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Police Documentation of Alcohol Involvement in Hospitalized Injured Drivers

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Objective: Injured drivers with blood alcohol concentration (BAC) above the legal limit are rarely convicted of impaired driving. One explanation is that police may have difficulty recognizing alcohol intoxication in injured drivers. In this study, we compare police documentation of alcohol involvement with BAC measured on arrival at a hospital. Our objectives were to determine how often police document alcohol involvement in injured drivers with BAC $\geq$ 0.05 percent and identify factors that influence police documentation of alcohol involvement.

Methods: We included injured drivers (1999–2003) who were admitted to a British Columbia trauma center or treated in the Vancouver General Hospital emergency department. We used probabilistic linkage to obtain police collision reports. Police were considered to have indicated alcohol involvement if (1) police documented that alcohol contributed to the crash, (2) the driver received an administrative sanction for impaired driving, or (3) the driver was criminally convicted of impaired driving. The proportion of drivers for whom police indicated alcohol involvement was determined relative to age, gender, BAC levels, crash severity, and crash characteristics. Multivariate logistic regression was used to identify factors independently associated with police indication of alcohol involvement.

Results: Two thousand four hundred and ten injured drivers (73.5% male) were matched to a police report. Overall, 857 (35.6%) drivers tested positive for alcohol (BAC $\geq$ 0) and 736/857 (85.9%) of alcohol-positive drivers had a BAC $\geq$ 0.05 percent (the legal limit in British Columbia). Of the 736 drivers with a BAC $>$ 0.05 percent at time of admission, police indicated alcohol involvement in 530 (72.0%). The criminal code conviction rate for impaired driving was 4.7 percent for drivers with 0.08 percent $\leq$ BAC $<$ 0.16 percent and 13.6 percent for drivers with BAC $>$ 0.16 percent. The following factors were associated with higher odds of police indicating alcohol involvement: (1) increasing blood alcohol levels, (2) a prior record of impaired driving, (3) involvement in a single-vehicle crash, (4) involvement in a nighttime crash, and (5) traffic violations or unsafe driving actions recorded by police.

Conclusions: Police recognized and documented alcohol involvement in 72 percent of injured drivers with BAC $\geq$ 0.05 percent. Police documentation of alcohol involvement was more common at higher BAC levels, in nighttime or single-vehicle crashes, for drivers who committed traffic violations or drove unsafely, and for drivers with a prior record of impaired driving. The low conviction rate of injured impaired drivers does not appear to be due to police inability to recognize alcohol involvement.

Keywords: impaired driving, DUI, alcohol, motor vehicle crashes, police

Introduction

Motor vehicle crashes (MVCs) are the leading cause of death for young adults. Each year in Canada, 125,000 MVCs result in over 12,000 serious injuries and 2400 fatalities. The societal costs of MVCs in Canada in 2004 was estimated at $63 billion (Vodden et al. 2007). By far the largest number of crashes is attributed to preventable human factors such as speeding, driver distraction, and alcohol impairment (Petridou and Moustaki 2000; Schlundt et al. 2004). Alcohol impairs the skills required for safe driving (Harrison and Fillmore 2011; Miller et al. 2009), even in people with acute tolerance to the motor incoordination and subjective intoxication associated with alcohol use (Weafer and Fillmore 2012). The risk of crashing is higher after any alcohol consumption and rises markedly as the blood alcohol concentration (BAC) increases. Compared to drivers with BAC = 0, crash risk is more than doubled at a BAC of 0.08 percent and is over 150 times higher in drivers with a BAC above 0.25 percent (Blomberg et al. 2009). Young drivers have a higher baseline risk of crashing, and this risk increases markedly with alcohol use (Peck et al. 2008). The proportion of Canadian traffic fatalities associated with alcohol impairment declined during the 1980s and early 1990s (Beirness et al. 1994), but this trend has leveled off (Transport Canada Road Safety Directorate 2008). In 2006, alcohol was detectable in 37 percent of fatally injured drivers in Canada (Mayhew et al.

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2009). In Canada, it is a criminal offense to operate a motor vehicle on a public road with a BAC > 0.08 percent. British Columbia, like several other provinces, also has administrative sanctions including fines and license suspensions for drivers with a BAC > 0.05 percent.

Most laws targeting impaired driving are based on deterring this dangerous activity by increasing the certainty, swiftness, and severity of punishment. Those apprehended for an offense are less likely to offend again (specific deterrence), and others are less likely to offend to avoid sanctions in the first place (general deterrence; Stafford and Warr 1993). Increasing the certainty of punishment is believed to act as a greater deterrent than increasing its severity (Nagin and Pogarsky 2001; Wright 2010). Motorists can be deterred from alcohol-impaired driving with visible police work that increases the public's perception of the certainty of punishment (Desapriya and Iwase 1996; Desapriya et al. 2007). Lowering the allowable BAC limit for driving (the per se limit) is also very effective in preventing alcohol-impaired driving (Wagenaar et al. 2007). Lowering the per se BAC limit from 0.10 to 0.08 percent resulted in a 7 percent reduction in alcohol-related traffic fatalities in the United States (Shults et al. 2001). International studies showed reductions in motor vehicle deaths and serious injuries following a reduction in BAC from 0.08 to 0.05 percent in Australia and from 0.05 to 0.02 percent in Sweden (Fell et al. 2006). These positive effects are seen at all BAC levels, suggesting a general deterrent effect (Mann et al. 2001).

Another important strategy to reduce impaired driving is to direct interventions at high-risk groups. A well-known high-risk group is convicted impaired drivers, and effective countermeasures have been developed for this population, such as remedial programs based on principles of brief intervention for alcohol problems (Dill et al. 2006; Mann et al. 1994; Wells-Parker et al. 2002). Studies have shown that alcohol-impaired drivers injured in collisions are another important high-risk group for recidivism (Biffl et al. 2004; Cydulka et al. 1998; Davidson et al. 1997; Fabbri et al. 2005; Lillis et al. 1995; Schermer et al. 2006; Soderstrom et al. 1990; Vingilis et al. 1996). We investigated this issue and found that over one third of drivers injured in a car crash were legally impaired by alcohol, but only 11 percent of drivers with a BAC > 0.08 percent were convicted of impaired driving (Purssell et al. 2004) and 31 percent drove again while impaired after leaving the hospital (Purssell et al. 2010). The low conviction rate of injured impaired drivers probably lowers the perceived certainty of punishment and thereby reduces the general deterrent effect that impaired driving laws have on the general public. Furthermore, injured impaired drivers who are not sanctioned avoid the specific deterrent effect of those laws and they do not benefit from rehabilitation programs that may be mandated if they are convicted of impaired driving. The low conviction rate of injured impaired drivers therefore represents a failure of road safety policy and is of great interest to road safety stakeholders. The reasons for this failure are likely multifactorial and may include (1) failure of police to recognize alcohol impairment, (2) police recognize driver impairment but choose not to recommend charges, (3) the crown attorney decides to not lay charges, or (4) charges are laid but the driver is not convicted.

For this study we will examined police reports on the same population of injured drivers that we investigated in 2010 (Purssell et al. 2010) and compare the documentation of alcohol involvement in police collision reports with the actual alcohol levels measured on arrival at the hospital. Our goal is to determine whether police inability to recognize alcohol intoxication in injured drivers might explain the low conviction rate that we have seen in this population. Our objectives are to (1) determine how often police document alcohol impairment in injured drivers with BAC $\geq$ 0.05%, (2) identify factors associated with police documentation of alcohol involvement, and (3) determine how often police indicate alcohol involvement in drivers with BAC = 0 on arrival in hospital.

Methods

Study Population

This study was approved by the University of British Columbia research ethics board. We included all drivers injured in crashes between 1999 and 2003 who were either admitted to a trauma center in the province of British Columbia (BC) and captured in the BC trauma registry or were treated in the emergency department of Vancouver General Hospital. We excluded passengers, motorcyclists, drivers who could not be linked to a BC driver license, and those who died of their injuries in the field. We also excluded drivers who did not have a blood alcohol measurement as part of their clinical care. Alcohol was measured in 35.7 percent of this population of drivers. If a driver was involved in more than one crash during the study period, only the first crash was included and subsequent crashes were excluded. Cases without a corresponding police collision report were also excluded.

Clinical data including driver age, gender, blood alcohol level at admission, disposition (expired, admitted to hospital, or discharged) were obtained from the BC trauma registry (admitted patients) or from electronic health information system of Vancouver General Hospital (emergency department patients).

Drivers' records were obtained from the Insurance Corporation of BC, which is sole provider of basic automobile insurance in BC and maintains police collision reports and driving records for every licensed driver in the province. Drivers' records included the police collision report for the index crash as well as history of previous crashes and driving violations. Probabilistic linkage between driver's license and demographic information was employed using driver name, gender, date of birth, postal code, and date of crash, as described previously (Purssell et al. 2004, 2010). Drivers' records were available from January 1, 1989, through December 31, 2005, but for this study we only considered events that occurred before the index crash. We compared actual BAC levels measured on arrival at the hospital with police documentation of alcohol impairment by the index driver.

Statistical Analysis

In this study, we defined the binary outcome variable "police indication of alcohol involvement" as positive if either (1) police documented alcohol as a contributory factor to

Table 1. Factors associated with police indication of alcohol involvement for 2410 injured drivers

Independent variables	*N*	Percentage of drivers with BAC > 0.05%	Number (%) of drivers indicated by police	*P* value[a]	Unadjusted odds ratio (95% confidence interval)
Driver characteristics					
Gender					
Female	638	20.7	108 (16.93)	<.0001	—
Male	1772	34.1	530 (29.91)		2.09 (1.66–2.63)
Age (years)					
<20	264	29.2	62 (23.48)	<.0001	—
20—30	770	43.0	278 (36.10)		1.84 (1.34–2.54)
31—65	1198	26.1	288 (24.04)		1.03 (0.75–1.41)
>65	178	7.87	10 (5.62)		0.19 (0.10–0.39)
Previous IDAs					
No	1752	18.7	262 (14.95)	<.0001	—
Yes	658	62.0	376 (57.14)		7.58 (6.19–9.29)
Traffic violations or unsafe action[b]					
No	969	17.3	133 (13.73)	<.0001	—
Yes	1441	39.42	505 (35.05)		3.39 (2.74–4.19)
Blood alcohol level					
BAC = 0	1553		79 (5.09)	<.0001	—
0 < BAC < 0.050	121		29 (23.97)		5.88 (3.66–9.46)
0.050–0.080	52		21 (40.38)		12.64 (6.94–22.99)
0.081–0.160	214		135 (63.08)		31.88 (22.28–45.62)
>0.160	470		374 (79.57)		72.69 (52.86–99.96)
Crash severity					
Another person injured:					
No	1159	34.1	343 (29.59)	.001	—
Yes	1251	27.3	295 (23.58)		0.73 (0.61–0.88)
Another person killed:					
No	2279	30.1	593 (26.02)	.041	—
Yes	131	38.9	45 (34.35)		1.49 (1.02–2.16)
Hospital admission:					
No	736	22.7	136 (18.48)	<.0001	—
Yes	1674	34.0	502 (29.99)		1.89 (1.53–2.34)
Length of stay (days)[c]: 0					
0	736	22.7	136 (18.48)	<.0001	—
1–7	874	36.4	256 (29.29)		1.82 (1.44–2.31)
>7	789	31.7	245 (31.05)		1.99 (1.56–2.52)
Police impression of injury:					
No injury	850	23.9	163 (19.18)	<.0001	—
Appear injured	1426	34.6	439 (30.79)		1.87 (4.53–2.30)
Crash characteristics					
Single motor vehicle:					
No	1575	21.7	282 (17.90)	<.0001	—
Yes	835	47.3	356 (42.63)		3.41 (2.82–4.11)
Night time crash:					
No	1377	16.6	195 (14.16)	<.0001	—
Yes	1033	49.2	443 (42.88)		4.55 (3.74–5.53)

[a]Bivariate analysis using Fisher's exact test.
[b]Traffic violations and unsafe actions do not include alcohol and drug impairment.
[c]Length-of-stay information was missing for 11 drivers.

the crash, (2) the driver was given a 24-h or 90-day administrative driving prohibition for alcohol-impaired driving, or (3) the driver was convicted of the criminal offense of alcohol-impaired driving for the index crash. A negative outcome indicated that there was no documentation of alcohol involvement as a contributory factor by police for the index drivers and no administrative sanctions or convictions for alcohol-impaired driving.

The proportion of injured drivers for whom police indicated alcohol involvement (the outcome variable) was determined and compared in relation to age, gender, BAC levels, crash severity, and crash characteristics using Fisher's exact test for the categorical independent variables (Table 1). Age and BAC levels were stratified into groups. BAC was categorized as 0, 0 to 0.049 percent, 0.050 to 0.080 percent, 0.081 to 0.160 percent, and >0.160 percent. In Canada, it is a

federal offense to drive with a BAC $\geq$ 0.08 percent and the BC Motor Vehicle Act provides for administrative sanctions such as license suspension for drivers with BAC $\geq$ 0.05 percent. Driver age was stratified into 4 groups: <20, 20 to 30, 31 to 65, and > 65 years. Crash severity was represented by a group of variables including (1) length of stay (1 = treated and released from emergency department, 2 = admitted to hospital for 1 to 7 days, 3 = admitted to hospital for more than 7 days), (2) another person injured, (3) another person killed, and (4) police impression of injury to index driver (1 = no injury, 2 = appears injured). Crash characteristics included (1) single- versus multivehicle crash and (2) nighttime versus daytime crash. Nighttime crashes were those occurring between 9 p.m. and 6 a.m. Previous driver records included prior alcohol-impaired driving activities (IDAs) defined as either a Criminal Code conviction for impaired driving, a 24-h or 90-day license suspension for impaired driving, or involvement in an MVC where police cited alcohol as a contributory factor (Purssell et al. 2010). To measure the strength of association between outcome and independent variables, we calculated bivariate odds ratios and 95 percent confidence intervals for each candidate variable.

An inclusive model approach of multivariate logistic regression modeling was used to identify a parsimonious group of important factors independently associated with the likelihood of police indicating alcohol involvement of the index drivers. Factors that were statistically significant at the $P \leq .25$ level on bivariate analysis were included in the multivariate logistic regression analysis and all conceptually appropriate interactions between predictor variables were assessed during the model building process.

We also modeled two additional logistic regression analyses using 2 populations of drivers based on their BAC levels. First, for all drivers with a BAC = 0, a false-positive model was constructed with the assumption that the majority of these drivers had BAC < 0.05 percent at the time of the crash and alcohol involvement should not have been indicated in the police report. Second, for drivers with BAC $\geq$ 0.05 percent, a false-negative model was constructed with the assumption that these drivers had a BAC $\geq$ 0.05 percent at the time of the crash and therefore police should have indicated alcohol involvement. A coding change was needed for the false-negative model: In this case the outcome variable became a lack of documented alcohol involvement.

A test of multicollinearity of the independent variables based on tolerance and the variance inflation factor (VIF) was first performed. Tolerance > 0.1 and VIF < 10 indicate no serious collinearity (Kutner et al. 2004). For each model, the area under the receiver operator curve (ROC) was used to examine the discrimination power and the Hosmer-Lemeshow goodness of fit test was calculated to test the agreement between predicted and observed data (Hosmer and Lemeshow 1980). All analyses were performed using Stata version 12.0 (Stata Corp., College Station, TX).

Results

During the study period, 4862 BC residents with injuries from a motor vehicle crash captured in the trauma registry and 2466 treated in the Vancouver General Hospital (VGH) emergency department (ED), a major urban trauma center in BC, had alcohol measured on arrival at the hospital as part of routine clinical care. Of these, 4237 from the trauma registry and 2380 from VGH could be matched to a valid BC driver's license. This included 976 duplicates (treated in the VGH ED and also captured in the trauma registry). From these 5641 injured patients we excluded 2135 patients who were passengers or motorcyclists or whose driver status was unknown. No driver was excluded due to being involved in more than one crash. Of the remaining 3436 drivers, 2410 could be matched to a police report corresponding to the index crash. The most likely reason for a nonmatch was that police did not attend that crash. Of those matched to a police report, 1772 (73.5%) were male. The median age was 33 years (interquartile range 24–49) for males and 36 years (interquartile range 23–46) for females. Overall, 857 (35.6%) drivers tested positive for alcohol (BAC > 0) and 736 (85.9%) of alcohol-positive drivers had a BAC above the BC legal limit of 0.05 percent. Of the 736 drivers with a BAC > 0.05 percent at the time of admission, police reported alcohol involvement in 530 (72.0%). Overall, police indicated alcohol involvement in 638 out of 2410 (26.5%) drivers, including 79 out of 1553 (5.1%) drivers with BAC = 0 on arrival at the hospital (Table 2).

Bivariate analysis of all drivers (n = 2410) indicated that (1) being male, (2) having a prior record of impaired driving, (3) having a higher blood alcohol level, (4) being involved in a single-vehicle crash, (5) being involved in a nighttime crash, (6) appearing injured at the crash scene (according to police), (7) requiring hospital admission, (8) having a longer hospital stay, and (9) being involved in a crash in which another person was killed were all associated with an increased likelihood of police reporting alcohol involvement (Table 1).

Table 2. Proportion of injured drivers who received criminal code DUI convictions or administrative sanctions or for whom police listed alcohol as a contributory factor in the crash according to BAC levels (N = 2410)

BAC level (%)	N	Any recognition of alcohol involvement (95% confidence interval)	24-H suspension only (impaired)	90-Day suspension only (impaired)	DUI conviction	Alcohol listed as contributory factor
BAC = 0	1553	5.1 (4.0–6.2)	0.5 (0.2–0.9)	0.3 (0.0–0.6)	0.6 (0.2–1.0)	4.7 (3.6–5.8)
0 < BAC < 0.05	121	24.0 (16.3–31.6)	3.3 (0.1–6.5)	1.7 (− 0.6 to 3.9)	1.7 (− 0.6 to 3.9)	23.1 (15.6–30.7)
0.05 ≤ BAC < 0.08	52	40.4 (26.9–53.9)	3.8 (− 1.6 to 9.3)	3.8 (− 1.4 to 9.1)	1.9 (− 1.8 to 5.7)	40.4 (26.9–53.9)
0.08 ≤ BAC < 0.16	214	63.1 (56.6–69.6)	14.5 (9.7–19.2)	5.6 (2.5–8.7)	4.7 (1.8–7.5)	62.1 (55.6–68.7)
BAC ≥ 0.16	470	79.6 (75.9–83.2)	23.8 (20.0–27.7)	14.9 (11.7–18.1)	13.6 (10.5–16.7)	76.4 (72.5–80.2)

Table 3. Logistic regression modeling of factors associated with police recognition of alcohol impairment ($n = 2410$)

Significant independent variables	Odds ratio (95% confidence interval)
BAC = 0	—
0–0.049%	4.04 (1.55–10.55)
0.050–0.080%	14.91 (5.47–40.62)
0.081–0.160%	49.92 (26.47–94.14)
>0.160%	126.12 (71.33–223.0)
Single-vehicle crashes	7.07 (4.18–11.94)
$BAC_{0.00–0.049}$ × Single vehicle	0.93 (0.29–2.97)
$BAC_{0.05–0.080}$ × Single vehicle	0.20 (0.05–0.71)
$BAC_{0.081–0.160}$ × Single vehicle	0.14 (0.06–0.31)
$BAC_{0.161}$ × Single vehicle	0.09 (0.05–0.19)
Nighttime crashes	2.56 (1.76–3.72)
Prior IDAs	4.34 (2.80–6.73)
Night time crash × Prior IDAs	0.53 (0.30–0.92)
Unsafe action	1.76 (1.30–2.39)

ROC = 0.931, Hosmer-Lemeshow $\chi^2(9) = 11.45$, $P = .1201$.

The first multivariate logistic regression model was developed for the entire population of injured drivers ($n = 2410$) to identify factors associated with police indication of alcohol involvement (Table 3). In this model, the following factors were associated with a higher odds of police indicating alcohol involvement: (1) increasing blood alcohol levels, (2) a prior record of impaired driving, (3) involvement in a single-vehicle crash, (4) involvement in a nighttime crash, and (5) traffic violations or unsafe driving actions recorded by police. Age and gender were not significant and were dropped from the model. There were significant interactions between BAC and single-vehicle crashes, as well as between nighttime crashes and a prior record of impaired driving. The effect of involvement in a single-vehicle crash on the likelihood of police indication of alcohol involvement depends on the BAC level and vice versa. At lower BAC levels, police were much more likely to indicate alcohol involvement in drivers involved in single-vehicle crashes, but this difference was less marked at higher alcohol levels, where police indicated alcohol involvement in most drivers regardless of crash type. Similarly, the impact of prior IDAs depends on whether the crash occurred at night or during the day. When the crash occurred during the day, the odds of drivers with previous IDAs being indicated as impaired by police were 4.34 times that of drivers with clean records. In contrast, when the crash occurred at night, the odds of drivers with previous IDA being indicated as impaired by police were only 2.30 times (4.34×0.53) that of drivers with a clean record. This model has both good discrimination (ROC = 0.931) and overall data fit (Hosmer-Lemeshow $\chi^2(9) = 11.45$, $P = .1201$).

The false-negative multivariable logistic regression was developed to identify factors associated with police failure to indicate alcohol involvement for drivers with a BAC $\geq$ 0.05 percent ($n = 736$). Police did not indicate alcohol involvement in 206 (28%) of these drivers. Higher odds of police failing to indicate alcohol involvement were associated with (1) daytime crashes, (2) drivers without a record of prior impaired driving, (3) drivers not cited for traffic violations or unsafe driving actions, and (4) BAC levels close to 0.05 percent (Table 4). Single-vehicle crash was not a significant factor in this model and could not be used to explain why police failed to indicate alcohol involvement in drivers with a BAC $\geq$ 0.05 percent. The final false-negative model had only fair discrimination (ROC = 0.675) but good calibration (Hosmer-Lemeshow goodness of fit test, $P = .534$).

Table 4. Logistic regression modeling of factors associated with police failure to indicate alcohol involvement among injured drivers with BAC $\geq$ 0.05 percent ($n = 736$)

Significant independent variables	Odds ratio (95% confidence interval)
BAC > 0.161%	—
0.081–0.160%	2.11 (1.47–3.03)
0.050–0.080%	5.60 (3.05–10.28)
Daytime crash	1.50 (1.05–2.16)
No prior impaired driving activities	1.84 (1.31–2.58)
No unsafe action	1.66 (1.13–2.44)

ROC = 0.6753; Hosmer-Lemeshow $\chi^2(8) = 5.08$, $P = .5336$.

A false-positive multivariate logistic regression was developed for drivers with a BAC = 0 at the time of admission to the ED ($n = 1553$). Alcohol involvement was indicated by police in 79 (5.1%) of these drivers. The final false-positive model illustrated that (1) having a prior record of IDAs, (2) being involved in a single-vehicle crash, (3) being involved in a nighttime crash, and (4) being cited for traffic violations or unsafe driving actions were all associated with higher odds of police indicating alcohol involvement (Table 5). No interaction terms were found to be significant. This false-positive model has both good discrimination (ROC = 0.868) and calibration (Hosmer-Lemeshow goodness of fit test, $P = .836$).

Discussion

The ability of police to identify alcohol impaired drivers is essential if these drivers are to be convicted of impaired driving. Other researchers have studied police investigation of alcohol involvement following a crash. Ostrom et al. (1992) found that police are more likely to investigate males and at-fault drivers. Waller (1971) found that police were less likely to report alcohol involvement in elderly drivers, not-at-fault fatalities, and drivers of new vehicles. Several previous studies have specifically investigated police detection of alcohol impairment in injured drivers. Most found that police were able to detect alcohol in the majority of legally impaired drivers but that convictions are uncommon. McLaughlin et al. (1993) studied police detection of alcohol and conviction rates in 3 driver

Table 5. Logistic regression modeling of factors associated with police indication of alcohol involvement among injured drivers with BAC = 0 ($n = 1553$)

Significant independent variables	Odds ratio (95% confidence interval)
Prior IDAs	7.15 (4.30–11.88)
Single-vehicle crashes	6.12 (3.56–10.53)
Nighttime crashes	2.97 (1.78–4.94)
Unsafe action	2.24 (1.27–3.96)

(Without transfer to another hospital) ROC = 0.8681; Hosmer-Lemeshow $\chi^2(8) = 2.78$, $P = .8360$.

cohorts admitted to a Michigan trauma center between 1988 and 1990, including injured impaired drivers, noninjured impaired drivers, and sober drivers. They found that only 49 out of 83 (59.2%) injured impaired drivers were convicted of impaired driving even though police detected alcohol involvement in 87.8 percent of these drivers (McLaughlin et al. 1993). Orsay et al. (1994) studied injured drivers admitted to 2 Chicago trauma centers in 1990. Police records and BACs were available for 446 drivers, of whom 139 (31.2%) had a BAC $>$ 0.10 but only 34 (24.4%) were cited for driving under the influence (DUI). Orsay et al. (1994) did not clarify whether the low DUI citation rate was due to police failure to recognize alcohol or for other reasons. Grossman et al. (1996) studied 1336 injured drivers who were treated in a Seattle trauma center after a crash between 1986 and 1993. All drivers had a police sobriety assessment and a BAC measurement. Overall, police correctly identified alcohol impairment in 483 of 532 (90.8%) drivers with a BAC $>$ 0.10 percent. If cases involving a breathalyzer were omitted, the detection rate dropped to 137 out of 186 (73.7%). Grossman et al. (1996) also noted that police were more likely to detect alcohol in younger drivers and in crashes occurring on weekends or at night. van Wijngaarden et al. (1995) compared police notes with blood alcohol tests obtained on 260 pedestrians admitted to a level 1 trauma center in Baltimore between 1987 and 1990 and found that police correctly documented alcohol involvement in 67 out of 99 (67.7%) injured pedestrians. Krause et al. (1998) reviewed medical charts of drunk drivers treated in a Michigan trauma center between 1991 and 1997 and found 65 legally impaired drivers who could be linked to police crash reports. Police correctly identified alcohol consumption in 56 of the 60 cases (93%) for which police impression of whether or not the driver had been drinking was available. Overall 36.2 percent of drivers were convicted of impaired driving (Krause et al. 1998). Sjogren et al. (1997) studied 104 hospitalized drivers and 133 fatally injured drivers from northern Sweden between 1991 and 1993. They reported that Swedish police assessment had a sensitivity of 69 percent and a specificity of 97 percent in detecting alcohol impairment in hospitalized drivers and a sensitivity of 53 percent and specificity of 100 percent in fatally injured drivers. Swedish police were more likely to suspect alcohol impairment in younger drivers, male drivers, and drivers involved in nighttime crashes (Sjogren et al. 1997).

Our study adds to this literature by studying a much large population of injured drivers with a wider range of blood alcohol concentrations and using multivariate logistic regression to identify factors independently associated with police documentation of alcohol involvement. Unlike some previous studies, we included all injured drivers for whom police filed a crash report, not just those where police specifically tested for alcohol impairment. In addition to studying the effects of crash characteristics and driver demographics as several others have done, we are the first to study the role that traffic violations and the previous driving record play in police documentation of alcohol. We found that police documented alcohol involvement in 72 percent of injured drivers with a BAC $\geq$ 0.05 percent. Not surprisingly, the alcohol level on arrival at the hospital was the strongest and most consistent predictor of police documenting alcohol involvement. The proportion of drivers for whom police indicated alcohol involvement ranged from 5.1 percent in drivers with a BAC = 0 to 79.6 percent in drivers with a BAC $>$ 0.16 percent on arrival at the hospital (Table 2). Alcohol involvement was also documented more often in drivers involved in nighttime or single-vehicle crashes, those who committed traffic violations or unsafe driving actions at the time of the crash, and those with a prior record of impaired driving. Driver gender and age were not independently associated with documentation of alcohol involvement.

Police did not document alcohol involvement in 28 percent of injured drivers with a BAC $\geq$ 0.05 percent. Even in drivers with a BAC $>$ 0.16 percent (twice the legal limit), alcohol was not mentioned in 20.4 percent of police reports. Police were less likely to document alcohol involvement in drivers with a positive BAC who were involved in daytime crashes, who had not committed a traffic violation or unsafe driving action, who had no prior record of impaired driving, and whose BAC levels were only slightly above the legal limit (Table 4). There are several reasons why police may not recognize or document alcohol impairment in injured drivers. Pressing duties at the crash scene may delay police arrival at the hospital and, once at the hospital, police may have limited access to injured drivers who are receiving medical treatment for their injuries. Using a standardized field sobriety test, California police were able to correctly identify 98 percent of uninjured drivers with a BAC $>$ 0.08 percent (Stuster 2006); however, alcohol intoxication is more difficult to detect in injured drivers who are unable to perform standard sobriety tests. Furthermore, these drivers may have alternate explanations for altered mental status, such as head injury, pain, or drugs given in the course of medical treatment. This is likely especially true when BAC levels are only slightly elevated and signs of impairment are more subtle (Brick and Carpenter 2001). Police detection of alcohol is based, in part, on the odor of alcohol on a driver's breath. In another California study, investigators examined the ability of experienced police officers to detect the odor of alcohol by having them smell exhaled breath from 6 volunteers who had BACs ranging from 0 to 0.13 percent. Under these conditions, police detected 71 out of 86 cases (83%) with BACs above 0.08 percent. The detection rate decreased to 58 out of 97 (60%) after food had been consumed (Moskowitz et al. 1999). The ability to detect alcohol on breath would likely be lower in the trauma setting, where the smell of alcohol might be overpowered by the smells of blood, vomitus, and other odors. In some cases, alcohol involvement may have been suspected but not documented in the collision report. This might occur if police were unable to gather sufficient evidence to prove that alcohol levels was elevated or if they felt that alcohol had not contributed to the crash. It is also possible that police chose not to document alcohol involvement because they felt that the driver had already been punished by virtue of being seriously injured.

As found previously (Barillo 1993; Fantus et al. 1991; Goecke et al. 2007; Purssell et al. 2004; Runge et al. 1996), the vast majority of injured drivers with s BAC $>$ 0.08 percent in this study were not convicted of impaired driving (Table 2). This low conviction rate is only partially explained by police failure to recognize alcohol involvement. For example, police indicated alcohol involvement in 79.6 percent of drivers with a BAC $>$ 0.16 percent (twice the legal limit), but only

13.6 percent of these drivers were subsequently convicted of impaired driving. A driver with a BAC above 0.08 percent could avoid conviction for several reasons: (1) police do not recommend charges, (2) the crown attorney decides not to press charges, (3) the case is settled out of court without a conviction, or (4) the case goes to court and the driver is not convicted. There may be a tendency to feel that an injured impaired driver has already been adequately punished. Unfortunately, we know that many injured impaired drivers will drive again while impaired following discharge from a hospital (Purssell et al. 2010). An impaired driving conviction can improve road safety by removing dangerous drivers from the road and, if accompanied by mandatory rehabilitation, may also reduce the chance of future drinking and driving.

Limitations

Because we included only the 35.7 percent of injured drivers with BAC measured on arrival at the hospital, our study may have a selection bias that could result in inaccurate measurement of police ability to detect alcohol in injured drivers. In most BC trauma centers, alcohol is measured according to the preference of the treating physician. Alcohol may be measured more often in drivers with severe injuries or unexplained altered mental status. It is not known whether physicians are more likely to measure alcohol in drivers who appear intoxicated (in which case the diagnosis is obvious) compared to those without definite intoxication (in which case the diagnosis is uncertain and the test will provide additional information). If more obviously intoxicated patients were selected, then the police's ability to correctly identify alcohol positive drivers would be falsely elevated. Conversely, if our sample included more cases where the diagnosis of intoxication was uncertain, then police performance would be falsely depressed. Although some selection bias is possible, we believe that it is small. The percentage of drivers with a positive BAC (35.6%) in our sample was virtually identical to the rate of 35.5 percent reported in another Canadian series in which 90 percent of injured drivers were tested for alcohol (Stoduto et al. 1993), and our results are similar to the alcohol positivity rate of 37.9 percent seen in fatally injured drivers in BC, where 83.8 percent of drivers are tested for alcohol (Beasley and Beirness 2011).

Another limitation is that there may be a discrepancy between the actual BAC at the time of the crash and the BAC measured on arrival at the hospital. This would be expected in cases where there is a long delay in transporting the driver to hospital. In general, injured drivers are transported rapidly, but delays are possible, especially if the crash occurs in a rural setting. Because alcohol is metabolized with time, it is possible that some of the false positives (where police indicated alcohol involvement in drivers with BAC = 0) may actually have been true positives (i.e., BAC > 0.05%) at the time of the crash. Because we do not know the time between the crash and arrival at the hospital, we are unable to eliminate this possibility but, to minimize it, we used BAC = 0 rather than BAC < 0.05 percent in the false-positive model. Conversely, it is also possible that some of the drivers with false negatives may have had BAC levels below the legal limit at time of crash but that those levels subsequently rose above the legal limit due to continued absorption or ingestion after the crash and before arrival at the hospital. We consider this scenario to be unlikely because most drivers with a BAC > 0.05 percent in our sample had very high BAC levels (mean level = 0.19%). Furthermore, Canadian law prohibits drivers from having a BAC > 0.08 percent in a sample obtained within 2 hours of driving.

A final limitation is that in some of the false-negative cases, police may have suspected alcohol involvement but chose not to indicate this in the police report. Our methods are unable to differentiate between failure to recognize alcohol involvement and failure to document it, but the practical outcome is the same: the driver receives no legal sanction for impaired driving.

Conclusions

Police recognize and document alcohol involvement in 72 percent of injured drivers with a BAC ≥ 0.05 percent. Alcohol documentation is more common at higher BAC levels, in nighttime or single-vehicle crashes, for drivers who committed traffic violations or drove unsafely, and for drivers with a prior record of impaired driving. Despite high rates of documentation, the majority of drivers with a BAC above the legal limit were not convicted of impaired driving. Further research is required to understand the reasons for these low conviction rates.

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