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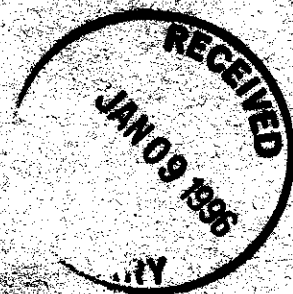
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Drugs and Alcohol Found in Fatal Civil Aviation Accidents Between 1989 and 1993

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16. Abstract <p>The FAA Office of Aviation Medicine's Civil Aeromedical Institute (CAMI) is tasked under public law 100-591[H.R. 4686]; November 3, 1988, AVIATION SAFETY RESEARCH ACT OF 1988 to conduct toxicology tests on aviation accidents and determine the effects of drugs on human performance. It is important for the FAA to identify the extent to which drugs and alcohol are being used by pilots involved in aviation accidents so that the FAA can take steps to prevent pilots from using drugs or alcohol, which could impair their ability to fly an aircraft. The toxicology reports prepared by the CAMI Forensic Toxicology Research Section are used by the FAA and the National Transportation Safety Board to determine the cause of aviation accidents and evaluate present FAA regulations.</p> <p>METHODS: Specimens (blood, urine, liver, kidney, vitreous, and other bodily specimens) were collected by pathologists near the accident and placed in evidence containers provided by CAMI. These samples were refrigerated and shipped by overnight air. Upon receipt, the specimens were inventoried and accessioned for the analysis of drugs, alcohol, carbon monoxide, and cyanide. All data collected by the laboratory were electronically entered into a computer for future analysis. The data base was searched using a program developed by the Forensic Toxicology Research Section. The data base was sorted based on the class of drug, controlled dangerous substance schedules I and II, controlled dangerous substance schedules III-V, prescription drugs, over-the-counter drugs, and alcohol.</p> <p>RESULTS: The Toxicology and Accident Research Laboratory received specimens from 1845 pilots for postmortem toxicology analysis between 1989 to 1993. Controlled dangerous substances, CDSs (schedules I and II), were found in 74 of the pilots analyzed. Controlled dangerous substances (schedules III - V) were found in 28 of the pilots tested. Prescription drugs were found in 110 of the pilots analyzed. Over-the-counter drugs were found in 207 of the pilots analyzed. Alcohol at or above the legal limit of 0.04% was found in 146 pilots analyzed. The reported number of positive drug cases has doubled over the past 5 years.</p> <p>CONCLUSIONS: Over-the-counter medications are the most frequently found drugs in fatal aviation accidents and many of these drugs, or the medical conditions for which they are being used, could impair a pilot's ability to safely fly an aircraft. The increased number of positive cases found in this research is most likely the result of improved methods of analysis, rather than an increase in the use of drugs. The low incidence of CDS III-V drugs found in fatal aviation accidents may be a result of the difficulty in finding and identifying the new benzodiazepines commonly prescribed in this class.</p>					
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DRUGS AND ALCOHOL FOUND IN FATAL CIVIL AVIATION ACCIDENTS BETWEEN 1989 AND 1993

INTRODUCTION

The Federal Aviation Administration (FAA) has the responsibility to ensure the safety of flight in general and commercial aviation. Part of this responsibility includes enforcement of alcohol and drug use regulations (14 CFR Part 91.17). The Civil Aeromedical Institute (CAMI) is responsible under the Department of Transportation (DOT) Order 8020.11A, Chap 4, Par 170, to "conduct toxicological analyses on specimens from, and special pathologic studies on, aircraft accident fatalities." In addition, DOT Order 1100.2C, Chap 53, Par 53-15 requires that CAMI "investigates selected general aviation and air carrier accidents and searches for biomedical and clinical causes of the accidents, including evidence of disease and chemical abuse." Post accident drug and alcohol testing after general aviation accidents provides information for monitoring compliance with these regulations. The investigation of fatal aviation accidents is the responsibility of the National Transportation Safety Board (NTSB) with the assistance of the FAA, as stated in the Independent Safety Board Act of 1974. This Act under Section 304 (b) Powers of the Board, subpart (5), authorizes the Board to obtain autopsies and seek other tests of persons who die as a result of aviation accidents. This authority is also stated in 49 CFR Part 831.10. The Act, Sec. 304(a)(1)(F) also states the Board shall provide for the participation by other agencies, in this case the Federal Aviation Administration. In fact, the Board may ask the Secretary of Transportation to conduct investigations of accidents. However, the Act requires that the Safety Board make the determination of cause or probable cause.

To fully carryout its aviation accident investigative responsibilities, the NTSB issued Safety Recommendation A-84-93 requesting the FAA to "establish at the Civil Aeromedical Institute the capability to perform state-of-the-art toxicological tests on the blood, urine, and tissue of pilots

involved in fatal accidents to determine the levels of both licit and illicit drugs at both therapeutic and abnormal levels." On December 1990, Recommendation A-83-93 was "Closed-Acceptable" after the Civil Aeromedical Institute laboratory was upgraded and fully staffed.

Under the cooperative efforts of the FAA and NTSB, specimens from the pilots who were fatally injured in aviation accidents were analyzed for drugs and alcohol, as part of the investigation into the cause of the accidents. Analysis for the presence of drugs in body fluids and tissues of pilots in these fatal accidents was used to assist in the determination of accident causation, and whether impairment from drug use and other medical conditions caused or contributed to the accident.

METHOD

Specimens (blood, urine, liver, kidney, vitreous, and other bodily specimens) were collected after the accidents and placed in evidence containers provided by CAMI. These samples were refrigerated and shipped by overnight air. Upon receipt, the specimens were inventoried and accessioned for the analysis of drugs, alcohol, carbon monoxide, and cyanide. Specimens were screened for drugs of abuse by immunoassay and any positives were confirmed by GC/MS. Specimens were screened for prescription and over-the-counter medications using a variety of analytical procedures including: immunoassay, HPLC, TLC, and GC/MS. Confirmation of positives in these classes was done by GC/MS or by a different analytical procedure than that used in the initial screening. The total number of drugs reported in this research does not include caffeine or nicotine. Alcohol is identified and quantitated in blood, vitreous fluid, and urine using head space gas chromatography. All positive alcohols at or above 20mg/dL are confirmed using fluorescence

polarization immunoassay (FPIA). Only cases with ethanol at or above 0.04% are reported in this study due to the FAA regulations forbidding the operation of an aircraft by a pilot with a blood ethanol reading at or above 0.04% (40mg/dL). All data collected by the laboratory are electronically entered into a computer for future analysis.

RESULTS

The Toxicology and Accident Research Laboratory received specimens from 1845 fatally injured pilots for postmortem toxicology analysis between 1989 to 1993 (Table 1.). During that time controlled dangerous substances (schedules I and II) were

found in 74 (4%) of the pilots analyzed. Controlled dangerous substances (schedules III - V) were found in 28 (2%) of the pilots tested. Prescription drugs were found in 110 (6%) of the pilots analyzed. Over-the-counter drugs were found in 207 (11%) of the pilots analyzed. Alcohol at or above the upper limit of 0.04% for pilots was found in 146 (8%) cases. The actual drugs identified in this study can be seen in Table 2. Some drugs, such as antihistamines, included in a given category may also be available in an another category. Multiple drug positives were found in several of the cases. It should be noted that drugs in table 2 are classified based on the pure drug, and that some of these drugs may be classified differently, depending on the formulation of the drug.

Table 1. Fatal Aviation Accidents with Drugs and Alcohol

Year	C1	C1%	C3	C3%	Rx	Rx%	OT	OT%	AI	AI%	Fatal
1989	8	2.3	7	2.0	7	2.0	24	6.9	28	8.0	349
1990	14	3.8	5	1.4	24	6.5	32	8.7	29	7.9	367
1991	22	5.7	3	0.8	24	6.2	42	10.8	30	7.7	389
1992	17	4.3	3	0.8	24	6.0	52	13.0	29	7.3	400
1993	13	3.8	10	2.9	31	9.1	57	16.8	30	8.8	340
Total	74	4.0	28	1.5	110	6.0	207	11.2	146	7.9	1845

C1 = Controlled Dangerous Substance Schedules I and II
Marihuana, Cocaine, etc.

C3 = Controlled Dangerous Substance Schedules III-V
Diazepam, Phentermine, etc.

Rx = Prescription Drugs
Amitriptyline, Imipramine, etc.

OT = Over-the Counter-Medications
Pseudoephedrine, Acetaminophen, etc.

AI = Alcohol levels equal to or greater than 0.04% (40.0mg/dL)
The values include in this tabulation incorporate cases in which the source of the alcohol is both known and unknown.

Fatal= Fatal pilots only

Table 2. All drugs identified between 1989 and 1993

Class	Drug	Cases	(%)
CI and CII	Marihuana	46	3
	Cocaine	15	1
	Codeine/Morphine	11	<1
	Amphetamine/Methamphetamine	6	<1
	PCP	0	0
	Barbiturates	18	1
	Synthetic Opiates	7	<1
	Methaqualone	1	<1
CIII - CV	Benzodiazepines	24	1
	Phentermine	2	<1
	Phendimetrazine	1	<1
Rx	Fluoxetine/Norfluoxetine	3	<1
	Imipramine/Desipramine	2	<1
	Amitriptyline/Nortriptyline	2	<1
	Sertraline	1	<1
	Maprotiline	1	<1
	Doxepine/Nordoxepin	1	<1
	Metoprolol	3	<1
	Atenolol	2	<1
	Propranolol	1	<1
	Acetylprocainamide/Procainamide	2	<1
	Quinidine	3	<1
	Verapamil/Norverapamil	5	<1
	Diltiazem	2	<1
	Triamterene	1	<1
	Cimetidine	2	<1
	Gemfibrozil	5	<1
	Phenytoin	6	<1
	Carbamazepine	3	<1
	Metoclopramide	2	<1
	Nizatidine	1	<1
	Diphenhydramine	32	2
	Promethazine	2	<1
	Brompheniramine	2	<1
	Cyclizine	2	<1
	Cyclobenzaprine	1	<1
	Naproxen	5	<1

Table 2. All drugs identified between 1989 and 1993 (Continued)

Class	Drug	Cases	(%)
Rx	Ibuprofen	3	<1
	Fenoprofen	1	<1
	Norpropoxyphene	1	<1
	Theophylline	1	<1
	Chloroquine	3	<1
	Lidocaine	31	2
	Thiopental	1	<1
	Ketamine	2	<1
	Aminophenazone	1	<1
	Griseofulvin	1	<1
	Orphenadrine	1	<1
OTC	Salicylates	96	5
	Acetaminophen	92	5
	Pseudoephedrine	47	3
	Phenylpropanolamine	26	1
	Chlorpheniramine	36	2
	Doxylamine	8	<1
	Dextromethorphan	3	<1
	Meclizine	1	<1
	Ephedrine	1	<1
	Dextrorphan	1	<1
	Guaiphenesin	1	<1
	Quinine	16	1

DISCUSSION AND CONCLUSION

Over-the-counter and prescription medications are the most frequently found drugs in fatal aviation accidents; many of these drugs, or the medical conditions for which they are being used, could impair a pilot's ability to fly an aircraft. Chlorpheniramine and diphenhydramine, two antihistamines found in 68 of the pilots analyzed, are sedative and may cause impairment of a pilot's ability to react to an emergency. Drugs used for cardiovascular, neurological, and psychiatric illness, where the drug and/or medical condition may cause incapacitation of the pilot, were found in 64 of the cases.

The low incidence of Controlled Dangerous Substances (CDS) III-V drugs found in fatal aviation accidents (Fig. 1) may be a result of the difficulty in finding and identifying the new benzodiazepines commonly prescribed in this class. New procedures, implemented in the latter half of 1993, resulted in a significant increase in the number of benzodiazepines found in 1993 (Fig. 1).

There appears to be a steady decrease in the percentage of positive schedules I and II drugs (Fig. 1). The procedures for schedules I and II drugs have not changed over the past 5 years, and the decrease

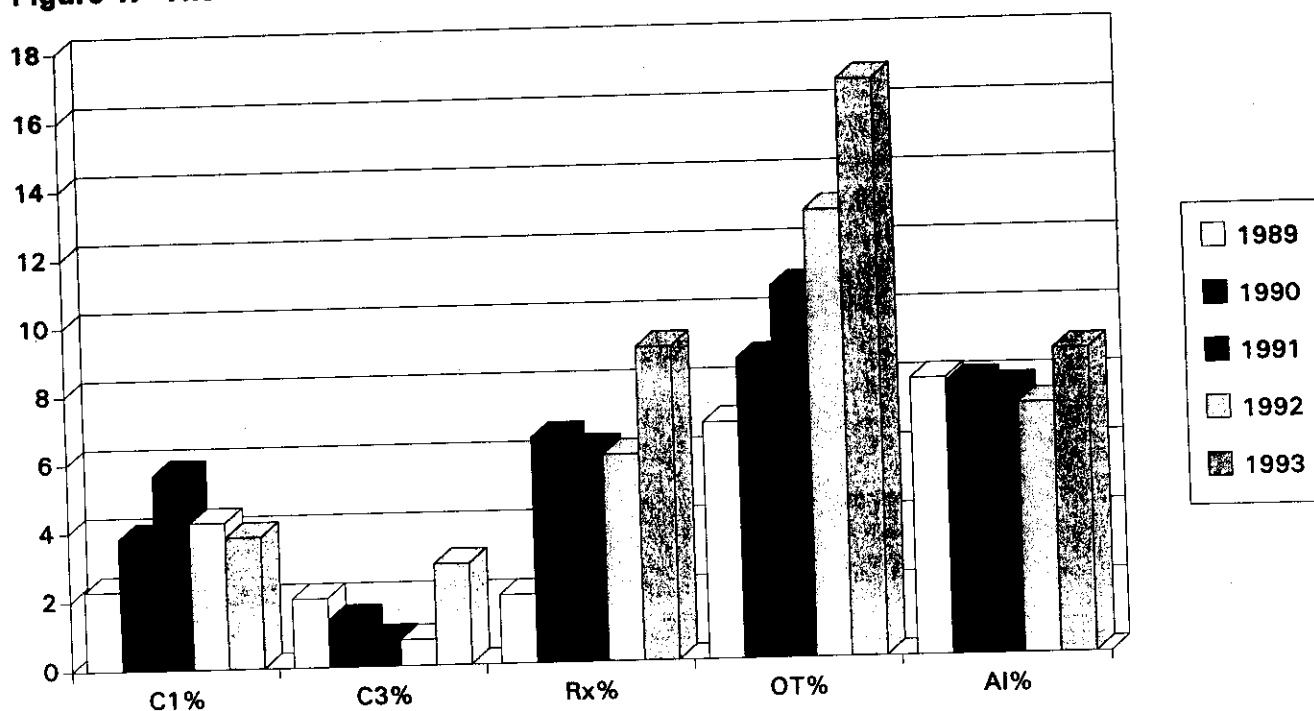
observed may be a real decrease in the number of pilots using controlled dangerous substances schedules I and II, and not an anomaly caused by changes in the method. The mean percentage of positive CDS I and II drugs is 4.0% over the past 5 years; the 1993 value of 3.8% is well within 1 standard deviation ($s = 1.2\%$), which suggests there is no significant change in the number of positive CDS I and II drugs.

The percentage of alcohol positives has remained relatively constant over the past 5 years. However, there is a 0.9% increase in the number of positive alcohol cases found in 1993, versus the mean percentage of alcohol cases of 7.9% found over the past 5 years with a standard deviation of 0.6%. Some of the alcohol cases reported in this study may be the result of postmortem alcohol production. The earlier research regarding postmortem alcohol (1) led to a change in the CAMI procedure used for the analysis of ethanol. Prior to 1993, blood was used in the initial screening for alcohol; whereas in 1993, only urine and/or vitreous fluid was submitted for the initial screening. If the initial screening of urine and/or vitreous was negative, the blood was not

tested and the case was reported as a negative for ethanol. In some cases, vitreous and urine were not available. In these cases, other factors were used to assist in determining the source of the ethanol. These other factors include a visual examination of the sample condition and the presence of other volatiles, such as higher alcohols and aldehydes, which might indicate putrefaction of the specimen. More of the cases reported in 1993 would be from the ingestion of ethanol, rather than from postmortem alcohol production because postmortem alcohol production is rare in urine and vitreous. Using urine and/or vitreous fluid routinely in the initial screen may reduce the number of positive alcohol cases reported in the future.

It would appear from the data in Table 1 that the number of pilots using drugs has increased over the past 5 years. However, new instruments and methods have made it possible to identify drugs that would not have been identified using the technology available in 1989, and this can explain the increase. All specimens are now being extracted using new methods that make it possible to recover a more diverse group of drugs. All specimens are now

Figure 1. The increased number of drugs found in pilots.



screened using a combination of HPLC, TLC, immunoassay, and Mass Spectroscopy, making it possible to identify more drugs at therapeutic and subtherapeutic levels. It is not clear from these data whether the increased number of positive drug cases (Fig. 1) found during this period is due to improved methods of analysis, or whether there is an actual increase in the use of drugs. Specifically, new more sensitive methods have been instituted for the analyses of OTC and Rx medications. These changes may explain the increased drug findings. Future measurements will provide additional information on this issue.

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