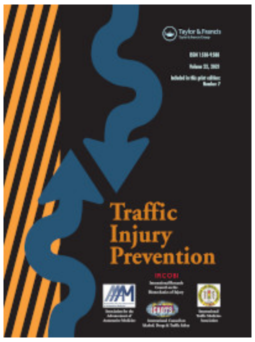

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State alcohol ignition interlock laws and fatal crashes

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ABSTRACT

Objective: Alcohol-impaired driving results in thousands of deaths annually. Alcohol ignition interlocks require a negative breath test to start a vehicle's engine, and 44 states have mandated some form of interlock law for drivers convicted of driving while intoxicated (DWI). The objective of this study was to estimate the association between interlock laws and fatal impaired-driving crashes.
Methods: Differences in three interlock laws were evaluated by comparing alcohol-impaired passenger vehicle drivers involved in fatal crashes between 2001 and 2019 in the United States across state and time. State/time differences unrelated to interlock laws were controlled for by fitting a Poisson model. The exposure measure was the number of passenger vehicle drivers in fatal crashes that did not involve impaired drivers. Laws requiring interlocks for drivers convicted of DWI covered: repeat offenders, repeat offenders and high-BAC offenders, all offenders, or none.
Results: The number of states with all-offender interlock laws during the study period went from three in 2001 to 29 in 2019, and the number of states with any of the three laws increased from 16 to 44. All-offender laws were associated with 26% fewer drivers with 0.08+ BAC involved in fatal crashes, compared with no law. Repeat-offender laws were associated with a 9% reduction in impaired drivers, compared with no law. Repeat and high-BAC laws were associated with a 20% reduction in impaired drivers in fatal crashes, compared with no law.
Conclusion: Laws mandating alcohol ignition interlocks, especially those covering all offenders, are an effective impaired-driving countermeasure that reduces the number of impaired drivers in fatal crashes.

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Alcohol ignition interlock laws; Fatality Analysis Reporting System (FARS); impaired driving

Introduction

In 2016, 10,497 people died in crashes involving drivers with blood alcohol concentration (BAC) 0.08+ g/dL in the United States (National Highway Traffic Safety Administration 2017), and such crashes cost society an estimated $125 billion in 2010 alone (Zaloshnja et al. 2013). Between 1982 and 1997, substantial progress was made to reduce crash deaths involving alcohol-impaired drivers (Fell and Voas 2006). However, since then progress has largely stalled (Dang 2008; Fell et al. 2009). U.S. state laws adopted over the past 100 years to control and reduce alcohol-impaired driving vary considerably between states (National Highway Traffic Safety Administration 2016). These laws form the legal structure that enables law enforcement to stop drivers on public roads and arrest them for driving while intoxicated (DWI), with probable cause.

In the late 1990s, states began enacting laws that required alcohol ignition interlock devices to be installed on the vehicles of certain offenders convicted of DWI, as an alternative or adjunct to the traditional license suspension system. When installed on a vehicle, the interlock controls impaired driving by preventing the engine from starting unless the driver blows into a sensor with a breath-estimated BAC less than a set level, usually 0.02–0.04 g/dL depending on state requirements. Currently, all states and the District of Columbia (DC) have legislation allowing or requiring the use of interlocks as a sanction for a DWI offense. Research has shown that interlocks reduce DWI recidivism by 64% while fitted on the DWI offender's vehicle (Elder et al. 2011; Willis et al. 2004), and so state laws requiring their installation are expected to be more beneficial than those laws simply allowing for it. Currently, laws that require interlocks target three types of DWI offenders: repeat offenders, those with high BAC (0.15+ g/dL), and first-time offenders. First-time offender laws have generally appeared only in conjunction with repeat offender laws, so these effectively cover all offenders and are referred to as such.

Evaluations of the interlock laws have largely been limited to single-jurisdiction studies measuring effects on DWI recidivism rather than on crashes. Research has indicated that drivers experience lower recidivism rates while interlock devices are on their vehicles than offenders whose license has been suspended (Beck et al. 1999; Elliott and Morse 1993; EMT Group 1990; Weinrath 1997), and first offenders experience lower 2-year recidivism rates (McCartt et al. 2018). However, some studies have investigated how interlock laws affected crash rates. McCartt et al. (2013) found that after Washington state's interlock law included all offenders, single-vehicle nighttime crashes (a surrogate for impaired-driving crashes) reported to police declined 8% per population using

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data during 1999–2006. In evaluating Nova Scotia's interlock program, a study found that the program was associated with reductions in recidivism in the province, as well as a reduction in fatal and serious alcohol-related crashes (Vanlaar et al. 2017). A national study with data ranging from 1999 to 2013 found that states with all-offender interlock laws had 15% fewer alcohol-involved crash deaths than states with less stringent interlock laws (Kaufman and Wiebe 2016). McGinty et al. (2017) found a 7% decline in fatal crashes involving at least one driver with 0.08+ g/dL BAC per licensed driver, and an 8% decline when looking at 0.15+ g/dL impairment during 1982–2013. A challenge with these and any such study is controlling for unrelated factors like economic changes, amount of driving, and changes in vehicle crashworthiness, all of which vary during the study periods; plus, many are not measured in existing data sets, so they cannot simply be included as covariates in models. While these studies used various methods to account for some of this variation, finding a good comparison group is an opportunity to strengthen the body of evidence of how these laws affect alcohol-related fatal crashes. McGinty et al. (2017) pointed out that selecting a group of states as a comparison group would not be feasible since nearly all enacted some kind of interlock law. This study used the national rate of alcohol-impaired fatal crashes as a covariate, but this could be affected by the increase of interlock laws if they are effective. Selecting a comparison group that largely is not affected by the study intervention and exists within the same state and time as the outcome measures optimizes the ability to account for unmeasured confounders with this increased specificity. For example, McCartt et al. (2010) and Trempel (2009) used crash involvements of middle-aged drivers (within the same state-quarter) as a comparison group for studying the effect of graduated driving licensing laws on teenagers' crash rates. The convergence of evidence from studies employing a variety of methods strengthens our understanding that alcohol ignition interlock laws benefit public health. The objective of the current study was to estimate the association between interlock laws and fatal impaired-driving crashes while using a comparison group that would help to account for these potential additional influences.

Methods

State interlock laws were coded from a systematic review of state legal codes. The current study examined years between 2001 and 2019 with a cross-sectional design. The onset of 2001 was selected as the start date because the actual codified text of the laws became clearer to interpret at that time. The end date of 2019 was selected because at the time of the current study, it was the most recent year for which all data required for the study was available. Portions of the interlock law in California varied from county to county. As a result, California was excluded from this study. For this analysis, states' interlock laws were coded as interlocks required for no specific class of offender (referred to as none or no law), repeat offenders, repeat and high-BAC offenders, or all offenders. These categories represented all combinations of interlock laws that existed during the study period.

The primary unit of analysis for this study was the state-quarter, which minimized the likelihood of zero cell counts while still capturing seasonal variation. Data on passenger vehicle drivers involved in fatal crashes during 2001–2019 were extracted from the Fatality Analysis Reporting System (FARS), a census of fatal crashes in the United States. Quarterly counts of impaired drivers at three levels (BAC 0.01+, 0.08+, and 0.15+ g/dL) were calculated using the multiple imputation results for missing BAC values provided in FARS (Subramanian 2002). These formed the outcome measures of the study. A total of 3,800 state-quarters (including the District of Columbia) were included.

Covariates included interlock laws, state, quarter, unemployment rate (obtained from the U.S. Bureau of Labor Statistics), and counts (at the state-quarter level) of passenger vehicle drivers involved in fatal crashes that did not involve any impaired drivers. As in McGinty et al. (2017), state was included in the model as random intercept terms to account for possible correlations. Laws were coded as "0" if they were absent for all or part of a quarter, and "1" if they were present for the duration of the quarter. The count of passenger vehicle drivers involved in crashes that did not involve any impaired drivers, henceforth referred to as drivers in unimpaired fatal crashes, was taken as a stricter measure than counts of unimpaired drivers, to minimize influence from interlock laws if they affect the number of impaired drivers—who may collide with unimpaired drivers. Drivers in unimpaired crashes are affected by many of the same factors as impaired drivers are: exposure (e.g., vehicle miles traveled, population), improvements in passenger vehicle crashworthiness and crash avoidance technology, changes to speed limits, etc.; so this controls for unobserved exposures to a greater extent than just controlling for state. Controlling for state, in addition to the use of the comparison group, helps to account for the varying rates of impaired driving by state. Unemployment rate was included as a measure of economic influences; the exposure effects of economic conditions would be reflected in the comparison group, but economic conditions also could affect the likelihood of reckless behaviors such as impaired driving (e.g., Wagenaar and Streff 1989). Each of the covariates in the current study clearly may be associated with the number of impaired drivers in fatal crashes, and all except interlock laws likely are also associated with the number of drivers in unimpaired fatal crashes. Interaction terms were included between drivers in unimpaired fatal crashes and state, quarter, and unemployment rate to allow effect estimates to reflect these relationships. This resulted in a large number of interaction terms, but these were not of interest and simply allowed for flexibility in the models. Reference cell coding was used in the models, with "none" being the reference category of interlock law, and the largest value (numerically or alphabetically) for the categorical comparison parameters taken as reference.

The number of impaired passenger vehicle drivers in fatal crashes was modeled against the covariates/interactions using Poisson regression with a log link and an estimated scale parameter to allow for overdispersion. Exponentiating parameter estimates allowed for a straightforward interpretation as percent change in number of impaired drivers for a one-unit increase in the covariate (e.g., law vs. no law, one percentage point increase in unemployment rate, etc.). Effects of

Table 1. Study populations by interlock law and year (number of states as of July 1 / average unemployment rate (percentage) in these states).

	None	Repeat	Repeat and high-BAC	All offenders
2001	34 / 4.5	10 / 4.5	3 / 5.6	3 / 5.3
2002	30 / 5.1	13 / 5.3	4 / 6.2	3 / 5.9
2003	26 / 5.6	15 / 5.7	6 / 5.8	3 / 6.7
2004	24 / 5.1	16 / 5.3	6 / 4.7	4 / 5.9
2005	24 / 4.9	15 / 5.0	6 / 4.2	5 / 5.7
2006	22 / 4.6	16 / 4.6	7 / 3.8	5 / 4.5
2007	22 / 4.6	12 / 4.6	11 / 3.8	5 / 4.3
2008	19 / 5.7	13 / 6.0	11 / 4.8	7 / 5.1
2009	14 / 9.1	15 / 9.3	10 / 8.1	11 / 8.0
2010	11 / 9.0	15 / 8.9	12 / 8.0	12 / 8.1
2011	8 / 9.0	13 / 8.5	13 / 7.9	16 / 7.4
2012	6 / 7.7	12 / 7.7	14 / 7.3	18 / 6.7
2013	7 / 6.9	11 / 7.4	13 / 6.5	19 / 6.3
2014	6 / 5.6	12 / 6.0	12 / 5.4	20 / 5.5
2015	6 / 4.7	8 / 5.0	11 / 4.8	22 / 5.0
2016	6 / 4.5	8 / 4.7	9 / 4.6	25 / 4.7
2017	6 / 3.6	8 / 4.2	9 / 4.1	27 / 4.2
2018	6 / 3.3	7 / 3.6	9 / 3.8	28 / 3.8
2019	6 / 3.2	6 / 3.4	9 / 3.6	29 / 3.6

Table 2. Study populations by interlock law and year (drivers with 0.08+ g/dL BAC in fatal crashes / drivers in unimpaired fatal crashes).

	None	Repeat	Repeat and high-BAC	All offenders
2001	5,849 / 16,899	2,812 / 7,427	773 / 2,457	563 / 1,477
2002	4,671 / 14,044	3,696 / 9,425	1,197 / 3,715	545 / 1,496
2003	3,548 / 11,016	3,917 / 11,054	1,622 / 5,414	556 / 1,464
2004	3,208 / 9,708	4,162 / 11,362	1,666 / 5,858	626 / 1,721
2005	3,187 / 9,180	3,679 / 10,340	2,104 / 6,611	815 / 2,223
2006	3,023 / 8,139	3,047 / 8,631	2,872 / 7,978	869 / 2,232
2007	2,938 / 7,792	2,321 / 6,892	3,271 / 9,603	829 / 2,138
2008	1,915 / 6,038	2,406 / 6,951	2,905 / 8,213	1,025 / 2,738
2009	1,469 / 4,537	2,382 / 7,002	2,557 / 7,083	1,206 / 3,344
2010	1,092 / 3,802	2,329 / 6,913	2,695 / 7,256	1,237 / 3,836
2011	702 / 2,528	1,841 / 5,592	3,012 / 8,509	1,503 / 4,748
2012	330 / 782	2,098 / 6,392	3,104 / 9,431	1,687 / 5,469
2013	384 / 951	1,895 / 5,959	2,854 / 8,511	1,911 / 5,877
2014	277 / 754	1,787 / 5,942	2,896 / 8,099	2,023 / 6,611
2015	350 / 1,218	1,442 / 5,138	2,843 / 8,786	2,656 / 8,612
2016	415 / 1,276	1,450 / 5,140	2,045 / 7,877	3,680 / 11,342
2017	492 / 1,680	1,372 / 5,208	1,835 / 7,428	3,772 / 11,586
2018	487 / 1,572	1,145 / 4,169	1,997 / 7,948	3,855 / 11,499
2019	459 / 1,557	1,082 / 3,957	1,717 / 8,007	3,776 / 11,632

interlock laws, adjusted for other covariates, were provided. Some discussion of the other covariates was provided in place of listing all the parameter estimates. Statistical significance of interlock law effects was determined from the Wald chi-squared tests provided in SAS GENMOD Procedure output. One model was run for each level of impairment.

Results

Midyear counts of states with interlock laws, as well as unemployment rates in these states, are provided in Table 1. Laws covering repeat offenders were the most common laws earlier in the study period, and provisions covering high-BAC offenders or first offenders were added to these later on. In 2001 (third quarter), three states required all offenders to get interlocks, three required it of repeat and high-BAC offenders, and 10 required only repeat offenders to get interlocks. By 2019 (third quarter), 29 states required interlocks for all DWI offenders, 9 for repeat and high-BAC offenders, and 6 for only repeat offenders—leaving six states that did not require interlocks of any specific group of offenders. Study populations, namely drivers with 0.08+ g/dL BAC and drivers in unimpaired crashes, are provided in Table 2.

The main results are provided in Table 3. Effects were statistically significant at the 0.05 level. Interlock laws covering repeat offenders were associated with 9% fewer impaired drivers (at all levels) in fatal crashes, compared with no laws. Requiring interlocks for high-BAC offenders as well as repeat offenders, compared with none, was associated with a 20% benefit for impaired drivers (all levels). All-offender laws were associated with a 26% benefit over no law for 0.01+ and 0.08+ g/dL drivers and a 24% benefit for drivers with BAC 0.15+ g/dL.

Unemployment rate was not strongly or statistically-significantly associated with impaired drivers in fatal crashes. Other covariates, both main and interaction terms, were mostly statistically-significantly associated with impaired drivers in fatal crashes. The large number of interaction terms between drivers in unimpaired crashes and state-quarter limits interpretability.

Discussion

This analysis found that all-offender laws are associated with fewer impaired-driving fatal crashes (26% fewer drivers with BAC 0.08+), compared with no law. Repeat-offender laws were associated with a smaller benefit (9% reduction in impaired drivers) compared with no law, and there was an additional benefit of including high-BAC offenders (20% compared with no law).

In 2019, about half of the states had laws requiring interlocks for all DWI offenders. Additional benefits are expected to be realized as more states enact such laws. Despite requirements to install interlocks, however, actual interlock installation rates often are far from 100% of offenders (Marques et al. 2001; McCartt et al. 2018; Roth et al. 2009; Willis et al. 2004). Though examining interlock installation rates was beyond the scope of the current study, future research may look at ways to increase interlock installation rates. In this study, laws that require interlock installation fell into two general categories: interlock installation required to drive during post-conviction license suspension, or interlock installation required to reinstate a driver license after conviction. While the latter is a stronger requirement, evaluations of these requirements must be reserved for future studies.

One possible mechanism, as discussed by Vanlaar et al. (2017), by which interlock requirements affect crash rates in the population is general deterrence. Under this mechanism, alcohol-impaired crashes could be reduced by stronger laws if drivers know that a first offense could lead to having an interlock and being responsible for its associated financial costs, and they believe this to be an unattractive option to the extent that they change their behavior (e.g., moderate their drinking before driving or make other arrangements like public transit). Vanlaar et al. (2017) found reductions in alcohol-related charges, convictions, and crashes following implementation of the program among the population, not only among people who were in the program. General deterrence would account for a larger benefit of these laws than simply addressing those convicted of DWI, thus further reducing harm from impaired driving.

This effort is not free of limitations. The primary outcome measure in the current study was limited to alcohol-related fatal crashes, which could arguably be called a relatively rare

Table 3. Estimated effects and 95% confidence intervals of interlock laws on impaired drivers in fatal crashes, 2001–2019.

	0.01+ g/dL	0.08+ g/dL	0.15+ g/dL
All-offender vs. none	−25.9 (−33.2, −17.9)	−26.2 (−33.4, −18.2)	−24.1 (−30.9, −16.6)
High-BAC and repeat vs. none	−19.8 (−24.8, −14.3)	−19.9 (−25.2, −14.2)	−19.9 (−25.2, −14.2)
Repeat-only vs. none	−8.7 (−14.6, −2.3)	−8.9 (−14.6, −2.7)	−9.0 (−14.9, −2.8)

and severe occurrence after consuming alcohol. Indeed, to assess the broader impact of alcohol ignition interlocks, nonfatal alcohol-related crashes should be assessed as well. However, alcohol reporting in nonfatal crashes is incomplete and highly variable in quality from state to state; hence only fatal crashes were investigated. Further, the current study used alcohol-related outcomes and alcohol-related legislation as predictors, but we did not examine the impact of alcohol consumption itself. Total alcohol consumption was considered for use in the current model, however, that data is only available as total gallons of ethanol consumed by state and year. As the current study examined only a small subset of the population (i.e., those involved in fatal crashes), the total population alcohol consumption variable seemed convoluted and hence was excluded from our analyses. In particular, alcohol consumption may be influenced by interlock law type, so they cannot be considered independent predictors in the model. Also, it is possible that the effects of law changes take time to materialize, however no lagged analysis was conducted in this study as that would make certain assumptions about similarities across states/time for these effect delays. Enforcement practices also likely differ by state, but there was no consistent way to measure and include these differences in the analysis. Future research should assess how the introduction of alcohol ignition interlock devices and the laws associated with them changed individual alcohol consumption among this high-risk population, as well as look at other measurable state-by-state differences.

However, despite the limitations discussed above, this study adds to the increasing body of knowledge about ignition interlock laws by further demonstrating that interlock laws, especially those covering all offenders, are an effective impaired-driving countermeasure for fatal crashes. Jurisdictions that do not currently have all-offender alcohol ignition interlock laws could expect large reductions in impaired-driving crash deaths if they do adopt these laws.

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