Federal Aviation Administration

DOT/FAA/AM-16/7
Office of Aerospace Medicine
Washington, DC 20591

Comparison of Pilot Fatalities and Number of Pilot Medical Examinations

Dennis V. Canfield
Kurt M. Dubowski
Guillermo J. Salazar
Estrella Forster

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

October 2016

Final Report

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AM-16/7		
4. Title and Subtitle Comparison of Pilot Fatalities and Number of Pilot Medical Examinations		5. Report Date October 2016 6. Performing Organization Code
7. Author(s) Canfield DV, Dubowski KM, Salazar GJ, Forster E		8. Performing Organization Report No.
9. Performing Organization Name and Address FAA Civil Aerospace Medical Institute P.O. Box 25082 Oklahoma City, OK 73125		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency name and Address Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591		13. Type of Report and Period Covered 14. Sponsoring Agency Code

15. Supplemental Notes

This work was accomplished under the approved tasks AM-B-15-TOX-206.

16. Abstract

Introduction: A 2004 U.S. Government Accountability Office (GAO) report stated: “Accurate, comprehensive information on designee activities is an important prerequisite for designee oversight and is integral to monitoring and evaluating the programs.” In 2008, the GAO reported the Federal Aviation Administration (FAA) planned “to continue reviewing AME-issued certificates and collecting the results.” In 2012, the Aerospace Medical Research Division was tasked to conduct a study to determine the relative risk of a pilot fatality associated with Aviation Medical Examiners (AMEs). Method: Data for this study were extracted from the FAA toxicology database for all pilots that died between 2003 and 2012 in aviation accidents and AME pilot exams from the Aeromedical Certification System/Document Imaging Workflow System (AMCS/DIWS) database between 2000 and 2012 time frame. The method was compared to NTSB reports and a review of AMEs that were outside the limits of agreement for all AMEs in this study. Results: Eighty percent (5,872) of the 7,317 AMEs had zero fatalities, and 876 of the AMEs (12%) had only 1 fatality in 10 years. One AME had 25 fatal pilots involved in aviation accidents during this 10 year study. The pilot fatality rate within the limits of agreement (LOA) was determined to be 1 fatality per 2,000 exams +/- 810. Approximately 254 AMEs (3.5%) had high fatality rates per exam and 120 (1.6%) had low fatality rates relative to the AMEs within the limits of agreement (6,942; 94.9%). Discussion: Most aviation accidents examined in this study were ruled pilot error by the NTSB but no reason was given for the pilot error. This research identified a small number of AMEs (254, 3.5%) with an atypically high pilot fatality rate per exam. Although this is a small number of AMEs the group accounted for 1,077 fatalities (37.7%) with 690 of these fatalities exceeding the 387 projected fatalities for this group over the 10 year study. The majority of AMEs (96.5%) had fatality rates within the limits of agreement or above demonstrating the success of the Aerospace Medical Certification and Aerospace Medical Education divisions.

17. Key Words	18. Distribution Statement
Medications, drugs, aviation, safety, fatal, pilots	Document is available to the public through the Internet: http://www.faa.gov/go/oamtechreports/

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	8	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGMENTS

We acknowledge the Federal Aviation Administration Office of Aerospace Medicine and the Office of Aviation Accident Investigation & Prevention as the main sponsoring organizations for this research. We would also like to thank William Hathaway of the FAA Protection and Survival Laboratory (AAM-630) for providing the data used for the number of exams completed for each AME in this study group.

Contents

Comparison of Pilot Fatalities and Number of Pilot Medical Examinations

Comparison of Pilot Fatalities and Number of Pilot Medical Examinations

INTRODUCTION

In 2003, an investigation was conducted in the state of California by the Inspector's General Office of the Department of Transportation and the Social Security Administration called "Operation Safe Pilot" to identify pilots that were fraudulently collecting Social Security benefits (1). This investigation led to criminal charges being filed against 45 airmen for falsification of medical applications (2). In addition, the U.S. House of Representatives Committee on Transportation and Infrastructure held hearings in 2007 and met with representatives from the Federal Aviation Administration (FAA) to consider the "FAA Oversight of Falsifications on Airman Medical Certificate Applications" and concluded that "Pilots that are physically or mentally unfit not only pose a danger to themselves and the flying public, they also jeopardize the lives and safety of anyone in their flight path" (3). The FAA has established stringent criteria to determine whether airmen are medically fit to fly. The Congressional Committee and the FAA agreed to "Enhance our quality control and AME oversight processes" (4). A U.S. Government Accountability Office (GAO) report issued in September of 2008 stated the "FAA has established two quality assurance review programs—one evaluating certificates that the Aviation Medical Examiners (AMEs) issued and the other evaluating certificate decisions made by FAA application examiners" (5).

The Aerospace Medical Research Division of the FAA is tasked with conducting aerospace medical research studies to determine ways to improve medical certification and the safety of the public. In an effort to continue the improvement of the medical certification process, the FAA Aeromedical Technical Community Representative Group (TCRG) requested that the Aerospace Medical Research Division conduct a study to evaluate AMEs' relative risk for a pilot fatality based on information stored in the agency's Toxicology Database (ToxDB) for fatal pilots involved in an aviation accident.

The FAA Office of Aerospace Medicine develops airman medical standards to protect the public's interests and prevent death and injury of crewmembers, passengers, and general public on the ground. Pilots are required by FAA regulations to obtain a medical certificate after successfully completing a medical examination by a certified AME. In the event of an aircraft accident, an integral part of the FAA's comprehensive safety mission includes conducting a forensic toxicology analysis of every pilot fatality where specimens are available. Following a fatal aviation accident, specimens from deceased pilots are collected by local pathologists and sent to the FAA Civil Aerospace Medical Institute's (CAMI's) Bioaeronautical Sciences Research Laboratory for toxicological analysis. The analysis determines the drugs present in postmortem specimens and the pathologies associated with the drugs of fatally injured pilots that may have been the probable cause or a factor in the aircraft mishap.

The toxicological results are utilized for individual aircraft accident investigation to determine the probable cause(s) of a particular accident and to gather data for research to prevent accidents. The toxicological results for each accident also provide essential information for medical certification specialists in terms of ensuring that the pilot was in compliance with and had been appropriately medically certified to fly. In addition to the importance for individual aircraft accident analysis, the toxicological results are continuously reviewed to understand unusual trends associated with individual AME activities that might become evident, so that proactive and preventive measures can be initiated to ensure continuous safety improvements in aeromedical certification.

Trend analysis may provide evidence to support proactive changes in airman medical certification activities as well as proactive AME education programs that improve the aerospace medical certification process. All of these activities are a part of the FAA Administrator's Priority Initiatives: "Risk-Based Decision Making: Build on safety management principles to proactively address emerging safety risk by using consistent, data-informed approaches to make smarter, system-level, risk-based decisions" (6). Earlier studies have suggested that medical conditions and medicines being taken were not being reported by the pilot nor discovered as a part of the pilot medical exam (7). A review of the literature did not identify research on the topic of determining AME relative risk of a pilot fatality. This 10-year study intends to test the null hypothesis that "Fatalities are directly proportional to the number of exams performed by an AME." This study intends to determine the relative risk (RR) of a pilot dying in a fatal aviation accident relative to the AMEs performing the exams.

MATERIALS AND METHODS

All toxicology case results from civil aircraft accident fatalities are stored electronically in a database maintained at CAMI called the ToxDB. This database was searched by AME number to identify the number of pilot fatalities for each AME during the period from 2003 to 2012. Information gathered from the ToxDB included class of airman certificate, class of medical certificate, age, accident location, and the type of flight certification of the associated accidents. Only pilots with a valid medical certificate in accordance with Title 14 of the Code of Federal Regulations (14 CFR), Chapter 1, Part 67 (8) were included in this study.

A search was also conducted of the CAMI Document Imaging Workflow System (DIWS) to identify the number of pilot exams performed by all practicing AMEs during the period 2000 to 2012. Some of the pilots in the study would have received a medical exam prior to the start of the study, and it was decided to include three additional years of exams to account for this possibility and because it would not impact the overall study.

The number of fatalities and exams performed were converted into a percentage of the maximum value found for fatalities and exams. This allowed a direct comparison of the number of fatalities and exams using a modified Bland-Altman difference graph (9) as follows: the percentage of fatal pilots was calculated by dividing the number of fatalities for each AME by the maximum number of fatalities for an AME. The percentage of exams was calculated by taking the number of exams per AME and dividing by the maximum number of exams performed by an AME. Using this method, the possible values for fatalities and exams can range from 1 to 100.

Statistical data reported were calculated with SigmaPlot 12.0 (Systat Software Inc., San Jose, CA) using the Bland-Altman method for comparing values that should be the same within statistical limits.

The relative risk (RR) was calculated using the number of fatal pilots found for each AME divided by the expected number of accidents for the AME using the calculated fatality rate per exam for the AMEs within the limits of agreement (LOA).

RESULTS

AME Fatal Pilot Distribution 2003-2012

During the course of this study there were 7,316 practicing AMEs. From 2003 to 2012, there was an average of 4,003 practicing AMEs per year. The number of practicing AMEs declined from 4,668 in 2003 to 3,390 in 2012. Of those AMEs, 1,444 (20%) had 1 or more medically certified pilots die while piloting an aircraft. Eighty percent (5,872) of the AMEs in this study had zero accidents over a 10 year period. Out of 1,444 AMEs with an aviation pilot fatality in this study, the majority (876, 61%) had only 1 fatality over the 10 year period.

Three groups of AMEs were identified in this study: (a) AMEs within the LOA of the proposed hypothesis, (b) AMEs below the LOA (high fatality rate), and (c) AMEs above the LOA (low fatality rate). The calculated mean bias was -0.1104 with a standard deviation (SD) of 3.4525. Thus, the LOA (Mean $\pm$ 1.96 SD) was -0.1104 $\pm$ 6.7669 resulting in the LOA range of -6.8773 to 6.6565.

The AMEs within LOA range had approximately 1 fatality per 2,000 exams $\pm$ 811. Only 254 AMEs (3.5%) were below the LOA for AMEs (High Fatality Rate).

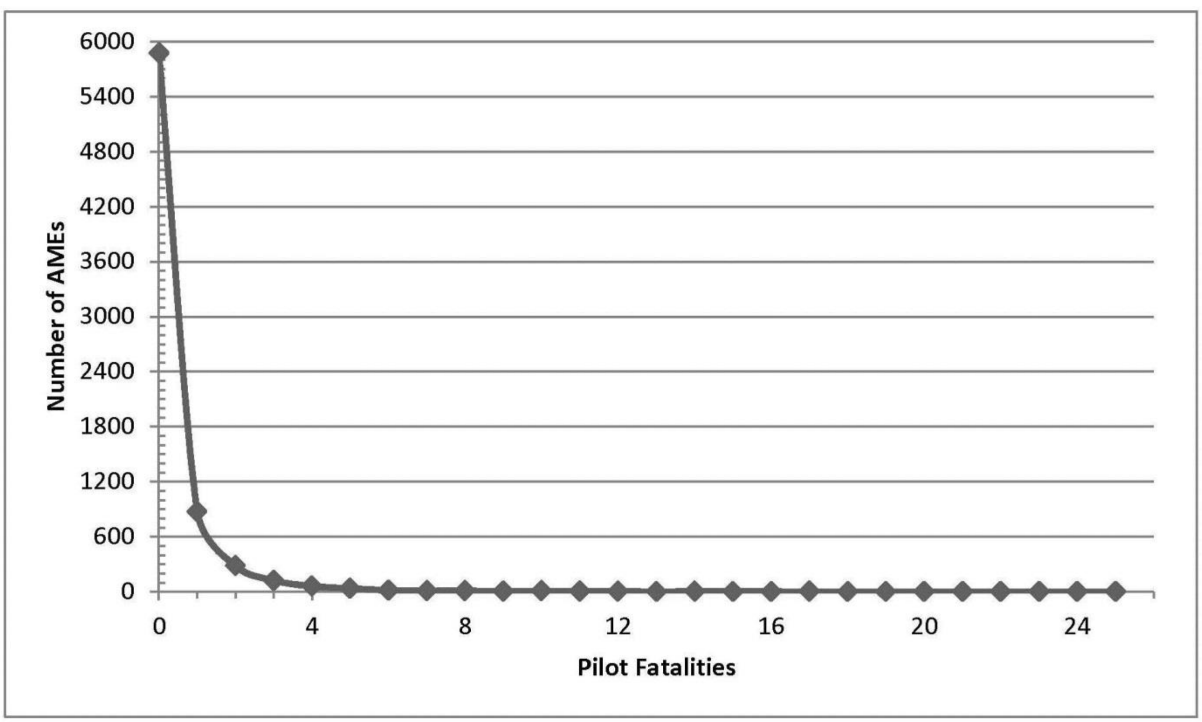

Figure 1. Distribution of fatally injured pilots by number of AMEs

There were 120 AMEs (1.6%) above the LOA (Low Fatality Rate). The majority of the AMEs (6,942, 95%) were within the LOA. The distribution of AMEs relative to fatality rates can be found in Table 1.

Table 1. Distribution of AMEs

AMEs	Totals	%
With Fatals	1444	19.7
Without Fatals	5872	80.3
Below LOA	254	3.5
Within LOA	6942	94.9
Above LOA	120	1.6
Total	7316	100.0

The total number of fatalities for the 2003–2012 period was 2,858. The small number of AMEs (3.5%) below the LOA had approximately three times as many fatalities as the AMEs within LOA (95%) and accounted for 37.7% of all fatalities that occurred. The AME group below the LOA had 7 times the fatality rate as the AME group above the LOA. The Relative Risk (RR) and percentage of pilot fatalities for the three groups of AMEs in this study are presented in Table 2.

Table 2. Distribution of Fatalities and Relative Risk (RR)

Fatals	Totals	%:RR
Below LOA:%	1077	37.7
Estimated:RR	387	2.8
Above LOA:%	233	8.2
Estimated:RR	623	0.4
Within LOA:%	1548	54.2
Estimated:RR	1628	1.0
Total:%	2858	100.0

AME Exam and Fatality Difference Graph

A modified Bland-Altman difference graph was created using the percentage of fatalities and exams to determine if there was a proportional relationship between the number of exams and the number of fatalities (Figure 2). The 95% confidence limit (CL) for the Lower LOA of -7.0144 to -6.7403 with a 95% CL and a 95% CL for the Upper LOA of 6.5194 to 6.7935. Fatality rates that were outside the LOA were considered atypical.

Validation of the Method

National Transportation Safety Board (NTSB) dockets and DIWS medical records were examined for both high fatality rate and low fatality rate AMEs to determine the presence of medical issues that may have been missed during the pilot medical exam. For example, there were no medical causes of aviation accidents reported by the NTSB for the low fatality rate AME that had 12 fatalities for 48,120 exams; whereas, a high fatality rate AME had three fatal pilots out of 17 fatalities (5,595 pilot exams) with unreported medical conditions determined to be the probable cause or a factor in the accident.

The age, gender, class of medical certificate, and region were approximately the same for both the high and low fatality rate AMEs. The only difference noted was found in the class of airman certificate where there were an increased number of commercial pilots in the high fatality rate AME group (n = 7 of 17 total, 41%) compared to the low fatality rate AME group (4 of 12, 33%). All other measurable conditions were found to be comparable for both the high pilot fatality rate AMEs and

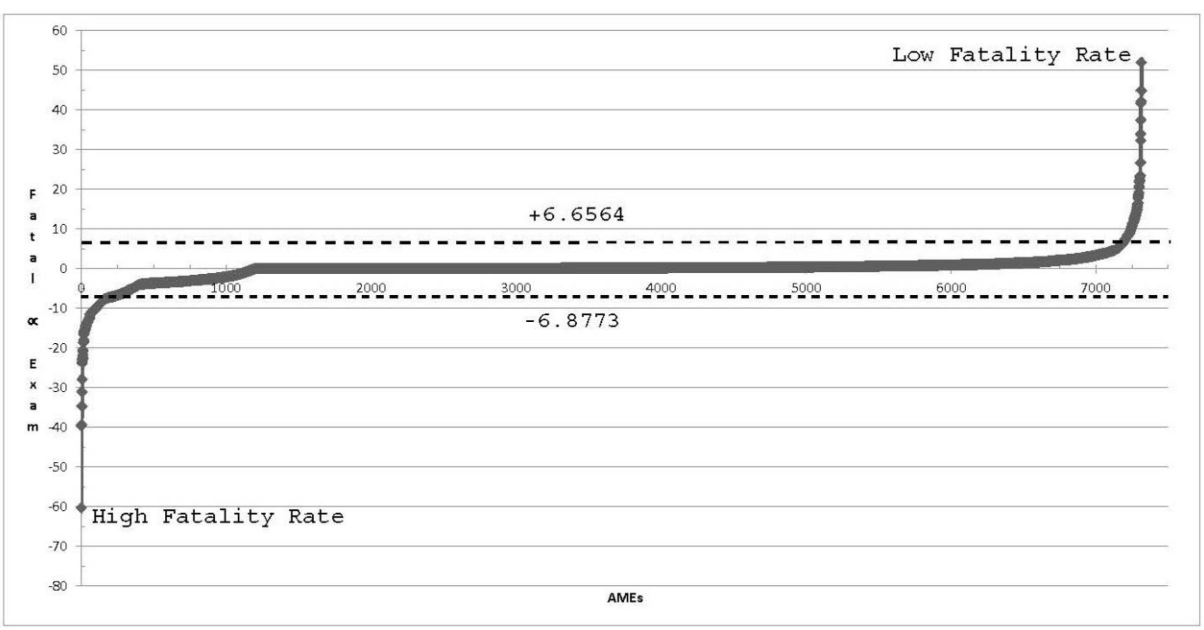

Figure 2. Difference graph for all AMEs in the study showing percent difference from mean for all AMEs

low pilot fatality rate AMEs which is consistent with earlier findings: “the distribution of medical certificate class and airman certificate type were very similar when the total fatalities group was compared to the group of fatalities found positive for drugs” (5).

DISCUSSION

In most aviation accidents, the NTSB found pilot error as the probable cause; however, it does not preclude the possibility that a medical condition, medications, or other substances being taken by the pilot interfered with pilot’s ability to control the aircraft. It is very rare for the NTSB to rule the probable cause of an accident as a medical event because of the difficulties in finding sufficient evidence such event impaired the pilot sufficiently to have caused the accident (10). Something that can be measured with some degree of certainty is the potential risk associated with the substances and medical issues identified through reported and unreported information to the FAA. However, further study is needed to determine what role, if any, the medical certification process played. The procedure used in this study was able to identify a small group of AMEs with atypical high fatality rate per exam; however, the significance is yet to be determined.

The null hypothesis for this study was rejected. This is, fatalities are not directly proportional to the number of exams performed by an AME. For 95% of the AMEs in this study, the original hypothesis was found to be true and only a small percentage was found to be atypical. However, this small atypical group of AMEs (3.5%) accounted for 1,077 pilot fatalities with 690 of these fatal pilots being above the number of fatalities expected for the number of exams performed. The 690 estimated fatal pilots only takes into consideration the fatal pilots and does not include passengers or ground fatalities related to these accidents that would make the loss of life even greater. Determining the reasons for the additional 690 pilot fatalities above the expected number of fatalities could help reduce the number of fatalities caused by aviation accidents. Identifying AMEs below the limits of agreement resulting from the sample used for his study will make it possible to focus on a small group of AMEs that might need additional training and support to improve the overall FAA medical certification process. Additionally, it could help identify a segment of the airman population requiring better outreach programs on the need to fully disclose medications and medical conditions, particularly if they develop in the interim period between airman medical examinations.

This study strongly suggests that Aerospace Medical Certification and Aerospace Medical Education have the potential to reduce some fatalities resulting from aviation accidents through improvements in the medical certification process and AME/Airman training. It seems obvious that this would be the case considering the dangers associated with sudden medical incapacitation or the reduced capabilities of a pilot that could have been avoided by early detection and remediation of the medical condition. This is consistent with the NTSB findings that concluded the “FAA medical certification requirements and DOT mandatory drug and alcohol testing requirements for safety-sensitive aviation personnel have been associated with fewer toxicological findings of impairing drugs and conditions among accident pilots subject to those requirements. Conversely, these results suggest that allowing pilots to fly without a medical certificate could contribute to an increased risk of pilot impairment while flying because study pilots without an FAA medical certificate were more likely to have toxicological evidence of impairing drugs and conditions” (11).

The relative danger associated with aviation accidents is often equated to surface accidents where a driver’s license is sufficient to operate a motor vehicle. However, it is important to recognize major differences between surface and aviation accidents. Surface vehicles are relatively confined to predefined spaces, whereas in aviation there are no physical boundaries to prevent aircraft from traveling over hospitals, schools, and homes. Additionally, surface vehicle drivers do not have the physical stresses of flight, spatial illusions, the operational multi-tasking, the diverse piloting skill set, and the decidedly higher speeds and shorter reaction times. This results in additional risk to the public on the ground and increases the potential of a catastrophic event not typically seen with surface vehicle accidents. The U.S. House of Representatives Committee on Transportation and Infrastructure found that “Pilots that are physically or mentally unfit not only pose a danger to themselves and the flying public, they also jeopardize the lives and safety of anyone in their flight path” (3).

The fact that the majority of the AMEs (96%) are within the limits of agreement or above demonstrates that the aerospace medical certification processes and AME selection and training process seem to be effective in reducing fatalities by preparing AMEs to identify high risk medical conditions that can result in the sudden incapacitation or reduced performance of the pilot.

REFERENCES

1. Office of Inspector General. (2005) Falsification of FAA Airman Medical Certificate Applications by Disability Recipients. US Department of Transportation, Publication No. July 22, 2005, Washington, DC.

2. Tilton, F. (2007) Operation Safe Pilot. Federal Air surgeon's Medical Bulletin 45:2, 2.

3. Committee on Transportation and Infrastructure, FAA Oversight of Falsifications on Airman Medical Certificate Applications, (2007), US House of Representives, Date 03/27/2007

4. Tilton, F. (2007) Operation Safe Pilot Revisited. Federal Air surgeon's Medical Bulletin 45:3, 2.

5. US Government Accountability Office. (2008) AVIATION SAFETY - FAA Has Taken Steps to Determine That It Has Made Correct Medical Certification Decisions. GAO, Publication No. GAO-08-997, Washington, DC.

6. FAA Strategic Initiatives - Make aviation safer and smarter, Available at http://www.faa.gov/about/plans_reports/media/FAA_Strategic_Initiatives_Summary.pdf, (2015).

7. Canfield, D.V., Salazar, G.J., Lewis, R.J., et al. (2006) Pilot medical history and medications found in post mortem specimens from aviation accidents. Aviat Space Environ Med 77:1171-1173.

8. Title 14 of the Code of Federal Regulations (14 CFR). Chapter 1, Part 67, U.S. Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001

9. Bland, J.M. and Altman, D.G. (1986) Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1:307-310.

10. Cullen, S.A., Drysdale, H.C., and Mayes, R.W. (1997) Role of medical factors in 1000 fatal aviation accidents: case note study. BMJ 314:1592.

11. NTSB. (2014) Drug Use Trends in Aviation: Assessing the Risk of Pilot Impairment. Publication No. NTSB/SS-14/01, Washington, DC.