Effect of Open Container Laws (OCL) on Alcohol-Related Fatalities in U.S. States

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Contents

Background

- The National Highway Traffic Safety Administration (NHTSA) reports that about 37 individuals died daily from motor vehicle traffic crashes involving drunk drivers with at least .08 BAC, translating to 32% (or 13,524 persons) drunk-driving deaths in 2022.

- Open container laws (OCL) prohibit drivers from possessing open (or broken seal) alcohol (beer, wine, distilled spirit, mixed drinks, and other alcoholic ingredients) containers within readily accessible areas in a vehicle such as the passenger seat.

- OCL exclude limousines, taxis, public party buses, motor homes, campers where passengers have restricted access to drivers while vehicles are in motion.

Motivation

- OCL varies across the U.S. in terms of passengers possessing or consuming alcoholic drinks.

- Specifically, 8 U.S. states have OCL exceptions for drinking: Alaska, Connecticut, Delaware, Mississippi (no fine for violation), Missouri, Rhode Island, Tennessee, Virginia (but this can create a debatable presumption that the driver was also drinking unless the driver proves otherwise) where passengers can possess and consume alcohol in at least 12-person capacity ”for-hire” vehicles , but otherwise there is penalty of at least a fine and possible jail-time. Moreover, no drinking but possessing alcohol in Arkansas and West Virginia.

Research Question

I seek to explore the following question:

- What are the effect of the Open Container Laws (and its exemption in certain states) on alcohol-related vehicle fatalities in U.S. states over time?

  ⇒ About 80% (or 41 out of 51 states) of U.S. states enforce the OCL for encouraging safe driving but since the very first implementation in 1998, not all states have implemented this law. Hence, are multiple Driving Under the Influence (DUI) policies complements or substitutes. Do political influence and/or societal push-backs exist?

  ⇒ This has public safety and life expectancy implications.

Prior Evidence

- Differences in environments with minimum legal drinking age (MLDA) via OLS regression was associated with greater drinking and related fatalities for adult males but insignificant effects for youths and adult females aged 18-20 from 1995-2005 (Kaestner and Yarnoff, 2011).

- Via quantile regression, preventive measures for combatting drunk driving should differ for locations with low versus fatality rates such that local conditions including people's alcohol-related attitudes and habits should be emphasized for low quantile areas while ex-post regulations are better for high quantile places (Ying, Wu and Chang, 2013).

- Panel generalized least squares (GLS) with regional and state-specific time effects show that higher beer taxes and zero tolerance laws were the most effective traffic policies in reducing alcohol-related fatalities across US regions (Chang, Wu, and Ying, 2012)

- Erickson et al. (2015): 2 national surveys with 48 out of 49 state patrols and 1,082 out of 1,631 sampled local law enforcement agencies based on jurisdiction's population size. Chi-square test revealed that most agencies reported saturation patrols (96%) followed by sobriety checkpoints (73%) with less than 50% for OCLs. By contrast, bivariate and multivariate analysis for the local agencies revealed much smaller proportion (63%, 42% and 41% respectively) of mitigating alcohol-involved car fatalities. Interestingly, sobriety checkpoints were more common in the dry South region such that agencies in areas with very common drinking-driving occurrences were likely to enforce multiple impaired driving laws.

- Existing studies were done using a few select states or using back-dated data as this study intends to use more recent data to examine how up-to-date OCLs have affected alcohol-related car fatalities.

Contribution

- Use more recent data (up till year 2020) to account for recent OCL influences on alcohol-related vehicle fatalities.
- Accounts for later-treated states.
- Factors in treatment heterogeneity using a more novel analytical technique - Staggered (Stacked) DID.
- More granular heterogeneity analysis is conducted by race, age, and gender sub-groups as an improvement on current studies rather than merely controlling for these variables

Data Sources

- Data on the implementation of OCL is gotten from the Alcohol Policy Information System (APIS) and Alcohol National Conference of State Legislatures; where OCL as the main regressor is either 1 or 0 for whether a given U.S. state has enacted the law or not.

- The outcome variable, gotten from the Fatality Analysis Reporting system (FARS) with up till 2021 data, is captured by MV alcohol-related fatality (note that is analyzed both as a count data using panel Poisson and OLS regression using alcohol-related fatality counts per 100,000 population).

- Moreover, individual covariates from the same FARS Accident, Person, and Alcohol Multiple Imputation Crash versus Person data are sex, age, race, weather, speed limit, previous dwi among others. Others are time trend for national variations over time, and state dummies.

Data Sources

- Other potential controls include state-related traffic laws (Blood Alcohol Concentration (BAC) limits, DUI, false ID, sobriety, consent, and penalty laws compiled from responsibility.org); graduated drivers licensing night & passenger restriction from Harper & Strumpf (2017); per capita ethanol & alcohol consumption from the National Institute on Alcohol Abuse and Alcoholism (NIAAA), legalized marijuana for recreation & medical purposes from MJBizDaily (2023), and regional variations.
- Additional state time-varying factors include income and unemployment from the Bureau of Labor Statistics (BLS) as well as population density (from which rural-urban residence is generated from the Census Bureau). Notably, this version of results were done using only the basic two-way fixed effects (TWFE) which has proven sufficient in controlling for confounding factors.
- For robustness checks, the results will be segmented for different gender (male versus female) categories, age groups (young dependents 0-17 years; working age 18-64 years; and old dependents 65+ years), region classifications, rural & urban residence via 1,000 population density, previous DWI, as well as by white and non-white racial groups based on data availability.

- Given the heterogeneous treatment years from 1998 to 2017, we use the Callaway & Sant'Anna's (CS) staggered Difference-in-Difference (DID) event study as the econometric method of analysis, which is complemented with the Stacked DID method (Bleiberg, 2021; Miller, 2023; Wing, Freedman and Hollingsworth, 2024) for robustness checks.
- The Staggered Difference-in-Difference (CSDID) by Callaway & Sant'Anna (2021) follows the basic static TWFE DID model:

$$Y_{st} = \alpha + \beta OCL_{st} + \mu_s + \tau_t + \epsilon_{st} \ldots\ldots (3.1)$$

- to account for heterogeneity in treatment (i.e., multiple treatment periods). This model is depicted as follows:

$$Y_{st} = \alpha + \beta_1 OCL_{st} + \beta_2 Post_{st} + \beta_3 OCL_{st} * Post_s + \beta_4 X_{st} + \mu_s + \tau_t + \epsilon_{st} \ldots\ldots (3.2)$$

- Which depicts the outcome variable (Y_{st}), and OCL_{st} represents the treatment dummy being in the post-period ($Post_{st}$), and the interaction term respectively for states s and time t. X_{st} and ϵ are the vector of covariates and residual term at the state-level over time while μ_s and τ_t are the state and year (for standard two-way) fixed effects.

- Furthermore, the dynamic DID which accounts for the leads and lags are also executed where the dummy being in the post-period is replaced by indicators of being in years $-K$ through $+L$ relative to the treatment year j which is the excluded reference period, in this case, 0:

$$Y_{st} = \sum_{(j=-K,j-s)}^{L} {}_jT_{sj} + \mu_s + \tau_t + \epsilon_{st} \ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

- Additionally, stacked DID pools/stacks data from different treatment cohorts that are treated at different times into a single dataset with including multiple treatment cohorts and a control group such that the treatment timing is aligned for a unified analysis.

- Using both staggered and stacked DID is justified due to their more plausible approach in addressing varying treatment times for DID analysis although with different model specifications applicable to various data structures.

- For descriptive statics, the main regressor – OCL1,2,3 as a binary variable has a mean that is closer to 1 suggesting that most U.S. states are fully OCL compliant. Demographically, more respondents tend to be male than female on average alongside a mean of 44 years (age). Meanwhile, the average race are non-Hispanics with almost 2 persons in the car and 2 persons not in the car of the drunk driver involved in MV crash.

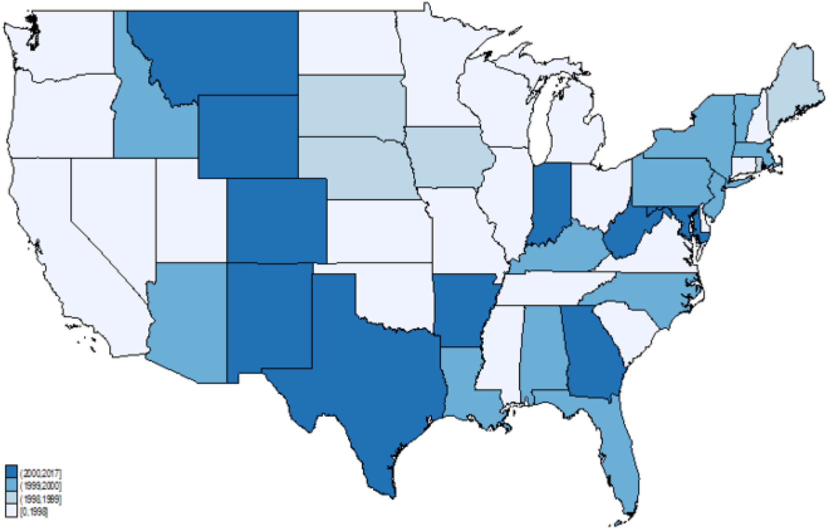
- Most persons involved in car crashes either used seat belts or helmets improperly. On average, the outcome variable shows less than 1 drunk driver was involved in fatal crashes with more than 1 number of fatally injured persons with severity level above 4.

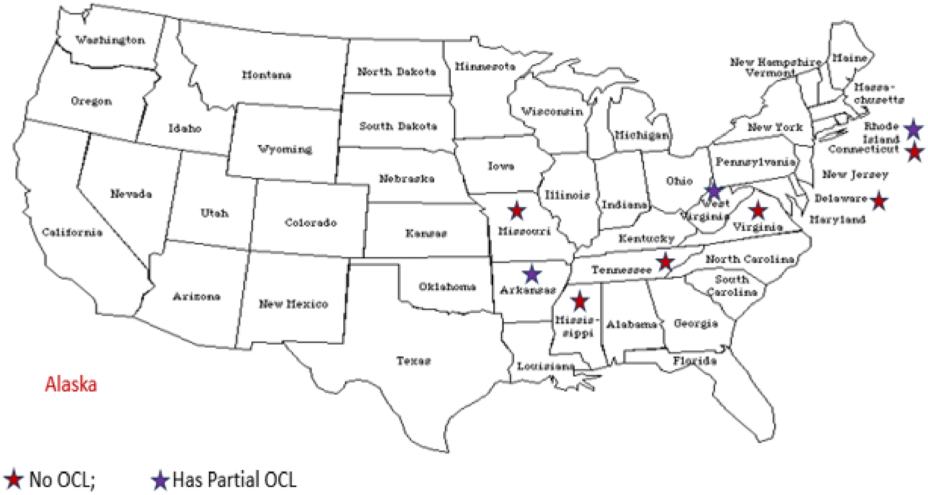
Table 1a: Heterogeneity Treatment Across U.S. States

State Code	State	Treatment Year	Penalty	State Code	State	Treatment Year	Penalty
1	Alabama	Q3 2000	Fine	27	Montana	Q4 2005	Fine
2	Alaska	Never Treated	Fine	28	Nebraska	Q3 1999	Fine
3	Arizona	Q3 2000	Fine & likely jail time	29	Nevada	1998	Fine & likely jail time
4	Arkansas	Q3 2017	Fine & likely jail time	30	New Hampshire	1998	Fine & license suspension
5	California	1998	Fine	31	New Jersey	Q3 2000	Fine & likely community service
6	Colorado	Q3 2005	Fine	32	New Mexico	Q2 2001	Fine & likely jail time, license suspension
7	Connecticut	Never Treated	Fine & likely jail time	33	New York	Q3 2000	Fine
8	Delaware	Never Treated	Fine	34	North Carolina	Q3 2000	Fine & likely jail time
9	District of Columbia	1998	Fine & likely jail time	35	North Dakota	1998	Fine
10	Florida	Q4 2000	Fine	36	Ohio	1998	Fine & likely jail time
11	Georgia	Q3 2001	Fine	37	Oklahoma	1998	Fine & likely jail time
12	Hawaii	Q2 2000	Fine & likely jail time	38	Oregon	1998	Fine
13	Idaho	Q3 2000	Fine & likely jail time	39	Pennsylvania	Q3 2000	Fine & likely jail time
14	Illinois	1998	License suspension	40	Rhode Island	Q3 1999	Fine & likely license suspension
15	Indiana	Q3 2005	Fine	41	South Carolina	1998	Fine & likely jail time
16	Iowa	Q3 1999	Fine	42	South Dakota	Q3 1999	Fine & likely jail time
17	Kansas	1998	Fine & likely jail time	43	Tennessee	Never Treated	Fine
18	Kentucky	Q4 2000	Fine & likely jail time	44	Texas	Q3 2001	Fine
19	Louisiana	Q2 2000	Fine	45	Utah	1998	Fine & likely jail time
20	Maine	Q3 1999	Fine	46	Vermont	Q2 2002	Fine
21	Maryland	Q3 2002	Fine	47	Virginia	Never Treated	Fine & likely jail time
22	Massachusetts	Q4 2000	Fine	48	Washington	1998	Fine
23	Michigan	1998	Fine, likely jail time & license points	49	West Virginia	Q2 2015	Fine & likely jail time
24	Minnesota	1998	Fine & likely jail time	50	Wisconsin	1998	Fine
25	Mississippi	Never Treated	N/A	51	Wyoming	Q3 2007	Fine & likely jail time
26	Missouri	Never Treated	Fine	9 Treatment Periods: 1998, 1999, 2000, 2001, 2002, 2005, 2007, 2015, 2017. 7 states were never treated.			

Source: Alcohol Policy Information System (APIS), from National Institutes of Health (NIH): National Institute on Alcohol Abuse and Alcoholism (NIAAA); Bieber & Ramirez (2023).

Figure 1a: Map of U.S. States showing Heterogeneity by OCL Treatment Period




Washington
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Minnesota
Oregon
Idaho
Wyoming
South Dakota
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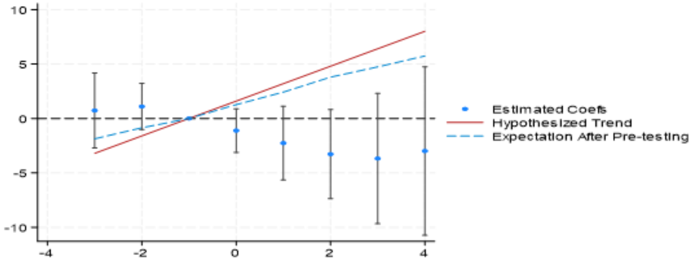
Virginia
Kansas
Missouri
Kentucky
North Carolina
Tennessee
South
Carolina
Arizona
New Mexico
Oklahoma
Arkansas
Missis-
sippi
Alabama
Georgia
Texas
Louisiana
Florida
Alaska
No OCL;
Has Partial OCL

Table 2: Summary Statistics of Raw Data

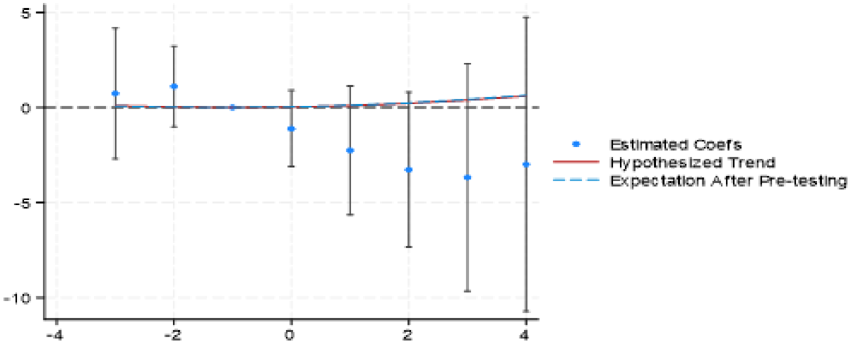
Variable	Definition, Mean, SD	Source
Drunk_dr (Y_{st})	Number (sum) of drunk drivers involved in fatal crash 0+, 587.91, 675.52	FARS (1990-2021)
rdrunk_dr (Y_{st})	Ratio of drunk drivers per 100,000 population in fatal crash 0+, .33, .55	FARS (1990-2021)
OCL1 ($T1_{st}$)	General: no OCL vs partial/fully compliant OCL, .568, .496	APIS (1998-2022)
OCL2 ($T2_{st}$)	Strict: Partial/no OCL vs fully compliant, .548, .498	
OCL3 (T_{st})	Has OCL but with or without Alcohol Consumption, .554, .497	
Fatals	Number of fatally injured persons in a crash with injury severity >=4, 1.19, .62	FARS Accident Crash (1990-2021)
Deaths	Number of deaths for the entire MV crash, 545,818.3, 6.52e+08	
Dr_drink	If driver involved in crash was drinking, .2, .4	
Drinking	Judgement-based police reported alcohol involvement, 4.3, 4.0	
Alc_det	Police method of determining alcohol, 7.9, 2.5	
Prev_dwi	Any previous DWI convictions for this driver that occurred within 3 years of the crash date, 5.6, 42.2	
Year Month/Hour	Month/year/hour in which the crash occurred (2004.2, 8.9); (6.7, 3.35); (13.4, 8.86)	
Persons	Number of motor vehicle occupants, 3.9, 4.47	FARS Person (1990-2021)
Per_no	The number of forms submitted for persons in motor vehicles, 1.7, 1.88	
Per_type	The number of forms submitted for persons not in motor vehicles, i.e., number of non-MV occupants, 1.7, 1.2	
Age	Age of person involved in crash, 44.4, 83.8	
Sex	Sex of person involved in crash, 1.45, 1.04	
Rest_use	The restraint equipment in use by the occupant, or the helmet in use by a motorcyclist, at the time of the crash, 12.7, 28.7	
Hispanic	Hispanic origin of persons in crash from death certificate, 8.6, 23.6	
A1-A10	10 plausible crash-blood alcohol concentration (BAC) values, 6.4, 9.7	FARS Alcohol Multiple Imputation Crash (MIACC)

Figure 2b: Proving Parallel Trends Via Reghdfe for Linear Regressions



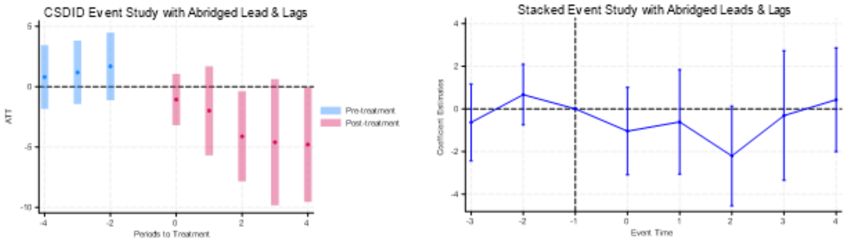
- Using standard Stata "reghdfe" command for linear regression with high-dimensional multiple FE sets to control for unobserved heterogeneity and the robust standard errors option (which is the default stacked DID regression method), the "pretrends" command verifies that the parallel trends assumption is satisfied.

- Here, if r(Slope) i.e., the linear pre-trend slope was 0.9395, there would be significant pre-trend only half of the time or with r(Power)=0.5. Thus, given that the linear pre-trend slope > .05, we can safely ascertain that the pre-trend estimates are insignificant.



To further verify if a non-linear relationship exists over time, we plot the quadratic graph using prior estimates and as seen below, the possibility of a non-linear relationship of OCL trends is statistically insignificant over time, hence we focus on the existent linear relationship with insignificant pre-trends and significant post-trends.

Figure 3: Staggered & Stacked DID Event Study for the Abridged Timeframe



For staggered DID in Figure 3 and Table 3a, the parallel trend assumption is satisfied with insignificant pre-trends before the OCL adoption across states followed by a downward trend post-treatment that is statistically significant at the 5% level in years 2 and 4.

Table 3a: Staggered & Stacked DID Event Study with Abridged Timeframe

VARIABLES	CSDID	Stacked DID
	(1) rdrunk_dr	(2) rdrunk_dr
Pre_avg	1.08	
	(1.19)	
Post_avg	-3.21*	
	(1.65)	
-4	.68	
	(1.24)	
-3	1.05	-.56
	(1.20)	(.86)
-2	1.51	.54
	(1.29)	(.73)
0	-.98	-.91
	(.97)	(1.01)
1	-2.27	-.70
	(1.68)	(1.23)
2	-3.66**	-2.11*
	(1.76)	(1.18)
3	-4.18*	-.04
	(2.45)	(1.48)
4	-4.95**	.60
	(2.41)	(1.16)
Constant		13.26***
		(1.01)
Adj R^2		0.79

- Note that the mean of the drunk-related fatality rate for treated states is 14.52. Following insignificant positive pre-trends, the states that implemented OCL experienced approximately 22% (i.e., -3.21/14.52= -0.22) significant less alcohol-related deaths per 100,000 people after the year of implementation, ceteris paribus. However, this significant effect seemingly persists over time with 25% and 34% reduced drunk driving fatalities 2 years and 4 years post-treatment.

- For complementarity purposes, stacked DID is also done which shows similar but weaker post-treatment effect of reduced alcohol related traffic deaths. Notice that stacked DID also mirrors the CSDID results with insignificant pre-trends such that OCL mitigates drunk driving deaths, and this is significant 3 years after the treatment.

Table 3b: CSDID and Stacked DID

VARIABLES	(1) Least Squares CSDID rdrunk_dr	(2) Least Squares CSDID rdrunk_dr	(3) Least Squares CSDID rdrunk_dr
1.interaction(post##OCL1)	-1.08		
	(1.65)		
1.interaction2(post##OCL2)		-1.01	
		(1.66)	
1.interaction3(post##OCL3)			-1.32
			(1.59)
Constant	12.78***	12.73***	12.89***
	(0.88)	(.85)	(.82)
Observations	1,530	1,530	1,530
R-squared	0.73	0.73	0.73

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

As can be seen in Table 3b, the Least Squares (LS) CSDID reveals insignificant negative post-treatment effect of OCL adoption on drunk-driving fatalities in US for the various forms of OCL adoption. This implies that those US states who enacted OCL did not experience sustained overall effect in reducing drunk-driving deaths over time.

Robustness Checks

Figure 4: CSDID Heterogeneity Analysis - by Gender and Age

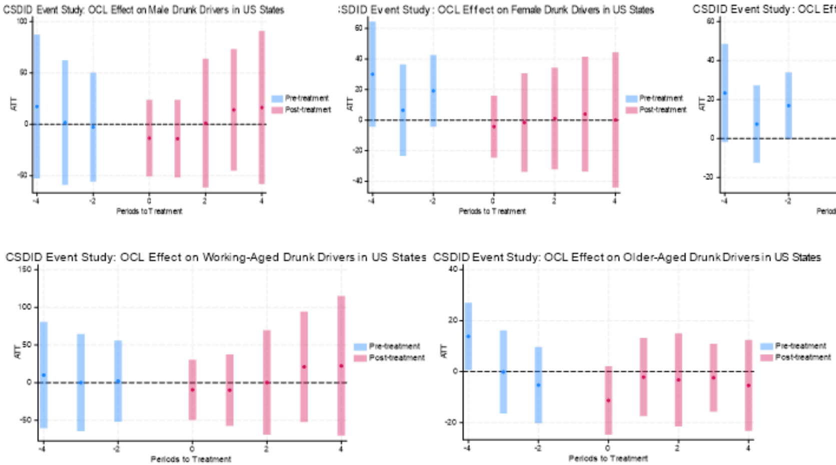


Table 5: CSDID Heterogeneity - by Race, Residence & Previous DWI

VARIABLES	(1) rdrunk_dr Whites	(2) rdrunk_dr Non-Whites	(3) rdrunk_dr Rural Residence	(4) rdrunk_dr Urban Residence	(5) rdrunk_dr No Previous DWI	(5) rdrunk_dr Previous DWI
Pre_avg	3.69*	4.15	1.03	-.54	36.23	-5.82
	(2.10)	(4.50)	(1.21)	(.58)	(38.32)	(4.51)
Post_avg	-1.01	-6.13	-3.04*	-4.73*	10.48	-.15
	(1.41)	(4.75)	(1.66)	(2.98)	(30.11)	(4.23)
-4	4.34*	6.81*	.71	-2.33	59.59	-4.44
	(2.23)	(4.35)	(1.26)	(.67)	(45.99)	(5.10)
-3	3.83*	3.61	.92	.77	20.70	-8.11
	(2.18)	(5.04)	(1.24)	(1.42)	(43.02)	(5.56)
-2	2.90	2.04	1.47	-.08	28.38	-4.92
	(2.08)	(4.68)	(1.32)	(1.72)	(33.58)	(4.42)
0	1.61	-1.52	-.99	-.32	-9.85	-.29
	(1.39)	(3.84)	(1.01)	(1.96)	(22.81)	(4.10)
1	-.29	-3.22	-2.05	-9.13***	-4.04	1.70
	(1.34)	(4.60)	(1.71)	(1.43)	(28.92)	(5.06)
2	-1.20	-7.44	-3.43**	-12.74***	13.53	2.79
	(1.78)	(5.28)	(1.74)	(2.46)	(37.46)	(4.95)
3	-1.86	-7.91	-3.90	-13.24***	25.87	-.45
	(1.79)	(6.03)	(2.46)	(2.08)	(39.39)	(5.56)
4	-3.32*	-10.55*	-4.83**	-15.24***	26.90	-4.48
	(1.75)	(6.38)	(2.40)	(2.73)	(49.87)	(4.68)

Table 6: CSDID Heterogeneity - by MV Deaths, Fatalities, Persons, Passengers, Drivers & Occupants

VARIABLES	(1) rDeaths	(2) rFatals	(3) rPersons	(4) rDriver	(5) rPassenger	(6) rMVocupant_nt_in_transport	(7) rOther_NonMV_ocupants
Pre_avg	-0.09	.94	8.67	-.01	-.02	.01	.06
	(.82)	(1.57)	(13.28)	(.37)	(.42)	(.03)	(.11)
Post_avg	.11	-1.02	2.09	-.93	.41	-0.025	-.02
	(1.21)	(3.30)	(19.74)	(.72)	(.80)	(.032)	(.13)
-4	.87	1.93	10.02	.29	.54	.038	.08
	(1.01)	(1.67)	(12.44)	(.42)	(.53)	(.037)	(.11)
-3	-0.73	-.43	-2.51	-.52	-.60	-0.048	-.107
	(.85)	(1.50)	(12.99)	(.41)	(.47)	(.052)	(.109)
-2	-0.41	1.31	18.49	.22	.02	.01	.21
	(.91)	(2.10)	(22.28)	(.43)	(.44)	(.04)	(.30)
0	-0.01	-.23	2.24	-.26	.25	-0.028	-.16
	(1.18)	(2.39)	(15.40)	(.41)	(.62)	(.039)	(.12)
1	-1.15	-1.88	-2.55	-.89	-.31	.003	.13
	(1.31)	(3.23)	(20.81)	(.70)	(.81)	(.035)	(.10)
2	.70	-.60	8.41	-1.01	.75	-.04	.01
	(1.36)	(3.09)	(16.04)	(.85)	(.76)	(.06)	(.15)
3	.47	.11	11.32	-.81	.77	.009	.02
	(1.48)	(4.01)	(23.95)	(.82)	(1.13)	(.037)	(.17)
4	.54	-2.53	-8.98	-1.67	.57	-.073*	-.11
	(1.51)	(4.67)	(29.36)	(1.11)	(.96)	(.043)	(.23)

Robustness Checks - Interpretation

- Figure 4 shows no heterogeneity by gender (although the results seem to be driven more by males) or age as there are insignificant post-trends across all model variations.
- Similarly, table 5 indicate slight heterogenous effect for whites compared to non-white race although a weak pre-trend seemingly exists for whites, so race might not be as informative. Rural residents appear to have more of a weak decline in line with the many respondents living in rural areas compared to urban residents, but no heterogeneity exists by the presence/absence of prior DWI.
- Moreso, table 6 suggests no heterogeneity exists by the MV deaths, fatalities or the number of persons in the car. But there is slight heterogeneity driven by if the MV occupant was not in the transport relative to being the driver or passenger in the vehicle with the drunk driver.

Table 7a: CSDID with Potential Controls as Outcome

VARIABLES	(1) PopDens	(2) Unemp	(3) speedlimit	(4) BAC_10	(5) GDLNR	(6) GDLPR
1.interaction	-6.36	-0.03	-0.11	0.07	-0.071	0.005
	(7.30)	(0.18)	(0.52)	(0.07)	(0.07)	(0.08)
Constant	379.1***	5.85***	68.53***	0.27***	0.65***	0.49***
	(5.32)	(0.14)	(0.28)	(0.04)	(0.04)	(0.04)
Observations	1,173	1,071	1,550	1,550	1,550	1,550
R-squared	0.99	0.84	0.85	0.71	0.74	0.75

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 7b: CSDID with More Potential Controls as Outcome

VARIABLES	(1) PCPI	(2) EBGPC	(3) ESGPC	(4) EWGPC	(5) legal_marijuana_rec	(6) legal_marijuana_med
1.interaction	-20.12	-0.001	-0.03	0.003	-0.003	0.10
	(853.4)	(0.02)	(0.02)	(0.01)	(0.03)	(0.07)
Constant	35,476***	1.25***	0.83***	0.35***	0.04**	0.21***
	(462.1)	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)
Observations	1,581	1,550	1,550	1,550	1,581	1,581
R-squared	0.96	0.85	0.93	0.90	0.32	0.62

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

As seen in Tables 7a and 7b, the interaction of OCL as treatment and the post-period insignificantly impacted each of these controls, thereby affirming that none of these factors significantly changed anything regarding how OCL affected drunk-driving deaths in the US.

Policy Implications and Concluding Remarks

- Policy implications for these research findings reflect that state related traffic laws and public policies generally affect the US population regardless of age, race, gender, region, residence locations or having prior DUI records.
- Furthermore, proper enforcement of such policies has the potential to improve life expectancy of vehicle owners within the US. are discussed in the context of life expectancy variations across the U.S. states.
- Nonetheless, political and societal pushbacks against alcohol-curbing laws exist and appear to be growing such that public health versus policy tradeoff persist.
- La (2024) suggests that the Californian Senate Bill 969 might be passed by January 1st, 2025, to allow bars and restaurants serve and consume alcoholic drinks on public streets for people above 21 years. Arpey (2024) and Kampf-Lassin (2024) also recognize similar patterns in New York, New Orleans among other US states advocating for more legalized public street drinking for greater revenue & economic booms.

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