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Prevalence of Ethanol and Drugs in Civil Aviation Accident Pilot Fatalities, 2009–2013

Arvind K. Chaturvedi
Kristi J. Craft
Jeffery S. Hickerson
Paul B. Rogers
Dennis V. Canfield

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

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NOTICE

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16. Abstract

Biological specimens from pilots fatally injured in civil aviation accidents are analyzed for ethanol and drugs at the Civil Aerospace Medical Institute (CAMI). Prevalence of these substances in the pilots has been evaluated on 5-yr intervals since 1989. In continuation, a fifth 5-yr study was conducted. The CAMI toxicology/medical certification and National Transportation Safety Board (NTSB) aviation accident databases were searched.

During 2009–2013, samples from 1,169 pilots were analyzed for ethanol and drugs. Aircraft involved in the accidents were primarily operating under general aviation. Most airmen were private pilots and held third-class medical certificates. In relation to the first 5-yr (1989–1993) period, the pilot fatality cases decreased by 37% and the presence of ethanol and/or drugs in the pilots increased by 239% in the fifth 5-yr period. The ethanol usage was unchanged, but increases were noted with illicit and prescription drugs. The prescription drugs found were consistent with those commonly used in general population. The use of ethanol and/or drugs by aviators, along with underlying medical conditions, was determined by the NTSB to be cause/factors in 5% of the accidents. The observed decrease in the fatality cases does not necessarily suggest the decrease in aviation accidents, as the numbers of active airmen also declined.

Although prevalence of ethanol and drugs has been evaluated in fatally injured aviators, such evaluation has not been performed in active pilots not involved in accidents. This type of comparative study would be crucial in assessing aviation safety.

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Contents

Prevalence of Ethanol and Drugs in Civil Aviation Accident Pilot Fatalities, 2009–2013

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INTRODUCTION

Under the U.S. Aviation Safety Research Act of 1988, biological specimens collected from pilots who were fatally injured in civil aviation accidents are toxicologically evaluated at the Federal Aviation Administration's (FAA's) Civil Aerospace Medical Institute (CAMI) located in Oklahoma City, OK (1,9). This type of evaluation is an essential part of aviation accident investigations. Such postmortem samples are submitted to CAMI by pathologists in coordination with the FAA's Office of Accident Investigation and Prevention upon an authorization granted by the National Transportation Safety Board (NTSB), responsible to conduct independent investigations of all civil aviation accidents in the United States (22,23).

Prevalence of ethanol and drugs in the population of fatally injured aviation accident aviators has been published by CAMI on 5-yr intervals since 1989. The previous four such studies have been for the 1989–1993 (2), 1994–1998 (4), 1999–2003 (8), and 2004–2008 (3) periods. In continuation of this effort, the presence of ethanol and drugs in the aviation accident pilot fatalities was studied for the 5-yr period of 2009–2013. Findings from this study are incorporated and discussed herein and compared with those of the previous four studies to determine trends of the ethanol and drug usage in the fatally injured airmen. The numbers of yearly CAMI pilot fatality cases were also compared with the yearly numbers of active airmen, obtained from the FAA's U.S. Civil Airmen Statistics (18), for establishing pattern of, and possible relationship between, these two groups of numbers.

METHODS

Postmortem Biological Samples

Types of autopsied biological samples submitted to CAMI were generally blood, brain, heart, kidney, liver, lung, spinal fluid, urine, and/or vitreous fluid. These biological specimens were shipped in a special evidence container known as "TOX-BOX" (9). A specific case number was assigned to each pilot fatality from which specimens were submitted to CAMI.

Only pilots were included in the present study (co-pilots were not part of the study). Since there is only one pilot in command of an aircraft, the number of pilots will be equivalent to the number of aviation accidents, and a particular CAMI case number is associated with a specific pilot fatality.

In this article, words—accident, airman, aviator, case, fatality, and pilot—are interchangeably used.

Analytical Toxicology

Submitted samples were analyzed for combustion gases (carbon monoxide and hydrogen cyanide), ethanol and other volatiles, and drugs, using standard procedures of the CAMI toxicology laboratory (6,8,9). The drugs comprised a wide spectrum of illicit (controlled substances) (13), prescription, and nonprescription (over-the-counter) drugs.

Toxicology Database

Results of the analyses of biological samples collected from the airmen fatally injured in aircraft accidents have been stored since 1990 in a toxicology database at CAMI. This databank also has information pertaining to relevant demographic elements, flying certificates, and medical certificates of aviators; operating categories in which the aircraft were flying; associated aircraft numbers; and aviation accident narratives, together with cause and factors in the accidents as determined by the NTSB. These pieces of information are retrieved from the FAA Multi-System Access Tool database (16), the CAMI Document Imaging and Workflow System (DIWS) (15,17), and the NTSB database (23). The CAMI toxicology database has a provision to link with the NTSB database, as well.

For the present study, the CAMI toxicology database was searched to find the number of aviators who were fatally injured in aviation accidents. Additionally, their postmortem samples were received at CAMI during 2009–2013 and toxicologically evaluated, including analyses for ethanol and drugs. An ethanol concentration of ≥ 40 mg·dl−1 (or mg·hg−1) in a sample was deemed positive for ethanol. Under the FAA regulation, this concentration of ethanol in blood is a blood alcohol concentration at which no person may operate or attempt to operate an aircraft (12,24). Caffeine and nicotine were excluded from the drug list of the present study. These are commonly used substances and were present, if any, in the pilot postmortem samples in toxicologically insignificant amounts.

Statistics

Means, figure plots, linear regression analyses, and associated calculations were made by using a Texas Instruments TI-60 Advanced Scientific calculator (1986 Texas Instruments Professional TI-60 Guidebook, Lubbock, TX) and a Microsoft® Office Excel 2010 program (Part of Microsoft Office Professional Plus 2010, © 2010 Microsoft Corporation, Redmond, WA). Equations of the linear regression analyses of data with the square of their correlation coefficient (R^2) values are incorporated in the respective figure. In these equations, each x-axis value signified one of the 24 yr (1990–2013), correspondingly representing as 1 to 24 numerical x-axis values.

RESULTS

Pilot Fatality Cases

During 2009–2013, the NTSB investigated 1,303 aviation accidents in which pilots were fatally injured. Of these accidents, bio-samples from 1,116 (86%) airmen were submitted to CAMI for analytical toxicology. However, during this 5-yr period, CAMI received postmortem samples from 1,192 aviators fatally injured in aviation accidents (Fig. 1). The inconsistency between the NTSB and CAMI numbers might have been because the NTSB may or may not submit postmortem samples from, or investigate, all aviation accidents. On the other hand, CAMI may receive samples from aviation accidents not investigated by the NTSB.

Of the 1,192 cases, seven were from foreign aviation accidents, and 10 were not analyzed due to an insufficient amount or unsuitability of samples or the decision of the accident investigator-in-charge to not have toxicological analysis performed. Therefore, the 17 fatalities were excluded from the 1,192 number, leaving 1,175 pilot fatality cases. In these fatality cases, three were analyzed for only ethanol and an additional three for only drugs. This selective analytical approach was taken because of the limited amount or unsuitable nature of the submitted samples. Thus, the remaining 1,169 pilot fatality cases were those that were analyzed for ethanol, as well as for drugs, and are part of the present study.

Fatally Injured Pilots

Of the aircraft associated with the 1,169 fatally injured aviators, 1,068 (91%) were operating under the general aviation category (Title 14 of the Code of Federal Regulations (CFR) Part 91) (11). The remaining aircraft were operating under agricultural (14 CFR Part 137), air-taxi and commercial (14 CFR Part 135), rotorcraft external-load (14 CFR Part 133), air carrier (14 CFR Part 121), ultralight (14 CFR Part 103), and other categories. Regarding medical credentials, 129 (11%) pilots held first-class, 326 (28%) held second-class, and 637 (55%) held third-class medical certificates. Medical certificate applications of some of the remaining airmen were deferred, denied, or pending. Some airmen did not hold any medical certificate or were not required to have a medical certificate—for example, it is not mandatory for sport pilots to have a medical certificate; a valid driver's license suffices the need to fly a sport aircraft (14). Of the 1,169 aviators, 579 (50%) were private, 347 (30%) commercial, and 143 (12%) airline transport pilots. There were also 43 student and 24 sport pilots; 33 aviators were uncertificated or without any flying certificate.

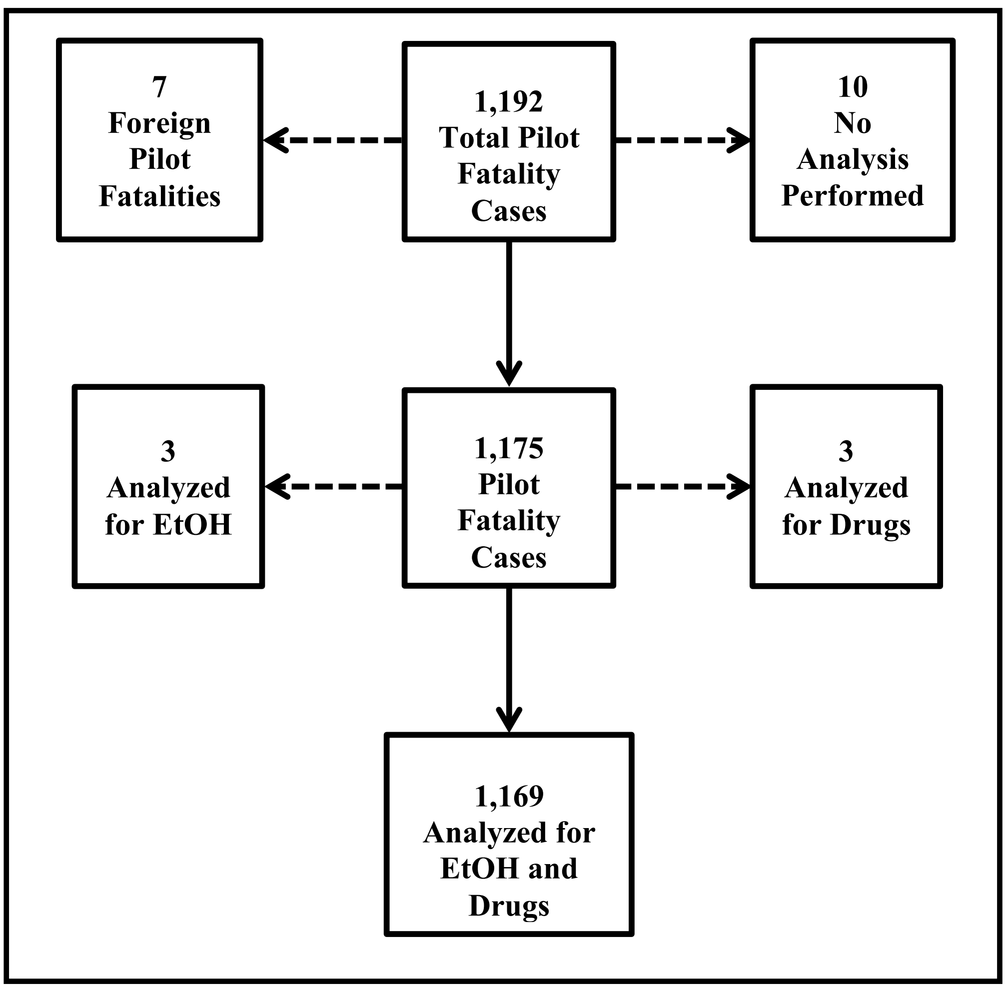

Figure 1. Flowchart illustration of 1,169 fatally injured civil aviation accident pilots whose postmortem biological samples were toxicologically evaluated, including for the presence of ethanol (EtOH) and drugs.

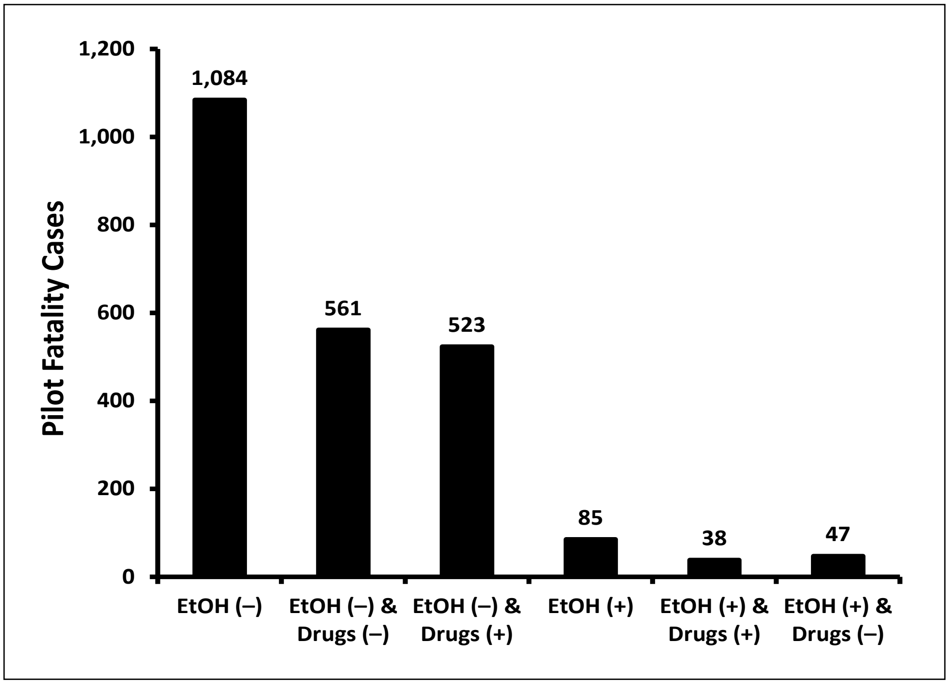

Figure 2. Pilot fatality cases that were determined to be negative or positive for ethanol (EtOH) and/or drugs. Drugs (-), drugs negative; Drugs (+), drugs positive; EtOH (-), ethanol negative; EtOH (+), ethanol positive.

Ethanol and Drugs

As exhibited in Figure 2, no ethanol and drugs were detected in 561 (48%) of the 1,169 pilots, whereas ethanol with or without drugs was present in 85 (7%) of the 1,169 pilots. Only drugs were present in 523 (45%) of the 1,169 cases; 38 (3%) of the 1,169 airmen had both ethanol and drugs in their system. This means that 48% of the airmen had drugs, with or without ethanol.

Illicit (controlled substances; 21 CFR Part 1308) (13), prescription, and nonprescription (over-the-counter) drugs found in the pilot fatalities are given in Tables I-III. In 2009–2013, illicit drugs were found in 16% of the pilots, prescription drugs in 35% and nonprescription drugs in 16% of the pilots (Fig. 3). The overall percentage of ethanol and/or drugs found in the population of fatally injured aviators increased from 31% during 1989–1993 (2) to 74% during 2009–2013, which is comparatively a surge in the presence of these substances by 239% from the first 5-yr study.

The pilot fatalities in which more than one analyte (ethanol or drugs/metabolites) was present were counted more than once to account for the presence of each of the analytes.

Table I. Illicit Drugs* Found in Pilot Fatalities (2009–2013).

Amphetamine	Barbiturates†	Benzodiazepines‡	Buprenorphine/ norbuprenorphine
Cocaine/ cocaine metabolites	Codeine	Fentanyl	Meprobamate
Methamphetamine	Methylone	Methylphenidate	Morphine
Normeperidine	Phentermine	Propoxyphene/ norpropoxyphene	THC/THC-COOH§
Synthetic opiates¶	Zolpidem	Zopiclone	

*Schedules of controlled substances, U.S. Drug Enforcement Administration (13)
†Butalbital and phenobarbital
‡7-Aminoclonazepam, α–hydroxyalprazolam, alprazolam, clonazepam, diazepam, lorazepam, midazolam, nordiazepam, oxazepam, and temazepam
§Δ^9- Tetrahydrocannabinol (THC)/11-nor-Δ^9-tetrahydrocannabinol-9-carboxylic acid (THC-COOH)
¶Dihydrocodeine, hydrocodone, hydromorphone, oxycodone, and oxymorphone

Table II. Prescription Drugs* Found in Pilot Fatalities (2009–2013).

Alfuzosin	Amitriptyline/ nortriptyline	Amlodipine	Atenolol
Atorvastatin	Atropine	Azacyclonol	Benazepril
Brompheniramine	Bupropion/ bupropion metabolite	Candesartan	Carbamazepine
Carisoprodol	Carvedilol	Cetirizine	Chloroquine
Chlorthalidone	Citalopram/ citalopram metabolites	Clonidine	Clopidogrel
Cyclobenzaprine	Diclofenac	Diltiazem	Donepezil
Doxazosin	Doxepin/ nordoxepin	Duloxetine	Enalapril
Etomidate	Fexofenadine	Flecainide	Fluconazole
Fluoxetine/ norfluoxetine	Furosemide	Gabapentin	Glipizide
Hydrochlorothiazide	Hydroxychloroquine	Indomethacin	Irbesartan
Isoproterenol	Labetalol	Lamotrigine	Levetiracetam
Lidocaine	Loratadine	Losartan	Metoclopramide
Metoprolol	Minoxidil	Montelukast	Nadolol
Olanzapine	Omeprazole	Ondansetron	Pantoprazole
Paroxetine	Pioglitazone	Pramipexole	Pravastatin
Promethazine	Propofol	Propranolol	Quetiapine
Quinidine	Ramipril	Ranitidine	Rizatriptan
Rosuvastatin	Sertraline/ desmethyl-sertraline	Sildenafil/ desmethyl-sildenafil	Sotalol
Tadalafil	Tamsulosin	Terazosin	Theophylline
Ticlopidine	Tramadol	Trazodone	Triamterene
Trimethoprim	Valsartan	Venlafaxine/ desmethyl-venlafaxine	Verapamil/ norverapamil
Warfarin			

*Depending upon the doses of some of these drugs in a particular pharmaceutical preparation and its formulation, the drugs may also fall in the nonprescription (over-the-counter) drug category.

Table III. Nonprescription (Over-The-Counter) Drugs* Found in Pilot Fatalities (2009–2013).

Acetaminophen	Chlorpheniramine	Dextromethorphan/ dextrorphan	Diphenhydramine
Doxylamine	Ephedrine	Famotidine	Ibuprofen
Naproxen	Oxymetazoline	Pheniramine	Phenylpropanolamine
Pseudoephedrine	Quinine	Salicylate	Yohimbine

*Some of these drugs may also fall in the prescription drug category depending upon their doses in a particular pharmaceutical preparation and its formulation.

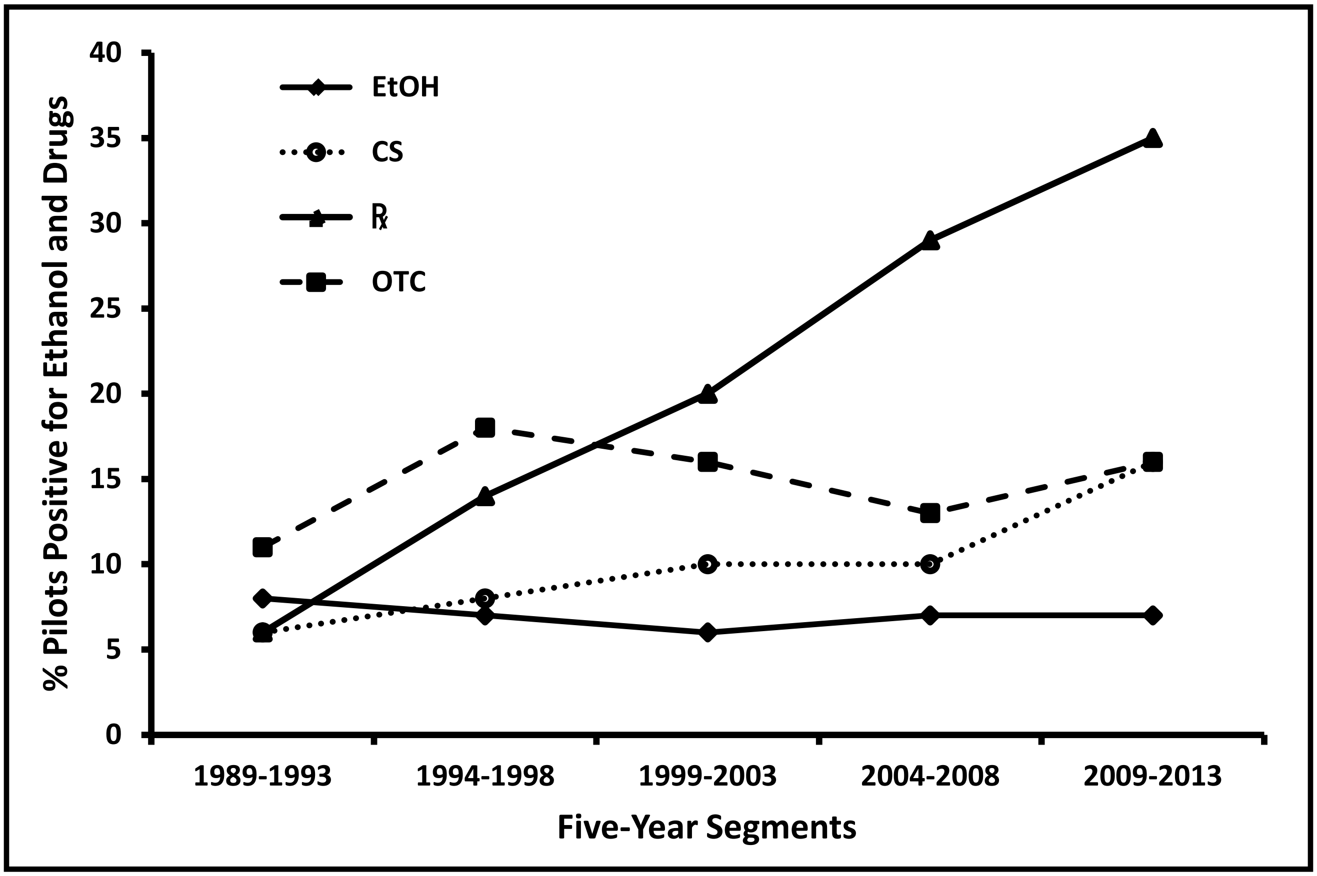

Figure 3. Percentages of pilots whose postmortem samples were positive for ethanol (EtOH), illicit drugs (controlled substances; CS), prescription (℞) drugs, and nonprescription (over-the-counter; OTC) drugs. The 100-percent values of pilot fatalities for the 5-yr segments were: 1,845 for 1989–1993 (2); 1,683 for 1994–1998 (4); 1,587 for 1999–2003 (8); 1,353 for 2004–2008 (3); and 1,169 for 2009–2013. Fatalities, in which more than one analyte (EtOH or drugs/metabolites) was detected, were counted more than once to account for the presence of each of the analytes under their respective categories.

NTSB Accident Investigation

In regards to the NTSB investigation, no information for 15 of the 1,169 accidents was available. Of the remaining 1,154 accidents, the use of ethanol and/or drugs, along with applicable underlying medical conditions, were determined to be cause and/or factors in 57 (5%) of the accidents.

DISCUSSION

The percentage (86%) of the NTSB-investigated aviation accidents from which postmortem pilot fatality samples were submitted to CAMI was comparable to that reported in earlier studies (80%; 86%) (9,10). The higher number of pilot fatality cases (1,192) processed at CAMI than that submitted by the NTSB (1,116) might be because the NTSB may or may not investigate accidents involving unregistered aircraft, and CAMI may receive samples from aviation accidents not investigated by the NTSB. As elaborated in previous publications (9,10), other reasons for not receiving postmortem samples at CAMI could be un-recoverability of the remains of the airmen from accident scenes, religious beliefs of the pilot's family regarding autopsy, and the investigator-in-charge's decision not to send samples to CAMI.

With reference to the first 5-yr period (1,845 pilot fatalities; 1989–1993) (2), the number of pilot fatality cases toxicologically evaluated at CAMI decreased by 9%, 14%, and 27% in the second, third, and fourth 5-yr periods, respectively (3,4,8). The decline in cases increased to 37% in the fifth 5-yr period. The decreasing trend in the pilot fatalities during the 25 yr could be translated into the trend in aviation accidents because (i) only pilots were included in the 5-yr studies, and (ii) there would be only one pilot in command of an aircraft—that is, one pilot per aircraft or one pilot fatality per accident.

The present study, per se, does not answer whether the observed decrease in the pilot fatalities is a true reflection of the decline in aviation accidents. To answer this question, the numbers of yearly pilot fatality cases from the CAMI toxicology database for the period from 1990 through 2013 were compared with the numbers of active airmen, given in the FAA's U.S. Civil Airmen Statistics for the 24-yr period (18). The pilot fatality group is based on factual numbers, while the active airman group on estimated numbers. An active airman is one who holds both an airmen certificate and a valid medical certificate (18). Linear regression analyses of the numbers of both groups revealed a decline in the pilot fatality cases (slope: –6.5570), as well as in the active airmen (slope: –3.4348) (Fig. 4). Such reduction in numbers does not necessarily suggest that there is a true decrease in aviation accidents with time, since both lines are descending (negative slopes), though the slope with the pilot fatalities is steeper than that with the active airmen. The observed decline in the pilot fatalities—thus, in aviation accidents—might be the resultant of the decreasing airman population and of the safety measures taken, implemented, and enforced by aviation regulatory authorities and industry in the past two and a-half decades.

The high percentage (91%; 1,068 of 1,169) of the operation of aviation accident aircraft under the category of general aviation (14 CFR Part 91) (11) was similar to the percentages (≈ 90%) noted in the previous three 5-yr studies (3,4,8). The pattern of maximum numbers of airmen (50%; 579 of 1,169) rated as private pilots, followed by commercial and airline transport pilots, was in agreement with that reported in the earlier two 5-yr studies (3,8). Consistent with the observations made in the previous three 5-yr studies (3,4,8), the majority of fatally injured aviators held third-class medical certificates; subsequent to this group of pilots were second- and first-class medical certificate-holding aviators. It should be mentioned that sport pilots are not required to have a medical certificate, since a valid driver's license suffices the need to fly an aircraft under the sport pilot flying category (14).

In comparison to the previous four 5-yr studies (2-4,8), the percentage of pilot fatalities (7%) wherein ethanol was found remained nearly the same (Fig. 3), suggesting the ethanol usage in the population of fatally injured airmen did not change in the past 25 yr. This "no-change" pattern is in agreement with the 2011–2013 National Survey of Drug Use and Health finding where the ethanol (alcohol) usage also remained almost the same within the age group of 26 and older individuals (19). An increasing tendency in the use of illicit drugs noticed in this survey (19) and in the DrugFacts published by the National Institute on Drug Abuse of the National Institutes of Health (20) is analogous to the increase found in the five 5-yr studies. With a net surge of 267%, an increase for illicit drugs from 6% during 1989–1993 (2) to 16% during 2009–2013 was evident in the fatally injured pilot population (Fig. 3). Although no clear-cut trend could be established for the nonprescription drug usage in the fatally injured airmen, an increasing trend was clearly evident with prescription drugs: an increase from 6% during 1989–1993 (2) to 35% during 2009–2013 (Fig. 3), signifying a jump in the prescription drug usage by 583%.

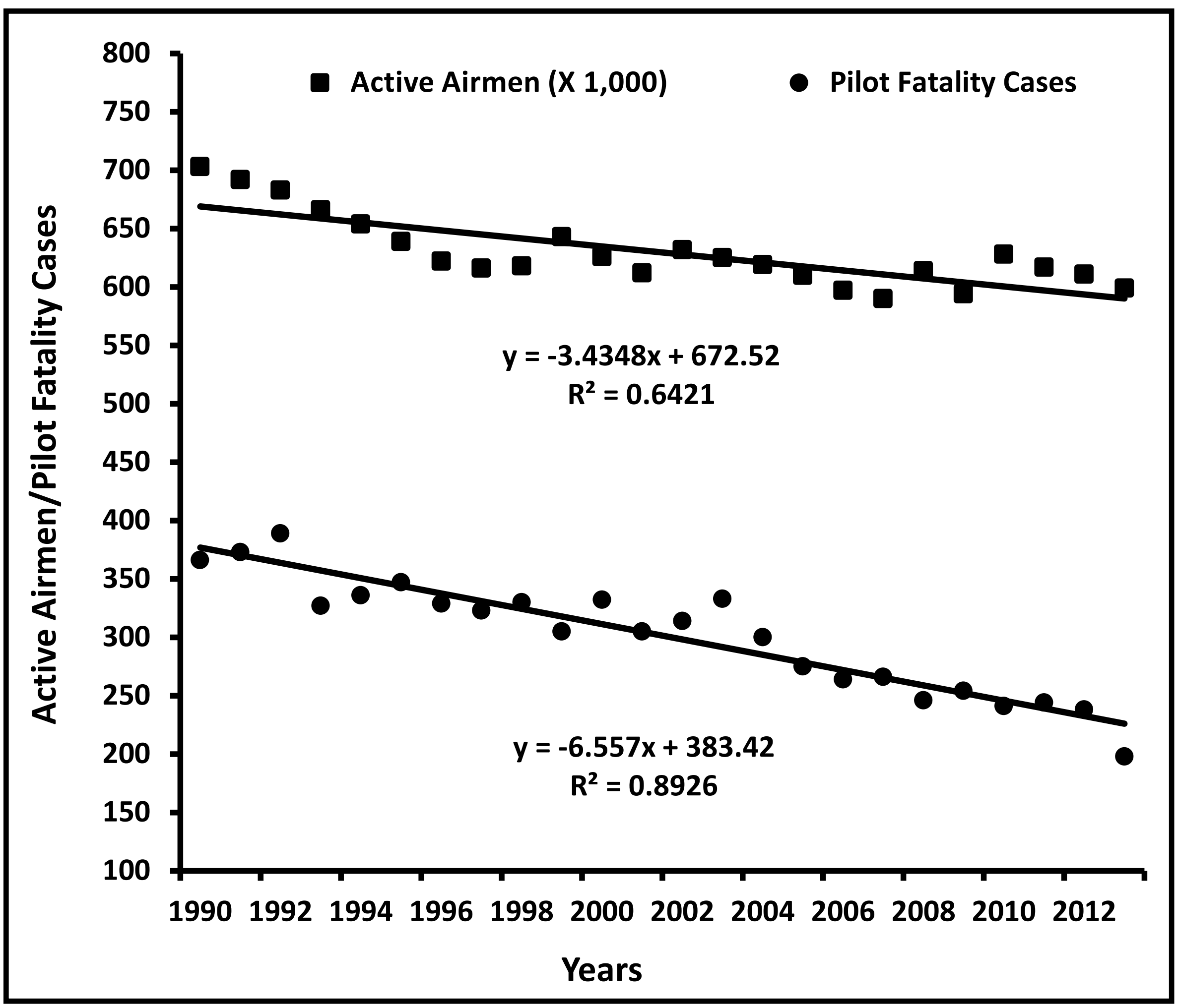

Figure 4. The numbers of active airmen from the FAA's U.S. Civil Airmen Statistics (18) and of pilot fatality cases toxicologically evaluated at CAMI during the 24-yr period (1990–2013).

When combined, the overall presence of ethanol and drugs in the fatally injured aviators went up from 31% during 1989–1993 (2) to 74% during 2009–2013, which is a surge of 239%. This increase is primarily attributed to the continuous rise in the use of prescription drugs.

In relation to the ethanol and illicit drug groups, the higher increase noticed in the prescription drug usage might be due to only one analyte in the ethanol group and the relatively limited numbers of analytes in the illicit drug category than the number of analytes in the prescription drug category. Because of inventions, new prescription drugs are constantly being introduced into the pharmaceutical market, thus the surge is clearly more evident with prescription drugs (Fig. 3). Additionally, the continuous advancement and improvement of the analytical methods, techniques, and instruments with time have been playing significant roles in easily analyzing and detecting drugs and their metabolites, even when they are present in small concentrations, in the submitted biological samples. In comparison to prescription drugs, the total number of analytes in the ethanol and illicit drug groups did not increase significantly during the mentioned time period. Furthermore, the consumption of ethanol and illicit drugs are regulated and controlled by local, state, and federal laws and law/drug enforcement agencies. Therefore, the inventions, analytical developments, and law/drug enforcement factors played contributory roles in potentiating the considerable increase of prescription drugs and in limiting the increase of ethanol and illicit drugs.

With aviation accident pilot fatalities, there is always a strong potential for putrefaction due to severe impact, damage, and open wounds to victims' bodies and, thus, for the postmortem production of ethanol (5-7). Nonetheless, the postmortem ethanol production could be ruled out by performing distribution of ethanol in accompanied multiple biological sample types. If ethanol is found in all the analyzed sample types, then the presence of ethanol could be deduced to be because of ingestion. If ethanol is absent in any other sample(s), then the presence of ethanol is attributed to other than ingestion, most likely to be from postmortem production. In the present study, there were six ethanol positive cases wherein the ethanol concentration in a sample was ≥ 40 mg·dl^{-1} (or mg·hg^{-1}), but there was at least one accompanying sample type in which ethanol was not detected. Based upon the selective presence of ethanol, it could be scientifically inferred that the presence of ethanol in these six cases was associated with the postmortem production of ethanol, rather than due to ingestion.

Illicit drugs—such as amphetamine, cannabis, cocaine, and methamphetamine—detected in the pilot fatalities could be linked to their unauthorized use by the aviators. However, the presence of drugs like atropine, benzodiazepines, narcotic analgesics, and lidocaine might be suggestive of the administration of these drugs by health care providers to the victims for various medical reasons and necessities at accident scenes and/or at health care facilities. Prescription and nonprescription drugs found in the pilots suggested the common usage of the medications for treating illnesses—for example, allergy and common cold, depression, fever, headache, hypertension, pain, and sleep disorders. The spectrum of drugs found in the pilots was in agreement with the common drugs used in general population. This consistency is similar to that reported earlier with aviation accident pilot fatalities for a particular time period such as during 1989–1993 (2), 1994–1998 (4), 1999–2003 (8), and 2004–2008 (3) and is obvious, as airmen are also part of society.

Because of a decision/situation not to investigate a particular accident or the involved aircraft are unregistered, not all aviation accidents are investigated by the NTSB. Information related to the investigations of 15 of the 1,169 accidents was not available; possibly, their investigations might not yet have been finalized. In spite of these exceptions, the NTSB has completed investigations of 1,154 (99%) of the 1,169 accidents. The use of ethanol and/or drugs by aviators, along with applicable underlying medical conditions, was determined to be the cause and/or factors in 5% (57 of 1,154) of the accidents. In the remaining accidents, the cause/factors were determined to be other than ethanol and/or drug usage and associated illnesses. These accidents might have been linked to the procedural/pilot errors, adverse weather conditions, and/or mechanical malfunction. Although many studies have been conducted to establish the prevalence of ethanol and drugs in airmen who were fatally injured in aviation accidents, it is not known how the prevalence of these substances is similar to that in the active airmen not involved in accidents. This type of comparative study, as suggested by the NTSB (21), would be helpful in assessing the safety risks of the use of ethanol and drugs by aviators while flying.

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