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Prevalence of Anti-epileptic Drugs found in Aviation Cases between 2000 and 2017

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16. Abstract

Anti-epileptic drugs (AEDs) are a group of drugs used for the treatment of epilepsy and other medical conditions, such as neuropathic pain, bipolar disorder, or migraine headaches. Many of the AEDs carry potential impairing risks because of their central nervous system (CNS) depressant effects. Therefore, the Forensic Sciences Section (FSS) of the Federal Aviation Administration conducted a study to evaluate the prevalence of AEDs in aviation accidents from 2000 – 2017.

During this 18-year time period, the FSS performed toxicology analysis on 5,996 biological specimens from aviation accidents. The toxicological evaluation revealed that 2,480 cases (41%) were positive for one or more drugs with AEDs detected in 52 cases. These cases involve 44 pilots, co-pilots, or flight instructors; six passengers; one crew member; and one parachutist.

The National Transportation Safety Board (NTSB) is responsible for obtaining pertinent medical history of pilots involved in accidents and determining the probable cause of aviation accidents. According to the NTSB case reports, the use of drugs or a medical condition was determined to be the cause or contributing factor in 13 of the 36 completed cases. The medical histories from the NTSB case reports revealed that nine airmen were in fact taking an AED for various medical conditions, including seizures. None of the airmen reported the use of an AED or medical condition associated with an AED on their most recent FAA medical exam.

The present study disclosed that the prevalence of AEDs in aviation cases received by the FSS was less than 1% for 2000 – 2017. Although the overall prevalence of AEDs is low, airmen should be educated on the CNS depressant effects associated with taking an AED that can affect flying.

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Introduction

Anti-epileptic drugs (AEDs) are a group of drugs prescribed for the treatment of epilepsy, a neurological disorder occurring when there is a disruption of electrical communication between neurons. Epilepsy is a group of disorders, not a single disease. There are several disorders within this group such as absence seizures, atonic seizures, catamenial seizures, cluster seizures, episodic disorders, Dravet syndrome, focal seizures (also known as partial seizures), focal seizures with secondary generalization, focal seizures with secondary generalized tonic clonic seizures, infantile spasms, juvenile myoclonic epilepsy, Lennox-Gastaut Syndrome, myoclonic seizures, tonic seizures, tonic clonic seizures, and West Syndrome with tuberous sclerosis (1). During the time period of 2000 – 2017, the Forensic Sciences Section (FSS) of the Civil Aerospace Medical Institute (CAMI) detected 11 different AEDs. These include carbamazepine, clonazepam, gabapentin, lamotrigine, levetiracetam, oxcarbazepine, phenobarbital, phenytoin, primidone, sodium valproate (valproic acid), and topiramate.

Eight of the 11 AEDs detected by the CAMI laboratory were in the top 200 prescribed drugs in 2017 with gabapentin making the list as the 12th most prescribed drug in 2017 (2). Gabapentin is also used for neuropathic pain so it is unknown if the high number of prescriptions is for the treatment of neuropathic pain or epilepsy. The other AEDs in the top 200 prescribed drug list in 2017 are clonazepam, lamotrigine, levetiracetam, oxcarbazepine, phenytoin, pregabalin, and topiramate.

AEDs may be prescribed for conditions other than seizures, such as chronic pain, neuropathic pain, bipolar disorder, fibromyalgia, migraine headaches, and trigeminal neuralgia (3). Thus, the presence of an AED in an accident investigation case does not necessarily indicate that an individual suffers from a seizure disorder. AEDs can cause many adverse effects including psychotropic and central nervous system (CNS) depression. Other symptoms include agitation, ataxia, cognitive impairment, diplopia, dizziness, nausea, headache, vomiting, fatigue, vertigo, blurred vision, tremors, and drowsiness (4).

The Federal Aviation Administration (FAA) regulations of medical standards and certificates for first-class airmen, second-class airmen, and third-class airmen are found in the Code of Federal Regulations (5). There are two rules under the neurologic standards in order for an airmen to obtain a medical certificate. The first is to have no established medical history or clinical diagnosis of epilepsy, no disturbance of consciousness, or no transient loss of control of nervous system function(s) without a satisfactory medical explanation of the cause. The second is to have no other seizure disorder, disturbance of consciousness, or neurologic condition that the Federal Air Surgeon, based on the case

history and qualified medical judgment, finds that the person is unable to safely perform the duties or exercise the privileges of the airman certificate applied for or held. Certification is possible, given a satisfactory medical explanation of the cause, as indicated by the Guide for Aviation Medical Examiners (6).

The prevalence of AEDs detected from 5,996 aviation cases is presented in this study. AEDs were detected in 52 accidents involving pilots, co-pilots, flight instructors, a crewmember, passengers, and one parachutist. A search of the results from the CAMI's Forensic Toxicology Database, the Document Imaging and Workflow System (DIWS), and the National Transportation Safety Board's (NTSB) Aviation Accident Database was performed to extract applicable information for the study. This information consisted of toxicology results of AEDs detected in the subjects tested, their flying and medical certification categories, demographics, and aeromedical histories. The cause and factors leading to the aviation accidents were evaluated. It is hoped that the results of the study will be useful in the investigations of AED associated aviation accidents and may be important to aeromedical authorities in regulating epileptic conditions and AED usage in airmen.

Methods

Following an aircraft accident, the NTSB and FAA initiate an investigation. An integral component of this investigation is the toxicological analysis of biological specimens from those involved in the accident. In fatal accidents, the local medicolegal death investigator (medical examiner or coroner) performs an autopsy under the Aviation Safety Research Act of 1988 and submits specimens to CAMI, located in Oklahoma City, OK (7). CAMI provides a collection kit, referred to as a Tox Box, which contains all the components needed to collect and ship specimens to the FAA's FSS. Biological samples collected from aviation accidents may include blood, urine, vitreous fluid, bile, liver, lung, kidney, spleen, muscle, brain and/or heart; however, CAMI receives blood in about 75% of the cases due to the violent nature of aircraft accidents.

Analysis for the presence of over-the-counter (OTC), prescription (Rx), and illicit drugs, as well as volatiles, combustion gases (carbon monoxide and cyanide), glucose and hemoglobin A1C, are performed (8-10). The tests performed are dependent on the availability of the biological specimens received and on the role of the victim in the affected aircraft. CAMI only performs an analysis on passengers for carbon monoxide in those cases involving a fire, and cyanide analysis on positive carbon monoxide results. This is because passengers are not in control of the aircraft and, therefore, toxicology testing on these individuals is considered not pertinent to the cause of the accident.

Additional toxicology tests may be performed on passengers at the request of the NTSB or FAA investigator. Toxicology analyses will be performed on all victims identified as the pilot, co-pilot, flight instructor, or any certificated individual from the accident.

AEDs are a group of drugs that the FSS has the ability to detect using solid-phase extraction techniques and instrumentation such as gas chromatography mass spectrometry (GC/MS), high performance liquid chromatography (HPLC), and liquid chromatography mass spectrophotometry (LC/MS). A positive finding of an AED in the preliminary tests will initiate additional analyses to confirm and/or quantitate if it is present.

Demographics of the accident and toxicology results are stored in CAMI's Forensic Toxicology database (ToxFlo™). The database was developed in 1990 specifically for aviation accident investigations and has information pertaining to all investigations and toxicology performed at the Forensic Sciences Laboratory during this time. During an airmen's medical evaluation, his/her medications and medical conditions are stored in DIWS. This information is obtained by the laboratory personnel and maintained in ToxFlo™ with each case. For the purposes of this report, medical information, toxicology results, and accident information stored in ToxFlo™ was reviewed for the time period of 2000 to 2017. The NTSB database was also evaluated for case reports, which includes medical history of the pilot and the probable cause determination.

Results

During 2000 – 2017, the FSS received biological specimens from 6,499 cases involved in aviation-related accidents. Of the cases received, toxicology was performed on 5,996 cases. The toxicological evaluation revealed that 2,480 cases (41%) were positive for one or more drugs. AEDs were determined to be present in 52 cases during 2000 – 2017. The cases involved 38 pilots, four co-pilots, two flight instructors; one crew member; one parachutist; and six passengers. Two of the cases (both pilots) in this study were nonfatal. For completeness of the data, the crewmember, passengers, and parachutist were included in the statistical data. These case types, however, are not considered to be operating an aircraft and are not routinely analyzed by the FSS. The pilots, co-pilots, and flight instructors were either in control, or potentially in control, of their aircraft at the time of the accident.

Of the 52 cases received, 50 were involved in an accident in which the flight was operating under the guidance of the Title 14 Code of Federal Regulations (CFR) Part 91 – General Operating and Flight Rules and one pilot was flying under the guidance of 14 CFR Part 137 – Agricultural Aircraft

Operations. The case involving the parachutist is not categorized by the laboratory as a flight operating under any CFR because the parachutist was outside the aircraft when the accident occurred.

The FAA divides the United States into nine regions as shown in Figure 1. The 52 cases in this study occurred in eight regions with no case coming from the Alaskan region. The Southwest, Southern, and Western-Pacific regions had 12, 12, and 10 accidents, respectively. The Central region had five accidents, while the Eastern and Northwest regions had four each. The New England region had three accidents and the Great Lakes region had two accidents.

Toxicology

The AEDs found in the 52 cases were carbamazepine, clonazepam, gabapentin, lamotrigine, levetiracetam, oxcarbazepine, phenobarbital, phenytoin, primidone, valproic acid, and topiramate. Six cases had only an AED detected, while the other 46 cases had other substances present in their system at the time of the accident (Figure 2). Two cases had more than one AED detected – one with lamotrigine and topiramate, the other with phenobarbital and primidone. The phenobarbital and primidone combination is expected because phenobarbital is a primary metabolite of primidone. Ethanol ($\geq$ 40 mg/dL) was detected in three of the 52 cases. Federal regulations state that no person may act as a crewmember of a civil aircraft while having a blood alcohol concentration of greater than 40 mg/dL (11). The other substances present in the cases included narcotic analgesics, antidepressants, antihistamines, antitussives, benzodiazepines, beta blockers, calcium channel blockers, muscle relaxants, and controlled substances.

There were 15 cases in which blood samples were available to quantitate the AEDs. The blood concentrations of AEDs, therapeutic ranges for the AEDs, and the victim's role in the accident are given in Table 2. The presence of AEDs in other sample types – kidney, liver, muscle, and urine – was confirmed by qualitative analysis.

Demographic Elements and Medical Certificate Status

There were 44 pilots, co-pilots, and flight instructors involved in the accidents during the time period studied. Forty-one (93%) were male and three (7%) were female, with an average age of 58.4 yrs (28-82, SD: 12.5). An FAA medical certificate is not required for a sport pilot or for a pilot operating a light-sport aircraft or glider. In this study, 10 of the 44 accidents involving nine pilots and one co-pilot did not require that the pilot hold a medical certificate (Figure 3). Although these pilots and co-pilot were not operating an aircraft that required a medical certificate, FSS personnel search the DIWS

database for past aeromedical history when the case is received at CAMI. Three pilots and one co-pilot were not found in the DIWS database, indicating that they had not participated in the FAA medical certification process. The other six pilots were located in the DIWS database, but all of them had an expired medical certificate.

There was 34 accidents involving 29 pilots, three co-pilots, and two flight instructors in which a medical certificate was required for the pilot to operate the aircraft (Figure 3). A valid medical certificate was held by 21 pilots, two flight instructors, and one co-pilot in these accidents. Six pilots and two co-pilots were determined to have an expired medical certificate. DIWS records indicate that one pilot was flying with a special issuance and one pilot had an expired special issuance.

Only 24 of the 44 pilots, co-pilots, and flight instructors in this study held a current medical certificate to fly (Figure 3). Eight airmen held a Class 2 medical certificate, while 16 held a Class 3 medical certificate. There were no Class 1 fatalities from 2000 – 2017 that were positive for an AED. The flying categories of the 24 airmen include: one student, one sport, three airline transport, five commercial, and 14 private pilots.

Aeromedical History

The medical certification process requires that an airmen have a medical examination by an Aviation Medical Examiner (AME) and they must disclose current medications and any neurological medical conditions. According to CAMI aeromedical records, 40 airmen (Valid Medical, N=24; Expired Medical, N=14; Current Special Issuance, N=1; Expired Special Issuance, N=1) were listed in the DIWS database. The latest examination was evaluated for medications and medical conditions reported by the airmen at the examination. None of the 40 airmen found in DIWS reported AED usage or neurological medical conditions to the FAA. However, a total of 19 airmen reported the use of other medical drugs for the treatment of various conditions including hypertension, depression, pain, and cardiovascular disease.

NTSB Database and Reports

The NTSB is responsible for the determination of probable cause of an aviation accident and for identifying other contributing factors that might have led to the mishap. During 2000-2017, the NTSB investigated 50 of the 52 accidents in which a subject in the accident was positive for an AED. The NTSB did not investigate the accident involving the parachutist or an accident involving an ultralight aircraft. The passengers (N=6) and crewmember (N=1) are not included in this evaluation of the

NTSB reports because none of these subjects were in control of the flight. Therefore, the NTSB investigated 43 accidents that involved the pilot, co-pilot, or flight instructor's use of an AED. The final report and probable cause have been issued in 36 of those accidents. The use of drugs or a medical condition was reported as the probable cause or contributing factor in 13 (36%) of the 36 accidents, which involved 12 pilots and one flight instructor. The NTSB did not specifically list any AED as the probable cause of these cases.

According to the NTSB database, 36 accidents (30 pilots, 4 co-pilots, 2 flight instructors) are complete with a final report and probable cause issued by the NTSB. In the investigation process, the airmen's personal physician medical records and the FAA's aeromedical history of the airmen are obtained, as available, by the NTSB for review. The NTSB found that in 27 of the 36 completed cases, there was no indication of AED usage as reported by the airmen or the personal physician's medical records. In two cases, the personal physician's medical records stated that the airmen were taking medications for psychosis or depression, but the medication was not specified.

The personal physician's medical records for nine airmen listed an AED in their current medications. These AEDs included carbamazepine, phenytoin, gabapentin, clonazepam, lamotrigine, and valproic acid, and were prescribed for seizures, depression, and chronic migraine headaches (Table 2). All nine of these airmen were operating an aircraft that required a valid medical certificate. Eight of the nine airmen held a valid medical certificate, thus they failed to disclose the use of an AED to the FAA at their AME examination. The remaining airman had an expired medical certificate and FAA aeromedical records show no history of a neurological medical condition or AED usage at his last medical examination.

Discussion

The role of the FSS at CAMI is to support the critical mission of the FAA's Office of Aviation Safety in maintaining and improving the safety of flying public. With the use of state-of-the-art analytical methodology, the FSS assists the NTSB in the investigation of aviation accidents (both fatal and non-fatal, as requested) by providing testing that identifies if a chemical substance had any effect on the pilot's ability to operate the aircraft. In addition, the FSS performs important research into the prevalence and usage patterns of licit and illicit drugs in pilots involved in fatal aviation accidents. The current study examined the presence of AED's in postmortem biological samples obtained from aviation accidents during the 2000 – 2017 period.

For the 18-year period studied, 52 cases tested positive for one or more AED's. Cases included individuals that were identified as pilots, co-pilots, flight instructors, a crewmember, passengers, and a parachutist. Data shows that the majority of the aviators were Class 3 private pilots that were current with their medical certification. Unless circumstances call for it, the NTSB does not routinely request toxicology testing on crewmembers, passengers, or parachutists. The presence of AEDs and other medications is important because they could have detrimental effects on the aviator's ability to operate their aircraft.

It is important to note that the presence of an AED does not conclusively indicate a seizure condition for the individual. These drugs are used to treat other health problems as well. For example, in addition to being an adjunct treatment for partial seizures, gabapentin is prescribed for neuropathic pain. Topiramate and valproic acid are also given for the treatment of migraine headaches. Lamotrigine is used as a mood stabilizer for bipolar disorder. This fact was borne out in the present study when reviewing reports from the 36 completed cases by the NTSB. Nine of those cases listed AED medication, three of which were for seizures, but other conditions ranged from depression to migraine headaches (Table 2).

AEDs carry potential performance impairing risks with them as a result of having CNS depressant effects. The 11 AEDs detected in the 52 cases evaluated in this study (Figure 2) are known to cause effects ranging from drowsiness to significant sedation. As a result, these drugs are not accepted by the FAA for pilot use due to effects that are detrimental to their ability to fly. Carbamazepine, for example, is a tricyclic antidepressant analogue used for treating epilepsy and trigeminal neuralgia. It is a CNS depressant with its primary effect being sedation that is detrimental to human performance. Four of the 52 cases in this study were positive for carbamazepine. Clonazepam is a benzodiazepine, a class of drugs known to cause significant performance impairment due to CNS depression. Four cases were positive for this drug as well. The drug recording the most positives from the 52 cases was gabapentin (17 cases). Among the most common side effects of this drug are somnolence, dizziness, and fatigue, all detrimental to pilot performance. Primidone and phenobarbital were also detected. Both of these AEDs have been on the market for decades and both have sedating effects. Interestingly, phenobarbital is also a metabolite of primidone, explaining the presence of both in one of the study cases.

The presence of multiple performance affecting medications in a subject was noted in this study as well. When an individual is taking multiple AEDs, or AEDs plus other substances, there is a potential for additive CNS depressant effects. Figure 2 shows that 46 of the 52 cases had medications in their

body in addition to the AED. These medications included opiates, antihistamines, and muscle relaxants, all of which enhance CNS depressant effects detrimental to appropriate aviator performance.

Quantitative analysis was performed on 15 of the cases in this study (Table 1). In the present study, eight different AED's were confirmed and quantified: carbamazepine, clonazepam, gabapentin, lamotrigine, oxcarbazepine, phenobarbital, phenytoin, and primidone. All of these drugs are known to have performance impairing effects such as drowsiness and dizziness. Most of the drug concentrations were below the blood value expected with consistent therapeutic use. Reasons for these low concentrations are unknown but could result from sub-therapeutic doses, non-compliance with prescription instructions, sporadic use, or abuse. Five cases, however, had drug concentrations within the therapeutic range increasing the chance of performance impairing effects alone or in combination with other substances. Interestingly, one pilot was found to have a slightly elevated blood concentration of gabapentin (12.3 micrograms/milliliter). The blood concentration in this pilot is within the range of values found in motor vehicle drivers arrested for impaired driving (12).

Caution must be exercised when interpreting the blood concentrations in Table 1. There must be a consideration of postmortem redistribution (PMR) and contamination from injury. PMR is a well-studied postmortem phenomenon that results in changes in drug concentration in blood (13). After death, a drug that is subject to PMR diffuses from highly concentrated tissues into the surrounding blood sources, changing the amount that was there when death occurred. The net change in concentration is influenced by the quantity of drug in the tissue at death, the drug's chemical and pharmacokinetic properties, orientation of the body, putrefaction, dosage ingested, and the time intervals between death and the collection of samples from the body (postmortem interval). A literature review of the drugs with quantitative values (Table 1) showed that only phenytoin is subject to significant PMR (14-16).

At the time of publication, 36 cases in this study have been completed by the NTSB. After careful consideration of all of the evidence, none of the AEDs detected in these cases were reported to have been causal or contributory to their respective aviation accident.

Conclusion

This study focused on the prevalence of AEDs found in aviation accidents handled by CAMI's FSS. AEDs are a group of drugs used for the treatment of epilepsy, as well as other medical conditions, such as neuropathy. The side effects of AEDs include dizziness, sedation, fatigue, and incoordination, all of

which could negatively influence the operation of complicated tasks, such as piloting an aircraft. From 2000 – 2017, 52 (1%) cases were positive for one or more AED with gabapentin being the most prevalent AED in the dataset. AEDs were present in pilots, co-pilots, flight instructors, passengers, a crew member, and a parachutist.

In 46 cases, there were substances other than an AED present causing a potential for additive CNS effects. Quantitative values were obtained in blood for 15 cases, but only five cases had drug concentrations within the therapeutic range.

The data reveals that 24 pilots, co-pilots, and flight instructors held a valid medical certificate. None of the airmen reported the use of an AED or a medical condition associated with AED use on their most recent medical examination; however, the NTSB case reports revealed that nine airmen were prescribed an AED at the time of the accident for seizures, migraine headaches, or chronic pain. The findings of this study confirm the necessity for airmen to fully disclose medications, particularly those that have the potential for impairing side effects which could have a negative influence on the safe operation of an aircraft.

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Figure 1. Number of Accidents involving AEDs per FAA Regions.

Figure 2. Number of Cases Positive with an AED

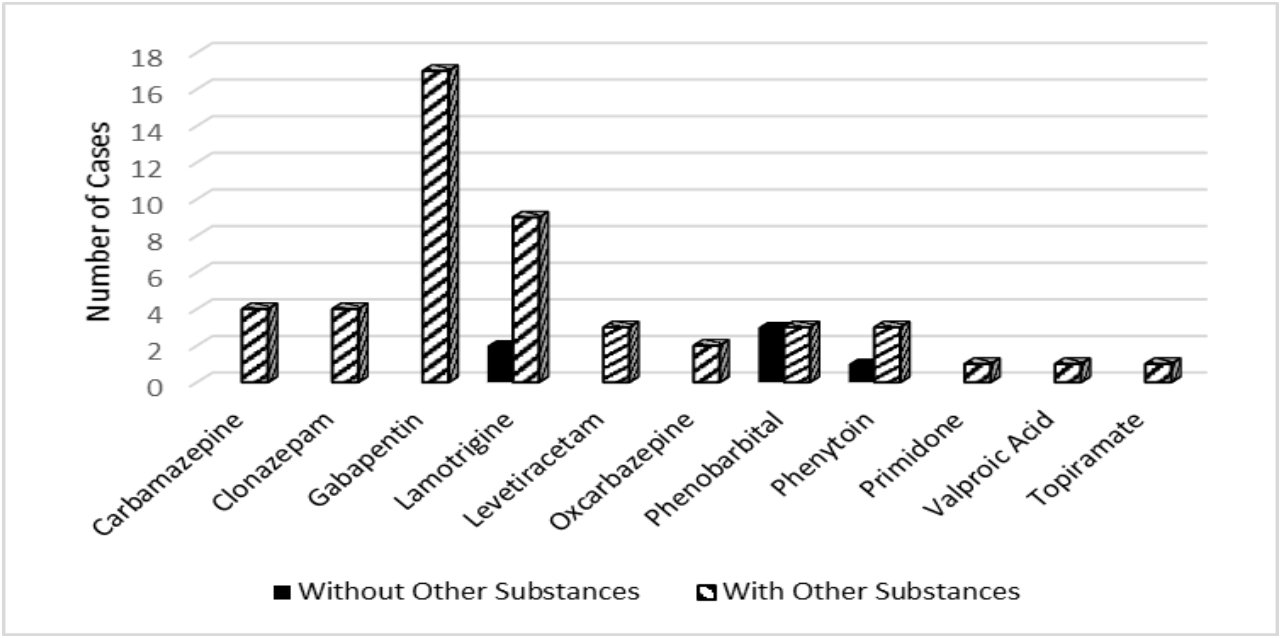

Figure 3. Medical Certification Status in regards to Aircraft Type

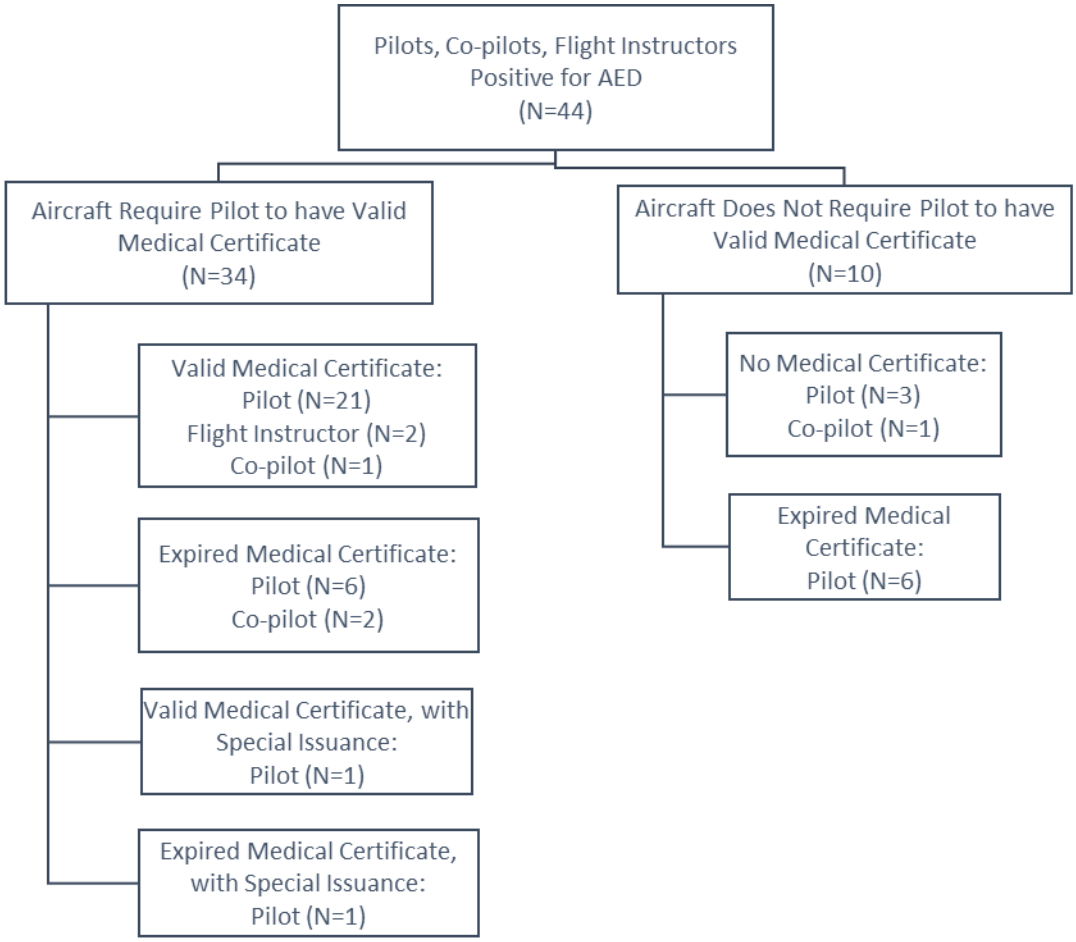

Table 1. Quantitative results for AEDs detected in the blood of 15 cases (* = same case).

Drug	Therapeutic Range[17,18] (μg/mL)	FSS Results (μg/mL)	Role
Carbamazepine	1.4 – 12	7.1	Pilot
		0.186	Pilot
Clonazepam	0.007 - 0.075	0.023	Co-pilot
		0.011	Pilot
Gabapentin	2 - 10	12.3	Pilot
Lamotrigine	2 – 19	11.3	Parachutist
		0.145	Passenger
Oxcarbazepine	10 – 35	1.8	Pilot
		2.4	Passenger
Phenobarbital	10 – 40	0.169	Pilot
		4.4	Passenger
		0.523	Pilot
		1.8	Pilot*
Phenytoin	10 – 20	8.7	Passenger
		3.5	Pilot
Primidone	2 - 19	3.1	Pilot*

Table 2. Aeromedical History and NTSB Causal of 9 Cases with AED usage.

Case	AED Detected	Other Substances Detected	Drug History	Medical History	NTSB Cause/Contributing Factor
1	Carbamazapine	Desipramine Imipramine Morphine Salicylate	Tegretol Aspirin Imipramine	Seizures Migraines	The pilot's low altitude maneuver using an excessive bank angle, and his failure to maintain airspeed which resulted in an inadvertent stall and subsequent collision with a building. A factor was the pilot's impairment from prescription medications.
2	Phenytoin		Dilantin (phenytoin)	Seizure 2-3 years prior to accident	The pilot's inadequate preflight inspection, which resulted in a total loss of engine power due to fuel contamination. A factor was the lack of an installed fuel strainer.
3	Gabapentin	Carisoprodol Fentanyl Fluconazole Meprobamate Metoclopramide Trimethoprim	Fentanyl Carisoprodol Gabapentin Alprazolam Metoclopramide Esomeprazole Fluconazole Levofloxacin Loratadine Triamcinolone	Chronic Back Pain Opiate Addiction Allergy Rhinitis	The flight instructor's improper decision to attempt a simulated engine failure at a low altitude and her failure to maintain clearance from trees and wires, while maneuvering. Also causal was the flight instructor's impairment from prescription medication.

Table 2. Aeromedical History and NTSB Causal of 9 Cases with AED usage.

Case	AED Detected	Other Substances Detected	Drug History	Medical History	NTSB Cause/Contributing Factor
4	Lamotrigine	Alprazolam Alpha-hydroxyalprazolam Citalopram Di-N-desmethylcitalopram N-Desmethylcitalopram	Valsartan/Hydrochlorothiazide Amlodipine Lamotrigine Escitalopram Clonazepam Alprazolam Esomeprazole	Diabetes Coronary Artery Disease High Blood Pressure Gastroesophageal Reflux Disease Degenerative Joint Disease Mouth Cancer Transient Ischemic Attack Tremors Short-term Memory Loss	The pilot's improper decision to attempt a flight with known serious medical conditions, which resulted in impairment during cruise flight, likely due to a stroke or transient ischemic attack. A factor was the pilot providing false information on his medical application.
5	Clonazepam 7-aminoclonazepam	Bupropion Bupropion Metabolite Chlorpheniramine Desmethylvenlafaxine (O-) Lidocaine Metoprolol Morphine Venlafaxine	Klonopin	Recent Overdose - hospitalization at psychiatric facility	The pilot's failure to maintain proper control of the airplane during an off airport landing. Contributing factors were the pilot's psychological condition, impairment due to overdose of prescription medication, inadequate in-flight planning and mountainous terrain.
6	Gabapentin	Acetaminophen Bupropion Bupropion Metabolite Dihydrocodeine Hydrocodone Tramadol Trazodone	Tramadol Gabapentin Trazodone Flurazepam Hydrocodone Bupropion	Anxiety Depression Muscle Pain Severe Headaches Obstructive Sleep Apnea Memory Loss	The pilot's failure to maintain control of the airplane for undetermined reasons. Contributing to the accident included his extensive use of medications and/or his multiple medical conditions and the failure of the FAA to follow up on his reported medication use.

Table 2. Aeromedical History and NTSB Causal of 9 Cases with AED usage.

Case	AED Detected	Other Substances Detected	Drug History	Medical History	NTSB Cause/Contributing Factor
7	Gabapentin	Acetaminophen Bupropion Bupropion Metabolite Cyclobenzaprine Dihydrocodeine Duloxetine Hydrocodone Hydromorphone Naproxen Propranolol	Propanolol Gabapentin Ibuprofen Naproxen Hydrocodone Ketorolac Promethazine Cyclobenzaprine Bupropion Methylprednisolone	Migraine Headaches Muscle Spasm	The pilot's impairment due to medication use, a migraine headache, or both, and his decision to continue the approach below minimums without the proper visual references, resulting in the subsequent collision with terrain. Contributing to the accident was the pilot's falsification of medical information provided to the FAA.
8	Lamotrigine	THCCOOH THC Diphenhydramine	Lamotrigine	Depression Seizure Disorder Opiate Addiction	The pilot's failure to maintain airplane control. Contributing to the accident was the pilot's impairment due to acute psychosis with paranoid thoughts.
9	Valproic Acid	THCCOOH THC Oxazepam Rosuvastatin	Divalproex Sodium (Valproic Acid)	High Cholesterol Hypertension Hypothyroidism Insomnia Dysthymia Sinus Disease Chronic Headaches	The pilot's loss of control of the airplane after pitching it excessively nose up during a go-around, which resulted in a subsequent aerodynamic stall/spin.