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Relationships Between Pilot Medical Certificate Class and Aviation Accidents in Alaska

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16. Abstract

Several studies have investigated the effect of pilot age, flying hours, gender, pilot error and expertise on aviation crashes in the United States. However, to our knowledge, an interaction effect of pilot age and medical certificate class on Alaskan aviation accidents was not reported in these studies. In the present study, we compared 365 cases (pilots who had an accident in Alaska: fatal and/or non-fatal) with 10,520 controls (pilots without an accident). The study indicated a significant association between having an accident and pilot medical certificate class, gender, age group and flying hours (hours flown in the last six months before their medical examination). Moreover, the interaction effect of age group and medical certificate class with having an accident was significant (Chi-Square 17.15; $p < 0.0007$). Among pilots with a first-class medical certificate, the study found no significant association between having an accident and the factors studied. In contrast, among pilots with a second-class and third-class medical certificate, the study found a significant association between having an accident and these factors. Aviation crashes in Alaska remain a major concern, and efforts should continue to identify potential risk factors to reduce the number of aviation accidents by promoting research and safety.

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RELATIONSHIPS BETWEEN PILOT MEDICAL CERTIFICATE CLASS AND AVIATION ACCIDENTS IN ALASKA

INTRODUCTION

Alaska is the largest state in the United States, with an area over 663,000 square miles and over 33,000 miles of coastline (Bailey, Peterson, Williams and Thompson, 2000; Bensyl, Moran and Conway, 2001). However, Alaska's road communication is very limited, and the majority (90%) of the state's communities (Bensyl, et al., 2001) are not connected by roads and highways. Due to the limited road communication system, rough terrain, adverse weather and extreme isolation, people in Alaska primarily travel by air or water (Bohrer and D'Oro, 2012) for shopping, camping and other activities throughout the year. It is said that "people in Alaska fly private aircraft like those in the lower 48 take taxis" (Detwiler et al., 2006).

Alaska's aviation environment is diverse. Scheduled air carriers (commuter airlines), which provide service using airplanes with 30 or fewer passenger seats operating under Title 14 of the Code of Federal Aviation Regulation (FAR) Part 135, play the most vital role in transporting people, goods and mail from air carrier hubs to smaller communities (National Institute for Occupational Safety and Health, 2016). For smaller communities and villages, commuter airlines serve as the primary means of transportation for day-to-day business in Alaska (National Transportation Safety Board, 1995). According to the Air Traffic Activity System (ATADS)-Federal Aviation Administration (FAA), the distribution of aviation operations increases significantly during the summer due to hunting, fishing, cargo and passenger transport, sightseeing, mining, game management and camping. Aviation in Alaska develops in response to the demand, and operates a greater number of flights in Alaska during summer compared to other months.

Aviation accidents[1] in Alaska are always a major concern for the Alaskan population. In an effort to develop mitigation strategies to reduce the number of accidents, a diverse team was formed in late 2009 by the FAA Flight Standards Division in Alaska to study the previous six years of Fatal[2] and Serious Injury[3] (FSI) accidents in Alaska and make recommendations to the Alaska Aviation Industry Council based on their findings. The FSI team, led by Dr. David Swartz, reviewed 649 accidents from the calendar years 2004-2009, interviewed several of the FAA flight

[1] NTSB defines an accident as "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight, and all such persons have disembarked in which any person suffers death or serious injury, or in which the aircraft receives substantial damage. A collision between aircraft is counted as one accident"

[2] NTSB defines a fatal injury as "an injury that results in death within thirty (30) days of the accident"

[3] NTSB defines a serious injury as one that "1) requires hospitalization for more than 48 hours within 7 days from the injury date, 2) results in a fracture of any bone, 3) cause severe hemorrhages, nerve, muscle or tendon damage, 4) injury to any internal organ, or 5) involves 2nd to 3rd degree burns, or burns affecting more than 5% of the body surface"

standard inspectors, and identified multiple factors such as pilot medical issues, unexpected flight conditions (controlled flight into terrain [CFIT][4], stall spin, wind, and willful violation) and maintenance. The FSI team found that pilot medical condition was one of the causal factors that accounted for 4% of the fatal and serious injury accidents. In addition, the team also found that pilots' increasing age was associated with pilots' total flight time and having an accident in Alaska during 2004-2009 (Swartz et al., 2010).

Pilot's age, gender, flight experience and weather are among the most widely reported factors associated with general aviation[5] and air taxi (nonscheduled commercial flights under 14 CFR Part 135) crashes (Kay et al., 1993; Kennedy et al., 2010; Li et al., 2003; Li et al., 2009; Tsang, 1992). In 1959, the Federal Aviation Administration (FAA) set an age limit for pilots in Federal Aviation Regulations (FAR) Part 121 operations, which prohibited individuals from serving as a captain or copilot of an aircraft in air carrier operations if they have reached 60 years of age (Kay et al., 1993). This rule was commonly known as the 'Age 60 Rule', and revised in 2007 under the "Fair Treatment for Experienced Pilots Act." Under this act, effective on July 15, 2009, pilots now can serve until reaching 65 years of age. Under federal regulatory action, commuter airlines are required to meet the same operational and equipment performance safety standards as major air carriers.

Aging is a significant factor that continuously impacts human acts, behavior, decision making and psychological functioning (Broach et al., 2003; Czaja, 1990). Studies have suggested that as human cognitive function and working memory decline due to aging, the ability to perform critical and complex tasks is affected (Kennedy et al., 2010; Salthouse, 1990). Researchers have also investigated the relationship between aging and performance in other areas of transportation. In the automobile industry, researchers suggested a "U" shaped relationship between aging and performance (Broach et al., 2003). In the 1990s, researchers indicated that the risk of having a traffic accident was greater for younger (16-19 years) and older (≥75 years) drivers (Massie et al., 1995). In a recent study, Benthem and Herdman (2016) found a strong correlation ($\rho = 0.057$) between age and cognitive function including working memory and vigilant attention. These researchers suggested that effects of aging on aviation accidents or safety are complex, and that it will be difficult to analyze and interpret the results precisely.

The relationship between a pilot's age and aviation safety remains controversial (Bazargan and Guzhva, 2011). Many previous studies indicated a significant effect of pilot age on the relationship between having an aviation accident and other risk factors on aviation safety (Golaszewski, 1983; Harkey, 1996; Kennedy et al., 2010; Tsang, 1992). Richard Golaszewski examined the relationship between pilot age and experience and pilot performance. He collected data from the National Transportation Safety Board (NTSB) Accident Records Database and the FAA's Comprehensive

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[4] CFIT, in general refers to accidents including flight operated under either instrument flight rules (IFR), visual flight rules (VFR) or during transitions from one mode to the other.

[5] General Aviation refers to all aviation except commercial including scheduled and non-scheduled airline operations and military aviation (Li and Baker, 1999).

Airman Information System (CAIS) Medical Certification Database for the years 1976-1980. Golaszewski categorized the data into two groups: all pilots and pilots holding a third-class medical certificate according to the pilot's flight time. Golaszewski found that for low values of recent flight time (under 50 hours a year), "accident rates generally increased with the age of the pilot" (Golaszewski, 1983). In 2011, Bazargan and Guzhva investigated the relationship between pilot age, gender and experience on pilot error and fatal accidents using more recent NTSB data from 1983 to 2002. Bazargan and Guzhva categorized pilot age into 6 groups: <20 years, 20-29 years, 30-39 years, 40-49 years, 50-59 years and ≥60 years; and found that the ratios of pilot error to total accidents were slightly different but not significant for the various age groups. However, with respect to fatal accidents, they found a significant difference among age groups. Bazargan and Guzhva found that older pilots aged ≥60 years were more likely to have a fatal accident than younger pilots (Bazargan and Guzhva, 2011).

Aviation accidents in Alaska remain tragic and common (Bohrer and D'Oro, 2012). During 1963-1981, the FAA and NTSB investigated 3,887 general aviation accidents in Alaska (Alaska Department of Health and Social Services, 1985). During 1980-1985, aviation accidents were one of the leading causes of mortality in the state of Alaska (Alaska Department of Health and Social Services, 1985); nearly 32% of occupational deaths were due to aircraft accidents, 19% were due to drowning and 10% were due to motor vehicle accidents (Schnitzer and Bender, 1990). During 1990-1999, 1,684 aviation crashes occurred in Alaska (Alaska Department of Health and Social Services, 2010). During 2004-2008, Alaska's aviation accident rate was more than double (13.59 vs. 5.85 per 100,000 flight hours) the national average (Bohrer and D'Oro, 2012).

Many studies have been conducted in an attempt to improve safety for the aviation population of Alaska (Bailey et al., 2000; Bensyl et al., 2001; National Transportation Safety Board, 1995; Swartz et al., 2010; Williams, 2011). Most have focused on risk factors such as equipment, navigation aids, ground infrastructure, technology, instrumental condition, visual meteorological conditions and/or pilot demographics (Bensyl et al., 2001; Capstone Safety Study, 2002; Shappell et al., 2006). Risk factors like weather, lightning, and terrain have been shown to play a significant role in aviation accidents in the pilot population of Alaska (Detwiler et al., 2006; National Transportation Safety Board, 1995). Williams summarized the analyses of 97 general aviation accidents in Alaska using the Human Factors Analysis and Classification System (HFACS) in 2011. In his report, skill-based error, violation, decision-based error and perceptual error were among the common aviation accident risk factors (Williams, 2011). Williams recommended immediate pilot training to improve pilot skills and decision-making processes to reduce aviation accidents in Alaska. Bailey et. al., found that CFIT was a major risk factor in the fatality rate in aircraft accidents in Alaska during 1990-1998 (Bailey et al., 2000). This report was prompted by these studies, and was an attempt to assess if pilot medical certificate class was linked to Alaskan aviation accidents and incidents during 2009-2013.

Pilot medical certification is a critical and complex process. The earliest evidence of the importance of good health, physical fitness and medical condition in the aviation industry was revealed from balloon flights in 1800s (William, 1963). However, the full extent of this importance was not experienced until the World War I when the impact of high losses of aviators was devastating for the aviation industry. During that time, a medical program was set with a higher medical and physical standards for the aviators. Since then, the British brought down the aviation fatality figure from 60% to 12% within two years by setting up the first British medical standard during World War I. During that time, the Germans were more advanced in this area, but France, Italy and the United States had similar experiences (William, 1963). By the early 1900s, medical standards became a routine procedure of pilot safety in the aviation industry. In 1917, U.S. Army Brigadier General Theodore Lyster established the Medical Service, and later developed a new standard for the pilot's medical examination in the United States (William, 1963). At present, in the United States, three classes of medical certificate are required under the FARs to become a pilot. Under title 14 of the code of federal regulations (14 CFR) Part 1, the FAA defines medical certificate as "acceptable evidence of physical fitness on a form prescribed by the administrator." In general, per FAR part 61.3, a first-class medical certificate is required for an airline transport pilot (ATP), a second-class medical certificate is required for commercial pilots, and a third-class medical certificate is required for student pilots, recreational pilots and private pilots. According to the FAA Act 1958 (Title 49), the FAA selects qualified physicians, called Aviation Medical Examiners (AME), from the private medical community to conduct airman medical examinations in order to issue medical certificates to aviation pilot applicants. Every examination requires the AME to check each pilot's characteristics and medical conditions including height, weight, vision, hearing, pulse, blood pressure, urine, mental health status and general health. Applicants who meet the FAA airman medical standards during the examination, are entitled to a medical certificate. The certificate may be issued with or without restriction or limitation, depending on their medical history and the duration of certain conditions. The aerospace medical certification division in the FAA's Civil Aerospace Medical Institute (CAMI) in Oklahoma City receives and processes more than 400,000 medical certificate applications every year (Federal Aviation Administration, 2017).

The medical standards for each class of medical certificate are set forth in 14 CFR part 67. There are no minimum or maximum ages for obtaining a medical certificate; however, 16 years is the minimum age requirement to hold a student pilot certificate. According to 14 CFR part 67, a third-class medical certificate requires the least restrictions compared to the first-class and second-class medical certificate requirements in certificate duration, vision testing and electrocardiogram (ECG) testing. For example, for pilots under age 40, a third-class medical certificate expires in 5 years, whereas first-class and second-class medical certificates expire in 1 year. For pilots aged 40 years and older, a third-class medical certificate expires in 2 years, whereas a first-class medical certificate expires 6 months after the examination. For all medical classes, the duration of the certificate may be shorter due to special issuances for certain medical conditions. Pilots with a first-class medical certificate require an ECG at age 35 and yearly after 40 years of age, whereas ECG is not routinely required for pilots with second-class and third-class medical certificates. The distance vision acuity requirement for a first-class medical certificate is 20/20 or better in each eye, whereas the minimum distance vision requirement for a third-class medical certificate is 20/40 with or without correction. For intermediate vision, pilots with a first-class and second-class medical certificate must meet the minimum vision standard of 20/40 in each eye, whereas pilots with third-class medical certificates have no requirement for intermediate vision standard (Federal Aviation Administration, 2017).

During 2009-2013, the NTSB reported a total of 365 general aviation accidents (fatal and/or non-fatal) in Alaska. We sought to investigate whether medical certificate class was linked to Alaskan aviation accidents, and if so, whether different medical certificate classes (first, second and third-class) influenced the odds of having an accident during 2009-2013. To our knowledge, this is the first attempt to explore the effect of pilot medical certificate class on the odds of having an accident for the Alaskan pilot population.

METHODS

The study sample (N = 10,885) consisted of 365 cases and a comparison group of 10,520 controls. Cases were defined as pilots in command with a valid medical certificate who had an accident (fatal and/or non-fatal) that occurred in the state of Alaska, and was recorded in the NTSB dataset during 2009-2013. Controls were all airmen without an accident that held a valid medical certificate during 2009-2013, and listed the state of Alaska as their residence. Data were collected on pilot medical certificate class (first-class, second-class and third-class), age, gender (male and female), accident status (yes or no) and pilot flying hours (flown in the six months before their last medical examination) for the 2009-2013 time period. The examination data from each airman's most recent medical examination was used for analysis.

For this analysis, age was determined based on the time of their last medical examination, and was categorized into four groups, 16-29 years (n = 2390), 30-44 years (n = 2620), 45-59 years (n = 3551) and ≥ 60 years (n = 2324). We also categorized pilot flying hours into two groups: ≤ 75 hours (n= 8369) and >75 hours (n = 2516), categories determined by the population average flying hours 76.5 (SD 142.1). Statistical testing included Chi-Square test and binary logistic regression (backward elimination). We set the level of statistical significance at $\alpha = 0.05$, and used a cut point of 15% (or greater) difference between the crude and adjusted Odds Ratio (OR) to detect confounding. All statistical analyses were conducted using the statistical analysis software SAS, version 9.3.

RESULTS

Table 1 shows the distribution of pilot age with respect to accident status and significant factors in Alaska during 2009-2013. Overall, pilots (N = 10,885) were aged 16 to 94.8 years, and averaged 45.7 years with a standard deviation (SD) of 15.9 years. Pilots with accidents (n = 365) were aged 19.0 to 82.8 years and averaged 48.4 years (SD = 14.1), whereas pilots without accidents (n = 10,520) were aged 16 to 94.8 years and averaged 45.6 years (SD = 16.0). Male pilots (n= 9821) were aged 16.0 to 94.8 years and averaged 46.6 years (SD = 15.8), whereas female pilots (n = 1064) were aged 16.0 to 87.5 years and averaged 38.1 years (SD = 15.1).

Table 2 shows the univariate analyses and significant associations between having an accident and medical certificate class (Chi-Square 70.94; $p < 0.0001$), gender (Chi-Square 18.02; $p < 0.0001$), age group (Chi-Square 17.15; $p = 0.0007$) and flying hours (Chi-Square 66.63; $p < 0.0001$). Using logistic regression, a significant interaction was detected between medical certificate class and age group (Chi-Square 23.32; $p = 0.0007$); therefore, we explored stratified results for each medical certificate class (first-class, second-class and third-class) using three multivariate logistic regression models (Table 3).

Pilots with a first-class medical certificate (n = 2212) were aged 16.1 to 75.8 years and averaged 43.0 years of age (SD = 12.9). Among pilots with a first-class medical certificate, the study found no significant association between having an accident and gender, age group and flying hours. In contrast, among pilots with a second-class and third-class medical certificate, the study found a significant association between having an accident and these factors.

Pilots with a second-class medical certificate (n = 2851) were aged 16.0 to 89.7 years and averaged 44.8 years of age (SD = 15.7). Among pilots with a second-class medical certificate, the percentage of pilots aged 16-29 years and ≥ 60 years were 10.9% and 24.2% in Alaskan accident cases, compared to 24.2% and 19.6% in controls, respectively (Table 3). Thus, among pilots with a second-class medical certificate, pilots aged ≥ 60 years were 2.1 times more likely to have an accident than pilots aged 16-29 years [95% confidence interval (CI), 1.2, 3.7] after adjusting for gender and flying hours. Among pilots with a second-class medical certificate, the percentage of pilots who flew ≤ 75 hours and who flew > 75 hours were 40.6% and 59.4% in Alaskan accident cases, compared to 74.7% and 25.3% in controls, respectively. Thus, among pilots with a second-class medical certificate, pilots who flew >75 hours were 3.9 times more likely to have an accident than pilots who flew ≤ 75 hours (95% CI: 2.8, 5.4) after adjusting for gender and age group (Table 3).

Pilots with a third-class medical certificate (n = 5822) were aged 16.0 to 94.8 years and averaged 47.2 years of age (SD =16.9). Among pilots with a third-class medical certificate, the percentage of male and female pilots were 96.6% and 3.4% in Alaskan accident cases, compared to 88.8% and 11.2% in controls, respectively (Table 3). Thus, among pilots with a third-class medical certificate, male pilots were 3.0 times more likely to have an accident than female pilots (95% CI: 1.2, 7.5) after adjusting for pilot age group and flying hours. Among pilots with a third-class medical certificate, the percentage of pilots aged 16-29 years, 30-44 years and 45-59 years were 10.1%, 22.8% and 38.9% in Alaskan accident cases, compared to 22.1%, 20.4% and 30.9% in controls, respectively. Thus, among pilots with a third-class medical certificate, pilots aged 30-44 and 45-59 years were 2.2 times (95% CI, 1.2-4.0) and 2.4 times (95% CI: 1.3, 4.2) more likely to have an accident than pilots aged 16-29 years, respectively after adjusting for pilot gender and flying hours (Table 3). Among pilots with a third-class medical certificate, the percentage of pilots who flew ≤ 75 hours and who flew > 75 hours were 87.3% and 12.8% in Alaskan accident cases, compared to 96.9% and 3.1% in controls, respectively. Thus, among pilots with a third-class medical certificate, pilots who flew > 75 hours were 3.9 times more likely to have an accident than pilots who flew ≤ 75 hours (95% CI: 2.4, 6.5) after adjusting for pilot gender and age group (Table 3).

Results of the study also indicated that overall, pilots flew a total of 787,273.6 flight hours with an average of 76.6 hours, ranging from 0 to 4350 hours in the six months before their last medical examination. Of all pilots, 3281 (31.9%) reported flying 0 hours in the last six months. Pilots with an accident, on average flew 131.6 hours, whereas pilots without an accident flew on average 74.6 hours. Male pilots, on average flew 79.8 hours, whereas female pilots on average flew 45.4 hours. Pilots with a first-class medical certificate on average flew 218.3 hours, whereas pilots with a second-class and third-class medical certificate flew on average 83.3 hours and 17.6 hours respectively, in the six months before their last medical examination.

DISCUSSION

In this report, we conducted a case-control study to investigate whether medical certificate class (first, second and third-class) was associated with Alaskan aviation accidents during 2009-2013. We compared 365 pilots with an accident (cases) to 10,520 pilots without an accident (controls). To ensure the robustness of the analyses, we used Chi-square test and binary logistic regression to examine the relationships between having an accident and medical certificate class, gender, age group and flying hours. The study indicated there was a significant association between having an accident and these factors in the pilot population of Alaska during 2009-2013. Moreover, the interaction of pilot age group and medical certificate class was significant on pilot having an accident.

A number of studies have investigated the effect of pilot age, flying hours and flying experience on aviation crashes (Broach et al., 2003; Detwiler, et al., 2006; Li and Baker, 1999). To our knowledge, the interaction between pilot age and medical certificate class on Alaskan aviation accidents has not been revealed in previous studies. Guohua Li, et al., found an interaction between weather condition and pilot error related to air carrier crashes in 2009 in the United States (Li et al., 2009). Richard Golaszewski reported the effect of pilot time (flying hours) and age on accident rates in the United States in 1983 for the period, 1976 through 1980. With respect to pilot age, Golaszewski found that older pilots (aged ≥ 70 years) and younger pilots (aged 20-29 years) had higher accident rates compared to other age groups (Golaszewski, 1983). In the present study, Figure 1 shows the effect of age group and medical certificate class on pilots having an accident during 2009-2013. Thus, after stratification and adjusting for gender and flying hours we found that older pilots (aged 45-59 years) with a third-class medical certificate were at higher odds of having an accident than other age groups (Table 3). This finding appears to be similar to the results of Golaszewski's study for the older pilots but not for the younger pilots (aged 16-29 years). The conflicting results could be due to the fact that Golaszewski combined pilot classes into two groups (all pilots and pilots holding third-class medical certificate), and analyzed data considering pilot recent flight time (estimated annual hours flown) and total flight time (cumulative life time experience). Golaszewski's combining pilot classes, and excluding air carrier and commuter accidents from the analysis could have produced different trends from those found in this study. Golaszewski also did not use any statistical analysis on the data.

Bazargan and Guzhva investigated the association of age, gender and flight experience with the incidence of aviation crashes in 2011(Bazargan and Guzhva, 2011). They categorized their study cases, covering the 1983-2002 period, into six age groups (< 20, 20-29, 30-39, 40-49, 50-59 and ≥ 60 years), and found that older pilots were more likely to have a fatal accident than younger pilots. They also noted a higher ratio of fatal to total accidents for the older pilots compared to younger pilots. In the present study, we categorized age into four groups (16-29, 30-40, 45-59 and ≥ 60 years), and found similar evidence that older pilots had a higher percentage of crashes in Alaska compared to younger pilots (Table 2). This finding was expected considering as pilots aged, they might become exposed to various health problems that could impair skills, cognitive function, and working memory, which could lead to aviation accidents (Kennedy et al., 2010).

Previous research has also identified gender and flight time as significant factors (Baker, et al., 2001; Li et al., 2009; Bazargan and Guzhva, 2011). Baker et al., found a large difference between male and female pilots in general aviation crashes with respect to pilot error. They also found that male pilots outnumbered female pilots in 1997. Of all pilots, only 5.8% were females. In the present study, with respect to pilot gender, we found evidence that male cases outnumbered female crash cases in Alaska (male 96.7% vs. female 3.3%). Bazargan and Guzhva reported that between 1983 and 2002, male pilots had a higher rate of accidents than female pilots as well as higher risk of fatal accidents. With respect to the ratio of pilot errors to total accidents, they found that female pilots had a slightly higher ratio of pilot errors than male pilots during 1983-1992 (male 0.81, female 0.83) and during 1993-2002 (male 0.81, female 0.82), but the difference was not significant. However, with respect to the ratio of fatal to total accidents, they found that male had a higher ratio of fatal accidents than female pilots during 1983-1992 (male 0.22, female 0.10) and during 1993-2002 (male 0.23, female 0.16), and the difference was significant. These results indicated that male pilots were more likely to have a fatal accident than female pilots in both decades. In the present study, we found evidence that male pilots were more likely to have an accident than female pilots (Table 3). This could be due to the fact that male pilots were significantly older (t value 17.4; $p < 0.0001$) than female pilots (male mean age 46.6 years with SD 15.8 vs. female mean age 38.1 years with SD 15.1) in the population of Alaska. Another explanation could be that, in respect to flying hours, male pilots were more experienced than female pilots (male mean flight hours 79.8 vs. female mean flight hours 45.4), and more experienced pilots were more likely to take riskier environment, ignore bad weather conditions, and take more challenging flights (Bazargan and Guzhva, 2011) than less experienced pilots. One example of that was, one pilot ignored an obvious fuel leak in the left wing and took off in an aircraft that caught on fire and crashed (Baker et al., 2001). Therefore, male pilots were more likely to be involved in a fatal accident than female pilots in Alaska.

The association between flying hours and aviation crashes has been investigated in several studies (Bazargan and Guzhva, 2011; Broach et al., 2003; Golaszewski, 1983; Li et al., 2009; Kennedy et al., 2010). Li et al., considered total flight time as a measure of pilot experience, and categorized total flight hours and flight time in the last 90 days into four groups (based on quartiles). They found that there was a significant association between flying hours in the last 90 days and aviation crashes, reporting that the aviation incident rate in Alaska was 22.8 crashes per 100,000 flight hours during 1983-2002. Bazargan and Guzhva categorized flying hours into five groups using FAR part 61 as a guide, and identified flying hours as a contributing factor to the increased risk of general aviation accidents in 2010. In the present study, we categorized flying hours into two groups (≤ 75 hours and > 75 hours), and found a similar association between flying hours and having an accident in Alaska. This finding was consistent with the previous study results of Li et al. Bazargan and Guzhva also found that pilots with < 300 total hours were more likely to have a general aviation accident than pilots with > 300 hours during 1983-2002. In this study, we found that pilots with > 75 flight hours were more likely to have an accident than pilots with ≤ 75 hours in Alaska.

The risks associated with Alaskan flight operations and the incidence of aviation accidents and incidents in that state could be managed and mitigated to various degrees by improving operational practices, training, increasing airport control facilities, and perhaps by improving navigational aids (Bailey et al., 2000; Bazargan and Guzhva, 2011; Capstone Safety Study, 2002; Detwiler et al., 2006; National Transportation Safety Board, 1995; Williams, 2011). Apart from these issues, others to consider include pilot medical certificate class (first-class, second-class and third-class), operator category (pilots, co-pilots, student pilots), event time of the day, or conditions such as light levels, visual factors, weather and terrain condition (Detwiler et al., 2006; National Transportation Safety Board, 1995; Williams, 2011).

One limitation of this study was that the data used for the pilot flying hours was self reported to the AME. Another limitation was that the flying hours were based only on the six months before the pilots' last medical examination. This self-reported information could be inaccurate. Also the reported flying hours might not accurately represent the amount of hours a pilot was actually flying before the accident, which could have resulted in misclassification of flying hours. Another limitation could be the assumption that all Alaskan aviation accidents were recorded timely and uniformly during 2009-2013. There is no data to verify this assumption. Results of this present study should be verified with follow-up studies due to the above limitations.

Despite these limitations, the present study improves the existing knowledge of various concerns regarding pilot medical certification classes, and their impact on aviation safety in Alaska. In the present study, we investigated whether medical certificate class was associated with Alaskan aviation accidents, and if so, whether different medical certificate classes (first, second and third-class) were associated with the odds of having an accident in Alaska during 2009-2013.

Although some of the findings of this study were not similar or not consistent with the results of a few previous studies, our findings strongly indicated that medical certification class, age, gender and flying hours were significant factors associated with pilots having an accident in Alaska. We also found that different medical certification classes (first, second and third-class) was associated with the odds of having an accident in Alaska.

Among pilots with a first-class medical certificate, the study found no associations between having an accident and these factors. In contrast, among pilots with a second-class and third-class medical certificate, the study found a significant association between having an accident and these factors. The present study also indicated an upward trend of having an accident with age. Moreover, the results of the study suggested that older pilots with a third-class medical certificate were more likely to have an accident in Alaska compared to the younger pilots with a third-class certificate. Hence, efforts should continue across the nation to identify factors to mitigate risk of aviation accidents and make aviation safer by promoting research and safety in Alaska.

Table 1: Pilot Age at Examination (Mean and Standard Deviation) with Respect to Accident Status (Cases and Controls) and Significant Factors in Alaska 2009-2013

Factors		Cases		Controls	
		Number of Pilots	**Mean Age (Standard deviation)**	**Number of Pilots**	**Mean Age (Standard deviation)**
Medical Class	First	51	42.0 (13.5)	2161	43.0 (12.9)
	Second	165	48.7 (14.1)	2686	44.5 (15.7)
	Third	149	50.4 (13.7)	5673	47.1 (17.0)
Gender	Male	353	48.5 (14.2)	9468	46.5 (15.9)
	Female	12	45.1 (11.8)	1052	38.0 (15.1)
Age Groups (Years)	16-29	48	25.7 (2.9)	2342	23.8 (3.9)
	30-44	96	37.8 (4.4)	2524	37.4 (4.4)
	45-59	133	52.7 (4.6)	3418	52.8 (4.2)
	≥ 60	88	66.0 (4.8)	2236	66.9 (5.6)
Flying Hours (flown in the 6 months before the last medical exam)	≤ 75Hours	216	49.5 (13.8)	8153	45.2 (16.9)
	< 75 Hours	149	46.8 (14.3)	2367	47.2 (12.2)
Overall		**365**	**48.4 (14.1)**	**10520**	**45.6 (16.0)**

Table 2: Classification of Study Sample and Univariate Analyses of Pilots with Respect to Accident Status (Pilots with an Accident and Pilots without an Accident) and Significant Factors in Alaska 2009-2013

Factors		Cases (Percent)	Controls (Percent)	Chi-Square p-value
Medical Class	First	51 (14.0)	2161 (20.5)	<0.0001
	Second	165 (45.2)	2686 (25.5)	
	Third	149 (40.8)	5673 (53.9)	
Gender	Male	353 (96.7)	9468 (90.0)	<0.0001
	Female	12 (3.3)	1052 (10.0)	
Age Groups (Years)	16-29	48 (13.2)	2342 (22.3)	=0.0007
	30-44	96 (26.3)	2524 (24.0)	
	45-59	133 (36.4)	3418 (32.5)	
	≥60	88 (24.1)	2236 (21.3)	
Flying Hours (flown in the 6 months before the last medical exam)	≤ 75 Hours	216 (59.2)	8153 (77.5)	<0.0001
	> 75 Hours	149 (40.8)	2367 (22.5)	

Table 3: Stratified Results and Multivariate Odds Ratios (OR) with 95 Percent (%) Confidence Interval (CI) by Pilots' Medical Certificate Class with Respect to Pilots with an Accident (Cases) and Pilots without an Accident (Controls) for the Pilot Population in Alaska during 2009-2013

Factors		**Medical Certificate First-Class**			**Medical Certificate Second-Class**			**Medical Certificate Third-Class**		
		Cases n=51 (%)	**Controls n=2161 (%)**	**OR & 95% CI**	**Cases n=165 (%)**	**Controls n=2686 (%)**	**OR & 95% CI**	**Cases n=149 (%)**	**Controls n=5673 (%)**	**OR & (95% CI)**
Gender	Female	3 (5.9)	177 (8.2)	Reference	4 (2.4)	238 (8.9)	Reference	5 (3.4)	637 (11.2)	Reference
	Male	48 (94.1)	1984 (91.8)	1.6 (0.5 -5.2)	161 (97.6)	2448 (91.1)	2.4 (0.9-6.8)	144 (96.6)	5036 (88.8)	**3.0 (1.2-7.5)**
Age Groups	16-29	15 (29.4)	440 (20.4)	Reference	18 (10.9)	650 (24.2)	Reference	15 (10.1)	1252 (22.1)	Reference
	30-44	14 (27.5)	670 (31.0)	0.6 (0.3-1.4)	48 (29.1)	695 (25.9)	1.8 (1.0-3.2)	34 (22.8)	1159 (20.4)	**2.2 (1.2-4.0)**
	45-59	16 (31.4)	853 (39.5)	0.6 (0.3-1.3)	59 (35.8)	814 (30.3)	1.8 (1.0-3.1)	58 (38.9)	1751 (30.9)	**2.4 (1.3-4.2)**
	≥ 60	6 (11.8)	198 (9.2)	0.9 (0.3-2.5)	40 (24.2)	527 (19.6)	**2.1 (1.2-3.7)**	42 (28.2)	1511 (26.6)	1.9 (1.0-3.5)
Flying Hours (flown in the 6 months before the last medical exam)	≤ 75	19 (37.3)	652 (30.2)	Reference	67 (40.6)	2006 (74.7)	Reference	130 (87.3)	5495 (96.9)	Reference
	> 75	32 (62.8)	1509 (69.8)	0.8 (0.4-1.6	98 (59.4)	680 (25.3)	**3.9 (2.8-5.4)**	19 (12.8)	178 (3.1)	**3.9 (2.4-6.5)**

Note: Significant odds ratios are indicated in bold

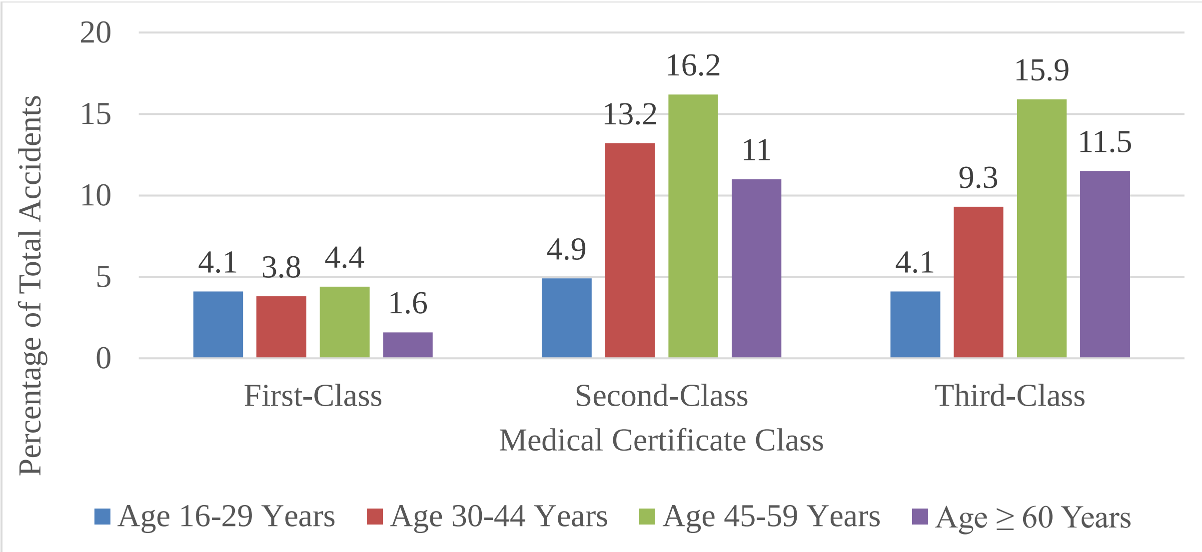

Figure 1. Percentage of Total accidents by Pilot's Medical Certificate Class and Age group in Alaska 2009-2013

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