Article

Is Declined Cognitive Function Predictive for Fatal Accidents Involving Aging Pilots?

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Abstract: Background. Civil aviation comprises airlines/charter operators and general aviation (GA). Currently, airlines are experiencing a pilot shortage, partly reflecting scheduled retirements mandatory for airline (but not GA) pilots aged 65 years, fueling a debate as to whether the retirement age should be increased. Herein, using 16–40 years-of-age aviators as a reference, we determined whether GA pilots aged 60+ years (i) incurred an elevated accident rate, employing, for the first time, age-tiered flight time as a measure of risk exposure and (ii) carried an excess risk for cognitive deficiency-related fatal accidents. Methods. Airplane accidents (2002–2016) involving Class 3 medical certificated pilots were per the National Transportation Safety Board (NTSB) databases. Age-tiered pilot risk exposure represented a summation of flight hours per Class 3 medical applications. Cognitive decline measures were per NTSB field codes. Statistical analyses employed Chi-Square, Mann–Whitney, logistic regression, and binomial tests. Results. Using flight hours as the denominator, the fatal accident rate for older pilots (41–80 years) was unchanged compared with aviators aged 16–40 years. In the logistic regression, no cognitive deficiency measure was predictive (p = 0.11, p = 0.15) for pilots aged 61+ years who were involved in fatal accidents. Conclusion. These findings question the necessity of an automatic disqualification of air transport pilots at 65 years of age.

Keywords: general aviation; pilot; age; cognitive function; fatal accident

1. Introduction

Civil aviation (by definition excluding all military operations) can be largely divided into air carriers/charter operators and all others, the latter referred to as general aviation [1]. Currently, air carriers (also referred to as airlines in the common vernacular) have been experiencing a shortage of qualified pilots as a consequence of a reduction in workforce brought about by the COVID-19 pandemic [2–4]. This shortage has been further exacerbated by a wave of scheduled retirements [3] mandatory for airline pilots at 65 years of age [5] as promulgated by the International Civil Aviation Organization (ICAO) [6].

As a result, there has been a push by aviation stakeholders in the USA to increase the mandatory retirement age of airline pilots [2]. It is worth noting that, in contrast, general aviation pilots have no upper age limit after which they are disallowed from exercising their flying privileges. Indeed, some active general aviation pilots (defined as holding at least a current Class 3 medical certificate) are in their seventh [7] and eighth [8] decades of life.

However, two separate counterarguments to raising the retirement age for airline pilots beyond 65 years have been advanced. The first concern centers on earlier studies reporting higher accident rates, or pilot errors, for general aviation pilots advancing in age [9,10]. Second, the natural cognitive decline associated with the aging process has led to the debate as to whether airline pilots can operate safely, especially in the face of an unexpected event (e.g., equipment failure, weather diversion) [11]. Indeed, flying an aircraft requires "fluid" mental abilities (decision-making, sequencing of responses, solving
problems quickly, multitasking), with these executive functions all declining from middle age onwards [11,12]. Flight simulation studies have generally been consistent with this view [13], with older pilots showing inferior performance in maintaining a flight path [14].

Notwithstanding the above arguments against raising the retirement age for airline pilots, the cited studies were not without limitations. Firstly, regarding the reports of a higher accident rate for older general aviation pilots, such research, without exception [9,10], has used age-tiered pilot count rather than age-tiered aviator flight time to calculate an accident rate. The potential problem with using pilot count as the denominator is that if older pilots accrue more flight time annually (compared with the younger group), this could lead to an artificially inflated accident rate as a consequence of increased risk exposure. Second, in the context of the cognitive decline studies, researchers noted considerable variation in executive function across individuals of a specific age range [12], concluding that cognitive assessment was superior to chronological age in predicting flight performance [13]. Additionally, other research on cognitive function found evidence that more advanced certification and/or flying experience for older pilots helped buffer against age-related declines in cognitive function [15,16].

Considering the shortcomings of the aforementioned research, we undertook a study with three objectives in mind. First, we challenged the assumption that pilot risk exposure is unchanged with advancing age. Second, we determined whether the accident rate, in which age-tiered flight time was used as a measure of risk exposure (i.e., denominator), was indeed elevated for general aviation pilots advancing in age. Third, we determined whether measures of cognitive function deficiency were predictive for older pilots involved in fatal accidents.

2. Materials and Methods

2.1. Human Subjects

The research performed herein was approved (24-068) by the Embry-Riddle Aeronautical University Institutional Review Board.

2.2. Procedure

The National Transportation Safety Board (NTSB) aviation accident Microsoft Access® databases (March 2023 and Pre 1982 releases) [17] were downloaded and queried for accidents (2002–2016) involving light airplanes (<12,501 lbs.) operated by a pilot holding a Class 3 medical certificate. We did not include accidents beyond 2016 since BasicMed, which allows general aviation pilots to bypass Class 3 medical certification, went into effect after this year [18]. Importantly, BasicMed does not record pilot flight time. Accidents earlier than 2002 were not included because of annual pilot-age-specific flight time data (see below) migration issues as cited by the provider (Civil Aerospace Medical Institute (CAMI)). The search was further restricted to accidents for which the flight was conducted under general aviation regulations (14CFR 91). For each accident, pilot age, certification, total flight experience, and injury severity were per the NTSB database.

Annual pilot age-specific flight times, employed as a denominator for accident rate calculations, were determined as follows. As a preface, for the period of study (2002–2016), all general aviation pilots were mandated to hold at least a Class 3 medical certificate [19], with the CAMI as a repository of these data. For each year of the aforementioned period, CAMI kindly provided six-month flight times and corresponding pilot ages for all aviators applying for a Class 3 medical certificate as reported on their application. For each aviator, this six-month flight time value was multiplied by two to derive an annual flight time and binned according to the age group and year of the Class 3 medical application. Age-tiered flight times (risk exposure) were calculated by summing these values for each aviator within a specified age group and across the designated period. Accident rates were determined for the 2002–2016 period using the age-grouped mishap count as the numerator and the aforementioned age-tiered flight time as the denominator.
Measures of deficient cognitive function or physical impairment/incapacitation for each accident were per prior published studies (see below), mapping each measure to the corresponding “finding_code” field in the NTSB Access database. For accidents in which a cognitive deficit was a contributing factor, the “finding_code” field was queried for the numeric value corresponding to the following terms in the personnel issues category: (i) action/decision–info processing/decision–decision making/judgment (02041520XX) [13], (ii) action/decision–info processing/decision–expectation/assumption (02041525XX) [13], (iii) psychological–attention/monitoring–attention (02021510XX) [20,21], (iv) psychological–attention/monitoring–task monitoring/vigilance (02021520XX) [11], (v) psychological–attention/monitoring–monitoring equip/instruments (02021525XX) [11], (vi) psychological–attention/monitoring–monitoring communications (02021530XX) [11], (vii) task performance–communication (personnel)–following instructions (02063537XX) [13], and (viii) task performance–workload management–task scheduling (02064010XX) [11,12]. Similarly, accidents due to physical impairment/incapacitation were identified by querying for numeric values corresponding to “neurological (02012045XX)”, “cardiovascular” (02012050XX), or “other loss of consciousness (02012055XX)”.

It should be noted that since the aforementioned codes were introduced into the NTSB database (Enhanced Accident Data Management System—eADMS) in 2006, and allowing for an arbitrary NTSB investigator familiarization period of two years, we restricted scoring of mishaps related to cognitive decline/physical impairment to the 2008–2016 period.

2.3. Statistical Analysis/Modeling

Differences in proportions were tested using a Pearson Chi-Square or Fisher Exact test (2-sided) [22,23]. Adjusted residuals (z-scores) were used to identify contributing cells [22]. A Mann–Whitney test [22] was used to determine if differences in the median value for annual aviator flight times (h) were statistically significant among the age groups. A binomial test was employed to determine if the fraction of accidents for which pilots (61+ years of age) were scored for a measure of cognitive deficiency and/or physical impairment differed from that for the reference group (aviators 16–40 years of age). Forward elimination logistic regression was used to determine which of the measure(s) identified in univariate analysis was/were predictive for older (61+ years of age) aviators involved in fatal accidents [24,25]. All statistical testing was performed using the SPSS v27 package (IBM®, Armonk, NY, USA).

3. Results


As discussed above, previous studies reporting an elevated general aviation accident rate with advancing age have been based on the premise that risk exposure (i.e., flight time) is identical across the pilot age range. However, as, anecdotally, older pilots fly more (presumably reflecting increased financial security), we challenged this assumption.

Towards this end, we first determined age-tiered median annual flight hours (2002–2016) using data reported by pilots for their Class 3 medical certificate applications. Note that 2016 was used as the final year to avoid the effect of BasicMed [18], for which pilot flight time is not recorded. BasicMed represents an alternate mechanism by which general aviation pilots can bypass FAA Class 3 medical certification, which came into effect in 2017 [18]. Interestingly, there was a more than 2-fold increase (Figure 1A) in median annual flight times for pilots 41–60 and 61–80 years of age compared with aviators 16–40 years old (42.7, 47.2, and 18.6 h, respectively), which were statistically significant differences ($p < 0.001$). Thereafter, however, the median annual flight time decreased ($p < 0.001$) by 6% for aviators 81 years of age or older.
In Figure 1, age-specific pilot flight time (2002–2016) was determined from Class 3 medical applications (i.e., reported as for the most recent 6 months) multiplied by a value of two to generate an annual flight time. In panel A, the bar height indicates median annual flight times with range bars depicting 25th and 75th percentiles. A Mann-Whitney test was used to determine statistical differences in median flight times among the age groups using a Bonferroni-corrected p value = 0.006. In panel B, the age-tiered risk exposure represents the product of pilot count and annual flight time summed across the specified age group. n represents the pilot count.

However, median flight times do not, in themselves, measure risk exposure, which is also a function of age-tiered pilot count. Accordingly, we then quantified (Figure 1B) risk exposure (product of age-tiered flight time and pilot count for the corresponding age bracket). Older pilots (41–80 years of age) showed a 2.5–4.5-fold elevated risk exposure compared with aviators 16–40 years of age, although there was a dramatic reduction thereafter (pilots 81+ years).

Accidents were obtained for the period spanning 2002–2016 involving pilots holding Class 3 medical certificates and operating under general aviation regulations (14CFR Part 91). Accidents were binned by pilot age, and the mishap rate was determined using flight time for the corresponding pilot age group as the denominator.

Nevertheless, these data clearly illustrate an increased risk exposure for pilots advancing in age (up to 80 years) and validate the concern that prior studies on age-dependent mishap risk [9,10,26], in which pilot count was used to calculate accident rates, should be interpreted with extreme caution.

Non-fatal and fatal accident rates were then determined based on the aforementioned risk exposure. A non-fatal accident rate of 17.4 per 100,000 flight hours was calculated for pilots 16–40 years of age, and we saw no evidence of an increase in this rate with advancing age (Figure 2). Similarly, the fatal accident rate was not elevated for pilots 41–60 or 61–80 years of age (Figure 2) when compared with younger (16–40 years of age) aviators (2.6, 2.9,
and 2.9 per 100,000 flight hours, respectively). However, a 33% increase in the fatal mishap rate was apparent for aviators 81+ years of age compared with the reference cohort (pilots 16–40 years old).

Together, these data, based on exposure risk, provide little evidence of an elevated fatal, or non-fatal, accident rate for general aviation pilots 41–80 years of age when compared with younger aviators (16–40 years old).

Considering the plethora of studies documenting cognitive decline in pilots advancing in age [13,16,27], we next determined whether there was a disproportionate count of fatal accidents involving older aviators for which cognitive deficiency was determined to be a contributing factor per the NTSB report. It should be noted that since cognitive deficiency and physical impairment codes were only introduced into the NTSB database in 2006 [17], this part of our study was restricted to 2008–2016. Considering this truncated time frame and the relatively small fatal accident count for pilots 81 years of age and older, we combined the two upper (61–80 and 81+) age brackets for this part of the analysis.

Surprisingly, for aviators 61 years of age or older, in the univariable analysis, fatal accidents related to one or more of the following cognitive deficiency measures (attention, task monitoring/vigilance, monitoring communications) in the attention monitoring sub-classification [20,21] trended downwards using the 16–40 years-of-age pilots as reference. (Table 1). Thus, one or a combination of these cognitive deficiency measures was cited in 2.8% and 5.6% of fatal accidents for the 61+ and 16–40 years-of-age pilot groups, respectively. Similarly, for the younger aviators, there was a disproportionate count ($p < 0.001$) of fatal accidents (Table 1) in which one or more factors (aggregated under the umbrella of action/information processing/decision sub-classification) [13] associated with cognitive decline were cited as contributing to the mishap. Specifically, whereas for 27% of fatal accidents involving pilots aged 61+ years, one or multiple factors in the action/info processing/decision sub-classification group were cited as contributing, this fraction rose to 37% for the young aviator cohort (16–40 years of age).
Table 1. Contribution of cognitive impairment to fatal accidents (2008–2016). NTSB reports (2008–2016) for accidents involving pilots 16–40 or 61+ years of age were queried for the indicated cognitive measures (factors). A binomial test was used to determine if there was a disproportionate count of accidents involving older pilots (61+ years) compared with the reference group (16–40 years). Since cognitive deficiency codes were introduced by the NTSB in 2006, earlier accidents per the current study were not assessed. ND, not performed because of a lack of statistical power.

<table>
<thead>
<tr>
<th>Major Personnel Issue Classification</th>
<th>Sub-Classification Factor</th>
<th>Cognitive Impairment Accident Count (n)</th>
<th>Total Fatal Accident Count (n)</th>
<th>Fraction of Fatal Accidents</th>
<th>Cognitive Impairment Accident Count (n)</th>
<th>Total Fatal Accident Count (n)</th>
<th>Fraction of Fatal Accidents</th>
<th>p Value</th>
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<tr>
<td>Psychological</td>
<td>Attention</td>
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<td>0.056</td>
<td>9</td>
<td>0.028</td>
<td>ND</td>
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<td></td>
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<td>Cognitive Overload</td>
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<td>Task Performance</td>
<td>Communication</td>
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<td>Following Instructions</td>
<td>90</td>
<td>0.367</td>
<td>87</td>
<td>0.273</td>
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<tr>
<td>Action-Decision</td>
<td>Action/Info Processing/Decision</td>
<td></td>
<td>33</td>
<td>0.307</td>
<td>87</td>
<td>0.273</td>
<td>&lt;0.001</td>
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<td>Identification/Recognition</td>
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<td>Understanding/Comprehension</td>
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<td>Expectation/Assumption</td>
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We next determined whether a disproportionate count of fatal accidents due to physical impairment/incapacitation was evident for older pilots (Table 2). The measures (factors) were neurological, cardiovascular, and other loss of consciousness. Indeed, for pilots 61 years of age or greater, while 4.1% of fatal mishaps were attributed to a physical impairment/incapacitation, no such deficiency was noted for any of the 90 fatal accidents involving aviators 16–40 years of age. Using a binomial test, this difference was highly statistically significant (p < 0.001).

Table 2. Physical impairment of pilots advancing in age involved in fatal accidents. NTSB reports (2008–2016) for accidents involving pilots 16–40 or 61+ years of age were queried as to whether the indicated physical impairment was causal for the fatal mishap. A binomial test was used to determine if there was a disproportionate count of accidents involving older pilots (61+ years) compared with the reference group (16–40 years). Since there were 0 cases of physical impairment for the younger pilots, a value of 1 was arbitrarily assigned to allow for binomial testing. Note that as physical impairment codes were only introduced by the NTSB in 2006, earlier accidents per the current study were not assessed.

<table>
<thead>
<tr>
<th>Sub-Classification</th>
<th>Factor</th>
<th>Physical Impairment Accident Count (n)</th>
<th>Total Fatal Accident Count (n)</th>
<th>Fatal Accident Fraction</th>
<th>Physical Impairment Accident Count (n)</th>
<th>Total Fatal Accident Count (n)</th>
<th>Fatal Accident Fraction</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical impairment/incapacitation</td>
<td>Neurological, cardiovascular, or other loss of consciousness</td>
<td>0</td>
<td>90</td>
<td>0.000</td>
<td>13</td>
<td>319</td>
<td>0.041</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

The fraction of fatal accidents (2002–2016) involving pilots with the indicated certificate (STU, student; SPRT, sport; PRI, private; REC, recreational; COMM, commercial; CFI, certified flight instructor; ATP, airline transport pilot) was calculated for aviators in the specified age range. For each age group, the sum of accident fractions = 1. Differences in
proportions were tested for statistical significance using a Chi-Square test and adjusted standardized residuals. n represents the accident count.

### 3.2. Pilot Certification and Flight Experience

Our univariable analysis finding that measures commonly associated with cognitive decline were not numerically over-represented in accidents involving older pilots was unexpected in light of published studies [11,13,27,28]. However, in earlier investigations, researchers have noted that advanced pilot certification and/or flight experience can offset age-related cognitive decline [15,16]. Indeed, younger (16–40 years of age) aviators involved in fatal accidents (2002–2016) were more likely (p < 0.001) to hold (Figure 3) a lower-level pilot certificate (student, sport, recreational, private). As a corollary, there was a disproportionately lower count of accidents in younger pilots holding an advanced certificate (commercial, certified flight instructor, airline transport pilot) when compared with pilots advancing in age (aged 61+ years).

![Figure 3. Highest pilot certificate for aviators involved in fatal accidents.](image)

In a similar vein, a more than six-fold lower level of total flight experience was evident (Figure 4) for young accident aviators (16–40 years of age) in comparison with mature aviators (61+ years of age). The difference in the median flight experience between the two age groups of accident aviators was strongly statistically significant (p < 0.001).

![Figure 4. Total flight experience for pilots involved in fatal accidents.](image)
Total flight times (h) for pilots 16–40 and 61+ years of age who were involved in fatal mishaps (2002–2016) are shown in Figure 4. Each filled circle represents a flight time value for one or multiple pilots, with the horizontal bar depicting median values. The data include flight times of a second crew member (if present), where that aviator occupied a crew member position. A Mann–Whitney U test was used to determine whether the difference in the medians for the two age groups was statistically significant. n represents the pilot count.

3.3. Multivariable Analysis of Measures Predictive for Accident Pilots Advancing in Age

We next undertook logistic regression [25] to identify the factor(s) predictive of aging pilot involvement in fatal accidents. Towards this end, parameters for which accident counts were numerically disproportionate for either pilot age group in the univariable testing (per Table 1) were included in model testing. Logistic regression allows for the quantification of the increased (or decreased) risk (odds ratio) of an older pilot (relative to the younger cohort: 16–40 years of age) being involved in a fatal accident while simultaneously adjusting for the effects of the other variables. This circumvents one of the limitations of univariable (proportion testing) analysis, which fails to take into account the effect of other variables.

Dichotomized accident pilot age (16–40 and 61+ years of age) was used as the outcome variable. Employing this logistic regression model with a constant only, 78.3% of the participants were classified correctly. The model was not improved in terms of predictive accuracy for older pilots (aged 61+ years) involved in fatal accidents by the addition of either measure of cognitive function deficiency (attention–monitoring or action–decision). More specifically, neither measure of cognitive function deficiency was predictive ($p = 0.11$ and $p = 0.15$, respectively) for the cohort of older accident pilots (61+ years of age) (Table 3).

The lack of statistical significance was reinforced by the confidence intervals crossing unity. Thus, the multivariable analysis indicated no increased risk for older pilots (61+ years of age) to be involved in a fatal accident in which either of these cognitive deficit measures were implicated.

**Table 3.** A logistic regression analysis of risk factors predictive for aging pilot involvement in a fatal accident. Measures (predictive variables) associated with accidents involving pilots advancing in age (61+ years of age) from the univariable analysis were tested in a logistic regression. The outcome variable was dichotomized into accidents involving pilots 16–40 and 61+ years of age. A cutoff of 500 h total flight experience was chosen based on this value being above Q3 for young (age 16–40 years) and below Q1 for mature (61+ years of age) accident pilots. Pilot certificate acronyms are as follows: STU (student), SPRT (sport), REC (recreational), PVT (private), COM (commercial), CFI (commercial), and ATP (airline transport pilot).

<table>
<thead>
<tr>
<th>Predictive Variable</th>
<th>Comparison</th>
<th>Significance ($p$ Value)</th>
<th>Odds Ratio</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention–monitoring deficit</td>
<td>Not contributory (referent)</td>
<td>0.11</td>
<td>0.30</td>
<td>0.07</td>
<td>1.30</td>
</tr>
<tr>
<td>Action–decision deficit</td>
<td>Not contributory (referent)</td>
<td>0.15</td>
<td>0.63</td>
<td>0.35</td>
<td>1.17</td>
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<tr>
<td>Pilot certification</td>
<td>STU-SPRT-REC-PVT (referent)</td>
<td>0.70</td>
<td>1.19</td>
<td>0.49</td>
<td>2.92</td>
</tr>
<tr>
<td>Total flight experience (&gt;500 h)</td>
<td>COM-CFI-ATP</td>
<td>&lt;0.001</td>
<td>0.06</td>
<td>0.03</td>
<td>0.11</td>
</tr>
</tbody>
</table>

4. Discussion

We report herein two novel findings. First, we found little evidence of an elevated fatal, or non-fatal, accident rate for GA pilots up to 80 years of age compared with aviators 16–40 years of age. Second, notwithstanding a small population size, aviators of 61+ years...
were at no greater risk than pilots 16–40 years of age for incurring a fatal accident in which a measure(s) of cognitive decline was/were implicated.

These findings were surprising, especially in the context of several previous studies reporting higher accident rates (irrespective of injury severity) for aging pilots \[10,29\]. How then can we reconcile our findings with past research? In one study \[29\], Li and co-workers reported that pilots 65 years of age or older carried the highest risk of a crash. However, as mentioned in the Introduction, the limitation of that study was in employing pilot count (as the denominator to express an accident rate) and, as we show herein, risk exposure shows a statistical increase with advancing age up to 80 years of age. In contrast, we found no evidence of an elevated fatal accident rate for pilots 61–80 years of age. Several possible reasons, in addition to the use of pilot count as a measure of risk exposure, could contribute to this difference including the following: (a) different age groups for the control cohort and (b) separate time frames of the two studies (1993–2002 and 2002–2016).

Our observations indicating that measures of cognitive decline were not disproportionately higher for fatal accidents involving pilots 61 years of age and older were also unexpected. Certainly, past research \[14\] has documented cognitive decline for aviators advancing in age consistent with the population at large \[12\]. In neuropsychological tests (assessing psychomotor speed, information processing speed, attention, and executive ability) on 220 aircraft pilots, researchers reported a gradual linear decline across several domains between 28 and 62 years of age. Furthermore, in a flight simulator study \[13\], pilots who failed to recall crosswind components or weather were more likely to be older. Older pilots also showed a decline in the speed of mental processing \[13\]. Resonant with these findings, researchers \[14\] reported lower performance of older pilots in maintaining their flight paths \[14\]. Such findings are consistent with the knowledge that executive functions (decision-making, problem-solving, planning and sequencing of responses, multitasking), processing speed, and reasoning, collectively referred to as “fluid” mental abilities, decline from middle age onwards \[12\]. For the aviator, such “fluid” abilities are germane to flight safety in the context of a constantly changing flight environment. Thus, a pilot must process new information to solve problems quickly and attend to complex attentional tasks for which selective (irrelevant) information is ignored or attention is divided (multitasking) between equally important tasks, sometimes in a sequential manner \[11\]. How then can our findings be reconciled with such previous reports clearly illustrating cognitive degradation with advancing age? Findings by Morrow and co-investigators \[16\] might shed light on this disparity. The investigators reported that greater flight experience helped buffer against age-related declines in cognitive resources \[16\], aligning with a separate study reporting the protective effect of flight time on pilot error in general aviation accidents \[30\]. Our finding of a six-fold higher total flight experience for pilots 61 years of age, or greater, is consistent with these prior reports. A second plausible reason is that older pilots may avoid flying single-pilot, electing instead to fly with a second qualified aviator to assist with crew duties.

How do our findings impact the current debate on increasing the retirement age of air carrier pilots beyond 65 years in the face of a current pilot shortage \[2–4\]? Despite the absence of an upward trend in fatal general aviation accidents involving older pilots (61+ years of age) related to deficient cognitive function, caution should be exercised in extrapolating these findings to the professional pilot. As noted above, general aviation is, for the most part, a discretionary activity, and pilots may eschew flights for which challenging conditions (e.g., degraded visibility, thunderstorms) are forecast. However, this is not the case for the air carrier pilot assigned to the flight crew of a scheduled flight.

The current study was not without limitations. First, the number of fatal accident cases for the analysis of cognitive decline and physical impairment was small. In fact, power analysis precluded statistical testing of age-related differences in the fraction of fatal accidents related to attention monitoring cognitive impairment. Second, the absence of flight recorders in general aviation aircraft meant that it is likely that some measures of cognitive function were not captured. Third, flight times per Class 3 medicals are self-reported with
no independent verification of their accuracy. Fourth, although our use of pilots 16–40 years of age as a reference group was rationalized based on prior research [27,31], we recognize that such a cohort likely also varies from the older group in the context of experience and risk-taking. Fifth, we recognize that while flight experience has been reported to buffer against age-related cognitive decline, paradoxically, it also represents a risk factor for a fatal outcome for visual flight into meteorological conditions [32]. Lastly, the reporting of incidents (in which no serious injury or substantial aircraft damage occurred) is not mandatory [33], and such mishaps would not appear in the NTSB accident database.

In conclusion, our studies illustrate that pilots up to 80 years of age are at no greater risk of incurring an accident (of any injury level) than their younger counterparts (16–40 years of age). Nevertheless, mature aviators, especially those with reduced total flight experience, should recognize the real potential for cognitive decline [13,27,28] and its negating effect on pilot performance in a dynamic flight environment. Such aviators would be well advised to (i) enroll themselves in an online course(s), which counsels older pilots on ways to operate safely in flight [34], and (ii) exercise prudence in electing to undertake operations in a challenging (e.g., instrument conditions, thunderstorms) flight environment. Finally, in the context of future accident studies on aging pilots, it would behoove researchers to employ age-tiered flight time as a measure of risk exposure [35] for determining accurate mishap rates.

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Informed Consent Statement: Patient consent was waived due to the research being categorized as “secondary research for which consent is not required”. The applicable criterion is: “Information, which may include information about biospecimens, is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained directly or through identifiers linked to the subjects, the investigator does not contact the subjects, and the investigator will not re-identify subjects”.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request with the following caveat. Restrictions apply to the availability of some of these data as addressed by the IRB approval.

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