Drugs in Fatally Injured Young Male Drivers

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Synopsis

One or more drugs were detected in 81 percent of 440 male drivers, aged 15–34, killed in motor vehicle crashes in California; two or more drugs were detected in 43 percent. Alcohol, the most frequently found drug, was detected in 70 percent of the drivers, marijuana in 37 percent, and cocaine in 11 percent. Each of 24 other drugs was detected in fewer than 5 percent. Except for alcohol, drugs were infrequently found alone; typically, they were found in combination with high blood alcohol concentrations. The causal role of drugs in crashes was assessed by comparing drivers with and without drugs in terms of their responsibility for the crash. Alcohol was associated with increased crash responsibility; the role of other drugs could not be adequately determined.

THE MAJOR ROLE OF ALCOHOL (ethanol) in motor vehicle crashes is well established. Blood alcohol concentrations (BACs) of at least 100 mg per 100 ml (0.10 percent by weight) are typically found in about 50 percent of fatally injured drivers, whereas very few drivers not in crashes but on the roads at the same times and places as those who crash have BACs of this magnitude (*1,2*).

The role of drugs other than alcohol—whether prescription drugs, over-the-counter drugs, or illicit drugs—is not established. Studies have indicated that various drugs such as marijuana, diazepam, and diphenhydramine impair performance of driving skills as measured in the laboratory (*3,4*); marijuana has also been found to impair actual car driving performance (*5,6*). However, there is insufficient evidence concerning the extent to which these and other drugs are present in drivers who crash, and, if present, the extent to which they contributed to the crash.

In the few studies in which injured drivers have been tested for a wide variety of drugs, alcohol has been found much more frequently than other drugs. A study of fatally injured drivers in Ontario, Canada, found that 26 percent tested positive for drugs other than alcohol and that among these drugs marijuana (12 percent) was detected most frequently (*7*). In a study of nonfatally injured drivers admitted to the emergency department of a hospital in Rochester, NY, drugs other than alcohol were detected in 22 percent; again, marijuana (9 percent) was the leading drug (*8*). BACs in excess of 0.09 percent were found in 67 percent of drivers fatally injured in single-vehicle crashes in North Carolina, but marijuana was found in only 6 percent (*9*).

If drugs other than alcohol are present in drivers who crash, there are difficulties in interpreting their contribution to the crash. Unlike measurements of alcohol, quantitative measurements of other drugs are not necessarily indicative of recent use, impairment, or degree of impairment. In addition, when other drugs are detected, alcohol is often present also; this creates difficulties in determining the contribution of other drugs to the crash. Most important, the extent to which drugs other than alcohol are found among drivers not in crashes, but similarly exposed, has not been determined, mainly because of difficulties involved in obtaining appropriate body fluids from a sample of such drivers. Instead, inferences about the contribution of drugs to crashes have been based on comparisons between crash-involved drivers thought to be responsible for the crash and those not responsible. Such comparisons have been made with respect to marijuana, and a higher percentage of drivers responsible for crashes has been found among drivers in whom marijuana was present than among drug-free drivers, which

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suggests that marijuana has a causal role in crashes (*7,8*).

All the studies of drugs in injured drivers have been based on geographically limited populations that may not represent other areas of the nation. In view of the uncertainty as to whether any drug other than alcohol plays more than a minor role in motor vehicle crashes, this study was undertaken in a population that has high drug use and high crash rates: young California males (*10*). The rationale for choosing this population was that if drugs other than alcohol were found infrequently, it would be likely that such drugs constitute a negligible problem on the highways in the United States.

Methods

Arrangements were made with coroners in four California counties to obtain blood samples from 15- to 34-year-old fatally injured male drivers of motor vehicles (except large trucks) during most or all of 1983 and part of 1982. The four counties were Los Angeles, Orange, Sacramento, and San Diego. California law requires that blood samples be drawn from all fatally injured drivers whose deaths occur within 24 hours following the crash. All deaths of drivers are reported to coroners' offices in the four counties; the offices submit to the California Highway Patrol (CHP) monthly reports on these drivers that are the basis for CHP tabulations of fatally injured drivers. The periods during which data were collected differed in the four counties: Los Angeles, April 1982–December 1983; Orange, January–October 1983; Sacramento, April 1982–December 1983; and San Diego, March 1982–December 1983. The sample was limited to drivers who died on impact or within 2 hours of the crash to minimize effects of metabolism and elimination on drug concentrations. Each coroner's office was provided with Teflon-lined, screw-capped vials, containing sodium fluoride and potassium oxalate, so that 15 ml samples of blood could be obtained.

For each case, California Highway Patrol reports were reviewed to determine driver responsibility for the crash, using the classification system developed by Haddon (*11*). In this system, probable responsibility of the driver is assumed if one vehicle was involved in the collision. In addition, in multiple-vehicle crashes, if the vehicle was in motion and the other vehicle(s) was not, or if all crash-involved vehicles were in motion but the fatally injured driver initiated the crash, probable responsibility is also assumed. Classifications of probable responsibility were based on the diagram and narrative description of the crash provided by the investigating officer. In collisions in which more than one vehicle was in motion, responsibility was assigned to the driver and vehicle traveling in the wrong direction; crossing the center line; failing to obey stop signs, red lights, or other right-of-way signs; or striking other vehicles from behind.

Comparisons of responsible and nonresponsible crash-involved drivers in terms of drug presence provide some evidence concerning the role of drugs in crashes. However, if a drug is associated with crash responsibility, it is not necessarily implicated as a causal factor. As Terhune notes, unlike case-control studies, in which crash-involved drivers are compared with other drivers on the road at the same times and locations, crash responsibility analysis does not completely control for effects on responsibility of time and location (*12*). In addition, it shares the limitation of case-control studies in that the drug effect cannot be separated from other characteristics of the involved persons and their vehicles that may be related to crashes. In this study, however, comparisons were made among people of the same sex and similar ages, controlling for two major crash-related characteristics.

In this study, blood was analyzed for 23 drugs or drug groups that have been identified by the National Highway Traffic Safety Administration as those that might impair driving (*13*). Drugs found (except volatile solvents, caffeine, heroin, and some hallucinogens) were quantified and toxicological analysis was performed according to procedures described by Crouch and coworkers (*14*), with some technical modifications (available from A. F. W. on request). Blood concentrations of Δ^9-tetrahydrocannabinol (THC) and 11-nor-9-carboxy-Δ^9-tetrahydrocannabinol (COOH-THC) were determined by capillary gas chromatography-negative ion chemical ionization mass spectrometry (*15*).

Results

In the periods for which data were collected in the four California counties, 789 male drivers 15–34 years old were killed. Information used to determine eligibility for the study was known for 762 drivers, of whom 514 (67 percent) were eligible. Eight of the 248 ineligible drivers were driving large trucks; the remainder survived for more than 2 hours. Eligible drivers were more likely than ineligible ones to be responsible for their crash (87 percent versus 79 percent, $\chi^2 = 6.91$, $P < 0.01$).

Of the 514 eligible cases, quantities of blood sufficient for analysis were obtained for 440 (86 percent); 222 samples were from Los Angeles County, 29 from Orange, 53 from Sacramento, and 136 from San Diego. There were no statistically significant differences, between eligible drivers for whom blood samples were and were not obtained, in age, time of day of the crash, vehicle type, number of involved vehicles, or crash responsibility.

The age distributions for the included eligible cases were as follows: 15–19 years (83 cases, 19 percent); 20–24 (166 cases, 38 percent); 25–29 (113 cases, 26 percent); and 30–34 (77 cases, 18 percent). (The exact age of one driver was unknown, but he was known to be between 15 and 34 years old.) Two hundred and twenty (50 percent) of the decedents were passenger car drivers, 160 (36 percent) were motorcyclists, 49 (11 percent) were drivers of pickup trucks or vans, and 11 (3 percent) were drivers of other types of motor vehicles, excluding large trucks. More crashes occurred during the nighttime hours of 9 p.m. to 6 a.m. (58 percent) than between 6 a.m. and 9 p.m. (42 percent). Slightly more than half of the drivers (53 percent) were killed in single-vehicle crashes. A determination of crash responsibility was made for 427 (97 percent) of the drivers, and 376 (88 percent) were estimated to be responsible for the crash in which they died. Crash responsibility was assigned to all of the single-vehicle drivers and to 75 percent of the drivers in multiple-vehicle crashes.

As shown in table 1, one or more drugs (up to seven) were detected in 81 percent of the drivers. (Lidocaine, an anesthetic used in emergency treatment, was detected in 33 drivers but was excluded from this and subsequent analyses that are intended to reflect drugs present at crash time.) Use of multiple drugs was common: two or more drugs were present in 43 percent of the 440 drivers. Excluding the drug-free group, two or more drugs were detected in the majority (53 percent) of the drivers. Crash responsibility increased as a function of number of drugs detected. Seventy-one percent of the drug-free group were responsible for their crashes, compared with 87 percent of those in whom one drug had been detected and 96 percent of those in whom two or more drugs were present ($\chi^2 = 34.94$, $P < 0.001$).

Table 2 lists the frequency of detection of various drugs and their pharmacological class. Twenty-seven different drugs were detected; in the 440 drivers, 630 specific incidences of drugs were found. Alcohol was present in 70 percent of the drivers. Cannabinoids (constituents of marijuana) were detected in more than

Table 1. Number of drugs detected per fatally injured young male driver and crash responsibility

	Drivers			
Number of drugs	*Number*	*Percent*		*Percent responsible for crash*
0	82		19	71
1	167	38	81	87
2	135	31		96
3 or more	56	13		95
Total	440		100	

Table 2. Drugs detected in fatally injured young male drivers

Drug	*Pharmacological class*	*Number of times detected*	*Percent of 440 drivers with drug*
Alcohol	Central nervous system depressant	308	70
Marijuana	Not currently classified	162	37
Cocaine	Central nervous system stimulant	47	11
Diazepam	Tranquilizer	19	4
Phencyclidine	Hallucinogen	18	4
Methamphetamine	Central nervous system stimulant	14	3
Phenyl-propanolamine	Sympathomimetic	12	3
Ephedrine	Sympathomimetic	10	2
Other drugs	Nonbarbiturate sedative—hypnotics ($N = 14$); barbiturate sedative—hypnotics ($N = 9$); narcotic analgesics ($N = 7$); anticonvulsants ($N = 4$); central nervous system stimulants ($N = 3$); tranquilizers ($N = 2$); antidepressants ($N = 1$)	40	[1]
Total		630	

[1] None of the 19 "other drugs" was detected in more than 1 percent of the drivers.

Table 3. Drugs detected in fatally injured young male drivers, by driver age

Drugs	Percent of drivers by age			
	15–19	20–24	25–29	30–34
Number:				
0	28	22	13	10
1	35	34	44	42
2 or more	37	45	43	48
Total	100 (*N* = 83)	[1]101 (*N* = 166)	100 (*N* = 113)	100 (*N* = 77)
Type:				
Alcohol	63	67	73	81
Marijuana	37	39	32	38
Cocaine	4	11	14	12
Average number per driver	1.3	1.4	1.5	1.6
Average number per driver, alcohol excluded	0.6	0.7	0.8	0.8

[1] Does not add to 100 due to rounding.

Table 4. Drugs detected in fatally injured young male drivers, by vehicle type

Drugs	Percent of drivers by vehicle driven		
	Passenger car (*N* = 220)	Motorcycle (*N* = 160)	Other (*N* = 60)
Number:			
0	15	26	14
1	40	34	41
2 or more	45	40	46
Total	100	100	[1]101
Type:			
Alcohol	75	61	78
Marijuana	35	40	34
Cocaine	15	7	7
Average number per driver	1.5	1.3	1.5
Average number per driver, alcohol excluded	0.8	0.7	0.7

[1] Does not add to 100 due to rounding.

one-third (37 percent), and cocaine was found in 11 percent. Each of the other 24 drugs was present in fewer than 5 percent of the drivers. Diazepam and phencyclidine (PCP) were each found in 4 percent.

Alcohol accounted for almost half (49 percent) of all drug detections, and high BACs were typical. Of the 308 drivers in whom alcohol was present, 52 percent had BACs of 0.10–0.19 percent and 30 percent had BACs of 0.20 percent or greater.

In all 162 drivers in whom cannabinoids were detected, THC, the pharmacologically active constituent of marijuana, and COOH-THC, one of its metabolites, were present. Detection of these substances can also indicate consumption of hashish, but it is assumed that in the population studied they were indicative of marijuana. The hydroxylated metabolite (OH) was often detected as well, but low concentrations of OH are very difficult to detect in hemolyzed whole blood. The distribution of THC was as follows: 38 percent of the cases were in the range 0.2–0.9 nanograms per milliliter (ng/ml); 22 percent, 1.0–1.9; 26 percent, 2.0–4.9; and 14 percent, 5.0 or more. For COOH-THC, in 30 percent of the cases, concentrations were less than 10 ng/ml; in 25 percent, 10–24.9; in 24 percent, 25–49.9; and in 22 percent, 50 or more. Practically all of the THC and COOH-THC in a blood specimen are bound to proteins in the plasma fraction; thus THC and COOH-THC concentrations in blood are approximately 50 percent of those in plasma.

Cocaine was found by itself or with its metabolite benzoylecgonine (BE) in 13 drivers; BE alone was found in 34 drivers. Concentrations of diazepam were generally in a range consistent with therapeutic use, except in 2 of the 19 cases. Seven of the 18 drivers in whom PCP was found had concentrations of 300 ng/ml or more, which are indicative of PCP intoxication.

Table 3 shows that the number of drugs detected increased with driver age ($\chi^2 = 12.60$, $P < 0.05$). Marijuana was found to about the same extent among drivers in each age group. Cocaine was found less often among teenage than among older drivers; alcohol was found more often among drivers 25 or older than among younger drivers. Table 4 shows that drugs were less likely to be found in motorcyclists than in drivers of passenger cars or other motor vehicles ($\chi^2 = 9.57$, $P < 0.05$). Motorcyclists were somewhat less likely than other drivers to have consumed alcohol but slightly more likely to have used marijuana. Other analyses indicated that, in general, drugs were more likely to be found in drivers who crashed at night (9 p.m. to 6 a.m.) than in those who crashed during daytime. However, marijuana was found to about the same extent during both periods. There were no statistically significant differences among cases from the four counties in number and types of drugs detected.

Drugs other than alcohol were infrequently found alone. Typically, they were combined with alcohol, and generally the BACs were 0.10 percent or greater. Table 5 shows that when alcohol was present, it was the only drug in 44 percent of the cases, whereas marijuana was found alone only 12 percent of the times it was detected and cocaine 4 percent. Other drugs were found alone 11 percent of the times detected. When marijuana, cocaine, and other drugs were found in combination with alcohol, BAC distributions were about the same as when alcohol was found alone. Table 6 shows that when alcohol was the only drug present, slightly more of the decedents had BACs in the very high ranges; however, when alcohol was combined with marijuana, cocaine, or other drugs, slightly more had BACs that were 0.10 percent or greater than when alcohol was the only drug present. Mean BACs were similar in all groups.

Table 7. Crash responsibility rates in relation to alcohol and marijuana detected in fatally injured young male drivers

Drug group	*Number*[1]	*Percent responsible for crash*	
Drug-free	78	71	
Alcohol alone:			
BAC < 0.10 percent	26	85	
BAC 0.10–0.14 percent	26	88	92
BAC ≥ 0.15 percent	78	96	
Marijuana:			
Alone	19	53	
With alcohol, BAC < 0.10 percent	15	93	
With alcohol, BAC 0.10–0.14 percent	20	95	95
With alcohol, BAC ≥ 0.15 percent	53	96	
With alcohol and other drugs	41	98	
With drug(s) other than alcohol	10	100	

[1] Information on crash responsibility not available for four drivers each in the drug-free, alcohol-alone, and marijuana groups.

NOTE: BAC = blood alcohol concentration.

Table 5. Drugs detected in fatally injured young male drivers: found alone, combined with alcohol, and combined with drugs other than alcohol

	Alcohol alone		*Marijuana*		*Cocaine*		*Other*	
Drug detected—	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Alone	134	44	19	12	2	4	12	11
With alcohol[1]			132	81	36	77	79	70
With drug(s) other than alcohol	174	56	11	7	9	19	22	19
Total	308	100	162	100	47	100	113	100

[1] Drugs other than alcohol may have been present also.

Table 6. Blood alcohol concentration (BAC) distributions when alcohol was found alone or with other drugs in fatally injured young male drivers

	Alcohol alone		*With marijuana*		*With cocaine*		*With other drugs*	
BAC (percent)	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
< 0.10	27	20	21	16	5	14	15	19
0.10–0.14	28	21	30	23	10	28	21	27
0.15–0.19	35	26	47	36	12	33	21	27
≥ 0.20	44	33	34	26	9	25	22	28
Total	134	100	132	[1]101	36	100	79	[1]101
Mean BAC	0.16		0.16		0.15		0.15	

[1] Does not add to 100 due to rounding.

Data on crash responsibility among drivers in whom alcohol and marijuana were detected are presented in table 7. Drivers in whom alcohol alone was present were more likely to be responsible for their crashes than were drug-free drivers (92 percent versus 71 percent, χ^2 = 15.75, $P < 0.01$), and crash responsibility increased with increasing BACs. Fifty-three percent of the 19 drivers in whom marijuana alone was found were estimated to be responsible for their crashes, compared with 71 percent of the 78 drug-free drivers ($\chi^2 = 1.47$, $P > 0.20$). Studies have found that the impairing effects of alcohol and marijuana on the performance of laboratory skills and closed-course driving are additive (*6,16*). Table 7 shows that drivers in whom both marijuana and alcohol were present were slightly more likely than drivers with alcohol alone to be responsible for crashes at BACs less than 0.15 percent, but this was not the case for drivers with BACs greater than 0.15 percent. None of these differences were statistically significant.

Laboratory studies indicate that effects of marijuana are present for at least several hours after smoking. Although interpretation of concentrations of THC and COOH-THC relative to time of smoking is not clear-cut, THC concentrations of 1.0 ng/ml or greater in blood may be indicative of recent smoking, and the ratio COOH-THC ÷ THC has been used to estimate time of smoking (*17*). However, recent research suggests that interpretation of this ratio is not possible without knowledge of whether the person is an infrequent or a frequent smoker (*18*). Crash responsibility rates for drivers in whom marijuana was detected were calculated relative to concentrations of THC, COOH-THC, and COOH-THC ÷ THC; none of these measures were associated significantly with crash responsibility.

Comparisons of crash responsibility rates among the groups listed in table 7 were also made separately for younger and older drivers, nighttime and daytime crashes, and drivers of passenger cars and motorcycles. This was done to control for any differences between the groups on any of these factors that, independently of drug effects, may be related to crash responsibility. Crash responsibility comparisons were also made for drivers in multiple-vehicle crashes. Although these analyses were constrained by small numbers, in each separate comparison the same patterns were found as those in table 7. Logistic regression analyses, taking into account driver age, BACs, and THC concentrations, were also done and showed that alcohol was significantly related to crash responsibility but that marijuana was not.

The numbers of drivers in whom cocaine and other drugs such as diazepam and PCP were detected were insufficient for these kinds of comparisons. Only two drivers (both crash responsible) had cocaine alone. Fourteen (13 crash responsible) had cocaine combined with alcohol, 21 (20 crash responsible) had cocaine combined with alcohol and one or more other drugs, and 9 (all crash responsible) had cocaine combined with drug(s) other than alcohol.

Discussion

Of the 789 young male drivers killed in motor vehicle crashes in four California counties in 1982 or 1983, 514 died on impact or soon after the crash and thus were eligible for inclusion in this study. One or more drugs were detected in 8 out of 10 of 440 fatally injured young men for whom there was sufficient data for analysis. Because ineligible drivers were less likely than those studied to be responsible for their crashes, the incidence of drugs among all young male drivers in the four counties might be somewhat lower.

Alcohol was by far the drug found most frequently, and the crash responsibility analysis provided evidence of its causal role in crashes. Two other drugs—marijuana and cocaine—were found frequently enough to constitute a potentially significant problem on the highways, at least among young California males. These drugs may not be found as often in females, in older populations, or in locations other than California. In studies of crash-involved drivers in other locations, the presence of marijuana was almost always limited to young males (*5,6*). Because the population in this study was deliberately chosen to represent a group with high drug use rates, drugs other than alcohol, marijuana, and cocaine are unlikely to be a major problem in fatal crashes, with the possible exception of diazepam, which is used more by older, female populations (*10*). It is, of course, possible that other drugs impair driving and contribute to crashes, but their low incidence among fatally injured drivers minimizes their importance.

There was some indication that concurrent use of more than one drug increases crash risk. This study provided evidence of the causal role of alcohol in crashes, but the role of other drugs could not be adequately determined. The marijuana analysis was constrained by small numbers and the fact that, in the population studied, crash responsibility rates related to alcohol alone were greater than 90 percent, so that adding marijuana could not increase these rates by much. There was no evidence in the present study that marijuana contributes to crashes, although two prior studies using crash responsibility analysis reported evidence that marijuana has a causal role (*7,8*).

It is possible that marijuana may not impair driving behavior that is related to crash risk or impair it sufficiently to increase crashes. It is also possible that impairment is compensated for in real-life highway driving. Alternatively, marijuana may impair driving and increase crash risks, but the crash responsibility method used is inadequate for determining this. Because control for exposure is partially lost in the responsibility analysis technique, drivers with marijuana who crash, compared with other drivers, may be on the roads at times and places where they are less apt to be responsible for crashes. Or they may drive erratically in such ways that they initiate crashes but are not identified as the responsible driver. The system used in this study for classifying responsibility is oversimplified in assigning 100 percent of the crash responsibility to one driver or the other; however, the use of more sophisticated systems was inappropriate because of the quality of data available from the police reports.

The fact that marijuana was found in more than one-third of the drivers in this study indicates that its role in crashes needs further investigation. Further studies are also needed to determine the incidence of marijuana and other drugs in crash populations other than young California males.

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Technical Assistance Offered to Community Health Programs through a Resource Model

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Synopsis

A multidisciplinary unit in the Department of Community Medicine, Mount Sinai School of Medicine, consists of a core group of specialists who plan, develop, and evaluate community health care programs. The primary