A Regional Approach to Aviation Accident Analysis in Hawaii

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BACKGROUND: The geographical circumstances, such as mountains and ocean, and specific aviation operations, especially sightseeing, make the state of Hawaii stand out in aviation. These conditions support a regional approach to aviation accident analysis.

METHODS: Accident reports of aviation accidents collected from the online National Transportation Safety Board database were used to study a 10-yr time period between 2008 and 2017.

RESULTS: There was a significantly higher proportion of fatal accidents during night, dawn, and dusk (6 out of 13) than during daytime (13 out of 74). In addition, a significantly higher proportion of accidents occurred in diminished light conditions among fixed wing airplanes (11 out of 48) as opposed to other aircraft (2 out of 39), and among twin-engine aircraft (6 out of 12) as opposed to single-engine aircraft (7 out of 74). Out of seven weight-shift control aviation accidents, four were reported to be fatal; the latter all took place during instruction.

DISCUSSION: Light conditions are the main environmental concern in Hawaiian aviation that particularly affect twin-engine fixed wing aircraft and warrant specific attention in advanced training exercises. Helicopter operations have not exhibited a diminished safety record since the 1990s, showing a lasting effect of a previous safety intervention. A relatively high number of fatal weight-shift control aircraft accidents requires further research in other parts of the United States.

KEYWORDS: general aviation, aviation accident, twin-engine aircraft, helicopter, light conditions.

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Aviation safety, specifically accident prevalence, varies according to geography for both air carriers, air taxi, and general aviation.[5,8] Subsequent studies have concentrated on Alaska as a geographic area of concern.[2,10] Regional differences within the United States may point to favorable weather conditions for aviation, such as the states of California and Florida, or unfavorable conditions creating particularly challenging operations, such as those in Alaska.

Other than Alaska, the state of Hawaii is one of few regions that received separate attention with regards to aviation accidents. The state of Hawaii stands out due to its environment of mountainous islands as well as its type of operations, which include a high percentage of both helicopter and fixed wing sightseeing operations. In 1994 the high rate of helicopter accidents involved in sightseeing made the Federal Aviation Administration address aviation safety with new regulations, which proved successful according to a subsequent helicopter accident analysis study.[6]

The following study compares previous research on Hawaii with more recent years but also includes other aircraft. It contrasts causes and contributing factors of helicopters with other aircraft as well as providing a general overview of aviation accidents of this island state. The results aim to assist state-specific regulations or interventions to optimize aviation safety.

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Table I. Comparison of Type of Aircraft in Hawaii Aviation Accidents.

AIRCRAFT	TOTAL	FATAL	SERIOUS INJURY	DESTROYED	SUBSTANTIAL DAMAGE	TURBINE	PISTON	NO ENGINE
Fixed-wing	48	10	8	6	40	9	39	0
Helicopter	28	4	4	2	25	17	11	0
Weight-shift control	7	4	1	0	7	0	7	0
Glider	4	1	1	1	3	0	3	1

METHODS

We extracted case reports from the Case Analysis and Reporting Online database made available by the National Transportation Safety Board (NTSB).[9] All aviation accidents occurring between 1 January 2008 and 31 December 2017 in the state of Hawaii were extracted and completed reports were selected for further analysis.

Each accident has a factual report and a probable cause statement that summarizes the findings of the NTSB investigator with a narrative, a set of findings that determines and codes the cause and contributing factors of the accident, as well as categorical data on the pilot, aircraft, airfield, and meteorological conditions. Findings in the accident reports were analyzed using the terminology and coding presented by the NTSB investigators.

Significant differences between expected and actual values within the dataset of categorical data was determined using Pearson's Chi-squared analysis using one degree of freedom, a 0.05 significance level, and a Fisher's exact test when cell counts fell below 5.

RESULTS

Between 1 January 2008 and 31 December 2017, 88 accidents were reported in the state of Hawaii. An accident with incomplete information was removed, leaving a total of 87 accidents for our analysis, which is 0.55% of the total number of accidents in the United States in that time period. The type of aircraft included gliders ($N = 4$), weight-shift control aircraft ($N = 7$), helicopters ($N = 28$), and fixed wing airplanes. The total number of weight-shift control aircraft accidents in the same period in the United States is 138, which means that an above average proportion of 5.07% of these accidents occurred in Hawaii. Lack of denominator data prevents further analysis of the risk of weight-shift control flights in Hawaii. There was a total of 44 fatalities among the 87 accidents, with an average of 2.3 fatalities per fatal accident. The distributions of damage and injury between the different aircraft is shown in **Table I**.

There was an average of 8.7 accidents per year, with 2016 having the most accidents ($N = 13$) and 2010, 2011, and 2015 having the fewest accidents ($N = 6$). Accidents happened under Part 91 ($N = 65$) in 74.7% of the cases, with a further 19.5% happening under Part 135 ($N = 17$). Furthermore, 29.9% of accidents were instructional flights ($N = 26$), of which 5 were fatal, a proportion of fatal accidents that was not significantly different from other operations ($P > 0.05$). Out of the five instructional fatal accidents, four pertained to weight-shift aircraft and one to a helicopter.

Pilots' ages ranged from 20 yr old to 84 yr old, with an average age of 47.8 yr, and 85.1% of pilots that were men. No significant differences could be determined between the type of accident for male and female pilots.

Pilot's total flight time ranged from 0 to 28,500 h, with a median of 2154.3 h, with one unreported case. Out of 26 pilots operating aircraft with turbine engines, 12 had more than 5000 total flight hours, which is a significantly higher proportion than 13 out of 60 accidents in which the pilots operated nonturbine engine aircraft ($\chi^2 = 5.27$, $P < 0.05$).

The majority of aircraft were single-engine ($N = 74$), with the remaining either twin-engine ($N = 12$) or unpowered ($N = 1$). Of the 86 powered aircraft, 69.8% had reciprocating engines ($N = 60$) and 30.2% had turbine engines ($N = 26$).

Out of 12 accidents with twin-engine aircraft, 6 were in nondaylight conditions, which is a significantly higher proportion than the 7 nondaylight accidents out of 74 with single-engine aircraft ($\chi^2 = 13.23$, $P < 0.05$). This result remains significant when only looking at fixed-wing twin-engine airplanes, of which 6 accidents out of 11 occurred in nondaylight while 5 out of 32 single-engine airplanes occurred in nondaylight ($\chi^2 = 8.08$, $P < 0.05$), but not for helicopters ($P > 0.05$). **Table II** shows a complete overview of the number of accidents per aircraft type with the light conditions in which the accidents took place.

Table II. Number of Accidents in Hawaii According to Light Conditions and Aircraft Type.

	DAYLIGHT	NON-DAYLIGHT
Total all aircraft	74	13
Airplane total	37	11
All single engine airplanes	32	5
Single engine reciprocating	29	4
Single engine turbo prop	3	1
All twin-engine airplanes	5	6
Twin engine reciprocating	3	3
Twin engine turbo fan	1	1
Twin engine turbo jet	1	0
Twin engine turbo prop	0	2
Glider	4	0
Helicopter total	26	2
All single engine helicopters	25	2
Single engine reciprocating	10	1
Single engine turbo shaft	15	1
Twin engine turbo shaft	1	0
Weight-shift	7	0

Table III. Comparative Data Between Time Periods.

	TIME PERIOD			
	1981–1994	**1995–2008**	**2008–2017**	**2008–2017**
Aircraft type	Helicopters	Helicopters	Helicopters	All aircraft
Total # accidents	37	22	28	87
Malfunctions % of total	51% ($N = 19$)	68% ($N = 15$)	25% ($N = 7$)	20.7% ($N = 18$)
VFR-IMC % of total	5% ($N = 2$)	32% ($N = 7$)	3.6% ($N = 1$)	4.6% ($N = 4$)
Ocean % of total	22% ($N = 8$)	5% ($N = 1$)	7.1% ($N = 2$)	16.1% ($N = 14$)
Fatal accidents % of total	21.6% ($N = 8$)	36% ($N = 8$)	14.3% ($N = 4$)	21.8% ($N = 19$)
# Passengers/flight	4.3	4.7	3	5.64

VFR: visual flight rules; IMC: instrument meteorological conditions.

Accidents occurred during the day in 85.1% ($N = 74$) of the cases, 4.6% occurred during dusk ($N = 4$), and 10.3% occurred during night or dark conditions ($N = 9$). Accidents occurred in visual meteorological conditions in 94.3% ($N = 82$) of all cases, with one accident not reporting the meteorological condition at the accident site. Hawaii has only two seasons. The winter season from November to April had 45 accidents, and the summer season from May to October had a similar number of 42.

There was a significantly higher proportion of fatal accidents during night, dawn, and dusk (6 out of 13) than during the day (13 out of 74) ($\chi^2 = 5.29$, $P < 0.05$). In addition, there was a significantly higher proportion of accidents that occurred in diminished light conditions among fixed wing airplanes (11 out of 48) as opposed to other aircraft (2 out of 39) ($P < 0.05$).

Of the 87 accidents, 71.3% were found to have issues related to the functioning of the aircraft ($N = 62$), 72.4% had personnel issues ($N = 63$), and 50.6% reported environmental issues ($N = 44$) according to the classification by the NTSB investigators. The accidents that were found to have been associated in part with environmental issues can be broken down into four categories: contribution to the outcome ($N = 14$), effect on crew ($N = 12$), effect on operations ($N = 15$), and effect on the equipment ($N = 7$).

Accidents involving environmental causes with an effect on the crew had 6 out of 12 accidents as fatal while all other causes combined had a significantly smaller proportion, with 13 fatal out of 43 accidents ($\chi^2 = 6.47$, $P < 0.05$). However, causes merely identified as environmental were not significantly more likely to involve a fatality.

DISCUSSION

The Hawaiian data confirm previous research that highlights the dangers of nondaylight conditions as well as the particular dangers for twin-engine airplanes.[1,3] Environmental issues that affected the crew of the aircraft, as specified by the NTSB investigators, were found to be more often fatal compared to other causes. In general, environmental conditions were expected to play a role in Hawaiian aviation, but this appeared to be mostly the case for light conditions.

It is also shown that Hawaii has a relatively high number of accidents that relate to weight-shift operated aircraft, which also have a disproportionate number of fatalities, especially during instruction. The study of weight-shift accidents may find a useful starting point in the state of Hawaii, particularly in comparison with other states.

The data collected for the time period between 2008 and 2017 is markedly different from that reported in a previous study on Hawaiian helicopter accidents as shown in **Table III**, although the time periods are not equal and no denominator data were available. However, the percentage of accidents in each category appears markedly different and the proportionate number of fatal accidents shows relevant differences in the absence of denominator data.[7] Environmental conditions remained significant, but not just for helicopters. The main finding did not pertain to visual flight rule flights into instrument meteorological conditions as in previous years, but instead to flights in diminished light conditions at night, dawn, or dusk. This result was more apparent in fixed wing aircraft, especially twin-engine fixed wing aircraft, which confirms previous accident analysis on twin-engine noncommercial general aviation aircraft.[1] As expected, twin-engine pilots have a higher number of flight hours compared to nonturbine engine aircraft, which suggest that the type of training and not the amount of training itself is important in preventing accidents with twin-engine fixed wing aircraft. In contrast with fixed wing aircraft, a recent study showed that twin-engine helicopters show a lower risk of accidents compared to single-engine helicopters both in Hawaii and Alaska.[4]

It is concluded that state-specific accident analysis is an insightful line of research but should include all types of aircraft. The focus of attention in Hawaii in both initial training and professional checks of pilots should remain on the environment and emphasize light conditions. In addition, the main concerns in Hawaii at the present time relate to twin-engine fixed wing aircraft and weight-shift operations, as opposed to helicopter operations, for which an intervention in the 1990s has shown a lasting effect.[6]

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