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Alcohol and marijuana use among young injured drivers in Arizona, 2008–2014

Ruth A. Shults[a], **Jefferson M. Jones**[b], **Kenneth K. Komatsu**[c], **Erin K. Sauber-Schatz**[a]

[a]Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia

[b]Epidemic Intelligence Services, Centers for Disease Control and Prevention, Atlanta, Georgia

[c]Arizona Department of Health Services, Phoenix, Arizona

Abstract

Objective: We examined alcohol and marijuana use among injured drivers aged 16–20 years evaluated at Arizona level 1 trauma centers during 2008–2014.

Methods: Using data from the Arizona State Trauma Registry, we conducted a descriptive analysis of blood alcohol concentration (BAC) and qualitative test results (positive or negative) for delta-9-tetrahydrocannabinol (THC) by year of age, sex, race, ethnicity, injury severity, seat belt use, motorcycle helmet use, and type of vehicle driven. To explore compliance with Arizona's motorcycle helmet law requiring helmet use for riders <18 years old, we examined helmet use by age.

Results: Data on 5,069 injured young drivers were analyzed; the annual number of injured drivers declined by 41% during the 7-year study period. Among the 76% (n=3,849) of drivers with BAC results, 19% tested positive, indicating that at least 15% of all drivers had positive BACs. Eightytwo percent of the BAC-positive drivers had BACs ≥0.08 g/dL, the illegal threshold for drivers aged ≥21 years. Among the 49% (n=2,476) of drivers with THC results, 30% tested positive, indicating that at least 14% of all drivers were THC-positive. American Indians and blacks had the highest proportion of THC-tested drivers with positive THC results (38%). In addition, 28% of tested American Indians had positive results for both substances, more than twice the proportion seen in all other race or ethnic groups. Crude prevalence ratios suggested that drivers who tested positive for alcohol or THC were less likely than those who tested negative to wear a helmet or seat belt, further increasing their injury risk. Helmet use among motorcyclists was lower among 16- and 17-year-old riders compared to 18- to 20-year-olds, despite Arizona's motorcycle helmet law requiring riders aged <18 years to wear a helmet.

Conclusions: About 1 in 4 injured drivers aged 16–20 years tested positive for alcohol, THC, or both substances. Most drivers with positive BACs were legally intoxicated (BAC ≥0.08 g/dL). All substance-using young drivers in this study were candidates for substance abuse screening and

CONTACT Erin K. Sauber-Schatz ige7@cdc.gov Division of Unintentional Injury, Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, 4770 Buford Highway, NE, MS F-62, Atlanta, GA 30341.

possible referral to treatment. Broader enforcement of existing laws targeting underage access to alcohol and alcohol-impaired driving could further reduce injuries among young Arizona drivers. To further reduce crash-related injuries and fatalities among all road users, the state could consider implementing a primary enforcement seat belt law and a universal motorcycle helmet law.

Keywords

Young drivers; marijuana; alcohol-impaired driving; traffic accidents; motorcycle helmets; trauma centers

Introduction

Motor vehicle crashes remain a leading cause of death for persons aged 16–20 years in the United States (Centers for Disease Control and Prevention [CDC] 2015). Driving while impaired by alcohol increases the risk of a motor vehicle crash for all drivers, and the risk is greatest among young, less experienced drivers (Voas et al. 2012). In every state, zero tolerance laws prohibit persons aged <21 years from driving with any measurable blood alcohol concentration (BAC; Insurance Institute for Highway Safety 2018).

Delta-9-tetrahydrocannabinol (THC), the most psychoactive substance in marijuana, has effects on alertness, coordination, mood, memory, and judgment (Ashton 1999). However, THC's effects on motor vehicle crash risk are not fully understood. Increasing THC concentrations in biologic fluids do not consistently equate with increased driving impairment (Sewell et al. 2009), and studies of crash risk among drivers of all ages by THC status have produced inconsistent results (Asbridge et al. 2014; Compton and Berning 2015; Li et al. 2013; Romano et al. 2014). However, studies examining driver error or crash risk among drivers who test positive for both alcohol and marijuana have consistently reported elevated risk compared to drivers testing positive for either substance alone (Downey et al. 2013; Dubois et al. 2015; Li et al. 2013; Sewell et al. 2009).

Arizona is one of 31 states that currently allows the sale of medical marijuana, but the sale of recreational marijuana remains illegal in the state (National Conference of State Legislatures 2018). The state's medical marijuana program began on April 14, 2011 (Arizona Department of Health Services [ADHS] 2017). Under Arizona law, drivers who test positive for THC at any concentration can be charged with driving under the influence of marijuana (Ariz. Rev. Stat. § 28–1381 2016).

Because of young persons' already heightened crash risk due to inexperience, their substance use is of special concern. Alcohol and marijuana are the substances most commonly used by adolescents and young adults (Arria et al. 2017; Johnston et al. 2017). Arizona data from 2015 indicate that 35% of high school students reported current drinking, 23% used marijuana, and 9% of those who drove had driven after drinking alcohol in the past 30 days (CDC n.d.). Similar state-level information is lacking for driving after marijuana use, but 2011 national data indicate that 12% of high school seniors report having driven after smoking marijuana in the past 2 weeks (O'Malley and Johnston 2013). One survey of students aged 18–20 years from 2 large public universities reported that 6% of all students and 31% of current marijuana users had driven after using the drug in the past 28 days; males reported much higher prevalence of driving after marijuana use than females (44 vs. 9%; Whitehill et al. 2014).

Alcohol and drug testing of nonfatally injured drivers is often incomplete, even among crashes that result in at least one fatality (fatal crashes). In Arizona in 2014, 42% of nonfatally injured drivers aged 16–20 years in fatal crashes had BACs recorded and only 16% had drug test results recorded in the national Fatality Analysis Reporting System (FARS; Tonja Lindsey, NHTSA, personal communication, March 30, 2018). To better understand the prevalence of alcohol and marijuana use among young drivers injured in crashes, we examined data from drivers aged 16–20 years evaluated at any of Arizona's 10 level 1 trauma centers (L1TCs) during 2008–2014. We described characteristics of drivers with positive BACs, positive THC results, and positive results for both substances. We also examined seat belt use, helmet use, and injury severity by BAC and THC status. Finally, to explore compliance with Arizona's motorcycle helmet law requiring helmet use for riders <18 years old, we examined helmet use by age (Ariz. Rev. Stat. § 28–964 2005).

Methods

The Arizona State Trauma Registry (ASTR) receives data from trauma centers in Arizona, including all L1TCs. ASTR contains data on patients triaged by emergency medical services to trauma centers, patients with injuries transported from one hospital to another, or patients meeting other criteria, as defined in the ASTR inclusion criteria (ADHS 2016).

The decision to perform alcohol or drug testing is dependent on the clinician's judgment; if the clinician does not suspect substance use, testing is less likely to be performed. When alcohol testing is performed, the patient's BAC is quantitatively measured in grams per deciliter (g/dL). Urine testing for other drugs or their metabolites, including THC, is done qualitatively using an enzyme immunoassay and reported as being either positive or negative (ADHS 2016).

For this descriptive report, we calculated the proportion of injured drivers aged 16–20 years evaluated at Arizona L1TCs who were tested for alcohol or marijuana and the proportion of those tested with positive BACs or THC results by age, sex, race, ethnicity, seat belt use, motorcycle helmet use, and type of vehicle driven. We defined race using the ASTR primary race variable; patients of multiple races can report a secondary race. According to the ASTR, race should be based upon patient self-report or as identified by a family member (ADHS 2016). Hispanic ethnicity was defined using the separate ethnicity variable. For drivers with positive BACs, we examined the BAC distribution. Next, to explore whether the BAC distribution varied by THC test result among drivers with positive BACs who were tested for THC, we examined the BAC distributions by THC status.

To explore the associations between substance use and protective equipment use (i.e., helmet use among motorcycle drivers or seat belt use among car, truck, or van drivers), we calculated crude prevalence ratios (PRs). Similarly, we explored associations between substance use and severity of injury, comparing drivers who tested positive for either substance or both to drivers who (1) tested negative and (2) were not tested or tested negative. The first set of analyses, in which only drivers who were tested were included, produced more conservative crude PRs, and those PRs are presented. A severe injury was defined as one with an Injury Severity Score of >15, which is commonly used to indicate the presence of major trauma (Baker et al. 1974; Palmer 2007).

Finally, we examined motorcycle helmet use by age to see whether motorcyclists aged 16 or 17 years were helmeted, as required by Arizona's motorcycle helmet law (Ariz. Rev. Stat. § 28–964 2005).

Because data were collected for public health purposes with personal identifiers removed, institutional review board approval was not applicable. Data analyses were conducted in SAS Ver. 9.3 and OpenEpi (Dean et al. 2006).

Results

During the 7-year study period of 2008–2014, 5,069 injured drivers aged 16–20 years were evaluated at Arizona L1TCs (Table 1). Eighty-two percent of drivers were in cars, trucks, or vans, and 18% were driving motorcycles (Table 2). The number of injured drivers declined 41% from 916 in 2008 to 543 in 2014 (Table 1).

A total of 76% of all drivers were tested for BAC, 49% were tested for THC, and 47% were tested for both substances (Table 1). Twenty-two percent were not tested for either substance. Among 3,849 drivers tested for BAC, 2,380 (62%) were also tested for THC, and among the 2,476 drivers tested for THC, 2,380 (96%) were also tested for BAC. Drivers aged 16 years were less likely than older drivers to be tested for either substance, and males were more likely than females to be tested for both substances (Table 2). Compared with whites, American Indians and blacks were more likely and Asians were less likely to be tested for both substances (Table 2).

During the 7-year study period, 15% of all drivers (including drivers not tested for alcohol; Table 1) and 19% of alcohol-tested drivers had positive BACs (Table 2). Likewise, 14% of all drivers (Table 1) and 30% of THC− tested drivers were positive for THC (Table 2), and 5% of all drivers (Table 1) and 10% of tested drivers were positive for both substances (Table 2). Among drivers who were tested for both substances and had a positive BAC, 32% were also positive for THC (data not shown).

Among drivers who were tested, the proportions with positive results for BAC, THC, and both substances increased with age (Table 2). Males had substantially higher proportions of positive results than females for either substance or the 2 combined. American Indians and blacks had the highest proportion of tested drivers with positive THC results at 38%, and the proportion of tested American Indians with positive results for both substances (28%) was more than twice the proportion seen in all other race/ethnic groups. The proportion of tested motorcyclists with positive BACs was substantially lower than the corresponding proportion of drivers of other vehicles (9 vs. 22%), but the proportions with positive THC results for the 2 groups were nearly identical (30 vs. 29%).

Among the 748 drivers with positive BACs, 82% (*n* = 612) had BACs ≥0.08 g/dL, the illegal threshold for drivers aged ≥21 years. Sixty percent (*n* = 441) of BAC-positive drivers had BACs ≥0.15 g/dL. Among drivers with positive BACs, the BAC distributions were similar regardless of whether they were tested for THC, tested positive for THC, or tested negative for THC (Figure 1). The median and mode BAC category was ≥0.15–0.20 g/dL regardless of THC test status or results.

Crude PRs suggested that drivers with either a positive BAC or THC result were between 40 and 90% more likely than their counterparts who tested negative for the substance to *not* wear a helmet or seat belt (Table 3). Drivers who tested positive for both substances were more likely to *not* wear a helmet or seat belt and more likely to be severely injured than their counterparts who tested negative.

Overall, 293 of the 918 (32%) motorcyclists were not wearing a helmet at the time of the crash; 67 of the 172 (39%) 16- and 17-year-olds were unhelmeted, as were 226 of the 746 (30%) 18- to 20-year-olds (data not shown).

Discussion

In a population of injured drivers aged 16–20 years evaluated at Arizona L1TCs, we found that at least 15% of all drivers (19% of BAC-tested drivers) had been drinking alcohol. Although drivers aged <21 years are prohibited by law from driving with any measurable BAC, 6 in 10 of the young drivers with positive BACs in this study were so intoxicated that they could have been charged in Arizona with “extreme DUI” (BAC ≥0.15 g/dL). This charge can result in sanctions including 90 days in jail, a $3,000 fine, alcohol treatment, and an ignition interlock requirement once a driver license is reinstated (Arizona Department of Transportation n.d.). Driving after any alcohol consumption in this group of young, relatively inexperienced drivers is of great concern. Compared with sober drivers of the same age, the risk of drivers aged 16–20 years being involved in a fatal crash is estimated to increase by 33% for drivers with BACs of 0.001–0.019 g/dL to nearly 500 times for those with BACs ≥0.15 g/dL (Voas et al. 2012).

Among drivers who were tested for both substances and had a positive BAC, 32% were also positive for THC, indicating that they had used marijuana at some point in the past. Although a positive urine THC result does not necessarily indicate recent marijuana use or impairment (Lapoint 2015), any simultaneous use of alcohol and marijuana would increase young drinking drivers’ already high crash risk (Downey et al. 2013; Dubois et al. 2015; Li et al. 2013; Sewell et al. 2009). Two national surveys suggest that simultaneous use of alcohol and marijuana may be common among some young people. Terry-McElrath et al. (2013) reported that 62% of high school seniors who used marijuana reported at least occasional simultaneous use with alcohol. These teens reported higher rates of receiving traffic violations and crash involvement than their counterparts who use both substances but not simultaneously or use alcohol alone (Terry-McElrath et al. 2014). A separate survey reported that among persons aged 18–29 years who drink alcohol, 15% report some simultaneous use of alcohol and marijuana (Subbaraman and Kerr 2015). The authors further use among injured drivers of all ages consistently find alcohol and marijuana to be among the most commonly detected substances, and the 2 are often found in combination (Baldock and Lindsay 2015; Brubacher et al. 2016; Walsh et al. 2005).

The finding that 39% of motorcycle riders aged 16 or 17 years were not helmeted at the time of the crash illustrates the difficulty of enforcing motorcycle helmet laws that do not apply to all motorcycle riders. Age-based motorcycle helmet laws such as Arizona's, which are meant to protect the youngest riders, have been shown to be largely ineffective in providing the intended protection (Peng et al. 2017).

The annual number of injured young drivers in our study declined by 41% during the 7-year period. During this same period, the total number of drivers aged 16–20 years involved in police-reported injury crashes in Arizona declined by 21% (Arizona Department of Transportation 2009, 2015). National studies indicate that the high unemployment rates among young persons during the most recent economic recession and recovery (Fogg et al. 2016; Rothstein 2012) contributed to declines in their miles driven (Davis et al. 2012; Highway Loss Data Institute 2015); thus, recession-associated reductions in driving may partially explain the decline in injured young drivers seen in this study. Also of note, traffic enforcement in Arizona increased markedly during this period. Arrests for driving under the influence of alcohol among persons aged <21 years increased by nearly 250% from 421 in 2008 to 1,461 in 2014, and arrests for driving under the influence of drugs among drivers of all ages increased by 500% from 694 in 2008 to 4,190 in 2014 (Arizona Governor's Office of Highway Safety 2017). Because we did not have access to impaired driver arrest records or crash incident reports for this study, associations between enforcement activity and alcohol- or drug-related crash occurrence could not be formally assessed. Surveillance systems that link information from multiple data sources including driving exposure and citation data, driver alcohol and drug test results, crash incident reports, and health care records would aid in more fully understanding the role of substance use in crash occurrence and its consequences (Milani et al. 2015).

Despite the reductions seen over the study period in the number of BAC-positive injured drivers, many young people in Arizona continue to put lives at risk by driving after drinking alcohol. Most of the young drinking drivers in this study were intoxicated, with many at extreme levels of intoxication. According to the American College of Surgeons (2014), all injured patients treated at L1TCs who screen positive for alcohol should receive an intervention and appropriate treatment referral. Our findings of alcohol and marijuana use among these young, least experienced drivers raise concerns about their access to the substances, particularly when considering the increased injury risk associated with simultaneous use of alcohol and marijuana.

Broader enforcement of existing laws targeting underage access to alcohol and alcohol-impaired driving could further reduce injuries among young Arizona drivers (CDC 2016; The Community Guide 2017; National Academies of Sciences, Engineering, and Medicine 2018). To further reduce injuries and fatalities when crashes occur, the state could consider implementing a primary enforcement seat belt law, which permits law enforcement officers to stop and cite a vehicle occupant solely for not wearing a seat belt, and a universal helmet law (The Community Guide 2017). Of relevance to Arizona, recent research found that primary seat belt enforcement is associated with higher levels of seat belt use than secondary enforcement in both rural and urban areas (Beck et al. 2017). For American Indians, the CDC has tailored proven strategies and tools that can be used to increase seat belt use and decrease impaired driving in tribal communities (CDC 2016). Finally, further research is needed into the feasibility of developing tests to evaluate driver impairment by marijuana (Governors Highway Safety Association 2017) and to understand how marijuana affects driving ability when used with other substances (Li et al. 2013).

Strengths and limitations

To our knowledge, this study is the largest population-based analysis of alcohol and marijuana use among underage, injured drivers in the United States. Because of Arizona's large American Indian population, the study provided data on alcohol and marijuana use among American Indians that is seldom available even in national studies because of small sample sizes. The large sample size also allowed us to examine substance use by year of age, which can be useful in targeting interventions to reduce both substance use and impaired driving. Lastly, the data provided a rare opportunity to examine motorcycle helmet use by age.

The study also has important limitations. Because we analyzed trauma registry data with personal identifiers removed, we did not independently verify the accuracy of the data. Because alcohol and drug testing was not universal, selection bias was likely present. However, our finding that at least 15% of all injured drivers had positive BACs is similar to the 2014 FARS national data for crash-involved drivers aged 15–20 years; 18% of young drivers who survived a crash in which at least one person died had positive BACs (NHTSA 2016). Comparable national data are not available for marijuana use among surviving drivers. A positive THC urine screen does not necessarily indicate recent marijuana use; urine screens can remain positive without indicating impairment for weeks, particularly in chronic users (Lapoint 2015). Sensitivity and specificity of the drug screens performed at the 10 L1TCs are unknown and could vary over time and location. Additionally, we did not exclude from the study the 11% of drivers who tested positive for drugs other than alcohol and marijuana. These drivers could have been impaired by drugs other than those of interest in this study. Lastly, the study results may not be generalizable to injured drivers treated in other hospital settings or in other states or jurisdictions.

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Disclaimer

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry.

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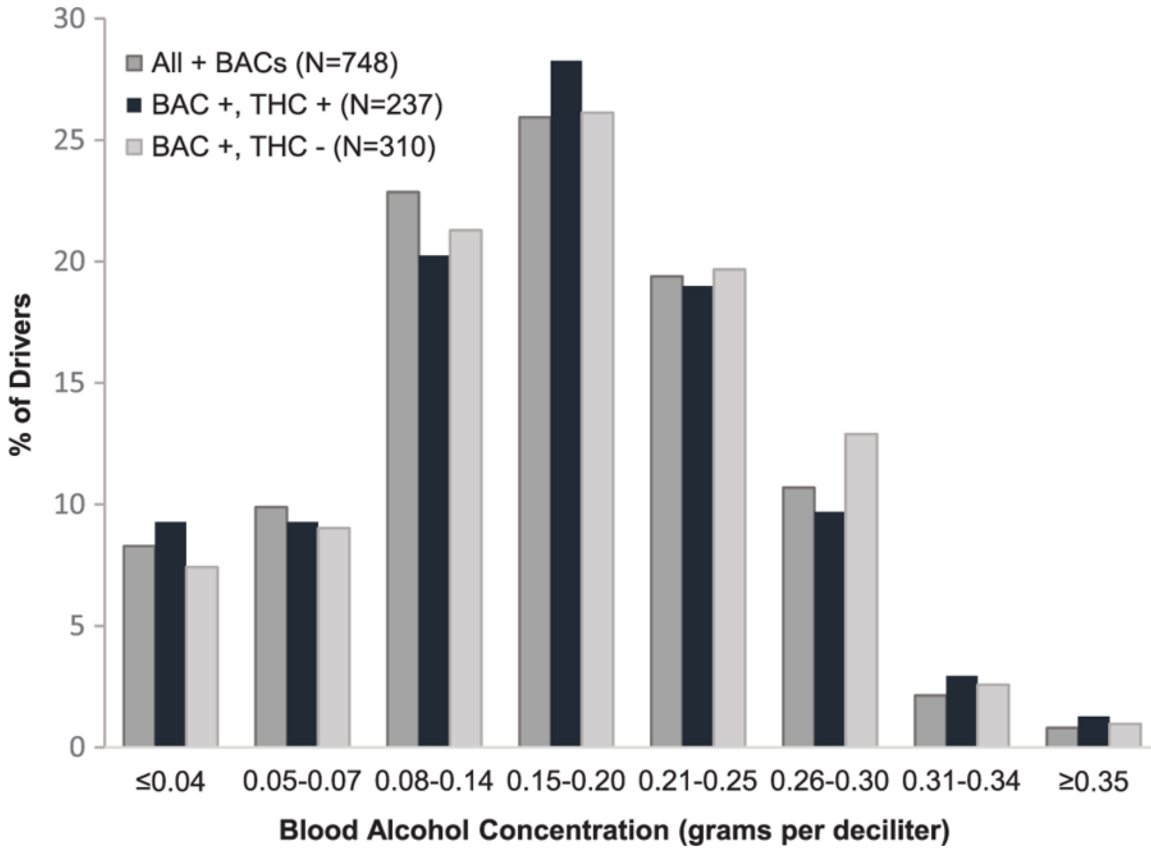

Figure 1.
BACs among injured drivers aged 16–20 years who tested positive for alcohol regardless of whether they were tested for THC ($N = 748$), drivers who tested positive for alcohol and THC ($N = 237$), and drivers who tested positive for alcohol and negative for THC ($N = 310$).

Table 1.

BAC and THC testing results among injured drivers aged 16–20 years evaluated at level 1 trauma centers by year, Arizona, 2008–2014.

	2008	2009	2010	2011	2012	2013	2014	Total
Number of injured drivers	916	771	761	722	706	650	543	5.069
BAC testing								
Number (%) with BAC test results	674 (74)	541 (70)	565 (74)	544 (75)	554 (78)	544 (84)	427 (79)	3.849 (76)
Number (%)[a] with positive BAC	163 (18)	123 (16)	107 (14)	112 (16)	100 (14)	88 (14)	55 (10)	748 (15)
THC testing								
Number (%) with THC test results	511 (56)	362 (47)	356 (47)	327 (45)	339 (48)	307 (47)	274 (50)	2.476 (49)
Number (%)[a] with positive THC	139 (15)	105 (14)	109 (14)	95 (13)	100 (14)	91 (14)	77 (14)	716 (14)
BAC and THC testing								
Number (%) with BAC and THC test results	488 (53)	336 (44)	346 (45)	325 (45)	328 (46)	298 (46)	259 (48)	2.380 (47)
Number (%)[a] with positive BAC and THC	59 (6)	41 (5)	31 (4)	37 (5)	27 (4)	27 (4)	15 (3)	237 (5)

[a]Percentages represent the percentage positive among all drivers (tested and not tested).

Table 2.

Characteristics of injured drivers aged 16–20 years evaluated at level 1 trauma centers by BAC and THC testing and test results, Arizona, 2008–2014.

	Total (*N* = 5,069)		BAC and THC testing: Tested for alcohol (*N* = 3,849)		BAC and THC testing: Tested for THC (*N* = 2,476)		BAC and THC testing: Tested for alcohol and THC (*N* = 2,380)		BAC and THC results: Positive BAC (*N* = 748)		BAC and THC results: Positive THC (*N* = 716)		BAC and THC results: Positive BAC and THC (*N* = 237)	
Characteristic	***N***	**Column %**	***N***	**Row %**	***N***	**Row %**	***N***	**Row %**	***N***	**Row %**[a]	***N***	**Row %**[a]	***N***	**Row %**[a]
Age in years														
16	454	9	303	67	201	44	184	41	24	8	43	21	12	7
17	746	15	525	70	354	47	339	45	72	14	87	25	21	6
18	1,196	24	920	77	574	48	558	47	163	18	160	28	55	10
19	1,363	27	1,086	80	686	50	666	49	234	22	213	31	75	11
20	1,310	26	1,015	77	661	50	633	48	255	25	213	32	74	12
Sex														
Female	1,972	39	1,411	72	899	46	853	43	179	13	169	19	43	5
Male	3,097	61	2,438	79	1,577	51	1,527	49	569	23	547	35	194	13
Race[b]														
White	3,657	72	2,687	73	1,678	46	1,616	44	458	17	476	28	140	9
Other	885	17	734	83	498	56	479	54	135	19	131	26	39	9
American Indian	274	5	230	84	164	60	157	57	124	54	62	38	44	28
Black	195	4	158	81	110	56	103	53	24	15	42	38	11	11
Asian	35	1	21	60	13	37	12	34	1	5	1	8	0	0
Hispanic[c]	1,534	30	1,177	77	781	51	755	49	257	22	221	28	70	9
Vehicle type driven														
Motorcycle	918	18	715	78	402	44	388	42	63	9	119	30	23	6
Car, truck, van	4,151	82	3,134	75	2,074	50	1,992	48	685	22	597	29	214	11
Total	5,069	100	3,849	76	2,476	49	2,380	47	748	19	716	30	237	10

[a]Percentages represent percentage of drivers who tested positive among drivers who were tested.

[b]20 drivers with unknown race and 3 Pacific Islander drivers are not displayed due to small sample size.

[c]Hispanic is not mutually exclusive of any race.

Table 3.

Crude associations between substance use status and protective equipment use and substance use status and injury severity among injured drivers aged 16–20 years who were tested for substance use at level 1 trauma centers, Arizona, 2008–2014.

Condition	Crude prevalence ratio	95% Confidence interval
No helmet		
BAC+ vs. BAC−	1.9	1.5, 2.5
THC+ vs. THC−	1.9	1.5, 2.4
BAC+ and THC+ vs. BAC− and THC−	2.9	2.2, 3.9
No seat belt		
BAC+ vs. BAC−	1.7	1.6, 1.9
THC+ vs. THC−	1.4	1.3, 1.6
BAC+ and THC+ vs. BAC− and THC−	2.1	1.8, 2.3
Severe injury[a]		
BAC+ vs. BAC−	1.4	1.2, 1.6
THC+ vs. THC−	1.2	1.0, 1.5
BAC+ and THC+ vs. BAC− and THC−	1.5	1.1, 1.9

[a]Injury Severity Score >15.