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Drugs (Other than or in Addition to Ethyl Alcohol) and Driving Behavior: A Collaborative Study of the California Association of Toxicologists

The influence of the consumption of ethyl alcohol on motor vehicle driver behavior is well established [*1,2*]. Innumerable other psychoactive drugs are now used widely by the populations of developed countries. That these drugs are also used by motor vehicle drivers on occasion has been documented [*3*] and discussed [*4*]. The effects of these drugs alone, in combination, or with ethyl alcohol on driver behavior are not fully understood. Approaches that could clarify such effects include prospective experimentation with human volunteers in simulated driving situations, prospective experimental studies with human volunteers in actual driving situations, retrospective toxicological analyses of fatal automobile accident victims in mass statistical studies, reconstruction of fatal automobile accidents, and comparative study of individuals with specific, observed driving behavior in real-life situations who were subsequently determined to be with and without drugs.

The study reported here is an example of the last approach and was performed as a collaborative effort by many members of the California Association of Toxicologists (CAT). The CAT had been requested by the California Highway Patrol in May 1973 to offer guidance as to the state of the art of drug testing and interpretation in drugs-and-driving situations.

Development of Study

The Liaison Committee of the CAT, in association with a systems analyst, a statistician, a representative of the California Highway Patrol, and a public defender, created a comprehensive data collection form containing about 375 data elements to be collected on each case (see Fig. 1). A total of 836 cases from 13 laboratories was collected between May 1973 and December 1975.

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California Association of Toxicologists - Liaison Committee
Drugs & Driving Study

Do Not Fill In
Study Case #_____

INSTRUCTIONS: Report all cases in which a sedative, hypnotic, stimulant, analgesic, narcotic, tranquilizer, antihistamine, or other related drug was suspected and/or identified in relation to real or potential vehicle driving performance. Report cases involving alcohol only when in combination with other drugs.

Age | Sex M F | Race | Chronic Drug User: Yes 0 No 1 Unknown 2 | If Yes, What Drugs? | Drug Prescribed? Yes No Unknown

Serious Diseases Present? If Yes, List: Yes No Unknown | Suspected Acute Drug(s): | When Taken | Amount Taken | Yes No Unknown / Yes No Unknown

Were Drugs in Possession at Time of Arrest or Accident? Yes No Unknown | If Yes, What Drugs? | How Much? | Apparent Prescription? Yes No Unknown

Date & Time Subject Apprehended:_____ | Yes No Unknown

Fatality of Subject: Yes No | Was Field Sobriety Test Performed? Yes No Unknown If Yes, State Type of Exam and Result.

Fatality of Others: Yes No If Yes, How Many?_____ | Driver Passenger Pedestrian

Function of Subject at Time of Arrest or Accident? | Other (specify)_____

State of Subject at Time of Obtaining Specimen (Check those observed.)
__Normal __Belligerent __Hallucinating __Impaired Balance __Impaired Coordination
__Awake __Disoriented __Unconscious __Impaired Vision __Slowed Reaction Time
__Lethargic __Loquacious __Affectionate __Staggering __Coma
__Euphoric __Emotional __Slurred Speech __Odor Observed (specify)_____ __Others (specify)_____

Job Category of Observer: __Police Officer __Criminalist __Toxicologist __Physician __Other (specify)_____

Driving Behavior Problem: Yes No
__Excessive Speed __Stop Light Violation __Weaving __Without Due Care __Driver under Influence __Right of Way
__Excessive Slowness __Stop Sign Violation __Other (specify)_____

If Accident, __Single Vehicle __Multiple Vehicle __Injury to Subject __Off Roadway __Into Barrier

Testing Laboratory | Specimen # | Date & Time Specimen Obtained_____ | Date & Time Specimen Analyzed_____

DRUG FINDINGS:	B	U	T	P	A	NTF		B	U	T	P	A	NTF		B	U	T	P	A	NTF
ALCOHOL, ETHYL							CHLORPHENIRAMINE							NICOTINE						
AMITRIPTYLINE							CHLORPROPAMIDE							NORTRIPTYLINE						
AMPHETAMINE							COCAINE							OXAZEPAM						
BARBITURATES,							CODEINE							OXYCODONE						
Long Acting							DIAZEPAM							PENTAZOCINE						
Short Acting							DIPHENHYDRAMINE							PHENOTHIAZINE						
Specific:							DIPHENYLHYDANTOIN							PHENYLBUTAZONE						
AMOBARBITAL							ETHCHLORVYNOL							PRIMIDONE						
BARBITAL							ETHINAMATE							PROPOXYPHENE						
BUTABARBITAL							FLURAZEPAM							SCOPOLAMINE						
PENTOBARBITAL							GLUTETHIMIDE							TOLBUTAMIDE						
PHENOBARBITAL							MEPERIDINE							TRIPELENNAMINE						
SECOBARBITAL							MEPROBAMATE													
BROMIDE							METHADONE							OTHERS (specify)						
CAFFEINE							METHAMPHETAMINE							_____						
CARBON MONOXIDE							METHAQUALONE							_____						
CARISPRODOL							METHYPRYLON							_____						
CHLORAL HYDRATE							MORPHINE							_____						
CHLORDIAZEPOXIDE																				

B = BLOOD U URINE T TISSUE P = PRESENT A ABSENT NTF = NOT TESTED FOR

1. Drug Found | Concentration in μg/ml. | Type Specimen

ANALYTICAL METHOD:
Isolation Technique: Resin column Yes No Resin Used_____ pH adjustment Yes No pH_____ Eluting Solvent_____
Extraction Yes No pH_____ Solvent Used_____ Other Techniques:_____
Identification Technique: UV GC TLC Other_____ Quantitation Technique: UV GC TLC Other_____
Confirmation or Verification Method(s): Yes No If Yes, What?_____

2. Drug Found | Concentration in μg/ml. | Type Specimen

ANALYTICAL METHOD:
Isolation Technique: Resin column Yes No Resin Used_____ pH adjustment Yes No pH_____ Eluting Solvent_____
Extraction Yes No pH_____ Solvent Used_____ Other Techniques:_____
Identification Technique: UV GC TLC Other_____ Quantitation Technique: UV GC TLC Other_____
Confirmation or Verification Method(s): Yes No If Yes, What?_____

Was Quality Control Program in Effect for Pertinent Drugs at Time of Analysis? Yes No Unknown. If Yes, Describe.

What Proficiency Testing Program(s) was engaged in by Testing Laboratory at Time of Analysis?

IF MORE THAN 2 DRUGS IDENTIFIED PER CASE, REPORT ADDITIONAL DRUGS FOUND ON BACK EXACTLY AS SHOWN ON FRONT FOR #1 & 2 DRUGS.

FIG. 1—*Comprehensive data collection form.*

Test and Control Groups

The overall test group consisted of 765 subjects in whom one or more psychoactive drugs other than or in addition to ethyl alcohol had been found and in whom a driving behavior problem had been documented.

The control group consisted of 71 unselected individuals who were apprehended in the same areas and manners as the drug group and who had a driving behavior problem of some sort, but in whom none of the drugs tested for were found.

Subject and Observer Characteristics

The subject in the study (test and control groups combined) was the driver in 97% of the cases. The specimen was blood in 97.5% of the cases and urine in 2.5%. The subject ages ranged from 15 to 85 years, with a mean of 27 years. Fifty-eight percent were between 16 and 24, and 83% were below 34. Seventy-nine percent were male and 21% female. Sixty-nine percent were white, 9.2% Mexican-American, 1.4% black, 0.4% Oriental, and 20% unstated. Ten percent of the total group were listed as chronic drug users with heroin, marihuana, diazepam, and barbiturates being the drugs most frequently named.[4] Less than 30% of the chronic drug users were said to have obtained their drugs on prescription. Eleven percent of the total sample were said to have a serious disease present. The most common diseases listed by the field observers were epilepsy, "nerves," "back pain," diabetes, hepatitis, hypertension, and a "bad leg."

The time of apprehension of the subject was between 12:01 and 3:00 a.m. in 25% and between 9:01 p.m. and midnight in 20%. There were significant numbers in all time blocks, however, the low being 2.5% between 6:01 and 9:00 a.m. The observer was a police officer in 86% of the instances. In 40% of the instances, accidents had occurred, of which 243 were multiple vehicle and 97 single vehicle in type. A fatality was present in 50 cases or 6%, of which 33 were the driver. A field sobriety test was reported in 70% of instances. Less than 2% of subjects passed. Drugs were found in the possession of the person in 26% of instances and a specific drug was suspected by the observer in 36% of instances.

Methods of Analysis

The most commonly reported laboratory identification techniques were ultraviolet absorption spectrophotometry (UV)/paper chromatography (29%), ultraviolet-thin-layer chromatography (17%), gas chromatography (GC) (16%), UV/GC (11%), and UV and thin-layer chromatography (each 3%). Specific testing for *Cannabis* substances in blood and urine was not performed in any of the laboratories.

Seventy-three percent reported using an extraction technique, while 1.2% reported using a resin column. Seventy-four percent used UV or GC as the quantitation technique. Seventy-seven percent indicated use of a confirmation or verification technique for presumptive positives. Eighty-six percent reported the presence of a quality control program in relation to that analysis. An aqueous standard was the usual reported method. Forty-six percent of the cases reported an associated participation in a proficiency testing program. The number of drugs tested for ranged from 1 to 48, with a mean of 21 and a standard deviation of 5.

Results

Driving Behavior Problem

Specific driving behavior problems were listed in 684 instances. The driving behavior problems noted (usually by the arresting officer) are shown in Table 1. The 20% in the "Other" category included such things as "illegal lane change" as well as "did not seem to know how to operate stick shift" or "backed into the bumper of a policeman."

State of Subject

Table 2 itemizes the state of subject observed (usually by arresting officer) at time of apprehension. The listing of "Others" included normal, unconscious, dead, euphoric, hallucinating, or affectionate.

[4]This observation was usually made by the arresting officer, and the basis for the observation was not known to the authors.

TABLE 1—*Percentage of instances in which specific driving behavior problems were reported* (n = *836*).

Behavior Problem	%
Weaving	52
Without due care	30
Driver under influence	29
Excessive speed	14
Excessive slowness	8
Stoplight violation	7
Right of way	5
Stop sign violation	3
Other	20

TABLE 2—*Percentage of instances in which specific subject states were noted* (n = *786, fatalities excluded*).

Subject State	%
Impaired balance	73
Slurred speech	72
Staggering	49
Impaired coordination	42
Odor	40
Disoriented	16
Lethargic	13
Impaired vision	13
Slowed reaction time	11
Belligerent	7
Others	17

Timing Elements

The elapsed time lag from the apprehension of the subject to the obtaining of the specimen ranged from 0.01 to 29.7 h, with a mean of 1.32 h and a standard deviation of 1.84. The duration between obtaining and analyzing the specimen ranged from 1 to 257 h, with a mean of 17 h and a standard deviation of 24.

Predictability of Drug

Drugs were found in the possession of the person in 26% of instances. Table 3 notes the frequency of agreement between the drug found in possession by arresting officer and the drug found in blood and urine by laboratory analysis as well as frequency of agreement between the drug suspected by arresting officer and the drug found by analysis.

Reliability of Ethyl Alcohol Odor Detection

An alcoholic odor on the subject was reported in 205 cases. Ethyl alcohol determinations were performed on samples from all these subjects. Table 4 denotes the results and comparison of these analyses. Note that alcohol was found in only 56% of the instances in which an alcoholic odor was reported.

TABLE 3—*Predictability of drug found by suspicion or possession.*

	Cases, *n*	Percentage of Instances the Drug Found Was	
		Same	Different
Drug suspected	260	53	47
Drug in possession	175	54	46

TABLE 4—*Relationship between report of odor of alcohol and presence of alcohol.*

	Cases	
	n	%
Alcoholic odor reported	205	...
Alcohol present	115	56
Alcohol absent	90	44
Alcohol detected	296	...
Alcoholic odor reported	115	39
Other odor reported	46	15
No odor reported	135	46

Drugs Tested For

In the various laboratories reporting the several hundred cases, a mean of 21 drugs was tested for with a range of 1 to 48 and a standard deviation of 5. The mean number of drugs tested for in the control group (21.9) was slightly more than in the test group (20.8). The drugs most frequently tested for were barbiturates, 99.8%; ethyl alcohol, 99.3%; glutethimide, 90%; meprobamate, 89%; ethinamate, 87%; diazepam, methaqualone, and chlordiazepoxide, 82%; and diphenylhydantoin, 75%. The drugs most frequently listed on the form but not tested for were scopolamine, 97%; bromide and carbon monoxide, 96%; phenothiazine, morphine, chloral hydrate, and cocaine, 95%; methadone, meperidine, and methamphetamine, 94%; and codeine, amphetamine, and amitriptyline, 93%.

Drugs Identified

The number of drugs found per individual case (including control group cases) ranged from 0 to 9 with a mean of 3. In the test group, a total of 40 different drugs were identified as present, either alone or in combinations. Table 5 details this frequency, Table 6 indicates the frequency with which multiple drugs were found, and Table 7 lists the most frequent combinations. In all, there were 87 different, unique combinations of drugs excluding any combination with alcohol.

Design and Results of Statistical Analyses

A general analysis involved compiling frequency distributions for all variables. Further analysis consisted of examining the distribution of various variables while controlling for other variables likely to influence the resulting distribution. Where sample size permitted, statistical comparisons were made between certain pertinent variables. A χ^2 test was employed for variables scaled in discrete categories. A one-way analysis of variance was

TABLE 5—*Number of times specific drugs were found alone or in combination with other drugs.*

Drug	*n*
Barbiturate	521
Secobarbital	177
Phenobarbital	105
Pentobarbital	61
Amobarbital	13
Butabarbital	8
Butalbital	6
Combinations	150
Ethyl alcohol	292
Diazepam	171
Methaqualone	64
Chlordiazepoxide	56
Meprobamate	36
Ethchlorvynol	21
Phencyclidine	7
Diphenylhydantoin	6
Miscellaneous (25 drugs)	44

TABLE 6—*Number of times drugs were found alone, in combination with other drugs, or in combination with alcohol* (n = *765*).

Drug	*n*
Single drug	283
Single drug plus alcohol	221
Two drugs[a]	180
Two or more drugs plus alcohol[a]	71
Three or more drugs	40

[a]Includes 74 cases of various barbiturate combinations.

TABLE 7—*Number of times certain drug combinations appeared in sample* (n = *482*).

Drugs	*n*
Alcohol and barbiturates	172
Barbiturates	74
Alcohol and diazepam	40
Alcohol and methaqualone	14
Phenobarbital and chlordiazepoxide	14
Secobarbital/amobarbital and diazepam	13
Alcohol and chlordiazepoxide	9

utilized for comparison between two or more continuous variables. The test (drug found) and control (drug not found) groups were compared on the variables of age, sex, race, frequency of accidents, number of driving problems, state of the subject, and field sobriety test. Significant differences were noted only for the variables of age and frequency of accidents. The age range, mean, and standard deviation for the test group were 15 to 85, 27, and 11, respectively, and in the control group were 17 to 69, 31, and 15, respectively. The mean age

difference between 27 and 31 is significant with a $P < 0.004$. Members of the test group had accidents in 46% of the instances, while the control group had accidents in only 23% of the instances. This difference is significant at the $P < 0.01$ ($\chi^2 = 13.15$). No additional differences were noted between the two groups even when the significant variable of frequency of accidents was held constant.

Within the test group, comparisons were made between an accident and nonaccident group and between a fatality and nonfatality group. There were sharp sex differences between the fatality group with 55% male and 45% female and the nonfatality group with 80% male and 20% female, statistically significant at the $P < 0.01$ level ($\chi^2 = 15.19$). When corrected for drivers only, the difference was still significant ($P < 0.004$). Less impressive, but still statistically significant at the $P < 0.025$ level ($\chi^2 = 6.24$) is the sex difference between the nonaccident group of 74% male and 25% female. No variable other than sex produced a significant difference between these groups.

Comparisons were done on pure drug and drug plus ethyl alcohol groups in which the numbers were substantial to assess frequency percentage of fatalities. Table 8 lists these findings. The most impressive feature is how the addition of ethyl alcohol to another single drug sharply increased the percentage of fatalities in the secobarbital, phenobarbital, and methaqualone groups. Comparisons between other types and combinations of drugs (where numbers of subjects permitted) revealed no statistically significant differences.

Quantitative blood levels were reported in most cases. Those in which numbers were statistically substantial and in which the drugs were found singly are listed in Table 9. Ideally, analysis centered on attempting to detect if any given discrete variable was associated with increasing levels of a specific drug. Such an analysis was performed for the drug secobarbital where the number of subjects (85) was sufficiently large. The subjects were divided into three groups based on the quantitative level of the drug: Group 1 contained 14 subjects with blood levels less than 2.99 μg/ml; Group 2 had 41 subjects with levels ranging from 3.0 to 5.99 μg/ml; and Group 3 contained 30 subjects with levels greater than 6.0 μg/ml. These three groups were compared in respect to all the identification variables such as age and sex, the state of subject and driving problem variables, frequency of accidents,

TABLE 8—*Percentage of fatalities for selected drug versus drug plus alcohol groups.*

	Fatalities Drug Alone		Fatalities Drug Plus Alcohol	
Drug	*n*	%	*n*	%
Secobarbital	85	4.7	67	16.4
Phenobarbital	29	10.3	42	16.7
Diazepam	48	0.0	40	2.1
Methaqualone	35	0.0	14	7.1
Secobarbital/amobarbital	30	0.0	17	7.7

TABLE 9—*Blood concentration (μg/ml) of selected drugs.*

Drug	*n*	Mean	SD	Minimum	Maximum
Secobarbital	85	4.89	2.28	trace	10.0
Diazepam	48	1.93	2.68	trace	17.0
Methaqualone	34	4.77	3.25	trace	14.0
Secobarbital/amobarbital	30	9.12	4.74	trace	20.0
Phenobarbital[a]	28	21.00	21.11	2.0	68.0

[a] Figures exclude one case reporting a concentration of 110 μg/ml.

fatalities, and field sobriety test results. None of these variables showed a significant association with the amount of secobarbital found in the blood. In fact, several reversals (albeit not significant) in the expected trend were found.

Discussions and Conclusions

1. The presence of psychoactive drugs other than, or in addition to, ethyl alcohol in persons with driving behavior problems was found to be common in California and Nevada.
2. Major objective alterations in sensory-motor capabilities headed by impaired balance and coordination, slurred speech, and staggering were common in drivers in whose blood psychoactive drugs were found.
3. Serious observed driving behavior problems headed by weaving, driving without due care, and accidents were common in such groups.
4. The typical person in this study who was driving with a psychoactive drug present in the blood or urine and who experienced a driving problem was a white male under the age of 30.
5. The correlation between a reported ethyl alcohol odor and a positive blood ethyl alcohol in regard to sensitivity and specificity was poor, with nearly 50% false positives and 50% false negatives.
6. Those psychoactive drugs other than ethyl alcohol that were most likely to be identified in a person with a driving behavior problem as shown in this study were a variety of barbiturates, diazepam, methaqualone, chlordiazepoxide, meprobamate, and ethchlorvynol.
7. More than one half of the time when one drug was found at least one other drug (including ethyl alcohol) was also present.
8. The arresting officer's ability correctly to predict which drug the suspect had in his body was approximately 50%, based on his own suspicion or on the finding of a drug in the subject's possession.
9. The presence of a detectable psychoactive drug was statistically associated with accident at a highly significant range in comparison with a control group.
10. Females driving with a detectable psychoactive drug in their blood were statistically more likely to have an accident than were males at a significant level and were statistically more likely than males to have a fatal accident at a highly significant level.
11. The addition of ethyl alcohol to another psychoactive drug appears significantly to increase the likelihood of a fatal accident.
12. In general, the correlation of blood levels of the various drugs and driving behavior problems, including accident and fatality, although interesting and much sought after, is not yet possible. Many additional numbers are necessary.

Critique

This study consists of a compilation of pooled data from many laboratories and many observers and scientists. The data are important, interesting, and useful and document the presence of a gigantic problem with innumerable ramifications. The test group which is reported is a large and significant one representing a major data base. The control group was small but consisted of subjects with comparable problems without identified drugs. Obviously, as presented, not all potentially active drugs were tested for in blood and urine in a manner likely to be positive. This applies especially to *Cannabis*. The study was conceived and carried out as a practical sampling of the driving populace as well as the state of the art of real-life applied drug detection in a toxicologically advanced area of a developed country.

It was not performed in a research setting but rather in a daily work mode with timely representative applicability.[5]

Ideally, one would like to investigate the relationship between the amount of a drug found and the degree of deterioration of driving behavior noted in the subject. Such an investigation would require an agreed-upon measure of behavioral and driving problems. Although no such continuous scale was employed in the present study, the results from comparison of discrete variables serve as a warning as to the difficulty of establishing a continuous, subjective scale of behavioral problems. The data suggest that the scale of behavioral problems would perhaps best be constituted from designated physical tasks performed under standardized conditions. Obviously, different observers, fatalities, and other uncontrolled variables limit the accuracy of such data in the field situation.

Data from an additional control group would also be desirable. This control group would consist of persons driving in real-life situations with the presence of comparable detectable psychoactive drugs in their blood or urine who are not exhibiting a driving behavior problem. It is hoped that we or others will now select situations for clear statistical comparison between the two types of control groups (no drug, but driving behavior problem, versus drug, and no driving behavior problem) and a study group in regard to each drug available to the populace that may influence driving behavior. Such studies should include any and all potential combinations that occur in driving situations as well as accurate blood levels of the correct substance(s) or metabolites.

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[5] For example, the finding of phenobarbital and chlordiazepoxide together in several instances is believed to be dependent upon the presence of a street drug with these drugs in combination during the fall and winter of 1973.