1 Relationship of Impaired-Driving Enforcement Intensity to Drinking and Driving on the Roads

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Background: It is principally the area of enforcement that offers the greatest opportunity for reducing alcohol-impaired driving in the near future. How much of a reduction in drinking and driving would be achieved by how much improvement in enforcement intensity?

Methods: We developed logistic regression models to explore how enforcement intensity (6 different measures) related to the prevalence of weekend, nighttime drivers in the 2007 National Roadside Survey who had been drinking (blood alcohol concentration [BAC] > 0.00 g/dl), who had BACs > 0.05 g/dl, and who were driving with an illegal BAC > 0.08 g/dl.

Results: Drivers on the roads in our sample of 30 communities who were exposed to fewer than 228 traffic stops per 10,000 population aged 18 and older had 2.4 times the odds of being BAC positive, 3.6 times the odds of driving with a BAC > 0.05, and 3.8 times the odds of driving with a BAC > 0.08 compared to those drivers on the roads in communities with more than 1,275 traffic stops per 10,000 population. Drivers on the roads in communities with fewer than 3.7 driving under the influence (DUI) arrests per 10,000 population had 2.7 times the odds of BAC-positive drivers on the roads compared to communities with the highest intensity of DUI arrest activity (>38 DUI arrests per 10,000 population).

Conclusion: The number of traffic stops and DUI arrests per capita were significantly associated with the odds of drinking and driving on the roads in these communities. This might reflect traffic enforcement visibility. The findings in this study may help law enforcement agencies around the country adjust their traffic enforcement intensity to reduce impaired driving in their community.

Key Words: Impaired Driving, Enforcement, Traffic Stops, Driving Under the Influence Arrests, 3 Blood Alcohol Concentration.

4 5 ALTHOUGH remarkable progress was made in reducing impaired-driving fatal crashes between 1982 and 1997 in the United States, since that time progress has stalled (Dang, 2008; Fell and Voas, 2006b). The proportion of all drivers involved in fatal crashes estimated to have been illegally intoxicated (blood alcohol concentration [BAC] ≥ 0.08 g/dl) was reduced from 35% in 1982 to 20% in 1997, a 43% decrease. However, that proportion has remained at 20 to 22% each year from 1998 (when it was 20%) through 2012 (when it was 21%) (NHTSA, 2013). During the period from 1982 to 1997, states adopted the modern set of impaired-driving laws found to be effective in most industrialized nations, including lower illegal BAC limits for driving (Hingson et al., 2000), administrative license revocation (ALR) (Wagenaar and Maldonado-Molina, 2007), and increased sanctions for those convicted of driving under the influence (DUI) of alcohol (Voas et al., 2008). No new sweeping general deterrent legislation similar to what occurred in the 1980s and 1990s is likely to occur in the near future. Although there is strong evidence for lowering the illegal BAC limit for driving from 0.08 BAC to 0.05 BAC (Chamberlain and Solomon, 2002; Fell and Voas, 2006a; Mann et al., 2001) that is unlikely in the near term, even though the National Transportation Safety Board (NTSB) recently made that a key recommendation in their 2013 report (NTSB, 2013). No increase in the minimum legal drinking age of 21 can be expected either. Most legislative changes in the past decade have been limited to minor adjustments and closing loopholes in current laws. Some states have begun mandating alcohol ignition interlock devices on the vehicles of convicted DUI offenders, but it is unclear whether this will have a general deterrent effect on drinking and driving, although one study has indicated that it might (McCartt et al., 2013). The aging of the population continues, the growth in the number of licensed young drivers (aged 16 and 17) is slowing down, so impaired-driving rates should be decreasing. Thus, it appears that the area of enforcement offers the greatest opportunity for reducing impaired-driving fatal crashes in the immediate future, yet little information exists on what levels of effort and resources are needed for effective enforcement.

Enforcement of drinking-and-driving laws is not without cost, and it must compete against other law enforcement activities, especially given the current economic strain on local and state budgets. How much of a reduction in

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Received for publication February 24, 2014; accepted October 8, 2014.

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DOI: 10.1111/acer.12598

A C E R	12598	WILEY	Dispatch: 25.10.14	CE: Swathilakshmi M.
Journal Code	Manuscript No.		No. of pages: 9	PE: Kalai

drinking and driving would be achieved by how much improvement in law enforcement? How does the relationship between increases in enforcement intensity and reductions in impaired driving differ between enforcement policies (i.e., traditional traffic stops/arrests vs. sobriety checkpoints)? Decision makers, public officials, and community organizations facing such policy and budgetary dilemmas would benefit from a better understanding of the association between improvements in the enforcement of drinking-and-driving laws and reductions in impaired driving.

Previous research on the effects of enforcement on impaired driving does not provide answers to these issues. Although many studies have provided evidence that increasing enforcement intensity above an initial baseline level is associated with reductions in alcohol-related crashes (Fell et al., 2008; Lacey et al., 1999; Shults et al., 2001), more precise information on how different enforcement intensity levels corresponds to reductions in impaired driving has yet to be developed. Research on DUI enforcement has not provided sufficient data to calibrate the enforcement effort level required to produce a measurable reduction in alcohol-related crashes (e.g., Fell et al., 2008). This has been the case because, although there are regularly maintained national, state, and local crash record systems, there are no similar record systems for enforcement intensity.

The issue of the level (intensity) of enforcement necessary to reduce impaired-driving prevalence (and resulting crash involvements) is also complicated by the different approaches to the enforcement of DUI laws. The majority of impaired-driving enforcement in the United States traditionally occurs as an adjunct to standard traffic enforcement activities in which officers patrol the highways looking for evidence of illegal, risky, or impaired driving (Stuster, 1997). This reliance on traditional enforcement based upon driving cues (Voas and Lacey, 1988, 1990) (e.g., stopping vehicles that are weaving in their lane, speeding, driving over the center line) continues despite evidence that other strategies, such as sobriety checkpoints, which are the U.S. adaptation of random breath testing in which all drivers are stopped or a systematic sample of drivers are stopped and assessed for evidence of impairment, hold considerably more promise for reducing alcohol-related crashes (CDC, 2012; Elder et al., 2002; Erke et al., 2009). Any attempts to understand how enforcement levels relate to reductions in impaired driving in the United States need to distinguish between traditional DUI enforcement versus sobriety checkpoints and collect measures corresponding to these different approaches by police. We define general deterrence as a countermeasure that affects members of the general public who do not necessarily experience DUI sanctions. Specific deterrence measures affect only the offenders who experience DUI arrest, conviction, and sanctions (Ross, 1982). There is an evidence that only about half of traffic stops result in a citation and only 3% are arrested for any crime including DUI (Eith and Durose, 2011). Therefore, traffic stops may be an important measure of enforcement visibility.

Another factor limiting our knowledge about enforcement and DUI in the United States is the relative lack of data available on the critical mediating variable—the prevalence of impaired drivers on the roadways. If augmented enforcement programs are to reduce alcohol-related crashes, they should also affect the number of high-risk drivers with elevated BACs on our roads. Most DUI enforcement studies have not included driver breath-test surveys to determine to what extent any increase in enforcement has produced a reduction in the prevalence of drinking drivers on the roads. The notable exceptions have been Lacey and colleagues (2006) evaluating low-staff checkpoints, and Williams and colleagues (1995) evaluating the North Carolina impaired-driving enforcement program. Although not associated with any specific enforcement effort, National Roadside Survey (NRS) studies on the prevalence of drinking and driving have been conducted each decade beginning in 1973. To date, the breath-test data from the 4 past surveys (1973, 1986, 1996, and 2007) have not been used to measure the effectiveness of DUI enforcement. This study used the measured driver BAC and self-report data on drinking and driving from the 2007 NRS and augmented these data with information collected from 41 of 71 police departments operating in the 60 NRS sites regarding 6 measures of the intensity of DUI enforcement activities. This unique data set allowed us to perform a multisite assessment of the relationship of enforcement intensity (with measures from both traditional DUI enforcement and sobriety checkpoints) to the prevalence of drinking and driving on the roads in 30 communities in the continental United States.

MATERIALS AND METHODS

Approach

We utilized the general model of the U.S. impaired driving system (see Fig. 1) to identify the relationship to be explored and the measures to be collected in our survey of participating police departments. A measure of the staff available for enforcement operations are the number of sworn officers authorized to make arrests. As only a portion of the sworn officers will be engaged in traffic management and/or enforcement at any given time, the number of traffic stops made by police may be the best measure of overall traffic enforcement. We hypothesized that traffic stops may serve as both a general deterrent to traffic violations (as they are visible to the driving public) and a specific deterrent to those drivers who are stopped. Finally, as much of the traffic enforcement does not specifically deal with impaired driving, DUI arrests are generally used to assess specific impaired-driving enforcement intensity. However, arrests may provide an underestimate of total DUI enforcement because other traffic stops visible to the public may enhance the general impression of enforcement activity. Saturation patrols specifically looking for DUI behaviors (e.g., weaving and speeding) are a method to increase DUI arrests. Sobriety checkpoints, in which all motorists can be stopped and checked for alcohol impairment, result in few DUI arrests but have been shown to have a strong general deterrent value (Fell et al., 2008; Lacey et al., 1999). Figure 1 depicts our interpretation of the DUI enforcement system in the United States.

We examined the influence of enforcement by 6 different enforcement measures: (i) the annual number of DUI arrests per capita; (ii) the annual number of DUI saturation patrols per capita; (iii) overall

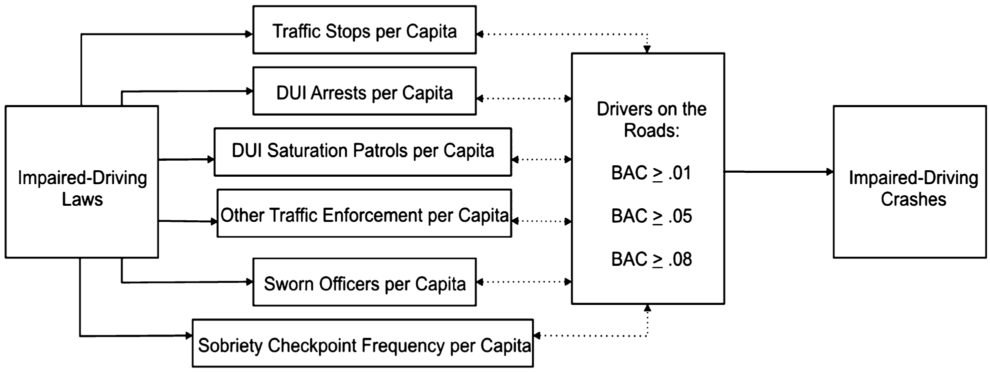

Fig. 1. Logic model of traditional U.S. impaired driving enforcement system.

traffic enforcement, as indicated by the total annual number of traffic stops per capita by police in their jurisdiction; (iv) the presence of overall law enforcement, as measured by the number of sworn officers per capita in the community; (v) overall traffic enforcement, as indicated by the number of seat belt citations, speeding tickets, other moving violations and warnings per capita; and (vi) general deterrence activities (sobriety checkpoints), as indicated by the frequency of checkpoint operations conducted by the police jurisdiction. We explored how the approaches and intensity of law enforcement related to the prevalence of nighttime drivers in the 2007 NRS who were alcohol positive (i.e., BAC > 0), who were at BACs ≥ 0.05, and who were driving with BACs over the illegal limit (i.e., with a BAC ≥ 0.08) in the specific community.

Data Sources

National Roadside Survey 2007. The 2007 NRS-interviewed drivers randomly stopped at 300 locations across 60 primary sampling units (PSUs) within the continental United States. Research teams worked with 71 police agencies within the 60 PSUs who assisted with safety measures during data collection. A full description of the procedures for conducting the survey can be reviewed in a series of reports (Lacey et al., 2009). In brief, sites were selected through a stratified random sampling procedure used by the National Highway Traffic Safety Administration (NHTSA) to develop national crash databases such as the National Accident Sampling System (NASS) General Estimates System (GES) (NHTSA, 1991). Data were collected during a 2-hour daytime session (Friday 9:30 AM to 11:30 AM or Friday 1:30 PM to 3:30 PM) and during four 2-hour nighttime periods (10 PM to midnight and 1 AM to 3 AM on Fridays and Saturdays) at 240 locations within 60 PSUs. Self-report and biological measures were voluntarily provided by drivers. Biological measures included breath alcohol (9,413 samples), oral fluid (7,721 samples), and blood (3,276 samples) (Lacey et al., 2009). However, only breath-test data were used in this study.

During the 2007 NRS, 10,909 vehicles entered data collection sites and were determined to be eligible for survey participation. Eighty-three percent of eligible drivers participated in the survey, and because some of those who declined to participate in the verbal interview still agreed to provide a breath sample, BACs were collected from 86% of eligible drivers. The current analysis excluded drivers sampled during the day on Friday, resulting in 6,859 weekend nighttime drivers with valid BAC readings (0.00 g/dl [no alcohol] and up).

In addition to the 3 dichotomous variables for alcohol-positive driving: (i) BAC > 0.00; (ii) BAC ≥ 0.05; and (iii) BAC ≥ 0.08, 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 were drawn from the NRS data.

Enforcement Data. The 71 police departments who participated in the 2007 NRS were contacted for this study by telephone and/or e-mail between June 2011 and March 2013. Enforcement data, such as total calls for service and DUI enforcement activities were collected for the 2007 calendar year to cover the 6-month periods prior to and during the 2007 NRS when BAC prevalence data were collected for drivers on the roads. This outreach resulted in obtaining data on enforcement activities from 48 of the 71 agencies contacted in the NRS. Note that the 48 enforcement agencies came from 41 PSUs. Five PSUs received data from different police agencies, either because they encompassed more than 1 county, or because different police agencies provided data. Of these, 4 encompassed different counties. For these 4 PSUs, we summed the enforcement information across the counties in the PSU and marked the use of checkpoints if any of the counties reported using them. For the remaining PSU, information was received from 2 different police departments. When the data were identical or similar across the 2 departments (meaning they used the same source for the numbers), we took the average, and when the information was very different (meaning they used their own independent sources), we summed the values across the 2 departments.

Several attempts were made to collect the data from the police departments. Of the 23 departments where we received no enforcement data, some said that the data we requested were not available for the year 2007, some referred us to contact who never responded to our requests, and some never responded despite numerous requests. We discovered that several of our original contacts in each of the 71 NRS police jurisdictions no longer worked in their respective agencies. This necessitated contacting a number of different police officials until the "right person" was reached who could help us with the data collection. In some instances, we made up to 10 calls attempting to obtain at least some enforcement data. After numerous calls, offers to pay agencies for their time in collecting such data and other actions, we had to settle on the data we received by the end of the second year. That amounted to full or partial data from only 48 of the 71 police agencies contacted.

Census Data. To control for differences in total miles driven across the PSUs, a surrogate measure (population aged 18 and older) was used as miles driven was not available at the PSU level. Census data on the driving population aged 18 and older in each of the counties comprising the PSUs was used to calculate rates of enforcement per 10,000 population (U.S. Census Bureau, n.d.).

Final Data Set. From these sources, we assembled 3 types of measures: (i) Prevalence of drinking drivers on the roads; BAC > 0.00, BAC ≥ 0.05, and BAC ≥ 0.08; (ii) Six enforcement intensity measures: DUI arrests and DUI saturation patrols per

10,000 population, traffic stops per 10,000 population, sworn officers per 10,000 population, other traffic enforcement activities per 10,000 population, and the frequency of sobriety checkpoints(weekly, monthly, less than monthly, never); (iii) 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., bar, restaurant, and party). Police activity in a PSU is likely to respond to the general level of problem behavior and criminal activity in the community. To the extent that these problems are correlated with other illegal activities such as DUI, failure to control for them will yield biased estimates of the relationship between police enforcement activities and the prevalence of DUI. We used calls for service rates per 10,000 population as a surrogate measure of crime in the community to control for the general need for police activity in our analyses. Thus, our models estimated the relationship between enforcement activities and the prevalence of DUI across communities with similar needs for police enforcement.

Of the 6,859 weekend nighttime drivers in the NRS with BAC readings, 3,646 came from PSUs that provided data on 5 of the 6 enforcement intensity variables: number of DUI arrest, traffic stops, other enforcement actions, total sworn officers, and saturation patrols. (Data on sobriety checkpoints were not included in this restriction because this field was not reported for a large number of PSUs. Instead, we control for missing data on this variable in our analyses). We further restricted our sample to drivers with valid age and gender information and those with data on where they were coming from. Our sample for final data analysis consisted of 3,562 cases from 30 PSUs.

Analyses

We analyzed the likelihood of BAC $\geq$ 0.01, BAC $\geq$ 0.05, and BAC $\geq$ 0.08 g/dl driving using logit models for each BAC outcome as a function of enforcement, driver, and driver characteristics, separately for each of the 6 enforcement activities. Due to the large variation in enforcement intensity across PSUs, we allowed the relationship between enforcement and DUI to vary for different levels of enforcement activity in the community by creating 4 dummy variables identifying whether each PSU fell into the first, second, third, or fourth quartile of per capita enforcement activity. NRS drivers are grouped into the different enforcement quartiles which indicate how their PSUs compare to others in enforcement intensity.

Police enforcement within a PSU may respond to the amount of illegal or problematic behavior within each PSU, including the prevalence of drunk driving. Thus, a PSU may have few traffic stops per capita because its general level of problem behavior is low. We controlled for this general need for police activity within the PSU using the logged per capita number of calls for service in our BAC models. Because drivers are clustered within PSUs and enforcement variables are measured at the PSU level, we accounted for the grouped nature of the data using random intercept mixed effects logit models estimated using the xtmelogit module of Stata 11.

We compared the BAC outcomes for the analysis sample of PSUs for which we obtained enforcement data with those of weekend nighttime drivers in the NRS PSUs for which enforcement data were not available. In the analysis, the prevalence of BAC-positive drivers was 12.3% (95% CI = [12.1, 14.4]) compared to 13.3% for the sample with missing enforcement data (95% CI = [11.2, 13.4]), a statistically insignificant difference. Similarly, the rates of BAC $\geq$ 0.05 drivers are similar across the 2 samples (5.2 vs. 4.5%, respectively) as are the rates of BAC $\geq$ 0.08 legally intoxicated drivers (2.5 vs. 2.4%, respectively). These comparisons suggest that the reporting of enforcement data was not related to the prevalence of alcohol-positive outcomes across PSUs.

RESULTS

Table 1 reports the percentiles for the distribution of available enforcement data collected from all PSUs and the proportion of NRS drivers in our sample exposed to the different levels of enforcement. Thus, a quarter of the PSUs with data reported fewer than 228 traffic stops per 10,000 population. The median number of DUI arrests is approximately 13 per 10,000 population in the PSUs. Note that with regard to the drivers sampled in the PSUs, 27% were exposed to fewer than 228 traffic stops per population while 57% of the NRS sample of drivers were exposed to <13 DUI arrests per population. Similarly, 56% of the NRS sample of drivers were exposed to less than the median per capita number of sworn officers. Note that half the drivers in our sample are exposed to <0.32 saturation patrols per 10,000 drivers, a very low rate. Indeed, 17% of drivers are 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 come from 1 PSU reporting 365 saturation patrols in 2007 (i.e., saturation patrols every night), a high number that indicates possible variation or misunderstanding in the definition of this activity across PSUs.

Table 2 presents the characteristics of sampled drivers in PSUs with the highest and lowest levels of enforcement intensity. Drivers in low traffic stop PSUs were significantly younger and almost twice as likely to be driving from a

Table 1. Distribution of Weekend Nighttime NRS Drivers by Enforcement Intensity Quartiles[a] (*N* = 3,562)

Enforcement activity	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Traffic stops per 10 K population	27% (<227.8)	23% (227.8 to 504.6)	25% (504.6 to 1274.5)	25% (≥1274.5)
DUI arrests per 10 K population	29% (<3.7)	28% (3.7 to 13.3)	22% (13.3 to 37.6)	21% (≥37.6)
Saturation patrols per 10 K population[b]	23% (<0.031)	22% (0.031 to 0.32)	21% (0.32 to 2.23)	34% (≥2.23)
Other enforcement activities per 10 K	23% (<64.9)	25% (64.9 to 186.7)	26% (186.7 to 925.4)	25% (≥925.4)
Total sworn officers per 10 K population	29% (<2.3)	27% (2.3 to 5.9)	19% (5.9 to 14.0)	25% (≥14.0)
Frequency of sobriety checkpoints[c]	Never 5%	Occasional 33%	Monthly 12%	Weekly 3%

DUI, driving under the influence; NRS, National Roadside Survey.
[a]Numbers in parentheses indicate the range of enforcement per 10,000 population within each quartile.
[b]10% of the sample is missing this information.
[c]43% of the sample is missing this information; only one police department reported weekly checkpoints.

Table 2. Sampled Driver Characteristics by Distribution of Enforcement Intensity

Variable	1st Quartile	4th Quartile
Traffic stops per 10 K population	0 to 227.8	=1274.5
Calls for service per 10 K	4632.7[a]	15450.1[a]
Driving from restaurant or bar	0.191[a]	0.097[a]
No seat belt	0.033	0.037
Driver age in years	33.9[a]	36.5[a]
Driver is white	0.603	0.599
DUI arrests per 10 K population	0 to 3.66	≥37.6
Calls for service per 10 K	4412.8[a]	20236.9[a]
Driving from restaurant or bar	0.171[b]	0.137[b]
No seat belt	0.036	0.021
Driver age in years	33.9[a]	36.4[a]
Driver is white	0.579[a]	0.471[a]
Saturation patrols per 10 K population		
Calls for service per 10 K	3540.2[a]	11813.3[a]
Driving from restaurant or bar	0.19[a]	0.11[a]
No seat belt	0.03	0.05
Driver age in years	35.5	34.5
Driver is white	0.60	0.62
Other enforcement actions per 10 K population	0 to 64.9	≥925.4
Calls for service per 10 K	7723.5[a]	15848.6[a]
Driving from restaurant or bar	0.143	0.113
No seat belt	0.04	0.033
Driver age in years	34.67	35.52
Driver is white	0.538[a]	0.455[a]
Total sworn officers per 10 K population	0 to 2.3	≥14
Calls for service per 10 K	509.9[a]	22152.1[a]
Driving from restaurant or bar	0.174	0.150
No seat belt	0.025	0.029
Driver age in years	34.02	35.94
Driver is White	0.61[a]	0.45[a]

DUI, driving under the influence.
[a]Significantly different at 99% level.
[b]Significantly different at 95% level.

restaurant, bar, or other similar venue. However, PSUs with the highest level of per capita traffic stops have over 3 times the number of calls for service than PSUs with the lowest level of traffic stop intensity. Similar patterns were observed between PSUs with high and low rates of DUI arrests, other enforcement, and sworn officers. Notably, drivers in PSUs with high rates of both DUI arrests and other traffic enforcement actions were significantly less likely to be white. Due to 43% missing data, sobriety checkpoints were not included in this table.

Relationship of Enforcement Activities With Alcohol-Positive Driving

Table 3 presents odds ratios from 6 random intercept logit models of BAC-positive (≥0.01), BAC ≥ 0.05, and BAC ≥ 0.08 drivers on the roads for the 6 different types of enforcement activities.

Traffic Stops

The first section of Table 3 shows that drivers exposed to the lowest intensity of traffic stops had 2.4 times the odds of BAC-positive, 3.6 times the odds of BAC ≥ 0.05, and 3.9 times the odds of BAC ≥ 0.08 drivers on their roads compared to those in the highest enforcement quartile. Those in the lowest traffic stop enforcement quartile communities also had 1.55 times the odds of BAC-positive and almost twice the odds of BAC ≥ 0.05 driving relative to drivers in the 2nd enforcement quartile. Drivers from PSUs in the 3rd quartile of traffic stop intensity also had lower odds of BAC ≥ 0.05 and BAC ≥ 0.08 driving compared to those in lowest traffic stop enforcement quartile communities; however, these differences were not statistically significant.

DUI Arrests

The relationship between DUI arrests per 10,000 population and the likelihood of alcohol-positive driving is shown in the second section of Table 3. Compared to drivers in PSUs in the highest quartile of DUI arrest activity, those in the lowest arrest activity quartile had 2.7 times the odds of BAC ≥ 0.08 driving (OR = 0.37, $p = 0.02$) but were not significantly different in odds of BAC ≥ 0.05 or BAC-positive driving. Drivers exposed to less intense DUI arrest activity in the 3rd and 2nd quartiles were not statistically different in their odds of alcohol-positive, BAC ≥ 0.05, or BAC ≥ 0.08 driving from those exposed to the least DUI arrest activity.

DUI Aturation Patrols

The third section of Table 3 suggests that compared to drivers exposed to the highest intensity of DUI saturation patrols, those in the lowest saturation patrol intensity quartile had 1.7 times the odds of alcohol-positive driving, 2.3 times the odds of BAC ≥ 0.05 driving, and 2.1 times the odds of BAC ≥ 0.08 driving. Drivers exposed to less intense saturation patrol activity in the 2nd and 3rd quartiles were not significantly different in their odds of alcohol-positive, BAC ≥ 0.05 or BAC ≥ 0.08 driving compared to those in the lowest saturation patrol intensity quartile.

Other Traffic Enforcement

The fourth section of Table 3 reveals that compared to drivers exposed to the highest intensity of other enforcement actions (e.g., speeding tickets, seat belt citations, other moving violations, and warnings), those living in the lowest enforcement quartile had 2.7 times the odds of BAC ≥ 0.08 driving but were not significantly different in their odds of alcohol-positive or BAC ≥ 0.05 driving. Similar to DUI arrest activity, lower intensity of other traffic enforcement had no significant relationship with alcohol-positive, BAC ≥ 0.05 or BAC ≥ 0.08 driving.

Sworn Officers

Data in the fifth section of Table 3 indicate that drivers exposed to a different number of sworn officers per capita

Table 3. Odds Ratios From Random Intercept Logit Models of BAC Outcomes

Variables	BAC > 0	BAC ≥ 0.05	BAC ≥ 0.08
Traffic stops per 10 K			
Lowest intensity relative to 2nd quartile	1.55[a] (1.12, 2.13)	1.95[a] (1.19, 3.13)	1.81 (0.98, 3.33)
Lowest intensity relative to 3rd quartile	1.29 (0.93, 1.79)	1.30 (0.63, 0.85)	1.59 (0.88, 2.86)
Lowest intensity relative to 4th quartile	2.43[a] (1.64, 3.57)	3.62[a] (2.0, 6.67)	3.89[a] (1.75, 8.33)
DUI arrests per 10 K			
Lowest intensity relative to 2nd quartile	1.062 (0.71, 1.59)	1.15 (0.66, 2.00)	1.28 (0.74, 2.22)
Lowest intensity relative to 3rd quartile	1.34 (0.82, 2.17)	1.52 (0.80, 2.86)	1.74 (0.92, 3.33)
Lowest intensity relative to 4th quartile	1.49 (0.81, 2.70)	1.79 (0.82, 4.00)	2.67[b] (1.99, 5.88)
Saturation patrols per 10 K			
Lowest intensity relative to 2nd quartile	1.32 (0.87, 2.00)	1.50 (0.88, 2.56)	1.20 (0.65, 2.22)
Lowest intensity relative to 3rd quartile	1.34 (0.83, 2.13)	1.76 (0.95, 3.23)	1.55 (0.76, 3.13)
Lowest intensity relative to 4th quartile	1.74[b] (1.12, 2.70)	2.33[a] (1.28, 4.17)	2.11[b] (1.02, 4.35)
Other enforcement actions per 10 K			
Lowest intensity relative to 2nd quartile	0.98 (0.62, 1.56)	0.90 (0.47, 1.69)	0.70 (0.36, 1.37)
Lowest intensity relative to 3rd quartile	1.17 (0.76, 1.82)	1.23 (0.68, 2.22)	1.39 (0.74, 2.56)
Lowest intensity relative to 4th quartile	1.48 (0.91, 2.38)	1.67 (0.85, 3.33)	2.71[b] (1.25, 5.88)
Total number of sworn officers per 10 K			
Lowest intensity relative to 2nd quartile	0.98 (0.61, 1.59)	1.19 (0.58, 2.38)	1.97 (0.98, 4.00)
Lowest intensity relative to 3rd quartile	1.54 (0.81, 2.94)	1.34 (0.53, 3.33)	2.22 (0.90, 5.55)
Lowest intensity relative to 4th quartile	1.47 (0.61, 3.57)	1.28 (0.36, 4.55)	3.26 (0.93, 11.11)
Frequency of sobriety checkpoints			
None relative to occasional checkpoints	1.21 (0.68, 2.17)	1.27 (0.57, 2.86)	0.81 (0.31, 2.08)
None relative to monthly checkpoints	0.96 (0.48, 1.92)	0.95 (0.37, 2.44)	0.68 (0.24, 2.00)
None relative to weekly checkpoints	1.02 (0.38, 2.78)	1.59 (0.34, 7.69)	1.98 (0.22, 16.67)
None relative to missing checkpoint data	0.97 (0.56, 1.69)	0.98 (0.46, 2.13)	0.74 (0.30, 1.85)
Observations	3,562	3,562	3,562
Number of groups	30	30	30

BAC, blood alcohol concentration; DUI, driving under the influence; NRS, National Roadside Survey.

Models controlled for logged calls for service as a surrogate for crime; NRS session from 1 AM to 3 AM, passenger in car, seat belt usage, origin of drive, and driver's age, gender and race/ethnicity were collected.

The 95% confidence intervals are in parentheses.

[a]Significant at 99% level.

[b]Significant at 95% level.

were not significantly different in their odds of alcohol-positive, BAC ≥ 0.05 or BAC ≥ 0.08 driving.

Sobriety Checkpoint Frequency

The sixth section of Table 3 indicates no significant relationship between alcohol-positive driving and the frequency of sobriety checkpoints in the PSU. Other specifications involving different combinations of the frequency categories did not alter this result. Note that only 3% of the sampled drivers (1 police department) reported conducting sobriety checkpoints on a weekly basis in 2007.

CONCLUSIONS

Of the 6 measures of enforcement intensity, the number of traffic stops per capita had the most consistent and significant effect on drinking and driving in the communities examined. Another way of describing the results that might be useful to law enforcement follows: Drivers in communities facing relatively little traffic stop enforcement had approximately twice the odds of driving at BACs ≥ 0.05 and BACs ≥ 0.08 relative to drivers facing the highest rates of traffic stop enforcement. This seems plausible as higher rates of traffic stops most likely translate to more drivers seeing the roadside traffic enforcement which may increase the perception of greater overall enforcement of traffic laws in the community. Highly visible enforcement has been shown to be effective in reducing impaired-driving crashes in several studies (e.g., Fell et al., 2008; Goss et al., 2008; Lacey et al., 1999; Stuster and Blowers, 1995), but this is the first time it has been related to specific measures of traffic stops and drinking drivers on the roads (assuming a higher rate of traffic stops per capita translates to more visible enforcement). Results from this study suggest that communities in our sample with a rate of traffic stops >1,275 per 10,000 also have significantly lower odds of BAC ≥ 0.05 drivers on their roads. Additionally, the odds of alcohol-positive and BAC ≥ 0.05 driving in sample communities with rates of 228 to 505 traffic stops per 10,000 are significantly lower than in communities with lower rates of traffic stops.

Regarding DUI arrest rates per capita, drivers in sample communities with DUI arrest rates of 38 arrests per 10,000 people or higher have a significantly lower odds of BAC ≥ 0.08 driving relative to drivers in the lowest enforcement PSUs. Similarly, drivers in sample communities exposed to the highest intensity of saturation patrols had lower odds of BAC ≥ 0.08 and BAC ≥ 0.05 driving compared to those in communities with few, if any patrols. However, caution is warranted given the uncertainty about the quality of the saturation patrol data as discussed earlier. Finally, drivers in communities with the highest rates of other traffic enforcement (seat belt violations, speeding tickets, citations for moving violations and warnings) also have lower odds of being BAC ≥ 0.08 on their roads. This most likely is highly correlated with and reflects the rate of traffic stops in the community. Indeed, other traffic enforcement has a weaker and less significant relationship with the odds of BAC ≥ 0.08 when we also control for the intensity of traffic stop enforcement in the PSU.

Unexpectedly, we found no significant relationship between sobriety checkpoint frequency and alcohol-positive driving, but this was likely due to small sample sizes, missing data in this enforcement category, and the fact that only one police department representing 3% of the available enforcement data in the 30 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).

These findings give law enforcement more qualitative information on the effects of their activities (our measures of enforcement) on the prevalence or propensity for alcohol-impaired driving. A logical next step in the research process will be to attempt to determine the thresholds where an increase in DUI arrests per capita, for example, significantly affects impaired driving. Are impaired-driving crashes or impaired drivers on the roads significantly reduced if a law enforcement agency doubles its DUI arrest rate from 20 to 40 per 10,000 population? This kind of research could compliment what we found in this study.

Limitations

Our analyses allowed police enforcement to have a nonlinear relationship with the prevalence of alcohol-impaired driving, specifically by grouping communities into categories based on quartiles of the enforcement intensity distribution. Given the lack of literature on appropriate thresholds for categories, our category definitions involve some arbitrariness. Our results are more qualitative in nature and do not aim to identify critical thresholds of enforcement intensity. The large range of some quartiles reflects the fact that PSUs in our data set varied widely in their enforcement intensity, especially as intensity increased. Other narrower definitions of enforcement categories may yield different implications for the relationship of enforcement intensity with DUI. However, narrowly defined categories will also be identified by fewer PSUs and drivers, potentially increasing the variance of estimated relationships.

While this study highlights the potential impact of increased police activities on DUI, our results may underestimate the preventive effect of DUI enforcement activities. This is because enforcement measures that are more closely related to DUI can themselves be responsive to the rates of DUI in the community. Thus, higher rates of DUI offenses due to such factors as greater availability of alcohol may provoke higher enforcement levels. We attempt to control for some of this responsiveness by including calls for service in our models as a surrogate for the general level of crime (and hence need for police activity) in the community. However, to the extent that we cannot fully control for this reverse causation in our study, our results will understate any preventive effect of DUI arrests on the likelihood of DUI on the roads. This downward bias is also likely to be present for other types of enforcement that are more closely related to DUI, such as checkpoints. It is likely to be less of a factor in the models of other enforcement activities that are less closely related to DUI such as traffic stops, other enforcement, and number of sworn officers. Thus, the measures that are more closely related to DUI enforcement may appear less important in determining the likelihood of DUI.

Another limitation is that we gathered enforcement data from the police agencies responsible for traffic enforcement on the specific roads where the NRS was conducted. These agencies may not reflect the full spectrum of enforcement faced by drivers who may travel through various jurisdictions in the course of their daily activities. To the extent that this results in a mismeasurement of the actual levels of police enforcement encountered by drivers, our results will understate any deterrent effect of police enforcement actions on impaired driving.

Many police agencies ignored our requests or told us they could not supply the data and/or that it was simply not available. Only one agency charged us a nominal fee for the data. One of the key data items that police jurisdictions had the most 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 numbers were not available. Most agencies did not supply real data or even estimates. This severely limited our data analysis of this enforcement strategy.

While the prevalence of alcohol-positive driving did not differ significantly between PSUs by their response to our request for enforcement data, enforcement agencies that provided us data were from slightly less urbanized counties relative to those did not respond to our query. According to the 2010 Census, 74% of the population in the responding counties lived in urban centers or urban areas, compared to 90% of the population in the nonresponding counties. The large number of nonresponding agencies limits the representativeness of this analysis. Given the large number of nonresponsive agencies, these and other potential differences limit the applicability of our results to the wider population.

8 ## 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. The authors also wish to thank the many officials from the 41 police agencies who provided enforcement data for our study. Finally, our appreciation goes out to the 2 reviewers of this manuscript. Their comments, suggestions, and edits substantially improved the quality of this article.

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