Drug Use Reported by U.S. Pilots, 2009–2014

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INTRODUCTION: There is a growing trend in the use of drugs, which could increase the likelihood of an aircraft accident. Evidence exists that pilots do not report all medications to the Federal Aviation Administration (FAA). The purpose of this study was to compare medications discovered by postaccident toxicology testing to those reported to the FAA to determine the veracity of pilot reported medications.

METHODS: Medications reported on applications for U.S. medical certificates were compared to those discovered during postaccident toxicology testing. Logistic regressions were performed using Age, Gender, Type of Flight Operation, Medical Class Issued, and whether a Special Issuance (SI) medical certificate was issued as independent covariates. Truth in Reporting a medication was the outcome variable.

RESULTS: Age and an SI medical certificate were good predictors of the likelihood of truthfully reporting medications. For each year of age the probability of a subject drug record being truthfully reported increased by 5%, while a pilot with an SI was 3.12 times more likely to be truthful than a pilot without an SI. When reported medications were limited to cardiovascular drugs, Age was the only good predictor of truthful reporting and, for every additional year of age, the probability of a subject drug record being truthfully reported increased by 3%.

CONCLUSIONS: This study showed that the probability of a pilot truthfully reporting medication use increases with Age and an SI medical certificate. When reported medications were limited to cardiovascular drugs, Age was the only good predictor of truthful reporting.

KEYWORDS: aviation, aviation safety, medications, pilots, reporting, truthful reporting.

DeJohn CA, Greenhaw R, Lewis R, Cliburn K. *Drug use reported by U.S. pilots, 2009–2014*. Aerosp Med Hum Perform. 2020; 91(7):586–591.

Title 14 CFR 61.53 (a) prohibits a person from acting as the pilot of an aircraft if they are taking medication "… that results in the person being unable to meet the requirements for the medical certificate...".[12] Title 14 CFR 91.17 states, "No person may act or attempt to act as a pilot…of a civil aircraft…[w]hile using any drug that affects the person's faculties in any way contrary to safety."[11]

Title 49 CFR 40.1 requires that personnel in safety-sensitive positions submit to pre-employment, reasonable suspicion, random, return to duty, follow-up drug and alcohol testing, and drug testing following accidents.[7] Although mandatory testing in the transportation industry, according to Title 49 CFR 40.85, is currently limited to opiates, marijuana, amphetamines, cocaine, and phencyclidine,[8] the increasing use of over-the-counter (OTC), prescription, and illicit drugs in the U.S. population has raised concern about the possible safety implications of increased drug use in aviation, especially in air transport operations.[18]

Studies of medication use among pilots involved in fatal aircraft accidents have shown increasing trends in the use of all categories of drugs.[6,17] Some medications have the potential to significantly impair alertness, judgment, reaction time, and behavior, all of which could impair the ability to safely operate an aircraft and increase the likelihood of an accident.[4,16] More specifically, there has been an increasing trend in the use of antihistamines by pilots,[19] in particular diphenhydramine.[4,16]

In addition to the increase in drug use, there is evidence that pilots do not report all medications they are taking to the Federal Aviation Administration (FAA). One recent study comparing pilot-reported medications to those identified during postmortem toxicological analysis found that the accuracy of

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This manuscript was received for review in November 2019. It was accepted for publication in April 2020.

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DOI: https://doi.org/10.3357/AMHP.5554.2020

pilot reporting of medication use was low, citing that only 8% had accurately reported the medications they were taking to the FAA.[3] Another study found that of 223 pilots found positive postaccident for psychotropic drugs, only 14 of those pilots had previously reported a psychological condition to the FAA, and only one reported the psychotropic medication later found during postaccident toxicological analysis.[5] In the same study, only 29 of 69 pilots who reported their cardiovascular disease reported the cardiovascular medication that was found during postaccident testing. Further, out of 15 pilots found positive postaccident for neurological medications, only 1 reported a neurological condition, and none of these 15 pilots reported the neurological medications found on postaccident toxicology.[5]

The FAA does not publish a list of prohibited or acceptable medications for use by pilots. However, a section of the Guide for Aviation Medical Examiners (AMEs)[13] does provide a "Do Not Use-Do Not Fly" list, which identifies certain drugs and medical conditions that AMEs should be aware of when a medical certificate application is submitted. The majority of drugs on the "Do Not Fly" list cause drowsiness, and time intervals specifying a safe period between drug use and safe flight are provided. In addition, drugs identified on a separate "Do Not Issue" list require a special issuance (SI) waiver from the FAA in order for the pilot to obtain a medical certificate. Airmen may be granted a time-limited SI medical certificate by the FAA Civil Aerospace Medical Institute (CAMI) Aerospace Medical Certification Division when it is evident a pilot has a medical condition that makes them ineligible for a regular medical certificate under Title 14, Part 67 of the Code of Federal Regulations.[13]

The FAA obtains over 95% of autopsy reports for individuals involved in fatal aviation accidents[15] and routinely tests blood and tissue samples from victims involved to determine medications used by a pilot that could have possibly caused impairment and led to an accident.[2,5] The purpose of this study was to compare medications discovered by postaccident toxicology testing to those reported to the FAA on medical certification applications in order to determine the accuracy/truthfulness of medication information provided by pilots.

METHODS

CAMI's Medical ANalysis TRAcking (MANTRA) database contains accident details, demographic information, and reported medications of pilots involved in fatal aircraft accidents. The CAMI Toxicological database (ToxFlo™) contains results from postmortem toxicological analysis of fatally injured pilots. Fatal accidents between 2009 and 2014 involving U.S. pilots in the MANTRA database were matched to those in ToxFlo. A subject drug record was defined as either a medication reported by a pilot, discovered on toxicology testing, or both reported and detected. All subject drug record findings associated with a pilot fatality were queried, but medications used to treat cardiovascular, psychological, or neurological conditions were evaluated in detail. These conditions were selected for two reasons: 1) they are serious conditions, and 2) they have the potential to rapidly incapacitate a pilot in flight. Further, medications used to treat such conditions are normally not started, discontinued, or changed without good documentation. By comparison, drugs used to treat less serious medical conditions are often started, discontinued, or replaced with other medications with little or no documentation, which can result in a clinically insignificant difference between reported medications and those found at the time of postmortem toxicological testing. This approach was also used by Canfield et al. in a previous report comparing pilot medical history and medications found postmortem.[3]

The combined dataset was used to compare medications reported to the FAA and those found on toxicological analysis in order to study the veracity of pilot medication reporting and to determine the prevalence of U.S. pilots who did not accurately report their medication use to the FAA. Toxicology results for ethanol, other alcohols, and illegal drugs were not analyzed for in this study as pilots generally do not report their use of such drugs to the FAA on their medical application. A subject was defined as any medically certified pilot or pilot-rated passenger where adequate autopsy records were available. A pilot-rated passenger was a medically certified pilot who was not in control of the aircraft at the time of the accident. When accidents involved multipilot crews or there was more than one pilot on board, all medically certified pilots for which adequate autopsy and toxicology records were available were included in the study.

Logistic regression models were used to determine odds ratios (ORs) for the association of selected covariates with truthfulness in reporting medications to the FAA. By odds, we mean the probability of an event occurring divided by the probability of it not occurring. In addition, by odds ratio, we mean the ratio of the odds of an event at one point to the odds of the same event at another. For example, an OR of 1.05 for events a year apart would indicate a five percent increase in the odds of the event per year.

The outcome variable was truth in reporting medications. The predictor variables were Age, Gender, Type of Operation, Class of Medical Certificate issued, and whether the pilot held an SI medical certificate. The comparison data set included medications found on postaccident toxicological analysis.

Descriptive statistics, logistic regression, and hypothesis testing were performed using Mathematica version 11 (Wolfram Research, Champaign, IL). Chi-squared tests were performed using SPSS version 21 (IBM, Armonk, NY). Odds ratios with 95% confidence intervals were calculated and hypothesis tests were performed at a statistical significance level of $\alpha = 0.05$.

RESULTS

Between 2009 and 2014, 911,896 airmen obtained FAA medical certificates, including 286,672 first-class, 209,851 second-class, and 415,373 third-class certificates. During that period 1485 pilots were fatally injured in 1213 accidents. The numbers of fatal accidents with toxicology results addressed in this study included general aviation (1111), air taxi (39), agricultural (34), external-load rotorcraft (7), flight training (3), air carrier (3), and unspecified type of operation (16).

CAMI performed postmortem toxicology testing on 1377 of the 1485 (92.7%) pilots. The combination of drugs detected in toxicology testing and drugs reported in exams for these pilots yielded 3090 subject drug records. The 1377 fatally injured pilots and their 3090 subject drug records are the focus of this study.

The average age of the 1377 subjects was 54.2 ± 14.9 yr and 7.9% (109/1377) held SI medical certificates. Men comprised 96.9% of the subjects. Of the subjects, 13.1% held first-class medical certificates, 30% held second-class certificates, and 54.2% held third-class certificates. In addition, 0.9% of subjects were deferred and 1.8% were denied medical certificates.

The percentage of the six medications most frequently detected on toxicological analysis that were tested positive/reported included: diphenhydramine (7.8% / 0%), acetaminophen (5.7% / 0.4%), ibuprofen (5% / 1.2%), amlodipine (3.5% / 3.3%), metoprolol (3.5% / 2.5%), and aspirin (3.4% / 7.3%).

The number of cardiac, neurotrophic, and psychotropic subject drug records is summarized in **Table I**. There were 3090 subject drug records where medications were either reported by a pilot, found on toxicological testing, or both. Truthful reporting was defined as any case where the medication reported by the pilot agreed with what was found by postmortem toxicological testing, including 546 subject drug records where no medication was reported (i.e., "None") and none was found. The number of pilots reporting cardiac, neurotrophic, and psychotropic drugs is shown in **Table II**.

A logistic regression was performed using 3090 subject drug records. Age, Gender, Type of Flight Operation, Medical Class Issued, and whether the medical certificate was an SI were independent covariates, while Truth in Reporting a medication was the dependent outcome variable. A Chi-squared test of deviance (also called a likelihood ratio test) was performed. The greater the deviance (DEV), the less likely that the model is a good fit for the data. In this case, however, a large DEV indicated that the logistic response function did not match the data at the 95% confidence level; therefore, the logistic regression model was not appropriate.

When the 546 cases in which applicants who reported no medications and where none were detected were excluded, a smaller DEV indicated that the logistic response function matched the data at the 95% confidence level and the logistic regression was appropriate. Age ($P < 0.01$), SI ($P < 0.01$), air carrier ($P = 0.04$), and flight training ($P = 0.04$) were significantly related to truthful reporting. Analysis of a possible logistic regression model with all of the independent covariates included shows that only four of those variables (Age, SI, Air Carrier Operations, and Flight Training Operations) are candidates for inclusion in a more parsimonious model because they are statistically significant ($P < 0.05$). However, since there were only two air carrier cases and three flight training cases, it was decided to retain only Age and SI in the parsimonious model. A log likelihood test was performed on this reduced model to determine if this model could be used. The results of this test indicated the other 11 variables could be eliminated from the model without significant loss of predictive power.

Similar testing to determine if either Age or SI could be eliminated as covariates from the model showed that retaining only one variable, either Age or SI alone, would unacceptably reduce the predictive power of the model. Therefore the final parsimonious model contained only Age (OR = 1.05, CI 1.03-1.06, $P < 0.01$) and SI (OR = 3.12, CI 2.26-4.31, $P < 0.01$).

To further explore the effects of age on truth in reporting, subjects were divided into three age groups, 50 yr old and under, 51 to 64 yr old, and 65 yr old and older, and a logistic regression analysis and a Deviance Goodness of Fit hypothesis test was performed on each age group excluding the 546 subject drug records where none was reported. In each age group of the Deviance Goodness of Fit test statistic, DEV was small and indicated that the logistic response function matched the data at the 95% confidence level so that the logistic regression model was appropriate for all age groups. Examining the covariates Age and SI, Age was only significant in the 50 to 64 yr age group ($P = 0.04$) and SI was significant in all three age groups (< 50 yr, $P = 0.03$; 50–64 yr, $P < 0.01$; ≥ 65 yr, $P < 0.01$).

A logistic regression, limited to the 506 subject drug records where only cardiac medications were involved, was performed with Age, Gender, Type of Flight Operation, Medical Class Issued, and whether the medical certificate was an SI as independent covariates and Truth in Reporting a medication was the dependent outcome variable. A Deviance Goodness of Fit hypothesis test was performed. The model deviance, DEV, was small, indicating the logistic response function matched the data at the 95% confidence level, and the logistic regression was appropriate for Age only (OR = 1.03; CI: 1.01, 1.05; $P < 0.01$).

Since 41% (209/506) of the cardiac subject drug records involved antihypertensives, a further logistic regression was performed that included cardiac medications, but excluded antihypertensives. Age, Gender, Type of Flight Operation, Medical Class Issued, and whether the medical certificate was an SI were independent covariates and truth in reporting a medication was the dependent outcome variable. A Deviance Goodness of Fit hypothesis test was performed. The model deviance, DEV, was small and the logistic regression was

Table I. Number of Cardiac, Neurotrophic, and Psychotropic Subject Drug Records.

MEDICATION CLASSIFICATION	NUMBER OF SUBJECT DRUG RECORDS REPORTING MEDICATION	NUMBER OF SUBJECT DRUG RECORDS TESTING POSITIVE FOR MEDICATION	NUMBER OF SUBJECT DRUG RECORDS REPORTED AND DETECTED	NUMBER OF SUBJECT DRUG RECORDS REPORTED OR DETECTED
Cardiac	398	233	125	506
Neurotrophic	0	1	0	1
Psychotropic	11	159	5	165

Table II. Number of Pilots Reporting Cardiac, Neurotrophic, and Psychotropic Drugs.

MEDICATION CLASSIFICATION	NUMBER OF PILOTS REPORTING MEDICATION	NUMBER OF PILOTS TESTING POSITIVE FOR MEDICATION	NUMBER OF PILOTS WHERE MEDICATION WAS REPORTED AND DETECTED	NUMBER OF PILOTS WHERE MEDICATION WAS REPORTED OR DETECTED
Cardiac	276	189	125	340
Neurotrophic	0	1	0	1
Psychotropic	11	115	5	121

appropriate at the 95% level; however, none of the covariates were significant, indicating that none of the covariates were significantly related to truthful reporting.

Toxicology testing results were positive for the presence of antihistamines in 358 pilots. An ANOVA hypothesis test on Age was performed for the six antihistamines, which indicated that there was a difference in age in at least one antihistamine as summarized in **Table III** ($P = 0.0001$).

We divided the six antihistamines into two groups based on drug approval dates: antihistamines used by pilots over 60 (older pilots) and antihistamines used by pilots under 60 (younger pilots). **Table IV** shows the antihistamines, number of pilots in each group and their mean age, mean FDA approval date, and mean OTC approval date for the two pilot age groups. A t-test comparing the mean age of the older and younger pilots showed a significant difference between the two age groups ($P = 0.00001$).

DISCUSSION

Inspection of Table II shows that, while diphenhydramine was the most frequently detected drug, no subjects reported taking the medication. Conversely, aspirin was the most frequently reported drug, but was the least frequently detected one among the group. Table III shows that 66% (125/189) of subjects reported their cardiovascular medications prior to their accident, while only 4% (5/115) of subjects reported their psychological medications, and no pilots reported their neurological medications prior to their accident.

Diphenhydramine is included with other sedating antihistamines that are addressed as “Do Not Fly” medications in the FAA AME Guide. Normally, airmen should not fly following the last dose of a sedating antihistamine until either five times the maximum pharmacological half-life of the medication, or five times the maximum hour dose interval, if pharmacological half-life information is not available. The prescribed wait time in the FAA AME Guide after taking diphenhydramine is 60 h, based on its maximum pharmacological half-life.[13] Because diphenhydramine is available over the counter and is used to treat such a wide variety of acute symptoms, it is understandable that it was frequently identified in postmortem toxicology, but its use was not reported to the FAA.

Conversely, aspirin or acetylsalicylic acid (ASA) was the most often reported but the least frequently detected drug in this study. It may have been more frequently reported because the use of ASA is unrestricted by the FAA and there is no consequence if a pilot reports its intended use, whether or not they take it. Also, ASA could have been detected so infrequently due to the short half-life, causing the drug to be eliminated rapidly from the body and not detected on postaccident toxicology testing. Furthermore, the CAMI Toxicology Laboratory only evaluates ASA in urine samples, and the laboratory does not receive urine samples from all subjects. In this study, only 787 of 1377 (57%) subjects were tested for ASA because a urine sample was received, which could also help explain the lower percentage of the detection of the drug in subjects.

Amlodipine and metoprolol were nearly equally reported and detected. This is most likely because both medications are used to treat hypertension, a common condition, which if treated and under control, would not be a barrier to medical certification.

Pilots with most cardiovascular conditions are often found to be eligible for a medical certificate and, although some may require an SI, there are usually several medications that are approved for use by the FAA to choose from to treat the condition. Since April 5, 2010, pilots with mild to moderate depression have been eligible to obtain an SI medical certificate if they are treated with one of four approved antidepressant medications: fluoxetine, sertraline, citalopram, or escitalopram.[9,10] Pilots with more than moderate depression, or those treated with unapproved antidepressants, could be inclined not to report their medical condition or their medication use to the FAA since this might result in a denial of their application for medical certification. Likewise, pilots with a seizure disorder would likely not report their medical condition or their medication use, since they would also not be eligible for a medical certificate. Similarly, pilots with certain neurological conditions

Table III. Association of Pilot Age with Type of Antihistamine.

ANTIHISTAMINE	MEAN AGE (YEARS)	NUMBER OF PILOTS	FDA APPROVAL YEAR	OTC APPROVAL YEAR
Brompheniramine	64.0	2	1955	1976
Cetirizine	62.2	40	1987	2007
Diphenhydramine	60.5	214	1946	1985
Fexofenadine	57.0	38	1996	2011
Chlorpheniramine	55.5	34	1950	1976
Loratadine	50.1	30	1993	2002

Table IV. Older vs. Younger Pilots and Type of Antihistamine Used.

ANTIHISTAMINE	AGE GROUP	MEAN AGE (YEARS)	NUMBER OF PILOTS	MEAN FDA APPROVAL DATE	MEAN OTC APPROVAL DATE
Brompheniramine	Older	60.8	256	1963	1989
Cetirizine					
Diphenhydramine					
Fexofenadine	Younger	54.5	102	1980	1996
Chlorpheniramine					
Loratadine					

such as Parkinson's disease or Wilson's Disease require an SI medical certificate and must use medications approved by the FAA. Canfield et al.[5] have also reported this pattern of reporting proportions of cardiovascular, psychological, and neurological conditions and associated medications.

A logistic regression performed on all 3090 positive drug findings showed that the response function did not match the data at the 95% confidence level; however, when 546 matches in which applicants who reported no medications and none were detected were excluded, the logistic regression was appropriate. The reduced model included Age (OR = 1.05; CI: 1.03–1.06; $P < 0.01$) and SI (OR = 3.12; CI: 2.26–4.31; $P < 0.01$). The OR for Age indicated that, holding SI constant, for every additional year of age the probability of a case being truthfully reported increased by 5%. When subjects were divided into three age groups, under 50 yr old, 51 to 64 yr old, and 65 yr old and older, a logistic regression analysis response function was appropriate for all age groups.

The OR for the variable SI indicated that, holding Age constant, a pilot with an SI would be 3.12 times more likely to be truthful than a pilot without an SI. To maintain their SI, pilots are required to periodically provide documentation to verify the status of their condition and any medications they are taking, which could explain this result.

When we divide the subjects into three age groups for analysis, in two of the groups (under 50 and 65 and over) the Age variable can be eliminated from the model. The SI variable should remain in the model for all three age groups. It is reasonable that after subdividing the data into age groups, the Age variable becomes a less useful predictor. The fact that the SI variable remains as a predictor, even in the separate age groups, reinforces its importance in the model.

When the logistic regression was limited to positive drug findings where only cardiac medications were involved, the model was appropriate for Age only (OR = 1.03; CI: 1.01–1.05; $P < 0.01$), indicating that for every additional year of age the odds of a case being truthful increases by 3%.

An examination of Table IV shows that older pilots tended to use antihistamines that have been on the market longer than younger pilots as shown by the earlier mean FDA approval and mean OTC approval dates associated with the older group.

In conclusion, older pilots tended to use antihistamines that have been on the market longer than those used by younger pilots. Diphenhydramine continues to be the most commonly identified drug on postmortem toxicology testing by the CAMI Toxicology Laboratory, even though it is listed as a sedating antihistamine, which is not approved by the FAA for use when flying.[13] This agrees with other studies of medications found after fatal civil aviation accidents.[1,2,17] Because it is associated with significant impairment in aviation performance, and is readily available over-the-counter, pilot education appears the best alternative to preventing its inappropriate use when flying, and the FAA Office of Aviation Medicine continues to educate pilots on its proper use.[14]

Only 4% of pilots on psychological medications prior to their accident reported their psychological medications to the FAA. Pilots with mild to moderate depression are eligible to obtain an SI medical certificate if they are treated with one of four approved antidepressant medications: fluoxetine, sertraline, citalopram, or escitalopram.[9,10] Unfortunately, if none of the four are efficacious, a pilot may seek treatment using an antidepressive medication that is not approved by the FAA, possibly explaining the low percentage of pilots who report their psychological medications to the FAA prior to their accident. Further, no pilots taking neurological medications prior to their accident reported them to the FAA. Pilots with a seizure disorder would likely not report their medical condition or their medication use since they would not be eligible for a medical certificate.

This study showed that the probability of a pilot truthfully reporting medication use significantly increases with Age and an SI medical certificate. Every additional year of age increased the odds of a drug record being truthfully reported by 5% when SI was held constant. Conversely, holding Age constant, a pilot with an SI would be approximately three times more likely to be truthful than a pilot without an SI.

There are reasons to suggest why pilots with a SI tend to be more truthful when reporting medications than pilots without a SI. Pilots who are more forthcoming about their health are more likely to come to the attention of the FAA when they report medical conditions and associated medications on their application for a medical certificate, resulting in the assignment of an SI to begin with. Once they have been granted an SI, the knowledge that details of their condition and treatment are routinely reported to the FAA provides an incentive to be truthful. The effect of increasing age on truthfulness in reporting medications may be related to the relationship between age and whether or not the pilot holds an SI. A 2010 FAA report found that a much greater proportion of older pilots required an SI due to the strong correlation of disqualifying medical conditions with age.[20]

Age and SI were not confounding variables. Retaining only one variable, either age or SI alone, unacceptably reduced the predictive power of the model. When the logistic regression was limited to subject drug records where only cardiac medications were involved, the logistic regression was appropriate for Age only, with the odds of a case being truthful increasing by 3% per year, possibly due to the strong correlation between age and cardiovascular disease.[21]

When the subjects were divided into three age groups for analysis, the Age variable can be eliminated from the model in two of the groups (under 50 and 65 and over), whereas the SI variable should remain in the model for all three age groups. The fact that the SI variable remains as a predictor, even in the separate age groups, is an indicator of its importance in the model. When reported medications were limited to cardiovascular drugs, Age was the only good predictor of truthful reporting, and for every additional year of age the odds of a case being truthfully reported increased by 3%. The results described here are based on a sample of pilots from fatal accidents between 2009 and 2014; however, these results might be used, with caution, to estimate truth in reporting for similar groups of pilots.

ACKNOWLEDGMENTS

We greatly acknowledge the CAMI Autopsy Team for their assistance in providing autopsy data from the MANTRA database, and the CAMI Forensic Sciences Section for their assistance in providing toxicology data and analysis from the Toxicology database. Without their patience, kind and efficient help, this study would not have been possible.

Financial Disclosure Statement: The authors have no competing interests to declare.

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