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What determines the success of states in reducing alcohol related crash fatalities? A longitudinal analysis of alcohol related crashes in the U.S. from 1985 to 2019

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Abstract

In the United States, nearly 28 people die in alcohol-related motor vehicle crashes every day (1 fatality every 52 minutes). Over decades, states have enacted multiple laws to reduce such fatalities. From 1982 to 2019, the proportion of drivers in fatal crashes with a blood alcohol concentration (BAC) above 0.01 g/dl declined from 41% to 22%. States vary in terms of their success in reducing alcohol-related crash fatalities. The purpose of this study was to examine factors associated with changes in fatalities related to alcohol-impaired driving at the state level. We created a panel dataset of 50 states from 1985 to 2019 by merging different data sources and used fixed-effect linear regression models to analyze the data. Our two outcome variables were the ratio of drivers in fatal crashes with BAC ≥ 0.01 g/dl to those with BAC=0, and the ratio of those with BAC ≥ 0.08 g/dl to those with BAC<0.08 g/dl. Our independent variables included four laws (0.08 g/dl BAC per se law, administrative license revocation law, minimum legal drinking age law, and zero tolerance law), number of arrests due to impaired driving, alcohol consumption per capita, unemployment rate, and vehicle miles traveled. We found that the 0.08 g/dl per se law was significantly associated with lower alcohol-related crash fatalities while alcohol consumption per capita was significantly and positively associated with crash-related fatalities. Arrests due to driving under the influence (DUI) and crash fatalities were nonlinearly correlated. In addition, interaction of DUI arrests and two laws (0.08 g/dl BAC per se law, and zero tolerance) were significantly associated with lower crash-related fatalities. Our finding suggests that states which

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have more restrictive laws and enforce them are more likely to significantly reduce alcohol-related crash fatalities.

Keywords

Driving while intoxicated (DWI); DWI Laws; Arrests; Alcohol consumption

1. Background

Driving while intoxicated (DWI) has been a formidable public health challenge since the invention of the automobile. The first law to restrict drinking and driving in the United States was passed in New York State in 1910 (Ying et al., 2013) followed by California in 1911 (Freeman, 2007). In 1931, the first efforts were made to chemically measure the blood alcohol concentration (BAC) (Widmark, 1981) and research by Heise (Heise, 1934) linked alcohol consumption to crashes. This led to the development of the breathalyzer by Robert Borkenstein in the 1950s which was the first practical device to measure BAC using someone's breath (Fell & Voas, 2006). This device became the modern-day breathalyzer carried in law enforcement vehicles and used to measure BAC at the point of arrest. Although many states began to institute laws against alcohol-impaired driving in the 1950s, enforcement was limited, and laws were vague enough that many people evaded prosecution and conviction (Darnell, 2015).

This began changing in the 1980s with the formation of Mothers Against Drunk Driving (MADD) and its advocacy for enhanced enforcement and stricter laws (Fell & Voas, 2006). Over 500 alcohol related statutes were passed in the 10 years between 1980 and 1990 (Ross, 1990). MADD and other advocates lobbied state legislatures for strict laws and enforcement. The major laws promoted by MADD include minimum legal drinking age (MLDA), BAC per se legal limits, administrative license revocation (ALR), and zero tolerance laws. MLDA increased the drinking age from 18 in most states to 21 nationally. The 0.10 g/dl BAC per se law (here forward, BAC measured in g/dl) followed by 0.08 BAC per se law lowered the BAC limit from 0.15 in many states to 0.10 and 0.08, respectively. The ALR law allowed immediate revocation or suspension of the driver's license if a driver's BAC was above the legal limit. Zero tolerance law made it illegal to have any level of alcohol for those under 21 (Fell & Voas, 2006). Over time, severity of the fine for DWI and the punishment for those convicted increased, and the push was to have the public to collectively recognize that alcohol impaired driving was socially unacceptable and a criminal offense (Fell & Voas, 2006; Ross, 1990).

As a criminal offense, laws that were passed and enforced gave the perception that swift, certain, and severe punishment would be administered to those caught (Ross, 1990). In this criminal justice philosophical context, it is generally understood that if the cost of the crime is greater than the perceived benefit of the crime, this will deter people from committing the crime (i.e., general deterrence), and convince those caught not to recidivate (i.e., specific deterrence) (Ross, 1990). In addition, enforcement needed to be bolstered and the public needed to be aware of this enforcement (Fell et al., 2014) along with knowledge about the extent and severity of penalties for alcohol impaired driving.

Public awareness created by the alcohol impaired-driving activist movement and subsequent enactment and enforcement of DWI laws contributed to the considerable reduction of alcohol-related crash fatalities. From 1982 to 2019, the proportion of drivers in fatal crashes with a BAC above 0.01 declined from 41% to 22%. However, the proportion of total traffic fatalities involving a drinking driver have remained relatively constant over the last 20 years at about 30%. In 2019, 10,142 people died in alcohol-related crashes (nearly 28 fatalities every day equating to 1 fatality every 52 minutes) (National Center for Statistics and Analysis, 2021) and these deaths were preventable. States vary in terms of their success in reducing alcohol-related crash fatalities between 1985 and 2019 (Figure 1). For example, Oregon and Tennessee had the same proportion of drivers in fatal crashes with BAC≥ 0.01 in 1985 (i.e., 0.36). However, the proportion was reduced by 0.16 in Tennessee between 1985 and 2019 while it declined only by 0.07 in Oregon during the same period. Identifying state-level factors associated with reduction in alcohol-related crash fatalities can inform and assist policy makers in considering effective strategies to reduce these fatalities further in their respective states.

Past studies investigated the impact of multiple DWI laws on alcohol-related crash fatalities. State-level analyses showed that underage drinking laws (i.e., possession, purchase, use and lose, and zero tolerance), 0.08 BAC per se law, and administrative license revocation law, were significantly associated with lower alcohol-related crash fatalities (Fell et al., 2009; Fell & Scherer, 2017; Fell, Scherer, et al., 2015; Voas et al., 2000). The state-level analyses did not include the impact of DUI arrests. The effect of DUI arrests was mostly examined at community level. For example, studies of DUI arrests in approximately 30 communities showed that the number of traffic stops and DUI arrests per capita affect the odds of alcohol-impaired driving significantly (Fell et al., 2014; Fell, Waehrer, et al., 2015). A more recent longitudinal county-level study investigated the impact of enforcement on alcohol-related crash fatalities in the U.S. and showed that DUI arrests are nonlinearly related to alcohol-related crash fatalities (Stringer, 2019). In other words, increasing DUI arrests initially reduced related fatalities. However, there is a point of diminished returns in which an increase in DUI arrests predicted an increase in alcohol-related crash fatalities. None of these studies examined the joint effect of DUI arrests and alcohol-related laws. One can hypothesize that the combination of high DUI arrest rates and the enactment of DWI laws contribute to the reduction in alcohol-impaired crash fatalities.

The purpose of this study was to investigate factors associated with the reduction in alcohol-related crash fatalities across states between 1985 and 2019. Specifically, we merged multiple data sources to examine the joint effect of DWI laws and DUI arrests in states, controlling for per capita alcohol consumption, unemployment rate, and vehicle miles travelled. This study informs state policymakers about factors that are likely to reduce alcohol-related fatalities and shed lights on the effect of DUI arrests.

2. Methods

2.1. Data sources

2.1.1. Traffic fatalities—Number of drivers involved in fatal crashes by their BAC level for each state from 1985 to 2019 were obtained from the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS). FARS is a census of fatal traffic crashes within the 50 states, the District of Columbia, and Puerto Rico. Only crashes that resulted in the death of a motorist or a non-motorist within 30 days of the crash, and those that occurred on a trafficway customarily open to the public are recorded in FARS. A driver is counted as a drinking driver if they were tested and their BAC was positive (BAC ≥ .01). When the BAC of the driver is missing or the driver was not tested, the BAC level is imputed based upon the police assessment, time of the crash, gender, age, and other factors (Subramanian, 2002).

Alcohol-involved crashes are affected by factors such as road conditions, geographical situations, variations of policing policies, and other conditions that cannot be measured. To control for such factors, we use ratios as outcome variables similar to past studies (Tippetts & Voas, 2001). Our first outcome variable is ratio of drivers in fatal crashes with BAC≥0.01 to drivers in fatal crashes with BAC=0 (i.e., no alcohol) and the other one is the ratio of drivers in fatal crashes with BAC≥0.08 to those with BAC<0.08 (Fell & Scherer, 2017). To check if our results are sensitive to using these ratios as dependent variables, we reported results when dependent variables are the number of drivers in fatal crashes with BAC≥0.01 per 10,000 population, and number of drivers in fatal crashes with BAC≥0.08 per 10,000 population in Table 1A and 2A in the appendix.

2.1.2. Laws—Four laws, 0.08 BAC per se, administrative license revocation (ALR), minimum legal drinking age 21 (MLDA), and zero tolerance laws are included in this study. The BAC per se laws indicate the BAC level at which a driver is considered to be intoxicated by law. The 0.10 BAC per se law reduced the BAC limit from 0.15 to 0.10 and the 0.08 BAC per se law lowered the BAC limit to 0.08. The ALR law allows the enforcement system and the state department of motor vehicles (DMV) to suspend a driver's license arrested for DWI. The MLDA law prohibits individuals younger than 21 from possessing, purchasing, and using alcohol. The zero tolerance law makes it illegal to have any level of alcohol for those under 21. Variables related to these laws are operationalized as dummy variables in which the variable is 1 after effective date in each state and zero otherwise. For example, Alaska's 0.08 per se law went to effect in 2001 so the variable 0.08 BAC per se law is 1 in 2001 for Alaska and zero before 2001. A 1-year lag of these laws was used in the models to capture the impact of delays in enforcement and public perception of these laws.

The effective date of 0.08 BAC per se law for each state was obtained from the NHTSA website (National Highway Traffic Safety Administration, 2021). The effective date of ALR, MLDA, and zero tolerance laws came from Fell and colleagues' research on laws enacted between 1982 and 2012 (Fell & Scherer, 2017). We updated their dataset by reviewing the NHTSA's Digest of Impaired Driving's documents (National Highway Traffic Safety Administration, 2007, 2011, 2012, 2013, 2015, 2016, 2017).

2.1.3. Enforcement—

The number of arrests due to driving under influence for each state between 1985 and 2019 was obtained from the FBI's Crime Data Explorer (CDE). To calculate DUI arrests per 100 population, we divided total DUI arrests per year by the population of each state. The data were reported by participating law enforcement agencies and obtained from CDE. Some states had many missing values (e.g., Florida) or unreliable DUI arrest data (e.g., one arrest in Delaware in 1994). As a result, we exclude four states (i.e., Florida, Illinois, Alabama, and Delaware) from the regressions reported in Table 2 and 3, but showed the results when all 50 states are included in Table 3A and 4A in the appendix.

2.1.4. Environmental variables—

We controlled for multiple state-level factors that were identified as predictors of alcohol-related motor vehicle crashes by past research, including per capita alcohol consumption, vehicle miles travelled, and unemployment rate. Per capita alcohol consumption in each state was acquired from the National Institute on Alcohol Abuse and Alcoholism website (Slater & Alpert, 2021). Total vehicle miles traveled and unemployment rate were from the Federal Highway Administration and the U.S. Bureau of Labor Statistics, respectively. Log of total vehicle miles traveled was used in the regressions.

2.2. Statistical analyses

We used the entity and time fixed effects method to analyze the panel data (Stock & Watson, 2012). By including entity fixed effects (i.e., dummy variables for each state) in the regression, this method controls for unobservable factors that vary across states but are constant over time (e.g., religious views on alcohol). In addition, this method includes time effects (dummy variables for each year) to control for unobservable variables that change over time, but they are constant across states (e.g., changes in technology and vehicle safety features that made driving safer in all states) (Hosseinichimeh et al., 2016). We accounted for serial correlation within states by clustering standard errors at the state level. This is necessary for analyzing motor vehicle crash fatalities over time because the error terms of the regression are most likely correlated over time in a given state. For example, snowfall affects crashes and it is likely that the amount of snow in a given state is correlated over time, resulting in serial correlation of the error terms.

To account for the impact of delay in perceiving the laws and enforcement, we used a 1-year lag of laws and enforcement. In other words, we regressed DUI arrests per 100 at t-1 and law variables at t-1 against outcome variables. We ran six regression models for each of the two outcome variables (i.e., ratio of drivers in fatal crashes with BAC ≥ 0.01 to drivers in fatal crashes with BAC=0, and ratio of drivers in fatal crashes with BAC ≥ 0.08 to those with BAC<0.08). Model 1 regresses fatality ratios and four laws, model 2 includes DUI arrests per 100, model 3 adds squared DUI arrest per 100 to check if DUI arrests and alcohol-related fatalities are nonlinearly related, model 4 includes control variables, and model 5 and 6 add interactions of laws and DUI arrests. All analyses were conducted in Stata 14.

3. Results

Table 1 displays summary statistics of state-level variables during the study period. These estimates were not adjusted by population and should not be interpreted as national estimates. The mean of the first outcome variable (i.e., ratio of drivers in fatal crashes with BAC ≥ 0.01 to drivers in fatal crashes with BAC=0) across the entire time frame (1985-2019) was 0.40 which ranged between 0.11 and 1.34. This ratio is above 1 in a few states. For example, the number of drivers in fatal crashes with BAC≥0.01 in New Hampshire in 1986 was 135 while the number of drivers in fatal crashes with BAC=0 was 101 so the ratio was 1.34. The mean of the second outcome variable (i.e., ratio of drivers in fatal crashes with BAC ≥ 0.08 to those with BAC<0.08) was 0.31 which ranged between 0.09 and 0.75. On average, around 23,470 drivers were arrested for driving under influence annually per state. To account for population differences across states, we used DUI arrests per 100 population with a mean of 0.46 arrests per 100. Similarly, we used vehicle miles traveled per capita. The average per capita alcohol consumption and unemployment rates were 2.37 gallons and 0.05 respectively.

Table 2 presents the regression results for the first outcome variable (crash-fatality ratio BAC≥0.01/BAC=0.00) in 46 states. The first column shows the results when all four laws were included. Enactment of 0.08 per se law was significantly associated with a lower crash-fatality ratio. DUI arrests per 100 is included in Model 2. In model 3, we added the squared term of DUI arrests per 100 to check if this variable has a nonlinear relationship with the fatality ratio. One-year lag of laws and DUI arrests were used in the regression. In model 4, alcohol consumption per capita, unemployment rate, and the log of vehicle miles traveled per capita were included. The size of the 0.08 per se law effect changed slightly after including these variables but the level of significance did not change. Enactment of 0.08 per se law was associated with a reduction in the fatality ratio by 0.03. DUI arrests per 100 (p=0.067) and squared of DUI arrests per 100 (p=0.081) became significant after adding control variables (Model 4) which implies that DUI arrests and alcohol-related crash fatalities are nonlinearly related. The sign of the quadratic term is positive indicating that DUI arrests and fatality ratio are related by a convex function in which the minimum point can be found by taking the derivative of the function in Model 4 ($-0.118 \times Arrest + 0.099 \times Arrest^2$). In other words, increasing DUI arrests per 100 is associated with lower crash-fatality ratio until reaching a point ($\frac{0.118}{2 \times 0.099} = 0.59$ arrests per 100 or 59 DUI arrests per 10,000 population), then increasing DUI arrests does not predict a lower fatality ratio.

In addition, in model 4, alcohol consumption per capita was significantly correlated with the dependent variables. One-unit increase in per capita alcohol consumption from 2.37 (mean of per capita alcohol consumption) to 3.37 was associated with an approximate 0.07 increase in fatality ratio.

Model 5 presents the results when the interaction of the 0.08 BAC per se law and DUI arrests per 100 were included. The interaction of DUI arrests and the 0.08 per se law was negatively and significantly associated with the fatality ratio. Similarly, in model 6, the interaction of the zero tolerance law and DUI arrests was significant. The interactions of DUI arrests and the other two laws (MLDA and ALR laws) were not reported in Table 2 because they were not significant. Table 3A in the appendix shows the results when all 50 states are included in the regressions.

Figure 2.a depicts the scatter plot of the fatality ratio (BAC≥0.01/BAC=0.00) and quadratic prediction plot (the solid lines) without the 0.08 per se law (left panel) and with the 0.08 per se law (right panel). The y-axis is the fatality ratio and the x-axis is one-year lag of DUI arrests per 100 population. Compared to the left panel (without the 0.08 per se law), fatality ratios were lower in the right panel (with the 0.08 per se law). In addition, the fitted quadratic plot shows that increasing DUI arrests initially reduced the fatality ratio in the presence of the 0.08 per se law. The same results can be observed for the zero tolerance law in Figure 2.b.

Table 3 presents the regression results when the outcome variable is the second fatality ratio (ratio of drivers in fatal crashes with BAC ≥ 0.08 to those with BAC<0.08). Similar to the previous results, the 0.08 per se law was negatively and significantly associated with the fatality ratio (Model 1 in Table 3). In addition, the MLDA law was significantly correlated with the lower fatality ratio. Model 3 shows that DUI arrests were nonlinearly related to the fatality ratio. In model 4, in which control variables were included, both the 0.08 per se law ($p<0.01$), the MLDA law ($p<0.1$), and the DUI arrest variables were significant. In addition, a one-unit increase in per capita alcohol consumption from 2.37 (mean of per capita alcohol consumption) to 3.37 was associated with an approximate 0.054 increase in the fatality ratio. The unemployment rate was positively correlated with the fatality ratio (BAC≥0.08/BAC<0.08) but it was not significant in the previous regressions reported in Table 2. In model 5, the interaction of DUI arrests per 100 and the 0.08 per se law was negative and significant. Similarly, in model 6, the interaction of DUI arrests and the zero tolerance law was significant and negative. The interactions of the other two laws (i.e., MLDA and ALR) and DUI arrests were not significant (not shown in Table 3).

4. Discussion

We constructed a panel data of state-level factors to examine the association between alcohol-related crash fatalities and laws and enforcement, controlling for per capita alcohol consumption, vehicle miles travelled, and the unemployment rate. We used the entity and time fixed effects method which controls for unobserved variables that do not change over time in states (e.g., geographical conditions, religious views on alcohol) and for unobserved influences that change over time but are constant across states (e.g., technological enhancement and safety features in cars that made driving safer). We included four DWI laws (0.08 per se law, ALR, MLDA, and zero tolerance) because past research showed them to be effective in reducing some measure of alcohol-impaired driving. Only one of them (0.08 per se law) was significantly ($p<0.01$) associated with both fatality ratios (i.e., BAC≥0.01/BAC=0.00, and BAC≥0.08/BAC<0.08). MLDA was significantly associated with the second outcome variable, the fatality ratio (BAC≥0.08/BAC<0.08). Past studies showed that the effect size of laws diminishes over time. Fell and colleagues updated the analyses of MLDA laws by expanding the analyses of fatalities between 1982 and 2004 to

1982 to 2012 and found lower effect sizes from the same laws when the time frame of the analysis increased (Fell, Scherer, et al., 2015). They hypothesized that the greatest impact was achieved immediately after implementing the laws due to high media coverage and enforcement.

We also found that DUI arrests and fatality ratios were nonlinearly related. Increasing the DUI arrest rate reduced fatality ratios initially but there was a point after which more DUI arrests do not predict a reduction in fatality ratios. The mean DUI arrests per 100 was 0.28 per 100 in 2019 which is substantially below the estimated turning point (i.e., 0.59 arrests per 100). In fact, in 2019, DUI arrests per 100 in forty-four states was lower than 0.59 DUI arrests per 100. These states can reduce alcohol-related crash fatalities by enhancing their impaired driving enforcement.

Past studies have found mixed results on the association between DUI arrests and alcohol-related crash fatalities. Analysis of DUI arrests and alcohol-related crash fatalities in the 95 counties of Tennessee showed a non-significant relationship between the two variables (Dula et al., 2007), while a community-level analysis found a negative and significant association between them (Fell et al., 2014). A nationwide county-level study of DUI arrests and alcohol-related crash fatalities found a nonlinear relationship between DUI arrests and the fatalities in which more DUI arrests reduced related fatalities initially followed by an increase in fatalities (Stringer, 2019). Our result is consistent with this study. Stringer (2019) hypothesized that the nonlinear relationship between DUI arrest and alcohol-related crash fatalities might be due to the saturation effect in which higher level of punishment may not have any impact when the saturation point is reached. Although macro level analyses (state-level analysis in this study and county-level analysis in Stringer (2019)) are not suitable for drawing conclusions about individual’s behaviors, Stringer hypothesized that more DUI arrests above the saturation point might predict higher fatalities because a DUI arrest might reduce an individual’s perceived chance of future arrest and increase future DWI offending (Stringer, 2019). This further exemplifies the complexity of DWI as a public health challenge (Hosseinichimeh et al., 2022) and individual-level studies are needed to examine behavioral components of this problem (Vaca et al., 2021; Vaca et al., 2022).

We also found that interactions of DUI arrests and two laws (0.08 per se law and zero tolerance) were associated with lower fatality ratios ($p<0.01$) which implies that enactment of these two laws combined with high enforcement measured in DUI arrests was associated with lower alcohol-related crash fatalities.

We found a positive association between per capita alcohol consumption and alcohol-related crash fatality ratios. This variable is positive and significant in all regressions regardless of the choice of dependent variables (Table 2, Table 3, Table 3A, and Table 4A) or number of included states (46 states in Table 2 and 3, and 50 states in Table 1A and Table 2A). This finding is consistent with past studies. A study of states’ alcohol policy environments showed that more restrictive alcohol policy environments were associated with fewer alcohol-related crash fatalities among adolescents and young adults (Hadland et al., 2017). Figure 3 depicts the changes in fatality ratio ($BAC\geq0.01/BAC=0.00$) as well as changes in alcohol consumption in 50 states between 1985 and 2019. The change in the fatality ratio is color-coded and the change in per capita alcohol consumption is captured by numbers on the map. In sum, states with a higher reduction in per capita alcohol consumption experienced a higher reduction in fatality ratio.

The unemployment rate was positively associated but was not significant when the outcome variable was the first fatality ratio (BAC≥0.01/BAC=0.00). However, it became significant and positive in association after we applied the second fatality ratio (BAC≥0.08/BAC<0.08). Our result is consistent with the finding of another study in which a positive association between unemployment rate and the fatality ratio was reported (Fell, Scherer, et al., 2015). Other similar studies did not control for unemployment rate in their regressions (Fell & Scherer, 2017; Stringer, 2019). One may expect to find a negative association between the unemployment rate and alcohol-related crash fatality because as the unemployment rate increases, miles traveled (i.e., exposure) would decline, and consequently crash-fatalities might decline as well. We propose two hypotheses for finding a positive association between unemployment rate and the fatality ratios. First, although miles traveled may decrease due to unemployment, the alcohol-related crash fatalities may not decline because unemployment may increase the alcohol drinking and in turn increase alcohol-related crash fatalities. In fact, past studies showed that unemployment is significantly associated with being a heavy drinker and higher frequency of heavy drinking (Crawford et al., 1987; Mossakowski, 2008). Second, our dependent variables are not number of drivers in fatal crashes but they are the ratios of drivers in fatal crashes (BAC≥0.01/BAC=0.00 and BAC≥0.08/BAC<0.08). Thus, one explanation for finding a positive association here is that the unemployment rate would reduce the denominator of the ratio (drivers in fatal crashes with BAC=0) more than the numerator (drivers in fatal crashes with BAC≥0.01). In other words, if an increase in unemployment rate leads to greater decline in miles travelled and crashes for drivers with BAC=0 than drivers with BAC≥0.01, the unemployment rate would be positively associated with the fatality ratio.

5. Limitation

This study has multiple limitations. First, this analysis is ecologic and cannot adjust for individual-level characteristics such as driving skill, age, race, ethnicity, and socioeconomic status of the drivers in alcohol-related fatal crashes. Second, a limitation within our data affects our study. Some states had many missing values for DUI arrests or the numbers were unusually low. For example, there were many missing values for arrests in Florida and only one arrest in Delaware in 2004. Therefore, we excluded four states to reduce the likelihood of using inaccurate and unreliable data. Third, there are contextual factors (e.g., environmental, financial, policy level) that could alter enforcement of impaired driving that are not included in our analysis.

6. Conclusion

States vary in terms of their success in reducing alcohol-related crash fatalities. Enactment of 0.08 per se laws and a reduction of alcohol consumption per capita were significantly associated with lower alcohol-related crash fatalities. Although DUI arrests and crash-fatality ratios were nonlinearly correlated, DUI arrests per 100 population is below the turning point in many states and a stronger enforcement has the potential to reduce alcohol-related crash fatalities in these states. States that take a comprehensive approach and combine laws and enforcement, and adopt restrictive alcohol policies are more likely to reduce alcohol-related fatalities.

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Appendix

Table 1A:

Fixed effect regression models of alcohol-related crash fatalities when dependent variables are the number of drivers in fatal crashes with BAC≥0.01 per 10,000 population in 46 states

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
0.08 BAC per se law	−0.040**	−0.042***	−0.040***	−0.028*	0.059	−0.024
ALR law	−0.014	−0.007	−0.012	0.003	0.006	0.006
MLDA law	0.033	0.029	0.028	−0.008	−0.002	−0.002
Zero Tolerance	−0.026	−0.029	−0.027	−0.035	−0.032	0.037
DUI arrest per 100		0.084	−0.243**	−0.326**	−0.177	−0.154*
DUI arrest per 100^2			0.269***	0.289***	0.222**	0.200**
Alcohol consumption per capita				0.246***	0.252***	0.253***
Unemployment rate				0.357	0.269	0.351
Vehicle miles traveled per capita (log)				0.033	0.030	0.030
(BAC 0.08 illegal limit)×(DUI arrest per 100)					−0.167***	
(Zero Tolerance)×(DUI arrest per 100)						−0.141**
Overall R^2	0.358	0.379	0.372	0.285	0.278	0.274
Within R^2	0.697	0.700	0.705	0.734	0.740	0.740
Number of observations	1,540	1,540	1,540	1,540	1,540	1,540

* p-value <0.1,

** p-value <0.05,

*** p-value <0.01

Table 2A:

Fixed effect regression models of alcohol-related crash fatalities when number of drivers in fatal crashes with BAC≥0.08 per 10,000 population in 46 states

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
0.08 BAC per se law	−0.040**	−0.039***	−0.036***	−0.027*	0.046*	−0.023
ALR law	−0.008	−0.002	−0.007	0.005	0.008	0.008
MLDA law	0.021	0.018	0.017	−0.010	−0.005	−0.006

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Zero Tolerance	−0.024	−0.027	−0.025	−0.031	−0.029	0.027
DUI arrest per 100		0.062	−0.248***	−0.320***	−0.195*	−0.180
DUI arrest per 100^2			0.255***	0.274***	0.218**	0.201**
Alcohol consumption per capita				0.210***	0.216***	0.216***
Unemployment rate				0.477	0.403	0.471
Vehicle miles traveled per capita (log)				0.024	0.022	0.022
(BAC 0.08 illegal limit)×(DUI arrest per 100)					−0.141***	
(Zero Tolerance)×(DUI arrest per 100)						−0.115**
Overall R^2	0.340	0.358	0.350	0.259	0.252	0.420
Within R^2	0.687	0.690	0.697	0.725	0.731	0.573
Number of observations	1,540	1,540	1,540	1,540	1,540	1,540

* p-value <0.1,

** p-value <0.05,

*** p-value <0.01

Table 3A:

Fixed effect regression models of alcohol-related crash fatalities when dependent variable is drivers in fatal crashes with BAC>0.01 / Drivers in fatal crashes with BAC=0 in 50 states

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
0.08 BAC per se law	−0.028***	−0.028***	−0.027***	−0.025**	0.026	−0.023**
ALR law	−0.011	−0.010	−0.012	−0.011	−0.008	−0.007
MLDA law	−0.030	−0.031	−0.031	−0.029	−0.025	−0.025
Zero Tolerance	−0.017	−0.017	−0.017	−0.018	−0.016	0.033
DUI arrest per 100		0.012	−0.081	−0.118**	−0.016	0.015
DUI arrest per 100^2			0.078*	0.101**	0.051	0.029
Alcohol consumption per capita				0.073***	0.071***	0.073***
Unemployment rate				0.620	0.532	0.579
Vehicle miles traveled per capita (log)				−0.088	−0.077	−0.078
(BAC 0.08 illegal limit)×(DUI arrest per 100)					−0.105***	
(Zero Tolerance)×(DUI arrest per 100)						−0.103***
Overall R^2	0.358	0.358	0.360	0.422	0.425	0.420
Within R^2	0.552	0.553	0.555	0.565	0.575	0.573
Number of observations	1,649	1,649	1,649	1,649	1,649	1,649

* p-value <0.1,

** p-value <0.05,

*** p-value <0.01

Table 4A:

Fixed effect regression models of alcohol-related crash fatalities when dependent variable is drivers in fatal crashes with BAC>0.08 / Drivers in fatal crashes with BAC<0.08 in 50 states

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
0.08 BAC per se law	−0.020***	−0.02***	−0.019**	−0.018**	0.019	−0.017**
ALR law	−0.006	−0.006	−0.007	−0.007	−0.005	−0.004
MLDA law	−0.028*	−0.028*	−0.028*	−0.024*	−0.021	−0.021
Zero Tolerance	−0.014	−0.014	−0.014	−0.015	−0.014	0.021
DUI arrest per 100		0.001	−0.079*	−0.109**	−0.034	−0.015
DUI arrest per 100^2			0.068*	0.087**	0.051	0.036
Alcohol consumption per capita				0.057***	0.055***	0.057***
Unemployment rate				0.639**	0.574**	0.610**
Vehicle miles traveled per capita (log)				−0.071	−0.063	−0.065
(BAC 0.08 illegal limit)×(DUI arrest per 100)					−0.077***	
(Zero Tolerance)×(DUI arrest per 100)						−0.073***
Overall R^2	0.329	0.329	0.330	0.359	0.361	0.356
Within R^2	0.538	0.538	0.541	0.554	0.565	0.562
Number of observations	1,649	1,649	1,649	1,649	1,649	1,649

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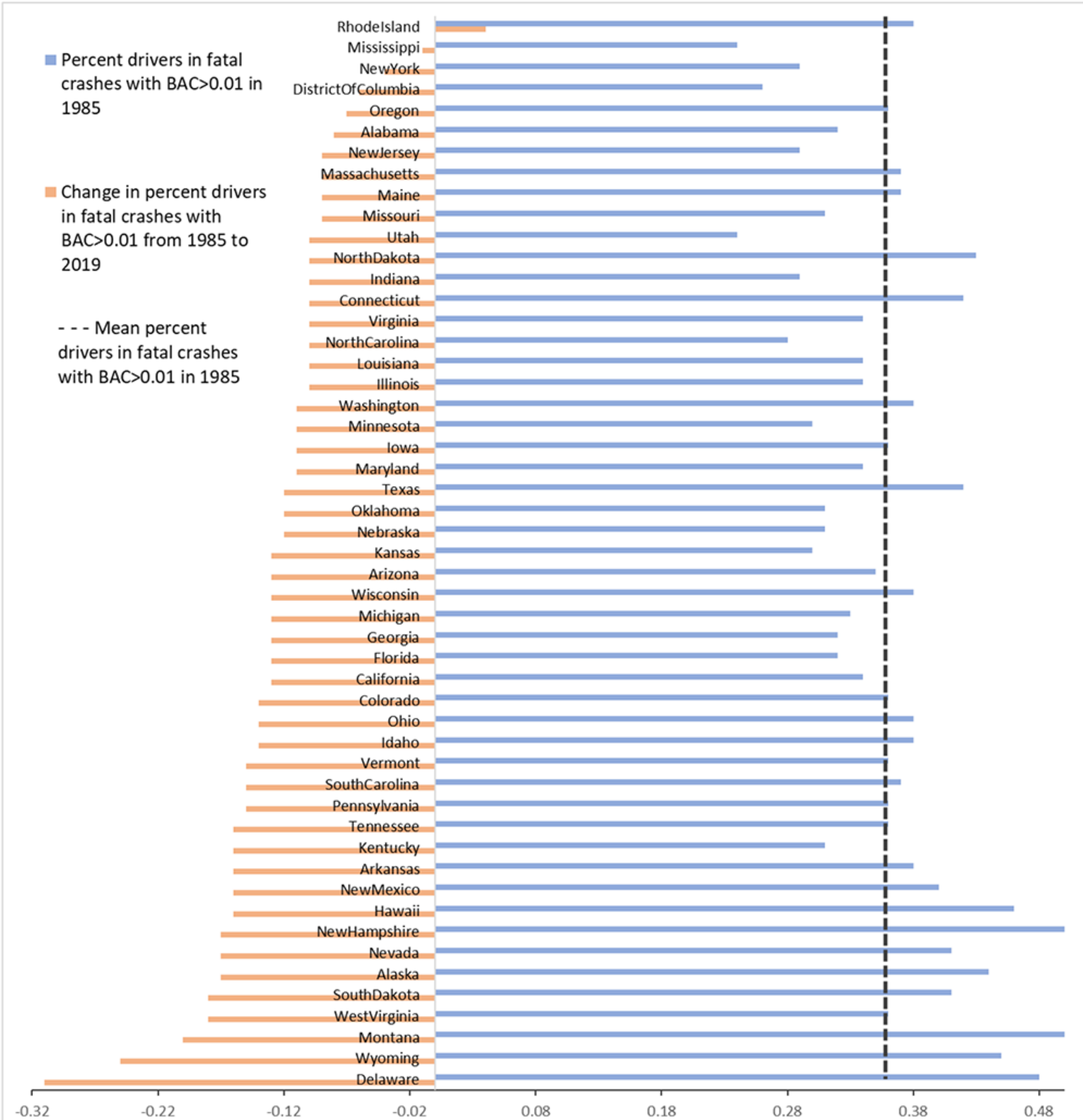

Figure 1.

Proportion of drivers in fatal crashes with BAC≥ 0.01 in 1985 (right bar chart), Change in proportion of drivers in fatal crashes with BAC≥ 0.01 from 1985 to 2019 (left bar chart), and mean proportion of drivers in fatal crashes with BAC≥ 0.01 in 1985 (dashed line). The mean was not adjusted by population and it is 0.36.

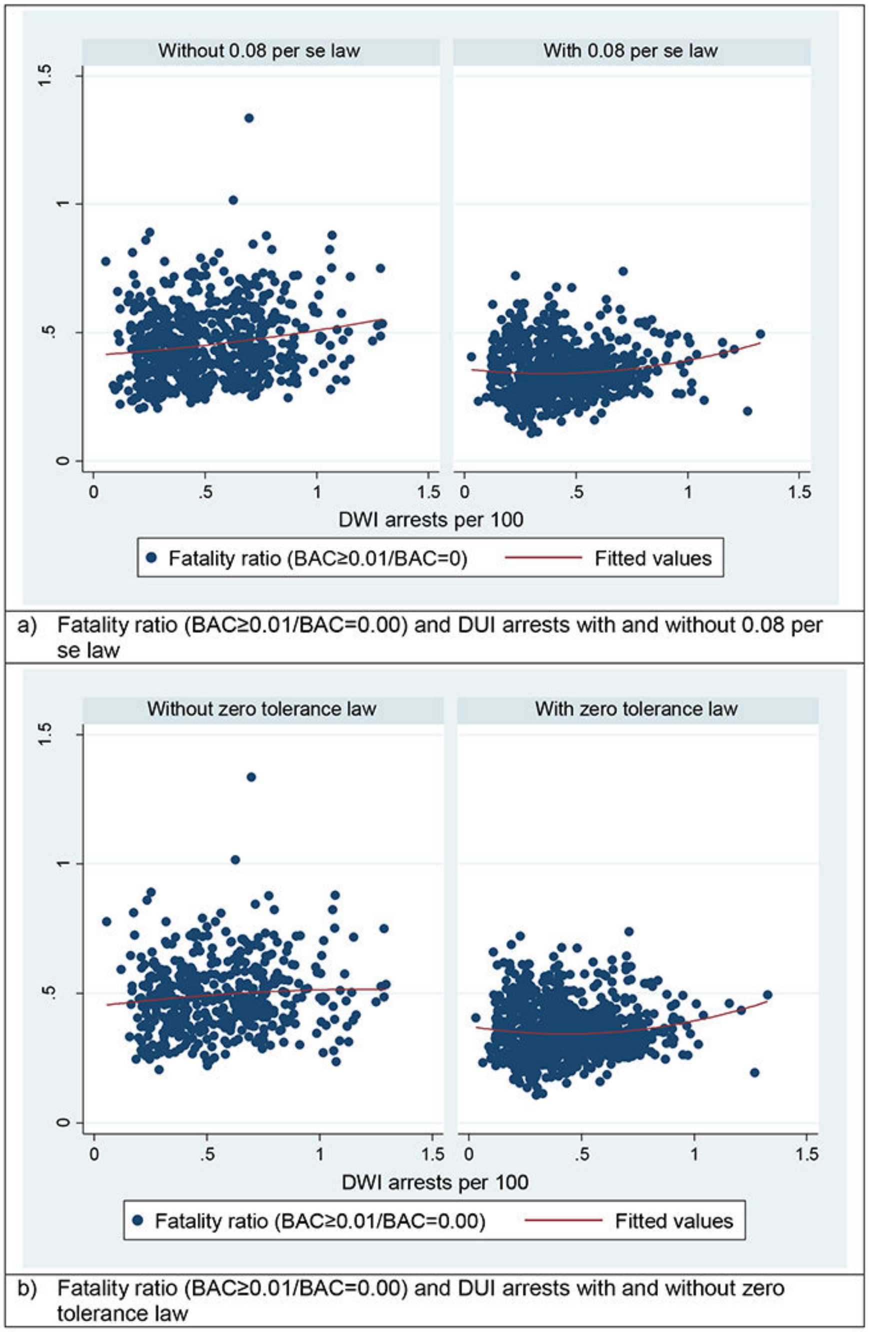

Figure 2.

Scatter plot of the fatality ratio (BAC≥0.01/BAC=0.00) and quadratic prediction plot (the solid lines)

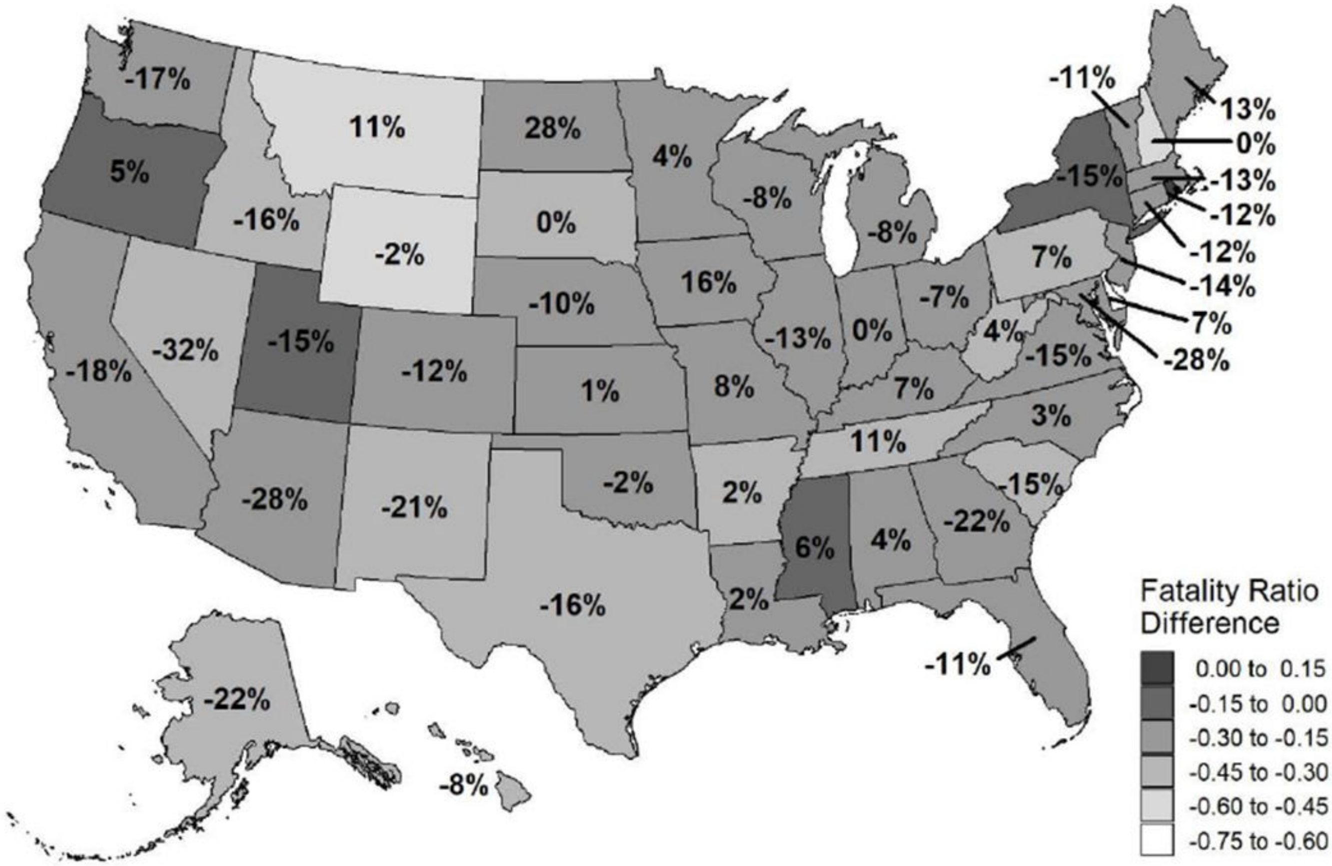

Figure 3.

Change in fatality ratio, BAC≥ 0.01/BAC=0 from 1985 to 2019. Numbers reported on the map are changes in per capita alcohol consumption.

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Table 1:

Summary statistics for 46 states from 1985 to 2019

Variables	Mean	Standard deviation	Minimum	Maximum
BAC≥0.01/BAC=0.00	0.40	0.13	0.11	1.34
BAC≥0.08/BAC<0.08	0.31	0.10	0.09	0.75
DUI Arrest annually per state	23,470	34,542	406	348,954
DUI Arrest per 100 population	0.46	0.22	0.03	1.33
Vehicle miles traveled per capita	9,882	1,862	5,088	18,296
Alcohol consumption per capita	2.37	0.53	1.19	4.99
Unemployment rate	0.05	0.02	0.02	0.14

Table 2:

Fixed effect regression models of alcohol-related crash fatalities when the dependent variable is the number of drivers in fatal crashes with BAC>0.01 / the number of drivers in fatal crashes with BAC=0 in 46 states

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
0.08 BAC per se law	−0.033***	−0.033***	−0.033***	−0.030***	0.025	−0.027**
ALR law	−0.009	−0.008	−0.009	−0.009	−0.007	−0.006
MLDA law	−0.028	−0.029	−0.029	−0.029	−0.025	−0.025
Zero Tolerance	−0.018	−0.018	−0.017	−0.018	−0.017	0.038
DUI arrest per 100		0.012	−0.086	−0.118*	−0.024	0.015
DUI arrest per 100^2			0.081	0.099*	0.057	0.030
Alcohol consumption per capita				0.072***	0.076***	0.077***
Unemployment rate				0.662	0.606	0.656
Vehicle miles traveled per capita (log)				−0.067	−0.069	−0.070
(BAC 0.08 illegal limit)×(DUI arrest per 100)					−0.106***	
(Zero Tolerance)×(DUI arrest per 100)						−0.110***
Overall R^2	0.355	0.355	0.357	0.437	0.433	0.428
Within R^2	0.549	0.549	0.551	0.560	0.570	0.569
Number of observations	1,540	1,540	1,540	1,540	1,540	1,540

* p-value <0.1,

** p-value <0.05,

*** p-value <0.01

Table 3:

Fixed effect regression models of alcohol-related crash fatalities when the dependent variable is the number of drivers in fatal crashes with BAC>0.08 / the number of drivers in fatal crashes with BAC<0.08 in 46 states

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
0.08 BAC per se law	−0.025***	−0.025***	−0.024***	−0.023***	0.017	−0.021**
ALR law	−0.003	−0.003	−0.004	−0.004	−0.003	−0.002
MLDA law	−0.027*	−0.027*	−0.028*	−0.025*	−0.022*	−0.022*
Zero Tolerance	−0.015	−0.015	−0.014	−0.015	−0.014	0.024
DUI arrest per 100		−0.000	−0.097**	−0.121**	−0.053	−0.028
DUI arrest per 100^2			0.079**	0.094**	0.064	0.046
Alcohol consumption per capita				0.054***	0.057***	0.058***
Unemployment rate				0.679**	0.638**	0.675**
Vehicle miles traveled per capita (log)				−0.045	−0.046	−0.047
(BAC 0.08 illegal limit)×(DUI arrest per 100)					−0.077***	
(Zero Tolerance)×(DUI arrest per 100)						−0.077***
Overall R^2	0.327	0.327	0.328	0.383	0.376	0.370
Within R^2	0.536	0.536	0.540	0.551	0.561	0.560
Number of observations	1,540	1,540	1,540	1,540	1,540	1,540