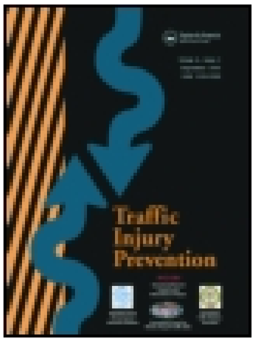

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Effectiveness of lowering the blood alcohol concentration (BAC) limit for driving from 0.10 to 0.08 grams per deciliter in the United States

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ABSTRACT

Objective: The current study evaluates of the effects of lowering the blood alcohol concentration (BAC) limit from 0.10 to 0.08 g/dL across all 50 states in the United States. Our objectives were to (1) estimate the effects of the 0.08 g/dL BAC limit on drinking driver fatal crash rates; (2) compare the effects from early-adopting states to the effects of late-adopting states; (3) determine the effects on drivers with low BACs (0.01–0.07 g/dL) and high BACs (0.08+ g/dL); and (4) estimate the lives saved since 1983 due to the adoption of 0.08 g/dL BAC laws.
Methods: Our study examined annual data from the Fatality Analysis Reporting System (FARS) for each jurisdiction from 1982 through 2014. Our basic outcome measure was the ratio of drinking drivers (BAC $\geq$0.01 g/dL) to nondrinking drivers (BAC = 0.00 g/dL). Covariates included 0.10 BAC laws, administrative license revocation (ALR) laws, seat belt laws, minimum legal drinking age (MLDA) laws, and unemployment rates. We utilized autoregressive integrated moving average (ARIMA) models for each state, where the implementation date of the law was modeled as a zero-order transfer function in the series, in addition to any extant trends that may have been occurring simultaneously. Before determining the specific impact of the implementation of 0.08 g/dL BAC laws, we conducted a time series analysis for each state. We tested for between-state mediating factors relating to our covariates.
Results: A total of 38 of the 51 jurisdictions showed that lowering the BAC limit was associated with reduced drinking driver fatal crash ratios, with 20 of those reductions being significant. The total effects showed a 10.4% reduction in annual drinking driver fatal crash rates, which is estimated to have saved an average of 1,736 lives each year between 1983 and 2014 and 24,868 lives in total. Implementing a BAC limit of 0.08 g/dL had significant impacts on both high- and low-BAC fatal crash ratios. Though early-adopting jurisdictions (1983–1999) demonstrated a larger decrease in fatal drinking driver crash ratios than did late-adopting jurisdictions (2000–2005), the results were not statistically significant ($P > .05$).
Conclusions: Our study of the effects of lowering the BAC from 0.10 to 0.08 g/dL in the United States from 1982 to 2014 showed an overall effect of 10.4% on annual drinking driver fatal crash rates, in line with other multistate studies. This research provides strong evidence of the relationship between lowering the BAC limit for driving and the general deterrent effect on impaired-driving fatal crash rates.

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Blood alcohol concentration (BAC) limits; drinking drivers; fatal crashes; 0.08 grams per deciliter; legislation; autoregressive integrated moving average (ARIMA)

Introduction

History of BAC limits in the United States

At the start of the 1970s, when the first U.S. national effort to control alcohol-impaired driving began, even those states that based their laws on the blood alcohol concentrations (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 0.15 g/dL BAC, although a few states had BAC levels of 0.12 or 0.10 g/dL. The U.S. Department of Transportation (DOT) used its authority under the Highway Safety Act of 1966 passed by the U.S. Congress to encourage all states to adopt 0.10 g/dL BAC as the level for intoxicated or impaired driving. As a result, all states and the District of Columbia began adopting the 0.10 g/dL BAC threshold. From the outset of the movement to adopt 0.10 g/dL BAC as the national standard, however, there were advocates for even lower BAC levels. By 1983, this sentiment had resulted in the enactment of 0.08 g/dL BAC *per se* laws in Oregon and Utah. In 1986, the DOT took its first formal step toward encouraging states to adopt a lower illegal limit by including a 0.08 g/dL BAC law as one of the regulatory criteria for a supplemental alcohol traffic safety grant under the program authorized by the U.S. Congress (2000) (23 U.S.C. 408).

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In 1988, after a series of studies examining the impact of alcohol on driving-related skills (Moskowitz and Robinson 1988) and 0.10 BAC limits (Zador et al. 1988), additional states began to consider 0.08 g/dL BAC levels, and 3 more states (Maine, California, and Vermont) joined Oregon and Utah in adopting the new BAC level. California's 1990 legislation lowered the state's *per se* limit from 0.10 to 0.08 g/dL BAC and established an administrative license revocation (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 combined resulted in a 12% decrease in alcohol-related fatalities (Research and Evaluation Associates 1991).

In 1991, NHTSA submitted a report to Congress in response to a congressional mandate to study the BAC at which a driver should be considered under the influence. The report—*Alcohol Limits for Drivers: A Report on the Effects of Alcohol and Expected Institutional Responses to New Limits* (NHTSA 1991)—was based on a review of existing literature on BAC limits and data collected on expected institutional responses to alternative limits. It concluded that, until a final recommendation is developed, 0.08 g/dL *per se* should be adopted by jurisdictions considering lowering their limits. In 1992, the DOT issued *Driving under the Influence: A Report to Congress on Alcohol Limits* (NHTSA 1992). This report declared, "States should be encouraged to enact 0.08 g/dL as the BAC level at and above which it is a per se criminal offense to drive" (p. iv).

Between 1992 and 1998, 10 additional states adopted 0.08 BAC *per se* laws. On June 15, 2000, the U.S. Senate passed a bill that included a general provision encouraging states to adopt 0.08 g/dL BAC laws by withholding a portion of a state's federal highway funds. The final 0.08 BAC Bill was adopted by Congress and signed by the president shortly after that.

Effectiveness of 0.08 g/dL BAC laws

There were 4 early studies of the impact of lowering the BAC limit to 0.08 that were conducted before 1999 (Hingson et al. 1996; Johnson and Fell 1995; Research and Evaluation Associates 1991). These studies controlled for many extraneous factors and provided initial evidence of the benefit of 0.08 BAC laws on alcohol-related crashes. These studies provided credible evidence of the impact of the 0.08 law, particularly in combination with the ALR law as was the case in several states. The findings from these studies were later supported by a series of studies examining the effects of lowering the limit to 0.08 BAC (Apsler et al. 1999; Hingson et al. 2000; Voas and Tippetts 1999; see also Voas et al. 2000). It was estimated at the time that if all 50 states had 0.08 BAC laws in 1997, an additional 590 fatalities would have been prevented (Voas et al. 2000). Similarly, later studies found a 7.2% reduction in traffic fatality rates associated with adoption of 0.08 BAC laws and that an additional 1,200 lives could be saved annually if the additional 23 states with ALR laws also adopted 0.08 BAC laws (Dee 2001). When additionally controlling for graduated driver licensing (GDL) laws, the 0.08 BAC limit was associated with a 5% reduction from the mean traffic fatality rate and 0.10 BAC limit laws were associated with a 2.4% reduction. This estimate suggested that lowering the limit from 0.10 to 0.08 BAC would garner a further reduction of 2.6% from the mean total fatal crash rate.

An independent task force, supported by the Centers for Disease Control, conducted an extensive and systematic review of all of the available studies of the effectiveness of 0.08 BAC laws (Shults et al. 2001). This task force found a median 7% reduction in measures of alcohol-related fatal crashes associated with 0.08 BAC laws. Because of this review, the Centers for Disease Control task force *strongly recommended* the enactment of 0.08 BAC laws as a measure for reducing alcohol-related fatalities and injuries. In 2005, Tippetts et al. conducted a meta-analysis of 0.08 BAC laws in 18 states and the District of Columbia and found a combined 14.8% reduction in the rate of drinking drivers in fatal crashes associated with the adoption of a 0.08 BAC law.

Though there have been several studies of the effectiveness of lowering the BAC limit from 0.10 to 0.08, these have been in one state or a small group of states. To our knowledge, no study has been conducted of the effects nationwide, in all 50 states and the District of Columbia. This study fills that critical gap in the research.

Objectives

Our basic objective in this study was to determine the effectiveness achieved by reducing the illegal *per se* BAC limit for driving from 0.10 to 0.08 g/dL in all 50 states and the District of Columbia. Under this basic objective, we (1) compared the effects from early-adopting states (under state initiatives during 1983–1999) to the effects of late-adopting states (under federal incentive influence from 2000 and later); (2) determined the effects on drivers with low BACs (0.01–0.07 g/dL) and with high BACs (0.08+ g/dL); and (3) estimated the lives saved since 1983 due to the adoption of 0.08 g/dL BAC laws. The current study sought to develop a model of the effects of changing the BAC laws from 0.10 to 0.08 on alcohol-related and non-alcohol-related fatal crash rates by state and year.

Methods

Legal research

In this study of BAC limits, our legal researchers used Westlaw and HeinOnline to review the legislative history of 0.08 BAC laws and identify the date these policies went into effect and to track the penalty for violating the law. See Appendix A (online supplement) for the effective dates of 0.08 g/dL BAC laws in each state, the penalties upon conviction of a 0.08 g/dL violation, the sanctions administered, and the statute numbers.

Outcome variable

For this study, annual traffic fatality data from 1982 to 2014 for each state was drawn from the NHTSA Fatality Analysis Reporting System (FARS; NHTSA 2015). FARS is a continuous census of vehicular crashes that (1) resulted in the death of an individual within 30 days of the crash, (2) occurred on U.S. public roadways, and (3) had been investigated and reported by police. The involvement of alcohol in the crash is derived from positive BAC data from tests on drivers. When these data are incomplete or missing, the BACs of drivers in the FARS database are imputed to obtain a more accurate picture of the involvement of alcohol in the crash (Subramanian 2002). After incorporating imputed BAC estimates for crashes without BAC data, all fatal crash drivers were divided into 2 groups: drivers with a BAC greater than 0.00 g/dL (or drinking drivers) and drivers with a BAC of 0.00 g/dL (or nondrinking drivers).

One method of accounting for a control condition is the use of ratios of crashes involving drinking drivers to crashes not involving drinking drivers (Fell et al. 2009; Tippetts et al. 2005; Voas, Tippetts, et al. 2007) where the number of fatal crashes when the driver had a positive BAC was in the numerator and fatal crashes where the driver had a BAC of zero was in the denominator. As a result, any change in the number of crashes involving drinking drivers will only change the numerator and, subsequently, allow for a more accurate appraisal of the change. For this reason, the current study used fatality ratios (alcohol-involved drivers [BAC $\geq$ 0.01] in fatal crashes/non-alcohol-involved drivers [BAC = 0.00] in fatal crashes) as its outcome measure. Additionally, to account for between-state differences, we sought to control for numerous state-level variables for which we had consistent data across states over the duration of the study period (1982–2014).

Predictor variable

To date, all 51 jurisdictions in the United States have reduced their legal BAC limit from 0.10 to 0.08 g/dL. The implementation dates range notably, however, from as early as 1983 (Utah and Oregon) to as recently as 2005 (Minnesota). The dates on which the 51 jurisdictions lowered their BAC limit are included in Table 1. To accommodate this large range in implementation dates, we collected data on our outcome and covariates dating back to 1982. The laws were coded as 0 if the law was absent for the duration of the year and 1 if the law was present for the entirety of the year. Years in which the law was implemented were coded as a fraction to indicate what percentage of the year was covered by the law. For example, a law in effect in September would be present for only one third of that year and was coded as 0.33; a law in effect in April would be present three quarters of the year and was coded as 0.75.

Beer consumption

Per capita beer consumption rates were measured as gallons of ethanol consumed via beer consumption per capita per jurisdiction per year. Data were obtained for individuals aged 15 years and older from the annual publication of the National Institute on Alcohol Abuse and Alcoholism's Alcohol Epidemiologic Data System. Beer consumption rates were only available as general numbers by state and year and not available for partitioning into age groups. Beer consumption was included as an intermediate outcome (i.e., both an outcome of changing a law and a predictor of alcohol-related fatal crashes) to account for the indirect effect of a law on fatal crash ratios.

Table 1. Effective dates for BAC 0.08 g/dL laws and average annual fatality ratios.

State	0.08 BAC effect date (month/day/year)	Fatality ratio[a]	State	0.08 BAC effect date (month/day/year)	Fatality ratio[a]
AL	10/01/95	0.892	MT	04/15/03	0.853
AK	09/01/01	0.818	NE	09/01/01	0.476
AZ	08/31/01	0.821	NV	09/23/03	0.783
AR	08/13/01	0.829	NH	01/20/04	0.824
CA	01/01/90	0.641	NJ	07/01/03	0.642
CO	07/01/04	0.640	NM	01/01/94	0.785
CT	07/01/02	1.021	NY	07/01/03	0.770
DE	07/12/04	0.656	NC	10/01/93	0.574
DC	04/13/99	1.289	ND	08/27/03	1.063
FL	01/01/94	0.694	OH	06/30/03	0.779
GA	07/01/01	0.576	OK	07/01/01	0.604
HI	06/30/95	0.901	OR	10/15/83	0.659
ID	07/01/97	0.824	PA	09/30/03	0.775
IL	07/02/97	0.725	RI	07/13/00	1.077
IN	07/01/01	0.552	SC	08/19/03	1.083
IA	07/01/03	0.683	SD	07/01/02	0.664
KS	07/01/93	0.749	TN	07/01/03	0.754
KY	10/01/00	0.554	TX	09/01/99	1.744
LA	09/30/03	0.989	UT	08/01/83	0.374
ME	08/04/88	0.520	VT	07/01/91	0.656
MD	09/30/01	0.608	VA	07/01/94	0.727
MA	06/30/03	1.427	WA	01/01/99	0.717
MI	09/30/03	0.633	WV	05/05/04	0.632
MN	08/01/05	0.520	WI	09/30/03	0.735
MS	07/01/02	1.081	WY	07/01/02	0.828
MO	09/29/01	0.979			

[a]Fatality ratio refers to drivers in alcohol-related fatal crashes/drivers in non-alcohol-related fatal crashes as derived from the FARS data set.

Other covariates

Any number of variables could potentially impact the rates of crashes involving drinking drivers (e.g., road conditions, gas tax revenues, geographical considerations, variations in policing policies). The probability of a crash becoming fatal is also a function of general automotive safety (i.e., advanced braking systems, air bags, lane correction warnings, etc.). Although it would be ideal to measure and control for each of these variables, obtaining accurate operational measures for each variable in each state would be impossible. Logically, however, most of these additional factors would also impact fatal crashes with nondrinking drivers; hence, the use of a nondrinking driver control condition should provide an adjustment for the unmeasured factors that potentially affect fatal crashes.

Prior research has demonstrated the efficacy of the minimum legal drinking age (MLDA) laws in reducing adverse alcohol-impaired driving outcomes. In particular, Fell et al. (2016) showed a significant impact on fatality ratios from MLDA laws among drivers under the age of 21. Because a disproportionately large number of fatal alcohol-related crashes are attributed to drivers in that age group, the current endeavor controlled for these effects as well.

Notably, prior research has demonstrated that the general health of each state's economy is related to both fatal crash rates and alcohol consumption (which itself is also related to fatal crash rates; Fell et al. 2016; Voas et al. 2000). As such, we used unemployment rates (U.S. Bureau of Labor Statistics 2015) as a measure of economic stability in each state, which has been used in prior research as a proxy measure for general economic strength (Fell et al. 2016; Scherer et al. 2015; Tippetts et al. 2005). Seat belt laws were coded as 0 if a state had no law; 1 if a state had secondary laws; and 2 if a state had primary seat belt laws. With secondary seat belt use laws, police must stop a driver for another traffic violation (e.g., speeding) before they can cite the driver for not wearing a seat belt. Primary seat belt laws allow police to stop and issue citations to drivers directly for not wearing a seat belt. In some cases, a state started out with secondary laws and then later upgraded their laws to primary laws. In such a case, the laws were initially coded as a 1 and then as a 2 when the law was upgraded to primary. Similarly, ALR laws have demonstrated their significant contribution to fatal crash rates (Klein 1989; Shults et al. 2001; Voas et al. 2000; Wagenaar et al. 2007) and were included in the current study as a covariate. Each of these laws were coded as 0 if the law was absent and 1 if the law was present.

Analysis

To adequately assess the impact of the implementation of a law, we utilized autoregressive integrated moving average (ARIMA) models (Box and Jenkins 1976), where the implementation date of the law was modeled as a zero-order transfer function in the series, in addition to any extant trends (observed or otherwise) that may have been occurring simultaneously in any given state at any given time. Consistent with prior research on this topic, we incorporated a 1-year lag effect for each law examined in the current effort (Fell et al. 2016; Scherer et al. 2015). The autoregressive component allows for the change of the effects of a variable over time while allowing for lagged effects. The moving averages are the linear regression terms over the duration of the study. Such analyses allowed us to limit the impact of potentially confounding differences in prelaw and postlaw levels, which could artificially alter the effect size of the actual law implementation. SAS Ver. 9.4 was used for the ARIMA models in the current study.

Before determining specific impact of the implementation of 0.08 g/dL BAC laws, we first conducted a time series analysis for each state. Then, the law effect size was derived by conducting an ARIMA for each state. The current study examined annual data for each jurisdiction from 1982 through 2014. Based on these estimates from each of the jurisdictions and standard error estimates, the 1,683 raw data (51 jurisdictions ×33 years) points from the 51 jurisdictions were pooled and weighted per population per year per jurisdiction into a single data set. We then tested for between-state mediating factors such as annual per capita beer consumption rates and the presence or implementation of ALR laws.

Of the covariates examined in the current study, per capita beer consumption by far had the most impact on the alcohol-related fatal crash ratio. A brief overview of the rates of fatal crash ratios by jurisdiction is given in Table 1, as are the implementation dates for the 0.08 law. Finally, the effect size for the 0.08 law implementation in each state and the District of Columbia was converted using the antilog function, which produced a single uniform effect size for each jurisdiction.

Results

Parameters of the autoregressive modeling notwithstanding, indicators of beer consumption and ALR/administrative license suspension law implementation demonstrated the largest effect on the outcome measure of alcohol-related fatal crash ratios (19.8% increase and 11.8% decrease, respectively). The results of the ARIMA displayed in Table 2 show the effect sizes of implementing 0.08 g/dL BAC laws in each state. The coefficients listed in Table 2 show the effect size for each jurisdiction of lowering the law to 0.08 from 0.10 g/dL after accounting for lag in the law and effect sizes of covariates listed in the Methods section. Though 38 of the 51 jurisdictions showed that lowering the BAC limit had a negative effect (a reduction) on alcohol-related fatal crash ratios, 20 of those reductions were significant at the $P < .05$ level after controlling for all covariates and potential confounders (e.g., ALR law implementation). Coefficients listed in Table 2 have been log standardized for interpretation. As such, a coefficient of −0.11 would indicate an 11% decrease as a result of implementing the law. Probability levels (i.e., P values) are displayed only when the results were statistically significant or, in the case of Utah, approached statistical significance.

Figure 1 shows a plot of these results for side-by-side interpretation. The zero line in the center of the chart would indicate no change following the implementation of a 0.08 g/dL BAC limit. The dot in the center of the bold lines indicates the effect size of the law in each state, and the lines spanning outward indicated the 95% confidence interval. As demonstrated in Figure 1, 20 of the 51 jurisdictions had statistically significant findings, with one state—Utah—approaching statistical significance (listed but not bolded). Importantly, the findings of a nonnegative effect size may not necessarily indicate that introducing the law increased the fatality ratio, because often the 95% confidence interval passes the zero line. This means that the law may still have decreased the fatality ratio; however, the standard error was too large to know that with any statistical certainty. Though a few states (Idaho, Iowa, Kentucky, and South Carolina) showed an increase in the fatality ratio associated with

Table 2. Effect of 0.08 g/dL law implementation on ratio of drinking to nondrinking drivers in fatal crashes.

State	Log-transformed coefficient	95% CI (lower, upper)	P value[a]	State	Log-transformed coefficient	95% CI (lower, upper)	P value[a]
AL	−0.0311	(−0.1238, 0.0616)		MT	**−0.1921**	**(−0.2676, −0.1166)**	**.000**
AK	−0.0048	(−0.0860, 0.0764)		NE	0.0327	(−0.1306, 0.1960)	
AZ	−0.0728	(−0.3794, 0.2338)		NV	−0.1437	(−0.3548, 0.0674)	
AR	0.0524	(−0.0696, 0.1744)		NH	−0.0564	(−0.1407, 0.0279)	
CA	−0.026	(−0.0986, 0.0466)		NJ	−0.2189	(−0.5176, 0.0798)	
CO	−0.0328	(−0.1729, 0.1073)		NM	**−0.2643**	**(−0.4421, −0.0865)**	**.033**
CT	**−0.2122**	**(−0.4125, −0.0119)**	**.047**	NY	**−0.421**	**(−0.7071, −0.1349)**	**.021**
DE	−0.1403	(−0.4514, 0.1708)		NC	**−0.3121**	**(−0.4042, −0.2200)**	**.000**
DC	**−0.2816**	**(−0.4949, −0.0683)**	**.029**	ND	−0.0078	(−0.2187, 0.2031)	
FL	**−0.2143**	**(−0.3481, −0.0805)**	**.032**	OH	−0.2121	(−0.5343, 0.1101)	
GA	0.1021	(−0.0413, 0.2455)		OK	**−0.2002**	**(−0.2912, −0.1092)**	**.000**
HI	**−0.2686**	**(−0.3997, −0.1375)**	**.016**	OR	0.1134	(0.0141, 0.2127)	
ID	0.1354	(0.0601, 0.2107)		PA	**−0.3642**	**(−0.5827, −0.1457)**	**.038**
IL	**−0.1168**	**(−0.1867, −0.0469)**	**.032**	RI	0.1869	(−0.1262, 0.5000)	
IN	0.003	(−0.1313, 0.1373)		SC	0.2113	(0.0070, 0.4156)	
IA	0.1212	(0.0491, 0.1933)		SD	0.0916	(−0.1458, 0.329)	
KS	**−0.3181**	**(−0.3903, −0.2459)**	**.000**	TN	**−0.1227**	**(−0.2099, −0.0355)**	**.000**
KY	0.2321	(0.0636, 0.4006)		TX	0.0522	(−0.0119, 0.1163)	
LA	0.0872	(−0.0365, 0.2109)		UT	−0.0316	(−0.3436, 0.2804)	.061
ME	**−0.403**	**(−0.5374, −0.2686)**	**.000**	VT	**−0.4701**	**(−0.7282, −0.212)**	**.000**
MD	**−0.2173**	**(−0.317, −0.1176)**	**.000**	VA	**−0.216**	**(−0.3972, −0.0348)**	**.039**
MA	**−0.2863**	**(−0.3739, −0.1987)**	**.000**	WA	−0.0786	(−0.1721, 0.0149)	
MI	−0.0697	(−0.1635, 0.0241)		WV	−0.1617	(−0.5038, 0.1804)	
MN	**−0.1987**	**(−0.2641, −0.1333)**	**.000**	WI	−0.0227	(−0.1231, 0.0777)	
MS	**−0.1862**	**(−0.2751, −0.0973)**	**.000**	WY	−0.1898	(−0.393, 0.0134)	
MO	−0.0328	(−0.3516, 0.2860)					

[a]P value displayed and bold when significant.

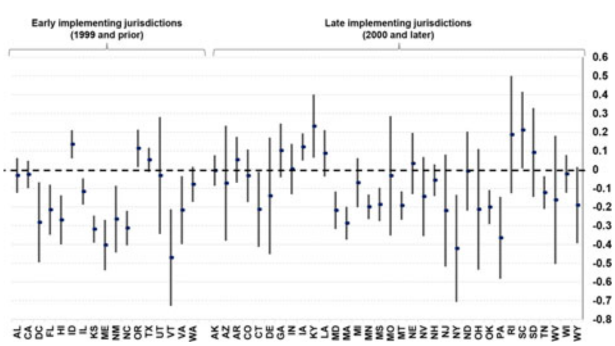

Figure 1. Mean change rates with 95% confidence intervals in ratios of drinking drivers to nondrinking drivers in fatal crashes.

the adoption of a 0.08 g/dL BAC limit, none of these were statistically significant.

Figure 2 shows a plot of individual state-level BAC ratios over the course of the study period (1982–2014). When all jurisdictions were pooled together, we determined that the overall effectiveness of the 0.08 g/dL BAC law implementation resulted in approximately a 10.4% reduction (95% confidence interval [CI], 8.6%–12.2%) in annual drinking driver fatal crashes.

Estimated lives saved since 1983

We sought to estimate how many lives have been saved in the United States by the implementation of 0.08 g/dL BAC laws since 1983. To do so, we used the 0.08 g/dL BAC legal limit law implementation dates (see Table 1) and we determined how many lives were saved following the law for each jurisdiction.

With an annual effect size of 10.4%, the 0.08 g/dL BAC law saved approximately 1,736 lives per year throughout the United States in years when the law was implemented. However, because not all jurisdictions implemented the law at the same time, we must factor in only the years in which the law was present. To do this, we used the implementation dates listed in Table 1 with the following equation:

$$X_{\mathrm{TOT}} = \left\{\beta\left(\frac{N}{1-\beta}\right)\left(\frac{T_2-T_1}{T_{\mathrm{TOT}}}\right)\right\}_1 + \left\{\beta\left(\frac{N}{1-\beta}\right)\left(\frac{T_2-T_1}{T_{\mathrm{TOT}}}\right)\right\}_2 \dots + \left\{\beta\left(\frac{N}{1-\beta}\right)\left(\frac{T_2-T_1}{T_{\mathrm{TOT}}}\right)\right\}_{51}.$$

In the above calculation, β represents the estimated law effect size, N represents the number of fatal crashes in that jurisdiction, T_2 represents the current year (i.e., 2014), T_1 is the year the law was implemented, and T_{TOT} represents the total number of years in the current study. This equation is replicated for each of the 51 jurisdictions and the results added up to yield total lives saved in the United States since law implementation (X_{TOT}). Using this calculation, we found that when we factor in differences between state law implementation dates and count lives retrospectively since 1983, we estimate that since its implementation, the 0.08 BAC law has saved an estimated 24,868 lives.

Comparison of 0.08 g/dL BAC limit law on low-BAC and high-BAC alcohol-related fatal crash ratios

We also compared the impact of the 0.08 g/dL law implementation date on fatal crash ratios involving drivers with a low BAC (BAC <0.08 g/dL) and again on fatal crash ratios involving drivers with a high BAC (BAC ≥0.08 g/dL). Interestingly, though implementing a BAC limit of 0.08 g/dL

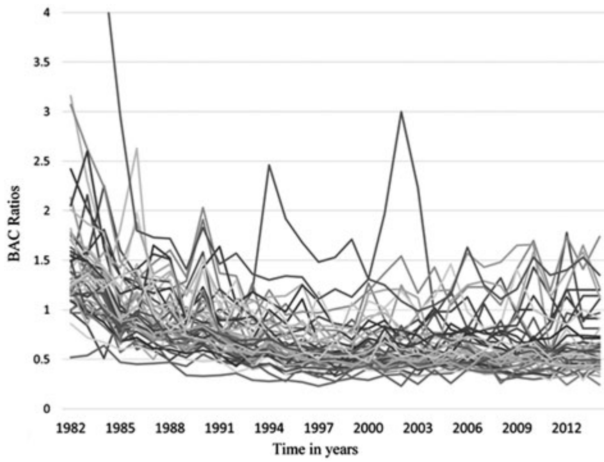

Figure 2. Plot of 0.01/0.00 BAC ratios by states over time.

had significant impacts on both high- and low-BAC fatal crash ratios, we found that even after accounting for a lag in law effectiveness, the implementation of the law had a significantly greater effect on fatal crash ratios involving drivers with a low BAC ($r = -0.149$; SE = 0.013; 95% CI, −0.136 to −0.162) than it did on fatal crash ratios involving drivers with a high BAC ($r = -0.101$; SE = 0.021; 95% CI, −0.080 to −0.122). That is, the implementation of the law resulted in a 13.6% decrease in fatal alcohol-related crash ratios for drivers with a low BAC, compared to a 9.1% decrease for drivers with a high BAC. See Table 3 for detailed results comparing low-BAC fatal crashes and high-BAC fatal crashes.

Comparison of early-adopting jurisdictions to late-adopting jurisdictions

To determine whether jurisdictions that adopted the law early on—under the state initiatives (year 1999 or prior)—had more positive outcomes than jurisdictions that adopted the law later (year 2000 or later), we conducted a separate analysis for each of these classes of jurisdictions (i.e., early-adopting jurisdictions and late-adopting jurisdictions). Table 3 shows that 17 of the 51 jurisdictions qualified as early-adopting, and the remaining 34 jurisdictions were classified as late-adopting. Though early-adopting jurisdictions demonstrated a larger decrease in fatal alcohol-related crash ratios ($r = -0.161$; SE = 0.134; 95% CI, −0.027 to −0.295) than did late-adopting jurisdictions ($r = -0.078$; SE = 0.178; 95% CI, 0.100 to −0.256), the results were not statistically significant at the $P = .05$ level. See Table 3 for detailed results comparing early-adopting jurisdictions compared to late-adopting jurisdictions.

Discussion

This study contributes to the literature examining the effectiveness of 0.08 BAC laws over time. Prior studies examining this phenomenon have been limited to examining only a cluster of jurisdictions (e.g., Bernat et al. 2004; Tippets et al. 2005; Voas et al. 2000). Further, the use of identical covariates and standardized methods allowed for results to be pooled and overall law effects to be adequately assessed. Our study of the effects of lowering the illegal BAC threshold from 0.10 to 0.08 g/dL in the United States from 1982 to 2014 in all 50 states and the District of Columbia showed an overall annual effect of 10.4% on alcohol-related fatalities, certainly in line with other multistate studies (e.g., 8% from Voas et al. 2000; 14.8% from Tippetts et al. 2005; 7.2% from Dee 2001). From this study, we estimate that lowering the BAC limit 0.08 g/dL in the United States has saved an average of 1,736 lives each year between 1983 and 2014 and 24,868 lives in total.

Table 3. Comparison of 0.08 g/dL law implementation on BAC level (low vs. high) and date of law adaptation (early vs. late).

	BAC level		Law adoption		Overall
	Low BAC	High BAC	Early-adopting	Late-adopting	All jurisdictions
Coefficient	−0.149	−0.101	−0.161	−0.078	−0.118
Enhanced standard error	0.013	0.021	0.134	0.178	0.036
t Statistics	−3.17	−3.79	−1.21	−0.89	−3.36
Effective df	50	50	16	33	50
One-tailed probability	.006	.003	.010	.013	.009
Effect size (%)	−13.6	−9.1	−14.3	−6.5	−10.4

Of the 51 jurisdictions examined in this effort, 38 demonstrated a significant decrease in fatality ratios following the implementation of the law. However, after controlling for a series of covariates that prior literature has demonstrated to have a significant impact on fatality ratios, only 20 of the 38 jurisdictions still showed a statistically significant decrease. This provides additional support for the overall effectiveness of the law.

Interestingly, about a third as many jurisdictions showed an increase in fatality ratios. Though none of these reached statistical significance, the result is still somewhat surprising. A factor that may have contributed to this finding is that with the exception of 3 of these states (Idaho, Oregon, and Texas), all of these states were late-adopting states. Similarly, it is feasible that in some cases states only changed the law to avoid losing federal funds for infrastructure and, as such, did not devote as much effort to media campaigns and enforcement as did early-adopting states. If true, this may have resulted in a reduced overall effect size for late-adopting states. The alcohol and hospitality industries also strenuously opposed lowering the BAC limit to 0.08, which probably contributed to the lack of more states adopting the 0.08 BAC on their own initiative rather than when the federal legislation was passed. Finally, there has been a general stagnation in the 0.08 g/dL BAC fatality rates since about the year 2000. This stagnation would have provided fewer post years in which to observe the impact of the 0.08 g/dL law (or any other law predicted to impact alcohol-related fatality rates) and, as such, has led to a false negative. This phenomenon may also explain the lower effect size for high-BAC crashes (−9.1%) relative to low-BAC crashes (−13.6%), which have not faced the same stagnation as the high-BAC fatal crash rates. Future research could examine exactly why this stalling of high-BAC alcohol-related crash rates occurred and how precisely it impacts alcohol-related legislation.

Opponents of lowering the BAC limit to 0.08 g/dL argued that the legislation would not affect problem drink drivers who reach high BAC levels. This study and others (Hingson et al. 2000; Tippetts et al. 2005; Wagenaar et al. 2007) demonstrate that the law did affect high-BAC drivers. It is possible, given the above findings, that many drivers thought that they were at greater risk of being caught driving while impaired and curtailed that behavior to some extent when the 0.08 law went into effect. It was the perception of the state getting tougher, not necessarily the reality. Recent research indicates that when other countries lowered their BAC limit from 0.08 to 0.05 g/dL, effects on alcohol-related fatal crashes were experienced (Bartl and Esberger 2000; Brooks and Zaal 1993; Homel 1994). Laboratory studies show that subjects are significantly impaired at 0.05 g/dL BAC and higher. The relative risk of a fatal crash is significant at 0.05 g/dL BAC and above. Lowering the BAC limit in the United States from 0.08 to 0.05 g/dL would most likely have a similar deterrent effect (e.g., Fell and Scherer 2017) as we found in this study of 0.08 g/dL BAC. In 2017, Utah became the first state in the United States to lower the BAC limit for driving to 0.05 g/dL. That could be the start of a movement in this country to the lower the BAC limit from 0.08 to 0.05 g/dL.

This provides strong evidence of the relationship between lowering the BAC limit for driving and the general deterrent effect on alcohol-related fatal crashes. Though there were arguments from some opponents against lowering the BAC limit to 0.08 g/dL (NHTSA 2002, 2003; Tippetts et al. 2005), the life-saving potential shown in this and other studies may offset any reduction in economic benefits made from alcohol sales in a jurisdiction; however, additional research is needed to determine the economic impact of lowering BAC laws on alcohol sales.

Strengths and limitations

Any number of variables could potentially impact the rates of fatal crashes involving drinking drivers (e.g., road conditions, automotive safety, geographical considerations, variations in policing policies). Although it would be ideal to measure and control for each of these variables, obtaining accurate operational measures for each variable in each state would not be possible. Logically, however, many of these additional unmeasured factors would also impact fatal crashes with nondrinking drivers; hence, the use of a nondrinking driver control condition should provide an adjustment for the unmeasured factors that potentially affect fatal crashes. It is also feasible that individuals who drink and drive differ in other meaningful ways that may impact the outcome of our modeling. For example, one could theorize that chronic drinkers have more difficulty maintaining employment and subsequently drive older, less safe vehicles, which compounds their risk. Unfortunately, such a detailed analysis was beyond the scope of the current study and could be examined in future research efforts.

Further, it is difficult to evaluate a law without some estimation of the impact of law enforcement for alcohol-related legislation. However, finding data that were consistent from jurisdiction to jurisdiction throughout the duration of the study was very difficult. Much of the data available vary dramatically in quality, data collection procedure, how the data are stored, and how available the data are for use in research between jurisdictions and are often scantly or inconsistently populated. Though including a detailed analysis of law enforcement in each jurisdiction for the duration of the study was beyond the scope of the current endeavor, future research should examine this as a contributor to the effectiveness of law implementation.

Finally, the current study sought to examine the impact of lowering the BAC level to 0.08 from 0.10. Doing so would necessarily require between-state comparisons, which may introduce numerous sources of potentially confounding data. A particular source of between-state differences that might be particularly salient in our analysis of BAC levels is the effects of other alcohol-related legislation and laws that may result in fewer fatalities (i.e., seat belt safety laws). For this purpose, the current study sought to control for as many between-state variables as possible in our analysis. However, despite this effort, there is almost certainly additional between-state variability for which we were not able to control, which may have impacted our outcomes positively or negatively.

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