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Pilot Age and Error in Air-Taxi Crashes

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Abstract

Introduction—The associations of pilot error with the type of flight operations and basic weather conditions are well documented. The correlation between pilot characteristics and error is less clear. This study aims to examine whether pilot age is associated with the prevalence and patterns of pilot error in air-taxi crashes.

Methods—Investigation reports from the National Transportation Safety Board for crashes involving non-scheduled Part 135 operations (i.e., air taxis) in the United States between 1983 and 2002 were reviewed to identify pilot error and other contributing factors. Crash circumstances and the presence and type of pilot error were analyzed in relation to pilot age using Chi-square tests.

Results—Of the 1751 air-taxi crashes studied, 28% resulted from mechanical failure, 25% from loss of control at landing or takeoff, 7% from visual flight rule conditions into instrument meteorological conditions, 7% from fuel starvation, 5% from taxiing, and 28% from other causes. Crashes among older pilots were more likely to occur during the daytime rather than at night and off airport than on airport. The patterns of pilot error in air-taxi crashes were similar across age groups. Of the errors identified, 27% were flawed decisions, 26% were inattentiveness, 23% mishandled aircraft kinetics, 15% mishandled wind and/or runway conditions, and 11% were others.

Conclusions—Pilot age is associated with crash circumstances but not with the prevalence and patterns of pilot error in air-taxi crashes. Lack of age-related differences in pilot error may be attributable to the “safe worker effect.”

Keywords

aging; air-taxi crashes; pilot error rates; safety

INTRODUCTION

The effects of aging on cognitive functions and piloting skills have been studied extensively. Research on pilots indicates that age-related declines are largely limited to domain-independent cognitive functions such as memory capacity and psychomotor skills. Domain-dependent cognitive functions that are directly related to flight tasks, such as decision making, tracking,

takeoff, and landing, are less sensitive to aging effects (9,10). Among the few flight-related tasks that are found to decline with advancing age are abilities to respond to verbal communication (9,10) and time-sharing efficiency (11). Older pilots tend to perform worse than younger pilots in executing long and rapidly spoken air traffic control commands and in multitasking under conditions of increased attentional demands.

The findings from flight simulator based experimental studies of older pilots have not been well corroborated by epidemiologic evidence. It is unclear whether the prevalence and characteristics of pilot error differ with pilot age, though it is conceivable that pilots at different stages of cognitive aging may have different error propensity and make different types of error. Pilot error has been identified as a contributing factor in 85% of general aviation crashes and 68% of commercial aviation crashes (4). However, relatively little is known about age-related variations in pilot error. In a study of commuter and air-taxi pilots, Li et al (5) reported that the prevalence and patterns of pilot error showed little change as pilots aged from the 40s into their 50s. However, that study was limited by its modest sample size (N = 165 crashes) and truncated age range (40–60 years) which may have reduced the likelihood of finding significant age effects. In a recent study of pilot error in air carrier crashes involving Part 121 operations, Li et al. (6) found that the prevalence and patterns of pilot error in air-carrier crashes do not appear to change with pilot age. However, the low prevalence rate of pilot error in air carrier crashes makes it difficult to fully assess age-related variation. The present study aims to examine the relationship between pilot age and error in a large case series of air-taxi crashes that are known to be much more likely to involve pilot error than air-carrier crashes (3). Based on our previous research on pilot aging and aviation safety, the goals of this study were twofold: 1) to investigate whether the prevalence of pilot error in air-taxi crashes is associated with pilot age; and 2) to determine whether the type of pilot error in air-taxi crashes varies with pilot age.

METHODS

The present study is a case series analysis of data for non-scheduled air-taxi crashes recorded by the National Transportation Safety Board (NTSB) between 1983 and 2002. The NTSB data system is the official repository of investigation reports on all aviation crashes occurring within the United States, including its territories, possessions, and international waters.

The NTSB is an independent federal agency charged by the U.S. Congress with investigating civil aviation crashes as well as major mishaps in other modes of transportation. NTSB investigations are conducted to determine the probable cause of the crash and to make recommendations for improving safety. The U.S. Federal Government defines an aviation crash as an occurrence associated with the operation of an aircraft in which any person suffers death within 30 d or serious injury, or in which the aircraft is damaged so severely that it requires major repair or replacement of the affected component. Procedures for notifying, investigating, and reporting aviation crashes are prescribed in detail by the Federal Government (2). Data gathered in the investigation are recorded using the standard Factual Report Aviation form (NTSB Form 6120.4) and a set of supplemental forms. The Factual Report Aviation form is a written narrative describing the facts, conditions, circumstances, probable causes, and contributing factors pertaining to the crash. A cause is defined as a condition that played an essential role in the causation of the crash (i.e., without its presence, the crash would not have occurred), and a factor as a condition that aggravated the development of the crash sequence (i.e., it made the crash more likely or more severe (7).

Data from the Factual Report Aviation form for every non-scheduled air-taxi crash occurring between 1983 and 2002 were reviewed by an experienced commercial pilot/flight instructor and aviation safety researcher who served as the project consultant. The project consultant coded the crash type, contributing factors, and pilot errors based on information contained in

the NTSB investigation report. In this study, pilot refers to the pilot-in-command, i.e., the crewmember who has the ultimate responsibility for the operational control of the aircraft, and pilot error is operationally defined as any performance factor attributed to the pilot-in-command that was identified either as a probable cause or as a contributing factor for any event in the crash sequence. Up to two pilot errors were counted for each crash. Excluded from this study were errors of unknown source

Data coded by the project consultant were merged with computerized data from the NTSB Factual Report Aviation forms and analyzed in relation to age and total flight time of the pilot-in-command at the time of the crash. Age was divided into five groups: <30 yr, 30–39 yr, 40–49 yr, 50–59 yr, and ≥ 60 yr. Group differences in crash circumstances and pilot errors were assessed based on Chi-square tests. Statistical analyses were performed using the Statistical Analysis System software (SAS Institute, Cary, NC).

RESULTS

A total of 1751 crashes of non-scheduled air taxis were studied. All but 86 of the pilots involved were men. At the time of the crash, pilots averaged 38.8 yrs of age (± 10.9 SD) and had logged 5870 h of total flight time (± 5201 SD) and 170 h (± 174 SD) in the 90 days preceding the crash.

Pilot Age and Crash Circumstances

Crash circumstances under select conditions differed for pilots across different age groups (see Table 1). Overall, 69% of the crashes occurred during daytime (7 a.m. to 6.59 p.m.), 82% on weekdays, 65% off airport, and 80% under visual meteorological conditions. Crashes among older pilots were more likely to occur during the daytime than at night ($p < .001$) and off airport rather than on airport ($p < .006$). Of the 1751 pilots involved in the crashes, 24% were fatally injured. Although the frequency of air-taxi crashes decreased progressively during the study period, the proportion of air-taxi crashes that involved older pilots increased significantly (Table 1).

Pilot Age and Crash Type

The types of crashes did not differ significantly with pilot age. Of the 1751 air-taxi crashes studied, 28% resulted from mechanical failure, 25% from loss of control at landing or takeoff, 7% from fuel starvation, 7% from visual flight rule (VFR) into instrument meteorological condition (IMC), 5% from taxiing, and 28% from other causes (e.g., improper instrument flight rule (IFR) approach, icing, stall, mountain terrain, gear up landing, midair collision, wire or utility pole strike, ramp injury, unknown or undetermined).

Pilot Age and Error

Pilot error was a contributing factor in 70% of the air-taxi crashes studied. The prevalence of pilot error did not vary significantly with pilot age (Table 2). The patterns of pilot errors were similar across age groups. Overall, 27% of the pilot errors identified were flawed decisions (related to crosswinds, flew aircraft with known defect, flying low, related to gear problem, related to engine power loss or shutdown), 26% were inattentiveness (improper preflight, did not see and/or avoid, careless –relative to fuel system, careless –relative to landing gear, set altimeter or avionics wrong, misinterpreted instruments or warning), 23% mishandled aircraft kinetics (could not recover from stall, did not use enough rudder or misused rudder, did not use flaps correctly, flared too high or improper flare, height-velocity curve (helicopter), mishandled rejected takeoff, poor response to bounce), 15% mishandled wind and/or runway conditions (misjudged short or narrow runway, poor handling of airport surf, poor response to hazardous runway), 5% were improper IFR procedure (below minimums anywhere on

approach procedure, off course, improper missed approach, sighted runway late and tried to land), 1% were misjudgments of conditions or distances while taxiing (misjudged slippery surf, misjudged wind, misjudged aircraft distance), 1% were poor crew interactions (certified flight instructor or pilot-in-command delayed remedial action or takeover of crew, pilot-in-command did not supervise crew, poor crew coordination), and 2% were other errors (did not use checklist, lost or unaware of position, misused mixture control, poor communications with air-traffic controller or in Unicom)). An example of a poor decision was the air-taxi pilot who was killed because he declined de-icing service for his ice-contaminated plane and then flew into known severe icing conditions

Pilot Age, Flight Experience, and Pilot Error

We then analyzed the data to determine whether crashes with and without pilot error differed by pilot age and flight experience as measured by total flight time and flight time in the last 90 days. The analysis revealed that crashes with pilot error did not differ significantly by pilot age and that neither total flight time nor flight time in the last 90 days was associated with the prevalence of pilot error (all p 's > .05).

DISCUSSION

This study examined the relationship between pilot age and error in air-taxi crashes. The results indicate that the prevalence and patterns of pilot error in non-scheduled air taxi crashes are similar across age groups. The types of crashes also did not vary with pilot age. More than half of the crashes (54%) were due to mechanical failure or loss of control during landing or takeoff. These factors can operate in isolation or in combination with one another. Although the overall frequency of air-taxi crashes decreased progressively during the study period, the proportion of air-taxi crashes that involved older pilots increased significantly. The increasing proportion of air-taxi crashes involving older pilots may simply reflect the fact that the air-taxi pilot population is aging. Overall, 70% of the air-taxi crashes were attributed to pilot error, regardless of pilot age. Flawed decisions, inattentiveness, and mishandling aircraft kinetics together accounted for more than three-quarters (76%) of all pilot errors identified in air-taxi crashes. This finding is consistent with our previous study of air-carrier crashes where 70% of the crashes were attributed to these three factors (6). In the Li et al. (6) study "decision errors" accounted for 25% of all pilot errors in 558 air-carrier crashes, which is comparable to our finding that 27% of all pilot errors were flawed decisions (e.g. flew aircraft with known defect; flew low). Weigmann and Shappell (12) analyzed 44 air-carrier crashes using the Human Factors Analysis and Classification system and found similar results. One quarter of all pilot errors in their study involved decision errors.

While the prevalence and patterns of pilot error did not show significant age-related variation, the circumstances of crashes among air-taxi pilots do appear to vary with age. Crashes involving older pilots were more likely to occur during the daytime rather than in the evening and off airport rather than on airport. The higher occurrence of daytime crashes may reflect the fact that older pilots generally have more seniority and therefore may have the opportunity to choose daytime flights; also, they may be more likely to fly during the daylight hours because of age changes in night vision that make flying in the dark more difficult. The higher percentage of off-airport crashes among older pilots may reflect differential exposure patterns related to greater seniority, with older pilots flying larger aircraft and longer flights than younger pilots (6). Younger pilots may fly shorter flights and have more takeoffs and landings, putting them at higher risk of on-airport mishaps.

It is unclear from these results the extent to which the prevalence and patterns of pilot error varies across aviation categories due to differences in pilot flight experience, type of aircraft, and environment. Pilot error represents a complex multivariate interaction between both

intrinsic performance factors (e.g., decision making skills, psychomotor speed) and extrinsic (e.g., weather condition) factors (1,,8). We did not directly assess pilots' cognitive abilities or their piloting skills under real or simulated flight conditions. There were also environmental factors that may affect flight safety such as weather conditions that we did not include in our analyses because of missing data.

The findings from our observational study do not necessarily contradict previous reports from simulation studies that the ability to accomplish some flight-related tasks declines with advancing age (9,10,11). These studies typically employ smaller samples with less experienced pilots under tightly controlled experimental conditions using outcome measures that are more domain-specific. Differences in research design, methodology, and study populations between observational studies and experimental studies may help account for the discrepancy in the findings.

The present study has several limitations. First, we confined the analysis to pilot error identified in crashes. Errors that did not lead to crashes were not recorded. The latter may represent a much larger proportion of the total number of pilot errors committed. Capturing those errors would require an in-flight surveillance system that sampled pilot behavior over representative times and flights. Without these data, we cannot definitively answer the question of whether the prevalence and patterns of pilot error change with pilot age. Second, this study was based on retrospective data over a 20-yr period. Secular trends in aircraft design, pilot training, federal regulations, and other factors may affect different age cohorts of pilots differently, thereby confounding the relationship of pilot error and pilot age as examined in this study. Finally, it should be emphasized that pilot error examined in this study represents only one component of human factors (4,5,8). Human factors research typically focuses on pilot performance. Other factors that may be causally linked to crash occurrence such as organizational culture, company safety practices, and pilot supervision were not adequately evaluated in this study.

Their limitations notwithstanding, the present results contribute to a deeper understanding of the relationship between pilot age and aviation safety. Results from the study indicate that the prevalence and patterns of pilot error identified in air-taxi crashes were similar across age groups. The reasons for the lack of age-related differences in prevalence and patterns of pilot error are unclear but may be attributable to the "safe worker" effect. Air-taxi pilots are required to undergo periodic medical examinations that are designed to screen physically and mentally unfit pilots, and they are subjected to constant competency tests on the job. Pilots who are identified as unfit undergo more rigorous testing using more sophisticated diagnostic tools and consultation that can lead to disqualification. These standard testing procedures effectively limit the number of unfit pilots who can continue to fly as they age. Future research should be directed toward studying the evolving relationship between pilot age and error using prospective longitudinal designs.

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Table 1
Circumstances of air-taxi (Part 135 nonscheduled) crashes by pilot age (10-year interval), United States, 1983–2002.

	Age (yr)										p-value	
	<30		30–39		40–49		50–59		>60			Total
Time of accident	n	%	n	%	n	%	n	%	n	%	n	%
7:00 AM – 6:59 PM	242	59.5	425	69.1	296	72.6	176	72.4	61	78.2	1200	68.5
7:00 PM – 6:59 AM	165	40.5	190	30.9	112	27.4	67	27.6	17	21.8	551	31.5
Location of accident												
On airport	159	40.2	210	35.7	130	32.6	65	27.7	23	30.7	587	34.7
Off airport	236	59.8	378	64.3	269	67.4	170	72.3	52	69.3	1105	65.3
Type of aircraft												
Airplane	383	94.1	487	79.2	309	75.7	193	79.4	71	91.0	1443	82.4
Helicopter	24	5.9	128	20.8	99	24.3	50	20.6	7	9.0	308	17.6
Engine type												
Reciprocating-fuel injected	264	65.7	283	47.1	163	40.6	102	42.9	36	48.0	848	49.4
Reciprocating-carburetor	61	15.2	91	15.1	71	17.7	43	18.1	14	18.7	280	16.3
Turbo Shaft	23	5.7	119	19.8	90	22.4	46	19.3	6	8.0	284	16.5
Turbo prop	26	6.5	56	9.3	43	10.7	13	5.5	4	5.3	142	8.3
Reciprocating	20	5.0	38	6.3	23	5.7	27	11.3	14	18.7	122	7.1
Turbo jet	6	1.5	8	1.3	5	1.2	3	1.3	1	1.3	23	1.3
Turbo fan	2	0.5	6	1.0	6	1.5	4	1.7	0	0.0	18	1.0
Time period												
1983–1987	175	43.0	231	37.6	119	29.2	70	28.8	19	24.4	614	35.1
1988–1992	106	26.0	153	24.9	125	30.6	52	21.4	14	18.0	450	25.7
1993–1997	85	20.9	133	21.6	93	22.8	52	21.4	20	25.6	383	21.8
1998–2002	41	10.1	98	15.9	71	17.4	69	28.4	25	32.0	304	17.4

Prevalence rates of pilot error among air-taxi (Part 135 non-scheduled) crashes by pilot age, United States, 1983–2002

Table 2

		Age (yr)										p-value	
		<30		30–39		40–49		50–59		>60			Total
Pilot error		n	%	n	%	n	%	n	%	n	%	n	%
No		134	32.9	184	29.9	131	32.1	58	23.9	18	23.1	525	30.0
Yes		273	67.1	431	70.1	277	67.9	185	76.1	60	76.9	1226	70.0
Total		407	100.0	615	100.0	408	100.0	243	100.0	78	100.0	1751	100.0