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Should Charity Air Medical Organizations Require Commercial Certification of Their Pilots?

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ABSTRACT

Background: Fixed-wing medical transportation crashes operating under 14CFRPart 91 show higher fatal outcomes than non-medical Part 91 flights. Advanced certification may translate into increased safety; yet we know of no charity aeromedical transportation requiring such certification. Herein, in a retrospective study, we determined (a) whether commercial certification is associated with a reduced fatality rate compared with the less stringent private pilot certificate and (b) accident causes.

Methods: The National Transportation Safety Board (NTSB) accident database was queried for fatal accidents in single engine aircraft occurring between 2002 and 2012. Poisson and proportion tests were used in statistical analyses.

Results: For the period spanning 2002-2012 commercial pilots showed a lower fatality rate. Under visual meteorological conditions aerodynamic stall was a frequent cause for fatal accidents affecting both airman cohorts equally. For operations in instrument meteorological conditions fatal accidents were most commonly attributed to instrument approach deficiency and spatial disorientation. At night, failure to maintain obstacle/terrain clearance ranked the most prevalent cause of fatal crashes.

Conclusion: Our data suggest that charity aeromedical transportation organizations should encourage their pilots to acquire commercial certification. Further, our study informs as to areas where general aviation training/currency should be directed towards reducing fatal accidents.

Keywords: charity aeromedical transportation, fatal accidents, general aviation, commercial pilots,

Highlights

1. Commercial pilots show a lower fatal accident rate than private airmen (Part 91)
2. Charity aeromedical flights at night should be conducted under IFR
3. General aviation pilots should increase their proficiency in instrument approaches
4. Increased emphasis should be placed on aerodynamic stall recovery

INTRODUCTION

General aviation (14 CFR Part 91) includes all civilian aviation apart from operations involving paid passenger transport the latter covered under 14 CFAR Part 121 and 135. Unfortunately, the fatality rate for general aviation is 82 times higher than that of the airlines [1]. Moreover, fixed-wing medical transportation crashes flying under the Part 91 umbrella show even higher fatal outcomes than non-medical Part 91 flights [2].

At the present time we are unaware of any charity aeromedical transportation organization requiring commercial certification of their pilots. A commercial license requires a higher level of precision in maintaining control of the airplane especially for takeoffs (control of airspeed) and landings (control of airspeed, precision in touchdown point) both phases of flight which carry the highest risk [3;4] of an aviation accident. Additionally airmen tested for the commercial license have to demonstrate after a simulated engine failure the ability to land at a specified runway touchdown point (± 200 feet) following course reversal from a low altitude (1,000 feet above the airport). In contrast, this task is not required for applicants seeking private pilot certification. Test standards for both commercial and private certification are described in the FAA Practical Test Standards (US Department of Transportation documents FAA-S-8081-12C and FAA-S8081-14B respectively).

In view of the more stringent requirements for commercial certification, we were interested in determining whether this rating affords an increased level of safety. Although there have been several prior reports on general aviation fatal crashes [1;3;5], we know of none that have compared fatal accident rates and causes for commercial and private pilot-certified airmen. The majority of studies on general aviation accidents aggregate all 14 CFR Part 91 operations inclusive of pilots holding various licenses as well as trainees with little distinction given to certification [6;7;8]. Along similar lines, accidents for single and multiple engine are typically grouped [9] despite the fact that the latter carry an increased risk of fatality [6]. Another limitation of earlier studies is that often general causes (e.g. pilot error, pilot-related) [10;11;3] rather than specific causes are cited. However, it is specific rather than general causes that inform where training should be focused.

In the present investigation, we compared the fatal accident rate for IFR-certified commercial and IFR-certified private airmen (2002-2011) and determined the accident causes. As of 2012, there were 89,155 and 50,617 IFR-certified commercial and IFR-certified private pilots respectively (http://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/2012/). We elected to study all accidents across the 14CFR Part 91 spectrum due to the paucity of fatal accidents involving aeromedical transportation which would preclude a robust statistical analysis. Hereafter we refer to these two groups of IFR-certified airmen as commercial and private pilots respectively. We restricted the study to IFR-certified airmen to capture a population engaging in "real world" flight operations inclusive of degraded visibility. Indeed, notable aeromedical transportation organizations (e.g. Angel Flight, Mercy Flight, Mercy Medical Airlift) require instrument certification for pilots We report herein that commercial certification is associated with a reduced risk of fatal accidents. Considering the overall diminished rate of fatal accidents, charity organizations participating in aeromedical transportation should encourage commercial certification for their airmen.

METHODS

The study did not constitute research involving human subjects regulated under 45CFR Part 46 (as per the U.S. Department of Health and Human Services-(http://www.hhs.gov/ohrp/policy/checklists/decisioncharts.html) as the research did not involve obtaining information from living individuals. The National Transportation Safety Board (NTSB) accident database (www.ntsb.gov/aviationquery) was queried for fatal accidents occurring in aircraft with a single, reciprocating engine occurring between Jan 2002 and Dec 2012 and operating under 14 CFR Part 91-general aviation. Amateur built aircraft were excluded from the study.

Records were imported into a custom database designed using the FileMaker Pro v11 software. We then searched our database for fatal accidents involving private or commercial pilots both with instrument certification. Fatal accidents in the following categories were deleted from our analyses: instructional flights, aerobatics, non-certificated pilots, glider and banner-tows, aerial observation, sky-diving, flight tests, suicides and injury involving a pilot or passenger located external to the involved aircraft. Fatal accident causes cited in our study were as per the NTSB determination. In cases where two certificated pilots were occupying the front seats in aircraft with dual controls we assumed that the pilot in the left seat was the one controlling the aircraft. For temporal studies, we used 2011 as the most recent cut-off year since the typical fatal general aviation investigation takes approximately 390 days from assignment to release of probable cause [12]. We defined night as per the NTSB report.

Annual aviation certification data (i.e. commercial and private pilots) were obtained from the publicly available FAA website (http://www.faa.gov/data-_research/aviation_data_statistics/civil_airmen_-statistics/"year"/). Annual flight hours for the general aviation fleet comprised of fixed wing single engine piston aircraft was obtained from the FAA (http://www.faa.gov/data_research/aviation_data_statistics/general_aviation/).

Statistics

A generalized linear model with Poisson response was fitted to year and commercial/private certification in order to compare accident rates. Proportion tests were used in comparing whether there were significant differences in fatal accident causes between commercial and private pilots. A Wilcoxon rank sum test with continuity correction was used to test for statistical significance in distance flown and aircraft weight.

RESULTS

Comparison of fatal accidents for commercial and private aviators.

We first asked whether the higher pilot certification is associated with increased safety. To our knowledge, there is limited data that supports this notion. Accordingly, we compared fatal accident rates for commercial and private pilots across a span of ten years. The analysis included fatal accidents in all weather conditions. The data were corrected for annual variations in the population of private and commercial pilots. In querying the NTSB database for fatal accidents in single engine (reciprocating) powered aircraft over the 2002-2012 period flown by commercial and private pilots, we identified 176 and 297 accidents respectively. Note that herein the terms commercial and private pilots refers to airmen who also hold instrument certification. For the two years spanning 2002-2003, the fatal accident rate (Figure 1) for private pilots was more than double (3.9 and 1.6 accidents per 100,000 pilots per million flight hours) that of commercial airmen. The higher fatal accident rate for private pilots was maintained through the 2008-2009 period but the difference diminished for the most recent period (2010-2011). Using a generalized linear model with a Poisson response, an analysis of all time periods combined indicated that commercial pilots had a lower fatality rate than private airmen ($p<3.78 \times 10^{-8}$).

We entertained the possibility that the higher accident rate for the private pilots was a result of not including accidents by commercial airmen flying under 14 CFR Part 135 rule. Querying of the NTSB database with identical criteria but now inclusive for accidents operating 14 CFR Part 135 led to an additional 25 accidents over the 10 year period. However even with the inclusion of these accidents we still observed a higher accident rate for private airmen (Poisson generalized linear model $p=1.24 \times 10^{-5}$).Re-running the Poisson response but adjusting solely for only the pilot populations also showed a statistical significant difference ($p<2 \times 10^{-16}$} for fatal accidents between the two aviator cohorts.

Causes of fatal accidents

We the determined the causes of fatal accidents for both commercial and private-certified airmen. Under visual meteorological conditions (Figure 2), aerodynamic stall was one of the most common causes for fatal accidents affecting both cohorts equally (22%). This was a somewhat surprising finding considering that airmen evaluated for commercial certification must demonstrate their ability to maintain control of the aircraft under conditions approaching a stall to a higher standard than airmen tested for the private pilot certificate. Failure to maintain obstacle/terrain clearance was also a frequent cause of fatal crashes for both commercial and private airmen accounting for 26 and 17% of accidents respectively. However, this difference was not statistically significant ($p=0.118$). Interestingly, malfunction of the engine/airframe ranked highly as a cause of fatal accidents for both groups of airmen (17 and 23% of accidents for commercial and private aviators respectively) under visual meteorological conditions.

Under the more challenging instrument meteorological conditions (Figure 3) where visual cues are lost, perhaps not surprisingly instrument approach deficiency, failure to maintain obstacle/terrain clearance and spatial disorientation were the most frequent causes of fatal accidents combined accounting for more than 60% of all accidents. Although the fraction of fatal accidents attributed to instrument approach deficiencies and spatial disorientation was lower for commercial airmen, this difference was not statistically significant (p-values = 0.247 and 0.145 respectively). Under instrument meteorological conditions, fatal accidents caused by loss of control (takeoff/landing/ in cruise) accounted for less than 5% of crashes for either cohort of aviators.

Prior studies have reported a higher fatal accident rate for general aviation flights conducted at night [9]. Further a previous report had reported that 43% of 14CFR Part 91 aeromedical flight accidents occur at night [2]. We therefore compared the causes of fatal accidents for commercial and private pilots at night (Table I). Failure to maintain obstacle/terrain clearance was the most frequent cause of fatal crashes at night and again comparable for both groups of aviators (31 and 29% for commercial and private pilots respectively). Spatial disorientation accounted for 8 and 15% of fatal accidents for commercial and private pilots respectively. It should be noted that 7 of 39 fatal accidents by commercial airmen attributed to either of these causes were under visual meteorological conditions conducted without an IFR flight plan. For private pilots, 44% (32/73) of night fatal accidents were due to either failure to maintain obstacle/terrain clearance or spatial disorientation -of these operations 56% (18/32) were conducted in the absence of an IFR flight plan. Perhaps not surprising given the reduced number of options for landing at night, engine/airframe malfunction was the second most common cause for fatal accidents at night accounting for 10 and 11% of the crashes for commercial and private pilots respectively.

Flight experience of airmen involved in fatal accident.

We then examined several co-variates that might account for the lower fatality risk for the commercial pilots (Table II). Advancing age has been associated with increased accident rate [13;14]; however the median pilot age for the two groups was similar (54 and 56 years respectively). Flight in instrument meteorological conditions also carries an elevated risk of an accident [15] but the total time in these weather conditions was similar for both groups- 49 and 41 hours for commercial and private pilots respectively. Conversely, flight experience is associated with increased safety [13] and commercial pilots showed a greater ($p<0.001$) total flight time (1,650 vs 1,058 hours). On the other hand, flight distances has previously been reported as a risk factor for accidents [15] and the median distance flown for the accident flight was greater for private airmen compared with commercial pilots (194 and 108 nm respectively) a difference that was statistically significant ($p<0.002$). Another potential confounder is maximum aircraft certified weight as this measure translates into a higher landing speed and impact force exerted on occupants is a square of landing speed [16]. Indeed aircraft flown by private airmen had a higher maximum certified weight than those flown by commercial pilots (3,140 and 2,745 lb respectively) ($p<0.0001$).

DISCUSSION

To our knowledge this is the first report determining the fatal accident rate and identifying causes for fatal accident for commercial and private pilots engaged in 14CFR Part 91 operations. We provide evidence for increased safety for the commercial airman operating under the Part 91 umbrella. On this basis, charity organizations, involved in aeromedical transportation, should encourage their pilots to seek such certification.

Additional certification has previously been reported to be associated with fewer pilot errors [10;17]. Indeed, our finding that the fatal accident rate for commercial-certified airmen was lower than the private pilots is in line with this contention. However, additional certification is not always associated with a higher degree of safety. We recently reported [18] that IFR-certification for private pilots was associated with a higher risk of a fatal accident. Although reduced fatal accident rate was evident for commercial airmen in the present study, nevertheless, there is always the possibility that confounders might contribute to the disparity. For example, private pilots fly larger aircraft and therefore occupants are subjected to greater impact forces, the latter a square function [16] of landing speed. Indeed, we noted a higher (3,140 vs. 2.745 lb) maximum certified gross weight for aircraft flown by the private pilots consistent with this possibility. It is possible that a superior safety record reflects increased flight experience [13]. Indeed, the commercial pilots had approximately 50% more total flight time compared with private aviators consistent with this notion. That said, both pilot groups showed an almost identical total time in make and model.

For operations under visual meteorological conditions, failure to maintain obstacle/terrain clearance was one of the most common causes for fatal accidents for both groups of airmen. Of the 59 accidents, only 6 were on an instrument flight plan which would guarantee terrain/obstacle clearance via the required minimum safe altitudes enroute and in the approach phase. Our finding of the high fraction of fatal accidents by commercial pilots operating under visual meteorological conditions attributed to aerodynamic stalls was surprising since flight maneuvers integral to commercial pilot training is devoted to aircraft control under conditions approaching an aerodynamic stall and to a higher standard than that required for the private pilot license. Furthermore, a higher level of precision in maintaining control of the airplane during takeoff and landing, phases of flight most vulnerable to aerodynamic stalls [3;4], are required for commercial pilot certification (FAA Practical Test Standards -US Department of Transportation documents FAA-S-8081-12C). Nevertheless it is important to recognize that the biennial flight review required (14 CFR 61.56) of all pilots operating under 14CFR Part 91 does not mandate evaluation of the abovementioned tasks required for initial commercial certification. We observed a higher rate for accidents attributed to engine/airframe malfunction than a prior study [19]. This divergence may reflect the fact that our study included airframe failure in addition to engine malfunctions. It should be noted that in our study, we did not include in-flight separation due to convective activity in our engine/airframe malfunction category.

For night operations, especially pertinent to aeromedical flights involving organ transportation, failure to maintain obstacle/terrain clearance was the most frequent cause of fatal accidents (for both pilot cohorts) accounting for nearly a third of all crashes. It is important to note that many night accidents attributed to this cause while conducted under visual meteorological conditions were not following an IFR flight plan. Although an IFR flight plan is not mandatory, pilots conducting night operations are susceptible to multiple visual illusions (e.g. black hole approach, false visual references) (http://www.faa.gov/pilots/safety/pilotsafetybrochures/media/SpatialD-_VisIllus.pdf). Accordingly, towards reducing accidents due to a failure to maintain obstacle/terrain clearance and spatial disorientation both commercial and private airmen should be strongly encouraged to conduct night flights, inclusive of those under visual meteorological conditions, under IFR. At minimum, pilots should plan night VFR flights per the FAA Operations Specification A-021 (www.faa.gov) as utilized by Helicopter Emergency Medical Services operating under 14 CFR Part 135.

We recognize that our study had limitations. For example, our study generalizes our findings across the general aviation fleet to charity aeromedical transportation. This approach was necessary since a small number of accidents involving 14CFR Part 91 aeromedical transport precluded a robust statistical analysis with this cohort. For the comparison of fatal accident rates for the two cohorts, the lack of flight time data for the denominator (non-accident commercial and private airmen) populations a common problem in general aviation studies [20], meant that we were unable to determine a rate based on this variable.

In conclusion, we provide evidence for increased safety under 14 CFR Part 91 operations for the commercial airman compared with private pilots. This increased safety would suggest that charity organizations, involved in aeromedical transportation, should encourage their pilots to acquire such certification. Our study also informs where general aviation training, be it initial or for currency, as well as technology (e.g. angle of attack indicators to alert for impending aerodynamic stalls) should be focused. Specifically increased emphasis should be placed on training for aerodynamic stall awareness/recovery, instrument approaches as well as the importance of conducting night flights by instrument flight rules. The latter point is particularly germane to flight operations involving organ harvests (e.g. http://www.flightsforlife.org/) where expedient transportation is required independent of lighting conditions.

FIGURE LEGENDS

Figure 1. Comparison of fatal accident rates for commercial and private pilots over time.

Fatal accidents (2002-2012) in all weather conditions. For each group of airmen, the data are normalized to the commercial and private pilot populations for the stated periods. n=number of fatal accidents.

Figure 2. Causes of fatal Accidents for commercial and private pilots in visual meteorological conditions.

Data are expressed as percentage of the total number of fatal crashes for commercial and private airmen with each group summing to 100%. Other-aircraft collision, exceed maximum design limits carburetor icing, avionics malfunction, pilot incapacitation, instrument approach deficiency, spatial disorientation, undetermined. n=number of accidents.

Figure 3. Causes of fatal Accidents for commercial and private pilots in instrument meteorological conditions.

Data are expressed as percentage of the total number of fatal crashes for commercial and private airmen. Each pilot cohort sums to 100%. Other- (aircraft-aircraft collision, exceed maximum design limits, carburetor icing, fuel contamination/exhaustion, airframe icing, avionics malfunction, engine/airframe malfunction, pilot incapacitation, undetermined). n=number of accidents.

Table I. Causes of fatal accidents at night for commercial and private airmen.

Fatal accidents (2002-2012) in all weather conditions at night.

	Commercial			**Private**	
Accident Cause	Number Accidents	Percentage		Number Accidents	Percentage
Convective Weather	1	**3**		3	**4**
Exceed Maximum Design Limits	1	**3**		2	**3**
Loss of Control (takeoff/landing/cruise)	3	**8**		1	**1**
Failure to Maintain Obstacle/Terrain Clearance	12	**31**		21	**29**
Fuel contamination/exhaustion	3	**8**		2	**3**
Engine/airframe Malfunction	4	**10**		8	**11**
spatial disorientation	3	**8**		11	**15**
Other (aerodynamic stall, aircraft-aircraft collision, airframe icing, drug/alcohol impairment, instrument approach deficiency, undetermined)	12	**31**		25	**34**
TOTAL	39	100		73	100

		Commercial-IFR	Private-IFR
Age	n	170	290
	median	54	56
	Q1, Q3	37, 62	49, 64
Total Flight Hours	n	167	298
	median	1,650	1034
	Q1, Q3	1051, 2998	478, 1972
Total Flight Hours (Make & Model)	n	71	153
	median	232	230
	Q1, Q3	59, 432	92, 516
Total Flight Time Actual instrument meteorological conditions (hours)	n	36	87
	median	49	41
	Q1, Q3	25, 193	16, 103
Recency 90 Days (all aircraft) (hours)	n	63	115
	median	33	24
	Q1, Q3	11, 76	14, 41
Recency 90 Days (Make &Model) (hours)	n	48	86
	median	18	22
	Q1,Q3	8, 34	12, 40
Recency 90 days actual instrument meteorological conditions (hours)	n	6	32
	median	0	3
	Q1, Q3	0, 2	2, 9
Recency 90 days simulated instrument meteorological conditions (hours)	n	6	14
	median	2	2
	Q1, Q3	0, 4	0, 4
Distance Accident Flight (nm)	n	157	159
	median	108	194
	Q1, Q3	0, 228	73, 333
Max Certified Weight (lbs)	n	162	266
	median	2745	3140
	Q1, Q3	2300, 3400	2745, 3600

Table II Population characteristics of the fatal accident airmen.

n=number of pilots. Q, quartile.

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