidence is strengthened even more because similar results were found in different countries (Australia and the United States) using different methods and different outcome measures.

Voas, Tippetts, and Fell (2003) used data on all drivers younger than 21 involved in fatal crashes in the United States from 1982 through 1997. Quarterly ratios of BAC-positive to BAC-negative drivers in each of the 50 states were analyzed in a pooled cross-sectional time-series approach. After accounting for differences among the 50 states in various background factors, changes in economic and demographic factors within states over time, and the effects of other related laws, results indicated a significant 24.4% reduction in alcohol-positive drivers younger than 21 who were involved in fatal crashes associated with the zero tolerance laws. The policy in the United States of making it illegal for underage drivers to have any alcohol in their systems appears to have been effective in reducing the proportion of fatal crashes involving youthful drinking drivers.

Before the adoption of zero tolerance laws, young drivers were under the same BAC limit standards as adults. Adopting zero tolerance laws is the same as lowering the

Table 3
Studies of the effectiveness of lowering the BAC limit for youth

Study	Results
Blomberg (1992) "Lower BAC Limits for Youth: Evaluation of the Maryland .02 Law."	A significant 11% decrease in police-reported alcohol crashes involving drivers younger than 21 associated with the .02 law. Decrease was 50% in six communities that highly publicized the law and the enforcement of it.
Hingson et al. (1992) "Reduced BAC Limits for Young People (Impact on Night Fatal Crashes)."	As a group, states that lowered BAC limits for youth had significantly greater postlaw reductions in nighttime fatal crashes among drivers younger than 21 relative to drivers older than 21 (34% for teens; 7% for adults) than the comparison states that did not lower the limit (26% for teens; 9% for adults).
Hingson et al. (1994) "Lower Legal Blood Alcohol Limits for Young Drivers."	SVN fatal crashes declined 16% in 12 states that lowered the limit for youth while it rose 1% in 12 comparison states that did not lower the limit for youth. Adult nighttime fatal crashes declined 5% and 6%, respectively, in the two groups.
Zwerling and Jones (1999) "Evaluation of the Effectiveness of Low BAC Laws for Younger Drivers."	Systematic review of the effects of zero tolerance laws indicate that all six studies showed significant reductions in injuries or fatalities associated with the implementation of lower BAC limits for youths younger than 21.
Voas et al. (2003) "Assessing the Effectiveness of Minimum Legal Drinking Age and Zero Tolerance Laws in the U.S."	Lower limits for youth have resulted in an average 24.4% reduction in alcohol-positive drivers younger than 21 involved in fatal crashes since their implementation in the United States.

BAC limit from .10 (or .08) to .02 for drivers younger than 21. Young drivers perceive this change the same way that adults perceive lowering the limit to .08 BAC—that the state is getting tougher on impaired driving.

Table 3 summarizes the research on lowering the BAC limit for youth.

6. Public support for lower BAC limits

Surveys in the United States indicate that most people believe they should not drive after two or three drinks (Royal, 2000). This is equivalent to a BAC of .05 for many people (NHTSA, 1994). Considering this reported attitude, the public favors a BAC limit of .05. The countries that have already adopted .05 BAC as their limit do not report any public outcry that the limit is too strict.

7. Conclusion

Mann, Macdonald, Stoduto, Bondy, and Shaikh (1998) reviewed all of the available scientific evidence in assessing the potential impact of lowering the BAC limit to .05. They assessed research on the effects of alcohol on driving performance; epidemiological research on the risk of collision involvement at various BACs; research on the impact of lowering the BAC limit in other countries and jurisdictions; and other possible issues such as public acceptance, police discretion, and judicial outcomes. This review concluded that the adoption of a .05 BAC could potentially reduce the motor- vehicle crash fatalities by 6% to 18%.

Chamberlain and Solomon (2002) conducted an extensive review of all of the issues surrounding a .05 BAC limit. The review summarized the effects of low doses of alcohol on driving behavior, the relative risk of a crash at various BAC levels, and the experience in other countries with lowering BAC limits, and presented a compelling case for a .05 BAC limit.

The scientific evidence accumulated over the past 50 years indicates a direct relationship between rising BAC levels and the risk of being involved in a motor-vehicle crash and documents that driving performance begins to deteriorate significantly at .05 BAC (Moore and Gerstein, 1981; Transportation Research Board [TRB], 1987; U.S. Department of Health and Human Services [DHHS], 1987). Because alcohol has been shown to have a wide variation of effects from subject to subject, special attention needs to be given to the selection of a BAC level in which the vast majority of drinking drivers are likely to be affected. This level appears to be .05 BAC. When all of the international evidence on lowering BAC limits is assembled, reviewed, and summarized, we have concluded that lowering the illegal BAC limit to .05 is an effective strategy in reducing impaired driving.

In general, the literature reveals that lowering the BAC illegal limit reduces drinking driver fatal crashes, whether it is from .10 BAC to .08 BAC or from .08 BAC to .05 BAC for adults, or from some higher BAC level to .02 BAC (or lower) for youth. The public does not think people should drive after two or three drinks. This translates to .05 BAC for most people. Laboratory research shows that most people's critical driving skills are significantly impaired at .05 BAC. The World Health Organization (2004) recommends an upper limit of .05 BAC for the general driving population and .02 BAC for young drivers as the best practice at this time.

Acknowledgement

The authors would like to thank MADD Canada and, in particular, Andrew Murie, Executive Director, for supporting this critical review of the evidence for lower BAC limits.

References

Apsler, R., Char, A. R., Harding, W. M., & Klein, T. M. (1999, March). *The effects of .08 BAC laws (DOT HS 808 892).* Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration.

Bartl, G., & Esberger, R. (2000). Effects of lowering the legal BAC limit in Austria. In H. Laurell, & F. Schlyter (Eds.), *Proceedings of the 15th international conference on alcohol, drugs and traffic safety- T'2000; May 22–26, 2000* Stockholm, Sweden: International Council on Alcohol, Drugs and Traffic Safety (ICADTS).

Bernat, D. H., Dunsmuir, W. T. M., & Wagenaar, A. C. (2004). Effects of lowering the legal BAC to 0.08 on single-vehicle-nighttime fatal traffic crashes in 19 jurisdictions. *Accident Analysis and Prevention, 36,* 1089–1097.

Blomberg, R. (1992). *Lower BAC limits for youth: Evaluation of the Maryland .02 law (DOT HS 806 807).* Washington, DC: U.S. Department of Transportation.

Borschos, B. (2000). An evaluation of the Swedish drunken driving legislation implemented on February 1, 1994. In H. Laurell, & F. Schlyter (Eds.), *International conference on alcohol, drugs and traffic safety- T'2000; May 22–26, 2000.* Stockholm, Sweden: International Council on Alcohol, Drugs and Traffic Safety (ICADTS).

Brooks, C., & Zaal, D. (1992). *Effects of a 0.05 alcohol limit in the Australian capital territory.* Canberra, Australia: Federal Office of Road Safety MR 10.

Chamberlain, E., & Solomon, R. (2002). The case for a 0.05% criminal law blood-alcohol concentration limit for driving. *Injury Prevention, 8* (Suppl. III), iii1–iii17.

Compton, R. P., Blomberg, R. D., Moskowitz, H., Burns, M., Peck, R. C., & Fiorentino, D. (2002). Crash risk of alcohol impaired driving. In D. R. Mayhew, & C. Dussault (Eds.), *Proceedings of alcohol, drugs and traffic safety- T 2002: 16th international conference on alcohol, drugs and traffic safety, August 4–9, 2002, vol. 1* (pp. 39–44). Montreal, Canada: International Council on Alcohol, Drugs and Traffic Safety (ICADTS).

Dee, T. S. (2001). Does setting limits save lives? The case of 0.08 BAC laws. *Journal of Policy Analysis and Management, 20*(1), 111–128.

DuMouchel, W., Williams, A. F., & Zador, P. (1987). Raising the alcohol purchase age: Its effects on fatal motor vehicle crashes in 26 states. *Journal of Legal Studies, 16,* 249–266.

Eisenberg, D. (2001). *Evaluating the effectiveness of a 0.08% BAC limit and other policies related to drunk driving.* Stanford, CA: Stanford Institute for Economic Policy Research, Stanford University.

Foss, R. D., Stewart, J. R., & Reinfurt, D. W. (1999). *Evaluation of the effects of North Carolina's 0.08% BAC law (DOT HS 808 893).*

Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration.

Henstridge, J., Homel, R., & Mackay, P. (1995). The long-term effects of random breath testing in Adelaide. In C. N. Kloeden, & A. J. McLean (Eds.), *Proceedings of the 13th international conference on alcohol, drugs and traffic safety- T'95, Aug 13–18, 1995* Adelaide, Australia: International Council on Alcohol, Drugs and Traffic Safety (ICADTS).

Hingson, R., Heeren, T., & Winter, M. (1994). Lower legal blood alcohol limits for young drivers. *Public Health Reports, 109*(6), 739–744.

Hingson, R., Heeren, T., & Winter, M. (1996). Lowering state legal blood alcohol limits to 0.08 percent: The effect on fatal motor vehicle crashes. *American Journal of Public Health, 86*(9), 1297–1299.

Hingson, R., Heeren, T., & Winter, M. (2000). Effects of recent 0.08% legal blood alcohol limits on fatal crash involvement. *Injury Prevention, 6*(2), 109–114.

Hingson, R., Howland, J., Heeren, T., & Winter, M. (1992). Reduced BAC limits for young people (impact on night fatal) crashes. *Alcohol, Drugs and Driving, 7*(2), 117–127.

Holder, H., Flay, B., Howard, J., Boyd, G., Voas, R. B., & Grossman, M. (1999). Phases of alcohol problem prevention research. *Alcoholism, Clinical and Experimental Research, 23*(1), 183–194.

Howat, P., Sleet, D., & Smith, I. (1991). Alcohol and driving: Is the 0.05% blood alcohol concentration limit justified? *Drug and Alcohol Review, 10*, 151–166.

Johnson, D., & Fell, J. C. (1995). The impact of lowering the illegal BAC limit to .08 in five states in the U.S. *39th annual proceedings for the association for the advancement of automotive medicine, October 16–18, 1995* (pp. 45–64). Chicago, IL: Association for the Advancement of Automotive Medicine.

Klein, T. M. (1989). *Changes in alcohol-involved fatal crashes associated with tougher state alcohol legislation (DOT HS 807 511).* Washington, DC: National Highway Traffic Safety Administration.

Kloeden, C. N., & McLean, A. J. (1994). *Late night drink driving in Adelaide two years after the introduction of the .05 limit.* Adelaide, Australia: NHMRC Road Accident Research Unit.

Lacey, J. H., Jones, R. K., & Wiliszowski, C. H. (2000, June). *Zero tolerance laws for youth: Four states' experience (DOT HS 809 053).* Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration.

Mann, R. E., Macdonald, S., Stoduto, G., Bondy, S., & Shaikh, A. (1998). *Assessing the potential impact of lowering the legal blood alcohol limit to 50 mg% in Canada (TR 13321 E. Transport).* Ottawa, Canada: Transport Canada.

McLean, A. J., Kloeden, C. N., McColl, R. A., & Laslett, R. (1995). Reduction in the legal blood alcohol limit from 0.08 to 0 05: Effects on drink driving and alcohol-related crashes in Adelaide. In A. J. McLean, & C. N. Kloeden (Eds.), *Proceedings of the 13th international conference on alcohol, drugs and traffic safety-T:95.; August 13–18, 1995* Adelaide, Australia: NHMRC Road Accident Research Unit.

Mercier-Guyon, C. (1998). Lowering the BAC limit to 0.05: Results of the French experience. Paper presented at the Transportation Research Board 77th Annual Meeting, Jan 11–15, 1998 Washington, DC.

Moore, M. H., & Gerstein, D. R. (1981). *Alcohol and public policy: Beyond the shadow of prohibition.* Washington, DC: National Academy Press.

Moskowitz, H., Burns, M., Fiorentino, D., Smiley, A., & Zador, P. (2000, August). *Driver characteristics and impairment at various BACs (DOT HS 809 075).* Washington, DC: Southern California Research Institute, National Highway Traffic Safety Administration.

Moskowitz, H., & Fiorentino, D. (2000, April). *A review of the literature on the effects of low doses of alcohol on driving-related skills (DOT HS 809 028).* Washington, DC: Department of Transportation, National Highway Traffic Safety Administration.

Moskowitz, H., & Robinson, C. (1988). *Effects of low doses of alcohol on driving-related skills: A review of the evidence (DOT HS 807 280).* Washington, DC: National Highway Traffic Safety Administration.

National Highway Traffic Safety Administration [NHTSA]. (1994, October). *Computing a BAC estimate.* Washington, D.C: National Highway Traffic Safety Administration.

Noordzij, P. C. (1994). Decline in drinking and driving in the Netherlands. *Transportation Research Circular, 422*, 44–49.

Norström, T., & Laurell, H. (1997). Effects of lowering the legal BAC-limit in Sweden. In C. Mercier-Guyon (Ed.), *Proceedings of the14th international conference on alcohol, drugs and traffic safety- T'97; Sep 21–26, 1997* (pp. 87–94). Annecy, France: Centre d'Etudes et de Recherches en Médecine du Trafic.

Research and Evaluation Associates [REA]. (1991). *The effects following the implementation of an 0.08 BAC limit and an administrative per se law in California (DOT HS 807 777).* Washington, DC: National Highway Traffic Safety Administration.

Rogers, P. (1995). *The general deterrent impact of California's 0.08% blood alcohol concentration limit and administrative per se license suspension laws.* Sacramento, CA: California Department of Motor Vehicles.

Royal, D. (2000, December). *National survey of drinking and driving: Attitudes and behavior: 1999 (DOT HS 809 190 - Vol. I: Findings).* Washington, DC: National Highway Traffic Safety Administration.

Shults, R. A., et al. (2001). Reviews of evidence regarding interventions to reduce alcohol-impaired driving. *American Journal of Preventive Medicine, 21*(4 Suppl.), 66–88.

Simpson, H. M., Mayhew, D. R., & Beirness, D. J. (1996). *Dealing with the hard core drinking driver (107 pp.).* Ottawa, Canada: Traffic Injury Research Foundation.

Smith, D. I. (1988). Effect on traffic safety of introducing a 0.05% blood alcohol level in Queensland, Australia. *Medicine, Science and Law, 28* (2), 165–170.

Tippetts, A. S., Voas, R. B., Fell, J. C., & Nichols, J. L. (2005). A meta-analysis of .08 BAC laws in 19 jurisdictions in the United States. *Accident Analysis and Prevention, 37*, 149–161.

Transportation Research Board [TRB]. (1987). *Zero alcohol and other options. Limits for truck and bus drivers (Special Report 216).* Washington, DC: Transportation Research Board, National Research Council.

U.S. Department of Health and Human Services. (1987). *Handbook for evaluating drug and alcohol prevention programs: Staff/team evaluation of prevention programs.* Bethesda, MD: U.S. Department of Health and Human Services.

U.S. General Accounting Office. (1999, June). *Report to congressional committees on highway safety: Effectiveness of state .08 blood alcohol laws (GAO/RCED–99–179).* Washington, DC: Author.

Voas, R. B., Taylor, E., Kelley Baker, T., & Tippetts, A. S. (2000, December). *Effectiveness of the Illinois .08 law (DOT HS 809 186).* Washington, DC: Department of Transportation, National Highway Traffic Safety Administration.

Voas, R. B., & Tippetts, A. S. (1999, September). *The relationship of alcohol safety laws to drinking drivers in fatal crashes (DOT HS 808 980).* Washington, DC: Department of Transportation, National Highway Traffic Safety Administration.

Voas, R. B., Tippetts, A. S., & Fell, J. (2003). Assessing the effectiveness of minimum legal drinking age and zero tolerance laws in the United States. *Accident Analysis and Prevention, 35*(4), 579–587.

Voas, R. B., Tippetts, A. S., & Fell, J. C. (2000). The relationship of alcohol safety laws to drinking drivers in fatal crashes. *Accident Analysis and Prevention, 32*, 483–492.

Voas, R. B., Tippetts, A. S., & Taylor, E. (2001, December). *Effectiveness of the Illinois .08 law: An update with the 1999 FARS data (DOT HS 809 382).* Washington, DC: National Highway Traffic Safety Administration.

World Health Organization [WHO]. (2004). World report on road traffic injury prevention [Online]. World Health Organization. Retrieved October, 2004, from the World Wide Web: http://www.who.int/violence_injury_prevention.

Zador, P. L., Krawchuk, S. A., & Voas, R. B. (2000). Alcohol-related relative risk of driver fatalities and driver involvement in fatal crashes in relation

to driver age and gender: An update using 1996 data. *Journal of Studies on Alcohol, 61*(3), 387–395.

Zador, P. K., Lund, A. K., Field, M., & Weinberg, K. (1988). *Alcohol-impaired driving laws and fatal crash involvement.* Washington, DC: Insurance Institute for Highway Safety.

Zwerling, C., & Jones, M. P. (1999). Evaluation of the effectiveness of low blood alcohol concentration laws for younger drivers. *American Journal of Preventive Medicine, 16*(1 Suppl.), 76–80.

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