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# Estimation of the Potential Effectiveness of Lowering the Blood Alcohol Concentration (BAC) Limit for Driving from .08 to .05 grams per deciliter in the United States

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## Abstract

**Background—**In 2013, the National Transportation Safety Board (NTSB) issued a report recommending that states lower the illegal blood alcohol concentration (BAC) limit for driving from .08 to .05 grams per deciliter. The NTSB concluded that there is a strong evidence-based foundation for a BAC limit of .05 or lower. Most industrialized nations have already enacted a .05 illegal BAC limit. This study was undertaken to contribute to the scientific evidence as to whether lowering the BAC limit to .05 will be an effective alcohol policy in the United States.

**Methods—**We accomplished our objective by (a) conducting a meta-analysis of qualifying international studies to estimate the range and distribution of the most likely effect size from a reduction to .05 BAC or lower; (b) translating this synthesis toward estimating the effects of reducing the current .08 BAC limit to .05 in the U.S.; and (c) estimating the life-saving benefits of the proposed .03 reduction in the driving limit from .08 to .05 BAC.

**Results—**In our meta-analysis of studies on lowering the BAC limit in general, we found a 5.0% decline in non-fatal alcohol-related crashes, a 9.2% decline in fatal alcohol-related crashes from lowering the BAC to .08, and an 11.1% decline in fatal alcohol-related crashes from lowering the BAC to .05 or lower. We estimate that 1,790 lives would be saved each year if all states adopted a .05 BAC limit.

**Conclusions—**This study provides strong evidence of the relationship between lowering the BAC limit for driving and the general deterrent effect on alcohol-related crashes.

**Keywords**

effectiveness; BAC limit; .05 grams per deciliter; meta-analysis; lives saved

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## Introduction

In every state in the U.S., it is illegal per se (i.e., no other evidence needed) for adults to drive with a blood alcohol concentration (BAC) of .08 grams per deciliter (g/dL) or greater, for drivers younger than 21 years to drive with any positive alcohol concentration (BAC ≥ .02), and for commercial drivers (e.g., trucks, buses, taxis) to drive with a BAC of .04 g/dL or greater. An analysis by Tippetts et al. (2005) found a significant decline of 14.8% in the rate of drinking drivers in fatal crashes after .08 laws were introduced in 18 states and the District of Columbia. An earlier study by Voas et al. (2000) found an 8% reduction in drinking drivers in fatal crashes associated with lowering the BAC limit to .08. Numerous other studies have confirmed these findings (Bernat et al., 2004, Dee, 2001, Eisenberg, 2001, Hingson et al., 2000, Shults et al., 2001). The adoption of so-called zero tolerance laws for drivers under age 21 has also been shown to be effective (Blomberg, 1992, Hingson et al., 1994).

In 1986, when the U.S. Department of Transportation (DOT) took its first formal step toward advocating for the illegal BAC limit to be lowered from .10 to .08, only two states had enacted such laws: Oregon and Utah in 1983. That federal government's initiative involved a regulatory action specifying the enactment of a .08 law as a criterion for a supplemental alcohol traffic-safety grant under a program authorized by the U.S. Congress (23 U.S.C. 408). Consequently, additional states began to consider .08 BAC per se levels, and three more states adopted the new level: Maine in 1988, California in 1990, and Vermont in 1991. Between 1992 and 1998, 10 additional states in the U.S. adopted .08 BAC per se laws. The movement toward a national standard for .08 BAC received renewed attention in the 105th Congress. On June 15, 2000, the U.S. Senate passed H.R. 4475 (the DOT Appropriations Bill for FY 2001), which included a general provision encouraging states to adopt .08 BAC laws by withholding a portion of a state's federal highway construction funds, beginning in FY 2004, for states that did not adopt the .08 limit. Congress adopted the final .08 BAC bill (Section 351) in 2000, and the President signed the law shortly thereafter. This federal legislation technically expired on September 30, 2013, but has been renewed by Congress each year since then.

Since the federal .08 BAC legislation was passed, a number of evaluation studies have been conducted. For example, Wagenaar et al. (2007) found direct effects of lowering the BAC limits in 28 states and estimated that 360 deaths were prevented by the .08 BAC law and that an additional 538 lives could be saved if the United States lowered its BAC limit to .05 BAC. Gorman, Huber, and Carozza (2006) on the other hand could not find any significant effects on alcohol-related crashes or fatalities due to the .08 BAC law in Texas. It has been 12 years since the last state adopted a .08 BAC law (Minnesota in 2005) and 34 years since the first state adopted a .08 BAC law (Utah in 1983).

### Significance of this Study

Laws adopted in the United States to control and reduce alcohol-impaired driving vary considerably between states (National Highway Traffic Safety Administration [NHTSA], 2016b). These laws have been adopted over the past 100 years and form the legal structure that enables law enforcement to stop drivers on public roads (with reasonable suspicion) and arrest them for driving while intoxicated (DWI) (with probable cause). Criminal sanctions for a first-offense DWI conviction typically consist of at least a driver's license suspension or revocation period decided by the judge; a fine; some alcohol education or intervention; and either some time in jail, some period under house arrest, or some minimal hours of community service. Currently, 41 states and DC have Administrative License Revocation (ALR) laws, which provide that the license of a driver with a BAC at or over the illegal .08 g/dL BAC limit is subject to an immediate driver's license suspension by the state department of motor vehicles. ALR laws are the most widely applied example of a traffic law where the sanction rapidly follows the offense. The power of ALR laws has generally been attributed to how swiftly and how consistently the sanction is applied (Shults et al., 2001; Voas et al., 2000).

Between 1982 and 1997, the key modern impaired-driving laws were adopted by most of the 50 states and DC (Fell and Voas, 2006). As a result, there was a substantial decrease in the proportion of traffic fatalities involving alcohol-impaired drivers during that period. In 1982, 35% of drivers involved in fatal crashes had illegal BACs (>.08 g/dL). That dropped to 20% by 1997. Since 1997, however, progress has stalled and the percent of drivers with illegal BACs has remained at about 21% (Dang, 2008, Fell et al., 2009).

On May 14, 2013, the National Transportation Safety Board (NTSB), an independent federal agency dedicated to promoting transportation safety, issued a report recommending, among other measures, that states lower the illegal BAC limit for driving from .08 to .05 g/dL (NTSB, 2013). Most industrialized nations have already enacted a .05 illegal BAC limit (World Health Organization, 2013). However, there was a lack of enthusiastic support from some organizations, such as Mothers Against Drunk Driving, who questioned the potential benefit of a .05 BAC law. The National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation did not formally support the recommendation either. Officials at NHTSA have stated, however, that States are free to lower their illegal BAC limit to .05 or lower if they feel that is appropriate and NHTSA will evaluate the effects (Michael, 2014). The National Safety Council has recommended a .08 BAC limit but issued a policy statement that would recommend lowering that limit to .05 g/dL BAC or lower (http://www.nsc.org/DistractedDrivingDocuments/Low-BAC-policy.pdf). On the other hand, in 1997, the American Medical Association recommended that the limit for driving should be .05 BAC. This lack of full support raises the issue as to whether enactment of a law reducing the illegal BAC limit for driving to .05 will be an effective strategy in the United States. This study should contribute significantly to the scientific evidence, either way, as to whether lowering the BAC limit to .05 will be an effective alcohol policy.

## Current Research

Numerous independent studies in the United States indicate that lowering the illegal BAC limit from .10 (adopted by states in the 1960s and 1970s) to .08 (adopted by states between 1983 and 2005) has resulted in 5% to 16% reductions in alcohol-related crashes, fatalities, or injuries (Voas et al., 2000, Dee, 2001, Eisenberg, 2001, Hingson et al., 2000, Shults et al., 2001, Bernat et al., 2004). The illegal limit is .05 BAC in many countries around the world, and several international studies indicate that lowering the illegal per se limit from .08 to .05

BAC reduces alcohol-related fatalities (Brooks and Zaal, 1993, Homel, 1994, Bartl and Esberger, 2000). Laboratory studies indicate that impairment in critical driving functions begins at low BACs and that most subjects are significantly impaired at .05 BAC (Ferrara et al., 1994, Moskowitz et al., 2000, Martin et al., 2013). The relative risk of being involved in a fatal crash as a driver is 4 to 6 times greater for drivers with BACs between .05 and .07 compared to drivers with .00 BACs (Voas et al., 2012). The extant literature has shown the efficacy of lowering the BAC limit: (1) from .10 to .08, (2) from .08 to .05, (3) from .05 to .03 or .02, and (4) for youth to any measurable amount of alcohol (zero tolerance laws). These law changes apparently serve as a general deterrent to drinking and driving. A recent survey of a nationally representative sample of drivers aged 18 years and older in the U.S. indicated that 63.6% support lowering the per se BAC limit from .08 to .05 (Arnold and Teftt, 2016).

This study provides a foundation for considering a reduction in the BAC limit to .05 by conducting a meta-analysis of studies that examined the impact of lowering the illegal BAC limit to .05 in foreign countries in order to estimate the effect of lowering the BAC limit from .08 to .05 in the United States.

# Methods

## Objectives

The specific objective of our study was to *estimate the potential effectiveness of reducing the illegal BAC limit for driving from .08 to .05 g/dL in the United States*. We accomplished this objective by (a) conducting a meta-analysis of qualifying international studies to estimate the range and distribution of the most likely effect size from a reduction to a .05 BAC limit or lower; (b) translating this synthesis toward estimating the potential benefits in the U.S. of reducing the current BAC limit from .08 to .05; and (c) analyzing the life-saving benefits of the proposed .03 reduction in the illegal limit from .08 to .05 BAC. Since effects of BAC limits on alcohol consumption measures is important to the hospitality industry and, perhaps, the economy, we included alcohol consumption measures in our analyses.

## Study Description

Our study sought to examine the literature on the effects of lowering the BAC limit and the impact of doing so on adverse driving outcomes (i.e., drinking and driving, and fatal and non-fatal alcohol-related traffic crashes). Though all studies that examined the impact of changing BAC limits were considered, the current study is organized into two primary sections. The first deals with lowering the BAC limit to .08 (generally from .10), and the second deals with lowering the BAC to .05 or lower.

To achieve this goal, we conducted extensive literature reviews using a series of databases that provided access to scholarly published literature including E-Journals, MEDLINE, PsycArticles, PsycInfo, and PUBMED. Using keywords relevant to the current endeavor (i.e., BAC, fatal crashes, .08 BAC, .05 BAC, reduce BAC, etc.), these searches produced 421 articles (See Figure 1 for flow diagram). Of those articles, 320were found not to contain studies examining the change of BAC laws. Of the remaining articles, 80 did not provide sufficient data to allow for inclusion in the meta-analysis conducted in the current study. This list of articles was then refined to include only empirical articles examining outcomes of changing BAC laws and which presented data sufficient (i.e., effect sizes) for inclusion in the current study. This resulted in 21 total articles. These articles were then carefully reviewed and references examined for further articles which may not have been uncovered by the literature searches. Any additional articles uncovered were then reviewed and references examined in a similar fashion and so on. This was continued until only articles already included in the extant database were uncovered. For the current study, only empirical journal articles were considered. As conference findings are not peer-reviewed and validated, they were only included in the current study if they were later converted to an empirically reviewed journal article. Government reports, however, were included unless the report was later converted into a journal article. In those cases, only the journal article was included in the current study. In the end, this enhanced search yielded a total of 37 articles for use in the analysis.

## Study Design

For this first study, we collected 37 empirical articles. However, as each study examined the effects of BAC changes differently, it was necessary to first standardize studies for comparison across groups. To do this, we first calculated Hedges G ($d_G$) (Durlak, 2009; Hedges, 1981) for each study representing standardized differences (i.e., the change in adverse driving-related outcomes pre- and post-BAC change) using the formula below where X represents the population means/percentages, $S^2$ represents variance, $n$ represents group sample size, and N represents total sample size. Values with the subscript 1 indicate values prior to the treatment (i.e., BAC limit change) while the subscript 2 indicates values following introduction of the treatment.

$$d_G = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2 N - 2}}$$

As shown in the formula, Hedges G is a more useful representation of the difference than Cohen's d, as the denominator represents the pooled variance. For studies that present multiple findings (i.e., a percent change for each jurisdiction studied), the overall change statistic is used. Note that change values were always rounded to the nearest whole number.

## Dependent Measures

Each of the studies examined in the current endeavor provided data regarding the effect of lowering the BAC limit either from .08 to .05 g/dL, or to .03 or lower. Several studies varied in terms of what outcome they were looking at and how that outcome was specifically measured. In our review, we found that 25 studies used fatal alcohol-related crashes as the outcome measure. Of these, 14 examined the effects of reducing BAC limits from .10 to .08 g/dL, while 11 examined reducing BAC limits to .05 g/dL or below. Further, nine studies examined the impact of changing BAC laws primarily on non-fatal alcohol-related crashes, while six others simply examined whether drivers had been drinking either by self-report or biological measurement. As each of these outcomes is relevant to the current study, each outcome type (i.e., alcohol consumption, fatal and non-fatal crashes) were considered in the analysis.

### Analysis

To analyze the cross-study impact of lowering the BAC limit, we conducted a series of meta-analyses. Meta-analysis is a common statistical methodology used to synthesize research findings from conceptually similar studies with the goal of drawing out a common conclusion (Lipsey and Wilson, 2001). A particular strength of meta-analysis is the aggregation of data to improve statistical power and, hence, derive more meaningful conclusions. Using the aggregate of effect sizes also allows researchers to synthesize multiple studies and avoid pitfalls where studies with significant findings weigh more to the outcome than studies which report an effect size, but not one that meets statistically significant criteria. Further, a particular strength of meta-analytic techniques is that they allow for inclusion of multiple studies despite the findings of individual studies. That is, even in the event that a study failed to find a significant effect of a change in alcohol-related crashes or outcomes following lowering of BAC limits, it was still included in the final analysis of the current study.

## Results

Our current analysis identified six studies examining how reducing BAC limits impacts alcohol-related variables (Table 1 and Figure 2). Two of those studies demonstrated modest decreases in self-reported alcohol consumption (Campos et al., 2013) and the number of drinks consumed before feeling drunk (Kerr et al., 2006). The four other studies found that lowering the BAC limit had no significant effect on alcohol-related outcomes (Aspler et al., 1999, Bernhoft and Behrensdorff, 2003, Noordzij, 1994, Schwartz and Davaran, 2013). Interestingly, the three studies that found a negative relationship between law implementation and alcohol-related variables (two of which were significant) relied primarily on self-report in their methods; however, this finding was not supported in studies relying primarily on biological data collection. This may indicate a difference in drivers' thoughts versus their behaviors. That is, lowering the BAC limit may begin to influence drivers' thoughts toward drinking and driving (which would be reflected in their self-reported responses), but behavioral change in these cases may be slow to follow.

Table 2 and Figure 3 summarize nine studies that assessed the impact of lowering the illegal BAC limit to .08 or below and the impact on non-fatal alcohol-related crashes. With the exception of the study by Maisy (1984), all studies found a significant decrease in non-fatal alcohol-related crashes following the reduction in BAC limit. Of those studies, only the studies by Kaplan and Prato (2007) and Wagenaar et al. (2007) examined the impact of reducing the BAC limit to .08 from .10, while the remaining six studies examined the impact of lowering the BAC limit to .05 or further.

Interestingly, the study by Blomberg (1992) found the most significant effect of lowering BAC limits pre- and post-law implementation. This may be due in part to the nature of the study conducted. That is, the study examined the impact of lowering BAC levels to .02 among underage drivers, while the other studies tended to examine drivers who were 21 years and older. This may be relevant because underage drinking in the U.S. has decreased substantially since the minimum legal drinking age of 21 was established in 1984 (O'Malley and Wagenaar, 1991, Johnston et al., 2009, Fell et al., 2016).

Studies that examined the impact of implementing legislation reducing the BAC limit from .10 to .08 g/dL show considerable variation between studies with effect sizes ranging from no effect to an 18% reduction in fatal crashes (Table 3 and Figure 4). Interestingly, 5 of the 14 studies examined in the current research did not find a significant impact of reducing the BAC limit to .08. Though they do note a decrease in fatal alcohol-related crashes following law implementation, it was not found to be statistically significant. Two primary reasons are presented to explain this lack of significance. First, some studies suggest that it is the frequent simultaneous implementation of other alcohol-related legislation, such as ALR laws, that explained most of the variance in the United States (Research and Evaluation Associates (REA), 1991). That is, though lowering the BAC limit may help in the reduction of fatal crashes, its simultaneous implementation with other more effective legislation may have inflated its relevance in studies that did not control for this. Second, some studies suggested that the decrease in fatal crash rates can be better explained by the natural declining trend of fatal crashes around the world rather than the implementation of a law (Foss et al., 2001). This, however, is in contrast to the study by Nagata et al. (2008), which controlled for natural trends and still found a notable impact of legislation limiting BAC levels.

Table 4 and Figure 5 show a summary of research examining the impact of implementing legislation reducing the illegal BAC limit (a) from .08 to .05, (b) from .05 to .03, or (c) from .05 to .02. Of particular note is the Nagata et al. (2008) study, which found a 38% reduction effect on fatal crashes after legislation was implemented reducing the BAC limit to .03. Though clearly relevant to the current study, and hence retained for analysis, this study could represent an outlier. Despite this, however, the studies by Andreuccetti et al. (2011), Nagata et al. (2008), Norström (1997), and Smith (1986) showed a significant decrease in fatal alcohol-related crashes when the illegal BAC limit was lowered to below .05. The other studies that looked at reducing the BAC limit lower than .05 found no significant impact on fatal crash rates (Assum, 2010, Nakahara et al., 2013, Živković et al., 2013). Similarly, three of the four studies examining the impact of lowering the illegal BAC limit to .05 found significant decreases in alcohol-related fatal crashes after law implementation (Homel, 1994, Hingson et al., 1998, Henstridge et al., 1997) while one did not (McLean et al., 1995). Importantly, McLean et al. (1995) note that the change in the law for the Australian illegal BAC limit did indeed reduce the number of fatal alcohol-related crashes, but the effects were both relatively mild and short-lived. As time passed after law implementation, the benefits of the law dissipated.

Table 5 shows the results of the meta-analysis. Results are presented after weighting for sample sizes in each study and comparing percent reductions in outcomes. Results are drawn from change values for each study listed in Table 1 to 4. In the event that a study found no significant (NS) effect of the law change, the effect size reported in the study was still included in the overall estimated impact.

### Variables related to alcohol use

Though two of the six studies examining variables related to alcohol use (Table 5, Row 1) did indeed find a significant impact on alcohol use outcomes of lowering BAC laws, these studies had only a mild effect size. Further, though all studies in this group were indeed alcohol-related outcomes, the specific outcome measures varied notably between studies making comparisons difficult.

### Non-fatal alcohol-related crashes

Ideally, studies would be categorized by the extent to which the BAC limit was reduced (i.e., from .10 to .08, from .08 to .05, from .08 to .03, etc.) and a separate analysis conducted for each. Unfortunately, given the relative scarcity of the studies examining the effects of lowering BAC limits on non-fatal alcohol-related traffic crashes that was not feasible and all eight studies (Table 5, Row 2) were combined for a single analysis.

Seven of the eight studies examining the impact on non-fatal alcohol-related crashes demonstrated significant decreases in outcomes. The only study that did not report significant effect sizes (Maisy, 1984) did report decreases in non-fatal alcohol-related crashes, though not of sufficient power to demonstrate significance. When all change values were combined, standardized, and weighted in the meta-analysis, implementation of laws to reduce the illegal BAC limit resulted in a 5.0% decrease in rates of non-fatal alcohol-related crashes.

### Reduction of BAC limit from .10 to .08 g/dL on fatal alcohol-related crashes

Our research into the effects of lowering the illegal BAC limit from .10 to .08 g/dL on fatal alcohol-related crashes yielded 14 suitable studies (Table 5, Row 3). When all change values were combined, standardized, and weighted in the meta-analysis, implementation of laws to reduce the illegal BAC limit from .10 to .08 g/dL resulted in a 9.1% decrease in the rates of fatal alcohol-related crashes. Of note, though, 12 of these studies were conducted on jurisdictions in the United States, with one study examining rates in Canada (Asbridge et al., 2015). Interestingly, the study that found the greatest effect of lowering the BAC limit to .08 was the study conducted by Asbridge et al (2015) (−18%) in Canada. This may indicate that the differences in policies and/or cultures between the United States and Canada may have had an additional influence on the effectiveness of the law. As such, we repeated the analysis on the 12 studies conducted in the United States and found a slightly reduced—though still significant—effect on alcohol-related fatal crash rates (−8.4%).

### Reduction of BAC limit to .05 g/dL or lower on fatal alcohol-related crashes

Finally, we examined studies that examined the impact of lowering illegal BAC limit to .05 mg/dl or lower (Table 5, Row 4). Our review found 11 studies that fit our criteria. Four of these studies examined the impact of lowering the illegal BAC limit to .05 (Homel, 1994, McLean et al., 1995, Henstridge et al., 1997, Hingson et al., 1998), while the remaining studies examined the effects of lowering the BAC limit to .02 or .03 (usually from .05). Again, an argument can be made that these are two fundamentally different types of studies and should thereby be analyzed separately. Unfortunately, given the relative sparsity of research examining the impact of reducing the BAC limit to .05 or below, the studies were combined into a single analysis in the current study.

When all change values were combined, standardized, and weighted in the meta-analysis, implementation of laws to reduce the illegal BAC limit to .05 or lower resulted in an 11.1% decrease in the rates of fatal alcohol-related crashes. This rate included one study by Nagata et al. (2008), which as we mentioned briefly above, demonstrated an unusually high effect size. However, even if this study is removed from the analysis, the remaining 10 studies still demonstrate a significant 9.9% reduction in fatal alcohol-related crashes.

### Estimated lives that would be saved with 11.1% decrease in the drinking-driving fatal crash rate if the U.S. adopts a .05 g/dL BAC limit

Following conventions set forth by Fell and his colleagues (2016) and given the overall effect sizes of reducing the illegal BAC limit to .05 g/dL (11.1%), we estimated how many lives could be saved annually if all 51 jurisdictions in the United States lowered their BAC limit to .05. Though rates of fatal alcohol-related crashes have been steadily decreasing since 1983, for estimation purposes we took the average number of fatal alcohol-related crashes over the course of the study. From 1982 to 2014, there was an average of 14,339 fatal alcohol-related crashes recorded per year. However, as this number already includes the lives saved by the law, we adjust for the effect of the .08 law to obtain an accurate estimate of lives saved by implementing the .05 law. Once this is done, we calculated lives saved using the following equation:

$$X=\beta\left(\frac{N}{1-\beta}\right)$$

In this equation, X is the number of lives saved by implementing the .08 BAC law, $\beta$ represents the estimated effect size and, $N$ is the total number of fatal alcohol-related crashes recorded per year. Therefore, a law effect size of 11.1% would result in an estimated 1,790 lives saved annually across the United States. Of note, however, the estimates used in the current endeavor incorporate numerous studies conducted outside of the United States. This necessarily means that international cultural effects and deviations in drinking and/or driving compared to the United States may impact this finding.

## Discussion

In our meta-analysis of studies of lowering the BAC limit in general (e.g., from .10 to .08, from .08 to .05, or to .03, etc.), we found no effect on variables related to alcohol use from 5 studies (e.g., reported drinking and driving, attitudes toward drinking and driving, arrests for DWI, positive breath test results from drivers on the roads). This is important for socioeconomic reasons. Apparently, drivers drank alcohol at the same rate as before the BAC reduction, but somehow avoided driving impaired more often after the BAC change. Possible reasons for this include more use of alternative transportation (e.g., taxis, public transportation, ride-sharing, walking) and drinking beverages with a lower alcohol content. When we consider that three other studies did not find meaningful effects, it is not surprising that the overall effect for alcohol use measures is non-significant. This result may be due to the nature of the studies used in the analysis. For example, an important factor in reducing rates of alcohol consumption is enhancing public awareness of a law rather than the impact of the law itself (Hingson et al., 2000). As such, it is possible that if the desired effect is to decrease alcohol use and/or increase risk perceptions associated with alcohol, then increasing media exposure to adverse alcohol-related outcomes may prove more beneficial than creating new and/or more stringent legislation.

There was a 5.0% decline in non-fatal alcohol-related crashes (from 8 studies). While a modest decline, it was significant. There are an estimated 4 million alcohol-related crash injuries annually in the U.S. (Zaloshnja et al., 2013), so a 5.0% reduction would be substantial. We found a 9.2% decline in fatal alcohol-related crashes from lowering the BAC to .08 (from 14 studies), and an 11.1% decline in fatal alcohol-related crashes from lowering the BAC to .05 or lower (from 11 studies). These findings are consistent with individual state or multi-state studies in the past (Tippetts et al., 2005, Voas et al., 2000, Bernat et al., 2004, Dee, 2001). Based on this potential effectiveness, lowering the BAC limit to .05 in the United States should be considered by state and federal safety officials. We estimate that doing so would save 1,790 lives each year if all states adopted a .05 BAC limit. Note that lowering the BAC limit to .05 did not have a significant effect on reported or measured drinking variables, which should reduce concerns by many opponents in the hospitality industry.

This study provides strong evidence of the relationship between lowering the BAC limit for driving and the general deterrent effect on fatal (and non-fatal) alcohol-related crashes. While there are arguments against lowering the BAC limit to .05 g/dL (Fell and Voas, 2014), the life-saving potential seems to be worth any likely negative public or financial effects.

## Strengths and Limitations

When conducting a meta-analysis, researchers typically combine studies that are similar in most respects in terms of their outcome variables, settings, and/or populations of interest. In actuality, studies of this kind are rarely very similar and often possess notable differences, which may make comparisons difficult despite efforts to standardize and weight the results. The current analysis is not immune to the differences that exist between studies—primarily in cases where the research is carried out in various countries throughout the world as is the case for much of the .05 BAC research presented here. Comparisons of these studies—despite their numerous and noteworthy differences—was deemed as both necessary and prudent.

Further, ideally each of the studies would have been screened for the quality of study conducted – that is, whether comparison groups were used and/or which additional variables were controlled for. This may be particularly relevant as prior research has found that the presence of comparison groups has been shown to reduce the effect size of similar studies examining effects of traffic laws on crash rates (Erke, Goldenbeld, & Vaa, 2009). However, given the complexity of the research question and the relative scarcity of articles, we chose not to further restrict power for the analysis. Future research should consider specific study designs to determine how study quality may impact the relationship between BAC reduction and adverse outcomes.

We also combined studies on lowering the BAC from .10 to .08 and from .08 to .03 or .02, with the few qualifying studies of lowering the BAC from .08 to .05. As is the case with any meta-analysis, combining studies with differing, if similar, methodologies and outcomes can artificially inflate or diminish overall effect sizes. Despite this, however, it is common when conducting a meta-analysis to attempt to combine similar studies to improve overall power and thereby reach more meaningful conclusions. Though this is not ideal, it was deemed necessary for the meta-analysis in this study.

This study produced an estimation of the potential effectiveness of lowering the BAC limit for driving from .08 to .05 based on our analysis of prior research. As in any change in public safety policy, effectiveness will depend on public awareness and attitude toward the change, the enforcement of the law change, and the perception of the risk of arrest or injury by would-be impaired drivers if they exceed the illegal BAC limit.

Finally, though the current study follows methodological considerations appropriate for a meta-analysis, an interesting additional element would have been an examination of the magnitude of predictor effects. That is, it is feasible that studies conducted in the 1980's and 1990's may have had significant methodological differences from those conducted in recent years which may have impacted the overall meta-effect reported herein. Future research may consider examining this phenomenon in greater detail. Further, future research could metricize BAC to determine exactly how many lives are saved for each .01 drop in BAC. Though the scarcity and variability of extant research examining BAC reductions and their effects on fatal crashes prohibits a meaningful examination of this question to date, as studies into this field increases in volume and complexity, this would be an interesting avenue of scientific inquiry.

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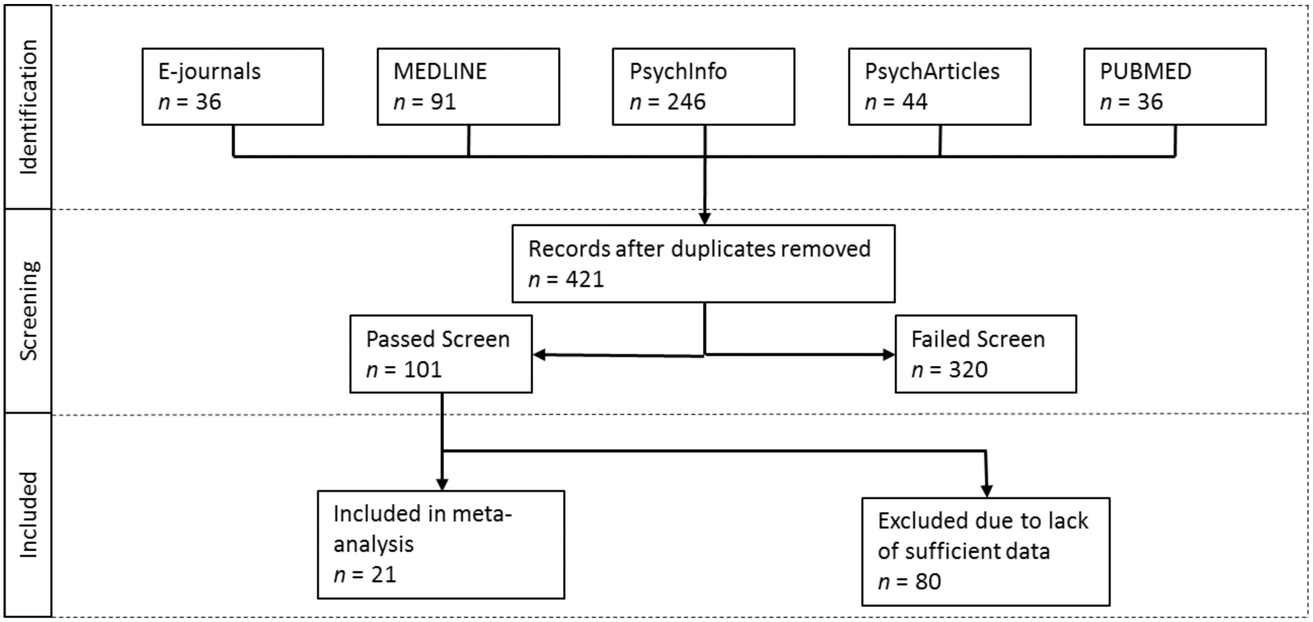


**Figure 1.**
Study selection flow diagram

| Article | Mean | SD | 95% CI lower | 95% CI upper |
|---|---|---|---|---|
| Aspler et al., 1999 | 0.031 | 0.047 | -0.016 | 0.078 |
| Bernhoff & Behrnsdorff, 2003 | -0.018 | 0.031 | -0.049 | 0.013 |
| Campos et al., 2013 | -0.023 | 0.007 | -0.03 | -0.016 |
| Kerr et al., 2006 | -0.011 | 0.004 | -0.015 | -0.007 |
| Noordzij, 1994 | -0.051 | 0.083 | -0.134 | 0.032 |
| Schwartz & Davaran, 2013 | 0.031 | 0.061 | -0.03 | 0.092 |

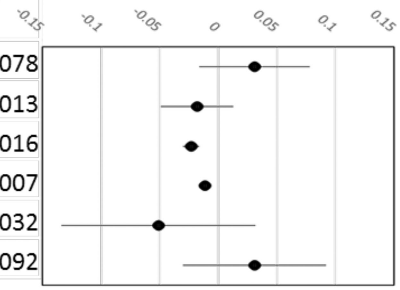


**Figure 2.**
Mean change in alcohol consumption outcomes after lowering of BAC limits.

| Article | Mean | SD | 95% CI lower | 95% CI upper |
|---|---|---|---|---|
| Blomberg, 1992 | -0.114 | 0.036 | -0.15 | -0.078 |
| Brooks & Zaal, 1993 | -0.059 | 0.037 | -0.096 | -0.022 |
| Desapriya et al., 2007 | -0.036 | 0.022 | -0.058 | -0.014 |
| Gorman et al., 2006 | -0.004 | 0.028 | -0.032 | 0.024 |
| Haque & Cameron, 1989 | -0.043 | 0.028 | -0.071 | -0.015 |
| Kaplan & Prato, 2007 | -0.077 | 0.03 | -0.107 | -0.047 |
| Karakus et al., 2015 | -0.021 | 0.019 | -0.04 | -0.002 |
| Maisey, 1984 | -0.036 | 0.021 | -0.057 | -0.015 |
| Wagenaar et al., 2007 | -0.058 | 0.041 | -0.099 | -0.017 |

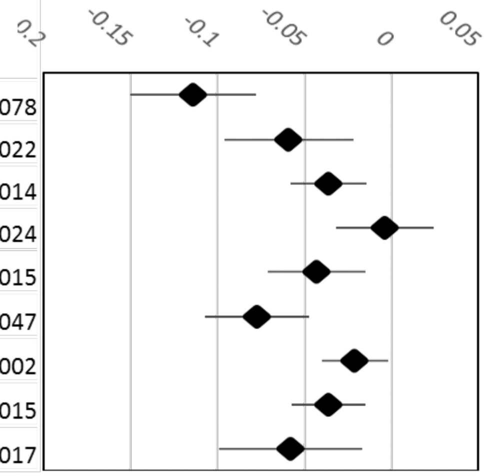


**Figure 3.**
Mean change in non-fatal alcohol-related crash rates after lowering of BAC limit to .08.

| Article | Mean | SD | 95% CI lower | 95% CI upper |
|---|---|---|---|---|
| Apsler et al., 1999 | -0.011 | 0.036 | -0.047 | 0.025 |
| Asbridge et al., 2015 | -0.181 | 0.063 | -0.244 | -0.118 |
| Bernat et al., 2004 | -0.052 | 0.027 | -0.079 | -0.025 |
| Bernhoff & Behrnsdorff, 2003 | -0.012 | 0.037 | -0.049 | 0.025 |
| Dee, 2001 | -0.067 | 0.034 | -0.101 | -0.033 |
| Foss et al., 2001 | -0.009 | 0.021 | -0.03 | 0.012 |
| Gorman et al., 2006 | -0.006 | 0.022 | -0.028 | 0.016 |
| Hingson et al., 1994 | -0.024 | 0.008 | -0.032 | -0.016 |
| Hingson et al., 1996 | -0.161 | 0.042 | -0.203 | -0.119 |
| Hingson et al., 2000 | -0.06 | 0.041 | -0.101 | -0.019 |
| Research and Evaluation Associates, 1991 | -0.118 | 0.037 | -0.155 | -0.081 |
| Rogers, 1995 | -0.01 | 0.046 | -0.056 | 0.036 |
| Voas et al., 2000 | -0.082 | 0.019 | -0.101 | -0.063 |
| Voas et al., 2002 | -0.146 | 0.051 | -0.197 | -0.095 |

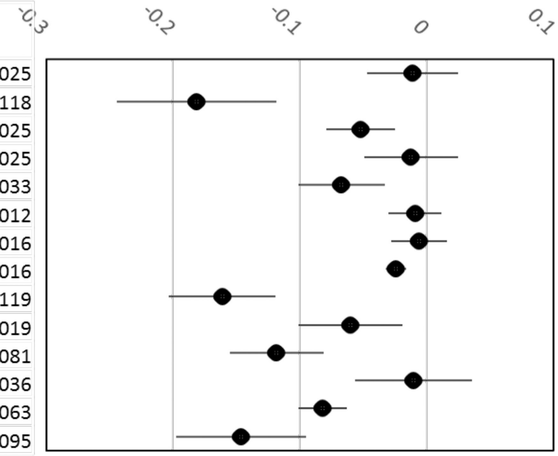


**Figure 4.**

Mean change in alcohol-related fatal crash rates associated with lowering BAC limit to .08

| Article | Mean | SD | 95% CI lower | 95% CI upper |
|---|---|---|---|---|
| Andreuccetti et al., 2011 | -0.018 | 0.007 | -0.025 | -0.011 |
| Assum, 2010 | -0.021 | 0.026 | -0.047 | 0.005 |
| Hingson et al., 1998 | -0.131 | 0.046 | -0.177 | -0.085 |
| Homel, 1994 | -0.133 | 0.037 | -0.17 | -0.096 |
| Henstridge et al., 1997 | -0.117 | 0.042 | -0.159 | -0.075 |
| McLean et al., 1995 | -0.009 | 0.062 | -0.071 | 0.053 |
| Nagata et al., 2008 | -0.384 | 0.099 | -0.483 | -0.285 |
| Nakahara et al., 2013 | -0.118 | 0.123 | -0.241 | 0.005 |
| Norström, 1997 | -0.1 | 0.061 | -0.161 | -0.039 |
| Smith, 1986 | -0.181 | 0.071 | -0.252 | -0.11 |
| Živković, et al., 2013 | -0.019 | 0.033 | -0.052 | 0.014 |

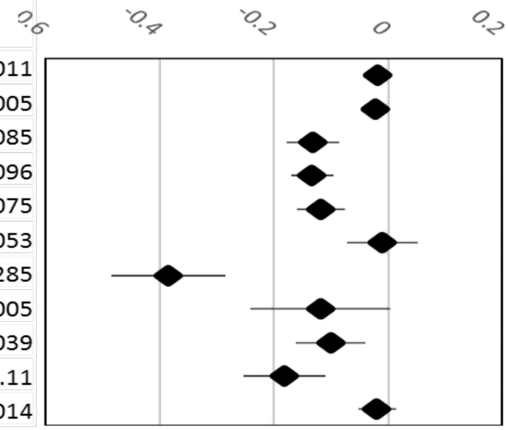


**Figure 5.**

Mean change in alcohol-related fatal crash rates associated with lowering BAC limit to .05

**Table 1**

Mean change in alcohol use among studies evaluating a reduction of the illegal BAC limit

| Article | Location/ Time Span | Outcome measure | Analysis used | Results | Change Value |
|---|---|---|---|---|---|
| Apsler et al., 1999 | U.S. 1982 to 1994 | Fatal crash rates in FARS | Time series analysis (ARIMA) | Though results varied notably between states, only marginal differences were found in alcohol consumption rates following law implementation. The increase was not significant. | NS |
| Bernhoff and Behrensdorff, 2003 | Denmark 1993 to 1999 | Self-reported drinking and driving, alcohol-related injury accidents | Chi-square and independent sample t-test | Drivers reported drinking less alcohol following law implementation. Findings were not statistically significant. | NS |
| Campos et al., 2013 | Brazil 2007 to 2009 | Rates of drinking and driving | Logistic regression analysis | Following the implementation of the law, there was a significant decrease in positive breath tests and self-reported rates of alcohol consumption. | −2 |
| Kerr, Greenfield, and Midanik, 2006 | U.S. 1979, 1995, and 2000 | Perception of drunkenness | Trend analysis using three cross-sectional surveys | Mean number of reported drinks to feel drunk declined significantly following law implementation for men (but not for women). | −1 |
| Noordzij, 1994 | Netherlands 1983 and 1992 | Alcohol use among roadside surveys | Observation of trend | Drivers who screened positive for alcohol decreased following the law implementation. | NS |
| Schwartz and Davaran, 2013 | U.S. (24 jurisdictions) 1990 to 2007 | Alcohol-related driving and arrests among gender | Two-way fixed-effects regression models | Alcohol-related arrests increased for both genders (though women in particular) after law implementation. Change was not statistically significant. | NS |

## Table 2

Mean change in non-fatal crashes among studies evaluating a reduction of the illegal BAC limit

| Article | Location/ Time Span | Outcome measure | Analysis used | Results | Change Value |
|---|---|---|---|---|---|
| Blomberg, 1992 | U.S. (Maryland) 1989 to 1990 | Crash rates of drivers under age 21 who had been drinking | Box-Jenkins time series analysis | Reduction of underage sanctions to .02. Implementing this law resulted in significant decreases in rates in which crash-involved underage drivers were found to have been drinking. | −11 |
| Brooks and Zaal, 1993 | Australia 1991 and 1992 | Drinking and driving and alcohol-related crashes | Chi-square and independent sample t-test | Following the law implementation, a significant decrease was noted in BACs of drivers on the road. | −6 |
| Desapriya et al., 2007 | Japan 1998 to 2005 | Alcohol-related crashes among male and female drivers | Logistic regression analysis | Introduction of reduced BAC limit resulted in significant decreases in alcohol-impaired drivers on the road and alcohol-related crashes. | −4 |
| Gorman, Huber, and Carozza, 2006 | U.S. (Texas) 1995 to 2002 | Fatal crash rates in FARS and TX Department of Public Safety reports on alcohol-related crashes | Time series analysis (ARIMA) | Separate ARIMA analysis was conducted for both outcome measures with no significant outcome detected. | NS |
| Haque and Cameron, 1989 | Australia (Victoria) 1984 to 1995 | Rates of serious traffic crashes | Pre-post comparison | Reduction in BAC limits resulted in mild non-significant decreases in alcohol-related driving and crashes. | −4 |
| Kaplan and Prato, 2007 | U.S. (22 jurisdictions) 1990 to 2005 | Alcohol-related single vehicle crashes and law effects on population segments | Poisson regression models | Reduction of BAC limit resulted in reduced numbers of casualties among single vehicle crashes. Female and elderly drivers were more adherent to new law requirements when compared to younger drivers and male drivers. | −8 |
| Karakus et al., 2015 | Turkey 2010 and 2011 | Non-fatal crashes among private sector and public transportation vehicles | Chi-square and independent sample t-test | Private sector drivers (who have a BAC limit of .05) were significantly more likely than public transportation sector drivers (who have a BAC limit of .00) to be involved in a non-fatal crash following reduction in BAC. | −2 |
| Maisey, 1984 | Australia (Western Australia) 1981 to 1983 | Alcohol use among drivers and alcohol-related crashes | Pre-post comparison | Reduction in BAC limits resulted in mild decreases in reported alcohol-related driving and rates of alcohol-related crashes. | NS |
| Wagenaar et al., 2007 | U.S. (28 jurisdictions) 1976 to 2002 | Single nighttime vehicle crashes and alcohol-related crashes | Time series analysis (ARIMA) | Due to considerable state by state variability, individual effects could not be deduced; however, pooled analysis demonstrated that changes in BAC law resulted in significant reductions in both single nighttime vehicle crashes and alcohol-related crashes. | −6 |

## Table 3

Mean change in fatal alcohol-related crashes among studies evaluating a reduction of the illegal BAC limit from .10 to .08 g/dL.

| Article | Location/ Time Span | Outcome measure | Analysis used | Results | Change Value |
|---|---|---|---|---|---|
| Apsler et al., 1999 | U.S. 1982 to 1994 | Fatal crash rates in FARS | Time series analysis (ARIMA) | Though results varied notably between states, overall few states demonstrated marginal differences between law implementation and fatal crash rates and/or alcohol consumption rates. In a few cases, there appeared to be an increase in alcohol consumption and law implementation, though not significant. | NS |
| Asbridge et al., 2015 | Canada 1962 to 1996 | Fatally injured drinking-drivers and fatally injured non-drinking drivers | Time series analysis (ARIMA) | There was a significant reduction in the number of fatally injured drinking-drivers, but no detectable impact on non-drinking driver fatalities. | −18 |
| Bernat, Dusmuir, and Wagenaar, 2004 | U.S. (19 jurisdictions) 36 months before and after 0.08 law implementation | Fatal crash rates in FARS | mixed-model Poisson regression analysis | Significant decreases in fatal crashes found in 3 of 19 states. | −5 |
| Bernhoff and Behrensdorff, 2003 | Denmark 1993 to 1999 | Self-reported drinking and driving, alcohol-related injury accidents | Chi-square and independent sample t-test | Rates of fatal alcohol-related crashes increased following law implementation. Findings were not statistically significant. | NS |
| Dee, 2001 | U.S. 1982 to 1998 | Fatal crash rates | Panel-based analysis | Following the adoption of the .08 BAC law, traffic fatalities were reduced by 7.2% in the 14 states that adopted them. | −7 |
| Foss et al., 2001 | U.S. (North Carolina) 1991 to 1996 | Fatal crash rates in FARS | Trend analysis | After accounting for the downward trend of fatal crashes, no significant effect was found due to law implementation. | NS |
| Gorman, Huber, and Carozza, 2006 | U.S. (Texas) 1995 to 2002 | Fatal crash rates in FARS and TX Department of Public Safety reports on alcohol-related crashes | Time series analysis (ARIMA) | Separate ARIMA analysis was conducted for both outcome measures with no significant outcome detected. | NS |
| Hingson et al., 1994 | U.S. (12 jurisdictions) Varied with each of twelve states examined | Fatal single vehicle nighttime crashes among drivers under age 21 | Log-linear analysis | Proportion of fatal single-vehicle nighttime crashes among young drivers decreased by 22% in states with .00 BAC limits, and by 2% in other states. | −2 |
| Hingson et al., 1996 | U.S. (5 jurisdictions) Varied with each of five states examined | Fatal crashes with drivers BAC ≥ .08 or BAC ≥.15 | Relative risk comparison | Four of five states showed a relative reduction compared with neighboring states that retained .10 BAC laws. | −16 |
| Hingson et al., 2000 | U.S. (6 jurisdictions) 1988 to 1998 | Fatal crashes in FARS | Relative risk comparison | After law implementation, fatal crashes decreased between 4% and 7% within states. Overall, fatal crash rates decreased by 6% compared to neighboring states. | −6 |
| Research and Evaluation Associates, 1991 | U.S. (California 1989 to 1990 | Fatal crash rates in FARS | Pre-post comparison | The combination of lowering the BAC limit to .08 and implementing the ALR law reduced alcohol-related traffic fatalities by 12%. | −12 |
| **Rogers, 1995** | U.S. (California) 1985 to 1993 | Fatal crash rates | Time series analysis | For fatal crashes, impact of lowering BAC from .10 to .08 was only detectable after ALR provisions were added. | NS |
| Voas, Tippetts, and Fell, 2000 | U.S. 1982 to 1997 | Fatal crash rates in FARS among underage drivers | Weighted least squares regression models | When examining all drivers, the reduction from BAC .10 to .08 resulted in a significant reduction in fatal crashes for all drivers. | −8 |

| Article | Location/ Time Span | Outcome measure | Analysis used | Results | Change Value |
|---|---|---|---|---|---|
| | | | | Among underage drivers, however, the reduction of BAC from .10 to .08, though in the right direction, is not significant. Variable variance among young drivers is likely accounted for by the success of the other MLDA laws. | |
| Voas, Tippetts, and Taylor, 2002 | U.S. (Illinois) 1989 to 2000 | Fatal crash rates in FARS | Time series analysis (ARIMA) | The proportion of drinking drivers in fatal crashes decreased by 14% in Illinois largely due to the passage of the .08 law. Rates in bordering states without the .08 law increased by 3%. | −14 |

FARS = Fatality Analysis Reporting System

MLDA = minimum legal drinking age

## Table 4

Mean change in fatal alcohol-related crashes among studies evaluating a reduction of the illegal BAC limit to .05 g/dL and below.

| Article | Location/ Time Span | Outcome measure | Analysis used | Results | Change Value |
|---|---|---|---|---|---|
| Andreuccetti et al., 2011 | Brazil 2001 to 2010 | Monthly traffic injuries and fatalities | Time series analysis (ARIMA) | Significant decreases in both traffic injuries and fatalities following law implementation. | −2 |
| Assum, 2010 | Norway 1995 to 2007 | Self-reported drinking and driving, fatal crash rates, and single nighttime vehicle crashes | Chi-square and independent sample t-test | Though drivers reported being less likely to drink before driving after law changes, there were no significant differences in single vehicle or fatal crashes pre- and post-law implementation. | NS |
| Hingson et al., 1998 | U.S. (Maine) 1982 to 1994 | Fatal crashes in FARS for drivers convicted of DWI in prior 3 years | Relative risk comparison | After law implementation, fatal crashes involving drivers with prior DWI declined as a percentage of total crashes while increasing in neighboring states. | −13 |
| Homel, 1994 | Australia (New South Wales) 1975 to 1986 | Fatal crashes for weekend drivers and fatal crashes during the week | Generalized linear modelling | Implementation of the law resulted in a significant decrease in fatal alcohol-related crashes among weekend drivers, but no significant difference was found among weekday drivers. | −13 |
| Henstridge et al., 1997 | Australia (New South Wales) 1982 to 1992 | Number of serious crashes, fatal crashes, and single nighttime vehicle crashes | Time series analysis (ARIMA) | Reduction of BAC levels to .05 resulted in significant decreases in total numbers of all crash types. | −11 |
| McLean et al., 1995 | Australia 1991 and 1992 | BAC levels of fatally injured drivers | None reported | The reduction permissible BAC laws resulted in a mild and temporary reduction in the BAC levels of fatally injured drivers. No lasting effects noted. | NS |
| Nagata, Setoguchi, and Hemenway, 2008 | Japan 1998 to 2004 | Traffic fatalities, severe traffic injuries, and all traffic injuries | Segmented regression analysis | All traffic injuries, severe and alcohol-related decreased after law implementation. | −38 |
| Nakahara, Katanoda, and Ichikawa, 2013 | Japan 1995 to 2006 | Monthly police records on fatal road crashes | Jointpoint regression models | Changes detected in trends of alcohol-related crashes had more to do with media events than with changes in BAC legislation. | NS |
| Norström, 1997 | Sweden 1987 to 1993 | Fatal crashes alone, single-vehicle crashes alone and all crashes | Time series analysis (ARIMA) | Significant decreases were found after law implementation in all three outcome measures. | −10 |
| Smith, 1986 | Australia (Tasmania, Western Australia, South Australia) 1980 to 1983 | Rates of overall fatal crashes for drivers and motorcyclists | Pre-post comparison | In all three states, there was a mild but significant impact of BAC reduction and GDL laws on crash rates for both drivers and motorcyclists ranging from 2% to 5%. | −18 |
| Živković, et al., 2013 | Serbia 2006 to 2011 | Alcohol use among fatally injured drivers | Independent samples t-test, one-way ANOVA, and chi-squared statistics | No significant effect was found for drivers who were under the influence of alcohol, or levels of alcohol found in their systems. The law appeared to have no notable effect. | NS |

FARS = Fatality Analysis Reporting System

GDL = graduated driver licensing

**Table 5**

Overall estimated mean impact of lowering BAC levels on alcohol use, fatal and non-fatal alcohol-related crashes

| Outcome | Number of studies | Estimated Impact | Standard Deviation |
|---|---|---|---|
| Alcohol consumption-related outcomes (Table 1) | 6 | −1.4 | 2.3 |
| Non-fatal alcohol-related crashes (Table 2) | 9 | −5.0 * | 2.6 |
| Lowering BAC to .08—fatal alcohol-related crashes (Table 3) | 14 | −9.2 * | 4.5 |
| Lowering BAC to .05 or lower—fatal alcohol-related crashes (Table 4) | 11 | −11.1 * | 5.5 |

* indicates significance at $p<.05$