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Substance-related traffic-risk behaviors among college students

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Abstract

Aims—Drunk driving is a major public health concern, but drugged driving has received little attention. This study examines drugged driving and riding with a drugged driver in a college student sample, in terms of prevalence, age-related trends, race/sex differences, overlap with drunk driving, and risk for alcohol and marijuana dependence.

Methods—Students (N=1194) ages 19 to 22 were interviewed annually for three years about past-year frequency of drugged driving, riding with a drugged/drunk driver, drunk driving, access to a car, and alcohol/drug dependence. Annual follow-up rates were excellent (88% to 91%). Repeated measures analyses were conducted using generalized estimating equations (GEE).

Results—One in six (17%$_{wt}$) 19-year-olds with access to a car drove drugged in the past year; prevalence remained stable through age 22. Drugged driving was more prevalent among males (p<.001) and whites (p<.01). Riding with a drugged driver varied by race and sex (overall prevalence 28%$_{wt}$ at age 19), was stable from age 19 to 21, and decreased by age 22 (p<.05). Annually, half of drugged drivers also drove drunk (ranges between 47% and 60%). Both drugged and drunk driving were independently associated with increased risk for alcohol dependence, holding constant age, sex, and race. Drunk driving did not add to the risk for marijuana dependence in the context of drugged driving.

Conclusions—The prevalence of drugged driving is similar to drunk driving among college students. Both are strongly associated with underlying alcohol and drug dependence. Prevention and treatment implications are discussed.

Keywords

Driving under the influence; Drugged driving; Traffic-risk behaviors

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1. Introduction

While drunk driving has long been recognized as a major public health concern, driving under the influence of other drugs (i.e., “drugged driving”) has received much less attention. The 2010 National Drug Control Strategy identified drugged driving as a national research priority, urging that prevention advancements for drugged driving be on par with those for drunk driving (Office of National Drug Control Policy, 2010). Drugged and drunk driving together accounted for 14% of U.S. drivers/motorcyclists involved in fatal crashes in 2008 (National Highway Traffic Safety Administration, 2008). Epidemiologic and experimental evidence shows that illicit and prescription drug use is associated with drug-related impairments in driving skills and increased risk of traffic accidents (Dussault et al., 2001; Fergusson et al., 2008; Hall, 2009; Rapoport et al., 2009; Sharma, 1976). Laboratory studies have linked marijuana intoxication to impairment of cognitive abilities and motor skills employed in driving (Lenne et al., 2010; Menetrey et al., 2005; Papafotiou et al., 2005; Ramaekers et al., 2006), and others have demonstrated an increased risk for motor vehicle collisions, holding constant other factors (Asbridge et al., 2005; Richer and Bergeron, 2009).

The annual prevalence of drugged driving is estimated at 2.9% among adults 26 and older, but is considerably higher (12.8%) in young adults 18 to 25 years old (Substance Abuse and Mental Health Services Administration, 2010b). The proportion of U.S. drivers testing positive for drugs is even higher, ranging as high as 16.3% for weekend nighttime drivers (Lacey et al., 2009). After alcohol, the most commonly detected drugs in both U.S. and European motorists tend to be marijuana, cocaine, benzodiazepines, and opiates, with polydrug use being prevalent (Christophersen and Morland, 1997; Lacey et al., 2009; Senna et al., 2010). Riding with a drugged driver is also common, with one in five high school seniors riding in a car driven by someone under the influence of marijuana during the past two weeks (O’Malley and Johnston, 2007). Narrowing the focus to illicit drug users, past-year drugged driving estimates vary widely, ranging from 23% to 90% (Albery et al., 2000; Jones et al., 2005; Matthews et al., 2009; Reilly et al., 1998; Walsh and Mann, 1999), with injection drug users having one of the highest rates (88%; Darke et al., 2004).

As with many risky behaviors, young white males are more likely than others to engage in drugged driving (Kelly et al., 2004; O’Malley and Johnston, 2007), yet these correlations are confounded by their association with drug use itself. Among drug-using individuals, drugged driving has been associated with more frequent drug use (Mallick et al., 2007) and drug dependence (Begg et al., 2003; Hingson et al., 2008). Drugged drivers are likely to engage in other substance-related traffic-risk behaviors, yet estimates of the degree of overlap vary widely. Among high school seniors who drove after using marijuana during the past two weeks, about one in three also drove after heavy drinking (O’Malley and Johnston, 2007), whereas in the general U.S. population, 77% of past-year drugged drivers also drove under the influence of alcohol (Substance Abuse and Mental Health Services Administration, 2002, 2010a).

College students are an important population for understanding drugged driving. Many of the correlates of drugged driving—including being young, unmarried, and having only a few years of driving experience (Asbridge et al., 2005; Walsh and Mann, 1999)—correspond to traditional college student characteristics, and full-time college students are at higher risk than their same-age counterparts (Substance Abuse and Mental Health Services Administration, 2003a). Also, risky behaviors abound in college, with 37.5% of full-time college students using illicit drugs annually (Substance Abuse and Mental Health Services Administration, 2005), and 13.9% engaging in unprotected sex as a result of drinking (American College Health Association, 2007). Previously we reported high rates of drunk

driving (17% of 19-year-old drivers) and riding with a drunk driver (38% of all 19-year-olds) in our college student sample (Beck et al., 2010).

In light of the dangers posed by drugged driving and college students' high risk for this behavior, this study aimed to: 1) estimate the annual prevalence of drugged driving and riding with a drugged driver; 2) evaluate age-related trends and race and sex differences in these two behaviors; 3) examine the degree of overlap between drugged and drunk driving; and 4) estimate the strength of the association of drugged and drunk driving with alcohol and marijuana dependence.

2. Methods

2.1. Study Design

Data were collected in the College Life Study, a prospective study of young adult health-related behaviors. At one large, public university in the mid-Atlantic region, 3401 incoming first-time, first-year students ages 17 to 19 were screened during summer orientation in 2004 (88.7% response rate). Next, 1253 (86.5% response rate) were sampled for longitudinal follow-up, beginning with a two-hour baseline assessment, consisting of interview and self-administered components, sometime during their first year of college (Year 1). Individuals who had used an illicit drug or nonmedically used a prescription drug at least once prior to college were purposively oversampled. Annual follow-up assessments achieved high completion rates [91.1% for Year 2 (n=1142), 87.9% for Year 3 (n=1101), and 87.6% for Year 4 (n=1097)]. Interviewers were trained extensively on interview administration and human subjects protections. Participants received $5 for the screener, $50 for each annual assessment, and a $20 bonus for on-time completion of follow-up assessments. Sampling, recruitment, and interview procedures are documented fully elsewhere (Arria et al., 2008). This study was approved by the university's IRB, and a federal Certificate of Confidentiality was obtained.

2.2. Participants

The analytic sample comprised 1194 individuals (47.7% male, 72.8% white) who participated in at least one assessment in Years 2 through 4 (corresponding to sophomore, junior, and senior years of college for students following a traditional track), and were ages 19 to 22 at the time of those assessments (see Section 2.4.). Year 1 data were not used due to overlap with high school experiences. Most (80.3%) were still enrolled at the same university by Year 4. Regarding socioeconomic status, more than two-thirds had a college-educated mother (37.7% four-year degree, 35.8% graduate degree). Compared with the 59 excluded individuals, the inclusion sample had slightly but significantly fewer men and was slightly younger.

2.3. Measures

2.3.1. Substance-related traffic-risk behaviors—Participants were asked how many times in the past 12 months they "drove while high on other drugs," inclusive of both illicit drugs and prescription drugs used nonmedically. Interviewers recorded the specific drug(s) used before driving. Responses were later dichotomized into "none" and "once or more." Dichotomous past-year variables were constructed similarly for riding with a drugged driver ("you were a passenger in a vehicle driven by someone under the influence of other drugs") and drunk driving ("you drove while drunk on alcohol").

2.3.2. Access to a car—Annually participants were asked if they had "access to driving a car during the past 12 months." All participants were asked questions about traffic-risk

behaviors regardless of access; however, some analyses were restricted to drivers only (see Section 2.4.).

2.3.3. Past-year drug use—A series of interview questions captured the past-year frequency of use for eleven different illicit and nonmedical prescription drugs (marijuana, inhalants, hallucinogens, cocaine, amphetamines, methamphetamine, heroin, ecstasy, and prescription stimulants, tranquilizers, and analgesics). Responses were later dichotomized as "none" and "once or more" for each drug.

2.3.4. Alcohol and marijuana dependence—Standard items corresponding to the DSM-IV criteria for dependence on alcohol and marijuana were administered annually (American Psychiatric Association, 1994; Substance Abuse and Mental Health Services Administration, 2003b). Individuals were coded as alcohol dependent if they experienced three or more of the following during the past year: tolerance, withdrawal, using more than intended, inability to cut back, spending a great deal of time using or obtaining alcohol, failure to fulfill major role obligations, and/or continued use despite alcohol-related problems with physical or mental health. Marijuana dependence was coded similarly, with the exception that withdrawal was not assessed (American Psychiatric Association, 1994). Individuals using the substance less than five days annually were not assessed for dependence and automatically coded as non-dependent.

2.3.5. Demographics—Participants' age at each interview was computed from university administrative data. Gender was recorded at baseline. Race was self-reported in Year 3 and later dichotomized for analytic purposes into white and non-white.

2.4. Analytic Samples

Because individuals who had tried an illicit drug at least once during high school were oversampled, statistical weighting was desirable to better represent the general population of screened students. Weights were computed based on pre-college drug use (as measured at screening), gender, and race by dividing the number of screened individuals in each drug use-gender-race cell by the corresponding number of sampled individuals. The present analyses report weighted prevalence estimates (denoted as $\%_{wt}$) for drugged driving, drunk driving, and riding with a drugged driver. Inferential statistics were evaluated using unweighted data.

Repeated measures analyses were undertaken using generalized estimating equations (GEE) (Hardin and Hilbe, 2003; Liang and Zeger, 1986), with age as the repeated factor. Data from Years 2 through 4 were available, corresponding to ages 18 through 23; however, small cell sizes precluded inclusion of observations for ages 18 and 23, leaving a final sample of 3286 observations for ages 19 to 22. Access to driving was an additional inclusion criterion for analyses on drugged and drunk driving, with the exception that the few individuals who denied having access to drive but did engage in drugged (n=36 observations) and/or drunk driving (n=30 observations) were retained in the analysis sample. Riding with a drugged driver was not restricted on the basis of access to driving a car. Thus, the analytic sample sizes varied slightly: 3011 observations for drugged driving, 3005 for drunk driving, and 3286 for riding with a drugged driver. All analyses were conducted using PASW Statistics 18.0 (IBM Corporation, 2009).

2.5. Analytic Strategy

A series of GEE models were developed to evaluate age-related changes in prevalence of drugged driving and riding with a drugged driver, as well as possible gender and race differences; estimated marginal means were requested to obtain prevalence estimates. Age

was the repeated factor, and gender and race were entered simultaneously as main effects. In subsequent models, the first-order interactions of age, gender, and race were added in turn. This series of GEE models was performed first for drugged driving, then for riding with a drugged driver. Following detection of a significant effect, pairwise comparisons were evaluated using Bonferroni correction for multiple comparisons. To further isolate the possible effects of gender and race, drugged driving analyses were repeated with the added inclusion criterion of past-year drug use. Lastly, cross-tabulations were examined to document the overlap between drugged and drunk driving.

A similar GEE approach was used to compare the odds of meeting criteria for alcohol and/or marijuana dependence, by the presence or absence of each traffic-risk behavior. Sex, race, and age were held constant, and age was the repeated factor. To understand whether drugged driving added any predictive value to drunk driving, comparisons were also made amongst the four mutually exclusive groups based on drunk driving (yes/no) and drugged driving (yes/no).

3. Results

3.1. Drugged Driving

The vast majority of students had access to a car in the past year, increasing slightly with age: 83%$_{wt}$ at age 19, 90%$_{wt}$ at age 20, 94%$_{wt}$ at age 21, and 96%$_{wt}$ at age 22. Regardless of age, among those who did have access, approximately one in six (16–17%$_{wt}$ annually) drove under the influence of a drug other than alcohol at least once in the past year (Figure 1). Marijuana was overwhelmingly the most commonly mentioned drug in drugged driving experiences (97%), followed by cocaine (13%) and nonmedical use of prescription analgesics (4%); 16% of those who mentioned marijuana also mentioned using one or more other drugs in drugged driving experiences. With respect to frequency, it was not uncommon for drugged driving to occur repeatedly in a given year. Annually, 57% to 67% of drugged drivers did so at least three times, and 27% to 37% at least ten times.

Drugged driving's stability was reflected by the absence of a significant statistical effect of age in the GEE model (Table 1). However, drugged driving differed significantly by gender and race. Drugged driving was more likely in males than females (*AOR*=2.4, *95%CI*=1.9–3.0, $p<.001$) and in whites than non-whites (*AOR*=1.5, *95%CI*=1.2–2.1, $p=.003$), holding constant age as the repeated factor. Aggregating responses over time, drugged driving was most prevalent for white males (30%$_{wt}$), followed by non-white males (17%$_{wt}$) and white females (16%$_{wt}$), and least prevalent for non-white females (8%$_{wt}$). The first-order interactions between gender, race, and age were not significant.

When the model was restricted to past-year drug users (n=1919), gender's effect was unchanged (*AOR*=2.2, *95%CI*=1.7–2.8, $p<.001$) and age remained non-significant, but race became non-significant. The estimated probability of drugged driving among drug users who had access to a car was 31%$_{wt}$ at ages 19, 20, and 21, and 33%$_{wt}$ at age 22. Aggregating responses over time, drugged driving prevalence was 44%$_{wt}$ for white males, 36%$_{wt}$ for non-white males, 28%$_{wt}$ for white females, and 21%$_{wt}$ for non-white females.

3.2. Riding with a Drugged Driver

Among all students—regardless of car access—one in four rode with a drugged driver annually (24–30%$_{wt}$; Figure 2). Unlike drugged driving, riding with a drugged driver decreased significantly after age 21, and was less likely at age 22 than age 19 (*AOR*=.8, *95%CI*=.6–.9, $p=.013$; Table 1).

As with drugged driving, riding with a drugged driver differed significantly by gender and race. Prevalence was highest for white males (42%$_{wt}$) and lowest for non-white females (17%$_{wt}$), with white females (31%$_{wt}$) and non-white males (24%$_{wt}$) in the middle range. Males were more likely than females to ride with a drugged driver (*AOR*=1.8, *95%CI*=1.5–2.2, $p<.001$), and whites more likely than non-whites (*AOR*=1.7, *95%CI*=1.3–2.1, $p<.001$). No significant interactions of gender, race, and age were observed, and the observed age-related decrease was consistent across all gender-race groups (all at $p<.01$).

3.3. Overlap between Drugged and Drunk Driving

In any given year, approximately half of drugged drivers were also drunk drivers (range 47% to 60% annually; Table 2), and conversely, about half of drunk drivers were also drugged drivers (45% to 58% annually). The vast majority (>90% annually) of drugged drivers also rode in a car driven by a drugged driver.

3.4. Risk for Marijuana Dependence and Alcohol Dependence

All four substance-related traffic-risk behaviors tested were significantly associated with both marijuana and alcohol dependence, even holding constant sex, race, and age (all $p<.001$; Table 3). Not surprisingly, marijuana dependence was likeliest among drugged drivers (23.5%), especially if they also drove drunk (25.5%). However, although drunk drivers were 2.4 times more likely than non-drunk-drivers to be marijuana dependent (*95%CI*=1.8–3.2, $p<.001$), drunk driving did not contribute significantly to marijuana dependence beyond the risk from drugged driving (25.5% vs. 21.9%, $p>.9$). Individuals who rode with a drugged driver were also at increased risk for marijuana dependence (*AOR*=13.2, *95%CI*=8.3–20.8, $p<.001$), as were those who rode with a drunk driver, albeit less so (*AOR*=2.5, *95%CI*=1.8–3.3, $p<.001$). Nearly all of the marijuana dependence cases in the entire sample engaged in drugged driving (93.8%), and half of them had driven both drugged and drunk (51.1%).

Alcohol dependence was common among drunk drivers (22.9%, Table 3) and higher still among drunk drivers who also drove drugged (28.7%). Drugged driving (*AOR*=2.5, *95%CI*=1.9–3.2, $p<.001$) and drunk driving (*AOR*=3.0, *95%CI*=2.4–3.9, $p<.001$) each conveyed similar increases in risk for alcohol dependence as separate main effects, and together, individuals who drove both drugged and drunk were significantly more likely to meet criteria for alcohol dependence compared to those who only drove drunk (28.7% vs. 18.0%, $p=.007$). Individuals who rode with either a drugged driver (*AOR*=2.9, *95%CI*=2.3–3.6, $p<.001$) or a drunk driver (*AOR*=3.1, *95%CI*=2.4–4.0, $p<.001$) were all at increased risk for alcohol dependence. Of all the alcohol dependence cases in the sample, 51.5% had driven drunk, and 32.3% had driven both drunk and drugged.

4. Discussion

In this study of college-attending young adults, one in six individuals with access to a car drove while high on a drug other than alcohol in the past year, regardless of age. As in earlier studies of U.S. and European drivers, marijuana was the drug most commonly used before driving (Christophersen and Morland, 1997; Lacey et al., 2009; Senna et al., 2010). Among all students, riding with a drugged driver was reported by 28%$_{wt}$ to 30%$_{wt}$ of 19- to 21-year-olds, followed by a slight but significant decline by age 22 (24%$_{wt}$). This was slightly higher than previously observed in high school seniors (O'Malley and Johnston, 2007). Both drugged driving and riding with a drugged driver were important indicators of risk for alcohol and/or marijuana dependence.

The finding that drugged driving was significantly more prevalent for males than females—even taking past-year drug use into account—supports and extends prior evidence from

general-population studies, many of which did not account for gender differences in drug use (Kelly et al., 2004; Substance Abuse and Mental Health Services Administration, 2003a). Although whites were more likely to drive drugged than non-whites, this association disappeared once the analysis was restricted to drug users and thus might be attributable to whites' greater overall drug involvement. However, we cannot rule out the possibility that whites might have had more frequent access to a car.

We observed only partial overlap in college students' risky driving behaviors, with about half of drugged drivers (47–60%$_{wt}$ annually) having also driven drunk. If replicated this finding could indicate that conventional estimates of drunk driving prevalence might underestimate the true extent of substance-impaired driving among college students. This degree of overlap is much less than what has consistently been observed in national data on U.S. young adults (ages 18 to 25), wherein about 77% of past-year drugged drivers have also driven drunk (Substance Abuse and Mental Health Services Administration, 2002, 2010a). While this discrepancy could be a result of sampling or measurement differences, it raises the possibility that drugged driving could be more distinct from drunk driving in college students compared to non-students—in addition to being more prevalent—and therefore more likely to go undetected in conventional drunk driving screens.

The study's strengths include its longitudinal design, large sample size, and high follow-up rates. The ability to focus analyses on individuals who had access to a car is an advancement over prior population-based studies, most of which did not take into account access to a car. Thus, it is not surprising that prevalence in this study was somewhat higher than in prior studies of young adults (Substance Abuse and Mental Health Services Administration, 2010b; Walsh and Mann, 1999). During the transition to young adulthood, access to a car is likely to increase with age, as it did in our sample. This could account for why we found no association of age with drugged driving, unlike prior evidence showing a distinct peak in drugged driving at age 21 followed by a decline starting at age 22 (Substance Abuse and Mental Health Services Administration, 2003a). However, in our analysis of riding with a drugged driver—regardless of access to a car—we observed a similar decline after age 21.

4.1. Limitations

Certain limitations of this study must also be acknowledged. Participants were ascertained from a single university, so generalizability to other settings (e.g., smaller private colleges, other geographic areas) might be limited. Although we have no indication that over- or underreporting occurred, self-report data are subject to biases related to recall and social desirability. Since we did not provide participants with an explicit definition of "drunk" or "under the influence of other drugs," we cannot say how many individuals might have been incorrectly classified due to differences in how participants subjectively interpreted these questions. Although many individuals reported both drunk and drugged driving in the past year, we have no information about how often simultaneous polysubstance use may have occurred in any given driving situation. Traffic-risk variables were dichotomized for ease of interpretation; however, in a Poisson model, drugged driving frequency yielded similar results regarding temporal stability and race/gender differences (both at $p<.01$).

4.2. Implications

An important contribution of this study is the finding that drugged driving was just as prevalent as drunk driving in our college student sample (Beck et al., 2010), but frequently occurred in different individuals (i.e., drugged drivers who did not drive drunk). Considerable attention has been given to drunk driving prevention and interdiction, and the present findings highlight the need to broaden existing efforts to address drugged driving more assertively and simultaneously with drunk driving. Early identification of and

intervention with drugged drivers is one important objective, especially in light of prior evidence that drugged driving offenders are likely to recidivate, perhaps even more so than drunk drivers (Christophersen and Morland, 1997; Christophersen et al., 2002). Given evidence of a link between driving under the influence of marijuana and reckless driving style (Richer and Bergeron, 2009), moving violations might be a helpful starting point for identifying individuals at risk for drugged driving. Increased enforcement of existing laws regarding impaired driving may be warranted in college communities. One promising strategy is roadside drug testing, which has been shown to be a more effective deterrent against drugged driving than either increases in the severity of sanctions or providing factual information about risks associated with drugged driving (Jones et al., 2005; Jones et al., 2006).

Considering that marijuana was usually the drug that was used before driving, it is important to acknowledge that no clear consensus exists in either the epidemiologic or experimental literature as to whether marijuana use alone is actually associated with an increased crash risk (Sewell et al., 2009). Although we did not explicitly ask about combinations of substances, many of these individuals probably had alcohol or other drugs in their system simultaneously with marijuana. Since many of the same drivers endorsed both behaviors separately, and since marijuana and alcohol are often consumed together, future investigations should include more systematic event-level assessments of this complex behavior. For example, drug-specific questions should be asked as well as questions about driving under the simultaneous influence of alcohol and marijuana. This is particularly important in light of evidence that the combined effects of alcohol and marijuana are especially dangerous for driving, even at relatively low levels of blood alcohol concentration (Sewell et al., 2009). Students who drive after drinking but without feeling “drunk” might be more impaired than they realize if they have also used marijuana within the past few hours, and accordingly might be underreporting their actual level of substance-impaired driving.

Apart from traffic safety concerns, our findings have broader implications for drug and alcohol prevention and intervention, as both drugged driving and riding with a drugged driver were strong indicators of serious underlying substance use problems—in this case, dependence on alcohol and/or marijuana. Substance-related traffic-risk behaviors should be integral to comprehensive prevention strategies promoting early intervention with high-risk individuals. College health providers could include routine questions on drugged driving (and riding) when screening patients for substance use problems. Campus administrators and policymakers should advocate for a law enforcement response that includes mandatory referral for evaluation and treatment for drugged driving offenders, and perhaps voluntary referrals for passengers as well. Conversely, driving privileges could be restricted for individuals sentenced to drug treatment programs until the program is completed.

The finding that most drugged drivers also rode with other drugged drivers (>90%) suggests that these individuals may have a tendency to affiliate with other drug-using peers, thereby reinforcing each other’s drug-related traffic-risk behaviors. One potential new area of research could be on the clustering of these behaviors and perceived risk within drug-using friendship networks. There is some evidence that the general public has low perceived risk around drugged driving, especially where marijuana is concerned. For instance, many college students perceive few impairment risks from marijuana use (Fischer et al., 2006) and regard drugged driving as more acceptable and less risky than drunk driving (McCarthy et al., 2007). Further research should identify effective strategies for modifying attitudes about drugged driving within drug-using peer networks.

References

Albery IP, Strang J, Gossop M, Griffiths P. Illicit drugs and driving: prevalence, beliefs and accident involvement among a cohort of current out-of-treatment drug users. Drug Alcohol Depend. 2000; 58:197–204. [PubMed: 10669072]

American College Health Association. National College Health Assessment: Spring 2006 reference group data report (abridged). J Am Coll Health. 2007; 55:195–206. [PubMed: 17319325]

American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders: DSM-IV. American Psychiatric Press; Washington, DC: 1994.

Arria AM, Caldeira KM, O'Grady KE, Vincent KB, Fitzelle DB, Johnson EP, Wish ED. Drug exposure opportunities and use patterns among college students: results of a longitudinal prospective cohort study. Subst Abuse. 2008; 29:19–38.

Asbridge M, Poulin C, Donato A. Motor vehicle collision risk and driving under the influence of cannabis: evidence from adolescents in Atlantic Canada. Accid Anal Prev. 2005; 37:1025–1034. [PubMed: 15992751]

Beck KH, Kasperski SJ, Caldeira KM, Vincent KB, O'Grady KE, Arria AM. Trends in alcohol-related traffic risk behaviors among college students. Alcohol Clin Exp Res. 2010; 34:1472–1478. [PubMed: 20528819]

Begg DJ, Langley JD, Stephenson S. Identifying factors that predict persistent driving after drinking, unsafe driving after drinking, and driving after using cannabis among young adults. Accid Anal Prev. 2003; 35:669–675. [PubMed: 12850067]

Christophersen AS, Morland J. Drugged driving, a review based on the experience in Norway. Drug Alcohol Depend. 1997; 47:125–135. [PubMed: 9298334]

Christophersen AS, Skurtveit S, Grung M, Morland J. Rearrest rates among Norwegian drugged drivers compared with drunken drivers. Drug Alcohol Depend. 2002; 66:85–92. [PubMed: 11850140]

Darke S, Kelly E, Ross J. Drug driving among injecting drug users in Sydney, Australia: prevalence, risk factors and risk perceptions. Addiction. 2004; 99:175–185. [PubMed: 14756710]

Dussault C, Brault M, Lemire AM, Bouchard J. The role of cocaine in fatal crashes: first results of the Quebec drug study. Annu Proc Assoc Adv Automot Med. 2001; 45:125–137. [PubMed: 12214346]

Fergusson DM, Horwood LJ, Boden JM. Is driving under the influence of cannabis becoming a greater risk to driver safety than drunk driving? Findings from a longitudinal study. Accid Anal Prev. 2008; 40:1345–1350. [PubMed: 18606265]

Fischer B, Rodopoulos J, Rehm, Ivsins A. Toking and driving: characteristics of Canadian university students who drive after cannabis use - an exploratory pilot study. Drugs (Abingdon Engl). 2006; 13:179–187.

Hall W. The adverse health effects of cannabis use: what are they, and what are their implications for policy? Int J Drug Policy. 2009; 20:458–466. [PubMed: 19362460]

Hardin, J.; Hilbe, J. Generalized Estimating Equations. Chapman and Hall/CRC; London: 2003.

Hingson RW, Heeren T, Edwards EM. Age at drinking onset, alcohol dependence, and their relation to drug use and dependence, driving under the influence of drugs, and motor-vehicle crash involvement because of drugs. J Stud Alcohol Drugs. 2008; 69:192–201. [PubMed: 18299759]

IBM Corporation. PASW Statistics (formerly SPSS). Somers, NY: 2009.

Jones, C.; Donnelly, N.; Swift, W.; Weatherburn, D. Contemporary Issues in Crime and Justice Bulletin. NSW Bureau of Crime Statistics and Research; Sydney, AU: 2005. Driving Under the Influence of Cannabis: The Problem and Potential Countermeasures; p. 1-15.

Jones C, Donnelly N, Swift W, Weatherburn D. Preventing cannabis users from driving under the influence of cannabis. Accid Anal Prev. 2006; 38:854–861. [PubMed: 16574046]

Kelly E, Darke S, Ross J. A review of drug use and driving: epidemiology, impairment, risk factors and risk perceptions. Drug Alcohol Rev. 2004; 23:319–344. [PubMed: 15370012]

Lacey, JH.; Kelley-Baker, T.; Furr-Holden, D.; Voas, RB.; Romano, E.; Ramirez, A.; Brainard, K.; Moore, C.; Torres, P.; Berning, A. 2007 National Roadside Survey of Alcohol and Drug Use by Drivers: Drug Results. National Highway Taffic Safety Administration; Calverton, MD: 2009.

Lenne MG, Dietze PM, Triggs TJ, Walmsley S, Murphy B, Redman JR. The effects of cannabis and alcohol on simulated arterial driving: influences of driving experience and task demand. Accid Anal Prev. 2010; 42:859–866. [PubMed: 20380913]

Liang KY, Zeger SL. Longitudinal data analysis using generalized linear models. Biometrika. 1986; 73:13–22.

Mallick, J.; Johnston, J.; Netzach, G.; Kennedy, V. Drugs and Driving in Australia: A Survey of Community Attitudes, Experience and Understanding. Australian Drug Foundation; Melbourne: 2007.

Matthews A, Bruno R, Johnston J, Black E, Degenhardt L, Dunn M. Factors associated with driving under the influence of alcohol and drugs among an Australian sample of regular ecstasy users. Drug Alcohol Depend. 2009; 100:24–31. [PubMed: 19013726]

McCarthy DM, Lynch AM, Pederson SL. Driving after use of alcohol and marijuana in college students. Psychol Addict Behav. 2007; 21:425–430. [PubMed: 17874895]

Menetrey A, Augsburger M, Favrat B, Pin MA, Rothuizen LE, Appenzeller M, Buclin T, Mangin P, Giroud C. Assessment of driving capability through the use of clinical and psychomotor tests in relation to blood cannabinoids levels following oral administration of 20 mg dronabinol or of a cannabis decoction made with 20 or 60 mg Delta9-THC. J Anal Toxicol. 2005; 29:327–338. [PubMed: 16105257]

National Highway Traffic Safety Administration. Traffic Safety Facts 2008: A Compilation of Motor Vehicle Crash Data From the Fatality Analysis Reporting System and the General Estimates System. Washington, DC: 2008.

O'Malley P, Johnston L. Drugs and driving by American high school seniors, 2001–2006. J Stud Alcohol Drugs. 2007; 68:834–842. [PubMed: 17960301]

Office of National Drug Control Policy. [Accessed on June 2, 2010] National Drug Control Strategy. 2010. http://www.whitehousedrugpolicy.gov/policy/ndcs.html

Papafotiou K, Carter JD, Stough C. The relationship between performance on the standardised field sobriety tests, driving performance and the level of Delta9-tetrahydrocannabinol (THC) in blood. Forensic Sci Int. 2005; 155:172–178. [PubMed: 16226154]

Ramaekers JG, Moeller MR, van Ruitenbeek P, Theunissen EL, Schneider E, Kauert G. Cognition and motor control as a function of Delta(9)-THC concentration in serum and oral fluid: limits of impairment. Drug Alcohol Depend. 2006; 85:114–122. [PubMed: 16723194]

Rapoport MJ, Lanctot KL, Streiner DL, Bedard M, Vingilis E, Murray B, Schaffer A, Shulman KI, Herrmann N. Benzodiazepine use and driving: a meta-analysis. J Clin Psychiatry. 2009; 70:663–673. [PubMed: 19389334]

Reilly D, Didcott P, Swift W, Hall W. Long-term cannabis use: characteristics of users in an Australian rural area. Addiction. 1998; 93:837–846. [PubMed: 9744119]

Richer I, Bergeron J. Driving under the influence of cannabis: links with dangerous driving, psychological predictors, and accident involvement. Accid Anal Prev. 2009; 41:299–307. [PubMed: 19245889]

Senna MC, Augsburger M, Aebi B, Briellmann TA, Donze N, Dubugnon JL, Iten PX, Staub C, Sturm W, Sutter K. First nationwide study on driving under the influence of drugs in Switzerland. Forensic Sci Int. 2010; 198:11–16. [PubMed: 20211534]

Sewell RA, Poling J, Sofuoglu M. The effect of cannabis compared with alcohol on driving. Am J Addict. 2009; 18:185–193. [PubMed: 19340636]

Sharma S. Barbiturates and driving. Accid Anal Prev. 1976; 8:27–31.

Substance Abuse and Mental Health Services Administration. Summary of National Findings. Rockville, MD: 2002. Results from the 2001 National Household Survey on Abuse: Volume I.

Substance Abuse and Mental Health Services Administration. Drugged driving: 2002 Update. The NSDUH Report. Office of Applied Studies; Rockville, MD: 2003a.

Substance Abuse and Mental Health Services Administration. 2002 National Survey on Drug Use and Health Questionnaire. Office of Applied Studies; Rockville, MD: 2003b.

Substance Abuse and Mental Health Services Administration. College Enrollment Status and Past Year Illicit Drug Use Among Young Adults: 2002, 2003, and 2004. The NSDUH Report. Substance Abuse and Mental Health Services Administration; Rockville, MD: 2005.

Substance Abuse and Mental Health Services Administration. Results from the 2009 National Survey on Drug Use and Health: Detailed Tables. Rockville, MD: 2010a.

Substance Abuse and Mental Health Services Administration. Summary of National Findings. NSDUH Series H-38A. Vol. I. Office of Applied Studies; Rockville, MD: 2010b. Results from the 2009 National Survey on Drug Use and Health.

Walsh GW, Mann RE. On the high road: driving under the influence of cannabis in Ontario. Can J Public Health. 1999; 90:260–263. [PubMed: 10489724]

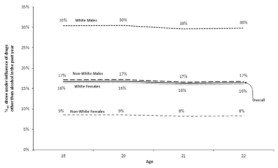

Figure 1.

Estimated likelihood of drugged driving, by race, gender, and age.

Note. Results computed as estimated marginal means from GEE model with age as a repeated factors. “Overall” prevalence was 16%$_{wt}$ at ages 19 and 20, 17%$_{wt}$ at ages 21 and 22.

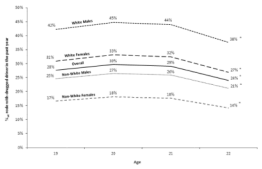

Figure 2.

Estimated probability of riding with a drugged driver, by race, gender and age.

Note. Results computed as estimated marginal means from GEE model with age as a repeated factor.

*Denotes significant change from the preceding year (p<.05).

Table 1

Results of repeated measures GEE predicting drugged driving and riding with a drugged driver on the basis of demographic characteristics.

	Drugged Driving, among all drivers (n=3011)		Drugged Driving, among all drivers who also used drugs in the past year (n=1919)		Riding with a Drugged Driver, among all participants (n=3286)	
	M (SE)	AOR (95%CI) p	M (SE)	AOR (95%CI) p	M (SE)	AOR (95%CI) p
Sex						
Male	.321 (.020)	2.4 (1.9–3.0) <.001	.461 (.025)	2.2 (1.7–2.8) <.001	.450 (.020)	1.8 (1.5–2.2) <.001
Female	.166 (.014)	1.0	.280 (.021)	1.0	.309 (.017)	1.0
Race						
white	.277 (.014)	1.5 (1.2–2.1) .003	.386 (.018)	1.2 (.9–1.6) .259	.438 (.015)	1.7 (1.3–2.1) <.001
Non-white	.198 (.020)	1.0	.346 (.031)	1.0	.320 (.022)	1.0
Age						
19	.248 (.016)	1.0	.370 (.023)	1.0	.389 (.017)	1.0
20	.241 (.015)	1.0 (.8–1.1) .964	.362 (.021)	1.0 (.8–1.2) .724	.405 (.016)	1.1 (.9–1.2) .280
21	.228 (.015)	.9 (.8–1.0) .157	.358 (.021)	1.0 (.8–1.1) .591	.388 (.016)	1.0 (.9–1.1) .952
22	.225 (.019)	.9 (.7–1.1) .227	.373 (.032)	1.0 (.8–1.3) .935	.327 (.023)	.8 (.6–.9) .013

Note. Results adjusted for all main effects shown. The interactions of sex, race, and age were tested and found to be non-significant ($p>.05$).

Table 2

Co-occurrence of drug- and alcohol-related traffic-risk behaviors, by age.

	Age 19	Age 20	Age 21	Age 22
Among drugged drivers (*n*)	(203)	(271)	(252)	(58)
% also drove drunk	47%	49%	60%	48%
% also rode with drugged driver	91%	94%	93%	93%
% also rode with drunk driver	77%	80%	87%	86%
Among drunk drivers (*n*)	(164)	(248)	(292)	(62)
% also drove drugged	58%	54%	52%	45%
% also rode with drugged driver	79%	79%	70%	52%
% also rode with drunk driver	90%	95%	93%	89%

Table 3

Results of repeated measures GEE predicting marijuana and alcohol dependence on the basis of four substance-related traffic-risk behaviors.

	Marijuana dependence		Alcohol dependence	
	M (SE)	*AOR (95%CI) p*	*M (SE)*	*AOR (95%CI) p*
Drugged Driving				
Yes	.235 (.024)	37.6 (22.7–62.3) <.001	.210 (.020)	2.5 (1.9–3.2) <.001
No	.008 (.002)	1.0	.097 (.009)	1.0
Riding with Drugged Driver				
Yes	.131 (.015)	13.2 (8.3–20.8) <.001	.192 (.016)	2.9 (2.3–3.6) <.001
No	.011 (.002)	1.0	.076 (.008)	1.0
Drunk Driving				
Yes	.106 (.013)	2.4 (1.8–3.2) <.001	.229 (.020)	3.0 (2.4–3.9) <.001
No	.048 (.006)	1.0	.089 (.009)	1.0
Riding with Drunk Driver				
Yes	.083 (.009)	2.5 (1.8–3.3) <.001	.173 (.014)	3.1 (2.4–4.0) <.001
No	.036 (.006)	1.0	.064 (.008)	1.0
Interaction of drugged and drunk driving[a,b]				
Drugged driving + Drunk driving +	.255 (.029)	46.9 (26.2–84.2) <.001	.287 (.028)	4.8 (3.5–6.5) <.001
Drugged driving + Drunk driving −	.219 (.029)	38.3 (21.2–69.2) <.001	.145 (.021)	2.0 (1.4–2.9) <.001
Drugged driving − Drunk driving +	.011 (.005)	1.5 (.6–3.8) .369	.180 (.024)	2.6 (1.8–3.7) <.001
Drugged driving − Drunk driving −	.007 (.002)	1.0	.078 (.008)	1.0

Note. All results were adjusted for age, sex, and race.

[a]Risk for marijuana dependence was significantly greater for the combination of drugged and drunk driving relative to drunk driving alone ($p<.001$) but not drugged driving alone ($p>.9$).

[b]Risk for alcohol dependence was significantly greater for the combination of drugged and drunk driving relative to either drugged ($p<.001$) or drunk driving alone ($p=.007$).