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The Role of Alcohol, Marijuana, and Other Drugs in the Accidents of Injured Drivers

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16. Abstract

A study was conducted of 497 drivers injured in a motor vehicle accident and treated at a hospital. The objectives were to determine the incidence of alcohol and other drugs in their blood systems at the time of the crash and the role these drugs may have played in the accident. The sample was considered conservative with respect to alcohol/drug incidence since only drivers who consented to a blood sample analysis were included.

The results showed that fully 38 percent of the drivers had alcohol or some other drug in their systems; alcohol was found in 25 percent, tetrahydrocannabinol in 9.5 percent and tranquilizers in 7.5 percent. Ten percent of the drivers had ingested two or more drugs. It was found that legally intoxicated drivers (BAC $\geq$.10 percent) had the highest culpability rate (74 percent) followed by drivers with lower alcohol levels (54 percent) and with THC (53 percent). The drug-free drivers in contrast had a culpability rate of 34 percent while the drivers with tranquilizers were judged culpable in 22 percent of their accidents.

Compared with the drug-free drivers, the alcohol-involved drivers were overrepresented in single-vehicle accidents and in the striking vehicles of rearend and head-on crashes. The "alcohol accident type" with the highest incidence (95 percent) of alcohol involvement was a single-vehicle crash between midnight and 6 AM on a curve.

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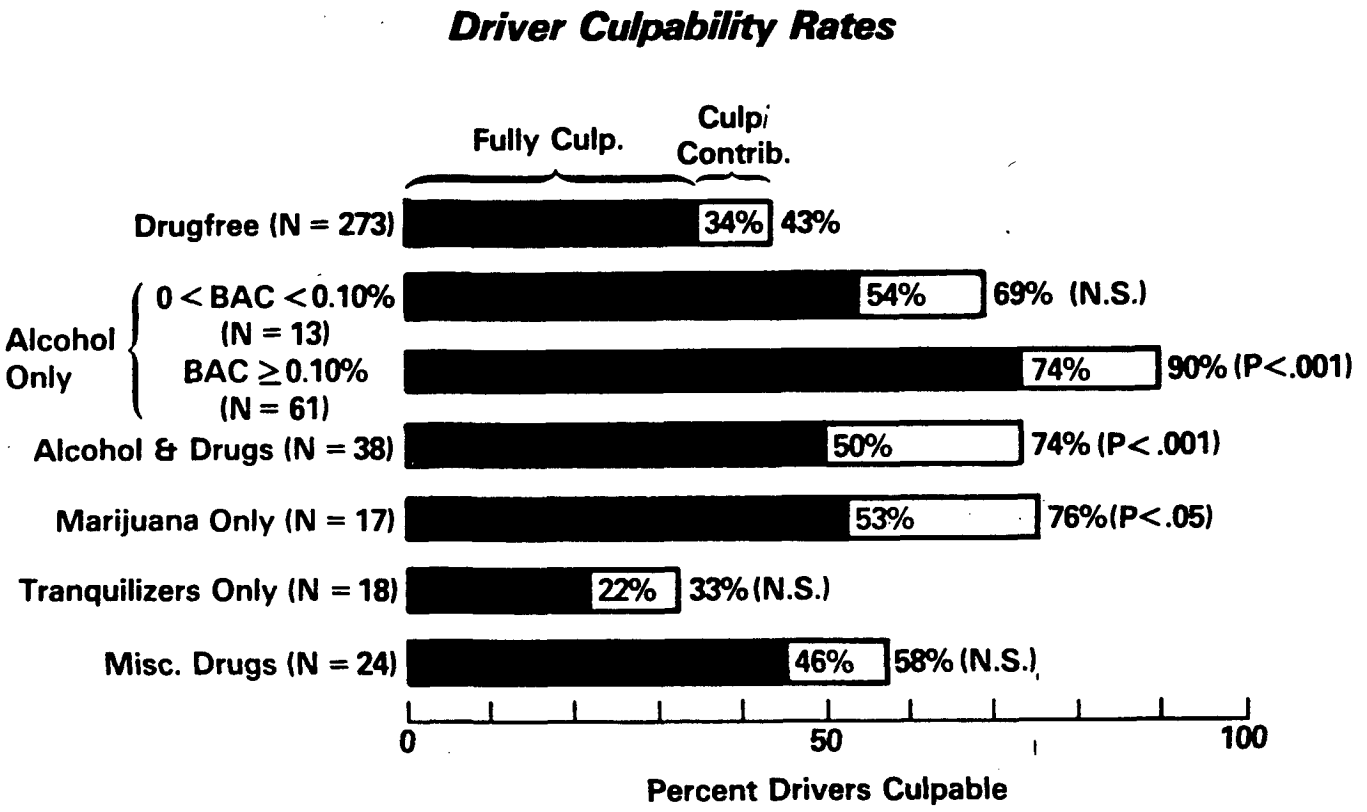

THE ROLE OF ALCOHOL, MARIJUANA AND OTHER DRUGS IN THE ACCIDENTS OF INJURED DRIVERS*

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The results showed that fully 38% of the drivers had alcohol or some other drug in their systems; alcohol was found in 25%, tetrahydrocannabinol in 9.5% and tranquilizers in 7.5%. Ten per cent of the drivers had ingested two or more drugs. It was found that legally intoxicated drivers (BAC $\geq$ .10%) had the highest culpability rate (74%) followed by drivers with lower alcohol levels (54%) and with THC (53%). The drugfree drivers in contrast had a culpability rate of 34% while the drivers with tranquilizers were judged culpable in 22% of their accidents.

Compared with the drugfree drivers, the alcohol-involved drivers were overrepresented in single-vehicle accidents and in the striking vehicles of rearend and head-on crashes. The "alcohol accident type" with the highest incidence (95%) of alcohol involvement was a single-vehicle crash between midnight and 6 AM on a curve.

The study confirms that alcohol continues to be a major highway safety problem, and it appears that marijuana may also be a problem. Among the recommendations are that "alcohol accident types" be developed for drunk driver detection and other uses, that driver-alerting countermeasures be developed, and that crash risks associated with prominent drugs be determined.

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QUESTIONS CONCERNING the role of alcohol and other drugs in motor vehicle accidents have been continually asked since the beginning of highway safety research. Many questions have been answered or at least adequate information has been provided to address them. But important questions still remain unanswered and large gaps in our knowledge still exist.

Throughout the years there have been numerous studies on the incidence of alcohol involvement in accidents. A recent state-of-the-art report on alcohol and highway safety [1]* discusses a number of studies which indicate that alcohol is involved in as much as 55-65 per cent of driver fatalities. The report concludes that nearly half of fatally injured drivers in the United States were legally intoxicated. Several individual studies conducted over the years appear to confirm this conclusion.

There is much less information on the other segments of the accident picture--injury and property damage accidents. The two most often cited studies concerning alcohol incidence in injury accidents are Borkenstein, et al., in 1964 [2] and Farris, Malone, and Lilliefors, 1976 [3]. These studies indicate that alcohol is involved in approximately 20 to 30 per cent of accidents resulting in an injury. The Borkenstein study also indicated that alcohol was involved in about 16 per cent of property damage only (no injury) accidents. These incidence rates in non-fatal crashes have not, however, been replicated to nearly the extent of the fatal-crash alcohol rates. Non-fatal accidents are an important segment of the societal loss in accidents due to alcohol and certainly more information is needed and more attention should be given them.

More recently there has been an intense interest on the part of the U.S. Congress, and highway safety officials in general, concerning the role of other drugs in highway crashes--especially marijuana. A recent report by the U.S. Department of Transportation to Congress [4] attempts to shed some light on the incidence of drugs other than alcohol in crashes. But there is not much information available. Because of numerous methodological problems, the literature is sparce on the incidence of commonly used drugs in accidents. Given these problems, the Report to Congress states there is no evidence to date that drugs other than alcohol are a significant highway safety problem. It goes on to state that much more research has to be conducted on the subject because of the relative scarcity of data when compared to alcohol. What research has been conducted has been mainly on fatally injured drivers. For example, Teale, et al. [5] found traces of tetrahydrocannibinol (THC), the psychoactive drug in marijuana and hashish, in six of 66 fatally injured car and motorcycle drivers in a study conducted in 1977. Last year, Warren, et al., [6] reported at the American Association for Automotive Medicine Conference that THC was found in 12 per cent of the fatally injured drivers and 13 per cent of the fatally injured pedestrians in crashes in the Province of Ontario, Canada in 1979-80.

*Numbers in brackets [] indicated references listed at the end of the paper.

There is, however, virtually no information on the incidence of drugs other than alcohol in non-fatal crashes.

Given the information we have on the role of alcohol and drugs in crashes, most of it is related to the presence of the substance. To what extent alcohol or other drugs are contributory or causal in these crashes is an important question. The measurement of relative risk tells us what the increased probability of a crash is, given that a driver is under the influence of alcohol or drugs. It is extremely important for indicating a causal relationship between a substance and crash involvement. But relative risk measures are difficult to obtain, and in their absence, other information is needed regarding causation.

For example, we know the relative risk of being involved in a fatal accident increases significantly as the blood alcohol concentration (BAC) levels of drivers increase over .10 per cent w/v. But why does the risk increase? What situations are drivers getting into that increases that accident involvement risk? Much laboratory research has been conducted on the effects of alcohol and some other drugs on simulated driving tasks. Moskowitz, et al., 1976 [7] found that visual search behavior was affected decrementally as subject BAC increased, but they did not find any effect with subjects who had smoked marijuana. What does this mean in the accident picture? Perchonok in 1978 [8] studied the accidents of drivers who were indicated on the police report to be alcohol involved and compared them to accidents of apparently-sober drivers. He found that the drinking driver accidents tended to occur under low traffic conflict situations (single vehicle, at night, two lane roads, on curves, etc.) and indicated that alcohol may have an effect on attention and tracking under these conditions. BAC data, however, were not generally available in his study.

To summarize, there is a real and urgent need to fill research gaps on the subject of the role of alcohol and other drugs in accidents. Surprisingly, very little research has been done on their role in non-fatal accidents. What research has been done has been mainly on the incidence of alcohol and drugs in fatal accidents. More data are needed on the incidence of drugs other than alcohol in accidents. In addition, in-depth information on the accident generation process is needed to learn more about the problems drivers apparently have while under the influence of alcohol and/or drugs.

OBJECTIVES

This study was originally designed to address several questions concerning the role of alcohol and other drugs in accidents. The more important questions that follow will be discussed in this paper:

(1) What are the incidence rates of alcohol, marijuana and other drugs in the blood systems of drivers injured in a motor vehicle crash?

This became literally the number one question in the study due to increased Congressional and public interest in the subject and the availability of acceptable toxicological

procedures to detect a wide variety of drugs of interest. Past research indicated that the alcohol incidence would be high, but very little was known concerning other drugs. Recent advances in measurement had been made [14] and this study provided an excellent opportunity to gather valid, reliable data on marijuana. Also, the widespread use of tranquilizers was causing some concerns, especially their use in combination with alcohol.

(2) What are the accident culpability rates associated with the more important drugs?

The goal here was to obtain indications of whether the various substances played a causal role in the accidents. Driver culpability rates within various driver-drug groups served that purpose.* Questions of interest were: What per cent of drivers who had positive BAC's were actually responsible for their accidents. What per cent were culpable who had BAC's $\geq$ .10%? What was the culpability rate for drivers who had THC in their blood systems? What about drivers who had used tranquilizers, or who had used alcohol and some other drug?

(3) What are the various collision types associated with the more prominent drugs, and what do they suggest about driver impairment?

In other words, are alcohol or drug related accidents mainly single-vehicle run-off-the-road types? Or do they involve traffic conflicts such as at intersections? Do they involve turning or lane changing? Are rear-end accidents overrepresented in any of the drug groups?

If we can answer these questions, we can provide important information toward understanding the implications of alcohol/drug impairment in real world driving. By comparing the collision configurations of the drug groups with the sober driver group, we may see some significant differences that suggest the form of impairment.

(4) What are the major "alcohol accident types" defined as collision type, driver variables, and accident circumstance combinations that have the highest proportion of drinking drivers?

This is different from question #3 in that we are concentrating on alcohol involved accidents and we are interested in various combinations of characteristics that are associated with an accident being alcohol-involved. For example, from past research we would suspect that single vehicle, run-off-the-road on-a-curve accidents, that occur late night or early morning on the week-ends, involving a male driver between 25 and 50 would have an extremely high probability of involving a drinking driver. Past research, however, has been sketchy on this subject and even though our sample size is not very large, we can provide some data on this question. This area of research (classifying "types" of accidents in behavioral terms) has been shown to have potential for countermeasures development in the study of pedestrian accidents [9].

*Culpability rates were used in lieu of calculating the relative risk associated with the use of alcohol and various drugs. In order to calculate relative risk measures, the incidence of alcohol and drugs in the blood systems of non-accident drivers on the road would be needed. This was beyond the scope of the study.

METHOD

To address the basic questions of this study, the overall strategy was: (1) to collect and analyze blood samples from injured drivers; (2) to determine the incidence rates of alcohol and other drugs in those samples; and (3) to examine relationships between the blood contents and variables describing the drivers' accidents. Injured drivers were studied because of the seriousness of their crashes and because living drivers can be questioned for details about the circumstances and causes of their accidents.

The sample size chosen was 500 injured drivers. While a larger sample was originally desired for performing the data analyses, this number was selected on the basis of costs and to provide reasonably reliable incidence rates for the alcohol and other substances.

The sampling plan was to identify all injured drivers as they came to the emergency department of a hospital, then request and obtain blood samples from all who were eligible to participate. This procedure would be followed until the desired sample size was achieved. Finding a hospital willing to cooperate in the study proved more difficult than expected, but eventually, after contacting several hospitals in different cities, the participation of Rochester General Hospital (Rochester, N.Y.) was obtained through the assistance of Dr. John D. States.

The Emergency Department staff, including secretaries, nurses, and physicians, were briefed on the study and their cooperation solicited. They were trained on the procedures involved, including the requesting and obtaining of written consent for a special blood sample. To be eligible for the study, an injured driver need have had a motor vehicle accident in Monroe County, N.Y. (the major area served by the hospital) within four hours of his appearance at the hospital. In the case of unconscious or incoherent drivers, blood was drawn if a relative provided written consent. The blood was analyzed only if the driver later gave written approval. In the case of minors, the written consent of both patient and a parent were required for the blood to be drawn and analyzed. All drivers were assured that their identities would be protected and that the data would be used only for research.*

These procedures were begun in May, 1979 and continued through September 1980, when the last driver was sampled.

"IN" DRIVERS VS. "OUT" DRIVERS - To enter the study, an injured driver needed (1) to be detected as eligible by someone on the Emergency Department staff, (2) to be asked to participate by a nurse or physician, (3) to consent to participate, and (4) to have a blood sample properly drawn and later analyzed. An eligible driver could be lost to the study through failure at any of these stages. An eligible driver from whom a useable blood sample was obtained is designated an "in" driver, while an eligible driver lost to the study is an "out" driver.

*New York State Law (Ch. 742, 1972) protects the confidentiality of data collected by its "approved accident investigation units," which include Calspan and the University of Rochester units.

To assess the success of these efforts, all police records in Monroe County were searched to identify drivers reported as taken to Rochester General Hospital. The hospital records were also examined to confirm that each driver had actually appeared there. In that way, drivers not detected as eligible by the Emergency Department were identified. Other special records were kept to reveal drivers not asked for blood, who refused a sample, or from whom a useable blood sample was not obtained. Attrition of the sample accruing from these various sources is shown in Figure 1.

It is necessary to ask just how different the "in" drivers were from the "out" drivers to see whether the "in" sample is biased or in some ways atypical. The two groups were compared on age, sex, vehicle type, time of accident, accident location, road type, collision type, driver culpability, and police indication of alcohol involvement. Differences between the groups were small on these dimensions, the main differences being the following:

(a) 24% of the "out" driver accidents occurred in the midnight-6AM period, compared with 17% of the "in" accidents; and (b) 17% of the "out" drivers were reported as alcohol-involved by the police, compared with 10% of the "in" drivers.

These data suggest that the sample lost a disproportionate number of drinking drivers, contrary to what is desired. Special analyses revealed that these losses were due mainly to the more severely injured drivers, many of whom were undetected as eligible or who could not be asked for a blood sample. Unavailability of a relative to provide consent accounted for some of the losses. Despite these problems, the "in" sample did contain a substantial portion of drinking drivers, as will be seen shortly.

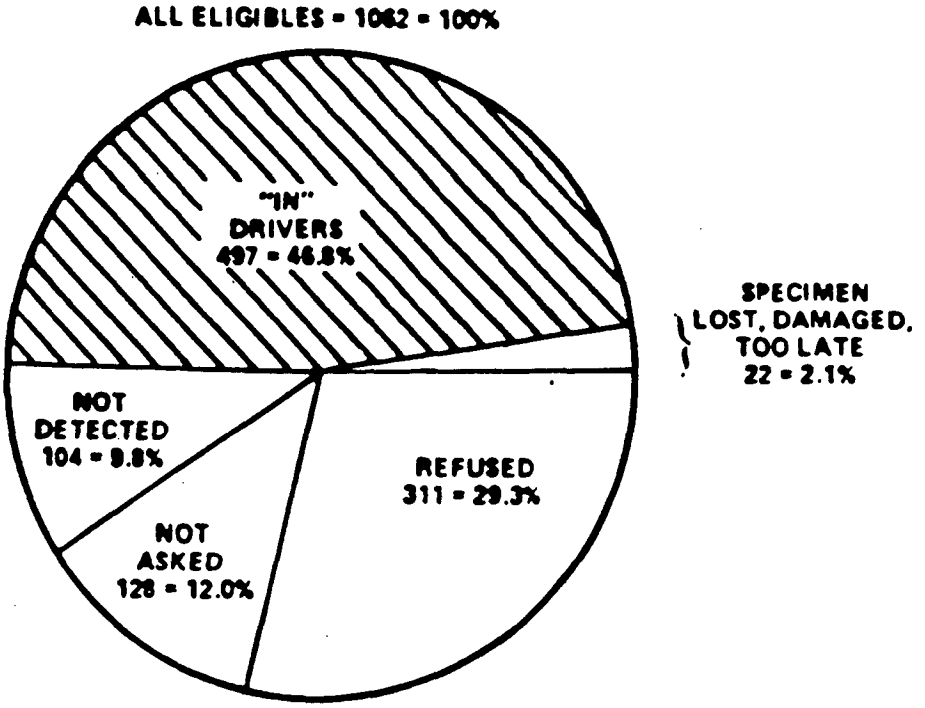
ACCIDENT DATA - In addition to the analyses of the blood samples, other data basic to the study consisted of the police accident reports and driver interviews. Earlier in the study, accident scene investigations and vehicle examinations also provided details of the accidents; collection of these data was terminated because of time and cost constraints.

It should be stressed that because the sample is limited to some of the injured drivers taken to one hospital, it must be considered exploratory. The value of the study is in its comprehensive assessment of a large number of possibly impairing substances, and in exploring the role of those substances in the crashes of injured but surviving drivers. An especially valuable feature of the study is that it permits comparisons between drivers known to be drug-free and those known to have ingested specific substances.

RESULTS

ALCOHOL/DRUG INCIDENCE RATES - At the University of Utah Center for Human Toxicology, the blood samples were analyzed for a large number of substances thought capable of impairing driver performance. The list of test substances was the product of workshops conducted by the National Highway Traffic Safety Administration and the National Institute on Drug Abuse [10].

FIGURE 1



Proportion of Drivers in Final Sample

Terhune/Fell

The analyses (Table 1) found that 38 per cent of the blood samples contained one or more of the test substances. Leading the list was ethanol, found in a quarter of the blood samples. This figure is remarkably close to the average result across two different studies with injured drivers, in Grand Rapids, Michigan [2] and the other in Huntsville, Alabama and San Diego [3]. As noted earlier, however, the drivers excluded from the study are likely to include a higher proportion of drinking drivers, so 25 per cent is probably a conservative estimate. Among the 25 per cent, a third involved alcohol combined with another drug.

Table 1 - Substance Incidence Rates

	N	%
Total samples analyzed	497	100.0
Samples with substances detected	188	38.1
Samples with 2+ substances	52	10.5
Substances Detected		
Ethanol: 0 < BAC < .10% w/v - 28 BAC ≥ .10% w/v - 97	125	25.3
THC (marijuana, hashish)	47	9.5
Tranquilizer (e.g. diazepam)	37	7.5
Sedative - hypnotic	14	2.8
Cocaine	10	2.0
Anticonvulsant	10	2.0
Analgesic	2	0.4

The second most common substance was the marijuana ingredient, THC (tetrahydrocannabinol) which was found in nearly a tenth of the drivers. Tranquilizers, comprising mostly diazepam, were the third most frequent substance group. Various other prescription drugs were found in small amounts, as was cocaine. It is worth noting that the prevalence of alcohol, marijuana, and tranquilizers accords with findings in the Ontario study of fatally injured drivers [11].

About a quarter of the samples that had one detected substance also had a second. Table 2 shows some of the main combinations. The most common mixture was alcohol and something else. When THC or cocaine were found, they were frequently in combination with alcohol.

Table 2 - Substance Combinations Found

Substance	N Drivers	By itself	Combined with Ethanol	Combined with other	Total
Ethanol	125	64.0%	---	36.0%	100.0%
THC	47	42.6	51.0	6.4	100.0%
Tranquilizer	37	54.1	32.4	13.5	100.0%
Cocaine	10	10.0	80.0	10.0	100.0%

While the drug analyses specified quantities of the various substances, it is often difficult to interpret the significance of those quantities. This is particularly true regarding THC, about which little quantitative information is available. With regard to the tranquilizers, however, the levels found indicated modest therapeutic dosages.

Age and sex breakdowns revealed distinctive patterns associated with the main substances (Table 3). Compared with the drugfree group, the tranquilizer group of drivers was mostly over age 30. In contrast, the alcohol, THC, and cocaine drivers were generally much younger. These drivers also included proportionately more male drivers than in the drugfree group.

Table 3 - Age and Sex Within the Substance Groups

	Driver Age		Driver Sex	
Substance*	Under 31	31+	Male	Female
Drugfree	55.6%	44.4%	58.2%	41.8%
Tranquilizer	32.4	67.6	54.1	45.9
Ethanol	69.1	30.9	76.0	24.0
THC	84.8	15.2	80.9	19.1
Cocaine	90.0	10.0	70.0	30.0

*Some drivers were in more than 1 substance group.

In summary, the predominant drug groups in the driver sample were alcohol, marijuana/hashish, and tranquilizers. Drivers with alcohol and/or THC in their blood were mostly males and younger people. Most of those who had ingested tranquilizers, in contrast, were over 30.

ACCIDENT CULPABILITY RATES - In the absence of exposure data, driver culpability rates may be used to indicate the relative crash risk associated with a drug. Two coders were trained to make culpability judgments, using a rating scale which ranged from "fully culpable" to "not culpable." For a driver to be judged "fully culpable" in a multiple-vehicle crash, his vehicle was required to be the first one to create the abnormal or dangerous situation precipitating the accident; only one driver per accident could be judged fully culpable.

To determine the reliability of coding, the two coders independently judged culpability for a common set of crashes. They agreed exactly in their judgments on 76 per cent of these cases. Their ratings also correlated 0.92 (Pearson), indicating a high degree of agreement. To avoid bias, all coding was done without the coders' knowledge of the driver's drug involvement.

To assess whether a drug or drug combination impairs drivers in the sense of raising crash risks, the fully culpable proportion of drivers with the drug (or combination) in their blood were compared with the comparable proportion of drivers

who were completely drug free. Table 4 presents data for the main substance groups.

Table 4. - Driver Culpability Rates

Substance Group		N (drivers)	% Culpable	Signif.*
Drugfree		273	34.4%	--
Ethanol - only	$0 < BAC < .10\%$	13	53.9%	N.S.
	$BAC \geq .10\%$	61	73.8%	$P < .001$
THC - only		17	52.9%	N.S.
Tranquilizer - only		18	22.2%	N.S.

*Chi-square tests compared substance group with drugfree group.

The results in Table 4 show that alcohol-involved drivers at high blood alcohol concentrations (BAC) were much more frequently culpable than the drugfree groups. This is completely consistent with the assessments of crash risk based on exposure data, as in the Grand Rapids and Huntsville-San Diego studies [2, 3]. Drivers with lower positive BAC's were more frequently culpable than the drugfree, but the sample was too small to reach statistical significance. Similarly, the marijuana-hashish group had a higher culpability rate than the drugfree, although the results did not reach statistical significance. The tranquilizer culpability rate was actually lower than the drugfree rate, but the lack of statistical significance suggests the difference was probably due to chance.

Not shown in Table 4 are the culpability rates for ethanol in combination with THC or tranquilizers. These groups differed little from the ethanol-only group in their culpability rates. Since the subsample sizes were so small, however, the study is inconclusive as to whether alcohol-drug combinations significantly affect driver impairment differently than the drugs do independently.

Because there were fairly distinctive age and sex patterns associated with the different substance groups, the results in Table 4 could be confounded by those variables. Consequently, the drug vs. drugfree comparisons were tested statistically within age-sex groups, wherever the cell sizes were sufficient. The indications in Table 4 were upheld in these analyses. In fact, the results for marijuana reached normal significance levels when controlling for age and sex. (THC-only males of ages 21-30 had a culpability rate of 66.7%.)

Somewhat similar analyses were performed in the Ontario fatally-injured driver study cited earlier [11]. There also the alcohol and cannabis groups were found significantly more culpable than the drugfree group. Differing from our study, however, it was found that drivers with tranquilizers or anti-depressants had the highest culpability rate. These were fatally-injured drivers, however, and they may have ingested greater quantities of the drugs than the drivers in our study.

COLLISION TYPES - While the culpability rates help to indicate dangerous impairment effects of drugs, they do not by themselves suggest how those effects are manifested. Helpful toward that end is an examination of the collision types associated with each drug group. To do that, each driver's collision type was established by using Calspan's CALAX coding system, which not only distinguishes varieties of single-vehicle accidents, but also identifies the role of each vehicle in multivehicle accidents as well [15]. In checking coding reliability, it was found that the two coders on the project averaged 85% agreement in assigning collision types. Coding was done without the coders knowing the alcohol/drug status of the drivers.

Results, using a simplified version of the CALAX system, are shown in Table 5. For contrast, the alcohol-only and drugfree drivers are shown in the two columns at the left. Notice how different their collisions are. Alcohol accidents

Table 5 - Collision Types Within Drug Groups

Collision Type	Ethanol only	Drug free	THC only	Tran-quilizers only
Single Driver	66.2% >	16.7%	18.8%	10.5%
Rearend, striking vehicle	12.2 >	8.5	6.3	5.3
Head on, striking vehicle	4.1 >	1.8	0	0
Interacting paths (angle,turning,merging)	8.1	45.0	37.5	47.4
"Victim" vehicle, rearend/ head on	1.4	21.3	18.8	31.6
Miscellaneous	8.1	6.7	18.8	5.3
Total	100.0%	100.0%	100.0%	100.0%
n (drivers)	74	282	16	19

are dominated by single-driver crashes, which include striking a parked vehicle. The second, but far less prominent, alcohol type is the rear (striking) vehicle in a rear-end crash. The third, but even less frequent, alcohol type is the striking vehicle in a head-on (or sideswipe) crash. In all three of these, the proportions for alcohol involved drivers exceed those of drugfree drivers. The impairment suggested by all three is consistent with indications from other studies; intoxication seems to severely reduce alertness, attentiveness, and tracking abilities.

Drinking drivers tend to be on the road in the early morning hours when there are fewer other vehicles around, and that could contribute to their prevalence of single-driver accidents. But even among night accidents, it was found that single-driver crashes accounted for 70 per cent of the alcohol-involved, and 22 per cent of the drug-free. Therefore, the single-driver crash does seem attributable to impairment.

Note that with the drugfree, the preponderant collision type involves interacting paths, accidents which include angle, merging, and turning accidents. Would we say that reflects a form of "impairment" for the drugfree? A more reasonable explanation is that since the drugfree drivers are involved in fewer of the alcohol collision types, their crashes must include proportionately more of the interacting path type. Note also in Table 5 that the drugfree drivers were most often in the "victim" vehicle of rear-end and head-on crashes.

As to the collisions of the THC and tranquilizer groups, their most remarkable aspect is their similarity to the drug-free group. Since the THC-involved were proportionately more culpable than drugfree drivers, their crashes were expected to appear at least somewhat different from the drugfree. To see in what ways they were culpable, their crashes were reviewed case by case. Their problems were characterized mainly by their variety, with a possible preponderance of speed-distance misjudgments. This should not be considered a "finding" of this study, but as a hypothesis for examination in the follow-on study with a larger sample size. Such a study should especially examine the accidents of drivers with higher THC concentrations and ethanol-THC combinations. For now it appears that cannabis impairments may be more subtle than alcohol impairments.

ALCOHOL ACCIDENT TYPES - Because our sample included a substantial number of alcohol-involved drivers, it was possible to do a special analysis to determine the sets of circumstances in which drinking drivers were most prevalent. (Uses of the results will be stated later.) These sets of circumstances are labeled "alcohol accident types."

The procedure followed was as follows. First, several variables were examined one at a time to get a first indication of the circumstances in which alcohol-involved crashes were most dichotomized to best differentiate groups of high and low proportions of drinking drivers. The variables that did this best are shown in Table 6.

How to interpret Table 6 is explainable by example: Of all the drivers having an accident between midnight and 6 AM, 75.9% had alcohol in their blood. At all other times, only 15.7% had positive blood alcohol. (The presence of any other drug was disregarded, in order to maintain sufficient numbers for further breakdown.)

Table 6. - Input Variables for "Alcohol Accident Types"

	% with BAC> 0			% with BAC> 0
1. Midnite-6AM	75.9%	vs.	All other times	15.7%
2. Single-driver accident	56.0%	vs.	Multi-driver accident	13.1%
3. Accident on curve	46.0%	vs.	Accident not on curve	22.4%
4. Fri.-Sat.-Sun.	34.0%	vs.	Other days	17.0%
5. Male driver	30.7%	vs.	Female driver	16.2%
6. Driver age < 50	29.3%	vs.	Driver age 50+	4.9%

The next step was to find the combinations of variables which yielded the highest proportions of alcohol-involved drivers. Results of this analysis were complex, so below (Table 7) are presented only the more simple and clearest findings. Identified were three circumstances which had fairly high proportions of drinking drivers, while also accounting for nearly half of all alcohol-involved drivers. The most outstanding "alcohol accident type" is that of a single-driver crash occurring between midnight and 6 AM on a curve; 95% of these involved a drinking driver.

Table 7. - Major "Alcohol Accicent Types"

Crash Circumstances	(1) All drivers	(2) Ethanol involved	(2)÷(1) % Ethanol involved
Single-driver; midnite-6 AM; curve	21	20	95.2%
Single-driver; midnite-6 AM; straight section	29	24	82.8%
Multiple drivers; midnite-6AM	27	14	51.9%
All others	400	60	15.0%
Unknown circumstances	17	7	-
Totals	494	125	

The circumstance variables not included in Table 7 should not be considered irrelevant to identifying "alcohol accident types." Rather, adding them in produces combinations that account for only tiny proportions of all alcohol-involved accidents. Of interest is the fact that driver age

and sex were not crucial to the alcohol accident types; they were overwhelmed by the other variables.

The alcohol accident types in Table 7 should not be regarded as universal. Their composition may be due in part to the urban nature of our sample, and they may even be peculiar to Rochester, New York. (There were eight rural accidents in the sample, but only one included an alcohol-involved driver.) This finding surely deserves reexamination in other cities, but it does suggest the crash circumstances of greatest alcohol-involvement.

The marijuana sample was too small to analyze for a "marijuana accident type," but it seems likely that the circumstances would be defined in terms of the times and places where people under 30 congregate and use cannabis.

Finally, it should be noted that "alcohol accident types" will reflect both circumstances in which drinking drivers are on the road, and the kinds of accidents the impaired driver is vulnerable to in those circumstances.

CONCLUSIONS

(1) The thirty-eight per cent incidence rate for drugs in injured-driver accidents is substantial, considering that this is probably a conservative estimate. However, exposure data are needed to determine overrepresentations of the various drugs in comparison with their incidences within drivers on the road.

(2) The twenty-five per cent incidence of alcohol among injured drivers accords with results in other studies. Clearly, alcohol continues to be a major problem in highway safety.

(3) The high culpabilities associated with alcohol and THC (marijuana/hashish) support findings from other studies. With THC, however, there is need for a larger study to establish (a) whether it indeed raises crash risks, and (b) the risks associated with specific concentrations.

(4) In contrast with findings elsewhere, tranquilizers were not found to be a highway safety problem in this study.

(5) Alcohol-involved drivers have especial difficulty in single-driver, head-on, and overtaking accidents, suggesting the need for countermeasures to overcome reduced alertness and inattention. The collision types of marijuana-involved drivers are less clear and in need of further study.

(6) "Alcohol accident types," defined in categories such as early morning, single-driver and curve, hold promise as proxy indicators of alcohol involvement. These may be useful in analyzing mass data files such as NASS and FARS where complete BAC data on drivers are not always available. They may also help in police detection of drinking drivers.

RECOMMENDATIONS

(1) Given the incidence of alcohol and drugs in this injured-driver study, it is recommended that the incidence of alcohol and drugs in fatal accidents be studied, at least for driver fatalities. A good mechanism would be to use the sites of the National Accident Sampling System (NASS) to obtain a nationally representative sample of driver fatalities. While it is recognized that collecting blood samples from drivers on the road may present serious problems, the feasibility of collecting such exposure data for drug crash-risk analyses should be determined.

(2) Should the collection of exposure data prove infeasible, it is recommended that the culpability analysis used in this study be used in subsequent studies, expecially the previously recommended fatal accident study. This will allow for comparisons with this study and some basis for drug association with accident causation.

(3) Although in this small study tranquilizers were not found to be a safety problem, in a larger study attention should be given to higher concentrations of tranquilizers and to alcohol-tranquilizer combinations. Laboratory evidence points to synergistic impairment with these two drugs, and tranquilizers may yet emerge as a highway safety problem.

(4) With reported indications that driver alertness and attention are impaired by alcohol, the recommendation by Moskowitz [7] to design the highway system for impaired drivers merits serious consideration. It should be determined whether increases in visual cues (e.g., larger, more prominant warning signs and lane and edge markings) or auditory cues (e.g., rumble strips on shoulder on curves) would keep some of these impaired drivers more alert and aware of the path of their vehicle.

(5) Further development of "alcohol accident types" is recommended as a guide for police detection of alcohol-impaired drivers in accidents. This would complement the Harris [12] system of clues for increasing the apprehension of drunk drivers. As Ross [13] noted in his worldwide study, increasing the perceived chances of being caught is a vital factor in the deterrence of drunk driving.

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