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IZA DP No. 16774

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ABSTRACT

Hit-and-Run or Hit-and-Stay? Unintended Effects of a Stricter BAC Limit*

Although they comprise a relatively small subset of all traffic deaths, hit-and-run fatalities are both contemptible and preventable. We analyze longitudinal data from 1982-2008 to examine the effects of blood alcohol concentration (BAC) laws on hit-and-run traffic fatalities. Our results suggest that lower BAC limits may have an unintended consequence of increasing hit-and-run fatalities, while a similar effect is absent for non-hit-and-run fatalities. Specifically, we find that adoption of a .08 BAC limit is associated with an 8.3% increase in hit-and-run fatalities. This unintended effect is more pronounced in urban areas and during weekends, which are typical settings for hit-and-run incidents.

JEL Classification: H73, I12, I18

Keywords: traffic fatalities, hit-and-run, BAC, DUI, FARS

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1. INTRODUCTION

Motor vehicle crashes are a leading cause of death in the US, which kill about 100 people and injure more than 7,500 each day, on average (NHTSA, 2021a). Despite steady and considerable technological improvements in vehicular safety since the 1970s, the traffic fatality rate in the US is more than twice the average of other high-income countries (CDC, 2016). One of the most widely reported and often tragic traffic events is hit-and-run (HR) crashes. More than 2,000 HR collisions occur in the US each day, on average, killing nearly 1,800 people and injuring more than 170,000 every year (Benson et al., 2018). A HR collision is when a driver flees the crash scene without stopping to render aid to the victim(s) or to file a police report. Besides being illegal, leaving the scene can cause more serious injuries and even fatalities as 60-70% of deaths in traffic collisions occur within the first hour of the crash (e.g., Yasmin et al., 2015). Even a 10-minute reduction in emergency response time can reduce the probability of death by as much as one-third (Sánchez-Mangas et al, 2010).

Existing research shows that drunk drivers are more likely to flee crash scenes (e.g., Solnick and Hemenway, 1994). In these cases, drivers who leave the scene not only fail to help the victims, but they essentially also end up removing evidence from the crime scene by driving their vehicle and sometimes buying time to sober up. Mothers Against Drunk Driving (MADD), a major traffic safety advocacy group with millions of worldwide members, was founded in 1980 by Candice Lightner, whose 13-year-old daughter was killed by a drunken HR driver in Southern California. Since then, MADD has been credited with raising public awareness about the dangers of impaired driving and strengthening traffic safety legislation such as raising the minimum legal drinking age to 21, lowering the blood alcohol concentration (BAC) limit to .08, and the implementation of zero alcohol tolerance for drivers under age 21 (Toomey, 2005; Zaloshnja et al., 2015).

In this paper, we discover that the .08 BAC laws may have an unintended effect of increasing HR traffic fatalities. HR cases make up about 12% of all police-reported traffic crashes and are typically much more prevalent in major metropolitan areas (Benson et al., 2018). For example, nearly half of all crashes in Los Angeles, California involve HR (Smith, 2015), which occur almost on a daily basis (Hillard, 2013). The consequences are particularly severe for non-motorists, as pedestrian fatalities constitute about two-thirds of all HR fatalities (Benson et al., 2018). The National Highway Traffic Safety Administration (NHTSA, 2021b) reports that, in 2019, pedestrian deaths accounted for 17% of all traffic fatalities and one-fifth of pedestrians killed in traffic crashes involved HR drivers. Between 1998 and 2007, while the annual number of pedestrian fatalities in the US declined, the proportion of HR pedestrian fatalities increased (MacLeod, et al. 2012). Our own calculations using the FARS data indicate that the proportion of HR pedestrian fatalities (relative to all fatalities) rose from 2.1% in 1998 to 2.3% in 2007.

We use state-specific annual data from the 1982-2008 Fatality Analysis Reporting System (FARS) to examine the effects of various traffic and alcohol policies on both HR and non-hit-and-run traffic fatalities (NHR). We present evidence that stricter driving-under-the-influence (DUI) policies may unintentionally increase HR incidents. This unintended consequence is more pronounced in urban areas and during weekends, which are typical settings for HR incidents. The positive and significant impact of a .08 BAC law on HR fatalities persists even after controlling for other drunk driving policies and in a series of other sensitivity analyses. We hypothesize that some drivers may be more likely to flee the crash scene once stricter DUI policies are adopted. Our findings have direct implications as to how policymakers can help reduce the number of HR crashes and fatalities, which are often preventable.

2. BACKGROUND

Some legislators describe the rising number of HR crashes as a “growing epidemic” and claim that the “prevailing statutes unwittingly encourage drivers to leave the scene” (Miami Herald Editorial, 2014). For example, under Florida law prior to 2014, fleeing the scene of a fatal collision carried lighter penalties compared to remaining at the scene and being charged with DUI. To address this legal loophole, the "Aaron Cohen Life Protection Act" took effect in 2014 which, among other measures, increased the mandatory minimum prison term from two to four years for a DUI driver convicted of leaving a crash scene resulting in the death of a person. However, DUI is difficult to establish even when the HR driver is apprehended soon after the crash. This Act was named after a Miami cyclist who was killed in a HR collision in 2012. The driver did not stop but turned himself in 17 hours later. Although the driver was on probation for cocaine charges at the time and law enforcement officials found evidence he had been drinking prior to the crash, BAC testing was not reliable due to the time lapse.

Florida is not the only state where legislators are considering policy changes to toughen HR laws. Concerns have been voiced in other states (e.g., California, Colorado, Connecticut, Delaware, New Jersey, Pennsylvania, and Texas) where similar loopholes exist (Keedle, 2002; Fender, 2010; Farr, 2011; Copeland, 2013). As an example, Pennsylvania has made changes to a law under which it was once argued "it's better to be a coward and run" (Farr, 2011). After five-year-old Kevin Miller was killed by a HR driver, Pennsylvania legislators passed "Kevin's Law" in 2014 to address this exposed loophole. The penalty for fatal HR was increased from a minimum of one year to three years in prison—making it equal to the mandatory minimum for vehicular homicide when intoxicated (Kalinowski, 2014).

Legislators in Texas also closed a loophole in 2013 that was thought to encourage intoxicated drivers who are involved in a collision to flee the scene (Dehn and Koh, 2013). Prior to passage of the new law, leaving a crash scene in Texas was a third-degree felony and carried a maximum penalty of 10 years in prison—only half of the penalty for causing a DUI-related traffic fatality. With the amended law, penalties for HR fatalities are now equal to those for intoxicated vehicular manslaughter. This is in line with the notion of "marginal deterrence," which suggests that expected sanctions should rise with harm such that those perpetrators who are not entirely deterred from committing a crime have a reason to moderate the extent of harm they cause (Polinsky and

Shavell, 2000). However, repeat DUI offenders may still have a strong incentive to flee the crash scene to avoid manslaughter or murder charges due to their prior convictions. This is because states typically levy much harsher sanctions for repeat offenders (Polinsky and Shavell, 2000).

Our study is not the first in the traffic safety literature to point out potential unintended consequences of well-meaning policy measures. Peltzman (1975) is one of the first as he argues that certain safety features in motor vehicles such as a seat belt may encourage some individuals to drive more aggressively or recklessly. However, studies have found no evidence in support of this so-called Peltzman effect (e.g., Cohen and Einav, 2003), as the protective effects of seat belt laws seem to dominate any offsetting driver behaviors. Carpenter and Stehr (2011) show that youth bicycle helmet laws encourage helmet use and reduce fatalities, but also significantly reduce bicycling.

A couple of studies express concern about, but do not investigate, the possible unintended consequences of DUI laws on HR incidents (Hijar et al., 2003; Fujita et al., 2014). Fujita et al. (2014) report an increase in HR crashes in Japan during the second half of the 2000s. Several strict drunk driving laws were introduced in Japan between 2002 and 2007, including lowering the BAC limit from .05 to .03. They conjecture that these policy changes may have reduced alcohol-involved crashes but may also have contributed to the rise in HR incidents. While no previous study has attempted a comparative evaluation of how drunk driving laws affect HR collisions, researchers have identified several factors that are associated with such incidents. HR is more prevalent in urban areas, at nighttime and early morning, under poor lighting conditions, during weekends, and when the drivers are distracted by cellular phones (Solnick and Hemenway, 1995; Tay et al., 2008; 2009; Zhou et al., 2016). HR drivers are more likely to be young, male, intoxicated, and driving a stolen, rental or someone else's vehicle and/or without a valid license (Solnick and Hemenway, 1995; Kim et al., 2008; MacLeod et al., 2012; Fujita et al., 2014; Benson et al., 2021).

Having consumed alcohol may impair the driver's logical thinking or rational decision making and intoxication can lead to more impulsive decisions (Sloan, 2020). While in some cases drivers may not be making a fully conscious choice to flee the scene, extant studies provide evidence drivers are more likely to do so when they perceive the risk of being caught or identified as relatively low. Solnick and Hemenway (1995) report that drivers tend to flee either when it is easy to do so or when they are likely to be punished. Similarly, Tay et al. (2008; 2009) report that drivers are more likely to leave the scene if they suspect serious legal consequences, such as when the crash involves two-wheel vehicles or pedestrians. Fujita and colleagues (2014) hypothesize that drivers are also more likely to leave the crash scene when they infer a lower likelihood of being witnessed. They examine national police data in Japan between 2001 and 2010 and find that drivers with passengers are more likely to remain on the scene compared to those who drive alone. They also report that drivers are more likely to leave the scene when they perceive the victim to be dead or severely injured. More recently, Jiang et al. (2016) use data from Shanghai, China to show the likelihood of a driver remaining on the scene increases if the objective factors surrounding the crash, such as bad weather, make them perceive themselves as not at fault for the collision. On the other hand, they find that alcohol involvement is significantly related to a driver's decision to flee a crash scene.

Sometimes, drivers not remaining on the crash scene may simply be looking to buy time to think things through or to "sober up" even when they expect to be eventually caught. For example, Hopkins and Chivers (2019) conducted in-depth interviews with HR drivers in the UK to develop a typology of drivers. While not all HR behaviors seem to be based upon rational decision making, Hopkins and Chivers (2019) identify a group of drivers who were "acting rationally in that they were aware that (as a result of drinking) if they reported the collision, they could be prosecuted for drink driving." If .08 BAC laws lead to increased enforcement of traffic laws, this alone could be the reason why some drivers, especially those with prior offenses or suspended licenses, flee the crash scene even without being engaged in impaired driving.

Most of the existing research focusing on HR crashes and fatalities is descriptive in nature. More importantly, these studies are subject to sample selection issues because driver characteristics are available only when the drivers are eventually apprehended or turn themselves in. These drivers can be systematically very different from those who are never identified. Crashes are deemed or suspected to be alcohol involved mostly based on victim or witness reports. To the best of our knowledge, no prior study has rigorously investigated the effects of drunk driving policies on HR traffic fatalities.

3. DATA AND METHODS

In this study, we use motor vehicle fatality data from FARS, a publicly available data source maintained by NHTSA. FARS is a census of all motor vehicle traffic crashes that occur on public roads in the US and result in a fatality within 30 days. We constructed annual data on total and HR traffic fatalities for the period of 1982-2008 for all 50 states. No IRB approval was needed since all analyses were conducted using publicly available secondary data and the unit of analysis is states instead of individuals. Crash characteristics, including the HR designation, come from police reports. Traffic fatalities refer to both motor vehicle occupants (i.e., drivers and passengers) as well as non-occupants (i.e., pedestrians, bicyclists) killed in traffic collisions.

A motor vehicle traffic crash is defined as a HR collision when the driver of a contact vehicle does not stop to render aid (including drivers who flee the scene on foot) before law enforcement officials arrive at the scene. We subtract the number of fatalities in such crashes from all traffic fatalities to obtain the count of "non-hit-and-run traffic fatalities," which is employed as an outcome measure in a side-by-side comparison of hit-and-run versus all other traffic fatalities. In addition, we construct finer measures by disaggregating fatalities according to various crash characteristics. Appendix Table A1 provides detailed definitions and a list of data sources for all variables used in the analyses.

Figure 1 presents comparative trends in HR traffic fatalities as well as a timeline for the number of states that adopted an illegal per se BAC limit of .08g/dL. Appendix Table A2 lists the effective dates for the illegal per se at .08 BAC laws in all 50 states. A *per se* statute makes it a strict and immediate violation to exceed the specified threshold, regardless of whether a crash occurred, or any other signs of impairment are evident. During the period of our analysis, most states dropped their per se limit from .10 to .08 BAC.[1] While this may seem like a minor change, it was the most significant shift in DUI policies since 1966 when the US Congress passed legislation encouraging all states to adopt a BAC limit of .10, along with illegal per se laws.[2] In 1982, the first year of our analysis, none of the states had yet adopted .08 as the per se BAC limit. Eighteen states adopted a .08 BAC law by year 2000. In 2001, the Department of Transportation Appropriations Act took effect, establishing .08 as the nationwide BAC limit. More importantly, states that did not comply by 2004 would be subject to reduced federal highway funding. As a result of this strong financial incentive, all the remaining 32 states complied by adopting a .08 BAC law. Since most states set the .08 BAC limit in response to this federal pressure, it is reasonable to assume that the policy change is exogenous. Our sensitivity analyses include a comparison between early versus later adopters.

Figure 1 indicates that the share of HR fatalities per 100 traffic deaths has been fairly stable in the 1980s but declined steadily during the 1990s. From 2000 until 2008, however, there has been a rising trend. While overall motor vehicle safety has greatly improved in the US during this entire period, HR fatalities became increasingly common starting in early 2000s. Our calculations using FARS data reveal that the share of HR fatalities in total fatalities went down by 16.1% between 1982 and 1999. Between 2000 and 2008, however, this share increased by 31.5%. Similarly, HR fatalities per capita increased by 8.9% since 2000, while overall traffic fatalities per capita decreased by 17.2% during the same period.

[Figure 1 Here]

[1] Some exceptions exist. For example, Georgia first reduced its BAC limit from .12 to .10 in 1991, and then further down to .08 in 2001. Maryland did not have a BAC limit until 1996, when it established a .10 BAC threshold, which was eventually set at .08 in 2002. Tennessee had a .04 BAC limit until 1993, when they increased the maximum BAC to .10, and then reduced it down to .08 in 2004.

[2] Voas and Lacey (2011) provide a detailed overview of the legislative history of BAC laws in the US.

Table 1 provides descriptive statistics for the entire sample. The average annual number of state-specific traffic fatalities in is about 853, of which more than 32 are identified as HR victims. Out of 1,350 state-year observations (50 states over 27 years), 32 have zero HR fatalities. The number of state-year observations with zero values increases (to as high as 242 for daytime HR fatalities) when we consider disaggregated measures of HR fatalities. On average, during the 1982-2008 period, HR victims make up about 4% of total traffic fatalities. Although this is a small share of total fatalities, they constitute highly preventable deaths; HR behavior is avoidable and staying on the scene to aid victims could significantly reduce the loss of life. A great majority of HR fatalities occur in urban areas (73%) and at nighttime (72%), and they are slightly more likely to occur during weekends (54%). Descriptive statistics in this table also reflect large variations in the fatality measures both between and within states.

[Table 1 Here]

Over our entire period of analysis, a little more than a third of the state-year observations had an illegal per se BAC law at .08. Based on evidence provided by the extant literature regarding their potential influence on traffic safety, we include other traffic and alcohol policies (e.g., Cohen and Einav, 2003; Dee at al., 2005; Freeman, 2007; Carpenter and Stehr, 2011) and all indicators (except speed limits) take on fractional values for the years in which laws changed. We again follow the existing literature by also including several control variables in our specifications (e.g., Ruhm, 2000; Dee and Evans, 2001; Freeman, 2007; Miller et al., 2009; Abouk and Adams, 2013; Anderson et al., 2013; Vandoros et al., 2014).

The empirical specification takes the following form:

$$F_{st} = \beta_0 + \boldsymbol{P}_{st}\beta_1 + \boldsymbol{X}_{st}\beta_2 + \lambda_t + \delta_s + \delta_s T_t + \varepsilon_{st} \tag{1}$$

where (F_{st}) is the count of fatalities in state (s) and year (t). The vector $\boldsymbol{P}$ includes various traffic policy measures, as listed in Table 1. The vector $\boldsymbol{X}$ contains state- and year-specific characteristics, also listed in Table 1, which could potentially influence traffic safety. Year fixed-effects, represented by (λ_t), control for annual secular nationwide changes in traffic safety. State-specific fixed-effects, denoted by (δ_s), account for any time-invariant differences in traffic safety across states. Although these specifications are inclusive of many predictors, other unobserved factors, beyond those captured by (λ_t) and (δ_s), may exist. Examples of such factors are trends in driving patterns and police enforcement, which could potentially lead to omitted variables bias. To address this concern, we also include state-specific linear time trends, $(\delta_s T_t)$, in our specifications. Thus, the estimated effect of the .08 BAC law on traffic fatalities is identified by annual within-state deviations, net of any state-specific linear time trends.

Since HR fatalities can be relatively rare (and include zeros), especially in smaller states, we follow a common practice in the traffic safety literature by employing count data models (e.g., Dee and Evans, 2001; Grabowski and Morrisey, 2004; Dee et al., 2005; Mok and Savage, 2005; Morrisey and Grabowski, 2005; Viauroux and Gungor, 2016; Betz and Jones, 2022). Even when aggregated at the state and annual level, HR fatalities tend to be bunched around relatively small integers (i.e., 19.2% of the observations are three or less, 34.2% seven or less, and 50.5% 15 or less). The distribution of the outcome measure makes ordinary least squares regression and conventional difference-in-differences models inappropriate options. Hence, count data models offer a more appealing alternative. Specifically, we estimate conditional fixed-effects negative binomial models to account for potential overdispersion in fatality counts (i.e., conditional on state fixed-effects denoted by (δ_s) as proposed by Hausman et al. (1984)). Likelihood ratio tests provide overwhelming evidence of overdispersion in the data, indicating that a Poisson model is rejected in favor of a negative binomial model. Later in the paper (see section 4.2), we present results from conditional fixed-effects Poisson models with cluster-robust standard errors, which produce not only larger but also more precise estimates. Conditional fixed-effects negative binomial models—offering both a more appropriate alternative due to overdispersion and a more conservative set of estimates in our context—are adopted as the default specification.

The indicator for illegal per se law at .08 BAC is the focus in our analysis. In each model, we include the logarithm of resident population in each state and year as the exposure variable. In modified specifications, we use alternative exposure variables—vehicle miles traveled and number of registered motor vehicles. In all estimations, standard errors are clustered to allow for non-independence of observations within each state. For brevity, we omit estimation results for year fixed-effects and state-specific time trends (and sometimes other variables), which can be obtained from the authors upon request.

4. ESTIMATION RESULTS

4.1. Core Results

In Table 2, we present estimation results for the conditional fixed-effects negative binomial models, where the first dependent variable is the overall traffic fatality count (columns 1-2). We then break the total count into HR (columns 3-4) versus NHR (columns 5-6) fatality counts. At the bottom of each specification, we also report the pre-law mean of the dependent variable to offer perspective for the magnitude of the estimates. We report the estimated incidence rate ratios (IRRs) and corresponding standard errors (in parentheses). IRRs, which are the exponentiated coefficients, refer to the predicted change in fatalities associated with the adoption of a .08 BAC per se law, holding all else constant. Statistical significance of the estimated effects is based on a test of the null hypothesis that no relationship is present between a fatality measure and the BAC laws (i.e., IRR=1).

[Table 2 Here]

Illegal per se at .08 BAC has no impact on overall (columns 1 and 2) or NHR (columns 5 and 6) fatalities even though many other policies have statistically significant effects on these fatalities including administrative license revocation, speed limits, and primary and secondary seat belt laws. While the .08 BAC results contradict some earlier research (e.g., Dee, 2001; Eisenberg, 2003), they are consistent with a growing body of more recent evidence suggesting small and/or statistically non-significant effects of the .08 BAC law (e.g., Grabowski and Morrisey, 2004; Dee et al., 2005; Morrisey and Grabowski, 2005; Freeman, 2007; Adams et al., 2012; Anderson et al. 2013; Wright and Lee, 2021). Similarly, empirical evidence based on the experience of various European countries reveals that reducing the BAC limit from .08 to .05 does not seem to be effective in improving overall traffic safety once other potentially confounding policies and factors are accounted for (Albalate, 2008; Francesconi and James, 2021). Typically, empirical findings (including those of Dee, 2001) indicate that a .08 BAC law may be effective only when combined with other policy measures. For example, Adams et al. (2015) find that BAC laws tend to be effective only when combined with primary seat belt laws.

In column 3, illegal per se at .08 BAC is associated with a statistically significant 7.8% *increase* in HR fatalities. Once other drunk driving laws are included in the regression (column 4), the effect of adopting a .08 BAC law becomes slightly larger, at 8.3%. A formal test of the differences in the estimated effects of .08 BAC laws on HR versus NHR fatalities is highly statistically significant. Considering that the average pre-law HR fatality count is relatively low, 29.5 per state-year, this change translates into about 2.5 additional HR fatalities annually per state or more than 122 additional fatalities across the US in a given year. The estimated magnitude is intuitively reasonable in comparison to the estimated (intended) effects of other policies on total traffic fatalities. For example, based on the estimates reported in column 2, the adoption of primary enforcement seat belt laws implies about 2,373 fewer traffic fatalities annually nationwide.

None of the other policy measures are significantly associated with HR fatalities. Administrative license revocation turns out to be the only DUI law that is effective in reducing overall traffic fatalities and this is usually credited to the fact that the sanction is swiftly applied after the offense (e.g., Fell and Scherer, 2017). These differences in policy effectiveness may reflect the unique nature of HR incidents and the fact that most of the victims are pedestrians rather than vehicle occupants. In our sample, 64.3% of the HR victims are pedestrians, with a steady decrease in this portion over time (from 77.2% in 1982 to 53.5% in 2008). HR fatalities are more likely to occur on roads with lower speed limits and to kill pedestrians (Solnick and Hemenway, 1995; MacLeod et al., 2012). Some of the traffic measures we consider can improve safety for motor vehicle occupants but not as much for pedestrians, who can be severely injured even when the vehicles are moving at lower speeds and their drivers are wearing seat belts.

Although the control variables are not the focus of our analyses, a few differences in the estimates in columns 4 versus 6 in Table 2 are noteworthy as these discrepancies might be due to the unique nature of HR incidents. First, both seat belt laws and speed limits are significantly related to NHR fatalities, but their effects on HR fatalities are non-significant. One possibility is seat belts offer effective protection for vehicle occupants but not for pedestrians who are frequent victims of HR crashes. As for speed limits, our finding is consistent with Solnick & Hemenway (1995), MacLeod et al., (2012), and Liu et al. (2018) who report that roads with lower speed limits are more likely to be the setting for HR crashes. Liu et al. (2018) conjecture that crashes on roads with lower speed limits are more likely to involve non-motorists such as pedestrians, which may make drivers feel more anxious to leave the scene. Indeed, Tay et al. (2008; 2009) find that drivers are more likely to flee the scene when the crash involves two-wheel vehicles or pedestrians. Lastly, greater income per capita is associated with significantly higher counts of all fatalities, but this impact is much more pronounced for HR fatalities. Barrios et al. (2020) explain that per capita income may be particularly important in explaining pedestrian fatalities as it tends to be highly correlated with smartphone use.

In Table 3, we analyze disaggregated fatality counts to provide further insight into potential causal pathways or mechanisms underlying the association between .08 BAC laws and HR fatalities. For brevity, we omit all estimation results except for illegal per se at .08 BAC law. A formal statistical test of the differences in estimated effects of the .08 BAC laws are presented at the bottom of each panel. In panel 3A, as expected, the unintended consequence of the .08 BAC law emerges most prominently through its effect on urban rather than rural HR crashes. However, the differences between the estimated effects of .08 BAC laws on HR and NHR fatalities are not statistically significant for either urban or rural crashes.

[Table 3 Here]

Panel 3B of Table 3 reports the estimates for weekday versus weekend crashes. While a .08 BAC law is not significantly associated with weekday HR fatalities, the estimated coefficient for weekend HR fatalities implies an increase of 87 weekend deaths across the country in response to the adoption of .08 BAC laws. In addition, the difference in the estimated effects of .08 BAC laws on weekend fatalities between HR and NHR crashes is highly statistically significant. Finally, in panel 3C, the estimated coefficient for .08 BAC laws is positive and statistically significant not only for nighttime but also daytime HR fatalities. The daytime findings are surprising but could potentially be due to the fact that daytime HR incidents are very rare with a vast variation (see Table 1). The difference in the estimated effects of .08 BAC laws on both daytime and nighttime fatalities between HR and NHR fatalities are statistically significant. Note that an illegal per se law at .08 BAC does not have a statistically significant nor economically meaningful effect on NHR fatalities in any of the specifications reported in Table 3. Collectively, these findings are in line with the previous literature, which reports that HR is more prevalent in urban areas, at nighttime when lighting is poor, and during weekends (e.g., Solnick and Hemenway, 1995; Tay et al., 2008; 2009; Zhou et al., 2016).

4.2. Sensitivity Analyses

The findings from a series of robustness checks are presented in Table 4, where each model corresponds to the estimation of a separate regression. In addition to the policy and control variables listed in Table 2, all specifications include year and state fixed-effects as well as state-specific linear time trends. To conserve space, we only report estimated coefficients for the illegal per se at .08 BAC variable and the corresponding standard errors are in parentheses. The full set of estimation results is available from the authors upon request.

[Table 4 Here]

Panel 4A repeats our baseline specifications from the core estimation results (same as columns 4 and 6 in Table 2). Since the estimates for NHR fatality counts never reach statistical significance, in our discussion below we focus on estimates for HR fatalities in the first column. We re-estimated the specifications in Table 2 using conditional fixed-effects Poisson as opposed to conditional fixed-effects negative binomial. This exercise, as presented in panel 4B, yields a similar estimated effect of illegal per se at .08 BAC laws on HR fatalities—8.7% compared to our baseline estimate of 8.3%. Given that alcohol use could potentially be a confounding factor when analyzing traffic fatalities, in panel 4C we incorporate overall alcohol consumption per capita, which leaves the core estimates unchanged. In panels 4D and 4E, we utilize two alternative exposure measures. Specifically, instead of resident population, we define the exposure variable as the number of vehicle miles traveled (panel 4D) and the number of registered motor vehicles (panel 4E). These exercises yield similar and somewhat larger estimated increases in HR fatality counts in response to adoption of .08 BAC laws. Considered collectively, these sensitivity tests offer strong supportive evidence for an unintended impact of a .08 BAC law on HR fatalities.

In panel 4F, we consider a restricted sample that focuses on those states with a more persistent problem of HR traffic crashes by excluding the 13 states that had zero HR fatalities in at least one year during the period of our analyses. The estimates associated with a .08 BAC law remain virtually the same compared to those from analyses of the full sample. Next, we consider smaller versus larger states in terms of resident population. Comparing results pertaining to the subsamples with lower versus higher than the median population (panels 4G and 4H, respectively), the sample sizes are now halved, so the estimates are less precise. Nevertheless, these findings indicate that the unintended effects of .08 BAC laws are still present in both larger and smaller states.

As explained earlier, a majority of states changed their BAC laws in response to the 2001 Department of Transportation Appropriations Act that established .08 as the national BAC limit. We consider these 32 states that adopted .08 BAC laws in response to federal pressure as late adopters, while the remaining 18 as early adopters. Once again, the reduction in the sample size yields less precise estimates. However, the results are driven by the late adopters (panel 4J) rather than the early adopters (panel 4I), and it is reasonable to assume that the policy change is exogenous for the late adopters. Besides the nationwide adoption of a .08 BAC limit, states were asked to implement a National Impaired Driving Crackdown initiative starting in 2003 (NHTSA, 2007) to reduce impaired driving. This program encouraged law enforcement agencies to conduct highly visible activities including sobriety checkpoints, patrols, signage, and other activities, especially during high-risk periods such as holidays. These efforts were complemented by congressionally-funded media campaigns, such as "Over the Limit, Under Arrest," which aired on national television and radio programs (US Government Accountability Office, 2008). The primary aim of these programs was to boost deterrence rather than increasing the number of impaired driving arrests. These crackdowns, conducted in a manner that is highly visible to the driving public, may partially explain why our results are driven by the late adopters. Overall, findings of these robustness checks using restricted samples do not alter our key results or conclusions.

We also considered alternative sets of policy and control variables. This exercise does not alter our conclusions and yields a similar estimated effect of illegal per se at .08 BAC laws on HR fatalities—8.6-8.7% compared to our baseline estimate of 8.3%. Finally, we estimated the same regressions as in Table 2, except with the count of fatal *crashes* as the dependent variable as opposed to the number of *fatalities*. The aim here is to address the question of whether the observed unintended consequence of a .08 BAC law may be due to an increase in the number of fatal crashes or an increase in the number of people per vehicle, especially if stricter BAC laws encourage people to carpool. This exercise produces estimates that are essentially identical in magnitude and statistical significance when compared to those in Table 2. Thus, we conclude that it is not necessarily the case that more people are dying per crash as states adopt .08 BAC laws, but rather an increase in HR fatal crashes.

5. DISCUSSION AND CONCLUSION

To the best of our knowledge, this is the first study on the effects of a drunk driving law on HR fatalities. The key policy implication of this research is that a stricter BAC law may increase HR fatalities. Specifically, the adoption of an illegal per se law at .08 BAC is associated with an 8.3% increase in HR fatalities. This unintended consequence is more pronounced in urban areas and during weekends, which are typical settings for HR incidents. Several possible mechanisms could explain this paradoxical result. While our study is unable to definitively confirm any of these, we suspect that some drivers who are under the influence of alcohol or drugs might flee a crash scene due to severe DUI sanctions, which are often more stringent than non-DUI HR penalties. Future policy research could shed more light on these potential mechanisms.

Reconciling our findings with the existing literature

Existing literature provides some support for our conjecture that the unintended effects could at least partly be due to intoxicated drivers fleeing crash scenes. It's been shown, for example, that drivers with positive BAC levels, operating a stolen vehicle, or with previous DUI arrests and license suspensions, are more likely to leave the crash scene (e.g., Solnick and Hemenway, 1994; 1995; Kim et al., 2008; MacLeod et al., 2012; Fujita et al., 2014). A greater proportion of HR crashes occur at night and during weekends, when drivers are more likely to be drinking (Solnick and Hemenway, 1994). Intoxicated drivers tend to flee the crash scene more often because they know they are at fault and they are aware of the severe punishments (Solnick and Hemenway, 1995). Similarly, Blomberg et al. (2009) report that apprehended HR drivers—when they agree to a BAC test—generate much higher BACs compared to drivers who did not flee the crash scene. Jiang et al. (2016) show that the likelihood of a HR is higher when more blame for the crash can be placed on the driver (e.g., being drunk) than the surrounding circumstances (e.g., adverse weather conditions). While these studies are subject to the sample selection issues mentioned earlier, they reveal consistent patterns and characteristics of drivers who flee collision scenes.

Surveys reveal that individuals who consume alcohol prior to driving are more likely to understand BAC laws compared to other drivers (NHTSA, 2010), and those who live in .08 BAC states are more likely to correctly identify their state's legal limit (NHTSA, 2003). Similarly, frequent DUI offenders turn out to be relatively more knowledgeable about DUI laws compared to those who do not drink and drive (Sloan et al., 2014). Thus, repeat offenders may flee crash scenes not only because they face much more severe charges than first-time offenders, but also because they are more likely to know about BAC laws given their prior convictions. Yu and Williford (1993) examine drunk driving behaviors and find that risky driving is associated with a higher likelihood of self-reported drinking and driving and yet, surprisingly, a lower likelihood of a DUI arrest. They speculate that this result could be due to previous DUI offenders engaging in subsequent drunk driving but making sure to drive in a manner so as to avoid detection by law enforcement.

Our estimated unintended effect of an illegal per se law at .08 BAC runs parallel to other traffic policy findings, where enforcement of traffic laws can produce unintentional consequences in the form of HR behavior. For example, Hijar et al. (2003) find that traffic law enforcement in Mexico has paradoxically raised pedestrian fatalities and led to 90% of traffic crashes being classified as HR. They explain that the Mexican Penal Code presumes drivers to be the guilty party in such crashes regardless of the circumstances. Similarly, Fujita and colleagues (2014) surmise that stricter drunk driving laws introduced in Japan may have contributed to a rise in HR behavior. Furthermore, our findings are also consistent with those of Adams et al. (2015) who find that motor vehicle drivers have changed their seat belt use in response to lowering BAC limits from .10 to .08—even if this seems to be a minor policy change. Specifically, they argue that intoxicated drivers seem to have started using their seat belts more judiciously to avoid being stopped for a seat belt violation and then being charged for drunk driving by law enforcement officials.

Limitations and related robustness checks

Our analysis has some shortcomings that are primarily due to data limitations. It is informative to differentiate between HR versus NHR fatalities and investigate how policy measures might affect each of these components. However, one potential concern is that overall fatalities are also a function of policy changes because a particular traffic crash is less likely to involve fatalities if a driver stays at the scene to render help to the victims. Thus, the risk of death is not independent of the HR behavior. Unfortunately, we are unable to disentangle these effects because FARS does not collect data on non-fatal crashes. Driver and vehicle characteristics are also largely missing in HR crashes. Such information is sometimes available when drivers are later apprehended or turn themselves in, which results in severe sample selection bias. Hence, we are unable to investigate the direct contributions of other important factors such as alcohol involvement. Alcohol involvement in each fatal crash is available in FARS data, but this information is mostly imputed based on various crash and driver characteristics, except when the BAC level of the driver(s) is directly measured/observed. Adams et al. (2012) provide a detailed description of the imputation as well as a discussion of the suspected measurement errors therein. Similarly, Betz and Jones (2022) provide an extensive discussion of the complications that arise when working with alcohol and drug use in the FARS. Concerns about the imputed alcohol involvement in a traffic crash is even greater in the case of HR incidents, where driver characteristics are missing by definition. Hence, we refrain from using this data element in our analyses.

Another limitation is the absence of state-specific data on HR laws for the period of our analysis. A study examining hit-and run penalties for eight states reveals a wide range of possible legal sanctions and penalties including fines, jail sentences, license suspensions, as well as misdemeanor or felony charges (Frisman, 2013). These penalties vary greatly subject to injury severity of the victim(s), the driver's prior violations and convictions, and each state's look-back period. We also lack information on sanctions and penalties pertaining to a DUI arrest, which range widely depending on numerous factors. Ideally, all these factors would be accounted for in the analyses to better understand the effects of DUI laws together with HR laws. Unfortunately, reliable measurement that adequately captures all aspects of state-specific legal sanctions for HR crashes (as well as their enforcement) are not available for the 1982-2008 period. Using Lexis–Nexis database searches, we updated the timing of HR laws for the eight states examined by Frisman (2013)—Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. For these states, we are able to confirm that no overlap is present in terms of timing of any significant changes made to HR laws and BAC limits. See Appendix Table A3 for the details. Thus, we find no evidence of omitted variables bias.

Our analyses assume that no omitted variables are correlated with both changes in BAC laws and changes in HR crashes, mainly because a majority of states reduced their BAC limits to .08 in response to federal pressure. Early adoption could have been influenced by other unobservable factors, such as attitudes about drunk driving or advocacy by private groups like MADD. In addition, changes in various alcohol or traffic policies may have occurred in response to sudden increases in traffic fatalities in general or HR fatalities in particular. Besides accounting for a large set of traffic policies and observable state characteristics, we attempt to mitigate potential omitted variables bias by including state and year fixed-effects as well as state-specific linear time trends in our models. Nevertheless, it is possible that differences in state-specific trends are not adequately captured by our specifications such as changes in enforcement of traffic laws. Unfortunately, we are unable to distinguish whether it is the .08 illegal per se BAC law itself or its enforcement that triggers the unintended effect on HR crashes. Recall that invalid driving licenses and previous DUI convictions have been shown to be significantly associated with HR behaviors (e.g., Solnick and Hemenway, 1995; MacLeod et al., 2012). If the adoption of lower BAC levels brings about increased enforcement of traffic laws in general and DUI laws in particular, drivers with invalid licenses and previous DUI convictions may be tempted to flee the crash scene even if they are not under the influence of any substances. Thus, the unintended effect of BAC laws would still arise.

Implications for policy and future research

Despite these limitations, and the fact that our analyses cannot definitively confirm nor rule out potential mechanisms, we present consistent and compelling evidence that stricter DUI laws may unintentionally increase HR incidents. The estimated unintended consequence of a .08 illegal per se BAC law is especially noteworthy given that this law seems to have little or no statistically significant effect on total or NHR fatalities. A complete welfare analysis of .08 BAC laws, including optimal design (e.g., Kenkel, 1993), is beyond the scope of this paper, but could be a fruitful avenue for future research. We believe our results have important implications vis-à-vis the existing literature investigating the effects of BAC policies on traffic fatalities in general and alcohol-related traffic fatalities in particular. If fleeing the crash scene becomes more prevalent among drunk drivers following the adoption of a more stringent BAC law, this could then artificially reduce (reported) alcohol-involved traffic fatalities. As a result, the estimated effect of the .08 BAC law on alcohol-involved traffic fatalities would be biased away from zero. This conjecture would hold as long as the rise in HR behavior is relatively faster than the decrease in alcohol-involved driving.

Our findings have direct implications for policymakers aiming to reduce the number of HR crashes and fatalities, which are extremely costly yet often preventable. The National Transportation Safety Board has urged policymakers to reduce the BAC limit down to .05 (Botelho, 2016). Utah became the first state to implement this change at the end of 2018, and other states including California and New York have introduced similar legislative proposals (Fell, 2019). However, even the advocacy group MADD argues that "the focus should be on other things" besides BAC laws. Instead, they propose that states require convicted drunk drivers who have a valid license to operate motor vehicles equipped with ignition interlock devices (i.e., breath- or touch-based testing devices that prevent the engine from starting if the driver has been drinking). To force drunk drivers to internalize the external costs associated with intoxicated driving, Hansen (2015) offers alternative policy proposals to lowering BAC limits. Based on our findings, rather than lowering the BAC limit alone, perhaps a better deterrence strategy would be to jointly design and enforce DUI and HR laws to maximize their combined effectiveness while minimizing potential unintended consequences.

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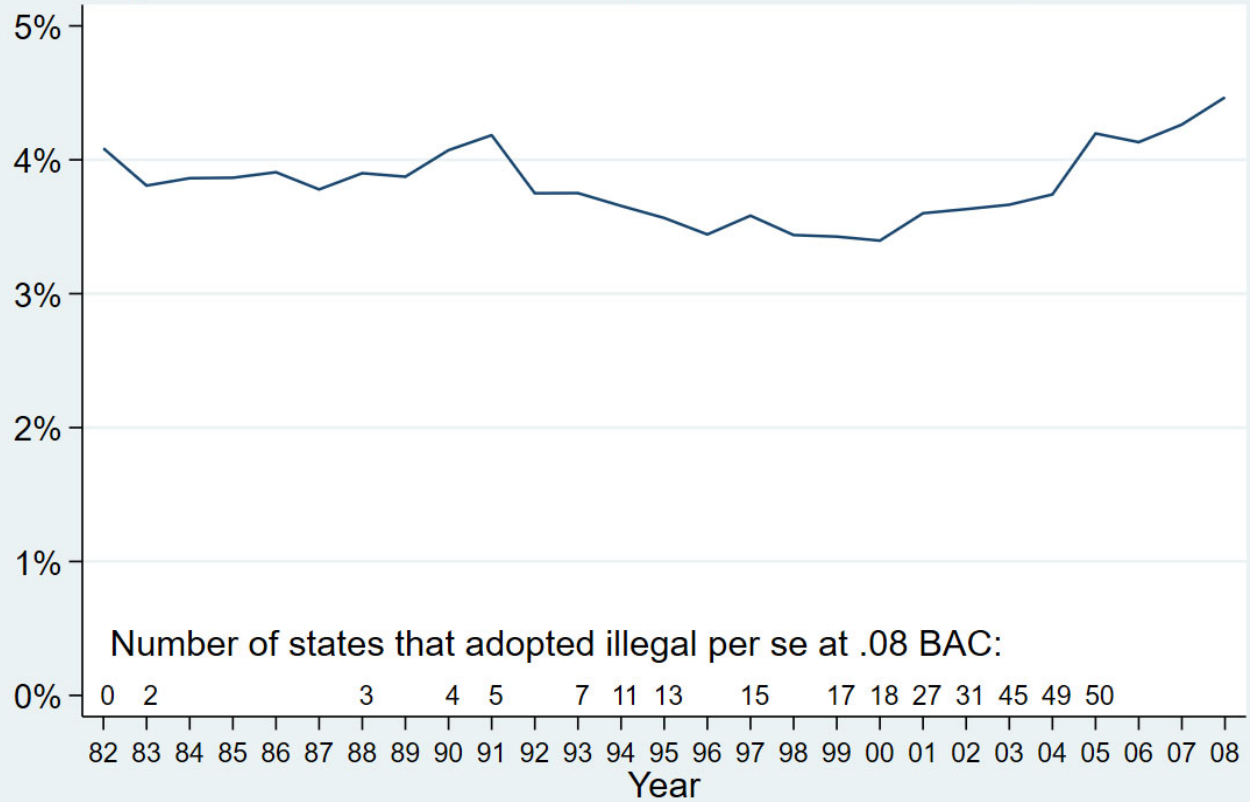
Figure 1: Hit-and-run fatalities per 100 traffic fatalities, 1982-2008



Notes: Data are from the Fatality Analysis Reporting System (FARS).

Table 1. Descriptive statistics, 1982-2008 (N=1,350)

Fatality measures	Mean	Std. Dev.	Min	Max
Total fatalities	852.9	856.0	62	5,504
Hit-and-run fatalities	32.5	56.2	0	437
Rural crashes	8.8	12.9	0	85
Urban crashes	23.6	45.4	0	367
Weekday crashes	14.4	24.9	0	194
Weekend crashes	17.6	30.9	0	255
Daytime crashes	8.6	16.5	0	150
Nighttime crashes	23.4	39.6	0	298
Non-hit-and-run fatalities	820.3	804.4	58	5,130
Rural crashes	488.8	408.5	7	2,256
Urban crashes	328.7	434.3	0	2,981
Weekday crashes	459.5	441.6	29	2,778
Weekend crashes	354.6	358.9	19	2,265
Daytime crashes	435.4	412.2	22	2,559
Nighttime crashes	378.7	392.2	12	2,484
Policy measures				
Illegal per se at .08 BAC	0.345	0.467	0	1
Administrative license revocation	0.625	0.479	0	1
Aggravated driving under the influence (DUI)	0.299	0.452	0	1
Minimum legal drinking age=21	0.893	0.301	0	1
Zero tolerance law(<0.02 BAC for age under 21)	0.496	0.493	0	1
Graduated driver-licensing	0.276	0.442	0	1
Speed limit>=70mph	0.284	0.451	0	1
Seat belt law - Primary enforcement	0.219	0.410	0	1
Seat belt law - Secondary enforcement	0.514	0.492	0	1
Control variables				
Population (1,000)	5,318	5,812	450	36,600
Unemployment rate (%)	5.689	1.991	2.300	17.800
Real personal income per capita (in constant 2008 $1,000)	33.002	6.376	18.609	57.763
High school graduates (%)	58.794	5.372	40.260	71.332
College graduates (%)	14.901	3.889	6.895	30.561
Light trucks as a proportion of all registered motor vehicles (%)	37.129	10.840	6.294	66.398
Vehicle miles traveled (VMT) per licensed driver (1,000)	13.728	2.524	7.748	29.691

Notes: Data on fatality measures come from the Fatality Analysis Reporting System (FARS). See Appendix Table A1 for all other data sources as well as definitions for all variables. All policy measures, with the sole exception of speed limits, take on fractional values for the years in which laws changed.

Table 2. Conditional fixed-effects negative binomial model results for traffic fatality counts, 1982-2008 (N=1,350)

	Total fatalities		Hit-and-run fatalities		Non-hit-and-run fatalities	
	(1)	(2)	(3)	(4)	(5)	(6)
Illegal per se at .08 BAC	0.997	1.002	1.078**	1.083**	0.994	0.999
	(0.011)	(0.011)	(0.029)	(0.031)	(0.011)	(0.012)
Administrative license revocation		0.968**		0.968		0.968**
		(0.012)		(0.040)		(0.012)
Aggravated DUI		0.993		0.981		0.992
		(0.011)		(0.036)		(0.011)
Minimum legal drinking age=21	0.976	0.971	1.020	1.012	0.974	0.970
	(0.017)	(0.017)	(0.064)	(0.067)	(0.018)	(0.017)
Zero tolerance law	1.008	1.011	0.979	0.981	1.009	1.012
(<0.02 BAC for age under 21)	(0.012)	(0.013)	(0.042)	(0.041)	(0.012)	(0.013)
Graduated driver-licensing	0.989	0.990	1.054	1.056	0.988	0.988
	(0.012)	(0.012)	(0.030)	(0.031)	(0.012)	(0.012)
Speed limit>=70mph	1.055**	1.060**	0.978	0.984	1.057**	1.063**
	(0.015)	(0.016)	(0.048)	(0.050)	(0.015)	(0.015)
Seat belt law - Primary enforcement	0.943**	0.943**	0.994	0.992	0.942**	0.942**
	(0.018)	(0.018)	(0.047)	(0.049)	(0.018)	(0.018)
Seat belt law - Secondary enforcement	0.969**	0.968**	0.998	0.997	0.968**	0.967**
	(0.011)	(0.011)	(0.036)	(0.036)	(0.012)	(0.012)
Unemployment rate	0.972**	0.973**	1.004	1.005	0.971**	0.972**
	(0.004)	(0.004)	(0.015)	(0.015)	(0.004)	(0.004)
Ln(Real personal income per capita)	1.880**	1.819**	3.376**	3.410**	1.857**	1.800**
	(0.213)	(0.213)	(1.102)	(1.259)	(0.205)	(0.206)
High school graduates (%)	1.000	1.000	0.983*	0.984*	1.000	1.000
	(0.002)	(0.002)	(0.007)	(0.007)	(0.002)	(0.002)
College graduates (%)	0.999	0.999	0.995	0.994	0.999	0.999
	(0.002)	(0.002)	(0.009)	(0.009)	(0.002)	(0.002)
Light trucks as a proportion of all	1.001	1.001	1.013**	1.012**	1.001	1.001
registered motor vehicles (%)	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)	(0.001)
Ln(VMT per licensed driver)	1.050	1.059	0.803	0.797	1.055	1.064
	(0.056)	(0.054)	(0.119)	(0.127)	(0.058)	(0.056)
Pre-law mean of the dependent variable	832.574		29.452		803.122	
p -value for the test of differences in estimated coefficients of illegal per se at .08 BAC						
specification (3) versus (5)				0.007**		
specification (4) versus (6)				0.012*		

Notes: Data come from the Fatality Analysis Reporting System (FARS). Estimated incidence rate ratios (IRR) are based on negative binomial regressions that condition on state fixed-effects and models also include year fixed-effects as well as state-specific annual time trends. The natural logarithm of the state population is treated as the exposure variable. Standard errors are in parentheses and are clustered to allow for non-independence of observations within each state. *, ** Significance at the 5 and 1 percent level, respectively.

Table 3. Estimation results by location, day, or time of the crash, 1982-2008 (N=1,350)

Panel 3A: Urban versus rural crashes

	Hit-and-run fatalities		Non-hit-and-run fatalities	
	Urban	**Rural**	**Urban**	**Rural**
	(1)	(2)	(3)	(4)
Illegal per se at .08 BAC	1.117**	1.044	1.062	0.974
	(0.036)	(0.048)	(0.036)	(0.019)
Pre-law mean of the dependent variable	21.180	8.163	313.873	486.257

p-value for the test of differences in estimated coefficients of illegal per se at .08 BAC	
specification (1) versus (3)	0.293
specification (2) versus (4)	0.097

Panel 3B: Weekend (between Friday 6pm and Monday 6am) versus weekday (Monday-Friday 8am-6pm) crashes

	Hit-and-run fatalities		Non-hit-and-run fatalities	
	Weekday	**Weekend**	**Weekday**	**Weekend**
	(5)	(6)	(7)	(8)
Illegal per se at .08 BAC	1.063	1.109**	1.010	0.984
	(0.037)	(0.038)	(0.012)	(0.014)
Pre-law mean of the dependent variable	12.932	15.951	445.536	351.964

p-value for the test of differences in estimated coefficients of illegal per se at .08 BAC	
specification (5) versus (7)	0.158
specification (6) versus (8)	0.001**

Panel 3C: Daytime (between 6am and 6pm) versus nighttime (after 6pm and before 6am) crashes

	Hit-and-run fatalities		Non-hit-and-run fatalities	
	Daytime	**Nighttime**	**Daytime**	**Nighttime**
	(9)	(10)	(11)	(12)
Illegal per se at .08 BAC	1.098*	1.081**	0.994	1.001
	(0.048)	(0.030)	(0.012)	(0.014)
Pre-law mean of the dependent variable	7.375	21.509	415.767	381.742

p-value for the test of differences in estimated coefficients of illegal per se at .08 BAC	
specification (9) versus (11)	0.023*
specification (10) versus (12)	0.014*

Notes: Data come from the Fatality Analysis Reporting System (FARS). Estimated incidence rate ratios (IRR) are based on negative binomial regressions that condition on state fixed-effects. Each cell is from a separate regression that uses the natural logarithm of the state population as the exposure variable. Each model also includes a vector of year fixed-effects and state-specific annual time trends as well as all the policy measures and control variables listed in Table 2. Standard errors are in parentheses and are clustered to allow for non-independence of observations within each state. *, ** Significance at the 5 and 1 percent level, respectively.

Table 4. Robustness checks (N=1,350 unless noted otherwise)

	Hit-and-run fatalities	Non-hit-and-run fatalities
	(1)	(2)
Panel 4A: Baseline results (same estimates as in columns 4 and 6 of Table II for comparison)		
Illegal per se at .08 BAC	1.083**	0.999
	(0.031)	(0.012)
Panel 4B: Conditional fixed-effects Poisson model results		
Illegal per se at .08 BAC	1.087**	0.992
	(0.026)	(0.011)
Panel 4C: Inclusion of alcohol consumption per capita		
Illegal per se at .08 BAC	1.083**	0.999
	(0.031)	(0.012)
Panel 4D: Vehicle miles traveled (VMT) as the exposure		
Illegal per se at .08 BAC	1.097**	1.002
	(0.036)	(0.014)
Panel 4E: Number of registered motor vehicles as the exposure		
Illegal per se at .08 BAC	1.125**	1.028
	(0.038)	(0.019)
Panel 4F: Restricting the sample to only the states with non-zero hit-and-run fatalities in all years (37 states, N=999)		
Illegal per se at .08 BAC	1.088**	1.002
	(0.032)	(0.013)
Panel 4G: States with smaller population (25 states, N=675)		
Illegal per se at .08 BAC	1.174	1.020
	(0.115)	(0.027)
Panel 4H: States with larger population (25 states, N=675)		
Illegal per se at .08 BAC	1.073*	0.984
	(0.035)	(0.012)
Panel 4I: Early adopters (18 states, N=486)		
Illegal per se at .08 BAC	1.072	1.006
	(0.050)	(0.015)
Panel 4J: Late adopters (32 states, N=864)		
Illegal per se at .08 BAC	1.158	0.967
	(0.104)	(0.024)

Notes: Data come from the Fatality Analysis Reporting System (FARS). Estimated incidence rate ratios (IRR) are based on negative binomial regressions that condition on state fixed-effects. Each cell is from a separate regression that uses the natural logarithm of the state population as the exposure variable unless specified otherwise. Each model also includes a vector of year fixed-effects and state-specific annual time trends as well as all the policy measures and control variables listed in Table 2, with the exception of VMT in the specification presented in Panel D. Standard errors are in parentheses and are clustered to allow for non-independence of observations within each state. *, ** Significance at the 5 and 1 percent level, respectively.

Appendix Table A1: Variable definitions and data sources

Variable	Definition	Sources
Fatality measures		
1 Total fatalities	All fatalities in motor vehicle traffic crashes	Fatality Analysis Reporting System (FARS) by National Highway Traffic Safety Administration (NHTSA)
2 Hit-and-run fatalities	All fatalities in hit-and-run motor vehicle traffic crashes, where hit-and-run refers to cases where a vehicle is a contact vehicle in the crash and does not stop to render aid (including drivers who flee the scene on foot).	FARS
3 Non-hit-and-run fatalities	The difference between (1) and (2) above	FARS
4 Total fatal crashes	All traffic crashes in which a fatality occurred	FARS
5 Hit-and-run fatal crashes	All fatal crashes that are classified as a hit-and-run traffic crash	FARS
6 Non-hit-and-run fatal crashes	The difference between (4) and (5) above	FARS
7 Urban (rural) crashes	Fatal traffic crashes that occurred in an urban (rural) area	FARS
8 Daytime crashes	Fatal traffic crashes that occurred between 6am and 6pm	FARS
9 Nighttime crashes	Fatal traffic crashes that occurred after 6pm and before 6am	FARS
10 Weekend crashes	Fatal traffic crashes that occurred between Friday 6pm and Monday 6am	FARS
11 Weekday crashes	Fatal traffic crashes that occurred after Monday 6am and before Friday 6pm	FARS
Policy measures		
12 Illegal per se at .08 BAC	Equals one if a state had a maximum allowable blood alcohol content (BAC) set at .08 for drivers and zero otherwise. A BAC per se statute makes it a violation in itself to exceed a BAC limit regardless of whether there is other evidence of intoxication. Takes on fractional values for the years in which laws changed.	Alcohol Policy Information System (APIS); Dang (2008); Utter, Subramanian, and Deutermann (2002)
13 Administrative license revocation	Equals one if a state had an administrative license revocation or administrative per se law and zero otherwise. Administrative license revocation allows law enforcement officers to suspend or revoke a driver's license if that individual fails or refuses to take a breath test. Takes on fractional values for the years in which laws changed.	Dang (2008); Knoebel and Ross (1996); The Insurance Institute for Highway Safety (IIHS)
14 Aggravated driving under the influence (DUI)	Equals one if a state had more severe sanctions for offenders with high BACs and zero otherwise, where the high-BAC threshold is established above the per se BAC limit for a standard offense (also referred to as "enhanced sanctions for higher BAC"). Takes on fractional values for the years in which laws changed.	Authors' own search through state statutes using LexisNexis database; Digest of State Alcohol Highway Safety-Related Legislation, Volumes 1-30, published by NHTSA

Appendix Table A1, continued

Variable	Definition	Sources
15 Minimum legal drinking age=21	Equals one if a state prohibited persons under 21 years of age from purchasing or publicly possessing alcoholic beverages and zero otherwise. Takes on fractional values for the years in which laws changed.	Hedlund, Ulmer, and Preusser (2001); O'Malley and Wagenaar (1990)
16 Zero tolerance law (<0.02 BAC for age under 21)	Equals one if a state prohibited persons under the age of 21 to drive with even a small amount of alcohol in their system (<0.02 BAC) and zero otherwise. Takes on fractional values for the years in which laws changed.	Anderson, Hansen, and Rees (2013); APIS; Hedlund, Ulmer, and Preusser (2001)
17 Graduated driver-licensing	Equals one if a state had a graduated driver-licensing law with an intermediate phase that gradually increases the driving privileges of teens as they advance through the licensing system and zero otherwise. Takes on fractional values for the years in which laws changed.	IIHS
18 Speed limit >=70mph	Equals one if a state had a speed limit of 70 mph or greater on rural interstates in a given year and zero otherwise.	IIHS
19 Seat belt law - Primary enforcement	Equals one if a state had a primary enforcement of seat belt law in a given year and zero otherwise. Takes on fractional values for the years in which laws changed. Primary enforcement allows law enforcement officers to issue a ticket to drivers or passengers for not wearing a seat belt, without any other traffic offense taking place.	IIHS
20 Seat belt law - Secondary enforcement	Equals one if a state had a secondary enforcement of seat belt law in a given year and zero otherwise. Takes on fractional values for the years in which laws changed. Secondary enforcement allows law enforcement officers to issue a ticket to drivers or passengers for not wearing a seat belt only when there is another citable traffic infraction.	IIHS
Control variables		
21 Population	Estimates of the July 1 resident population in 1,000s.	U.S. Census Bureau
22 Unemployment rate	Annual state unemployment rate as a percent of the labor force.	U.S. Bureau of Labor Statistics
23 Real personal income per capita	Personal income per capita in constant 2008 $1,000s.	U.S. Bureau of Economic Analysis
24 Proportion of high school graduates	High school graduates as a percent of the total population.	Frank (2009)
25 Proportion of college graduates	College graduates as a percent of the total population.	Frank (2009)

Appendix Table A1, continued

Variable	Definition	Sources
26 Proportion of light trucks	Light trucks as a percent of all registered motor vehicles, where light trucks include pickups, panels, delivery vans, personal passenger vans, passenger minivans, and utility-type vehicles.	Federal Highway Administration (FHWA)
27 Vehicle miles traveled	Vehicle miles traveled (VMT) on public roads in 1,000s.	FHWA
28 Number of licensed drivers	Numbers are estimated by FHWA.	FHWA
29 Alcohol consumption per capita	Gallons of ethanol content of alcohol consumption per capita age 21 and older.	Haughwout, LaVallee, and Castle (2015)

Sources: Mark Anderson, Benjamin Hansen, and Daniel I. Rees. 2013. "Medical Marijuana Laws, Traffic Fatalities, and Alcohol Consumption," Journal of Law and Economics, 56(2), pp.333-369.

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Kathleen Y. Knoebel and Dr. H. Laurence Ross. 1996. "Effects of Administrative License Revocation on Employment," NHTSA Report No. DOT HS 808 462, Washington, DC: National Highway Traffic Safety Administration.

NHTSA, 1983-2015. Volumes 1-30 of the Digest of State Alcohol Highway Safety-Related Legislation by the National Highway Traffic Safety Administration (NHTSA) are available at https://nhtsa.dr.del1.nhtsa.gov/Driving-Safety/Impaired-Driving/Digest-of-State-Alcohol-Highway-Safety%E2%80%93Related-Legislation.

Patrick M. O'Malley and Alexander C. Wagenaar. 1990. "Minimum Drinking Age Laws: Effects on American Youth, 1976-1987," Institute for Social Research Working Paper, The University of Michigan. Ann Arbor, MI.

Dennis Utter, Rajesh Subramanian and William Deutermann. 2002. "State Alcohol Related Fatality Rates," NHTSA Report No. DOT HS 809 528. Washington, DC: National Highway Traffic Safety Administration.

Appendix Table A2: Effective dates for illegal per se BAC at .08 laws by state, 1982-2008

State	Effective date	State	Effective date	State	Effective date
Alabama	10/1995	Louisiana	9/2003	Ohio	6/2003
Alaska	9/2001	Maine	8/1988	Oklahoma	7/2001
Arizona	8/2001	Maryland	9/2001	Oregon	10/1983
Arkansas	8/2001	Massachusetts	6/2003	Pennsylvania	9/2003
California	1/1990	Michigan	9/2003	Rhode Island	7/2000
Colorado	7/2004	Minnesota	8/2005	South Carolina	8/2003
Connecticut	7/2002	Mississippi	7/2002	South Dakota	7/2002
Delaware	7/2004	Missouri	9/2001	Tennessee	7/2003
Florida	1/1994	Montana	4/2003	Texas	9/1999
Georgia	7/2001	Nebraska	9/2001	Utah	8/1983
Hawaii	6/1995	Nevada	9/2003	Vermont	7/1991
Idaho	7/1997	New Hampshire	1/1994	Virginia	7/1994
Illinois	7/1997	New Jersey	1/2004	Washington	1/1999
Indiana	7/2001	New Mexico	1/1994	West Virginia	5/2004
Iowa	7/2003	New York	7/2003	Wisconsin	9/2003
Kansas	7/1993	North Carolina	10/1993	Wyoming	7/2002
Kentucky	10/2000	North Dakota	8/2003		

Sources: Kristina D. Arsenault. (2002). Comparison of .08 and .10 BAC Limits and Fatality Rates. Connecticut Office of Legislative Research (OLR) Research Report No. 2002-R-0516. Hartford, CT: OLR.

Jennifer N. Dang. (2008). Statistical Analysis of Alcohol-Related Driving Trends, 1982-2005. NHTSA Report No. DOT HS 810 942. Washington, DC: National Highway Traffic Safety Administration.

Dennis Utter, Rajesh Subramanian, and William Deutermann. (2002). State Alcohol Related Fatality Rates. NHTSA Report No. DOT HS 809 528. Washington, DC: National Highway Traffic Safety Administration.

Alcohol Policy Information System (APIS) Web site www.alcoholpolicy.niaaa.nih.gov/. National Institute on Alcohol Abuse and Alcoholism.

Appendix Table A3: Changes in illegal per se at .08 BAC and hit-and-run laws for selected states, 1982-2008

State	Illegal per se at .08 BAC	Hit-and-run laws*
Connecticut	7/2002	Minor amendments in October 1997.
Maine	8/1988	No changes.
Massachusetts	6/2003	The definition of leaving the crash scene was modified in January 1990. In March 1993, an amendment was made such that fault is no longer a prerequisite to requirement that motorists stop and identify after collision.
New Hampshire	1/1994	Minor amendments in 1990 and 1997.
New Jersey	1/2004	Hit-and-run laws were enacted in December 1994 and minor amendments were made in June 2003 and January 2008.
New York	7/2003	Minor amendments in November 1985, July 1986, and June 2005.
Rhode Island	7/2000	Minor amendments in June 1995 and July 2006.
Vermont	7/1991	Minor amendments in May 1996.

Notes: *Minor amendments in hit-and-run laws are typically increases in the associated penalties.
Sources for illegal per se at .08 BAC laws: Jennifer N. Dang. (2008). Statistical Analysis of Alcohol-Related Driving Trends, 1982-2005. NHTSA Report No. DOT HS 810 942. Washington, DC: National Highway Traffic Safety Administration.
Dennis Utter, Rajesh Subramanian, and William Deutermann. (2002). State Alcohol Related Fatality Rates. NHTSA Report No. DOT HS 809 528. Washington, DC: National Highway Traffic Safety Administration.
Alcohol Policy Information System (APIS) Web site www.alcoholpolicy.niaaa.nih.gov. National Institute on Alcohol Abuse and Alcoholism.
Source for hit-and-run laws: Frisman, P. (2013). Driving Under the Influence and Hit and Run Laws. Office of Legislative
Research Report 2013-R-0235. Hartford, CT: Connecticut General Assembly. Available at http://cga.ct.gov/2013/rpt/2013-R-0235.htm.