Drug and Alcohol Involvement in Four Types of Fatal Crashes*

EDUARDO ROMANO, PH.D.,† AND ROBERT B. VOAS, PH.D.

Impaired-Driving Center, Pacific Institute for Research and Evaluation, 11720 Beltsville Drive, Suite 900, Calverton, Maryland, 20705

ABSTRACT: Objective: The aim of this study was to explore the relationship of drunk and drugged driving to the occurrence of fatal crashes associated with speeding, failure to obey/yield, inattention, and seat belt nonuse. **Method:** We examined data for fatally injured drivers involved in single-vehicle crashes killed in states in which more than 79% of the drivers were tested for drugs other than alcohol and had a known result. **Results:** About 25% of the drivers tested positive for drugs, a figure almost double that estimated by the 2007 National Roadside Survey. Cannabinoids and stimulants each contributed to about 23% of the drug-positive results (6% among all fatally injured single-vehicle drivers). Stimulants more than cannabinoids were found to be associated with the four types of crashes under study. Some drugs showed a protective effect over the four crash types under study. Significant interactions between drugs and alcohol were observed. Stimulants contributed to the different types of fatal crashes irrespective of the levels of alcohol consumed by the drivers. **Conclusions:** This study provides further evidence of a link between drug consumption and fatal crashes. It also opens the door to some interesting and sometimes unexpected questions regarding the way drugs contribute to crashes, which we found varies depending on the type of crash considered, the class of drug, and the presence of alcohol. Research is also needed on drugs that could have a protective effect on the occurrence of fatal crashes. These findings could be highly relevant to the design of drug-related traffic laws and programs targeted at curbing drugged driving. (*J. Stud. Alcohol Drugs, 72,* 567–576, 2011)

THE ROLE OF DRUGGED DRIVING in fatal crashes has been overshadowed by the significance of alcohol impairment. Since the middle of the 20th century, alcohol has been the most important factor for drivers involved in fatal crashes. Highway fatality records indicate that, in the 1960s, as many as half of all fatalities could be traced to an alcohol-related crash; currently, that proportion has been reduced to about a third of all fatalities. Unfortunately, the proportion of fatal crashes resulting from impairment by drugs other than alcohol has been hidden by the police officers' inability to detect drug involvement and the cost of obtaining laboratory confirmation of drugs in bodily fluids. Additionally, the policies in some jurisdictions do not allow investigating or prosecuting the possibility of drug involvement if an impaired-driving conviction can be obtained based on the driver's blood alcohol concentration (BAC; Compton et al., 2009).

There is a growing interest in the extent to which the use of drugs by drivers is related to crash involvement (Dobbs, 2005; Jones et al., 2003; Moskowitz and Wilkinson, 2004; Walsh et al., 2004). These reviews have covered laboratory, simulator, and research studies of arrested and crash-involved drivers and on-road studies of specific driving skills. Although this work suggests a connection between drug use and driving impairment, a specific quantitative relationship between drug concentration and driving impairment has not been established (Compton et al., 2009).

Despite this limited knowledge, laws criminalizing drugged driving are being enacted and enforced. Internationally, the most aggressive enforcement is occurring in Australia, where the police have adapted their highly successful alcohol random breath-testing programs (Homel, 1993) to the testing of other drugs using oral fluid (Boorman and Owens, 2010; Boorman and Swann, 2010; Faulks and Irwin, 2010). Aside from enforcing drugged-driving laws, European researchers are seeking rapid drug-testing methods that can be used in enforcement through the international cooperative Roadside Testing Assessment (ROSITA) program (Verstraete and Raes, 2006). In another international effort—Driving Under the Influence of Drugs, Alcohol and Medicines (Kuijten, 2009), a 5-year project established by the European Commission—several European countries have embarked on a program to establish drug-impairment thresholds by comparing drug levels of injured drivers with those of drivers recruited at random roadside surveys.

In the United States, the 2007 National Roadside Survey found that the percentage of drivers who were using drugs (14%) was greater than the percentage who were using alcohol (12%; Lacey et al., 2009). This somewhat startling result led the White House Office of National Drug Control Policy (2010) to call for states to pass drug per se laws in 2010. Currently, 17 U.S. states have drugged-driving per se laws, of which 15 specify zero tolerance for any measureable amount of an illicit drug. As described in the National Highway Traffic Safety Administration (NHTSA) report to Congress

Received: October 25, 2010. Revision: April 12, 2011.

*This research was supported by National Institute on Alcohol Abuse and Alcoholism Grant P20AA017831.

†Correspondence may be sent to Eduardo Romano at the above address or via email at: romano@pire.org.

(Compton et al., 2009), enforcing these laws will be difficult because, among other problems, the United States does not have a true per se illegal law (like the one in Australia allowing for random breath testing) for either alcohol or other drugs that will allow officers to stop cars at random and demand a chemical test. The Fourth Amendment to the U.S. Constitution requires that searches be reasonable—meaning that there must be evidence or probable cause that the suspect has used alcohol or another drug. Absent that information, the officer cannot require a test, and even if one has been collected, its admission in court can be blocked if the defense can show that the officer lacked probable cause to require the test. To meet these requirements for enforcing drinking-and-driving laws, the NHTSA has funded extensive research for the development of manuals describing vehicle maneuvers that indicate the driver may be intoxicated and that illustrate the appearance and actions of drivers who may be under the influence of alcohol. Although NHTSA has developed a drug-recognition-expert program for police officers, the number that can be trained and qualified under that program is limited.

To increase the rate of apprehension of drugged drivers, police officers will need a set of vehicle maneuvering cues that suggest the driver may be impaired by a drug. Normally, traffic officers respond to typical driving offenses, such as speeding, red-light running, and failure to use seat belts. In this study, we attempted to determine whether the types of offenses provided a cue to the drugged status of the driver. In the process, we explored the relationship of drunk and drugged driving and the two combined to crashes involving specific types of driving errors.

To accomplish this, we analyzed data from the Fatality Analysis Reporting System (FARS), which is a census of all crashes on U.S. public roads that result in a death within 30 days. FARS contains an estimate of the BAC of every driver involved in a fatal crash based on an actual measurement or an imputed value based on other factors in the crash (Subramanian, 2002). Drug information is more limited, but 20 of the 50 states have provided drug use information on at least 80% of their fatally injured drivers. A major strength of FARS is its extensive data set on the characteristics of the crash and its inclusion of important driver demographics, such as age and gender. Based on this information, we explored the relationship of drugs and alcohol in fatally injured drivers in single-vehicle crashes (where the responsibility is clear) involving four driver error factors: speeding, failure to obey or yield, inattention, and failure to use a seat belt.

Method

Case selection

Data were obtained from the 1998–2009 FARS (NHTSA, 1998–2009). Table 1 lists the states from which information

Table 1. States/year with more than 79% of fatally injured drivers with known lab result: Number of fatally injured drivers with drug information in the database by state and year

	Year												
Location	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
California	1,075	1,125	1,227	1,363	1,441	1,460	1,430	1,178	1,211	1,162	1,046	871	14,589
Colorado	0	0	0	0	0	247	0	136	188	214	200	169	1,154
Connecticut	149	0	144	121	130	122	0	90	134	131	0	89	1,110
District of Columbia	0	0	0	0	0	0	13	0	7	7	0	6	33
Georgia	0	0	478	0	0	0	0	0	0	0	0	0	478
Hawaii	52	33	0	0	34	47	53	62	58	58	50	57	504
Illinois	0	0	0	0	0	0	534	516	528	471	0	0	2,049
Maryland	49	0	0	0	0	0	0	225	272	225	230	221	1,222
Massachusetts	154	169	0	0	0	0	0	0	0	0	0	0	323
Minnesota	0	0	0	0	0	0	0	0	0	0	0	160	160
Montana	0	0	0	47	114	118	116	108	118	144	0	111	876
Nevada	0	0	0	0	0	0	0	0	0	143	125	95	363
New Hampshire	57	69	60	0	74	59	91	95	67	0	80	0	652
New Jersey	0	227	242	244	256	232	0	260	247	279	206	190	2,383
New Mexico	0	153	0	0	0	159	190	211	217	174	162	177	1,443
North Carolina	0	0	0	510	569	644	685	600	641	615	605	399	5,268
North Dakota	0	0	0	0	0	42	0	56	0	46	49	0	193
Ohio	0	0	0	0	0	0	0	527	540	550	525	417	2,559
Pennsylvania	0	0	0	0	0	0	0	679	633	672	630	516	3,130
Rhode Island	40	51	46	48	48	60	44	40	41	32	0	0	450
Vermont	0	0	0	0	0	35	50	49	55	43	36	40	308
Virginia	0	0	0	391	0	0	0	0	0	0	0	0	391
Washington	0	0	0	264	294	254	242	280	274	278	237	227	2,350
West Virginia	161	168	194	182	214	171	204	177	188	200	205	187	2,251
Total	1,737	1,995	2,391	3,170	3,174	3,650	3,652	5,289	5,419	5,444	4,386	3,932	44,239

Source: Fatality Analysis Reporting System database, downloaded August 2010 (National Highway Traffic Safety Administration, 1998–2009).

on drug involvement was drawn for each year. Data were limited to fatally injured drivers because surviving drivers are rarely tested for drugs. We also limited the data to drivers in single-vehicle crashes to select the events for which the drivers of interest were likely to be responsible rather than crashes in which two or more drivers were involved. This strategy, which relies on a subset of states and drivers that isolates the characteristics (drug use and crash responsibility) required for our study, is not new but is typical of many studies using the FARS data.

To ensure a proper identification of crash responsibility, in addition to limiting the sample to single-vehicle drivers, we discarded drivers who (a) presented a condition signaling them as mentally challenged, (b) were involved in a police chase, (c) were driving buses or farm equipment, or (d) were parked or in the process of parking a vehicle. After these manipulations, 44,239 drivers remained in the file.

As shown in Table 1, only two states (California and West Virginia) tested more than 79% of the fatally injured drivers for drugs in each of the years under consideration. If only the most recent 5 years are considered, the number of states increases to 12, suggesting that the number of states collecting these measures is rising.

Measures

Age and gender. We incorporated age and gender into our analyses to capture different age-based patterns of drug consumption (e.g., recreational, prescription) as well as age variations in risk taking. Five age groups of drivers were examined: 20 years and younger, 21–34, 35–64, 65–74, and 75 and older. Although information on race and ethnicity has been present in FARS since 1999, some states have not provided this information to the FARS data managers. Because this study relies heavily on state-based information on drugs and to avoid discarding drug information as a result of missing racial/ethnic information, we excluded this demographic variable.

Drugs other than alcohol. Results from drug tests are stored in FARS in three variables (named as DRUGRES1–3 in the FARS database; NHTSA, 2010). Each variable informs the outcome of the laboratory test with a code ranging from 000 (Not Tested for Drugs) to 999 (Unknown If Tested for Drugs). The following list shows the correspondence between these codes and drug classes that applies to FARS: 000 (Not Tested for Drugs); 001 (No Drugs Reported/Negative); 100–295 (Narcotics); 300–395 (Depressants); 400–495 (Stimulants); 500–595 (Hallucinogens); 600–695 (Cannabinoids); 700–795 (Phencyclidine/PCP); 800–895 (Anabolic Steroids); 900–995 (Inhalants); 996 (Other Drugs); 997 (Tested for Drugs, Results Unknown); 998 (Tested for Drugs, Drugs Found, Type Unknown/Positive); and 999 (Unknown if Tested/Not Reported). We followed this list, but because of some small sample sizes, some classes of drugs (Hallucinogens, Phencyclidine/PCP, Anabolic Steroids, and Inhalants) and drugs of an unknown type were collapsed into the "996-Other Drugs" class. Thus, more than half of the drivers in this miscellaneous category have tested positive for drugs, but that drug is not specified in the database. Because each of the three DRUGRES variables could indicate the presence of a drug, we examined all three. Presence of different drugs in the three variables denoted multidrug use.

Alcohol. To establish alcohol consumption, we relied on (a) the actual BAC as measured and reported in FARS and (b) the multiple imputation of BAC values when the actual BAC values were missing, as is currently done in the FARS (Subramanian, 2002). Based on these criteria, we built a four-level "alcohol" variable denoting drivers at BAC = .00; .00 < BAC < .05; .05 ≤ BAC < .08; and BAC ≥ .08.

Crash types. For assigning crash types, we used information from the following FARS variables (NHTSA, 2008): the Driver Condition Factor (DR_CF), the Person-Related Factor (P_CF), and the Violation Charge (VIOLCHG). Table 2 shows the codes we applied to identify the crash factors. FARS provides up to four driver-condition factors (DR_CF1–DR_CF4), three person-related factors (P_CF1–P_CF3), three violation-charged indicators (VIOLCHG1–VIOLCHG3) per driver, and information on the restrains systems use (REST_USE). Presence of a pertinent condition code in any of the factors under consideration resulted in a proper type of crash identification. Drivers identified in each crash type were compared against crashed drivers with no identified crash type or driver condition.

Statistical analyses

We first applied descriptive analyses (chi-square test) to investigate drug and alcohol prevalence (BAC ≥ .08) and demographic characteristics in each of the four crash types under study. As mentioned, the comparison groups included crashed drivers with no identified crash type or driver condition. For speeding, failure to obey or yield, and inattention, the comparison group included drivers with a driver condition factor of zero (DR_CF = 0). For inattentive drivers, the comparison group was a subset of that group: those involved in 2004–2009 crashes. Seat belt use in FARS was denoted by the variable REST_USE. Therefore, the comparison group for seat belt nonusers (identified by REST_USE = 0) was based on this variable and included drivers who did use a seat belt (identified by REST_USE > 0). We then ran logistic regressions to investigate the joint contribution of drugs, alcohol, and demographics to each of the four types of crashes under study. We ran regressions for main effects only and for both main effects and dual Drug × Alcohol interactions. In all, eight regressions were run: one main effects only and one main effects plus interactions for each of the four types of crashes under consideration. We used the MIAnalyze procedure in SAS 9.1. (SAS Institute Inc., Cary, NC) to combine and analyze the 10 BAC imputations.

Results

This section is divided into two parts. First, we present the results of the descriptive analyses, which focus on single associations between drug class and crash type. Next, we present the outcome of the logistic regressions, which examine the joint contribution of alcohol, drug class, and demographics to each of the four crash types under consideration.

Table 2. Fatality Analysis Reporting System variables and criteria used to create crash types

Variable	Related factors—driver level (DR_CF)	Related factors—individual level (P_CF)	Restraint system use (REST_USE)	Violations charged (VIOLCHG)
Failure to obey/yield	• Failure to Yield Right of Way (DR_CF # 38) • Failure to Obey Actual Traffic Actual Signs, Traffic Control Devices, or Traffic Officers, Failure to Observe Safety Zone Traffic Laws (DR_CF # 39)	• Passing where Prohibited by Posted Signs, Pavement Markings, Hill or Curve, or School Bus Displaying Warning not to Pass Line (P_CF # 33) • Failure to Yield Right of Way (P_CF # 38) • Failure to Obey Actual Traffic Signs, Traffic Control Devices, or Traffic Officers, Failure to Obey Safety Zone Traffic Laws (P_CF # 39) • Passing Through or Around Barrier Positioned to Prohibit or Channel Traffic (P_CF # 40) • Failure to Observe Warnings or Instructions on Vehicles Displaying Them (P_CF # 41)		• Fail to Stop for Red Signal (VIOLCHG #31) • Fail to Obey Flashing Signal (yellow or red) (VIOLCHG #34) • Fail to Obey Signal generally (VIOLCHG #35) •Violate RR Grade Crossing Device/ Regulations (VIOLCHG #36) •Fail to Obey Stop Sign (VIOLCHG #37) • Fail to Obey Yield Sign (VIOLCHG #38) • Fail to Obey Traffic Control Device generally (VIOLCHG #39)
Inattention	• Inattentive/Careless (DR_CF # 6) (talking, eating, cell phones, etc.)	• Interfering with Driver (P_CF # 5) (obstructing driver's view, striking driver with body or object; rambunctious individuals who make driver inattentive, even without touching driver or controls) • Inattentive (P_CF # 10) (reading, talking, eating)		•Inattentive, Careless, Improper Driving (VIOLCHG #4)
Speeding	• Driving Too Fast for Conditions or in Excess of Posted Speed Limit (DR_CF # 44) • Operating at Erratic or Suddenly Changing Speeds (1982–1994) (DR_CF # 46)	• Driving Too Fast for Conditions or in Excess of Posted Maximum (P_CF # 44)		• Racing (VIOLCHG #21) • Speeding (above the speed limit) (VIOLCHG #22) • Speed Greater Than Reasonable and Prudent (not necessarily over the limit) (VIOLCHG #23) • Exceeding Special Speed Limit (e.g., for trucks, buses, cycles, or on bridge, in a school zone, etc.) (VIOLCHG #24) • Energy Speed (exceeding 55 mph, nonpointable) (VIOLCHG #25) • Speed-Related Violations Generally (VIOLCHG #29)
Seat belt nonuse			• (REST_USE # 0) indicates nonuse. REST_USE#1 to #15 show use and describe different types of seat belts	

Notes: Alcohol (blood alcohol concentration) was either obtained from tested drivers in the field or imputed by the National Highway Traffic Safety Administration. Codes in table were those used to identify the occurrence of a crash type. To account for multiple violations, there are four driver-condition factor variables (DR_CF1–DR_CF4), three individual-condition factor variables (P_CF1–P_CF3), and three violation-charge variables (VIOLCHG1–VIOLCHG3) in the database. Presence of the targeted code in any of these variables indicates that the driver has committed the corresponding violation. BAC = blood alcohol concentration.

Descriptive analysis

The descriptive associations between the drug classes and the four crash types under study are shown in Table 3. Because only drivers with valid crash information were included in each of the four types of crashes, the number of drivers varies across crash types.

Drug-positive drivers. Of the 44,239 fatally injured drivers with drug-tested information in the file, about 25% tested positive for drugs (n = 10,997). This figure almost doubles the 14% drug prevalence estimated by the 2007 National Roadside Survey (Lacey et al., 2009), suggesting a possible contribution of drugs to the occurrence of fatal crashes. Among the tested drugs, cannabinoids (marijuana, tetrahydrocannabinol [THC], and other cannabinoids) and stimulants (cocaine, amphetamines, benzphetamines, methamphetamines, and other stimulants) were the most prevalent: Each contributed to about 23% of the drug positives. This estimate, combined with the 25% of drug positives, yields an estimated rate of 6% for each drug class among all fatally injured single-vehicle drivers. Compared with the prevalence estimates obtained in the 2007 National Roadside Survey of nighttime drivers for marijuana (7.6%) and with the much smaller prevalence of stimulants (1.9%), the 6% obtained for fatally injured drivers seems to suggest that stimulants may be a larger contributor to crash risk than cannabinoids. Most drivers in the file were below the .08 BAC limit (63%), age 34 years or younger (47%), and male (77%).

Speeding. Among the drivers with information on speeding, the rates of drug-positive drivers in the selected states were significantly higher among those who were speeding (25.5%) than among those who were not speeding (21.2%), suggesting again an association between drug consumption and involvement in speed-related fatal crashes. The distribution of drug classes among drivers involved in speeding was significantly different from the distribution among drivers with "no driver condition." Cannabinoids and stimulants were the drug classes most frequently found among the drivers who sped compared with those who did not (26.8% and 25.5%, respectively). Furthermore, although not shown in Table 3, cannabinoids and stimulants were also the most prevalent drug classes consumed by multidrug users in the selected states. About 60% of all the multidrug users consumed stimulants, with the corresponding figure for cannabinoids being 55%. About 35% of all multidrug users consumed both cannabinoids and stimulants at the same time. Thus, either alone or combined with other drugs, can-

TABLE 3. Percentage of fatally injured drivers involved in four crash types by drug, alcohol, and demographic characteristics (1998–2009)

		Speeding		Failure to obey/yield		Seat belt use		Inattention (2004–2009 only)	
Variable	All	No	Yes	No	Yes	No	Yes	No	Yes
N	44,239	2,568	15,261	2,568	4,279	20,790	20,152	1,816	3,303
Drugs									
Drug negatives	75.1%	78.8%	74.5%	78.8%[N.S.]	79.9%[N.S.]	71.8%	78.6%	75.8%[N.S.]	75.4%[N.S.]
Drug positives	24.9%	21.2%	25.5%	21.2%[N.S.]	20.1%[N.S.]	28.2%	21.4%	24.2%[N.S.]	24.6%[N.S.]
Cannabinoids	22.7%	16.9%	26.8%	16.9%	19.1%	23.6%	22.5%	18.0%	23.1%
Depressant	6.8%	6.4%	5.4%	6.4%	7.8%	6.5%	7.2%	6.4%	5.8%
Narcotic	9.3%	9.7%	6.4%	9.7%	10.8%	8.7%	10.1%	10.5%	10.0%
Stimulant	22.5%	11.9%	25.5%	11.9%	19.8%	22.2%	22.2%	10.3%	16.4%
Other drugs	23.8%	43.0%	22.0%	43.0%	30.1%	23.1%	24.6%	42.2%	28.5%
Multidrug	14.9%	11.9%	14.0%	11.9%	12.4%	15.9%	13.4%	12.6%	16.2%
Alcohol									
BAC = .00	58.0%	77.0%	47.0%	77.0%[N.S.]	77.0%[N.S.]	46.0%	70.0%	76.0%	61.0%
.00 < BAC < .05	3.0%	3.0%	3.0%	3.0%[N.S.]	3.0%[N.S.]	3.0%	3.0%	3.0%	3.0%
.05 ≤ BAC < .08	2.0%	2.0%	3.0%	2.0%[N.S.]	2.0%[N.S.]	3.0%	2.0%	2.0%	2.0%
BAC ≥ .08	37.0%	17.0%	47.0%	17.0%[N.S.]	18.0%[N.S.]	48.0%	25.0%	19.0%	34.0%
Age, years									
16–20	14.1%	7.9%	19.4%	7.9%	11.9%	51.5%	74.9%	8.6%	13.9%
21–34	32.8%	26.1%	41.6%	26.1%	21.3%	48.5%	25.1%	25.8%	31.5%
35–64	41.4%	51.6%	35.2%	51.6%	33.1%	14.3%	13.9%	52.0%	42.7%
65–74	5.6%	7.6%	2.1%	7.6%	11.1%	35.2%	30.4%	7.2%	5.4%
≥75	6.1%	6.9%	1.7%	6.9%	22.6%	41.7%	41.3%	6.4%	6.4%
Gender									
Male	77.3%	75.7%	83.8%	75.8%	66.7%	80.2%	74.2%	77.3%[N.S.5]	74.2%[N.S.5]
Female	22.7%	24.2%	16.2%	24.2%	33.3%	19.8%	25.8%	22.6%[N.S.5]	25.8%[N.S.5]

Notes: Comparison drivers for speeding, failure to obey/yield, and inattention-related crashes were defined by drivers with no identified driver's crash contributing factor (DR_CF = 0). A different variable clearly identifying seat belt use was applied to drivers according to those who wore a seat belt and those who did not. Percentages for "drug positives" include 270 drivers who tested positive for an unidentified drug. However, percentages for drug class are based only on the 10,727 drivers with known lab results. Fatally injured drivers tested for drugs involved in single-vehicle crashes only. Percentages denote column percentages (e.g., 75.1% of the drivers were drug negative [13,394]). With the exception of those denoted as "[N.S.]" (not significant) and "[N.S.5]," all comparisons were statistically significant ($p < .01$). Comparison denoted as "[N.S.5]" denotes a p value < .05. BAC = blood alcohol concentration.

nabinoids and stimulants were significantly associated with speeding.

Interestingly, "other drugs" seemed to have a protective effect on speeding. Because this miscellaneous category largely includes drugs that have not been specified in the database, and because most lab efforts by participant states aim to measure illicit and/or risky (unsafe) drugs, we could speculate that most of those nonidentified drugs were medications.

Being impaired by alcohol (BAC ≥ .08), being age 34 years and younger, and being male also were significantly associated with speeding. Interestingly, no difference in speeding-related crashes was observed for intermediate BAC levels (i.e., .00 < BAC < .08). This finding, however, should not be interpreted as intermediate BAC levels not influencing the overall likelihood of speeding because the fatally injured drivers in the database form a special sample of drivers in which high levels of alcohol impairment is not uncommon.

Failure to obey or yield. The occurrence of drug positives among drivers who failed to obey or yield was not significantly different from that among drivers with no driver condition. Despite this overall lack of significance, the rate of stimulant use was significantly higher among drivers who failed to obey or yield than among drivers with no driver condition (more than double). Thus, although the overall rate of drug positives in the selected states was similar among those who failed to obey or yield and drivers with no driver condition, differences in the individual drugs of preference explained some of the variation, with stimulants being significantly associated with failing to obey or yield at a traffic signal. As with speeding, other drugs also seemed to have a protective effect on failing to obey or yield.

Multidrug use and alcohol were not associated with failure-to-obey or -yield crashes. Although not reported in Table 3, multidrug use and alcohol were found to be significantly associated with a specific subtype of failure-to-obey or -yield crashes: red-light running ($p < .05$ for multidrug use, $p < .01$ for BAC ≥ .08). Thus, multidrug use and alcohol seemed to have a different effect on red-light running than on other failure-to-yield crashes (i.e., the relatively large number of failure-to-yield crashes in this group [relative to failure to obey] causes this lack of significance). This finding confirms a report by Campbell et al. (2004), who also found that, although alcohol was not associated with failure-to-yield crashes, it was nevertheless associated with failure-to-obey crashes, such as red-light running. Regarding age, failure to obey or yield in the selected states occurred more often among the young (≤21 years of age) and the old (≥75 years of age). This finding may reflect both risk-taking attitudes by youth and lack of motor or reaction skills among the elderly. Men were more likely than women to fail to obey or yield.

Seat belt nonuse. The occurrence of drug positives was significantly higher among drivers who did not use a seat belt (28.2%) than among those who did (21.4%). This finding shows that, overall, drug consumption does affect seat belt use. However, the role that an individual's composition of drugs plays in shaping seat belt nonuse was less clear because the drug class distribution among seat belt users and nonusers visually appeared to be similar. Although similar in appearance, the two distributions were nevertheless significantly different ($p < .01$). The relatively large number of drivers with information on seat belt use increased the statistical power of all involved contrasts, producing a statistically significant effect of drug class on seat belt–related crashes. Interestingly, the protective role that the miscellaneous other-drugs group played on speeding and failure-to-obey or -yield crashes did not occur for seat belt nonuse.

Our findings confirmed previous reports showing the causal role of alcohol on seat belt nonuse (Romano et al., 2005; Tsai et al., 2010), with alcohol impairment (BAC ≥ .08) significantly associated with seat belt nonuse. Drivers ages 21–34 years were more likely to drive without wearing a seat belt than drivers of any other age. Seat belt use was higher among drivers age 65 years and older. Men were less likely than women to wear a seat belt.

Inattention. The occurrence of drug positives in inattention-related fatal crashes in the selected states was not significantly different from that among drivers with no driver condition. Despite this overall lack of significance, the use rates of cannabinoids, stimulants, and multiple drugs were significantly higher among inattentive drivers than among drivers with no driver condition. Alcohol impairment was significantly associated with inattention. Inattention was particularly higher among underage drivers: The inattention rate for drivers ages 16–20 was 1.6 times higher than among drivers with no driving condition.

A clear pattern emerges from Table 3. The role of drugs in the occurrence of fatal crashes depends not only on the consumption of drugs but also on the class of drugs consumed, with variations in both variables depending on the types of crashes under consideration.

Logistic regressions

Table 3 shows the separate, bivariate association between each of the explanatory variables under consideration and the four crash types under analysis. To investigate the joint contribution of the explanatory variables to each of the crash types under consideration, we applied logistic regression. Table 4 shows the outcome of the four logistic regressions modeling the likelihood of a fatal crash to be associated with speeding, failure to obey or yield, seat belt nonuse, and inattention as a function of drug class, alcohol, age, and gender. Table 4 largely displays the outcome of main effects models. Although estimated separately as full models and for economy, the outcome of the Drug × Alcohol interactions that were statistically significant is also shown in Table 4.

TABLE 4. Outcome of logistic regressions modeling the contribution of drugs, alcohol, and demographic characteristics to the occurrence of four crash types (1998–2009)

	Speeding		Failure to obey/yield		Seat belt nonuse		Inattention (2004–2009 only)	
Variable	OR	$P > z$	OR	$P > z$	OR	$P > z$	OR	$P > z$
Drugs other than alcohol (ref.: tested negative)								
Cannabinoids	1.243	.061	1.224	.142	1.199	<.0001	1.071	.633
Depressant	1.268	.217	1.111	.629	1.342	.000	0.851	.512
Multidrug	1.463	.006	1.248	.176	1.776	<.0001	1.346	.076
Narcotic	1.088	.598	1.045	.8432	1.425	<.0001	1.062	.7532
Other drugs	0.647	<.0001	0.637	<.0001	1.384	<.0001	0.652	<.0001
Stimulant	2.514	<.0001	2.066	<.0001	1.298	<.0001	1.579	.011
Alcohol (ref.: BAC = .00)								
.00 < BAC < .05	1.267	.053	1.108	.480	1.495	<.0001	1.187	.318
.05 ≤ BAC < .08	2.303	<.0001	1.247	.279	1.832	<.0001	1.324	.207
BAC ≥ .08	4.208	<.0001	1.556	<.0001	2.831	<.0001	2.374	<.0001
Age, years (ref.: 21–34)								
16–20	2.194	<.0001	1.953	<.0001	1.170	<.0001	1.525	.000
35–64	0.479	<.0001	0.824	.003	0.976	.308	0.751	<.0001
65–74	0.305	<.0001	2.024	<.0001	0.928	.117	0.824	.142
≥75	0.292	<.0001	4.647	<.0001	0.793	<.0001	1.121	.388
Gender (ref.: females)								
Males	1.349	<.0001	0.659	<.0001	1.173	<.0001	0.756	<.0001
Other Drug × Alcohol interactions								
Cannabinoid × BAC ≥ .08	0.403	.001	0.471	.001	0.818	.033	0.501	.004
Depressant × BAC ≥ .08	0.305	.003	0.441	.113	0.871	.433	0.626	.354
Multidrug × BAC ≥ .08	0.297	<.0001	0.321	<.0001	0.671	<.0001	0.401	.012
Other drugs × BAC ≥ .08	0.588	.005	0.586	.025	1.240	.035	1.240	.515

Notes: Comparison drivers for speeding, failure to obey/yield, and inattention-related crashes were defined by drivers with no identified driver's crash contributing factor (DR_CF = 0). A different variable clearly identifying seat belt use was applied to drivers according to those who wore a seat belt and those who did not. With the exception of the Drug × BAC ≥ .08 interaction rows, coefficients and *p* values in this table were estimated for main effects model. Although added in this table to save space, the five rows denoting Drug × BAC ≥ .08 interactions were estimated from separate models. Only statistically significant Drug × Alcohol interactions (at least for one of the four types of crashes under study) were included in this table. OR = odds ratio; ref. = reference; BAC = blood alcohol concentration.

Speeding. Cannabinoid (although marginally significant), stimulant, and multidrug users were more likely to speed than drivers with no drugs in their systems. Among these drugs, stimulants were found to be closely associated with speeding, with the odds of speeding about double those for drivers using cannabinoids. The protective role of the miscellaneous other-drugs group on speeding that surfaced in Table 3 also appears in Table 4. Although stimulant and multidrug use were found to be significant contributors to speeding, the largest contributor to speeding was alcohol, an important crash factor even at relatively low BAC levels. The contribution of alcohol to speeding increased with the BAC level; the largest increase was at BAC ≥ .08, with an odds ratio (OR) almost doubling that for intermediate BAC levels or stimulants. As expected, speeding was more likely to occur among young male drivers.

Failure to obey or yield. The contribution of drugs to the likelihood of failure to obey or yield shows a slightly different pattern than that found for speeding. As was the case with speeding, stimulants were found to be a significant contributor to the likelihood of failure to obey or yield. Unlike the case with speeding-related crashes, multidrug users were no longer significant contributors to failure-to-obey or -yield crashes. As with speeding, the miscellaneous other-drugs group had a protective effect on failure-to-obey or -yield crashes. Also, as with speeding, alcohol was an important contributor to failure to obey or yield. Alcohol was also an important contributor to failure-to-obey or -yield crashes, albeit significant only for BAC ≥ .08 and with an OR lower than that of stimulants. Drivers ages 75 and older were much more likely to fail to obey or yield than drivers of any other age. Drivers ages 35–64 were the least likely to fail to obey or yield. Male drivers were less likely than their female counterparts to be fatally injured in a failure-to-obey or -yield crash.

Seat belt nonuse. Unlike the case with speeding or failure to obey or yield, the presence of any of the drugs under study reduced the likelihood of wearing a seat belt. Even the miscellaneous other-drugs group was found to be a contributor to these crashes. Alcohol was again the most important contributor to this type of crash, with an OR for BAC ≥ .08 that doubled for any individual drug. Seat belt use differed

by age, being relatively low among the youngest drivers and high among the oldest. As expected, male drivers were less likely than their female counterparts to wear a seat belt.

Inattention. Stimulants were the only drug class found to significantly increase the likelihood of an inattention-related fatal crash, albeit only at the 5% α level. Multidrug use also contributed to inattention crashes, but its significance was marginal ($p = .076$). The miscellaneous other-drugs category again showed a protective factor against crashes. Cannabinoids were found statistically nonsignificant. Alcohol impairment was again the most important contributor to these types of crashes, with ORs that doubled that of stimulants. Regarding age, inattention-related crashes were more prevalent among the young and the old: drivers ages 16–20 and 75 and older. Women were more likely than men to be involved in this type of crash.

Interaction terms. The joint effect of alcohol and drugs was further explored by the addition of interaction terms to the main effect models. Interestingly, only the interaction of drugs with BAC ≥ .08 was significant. No drug interaction with relatively low BAC levels (i.e., BAC < .08) was found to be a significant contributor to any of the four crash types under study. Also interesting was the direction of these significant interactions, all of them showing an OR of less than 1. When statistically significant, the direction of the estimated ORs for interaction terms suggests that the influence of the drug classes shown by the main effects models depends on the level of alcohol in the driver's system being greater at lower BAC levels. For instance, that seems to be the case for cannabinoids or multidrugs in each of the four types of crashes under study as well as for the miscellaneous other drugs in all crash types (except inattention) and for depressants in speeding. In other words, this finding suggests that the consumption of cannabinoids or multidrugs does have an influence on these crashes but mostly in the absence of alcohol. Even the protective role that the miscellaneous other-drugs class seems to play on these crashes is affected by the levels of alcohol consumed by the drivers.

It is interesting to note the nonsignificance of the Stimulants × Alcohol interaction. The main effects models have shown that stimulants were significantly associated with each of the crash types under study. However, the lack of significance of its interactions with alcohol suggests that, unlike that for cannabinoids or multidrugs, the contribution of stimulants to crashes occurs irrespective of the level of alcohol consumed by the drivers.

Discussion

To our knowledge, this study is the first to use FARS to investigate the role of drugs other than alcohol in the occurrence of different types of fatal crashes. Albeit constrained to a selected group of states, this study is among the first to provide an estimate of drug prevalence among fatally injured drivers (25%). By comparing it with the drug-prevalence estimates among nighttime drivers reported in the 2007 National Roadside Survey (14%; Lacey et al., 2009), this study provides further evidence about the negative role that drugs play in the occurrence of fatal crashes.

In considering the negative effects of drug use, it is important to keep in mind that a drug may increase the risk of crash involvement through its influence on driving skills at the time of the crash. Alternatively, drug use (in particular when illegal) may define a class of drivers per se who are risky enough to consume those drugs. In other words, the risk of crash involvement associated with drug use may occur regardless of the amount of drug taken when the crash occurs. An example of this effect is provided by the role of stimulants on increasing the likelihood of a crash that could be related to the use of a particular drug class and/or the risk-taking or impulsivity characteristics of the involved drivers.

Several authors (Cherpitel, 1999; Coghlan and Macdonald, 2010; Macdonald et al., 2008) have studied these associations and reported an increase in unintentional injuries among drivers showing a combination of stimulants and risk-taking or impulsivity characteristics. Authors such as Cherpitel (1999) and Macdonald et al. (2008) argued that the risk-taking or impulsivity characteristics of the drivers, rather than the consumption of drugs, is the main reason these injuries occur. Individuals with risk-taking personalities are also more likely to consume stimulants than other individuals. Although the relative contribution of risk-taking/impulsivity characteristics and stimulants to speeding-related fatal crashes could not be assessed in this study, this effort clearly shows that stimulants are indeed associated with the occurrence of those types of fatal crashes. In contrast, the miscellaneous other-drugs class was shown to have a protective effect over the four crash types under study. We speculated that the observed protective effect of drugs in this class was related to their use as medications and other over-the-counter drugs. If this is the case, they may identify a low-risk user who drives more carefully and is less likely to use alcohol or illicit drugs.

Although our analysis simultaneously included gender and age as explanatory variables, many uncontrolled personal variables associated with driving risk undoubtedly influenced our results. We believe that the relative contribution of drug presence versus the characteristics of drug users to crash involvement deserves further study. It is possible that for some classes of drug users, their risks of involvement are greater when drug free than when under the influence.

As mentioned, cannabis was associated only with speeding (albeit only marginally, $p = .061$) and seat belt nonuse. Although cannabis has been found to be associated with the occurrence of unintentional injuries (Cherpitel, 1999; Macdonald et al., 2008), unlike stimulants, it would be expected to reduce the motivation to speed. We might speculate that

the marijuana relationship to speeding is related to the characteristics of the users who may be more likely to be risk takers than to the acute effects of the drug on the body. In any case, speculation regarding the basis of the relationships uncovered by this study should be guarded, because drug and BAC levels were not available to the study.

Thus, an important finding of this study shows that there is a link between drug consumption and fatal crashes, but the contribution of the different drug classes involved varies depending on the type of crash considered. Among the two drug classes most commonly used, stimulants more than cannabinoids were found to be associated with the four types of crashes under study. The second important finding of this study involves the presence of alcohol. Broadly speaking, we found that the contribution of drugs to fatal crashes is important mainly in the absence of an impairing level of alcohol. When drivers are alcohol impaired, the influence of other drugs is less significant. Counter to the commonly held belief, no synergistic reinforcing drugs–alcohol effect seems to occur. What seems to happen is, when alcohol is present, it is the main source of impairment. This suggests that the current procedure in the criminal justice system of not pursuing potential drug offenders where an illegal BAC is available is appropriate. Further, by comparing the OR obtained for drugs and alcohol, it is clear that alcohol is the main single contributor to three of the four types of crashes under study.

The sole exception regarding the Alcohol × Drug interactions under study involved stimulants. Stimulants seem to depart from the other drug classes in two ways. First, stimulants have a damaging role on failure-to-obey or -yield crashes that is as severe as that of alcohol. This is in keeping with prior studies in which amphetamines have been implicated in studies of crash-involved drivers. Second, and unlike cannabinoids, stimulants contributed to the different types of fatal crashes irrespective of the levels of alcohol consumed by the drivers. Thus, the findings coming from this study suggest not only that different drugs are associated with different types of fatal crashes but also that the role other drugs play in those crashes might be as severe as that of alcohol. A third finding of this study involves the miscellaneous other-drugs class. This class has shown a protective effect over the four crash types under study. Unfortunately, lack of detail about the individual drug composition of this miscellaneous other-drug class prevents a further understanding of this somehow surprising result. We have speculated that the observed protective effect of this drug class was caused by medications and other over-the-counter drugs, which are not the main target of laboratory analyses in the participant states. Nevertheless, we believe this speculation about the role of medications on crashes is one that should be formally hypothesized and properly evaluated in future research efforts.

Despite its pioneering findings, this study has several limitations. First, because of lack of information on drugs, only 20 of the 50 states were included in the analyses. This study is therefore based on a select number of drivers from a select number of states. These small numbers warn that the associations we found and discussed should be taken with caution. Nevertheless, the strategy of using only data coming from states with specific laws or programs of interest and with good data is reminiscent of that in many past studies, particularly from the earlier days of alcohol research, when only about 15 states were accurately reporting BACs on fatally injured drivers (e.g., Perrine et al., 1989). The BAC of drug-using drivers has proven to be a major determining factor in the significance of drugs to crash involvement. For alcohol, dosage is directly related to impairment. It is reasonable to expect that dosage should also have an effect in determining the levels of impairment associated with the drugs we have studied. Unfortunately, the concentrations of drugs other than alcohol that impair driving performance and significantly raise crash risk remain to be defined. Until such concentrations have been defined, the FARS data on drugs will be difficult to interpret. Further, the capabilities of the laboratories that conduct drug analyses vary from state to state, with some differing in their definitions of the presence of the drug of interest in biological samples. Until a national standard for the analysis of each of the key drugs associated with crash involvement can be developed, it will be difficult to combine results across states. Finally, it is important that analyzing only the presence of the drug in the body of a driver does not provide reliable information on the acute effects of the substance on the driver's performance because the observed differences among the users of different classes of drugs may be a result of the characteristics of those who choose that particular drug rather than the acute effects of the drug itself.

Despite its shortcomings, this study opens the door to some interesting and sometimes unexpected questions and hypotheses that need to be studied further, because drugs do contribute to fatal crashes, but the way they contribute varies depending on (a) the type of crash, (b) the class of drug, and (c) the presence of alcohol. Also, more research is needed on some drugs that are not well defined that could have a protective effect on the occurrence of fatal crashes. Findings from more research could be highly relevant to the design of drug-related traffic laws as well as public health programs and policies targeted at curbing drugged driving.

Acknowledgments

The authors thank two anonymous reviewers who helped us enormously with their suggestions and guidance.

References

Boorman, M., & Owens, K. (2010, August). An evaluation of the deterrent value of random breath testing (RBT) and random drug testing (RDT)

across Australia. In B. Logan & J. Morland (Eds.), *ICADTS T2010 Conference, 11–26 August.* Oslo, Norway: International Council on Alcohol, Drugs, and Traffic Safety.

Boorman, M., & Swann, P. (2010, August). Victoria impaired driving legislation (2000) and random roadside oral fluid legislation (2004): Theory and results of 2 different enforcement strategies. In B. Logan & J. Morland (Eds.), *ICADTS T2010 Conference, 11–26 August.* Oslo, Norway: International Council on Alcohol, Drugs, and Traffic Safety.

Campbell, B. N., Smith, J. D., & Najm, W. G. (2004). *Analysis of fatal crashes due to signal and stop sign violations.* Washington, DC: National Highway Traffic Safety Administration.

Cherpitel, C. J. (1999). Substance use, injury, and risk-taking dispositions in the general population. *Alcoholism: Clinical and Experimental Research, 23,* 121–126.

Coghlan, M., & Macdonald, S. (2010). The role of substance use and psychosocial characteristics in explaining unintentional injuries. *Accident Analysis & Prevention, 42,* 476–479.

Compton, R., Vegega, M., & Smither, D. (2009). *Drug-impaired driving—Understanding the problem and ways to reduce it: A report to Congress.* Washington, DC: National Highway Traffic Safety Administration.

Dobbs, B. (2005). *Medical conditions and driving: A review of the scientific literature (1960–2000).* Washington, DC: National Highway Traffic Safety Administration.

Faulks, I., & Irwin, J. (2010). *Drink driving and Australian alcohol policy developments in 2008–2009.* Wahroonga, NSW, Australia: TRB Committee on Alcohol, Other Drugs, and Transportation, Safety and Policy Analysis International.

Homel, R. (1993). Random breath testing in Australia: Getting it to work according to specifications. *Addiction, 88,* 27S–33S.

Jones, R. K., Shinar, D., & Walsh, J. M. (2003). *State of knowledge of drug-impaired driving.* Washington, DC: National Highway Traffic Safety Administration.

Kuijten, C. (2009). *Evaluation of oral fluid screening devices by TISPOL to harmonise European police requirements (ESTHER).* DRUID 6th Framework Programme Deliverable 3.1.1. Retrieved from: www.druid-project.eu.

Lacey, J. H., Kelley-Baker, T., Furr-Holden, D., Voas, R. B., Romano, E., Ramirez, A., . . . Berning, A. (2009). *2007 National Roadside Survey of Alcohol and Drug Use by Drivers: Drug Results* (DOT HS 811 249). Washington, DC: National Highway Traffic Safety Administration.

Macdonald, S., Erickson, P., Wells, S., Hathaway, A., & Pakula, B. (2008). Predicting violence among cocaine, cannabis, and alcohol treatment clients. *Addictive Behaviors, 33,* 201–205.

Moskowitz, H., & Wilkinson, C. J. (2004). *Antihistamines and driving-related behavior: A review of the evidence of impairment.* Washington, DC: National Highway Traffic Safety Administration.

National Highway Traffic Safety Administration. (2010). *FARS Analytic Reference Guide 1975 to 2009* (DOT HS 811 352). Washington, DC: Author. Retrieved from http://www-nrd.nhtsa.dot.gov/Pubs/811352.pdf

National Highway Traffic Safety Administration. (1998–2009). *Fatality Analysis Reporting System (FARS).* National Highway Traffic Safety Administration: Washington, DC. Retrieved March 31, 2010, from ftp://ftp.nhtsa.dot.gov/fars

Office of National Drug Control Policy. (2010). *National Drug Control Strategy, 2010.* Washington, DC: Author.

Perrine, M. W., Peck, R. C., & Fell, J. C. (1989). Epidemiologic perspectives on drunk driving. In *Surgeon General's Workshop on Drunk Driving: Background Papers.* Rockville, MD: Office of the Surgeon General, U.S. Department of Health and Human Services, Public Health Service, pp. 35–76. Retrieved from http://profiles.nlm.nih.gov/ps/access/NNBCXY.pdf

Romano, E., Tippetts, S., Blackman, K. O., & Voas, R. (2005). Acculturation, income, education, safety belt use, and fatal motor vehicle crashes in California. *Prevention Science, 6,* 139–148.

Subramanian, R. (2002). *Transitioning to multiple imputation—A new method to estimate missing blood alcohol concentration (BAC) values in FARS.* Washington, DC: Mathematical Analysis Division, National Center for Statistics and Analysis, National Highway Traffic Safety Administration, U.S. Department of Transportation.

Tsai, V. W., Anderson, C. L., & Vaca, F. E. (2010). Alcohol involvement among young female drivers in US fatal crashes: Unfavourable trends. *Injury Prevention, 16,* 17–20.

Verstraete, A., & Raes, E. (2006). *Rosita-2 project.* Belgium: Ghent University, Department of Clinical Biology.

Walsh, J. M., Gier, J. J., Christopherson, A. S., & Verstraete, A. G. (2004). Drugs and driving. *Traffic Injury Prevention, 5,* 241–253.