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Toxicological Findings in Fatally Injured Pilots of 979 Amateur-Built Aircraft Accidents

Arvind K. Chaturvedi
Kristi J. Craft
Jeffery S. Hickerson
Paul B. Rogers
John W. Soper

Civil Aerospace Medical Institute
Federal Aviation Administration
Oklahoma City, OK 73125

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16. Abstract

Biological samples collected from fatally injured pilots in aviation accidents involving all types of aircraft, including amateur-built aircraft, are submitted to the Civil Aerospace Medical Institute (CAMI) for accident investigation. These samples are analyzed for fire gases, ethanol, and drugs. Trends of amateur-built aircraft accidents and toxicological findings in the associated pilot fatalities have not been examined. Amateur-built aircraft accidents that occurred during 1990–2009 were evaluated by retrieving necessary information from the CAMI toxicology database. Probable cause and factor in the amateur-built aircraft mishaps were obtained from the National Transportation Safety Board's (NTSB's) aviation accident database. Of 6309 aviation accidents from which CAMI received postmortem samples, 979 (16%) were related to amateur-built aircraft. The highest number of aviation mishaps occurred during summer, which was true with amateur-built as well as with all other aircraft. There was a decreasing trend in accidents of non-amateur-built aircraft, whereas there was an increasing trend in accidents of amateur-built aircraft. In the 979 accidents (pilots), 392 were positive for ethanol and/or drugs. Ethanol was found in 29 pilots, drugs in 345, and ethanol plus drugs in 18. For ethanol/drug-related accidents also, a decreasing trend was observed with non-amateur-built aircraft and an increasing trend with amateur-built aircraft. Of the 392 amateur-built aircraft, 388 (99%) were flying under the general aviation category. In the 392 pilots, 238 (61%) held private pilot flying certificates and 260 (66%) third-class airman medical certificates. The spectrum of drugs found in the amateur-built aircraft accident pilot fatalities was consistent with commonly used drugs in the general population. The percentage of pilots wherein prescription drugs were detected was 26% for amateur-built aircraft, whereas it was 16% for non-amateur built aircraft and 18% for all aircraft. Ethanol/drug use and medical condition were determined to be a cause or factor in 42 (11%) of the 385 ethanol/drug-positive amateur-built aircraft accidents investigated by the NTSB. However, the contributory role of the mechanical malfunction of home-built aircraft cannot be ruled out in the observed increasing trends in their accidents, with or without ethanol and/or drugs. The increasing trend of such accidents is of significant concern.

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INTRODUCTION

Toxicological evaluation of biological samples collected from fatally injured pilots in aviation accidents is an integral part of aviation accident investigation. These biological samples are submitted for the evaluation by local pathologists to the Federal Aviation Administration's (FAA's) Civil Aerospace Medical Institute (CAMI; Oklahoma City, OK). The sample submissions are coordinated with the FAA's Office of Accident Investigation upon an authorization granted by the National Transportation Safety Board (NTSB) (2,16). The NTSB investigates aviation accidents that occur within the jurisdiction of the United States.

Obviously, any types of aircraft flying under any operating categories—for example, general aviation, air taxi and commuter, air carrier, agricultural, rotorcraft, and Ultralight (9,10)—could potentially be involved in accidents (1,5-7,15,28-30). There are a number of aircraft from many manufacturers such as Aero Commander, Bell Helicopter, Boeing, Cessna, Piper, Lockheed, McDonnell Douglas, and Rockwell International. One of the aircraft types is amateur-built aircraft, which is also referred to as "experimental home-built" or "experimental amateur-built" aircraft. This aircraft type is defined as an aircraft of which a major portion has been fabricated and assembled by person(s) who undertook the construction project solely for their own education or recreation (11,20). Some amateur-built aircraft are registered and some are not. They may also be included in the Ultralight-vehicle flying category (9,10).

Several studies covering epidemiological and toxicological aspects of aviation accident investigations have been reported in the literature (1,5-7,14-16,28,29). However, trends of amateur-built aircraft accidents and toxicological findings in the associated fatally injured pilots have not been examined. In the present study, toxicological results of fatally injured pilots of amateur-built aircraft mishaps that occurred during 1990–2009 were evaluated by retrieving and analyzing necessary information from the CAMI toxicology database. Trends of all aircraft accidents that occurred during the 20-year period were also summarized herein in relation to the amateur-built aircraft accidents.

MATERIALS AND METHODS

Biological Specimens

Autopsied specimens (blood, urine, liver, kidney, vitreous fluid, and other body samples) collected from fatally injured pilots of U.S. civil aviation accidents are submitted to CAMI in the FAA's TOX-BOX evidence containers (2,16). A unique case number is assigned for the toxicological evaluation of the submitted biological samples of each of these fatalities—that is, one case number per fatality. These aviation accidents entail registered, as well as unregistered, aircraft. All aviators involved in these mishaps do not necessarily hold airman flying and/or medical certificates required to legally pilot an aircraft.

Toxicological Analyses

Submitted samples are analytically evaluated for the presence of fire gases (carbon monoxide and hydrogen cyanide), ethanol/volatiles, and drugs by screening (preliminary analysis), followed by their confirmation and/or quantitation (15,16). Carbon monoxide is measured as carboxyhemoglobin (COHb) by a spectrophotometric method and confirmed by gas chromatography (GC), whereas hydrogen cyanide in blood is quantitated as cyanide ion (CN^-) by a colorimetric method and confirmed by high-performance liquid chromatography (HPLC) (12,13). Ethanol/volatiles are determined by dual capillary column-flame ionization detection by headspace GC. Prescription (℞) and nonprescription (over-the-counter; OTC) drugs are analyzed by fluorescence polarization immunoassay, HPLC, gas chromatography-mass spectrometry (GC-MS), and liquid chromatography-mass spectrometry (LC-MS). Examples of these drugs are acetaminophen, antidepressants, antihistamines, antihypertensives, decongestants, phenytoin, propoxyphene, quinidine, salicylate, and theophylline. Scheduled drugs (controlled substances) (8,19)—such as amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine, methamphetamine, opiates, and phencyclidine—are screened by radioimmunoassay/fluorescence polarization immunoassay and confirmed/quantitated by GC-MS and/or LC-MS (13,15,16).

Databases

All toxicological results of civil aircraft accident pilot fatalities are electronically stored in a database maintained at CAMI since 1990. This CAMI toxicology database was searched for a 20-year period (1990–2009) for fatal aviation accidents wherein pilots were fatally injured, and their postmortem samples were submitted for toxicological analyses. This search included all types of aircraft, including amateur-built aircraft. Furthermore, the search entailed airman flying and medical certificates of those fatally injured pilots who were involved in the amateur-built aircraft accidents and whose postmortem samples were found to be positive for ethanol and/or drugs. A concentration of ethanol $\geq$40 mg/dL (or mg/hg) was considered positive and included in the pilot fatality cases. This ethanol concentration in blood is a legal blood alcohol concentration under the FAA regulation at which no person may operate or attempt to operate an aircraft (18,27). Caffeine and nicotine were not included in the drug category, as these are commonly used substances and were present in the pilot postmortem samples in toxicologically insignificant amounts.

Flying certificate categories for aviators applicable to their medical certificate types (first-, second-, and third-class) are described as (i) first-class: airline transport pilot; (ii) second-class: commercial pilot, flight engineer, flight navigator, crop duster, or air traffic tower operator (not including FAA employee air traffic control specialists); and (iii) third-class: private pilot, recreational pilot, flight instructor, or student pilot (9,10,17,21). Airman medical certificates are valid from six months up to five years, depending upon the medical certificate class and the pilot age. Types and frequency of physical examinations of pilots for the certifications, including special issuance airman medical certificates, are described in the Code of Federal Regulations (CFR) and the FAA Guide for Aviation Medical Examiners (10,17,21).

Information related to aircraft flight categories and airman flying and medical certificates was obtained from the NTSB's aviation accident database (Washington, DC) and CAMI's medical certification database. Pilots who did not have airman flying and/or medical certificates were also part of the study. The cause- and factor-associated information of the accidents included in the study was based upon the findings reported in the NTSB aviation accident database.

Since the search in the study was limited to only pilots, the number of pilot fatalities translates into the equivalent number of aviation accidents with the argument of "one pilot per aircraft." Also, a unique case number for performing toxicological analyses was given to each pilot fatality—that is, one toxicology case number for each fatality. Therefore, the words "accidents," "pilots," "fatalities," and "cases" are interchangeably used in the present study.

Statistics

Means and standard deviation (SD) values were calculated by using Microsoft® Office Excel 2003 (Redmond, WA) or a Texas Instruments TI-60 Advanced Scientific Calculator (Texas Instruments Professional TI-60 Guide Book 1986, Lubbock, TX). SD values were based upon the entire population given as argument—that is, data taken from every member of a population—and are abbreviated herein as SD_n, where "n" is the sample size. Regression analyses were performed for each group of interest with SAS version 9.2 at $\alpha = 0.05$ (SAS Institute, Cary, NC). Therefore, any p value < 0.05 is significant, whereas a p value $\geq$0.05 is not significant. A test for parallel slopes—that is, all increasing trends (positive slopes) and all decreasing trends (negative slopes)—for amateur-built and for non-amateur-built groups was accomplished through the inclusion of an interaction term for both the amateur-built and the non-amateur-built accident models. This interaction term was not significant in these models ($p = 0.4542$), indicating no difference within the groups of the positive and of the negative slopes. Equations of the linear regression analysis of data with the square of their correlation coefficient (R^2) values are incorporated in the respective figures. In these equations, each x-axis value represented one of the 20 years ('90–'09) correspondingly representing as 1 to 20 numerical x-axis values. Based upon these regression lines, trends of the future y-axis values were also projected for the additional seven years—that is, up to 2016. For the year 2010, those projected values from the regression lines were compared with those of the actual values obtained from the CAMI toxicology database. This comparison was carried out to establish the closeness in those projected and actual values.

RESULTS

During 1990–2009, biological specimens from 6309 fatally injured pilots involved in aviation accidents were submitted to CAMI (Yearly Mean ± SD_n: 315.5 ± 39.3; n = 20; Range: 246 – 385), which correspond to the equal number of aviation accidents because there will be only one pilot for piloting an aircraft. Of the 6309 accidents, 979 (16%) were associated with amateur-built aircraft (Yearly Mean ± SD_n: 49.0 ± 11.9; n = 20; Range: 26 – 74). The remaining 5330 (84%) were related to other types of aircraft (Yearly Mean ± SD_n: 266.5 ± 47.4; n = 20; Range: 172 – 347). Monthly averages for the 1990–2009 aviation accidents (n = 20) from which CAMI received samples indicated that the highest number of accidents occurred during summer—that is, from June to September (Fig. 1). This accident pattern was observed with amateur-built aircraft, as well as with non-amateur-built aircraft.

Based upon the number of yearly accidents during the 20-year period, there was a decreasing trend in the number of accidents involving aircraft types other than amateur-built aircraft, whereas there was an increasing trend in accidents involving only amateur-built aircraft (Fig. 2). The decrease versus increase in the accident trends was clearly evident as the slope of one regression line was negative and the other was positive, while the absolute numerical values of the slopes were same. From the linear regression analyses, the projected value for the non-amateur-built aircraft accidents in 2010 came out to be 76%, whereas the actual value from the CAMI toxicology database for this year was 77%; and the projected and actual values for the amateur-built aircraft accidents in 2010 were also very close—that is, 24% and 23%, respectively.

Of the 979 accidents (pilot fatalities), postmortem samples of 392 pilots were positive for ethanol and/or drugs. Only ethanol was found in 29 pilots, only drugs in 345, and both ethanol and drugs in 18. When the annual number of accidents with ethanol is plotted, it showed a decreasing trend in accidents involving non-amateur-built aircraft and an increasing trend in accidents involving amateur-built aircraft (Fig. 3); this group of accidents included those pilot fatalities in which, along with ethanol,

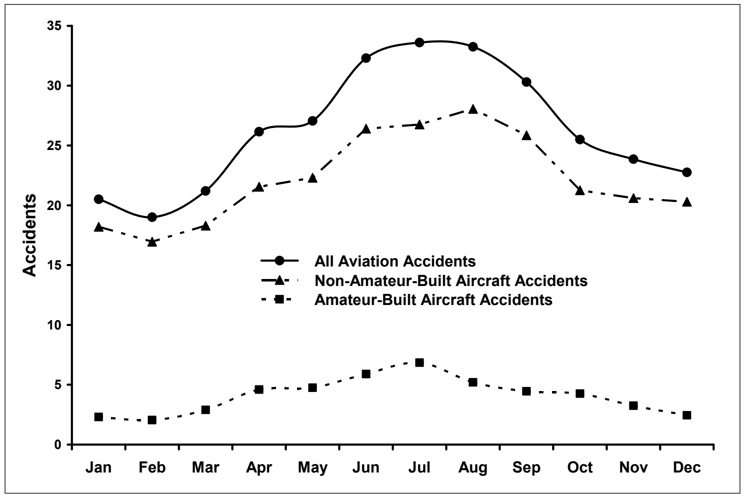

Figure 1. Monthly averages of the U.S. aviation accidents from which postmortem samples of fatally injured pilots were submitted to CAMI for toxicological evaluation. These accidents consist of all aircraft types, including amateur-built aircraft. These mishaps occurred during the 20-year period of 1990–2009. Each point is an average of 20 values.

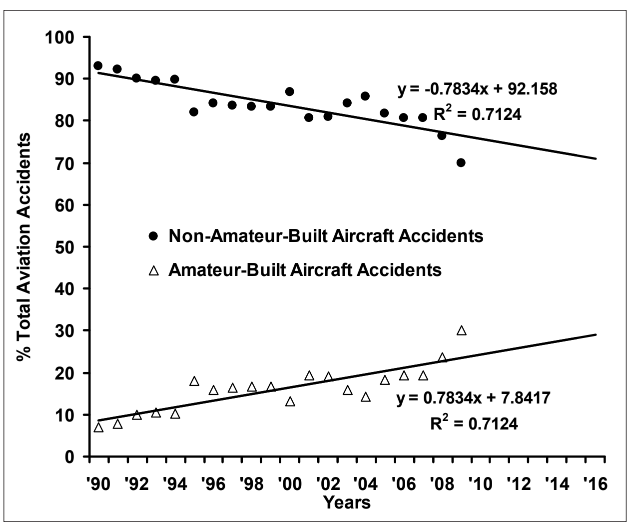

Figure 2. Yearly percentages of non-amateur-built and amateur-built aircraft accidents with respect to the total accidents (1990–2009) involving all aircraft types from which postmortem samples of fatally injured pilots were submitted to CAMI. Yearly mean ± SD_n value of all aircraft type accidents was 315.5 ± 39.3 (n = 20).

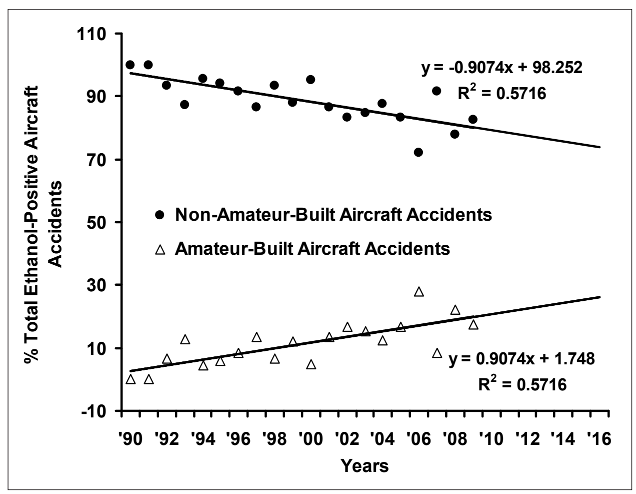

Figure 3. Yearly percentages of non-amateur-built and amateur-built aircraft accidents with respect to the total accidents (1990–2009) involving all aircraft types from which postmortem samples of fatally injured pilots were submitted to CAMI and those pilot fatality cases were found to be positive for ethanol. Drugs were also found in some of these ethanol-positive cases. Such drug cases with ethanol were also part of this group of ethanol-positive accidents. Yearly mean ± SD_n value of all aircraft type accidents with ethanol was 22.8 ± 5.7 (n = 20).

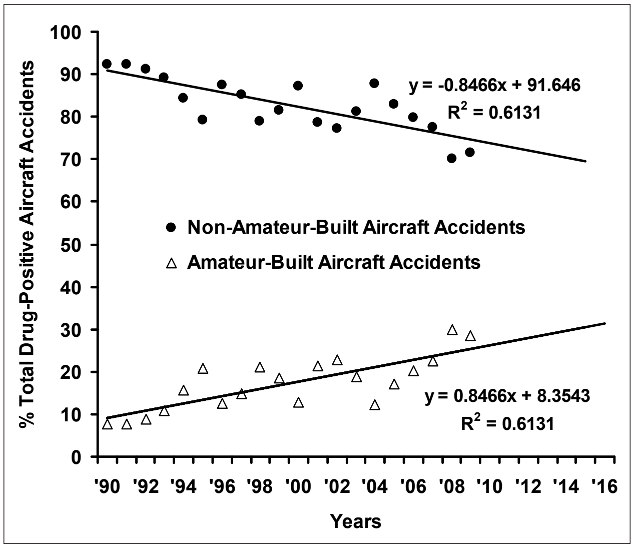

Figure 4. Yearly percentages of non-amateur-built and amateur-built aircraft accidents with respect to the total accidents (1990–2009) involving all aircraft types from which postmortem samples of fatally injured pilots were submitted to CAMI and those pilot fatality cases were found to be positive for drugs. Ethanol was also present in some of these drug-positive cases. Such ethanol cases with drugs were included in this group of drug-positive accidents. Yearly mean ± SD_n value of all aircraft type accidents was 112.5 ± 11.8 (n = 20).

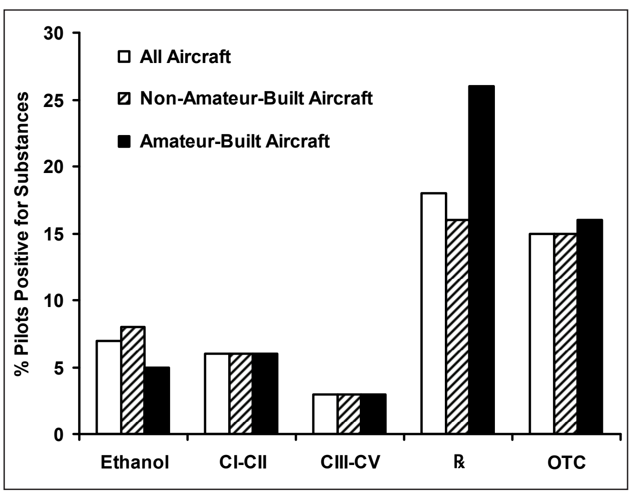

Figure 5. Percentages of pilots whose postmortem samples were positive for foreign substances. These substances were ethanol, scheduled drugs (controlled substances; CI–CV) (8,19), prescription (℞) drugs, and nonprescription (over-the-counter; OTC) drugs. The 100-percent values are 6309 pilots for all aircraft, 5330 for non-amateur-built aircraft, and 979 for amateur-built aircraft. More than one substance was present in some pilot fatalities. Those pilots were counted more than once—that is, for ethanol and for each drug (and/or metabolites) under the respective categories.

drugs were also present—that is, pilots were positive for ethanol and for ethanol and drugs. These decreasing and increasing trends were supported by the equal absolute slope values of the lines with opposite signs. Similar trends in accidents were observed with non-amateur-built and amateur-built aircraft in which pilots were determined to be positive for drugs—that is, they were positive for drugs and for drugs and ethanol (Fig. 4). For 2010, the projected value from the linear regression equation and the actual value from the toxicology database for the non-amateur-built aircraft accidents involving ethanol were 79% and 82%, respectively; and for the amateur-built aircraft accidents they were 21% and 18%, respectively. Similarly, respective projected and actual accident values for the non-amateur-built aircraft with drugs were 74% and 76% in 2010. Such values for the amateur-built aircraft with drugs were 26% and 24%.

As anticipated, 99% (388 of 392) of the amateur-built aircraft involved in the fatal accidents were flying under the general aviation category (CFR Part 91) (9,10). One of the 392 accidents was under the Ultralight flying category (CFR Part 103) and another under the agricultural category (CFR Part 137). The flying categories of two accidents were not assigned; the involved aircraft were unregistered. The airman flying ratings of the pilots involved in these amateur-built aircraft were: 29 airline transport, 78 commercial, 238 private, and 16 student pilots (9,10). The remaining 31 pilots were either non-certificated or their flying ratings were not known. Of the 392 pilots, 21 held first-class, 72 held second-class, and 260 held third-class airman medical certificates. The medical certification of 12 pilots was denied or deferred. The status of the medical certification of 27 pilots was unknown.

Including ethanol, drugs and/or their metabolites detected in the 392 pilot fatalities are listed in Table I. This list contains the whole spectrum of drug types, covering scheduled drugs (controlled substances; CI–CV) (8,19) and ℞ and OTC drugs. Of the 6309 pilots involved in all aircraft accidents, 455 (7%) had ethanol, 372 (6%) had CI–CII drugs, 176 (3%) had CIII–CV drugs, 1112 (18%) had ℞ drugs, and 939 (15%) had OTC drugs. These drug percentages are illustrated in Figure 5; in this figure, the respective drug percentages for the 5330 pilots of non-amateur-built aircraft and the 979 pilots of amateur-built aircraft are also incorporated for comparison. More than one foreign substance—ethanol and drugs (and/or their metabolites)—was present in many of the pilot fatalities. Therefore, those fatalities were counted more than once for the presence of each substance—that is, for ethanol and/or for each drug under the respective drug categories. As is evident from the figure (except for ℞ drugs), in general, pilot percentages under different

Table I. Including Ethanol, Drugs and Their Metabolites Found in the Fatally Injured Pilots in the Amateur-Built Aircraft Accidents

Acetaminophen	Desipramine	Lansoprazole	Propoxyphene/
Alfuzosin	Dextromethorphan/dextrorphan	Lidocaine	norpropoxyphene
Alprazolam/	Diazepam/nordiazepam/	L-Methamphetamine	Propranolol
α-hydroxyalprazolam	temazepam/oxazepam	Losartan	Pseudoephedrine
Amitriptyline/nortriptyline	Diclofenac	Meclizine	Quinine
Amlodipine	Dihydrocodeine	Mefloquine	Ranitidine
Atenolol	Diltiazem	Metoprolol	Salicylate
Atropine	Diphenhydramine	Midazolam	Sertraline/desmethylsertraline
Azacyclonol	Donepezil	Minoxidil	Sildenafil/sildenafil metabolite
Bisoprolol	Doxazosin	Mirtazapine	Terazosin
Brompheniramine	Doxylamine	Morphine	Δ^9- Tetrahydrocannabinol
Buprenorphine/	Duloxetine	Nadolol	(THC)/11-nor-Δ^9-tetrahydro-
norbuprenorphine	Ephedrine	Naproxen	cannabinol-9-carboxylic acid
Bupropion/	Ethanol	Nifedipine	(THC-COOH)
bupropion metabolite	Etomidate	Nizatidine	Thebaine
Butalbital	Famotidine	Norchlordiazepoxide	Theophylline
Carvedilol	Fenfluramine	Normeperidine	Tramadol
Cetirizine	Fentanyl	Omeprazole	Trazodone
Chloroquine	Fluconazole	Paroxetine	Triamterene
Chlorpheniramine	Fluoxetine/norfluoxetine	Pentobarbital	Trimethoprim
Cimetidine	Gabapentin	Phenobarbital	Valproic acid
Citalopram/	Hydrochlorothiazide	Phentermine	Valsartan
N-desmethylcitalopram/	Hydrocodone	Phenylpropanolamine	Varenicline
di-*N*-desmethylcitalopram	Hydromorphone	Phenytoin	Venlafaxine/
Cocaine/cocaethylene/	Ibuprofen	Pioglitazone	desmethylvenlafaxine
benzoylecgonine/ecgonine	Irbesartan	Procainamide/	Verapamil/norverapamil
methyl ester	Ketamine	*N*-acetylprocainamide	Zolpidem
Codeine	Labetalol	Promethazine	

categories of the foreign substances were almost similar for all, non-amateur-built, and amateur-built aircraft groups. Such pilot percentage for ℞ drugs was 26% with amateur-built aircraft, whereas it was 16% with non-amateur-built aircraft and 18% with all aircraft.

Of the 392 ethanol/drug-positive accidents, 385 (98%) were investigated by the NTSB. As summarized in Table II, pilot's health, performance impairment, or poor judgment associated with the use of ethanol and/or drugs was determined to be the cause/factor in 42 (11%) out of the 385 accidents investigated by the NTSB. This information is based on the findings reported in the NTSB aviation accident database through September 2011. Of these 42 accidents, cocaine and marihuana were involved in 9 (21%) accidents, ethanol in 9 (21%), and diphenhydramine in 14 (33%). Other drugs such as analgesics, amitriptyline, benzodiazepines, fluoxetine, paroxetine, sertraline, and verapamil were also present in the pilots of the 42 accidents (Table II). In fatalities wherein more than one substance was present, they were counted more than once.

DISCUSSION

The increase observed in the number of non-amateur-built and amateur-built aircraft accidents during summer (June-September) was similar to the pattern observed in a previous study for fatal aircraft accidents that occurred during the 11-year period of 1990–2000 (16). Such increase in accidents could be attributed to the higher aviation activities during these summer months. Although there was a decreasing trend in non-amateur-built aircraft accidents during the 20-year period (1990–2009), there was a clear-cut indication that amateur-built aircraft accidents were increasing with a projection that the increase would continue in the future. Similarly, the decreasing trend with non-amateur-built aircraft accidents and the increasing trend with amateur-built aircraft accidents were also observed with those mishaps in which pilots were fatally injured and ethanol and/or drugs were present in their system. In other words, the number of amateur-built aircraft accidents with ethanol and/or drugs was rising during the 20-year period, while for the same period, there was a decreasing trend in non-amateur-built aircraft accidents with ethanol and/or drugs.

The majority of the pilots in the ethanol and/or drug-positive subset of amateur-built aircraft mishaps were private pilots (61%; 238 of 392) and held third-class medical certificates (66%; 260 of 392). Was the increase observed in the accidents with the amateur-built aircraft associated with the health and age of the aviators of the subset in relation to their flying and medical certificate categories? Although it is difficult to answer this question from the present study, there was a 63% increase in the presence of ℞ drugs in the amateur-built aircraft accident pilot fatalities in comparison to the pilots of non-amateur-built fatal aviation accidents. This observation suggests that those amateur-built aircraft pilots had a relatively higher susceptibility for taking ℞ drugs to treat medical conditions. Therefore, speculatively, the role of the high usage of ℞ drugs by the pilots cannot be overlooked in the increase observed with the amateur-built aircraft accidents.

In general, the spectrum of drugs found in the pilot fatalities of the amateur-built aircraft accidents was consistent with the common drugs used in the general population and was similar to those reported earlier with aviation accident pilot fatalities wherein selective serotonin reuptake inhibitors (1) and antihistamines (29) were present. A similar drug usage pattern was notable in four studies conducted for the period of 1989–2008 for pilots fatally injured in aviation accidents (5-7,15). Drugs like atropine, lidocaine, benzodiazepines, and narcotic analgesics found in the amateur-built aircraft accident pilot fatalities might have been administered by health care providers for resuscitation, seizure control, pain reduction, and/or surgical procedures at accident scenes and/or at medical facilities. On the other hand, the presence of scheduled drugs (controlled substances) (8,19)—for example, cocaine and marihuana—could have been related to their unauthorized use. The presence of ℞ drugs found in the pilots reflected the common usage of medications—such as antihypertensives and antidepressants—similar to the usage in the general population (3,5-7,15,23-25,31,32). OTC drugs found were primarily associated with drugs used to alleviate allergy and common cold symptoms.

Ethanol and drug use and/or medical conditions were cause or factor in 42 (11%) of the 385 accidents investigated by the NTSB. The remaining 343 accidents in which the aviator was found to be positive for the foreign substances were determined to be attributed to adverse weather conditions, mechanical malfunction, and/or procedural/pilot errors. Because these flying machines are home-built, their major portion is fabricated and assembled by person(s) who undertook the construction project solely for their own education or recreation (11,20). Home-built aircraft are assembled using various parts and components. That manufacturers' instructions will be followed, while assembling those parts/components, cannot be verified, as there is always a potential for shortcuts during their assembly and/or a lack of experience of the aircraft builders, thereby increasing the chances for mechanical malfunctions. For example, a home-built plane was forced to land when the engine quit because the person who built it wired the battery incorrectly (4). The number of home-built experimental

Table II. Ethanol and Drug Use and/or Medical Conditions as the Cause or Factor in the Amateur-Built Aircraft Accidents as Determined by the NTSB

Accident	Presence of Ethanol, Drug(s), and/or Drug Metabolite(s)	Cause	Factor
1	Diphenhydramine, fluoxetine, norfluoxetine, and trazodone	Hypoglycemic condition	–
2	Diphenhydramine, chlorpheniramine, diazepam, and nordiazepam	Impairment of judgment and performance due to drugs	–
3	Diphenhydramine and acetaminophen	Impairment of judgment and performance due to diphenhydramine	–
4	Benzoylecgonine	Poor judgment of the pilot from use of cocaine	–
5	Ethanol and THC-COOH	Impairment due to use of ethanol	–
6	Amitriptyline, nortriptyline, verapamil, and norverapamil	Use of a sedating prescription antidepressant drug	–
7	Diphenhydramine, acetaminophen, amitriptyline, nortriptyline, propoxyphene, and norpropoxyphene	Use of unapproved medications	–
8	Diazepam, nordiazepam, morphine, and phenobarbital *Note*: The blood sample collected approximately 3 hr after the accident disclosed the presence of 0.11% ethanol by the local medical examiner.	Impairment due to use of ethanol	–
9	Ethanol	–	Impairment due to use of ethanol
10	Ethanol, diphenhydramine, cocaine, cocaethylene, and benzoylecgonine	–	Consumption of ethanol
11	Diphenhydramine, acetaminophen, nordiazepam, oxazepam, propranolol, and norchlordiazepoxide	–	Drug impairment
12	THC and THC-COOH	–	Drug impairment
13	Acetaminophen, hydrocodone, trazodone, dihydrocodeine, bupropion, bupropion metabolite, and tramadol	–	Extensive use of medications

14	Ethanol and quinine	–	Impairment due to use of ethanol
15	Pseudoephedrine, brompheniramine, chlorpheniramine, and phenylpropanolamine	–	Impairment due to use of drugs
16	Chlorpheniramine and amlodipine	–	Impairment due to ingestion of an over-the-counter sedating antihistamine
17	THC and THC-COOH	–	Impairment due to use of marihuana
18	THC and THC-COOH	–	Impairment due to recent use of marijuana
19	THC, THC-COOH, and tramadol	–	Impairment due to the recent use of marijuana and a prescription painkiller
20	Diphenhydramine	–	Impairment due to the use of a over-the-counter medication with sedative effects
21	Chlorpheniramine, naproxen, and atropine	–	Impairment from an over-the-counter sedating antihistamine
22	Temazepam, nordiazepam, oxazepam, THC, and THC-COOH	–	Impairment from recent marijuana use
23	Morphine, codeine, hydrocodone, dihydrocodeine, hydromorphone, paroxetine, and tramadol	–	Impairment from the effects of prescription painkilling drugs
24	Diphenhydramine and brompheniramine	–	Impairment of judgment and performance due to use of drugs
25	THC and THC-COOH	–	Impairment of the pilot by THC
26	Diphenhydramine, acetaminophen, metoprolol, hydrocodone, dihydrocodeine, and zolpidem	–	Impairment of the pilot by the use of drugs
27	Diphenhydramine and dextromethorphan	–	Likely impairment by an over-the-counter drug that degraded physical and mental performance of the pilot

28	Lidocaine and atropine	–	Physical impairment
29	Ethanol	–	Physical impairment due to use of ethanol
30	Diphenhydramine and salicylate	–	Physical impairment due to use of drugs
31	Acetaminophen, nordiazepam, oxazepam, alprazolam, α-hydroxyalprazolam, hydrocodone, hydromorphone, venlafaxine, and desmethylvenlafaxine	–	Physical impairment of the pilot
32	Amitriptyline, nortriptyline, hydrocodone, dihydrocodeine, hydromorphone, and doxylamine	–	Pilot's impairment due to prescription medications
33	Ethanol	–	Pilot's intentional operation of the airplane while impaired by ethanol
34	Acetaminophen, alprazolam, α-hydroxyalprazolam, and triamterene	–	Use of alprazolam
35	Ethanol, fluoxetine, and norfluoxetine	–	Physical impairment due to ethanol consumption
36	Diphenhydramine, codeine, paroxetine, bupropion, and bupropion metabolite	–	Use of a painkiller and an antihistamine
37	Ethanol, pseudoephedrine, phenylpropanolamine, and diphenhydramine	–	Use of an over-the-counter antihistamine
38	Amitriptyline, nortriptyline, and paroxetine	–	Use of prescription drugs
39	Quinine	–	Use of quinine
40	Fluoxetine, norfluoxetine, and mirtazapine	–	Use of unapproved medications
41	Diphenhydramine, sertraline, and desmethylsertraline	–	Drug impairment
42	Acetaminophen, propoxyphene, and norpropoxyphene	–	Use of an unapproved drug

planes is increasing, and safety concerns with this category of aircraft have been raised in newspapers (4,22). This type of aircraft is the focus of a joint safety study of the NTSB and the Experimental Aircraft Association (26). In view of these considerations, a contributory role of the mechanical malfunction of these amateur-built flying devices, along with growth in their numbers, cannot be ruled out in the increasing trends in the home-built aircraft accidents, with or without the involvement of ethanol and/or drugs. The increasing trend of such accidents is of significant concern.

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