Published in final edited form as:

Accid Anal Prev. 2014 December ; 0: 181–186. doi:10.1016/j.aap.2014.09.002.

Effects of Enforcement Intensity on Alcohol Impaired Driving Crashes

James C. Fell, M.S., Geetha Waehrer, Ph.D, Robert B. Voas, Ph.D, Amy Auld-Owens, Katie Carr, and Karen Pell

Pacific Institute for Research and Evaluation (PIRE) 11720 Beltsville Drive, Suite 900 Calverton, Maryland 20705-3111

Abstract

Background—Research measuring levels of enforcement has investigated whether increases in police activities (e.g., checkpoints, driving-while-intoxicated [DWI] special patrols) above some baseline level are associated with reduced crashes and fatalities. Little research, however, has attempted to quantitatively measure enforcement efforts and relate different enforcement levels to specific levels of the prevalence of alcohol-impaired driving.

Objective—The objective of this study was to investigate the effects of law-enforcement intensity in a sample of communities on the rate of crashes involving a drinking driver. We analyzed the influence of different enforcement strategies and measures: (1) specific deterrence - annual number of driving-under-the-influence (DUI) arrests per capita; (2) general deterrence - frequency of sobriety checkpoint operations; (3) highly visible traffic enforcement -annual number of traffic stops per capita; (4) enforcement presence - number of sworn officers per capita; and (5) overall traffic enforcement - the number of other traffic enforcement citations per capita (i.e., seat belt citations, speeding tickets, and other moving violations and warnings) in each community.

Methods—We took advantage of nationwide data on the local prevalence of impaired driving from the 2007 National Roadside Survey (NRS), measures of DUI enforcement activity provided by the police departments that participated in the 2007 NRS, and crashes from the General Estimates System (GES) in the same locations as the 2007 NRS. We analyzed the relationship between the intensity of enforcement and the prevalence of impaired driving crashes in 22 to 26 communities with complete data. Log-linear regressions were used throughout the study.

Results—A higher number of DUI arrests per 10,000 driving-aged population was associated with a lower ratio of drinking-driver crashes to non-drinking-driver crashes ($p=0.035$) when controlling for the percentage of legally intoxicated drivers on the roads surveyed in the community from the 2007 NRS. Results indicate that a 10% increase in the DUI arrest rate is

© 2014 Elsevier Ltd. All rights reserved.

Corresponding Author: James C. Fell Pacific Institute for Research and Evaluation 11720 Beltsville Drive, Suite 900 Beltsville, MD, 20705 USA Phone: 301-755-2739 fell@pire.org.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

associated with a 1% reduction in the drinking driver crash rate. Similar results were obtained for an increase in the number of sworn officers per 10,000 driving-age population.

Discussion—While a higher DUI arrest rate was associated with a lower drinking-driver crash rate, sobriety checkpoints did not have a significant relationship to drinking-driver crashes. This appeared to be due to the fact that only 3% of the on-the-road drivers were exposed to frequent sobriety checkpoints (only 1 of 36 police agencies where we received enforcement data conducted checkpoints weekly). This low-use strategy is symptomatic of the general decline in checkpoint use in the U.S. since the 1980s and 1990s when the greatest declines in alcohol-impaired-driving fatal crashes occurred. The overall findings in this study may help law enforcement agencies around the country adjust their traffic enforcement intensity in order to reduce impaired driving in their community.

Keywords

driving-under-the-influence (DUI); enforcement intensity; impaired-driving crashes; traffic stops; sworn officers

1. Background

Substantial progress has been made in reducing impaired driving in the United States since the early 1980s. According to the National Highway Traffic Safety Administration's (NHTSA's) Fatality Analysis Reporting System (FARS), the proportion of all drivers in fatal crashes estimated to have been legally intoxicated (blood alcohol concentration (BAC) $\geq .08$ g/dL) has decreased from 35% in 1982 to 20% in 1997, a 43% decrease in that proportion. However, since 1997, that proportion has varied only slightly through 2012. One indicator of the extent of the problem is the wide variability in the states of the percentage of drivers in fatal crashes with illegal BACs. Averaged over a 5-year period (2002-2006), the percentages range from a low of 12% in Utah to a high of 31% in Montana. Among many reasons for this wide variability in the states, despite basically similar impaired driving laws, are the resources devoted to policing and the enforcement strategies applied to deterrence programs.

Research shows that the solutions to impaired driving lie mainly at the state and local community levels where the laws are applied and enforced, programs are implemented, and changes can be made. State and local community leaders need evidence-based strategies that can increase the perceived risk of being stopped and arrested by law enforcement if driving while impaired. Since most states currently have a good infrastructure of impaired-driving laws, all other factors being equal, states with highly visible, highly publicized impaired-driving enforcement programs tend to have lower rates. Georgia is a good example. It has conducted highly visible, frequent, publicized DUI enforcement throughout the state for the past several years (Fell et al., 2008a). It now has one of the lowest impaired-driving-related fatal-crash rates in the nation, going from 34% in 1982 to 15% in 2011—a 56% reduction in that proportion.

One recent study used statewide datasets to generate a metric of driving-while-intoxicated (DWI) enforcement and prosecution that focused on the rate of proactive DWI arrests (Dula

et al., 2007). This analysis found no relationship between the level of DWI arrest activity and DWI-related crashes, suggesting that although the current level of resources and mix of enforcement policies may maintain the reductions in DWI crashes attained in the 1980s and 1990s, current methods are unlikely to lead to additional systematic reductions unless their deterrence value can be enhanced, such as through improved enforcement technology and increased media support.

Other studies have demonstrated connections between increased law-enforcement-activity levels and reductions in crashes. Johnson, Tippetts, and Vishnuvajjala (2009) performed a statistical analysis of alcohol-impaired-driving fatalities and law-enforcement-activity level (measured by DWI arrests) between 2001 and 2006. Fifteen states that experienced decreases during that period were compared to 15 states that experienced increases in impaired-driving fatalities. Increases in DWI arrests per vehicle mile traveled in a state were significantly associated with reductions in alcohol-impaired-driving fatalities in those states.

Research also shows associations between traffic crashes and certain community environmental and cultural factors, legislation, and policies in addition to law-enforcement strategies (Gruenewald et al., 1997; Holder, 1998; Ross, 1984; Sivak, 2009). For example, it has been reported that the number of fatal crashes are associated with certain factors, such as the amount and type of travel, that is, vehicle miles traveled (O'Neill and Kyrychenko, 2006); whether the community is in an urban or rural area (Burgess, 2005; O'Neill and Kyrychenko, 2006); safety-belt-usage rate, proportion of licensed drivers who are males, proportion of licensed drivers older than age 64, income per capita, and deaths caused by alcohol-related liver failures per capita (Sivak, 2009). In addition to such community and environmental factors, a number of individual characteristics are related to fatal crashes: driving on roads at high speeds, driving with high BACs, and/or driving while unrestrained (Borkenstein et al., 1974; Peck et al., 2008; Voas et al., 2007).

1.1 Prior Study

While specific local and state enforcement programs have been evaluated, to our knowledge, there is no national information currently available that could help policymakers answer questions related to the cost effectiveness of enforcement procedures. To address that issue we took advantage of nationwide data on the local prevalence of impaired driving from the 2007 National Roadside Survey (NRS) and measures of DUI enforcement activity provided by the police departments that participated in the 2007 NRS (police cooperation was intrinsic to the success of the 2007 NRS). We conducted an exploratory study (Fell et al., 2014, under review) of the relationship between the intensity of enforcement and the prevalence of drivers with positive BACs on the road. That study related three measured BACs of drivers in the 2007 NRS ($BAC > .01$; $BAC > .05$; $BAC > .08$) with six measures of enforcement intensity collected from 41 out of 71 police departments operating in the 60 communities of the NRS. We found that the number of traffic stops per capita was highly significant with drivers in those communities in the upper half of traffic stop rates having significantly lower odds of alcohol impairment ($BAC > .05$) and legal intoxication ($BAC > .08$). The same pattern was found for DUI arrests where drivers on the roads in the communities in the highest quartile of DUI arrests per capita had significantly lower odds of

legal intoxication (BACs>.08). A similar result was obtained for saturation patrols and for citations for other traffic violations.

1.2 Current Study

In this current follow-up study, we use the same enforcement data to study the relationship of enforcement intensity to alcohol-impaired-driving crashes from the national General Estimates System (GES). Specifically, we measured the intensity of enforcement based on five independent predictors (per capita): number of sworn officers, number of traffic stops, number of DUI arrests, number of other traffic citations (e.g., for speeding; running a red light; seat belt use violations; etc.), and the number of sobriety checkpoints, relating these measures to the ratio of impaired driving crashes to non-impaired driving crashes (crash incidence ratio or CIR) from the GES. We excluded saturation patrol frequency for this study because only 19 PSUs reported that data and half of the drivers in that sample were exposed to less than 0.32 saturation patrols per 10,000 drivers, a very low rate. Indeed, 17% of drivers were in PSUs with no saturation patrol activity accounting for 72% of the lowest patrol intensity quartile. At the other end of the spectrum, 108 drivers came from one PSU reporting 365 saturation patrols in 2007 (i.e. saturation patrols every night), a high number that indicates possible extreme variation or more likely a misunderstanding in the definition of this activity across PSUs. In this current analysis, we controlled for the BAC level of the drivers on the road using data from the 2007 National Roadside Survey in order to isolate the effect of enforcement on impaired driving crashes.

2. Methods

2.1 Data Sources

2.1.1. National Roadside Survey 2007 (NRS)—A full description of the procedures employed in the 2007 NRS is contained in three reports (Lacey et al., 2009). In brief, drivers in the NRS were randomly stopped at 300 locations across 60 primary sampling units (PSUs) within the continental United States. Sites were selected through a stratified random sampling procedure used by NHTSA to develop national crash data for databases such as the General Estimates System (GES) (NHTSA, 1991). Data were collected during a 2-hour Friday daytime session at 60 locations and during four 2-hour nighttime periods (10 p.m. to midnight and 1 a.m. to 3 a.m. on both Fridays and Saturdays) at 240 locations. Both self-report and biological measures were taken. Biological measures included breath alcohol samples from 9,413 drivers. Oral fluid samples from 7,721 drivers, and blood samples from 3,276 drivers were also collected but not used in this report (Lacey et al., 2009).

In the 2007 NRS, a total of 10,909 drivers entered the data-collection site and were determined as eligible for survey participation. (For example, drivers in commercial vehicles such as pizza delivery cars, drivers younger than aged 16, and drivers who could not communicate in either English or Spanish were not eligible to participate). Eighty-three percent of eligible drivers participated in the survey, and because some of those who refused to participate in the survey agreed to provide a breath sample, BACs from preliminary breath- testing units were available on 86% of the eligible drivers. A passive alcohol sensor (PAS) was used when the drivers first approached the survey team. The PAS reading and

other measures (gender and time of night) were used to impute the BACs of drivers who entered the site but refused to provide a breath sample. Thus, the actual BAC readings were corrected for non-participating drivers. The current analysis excluded drivers sampled during the day on Friday, resulting in 6,859 weekend nighttime drivers with valid BAC readings.

Three dichotomous dummy variables representing different BAC levels were defined for this study: (1) drinking drivers with BACs greater than zero; (2) impaired drivers (those with a BAC $>.05$); and (3) intoxicated drivers (those with BACs $>.08$, above the legal limit). In addition, data on driver characteristics including age, gender, race/ethnicity, whether a passenger was in the car, seat belt usage, and where the driver was coming from (e.g., a bar, restaurant, party, work, etc.) were also available in the NRS. In each individual PSU, the percent of drivers on the roads with positive BACs ranged from 1.3% to 20.9% and the percent who were intoxicated ranged from 0.0% to 5.1%.

2.1.2 Enforcement Data—For data on types and intensity of police enforcement activity, representatives of the 71 police departments where roadside data were collected for the 2007 NRS were contacted by telephone and/or e-mail. Contacted officers either provided the data from their records or, where such records were not available, referred us to other sources. Enforcement data were collected for the 2007 calendar year to cover the 6 months before and the 6 months of the 2007 NRS during which the BAC prevalence data were collected for drivers on the roads. This outreach resulted in data on some enforcement activities from 41 of the 71 police agencies in the 60 PSUs included in the NRS. Of these, 5 provided data from more than one source (e.g. police department and state highway police or sheriff's department). For these PSUs, enforcement data was appropriately summarized across the different sources. Several attempts were made to collect the data from the police departments. For the 31 departments where we have no enforcement data, some said that kind of data was not available for the year 2007, some referred us to other contacts who never responded to our frequent requests, and some merely never responded despite numerous requests.

2.1.3 Alcohol-Impaired Driving Crash Outcomes—Alcohol-impaired-driving involvement in crashes was analyzed using the crash incidence ratio (CIR) defined as the ratio of police reported alcohol-impaired driving-involved crashes in the GES data to crashes without police reported alcohol-impaired driving involvement.

2.2 Explanatory Variables

Impaired driving rates: Using data from 6,859 weekend nighttime drivers in the NRS with BAC readings, rates of alcohol-positive (BAC $>.01$), impaired (BAC $>.05$), and intoxicated (BAC $>.08$) driving were calculated for each NRS site as the ratio of the number of drivers in each of these categories to the total number of drivers passing through the roadside survey site. Specifically, drivers with a BAC greater than zero were defined as alcohol-positive while those with BACs $>.05$ were BAC-impaired. Finally, BAC-intoxicated identified drivers who were legally intoxicated (BACs $>.08$).

Police Enforcement Intensity: From the data collected through contacts with the police departments, we generated five enforcement measures for each PSU. We also controlled to the extent possible for differences in total miles driven across the PSUs by calculating rates of enforcement per 10,000 population using census data on the driving population aged 18 and older in each of the counties comprising the PSUs (U.S. Census Bureau, n.d.). Estimated vehicle miles travelled (VMT) is available at the State level via the Federal Highway Administration, but not at the individual community (PSU) level. The five enforcement measures studied were: (1) the number of DUI arrests per 10,000 population provided a measure of the intensity of traditional impaired-driving enforcement based on police traffic-patrol procedures; (2) the frequency with which sobriety checkpoints are conducted (weekly, monthly, less than monthly, never) provided a measure of this general deterrent enforcement procedure, which produces relatively few DUI arrests but has been shown to reduce alcohol-related crashes (Elder et al., 2002; Fell et al., 2004; Lacey et al., 1999; Peek-Asa, 1999; Shults et al., 2001); (3) the number of traffic stops per 10,000 population provided a measure of the overall intensity and visibility of traffic enforcement in the community covered by the police department; (4) the total number of sworn officers per 10,000 in the community population provided a measure of police presence, and (5) the number of other enforcement activities (warnings, seat belt citations, speeding citations, and other moving violations) recorded per 10,000 people in the community provided a measure of overall traffic enforcement.

Economic, environmental variables: We controlled our models for the influence of economic activity in the region using data on the local unemployment rate (U.S. Bureau of Labor Statistics, 2008). Per capita alcohol consumption and alcohol outlet density were not available for this study, however, the prevalence of alcohol-related nighttime activity and alcohol availability in the PSU was estimated by proxy by calculating the proportion of all drivers (from the NRS data) who reported driving from a restaurant, bar, or other alcohol outlet. While the demographics, religiosity, and socioeconomics of the county may also be associated with the rate of alcohol involvement in crashes, we reported results from the parsimonious specification that omits these controls because of the small samples involved. Results were substantively similar with or without these demographic controls.

Of the original 60 PSUs in the NRS, 36 had available crash data from the GES. Restricting the analysis to those PSUs with valid data on the different enforcement measures resulted in smaller samples ranging from 22 PSUs for the analysis involving other enforcement strategies to 26 PSUs for the analysis involving DUI arrest rates. Therefore, while not nationally representative, this multi-site approach is rare in the analyses of DUI enforcement effects.

3. Analyses

We examined the relationship between the Crash Incidence Ratio (CIR) and PSU-level enforcement, separately for each of the five enforcement activities, while also controlling for the rate of alcohol-involved driving measured at each PSU via the roadside surveys. Logged crash outcomes were analyzed using log-linear regressions with robust standard errors and Stata 11. The main explanatory variables were also specified in log form allowing the

intensity of police enforcement and the rate of alcohol-positive driving to have a non-linear relationship with the rates of alcohol-impaired-driving crashes. To avoid losing PSUs with no cases of impaired or intoxicated driving from the analysis (log of zero is undefined), 0.001 was added to the rate of impaired and intoxicated driving before logs were taken. The percent change in alcohol-related crash rates associated with a 10% change in enforcement intensity or BAC rates can be calculated as 1.1^{β} where β is the coefficient on the logged independent variable.

Note that our use of the CIR uses non-alcohol related crashes as a control group and thus helps to adjust for a range of known and unknown factors that may affect the number of all types of crashes (Dang, 2008). Some examples of these are population growth and demographic changes, driving exposure (reflected in VMT and indirectly in economic indicators), general changes in vehicle safety (such as air bags, electronic stability control and trends toward driving larger vehicles), weather, and road conditions. Although it was theoretically possible to try to account for the effects of all such factors on alcohol-related crashes individually via covariate techniques, realistically it was impossible to obtain operational measures for all of the known extraneous influences. There are also many other general influences of which we may be unaware. To the extent that these potentially confounding factors similarly affect the risk of non-alcohol-related crashes as they do alcohol-related crashes, we can adjust for them by using non-alcohol-related crashes as a control group via the CIR. The superiority of the CIR as an outcome measure is explained in detail in Voas et al. (2007).

To assess the extent to which PSUs in the NRS were representative of PSUs in the total GES, we compared the crash outcomes for the 36 PSUs in the NRS with GES crash data with those from the 24 PSUs in the GES which were not part of the NRS in 2007. The CIR was 0.076 (95% CI=[0.066, 0.086]) among the 36 PSUs in the 2007 NRS, and 0.091 (CI=[0.075, 0.107]) in the 24 PSUs that were not part of the NRS, a difference which was not statistically significant, but still substantial.

4. Results

Table 1 presents means of the main explanatory variables for NRS PSUs with data on crashes. Approximately 12.5% of nighttime drivers in these PSUs recorded BAC levels greater than zero; 4.7% of drivers were alcohol-impaired with BAC levels of 0.05 or greater; and 2.4% were legally intoxicated with BAC levels of 0.08 or higher. Police departments in these PSUs reported an annual average of 2,268 traffic stops per 10,000 driving population, with more than 2,185 recorded citations for seat-belt, speeding, and other moving violations per 10,000 population. These rates dwarfed the annual 67 DUI arrests per 10,000 drivers. Approximately 28% of the PSUs reported using sobriety checkpoints – however, this variable was missing for more than half of the sample. In an indication of the nighttime driving environment, 13% of nighttime weekend drivers reported that their trips were from a restaurant, bar, hotel, or similar alcohol serving commercial establishment. Of the nighttime drivers with positive BACs, approximately 30% were coming from an alcohol serving commercial establishment.

4.1 Relationship of Enforcement Activities with Alcohol-Impaired Driving Crashes

Table 2 presents the results of a series of log-linear regressions of the five enforcement measures on the ratio of alcohol-impaired to non-alcohol-impaired crashes controlling for driver BAC levels. The first section includes the number of traffic stops per 10,000 driving population in the PSU which was not significantly related to the ratio of alcohol-impaired driving crashes to non-alcohol-impaired driving crashes in the PSU. This result persists when the percentage of alcohol-positive, impaired, and intoxicated drivers on the roads in the PSU are controlled for in columns (3), (5), and (7).

Models also control for the local unemployment rate, a dummy for missing unemployment rate, and percentage of nighttime drivers from a bar, restaurant, hotel or similar establishment based on NRS drivers surveyed in nighttime sessions from 10 pm to midnight and 1 am to 3 am.

Robust p-values in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Column (1) Relationship of enforcement to crash rate not controlling for BAC levels of drivers on the roads

Columns (2), (4), (6) Relationship of BAC levels to crash rates not controlling for enforcement

Columns (3), (5), (7) Relationship of BAC levels to crash rates controlling for enforcement

The logged number of DUI arrests per 10,000 driving-aged population is negatively associated with the ratio of alcohol-impaired driving to non-alcohol impaired driving crashes ($p = 0.035$) when controlling for the percentage of legally intoxicated drivers surveyed in the PSU. Results indicate that a 10% increase in the DUI arrest rate is associated with a 1% reduction in the alcohol-impaired-driving crash rate. Similar results are obtained for an increase in the number of sworn officers per 10,000 driving-age population.

There were no significant associations of alcohol-impaired-driving crash rates with other types of enforcement actions such as citations for seat belt, speeding, other moving violations and warnings, or with the use of sobriety checkpoints. Contrary to expectations, the percentage of BAC-positive and BAC-intoxicated drivers were negatively (rather than positively) associated with the ratio of alcohol-impaired driving to non-alcohol-impaired driving crashes. For example, a 10% increase in the percentage of BAC-intoxicated drivers is associated with 1% to 2% reduction in the rate of alcohol-impaired-driving crashes controlling for the different types of police enforcement.

5. Conclusions

Highly visible enforcement has been shown to be effective in reducing impaired driving crashes in several studies (e.g., Fell et al., 2008b; Goss et al., 2008; Lacey et al., 2006; Wells et al., 1992). Total traffic stops may be a good measure of the level of visibility of enforcement. In our prior study on the impact of enforcement on the prevalence of drinking

and driving using data from the 2007 NRS (Fell et al., 2014, under review), in communities with the lowest rates of traffic stops per capita, drivers had 3.6 times the odds of being impaired ($BAC > .05$) and 3.8 times the odds of being intoxicated ($BAC > .08$) on their roads. In this current study, where the prevalence of drinking drivers was controlled, the direction of the effect of traffic stops, though in the expected direction, was not significant. However, two other measures of enforcement intensity, the number of sworn officers per capita (perhaps representing law enforcement presence in the PSU) and the number of DUI arrests per capita (perhaps representing the intensity of DUI enforcement) were significantly related to impaired-driving crashes. With regard to DUI arrest rates per capita, a 10% increase in the DUI arrest rate was associated with a modest 1% reduction in the impaired driving crash rate. The overall findings in this study may help law enforcement agencies around the country adjust their traffic enforcement intensity in order to reduce impaired driving in their community.

It was not unexpected that we found no significant relationship between sobriety checkpoint frequency and alcohol-positive driving, given that so few of the police departments reported using them. Only one police department, representing 3% of the PSUs, reported conducting them weekly. Weekly checkpoints may very likely be the key threshold for checkpoint effectiveness (Elder et al., 2002; Fell et al., 2004; Lacey et al., 1999; Peek-Asa, 1999; Shults et al., 2001).

A possible explanation for the negative association of alcohol-positive driving rates in Table 2 with alcohol-related crashes may be the failure of our proxy measure of alcohol availability (drivers coming from bars and restaurants) to adequately capture the alcohol culture in the PSU. It is also possible that high rates of BAC-intoxicated driving in any community trigger a societal response focused on enforcement and responsible drinking and driving that, in turn, affect the rates of alcohol-impaired driving crashes. On the other hand, if alcohol-positive driving rates themselves are the product of unobserved factors associated with both impaired driving and crash frequency (i.e., higher income communities may have more drinking drivers with a greater means for discretionary social travel, but also may have safer roads and newer cars which may reduce non-alcohol-related crashes more than alcohol-related crashes), then the coefficients are biased estimates of causal relationships between alcohol-involved driving and alcohol-related crash rates.

5.1 Limitations

Since we did not have GES or enforcement data from all 60 PSUs in the 2007 NRS, our data cannot be considered as nationally representative of the United States. However, we did have enforcement intensity measures, roadside BAC data and GES crash data from 22 to 26 PSUs for our analyses, so this should be considered a multi-site study with a convenience sample of communities. We are not aware of any similar studies of DUI enforcement that have more than two or three sites in their sample. Another limitation in the data to note is that our comparison of the 36 PSUs in the 2007 NRS where we had GES data had a CIR of 0.076 which was quite different than the CIR (0.091) for the 24 PSUs that were not in the 2007 NRS. While that difference was not statistically significant, it was considered substantial on a practical basis.

Another potential problem lies in the reporting of alcohol-involved crashes in the GES. As Zaloshnja, Miller, and Blincoe (2013) reported, a large fraction of the GES count of alcohol-involved crashes also involve a DUI arrest. In addition, Miller, Gibson, Zaloshnja et al. (2012) found widespread underreporting of alcohol-involved crashes with differences across states. To the extent that this underreporting is correlated with DUI enforcement intensity, our estimates associations between enforcement and alcohol-involved crashes may be biased. In order to account somewhat for these problems with the GES count of alcohol-involved crashes, we also analyzed the ratio of single vehicle nighttime (SVN) crashes to multiple vehicle daytime (MVD) crashes, a proxy measure used in many studies for alcohol involvement (e.g., Heeren et al., 1985; Voas et al., 2009). We did not find any associations of those ratios (SVN/MVD) to any of the enforcement intensity measures (tables not shown).

After we proceeded several months into the enforcement data collection phase, we discovered that several of our original contacts in each of the 71 NRS police jurisdictions no longer worked in that agency. This necessitated contacting a number of different police officials until the “right person” was reached who could help us with the data collection considerably. In some instances we made up to 10 calls in attempts to obtain the data. We finally had to settle on full or partial data from only 43 of the 72 police agencies contacted. One of the key data items police jurisdictions had difficulty providing was the number of sobriety checkpoints they conducted in 2007 (only 30 PSUs provided these data). Many police jurisdictions do not routinely keep such data, so we asked for estimates if real data were unavailable. Most agencies did not supply real data or estimates. This severely limited our data analysis of this enforcement strategy.

Acknowledgments

The research for this article was conducted under a grant from the National Institute of Alcohol Abuse and Alcoholism (NIAAA) entitled: Relationship of Impaired Driving Enforcement Intensity to Drinking and Driving (R21 AA018761). The authors thank Mr. Gregory Bloss of the NIAAA for his positive guidance throughout the grant process and his important suggestions concerning this manuscript.

References

- Borkenstein RF, Crowther RF, Shumate RP, Ziel WB, Zylman R. The role of the drinking driver in traffic accidents. *Blutalkohol*. 1974; 11(Supplement 1):1–132.
- Burgess, M. Contrasting rural and urban fatal crashes 1994–2003. U.S. Department of Transportation, National Highway Traffic Safety Administration; Washington, DC: 2005.
- Dang, JN. Statistical analysis of alcohol-related driving trends, 1982–2005. National Highway Traffic Safety Administration; Washington, DC: 2008.
- Dula CS, Dwyer WO, LeVerne G. Policing the drunk driver: Measuring law enforcement involvement in reducing alcohol-impaired driving. *Journal of Safety Research*. 2007; 38(3):267–272. [PubMed: 17617235]
- Elder RW, Shults RA, Sleet DA, Nichols JL, Zaza S, Thompson RS. Effectiveness of sobriety checkpoints for reducing alcohol-involved crashes. *Traffic Injury Prevention*. 2002; 3(4):266–274.
- Fell J, Waehrer G, Voas R, Auld-Owens A, Carr K, Pell K. Relationship of impaired driving enforcement intensity to drinking and driving on the roads. *Alcoholism: Clinical and Experimental Research*. 2014 under review.
- Fell JC, Lacey JH, Voas RB. Sobriety checkpoints: Evidence of effectiveness is strong, but use is limited. *Traffic Injury Prevention*. 2004; 5(3):220–227. [PubMed: 15276922]

- Fell, JC.; Langston, EA.; Lacey, JH.; Tippetts, AS.; Cotton, R. Evaluation of Seven Publicized Enforcement Programs to Reduce Impaired Driving: Georgia, Louisiana, Pennsylvania, Tennessee, Indiana, Michigan, and Texas. National Highway Traffic Safety Administration; Washington, DC: 2008a.
- Fell JC, Tippetts AS, Levy M. Evaluation of seven publicized enforcement demonstration programs to reduce impaired driving: Georgia, Louisiana, Pennsylvania, Tennessee, Texas, Indiana, and Michigan. *Annals of Advances in Automotive Medicine*. 2008b; 52:23–38. [PubMed: 19026220]
- Goss, C.; Van Bramer, L.; Gliner, J.; Roberts, I.; DiGuseppi, C. Increased police patrols for preventing alcohol-impaired driving (review). The Cochrane Collaboration, Cochrane Library, Wiley & Sons, Limited; 2008. p. 1-89.
- Gruenewald, P.; Treno, A.; Taff, G.; Klitzner, M. Measuring Community Indicators: A Systems Approach to Drug and Alcohol Problems. Sage Publications; Thousand Oaks, CA.: 1997.
- Heeren T, Smith RA, Morelock S, Hingson RW. Surrogate measures of alcohol involvement in fatal crashes: Are conventional indicators adequate? *Journal of Safety Research*. 1985; 16(3):127–133.
- Holder, H. Alcohol and the Community: A Systems Approach to Prevention. Cambridge University Press; Cambridge, MA: 1998.
- Johnson, MB.; Tippetts, AS.; Vishnuvajjala, R. Identifying demographic, socioeconomic, funding and enforcement predictors of state-level change in alcohol-impaired crashes. National Highway Traffic Safety Administration; Washington, DC: 2009. p. 28
- Lacey, JH.; Jones, RK.; Smith, RG. An evaluation of Checkpoint Tennessee: Tennessee's statewide sobriety checkpoint program. National Highway Traffic Safety Administration; Washington, DC: 1999.
- Lacey JH, Kelley-Baker T, Ferguson SA, Rider RP. Low-manpower checkpoints: Can they provide effective DUI enforcement for small communities? *Traffic Injury Prevention*. 2006; 7(3):213–218. [PubMed: 16990234]
- Lacey, JH.; Kelley-Baker, T.; Furr-Holden, D.; Voas, RB.; Moore, C.; Brainard, K.; Tippetts, AS.; Romano, E.; Torres, P.; Berning, A. 2007 National Roadside Survey of Alcohol and Drug Use by Drivers. U.S. Department of Transportation, National Highway Traffic Safety Administration; Washington, DC: 2009.
- Miller TR, Gibson R, Zaloshnja E, Blincoe LJ, Kindelberger J, Thomas A, Ho S, Bauer M, Sperry S, Peng J, Singleton M, Smith TJ, Zhang Y. Underreporting of driver alcohol involvement in United States police and hospital records: Capture-recapture estimates. *Annals of Advances in Automotive Medicine*. 2012; 56:87–96. [PubMed: 23169120]
- National Highway Traffic Safety Administration. National accident sampling system general estimates system technical note, 1988 to 1990. National Highway Traffic Safety Administration; Washington, DC.: 1991.
- O'Neill B, Kyrychenko SY. Use and misuse of motor vehicle crash death rates in assessing highway safety performance, Insurance Institute for Highway Safety. *Traffic Injury Prevention*. 2006; 7(4): 307–318. [PubMed: 17114086]
- Peck RC, Gebers MA, Voas RB, Romano E. The relationship between blood alcohol concentration, age, and crash risk. *Journal of Safety Research*. 2008; 39(3):311–319. [PubMed: 18571573]
- Peek-Asa C. The effect of random alcohol screening in reducing motor vehicle crash injuries. *American Journal of Preventive Medicine*. 1999; 16(1S):57–67. [PubMed: 9921387]
- Ross HL. Social control through deterrence: Drinking-and-driving laws. *Annual Review of Sociology*. 1984; 10:21–35.
- Shults RA, Elder RW, Sleet DA, Nichols JL, Alao MO, Carande-Kulis VG, Zaza S, Sosin DM, Thompson RS. Reviews of evidence regarding interventions to reduce alcohol-impaired driving. *American Journal of Preventive Medicine*. 2001; 21(4 Suppl):66–88. [PubMed: 11691562]
- Sivak M. Homicide rate as a predictor of traffic fatality rate. *Traffic Injury Prevention*. 2009; 10(6): 511–512. [PubMed: 19916119]
- U.S. Bureau of Labor Statistics. [May 28, 2008] Local Area Unemployment Statistics: Information and Analysis. 2008. at <http://www.bls.gov/LAU>
- U.S. Census Bureau, n.d. Vintage. 2007 state population datasets. U.S. Census Bureau; at http://www.census.gov/popest/data/historical/2000s/vintage_2007/datasets.html [May 15, 2013]

- Voas RB, Fell JC, Tippetts AS, Blackman K, Nichols J. Impact of primary safety belt laws on alcohol-related front-seat occupant fatalities: Five case studies. *Traffic Injury Prevention*. 2007; 8(3):232–243. [PubMed: 17710712]
- Voas RB, Romano E, Peck R. Validity of surrogate measures of alcohol involvement when applied to nonfatal crashes. *Accident Analysis and Prevention*. 2009; 41(3):522–530. [PubMed: 19393802]
- Wells JK, Preusser DF, Williams AF. Enforcing alcohol-impaired driving and seat belt use laws, Binghamton, New York. *Journal of Safety Research*. 1992; 23(2):63–71.
- Zaloshnja E, Miller T, Blincoe L. Costs of alcohol-involved crashes, United States, 2010. *Annals of Advances in Automotive Medicine*. 2013; 57:3–12. [PubMed: 24406941]

Highlights

- ▶ Is the intensity of enforcement related to the prevalence of impaired driving crashes?
- ▶ A 10% increase in the DUI arrest rate was associated with a 1% reduction in the drinking driver crash rate.
- ▶ The findings may help law enforcement agencies adjust their traffic enforcement intensity.

Table 1

Sample Means

Variable	N	Mean	(Std. Deviation)
% alcohol-positive (BAC>0)	36	0.125	(0.05)
% alcohol- impaired (BAC>=0.05)	36	0.047	(0.031)
% alcohol intoxicated (BAC>=0.08)	36	0.024	(0.018)
# Traffic Stops per 10K drivers	23	2268.29	(6907.29)
# DUI Arrests per 10K drivers	26	67.49	(236.18)
# Sworn Officers per 10K drivers	25	12.76	(17.24)
# Other Enforcement per 10K drivers	23	2185.64	(7953.27)
% PSUs using sobriety checkpoints	36	0.28	
Unemployment Rate	36	0.05	
% Driving from Restaurant, Bar etc.	36	0.13	

Table 2

Association of CIR with Five Enforcement Measures

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	BAC > 0		BAC ≥ 0.05		BAC ≥ 0.08		
Log (#Traffic Stops per 10K)	−0.061 (0.150)		−0.062 (0.239)		−0.075 (0.114)		−0.066 (0.148)
Log (Percentage BAC>0)		0.097 (0.711)	−0.014 (0.963)				
Log (Percentage BAC ≥ 0.05)				−0.062 (0.551)	−0.104 (0.365)		
Log (Percentage BAC ≥ 0.08)						−0.141* (0.099)	−0.148* (0.087)
N	23	23	23	23	23	23	23
Log (DUI Arrests per 10K)	−0.052 (0.165)		−0.071* (0.087)		−0.077* (0.094)		−0.077* (0.069)
Log (Percentage BAC>0)		−0.203** (0.032)	−0.255*** (0.009)				
Log (Percentage BAC ≥ 0.05)				−0.091 (0.358)	−0.133 (0.199)		
Log (Percentage BAC ≥ 0.08)						−0.160* (0.065)	−0.190** (0.039)
N	26	26	26	26	26	26	26
Log (Other Enforcement per 10K)	−0.020 (0.721)		−0.019 (0.770)		−0.026 (0.643)		−0.029 (0.587)
Log (Percentage BAC>0)		0.075 (0.772)	0.029 (0.932)				
Log (Percentage BAC ≥ 0.05)				−0.015 (0.883)	−0.041 (0.691)		
Log (Percentage BAC ≥ 0.08)						−0.127 (0.137)	−0.140* (0.090)
N	22	23	22	23	22	23	22
Log (Sworn officers per 10K)	−0.092** (0.021)		−0.100** (0.018)		−0.097** (0.027)		−0.105** (0.020)
Log (Percentage BAC>0)		−0.200** (0.039)	−0.233** (0.012)				
Log (Percentage BAC ≥ 0.05)				−0.118 (0.217)	−0.129 (0.182)		
Log (Percentage BAC ≥ 0.08)						−0.164* (0.058)	−0.187** (0.039)
N	25	25	25	25	25	25	25
Use Sobriety Checkpoints	0.086 (0.621)		0.136 (0.458)		0.108 (0.546)		0.113 (0.519)
Log (Percentage BAC>0)		−0.188* (0.061)	−0.215* (0.056)				
Log (Percentage BAC ≥ 0.05)				−0.118 (0.217)	−0.123 (0.228)		
Log (Percentage BAC ≥ 0.08)						−0.163* (0.057)	−0.168* (0.063)
N	26	26	26	26	26	26	26