General Aviation Flight Safety During the COVID-19 Pandemic

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BACKGROUND/OBJECTIVE: The COVID-19 virus has caused over 582,000 deaths in the United States to date. However, the pandemic has also afflicted the mental health of the population at large in the domains of anxiety and sleep disruption, potentially interfering with cognitive function. From an aviation perspective, safely operating an aircraft requires an airman's cognitive engagement for: 1) situational awareness, 2) spatial orientation, and 3) avionics programming. Since impaired cognitive function could interfere with such tasks, the current study was undertaken to determine if flight safety for a cohort of single engine, piston-powered light airplanes was adversely affected during a period of the pandemic (March–October 2020) prior to U.S. approval of the first COVID-19 vaccine.

METHODS: Airplane accidents were per the National Transportation Safety Board Access® database. Fleet times were derived using Automatic Dependent Surveillance-Broadcast. Statistics used Poisson distributions, Chi-squared/Fisher, and Mann-Whitney tests.

RESULTS: Little difference in accident rate was evident between the pandemic period (March–October 2020) and the preceding (January–February) months (19 and 22 mishaps/100,000 h, respectively). Similarly, a proportional comparison of accidents occurring in 2020 with those for the corresponding months in 2019 failed to show over-representation of mishaps during the pandemic. Although a trend to a higher injury severity (43% vs. 34% serious/fatal injuries) was evident for pandemic-period mishaps, the proportional difference was not statistically significant when referencing the corresponding months in 2019.

CONCLUSION: Surprisingly, using accidents as an outcome, the study herein shows little evidence of diminished flight safety for light aircraft operations during the COVID-19 pandemic.

KEYWORDS: COVID-19, general aviation, pandemic, accidents.

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To date, the coronavirus 2019 disease (COVID-19) caused by an RNA virus targeting the respiratory system[9] has led to over 582,000 deaths in the United States.[7] Importantly, the ramifications of the disease have extended well beyond the physical effects of the disease on the respiratory system. Indeed, the mental health of the population at large has been adversely affected in several domains: anxiety, depression, and disrupted sleep as assessed using standardized measures.[8,23,32] Several reasons likely underlie this deterioration in mental well-being. Specifically, an up to fourfold increase in U.S. unemployment[9,33] has been reported in the United States and, indeed, few sectors of the U.S. economy have been unaffected,[9] culminating in income loss/insecurity. Additionally, the potential for COVID-19 infection has also been identified as another source of anxiety for the general public.[8]

Not surprisingly, cognitive function[14,16] requisite for flight safety is negatively affected by fatigue/stress/sleep disruption and, indeed, such detriments have been cited as contributing factors in previous airplane accidents.[24,31] Piloting an aircraft is a demanding task requiring cognitive engagement and rapid responses. Thus, 1) situational awareness,[14] 2) spatial

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orientation,[29] 3) correctly programming avionics for routing/radio communications, and 4) performing an instrument approach with no outside visual reference, necessitating instrument scanning and interpretation, are all required for safe flight. Moreover, with the advent of electronic flight displays, now installed in 20% of piston-powered light aircraft,[17] a corresponding increase in the amount of displayed information again requires increased cognitive vigilance.[2,4,26] Also pertinent to safe operations, the dynamic nature of weather often requires timely in-flight reassessment and implementation of an alternative plan.[5,6,31]

Another COVID-19-related consideration which could affect flight safety is the potential for diminished flying frequency for the nonprofessional pilot. This may happen for a plethora of reasons: 1) the mandatory public "lock-downs" in some cities across the United States during the pandemic; and 2) a discretionary activity readily affected by disposable income.

Considering the aforementioned arguments, the current study was undertaken to determine if flight safety for a cohort of nonrevenue, single-engine, piston-powered light (<12,501 lb)[3] U.S.-registered airplanes was adversely affected during the COVID-19 pandemic. Toward this end, accident rates/proportions and occupant injury severity involving these airplanes, operating under general aviation rules (14 CFR Part 91[12]), during and preceding the COVID-19 pandemic were compared.

METHODS

Unless indicated otherwise, the study cohort was limited to individually owned airplanes (i.e., no co-owners) with valid registrations, equipped with Automatic Dependent Surveillance-Broadcast (ADS-B), in the states bordering the southern U.S. border (California, New Mexico, Arizona, Texas, Louisiana, Georgia, and Florida). The study was restricted to the following make/models based on their common usage post private pilot certification: Beech 33/35/36; Cessna C182,210; Cirrus SR20/22; Mooney M20; and Piper PA28/32.

Airplane accidents operating under 14CFR Part 91 regulations were identified from the National Transportation Safety Board (NTSB) Access® database (Dec. 31, 2020, release).[27] The pandemic period captured herein was inclusive of March–October 2020. The cutoff date of Oct. 31, 2020, for accident capture was selected for two reasons: 1) to allow for mishaps to be published (at least in a factual or preliminary format) in the publicly available NTSB database; and 2) prior to the U.S. Food and Drug Administration approval of a COVID-19 vaccine later in that year.[22] Queries were exported to Microsoft Excel® and checked for duplicates using the assigned NTSB number, after which any replicates were deleted. Injury severities[11] were per the NTSB report.

Exposure (for use as a denominator to calculate accident rates) was determined using times accrued by accident and nonaccident aircraft (both with valid certificates) for the aforementioned airplane cohort using the FlightRadar24.com web-tracking application. This web-tracking program uses ADS-B receivers to track ADS-B-out equipped aircraft, equipage of which became a legal requirement on January 1, 2020, for airplanes operating in much of the U.S. national airspace system[19] (see caveat below addressing nonequipped aircraft). For each airplane (based on its civil N-registration), FlightRadar24.com provides the date for each flight and the corresponding flight duration. Data were imported into Microsoft Excel® and flight durations summed using a Pivot Table function. It should be noted that not all aircraft could be tracked by FlightRadar24.com due to: 1) blocked registrations, or 2) insufficient data from Flightradar24.com.

For the present study, fleet times (herein comprised of airplanes of the aforementioned make/model with valid registrations, in single ownerships, and registered in the states adjacent to the U.S. southern border) was based on 925 airplane flight histories available. However, the author recognizes that not all light aircraft were ADS-B-out equipped by January 1, 2020, with progressive equipage increments over the study period. Thus, the raw fleet time was adjusted for monthly ADS-B equipage increments [data kindly provided by the FAA (adsb@faa.gov) using January 1, 2020, as referent to derive the "ADS-B-Equipage Adjusted Fleet Time": ADS-B-Equipage Adjusted Fleet Time (h) = (1 – cumulative fractional increase in equipage) * Raw Fleet Time (h)]. Also, to account for the entire fleet of 9214 aircraft, which included nonindividually owned aircraft, excluded from the analysis, the aforementioned "ADS-B-Equipage Adjusted Fleet Time" was corrected to reflect this fraction. Thus, fleet exposure used as denominator for calculating accident rates took into account both incremental ADS-B equipage over the study period and nonindividually owned airplanes (of the same make/model) for the aforementioned states.

The Aviation Safety Reporting System (ASRS)[25] "COVID-19 Related Events" dataset collected through November 2020 were kindly provided by Becky Hooey (Director, NASA Aviation Safety Reporting System) and comprised 837 reports. These were manually parsed and reports generated by air carrier/charter operator pilots, air traffic controllers, aircraft mechanics, and flight attendants were deleted, reducing the dataset to 113 airman-generated 14CFR Part 91-related reports.

Changes in accident rates were tested for statistical significance using a Poisson Distribution.[10] Proportional changes were statistically tested using a 2-sided Pearson Chi-squared.[1] Finally, differences in flight times between groups constituted by 1) accident aircraft and 2) the corresponding fleet were tested using a Mann-Whitney *U*-test.[20] All statistics were performed with SPSS v26 (IBM Corp, Armonk, NY).

This study was not considered human subject research by virtue of all data used in the current investigation being in the public domain. Accordingly, the research was exempt from IRB review.

RESULTS

Aviation Safety Reports by Airmen Operating Under 14CFR Part 91 During the COVID-19 Pandemic

As a first undertaking, the ASRS "COVID 19-Related Event" dataset filed by pilots operating in accordance with 14CFR

TABLE I. Categories of 14CFR Part91 Pilot-Generated ASRS Reports.

AIRMAN REPORT CATEGORY	COUNT (*N*)	%
Air Traffic Control under-staffing	31	27.4
Error unrelated to pandemic	9	8.0
Concern with whether currency requirements satisfied	7	6.2
Degraded skills reflecting reduced flying due to pandemic	40	35.4
Variance in pilot routine/procedures/ operations due to pandemic	26	23.0
Total	113	100

ASRS reports in the "COVID-19-Related Events" dataset were filtered for those filed by airmen operating under general aviation (14CFR Part91) regulations and categorized by the author based on the report synopsis.

Part 91 regulations was analyzed toward getting subjective data as to the effect of the COVID-19 pandemic on general aviation flight safety. Toward this end the reports were categorized by the author. Interestingly, of 113 reports, the largest category, constituting 35% of the total, was "degraded skills reflecting reduced flying due to the pandemic" (**Table I**). "Air Traffic Control under-staffing" represented the second most prevalent category (27%) of reports filed by general aviation pilots.

A Comparison of Accident Rates Preceding and During the COVID-19 Pandemic

The erosion of piloting skills due to lack of flying cited by airmen in the aforementioned ASRS reports prompted an objective analysis to determine accident rate both during, and prior to, the COVID-19 pandemic. Toward this end, the accident rate was computed for a subset of light airplanes (see Methods) commonly used post private pilot certification and fulfilling several criteria: 1) airplanes registered in a region (states adjacent to the U.S. southern border) of the United States less impacted by seasonal freezing conditions—most light aircraft are not anti/de-icing equipped; 2) with valid registration certificates; and 3) in individual ownership, enabling compilation of accrued flight histories (fleet exposure for calculating an accident rate) unaffected by multiple individuals operating the same aircraft.

Surprisingly, little change in the accident rate (**Fig. 1**) was apparent during the pandemic months (March–October 2020) compared with the period (January–February) immediately preceding it. Thus, an accident rate between 19 and 25 (per 100,000 h) overlapped with the prepandemic reference period (22/100,000 h). A Poisson distribution was used to determine if the modest changes in accident rate were statistically significant. However, confidence intervals for the incident rate ratios for the three aggregate time points (March–May, June–August, September–October) encompassing the pandemic all crossed unity and were not statistically significant when referencing the January–February 2020 (prepandemic) period. It should be noted that an accident rate was not computed prior to January 2020 since equipage of airplanes with ADS-B-out operating in the United States was not required until January 1 of that year.[19]

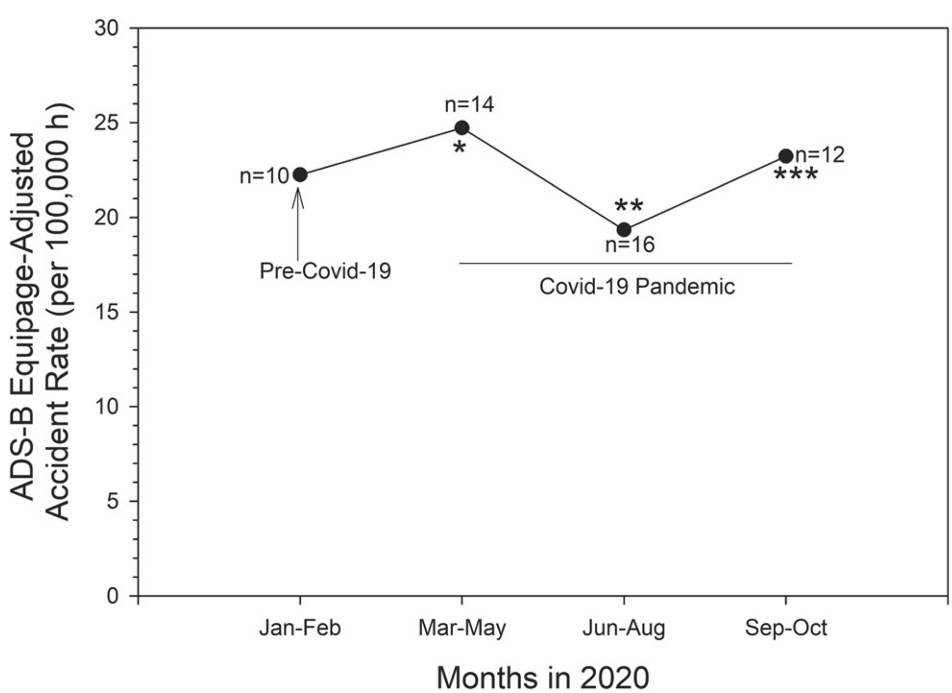

Fig. 1. Accident rates during and preceding the COVID-19 pandemic. The accident rate was calculated using mishap count (n) for the selected airplane make/models (as specified in the Methods section) and exposure (used as the denominator) comprising ADS-B data for 925 airplanes for the corresponding fleet. The denominator was adjusted for 1) monthly ADS-B equipage increments using January 1, 2020, as referent, and 2) the entire fleet of 9214 aircraft across the states. A Poisson distribution was used to determine if accident rates varied with respect to the pre-COVID-19 period (Jan.–Feb. 2020). **P* = 0.799, ***P* = 0.728, ****P* = 0.920.

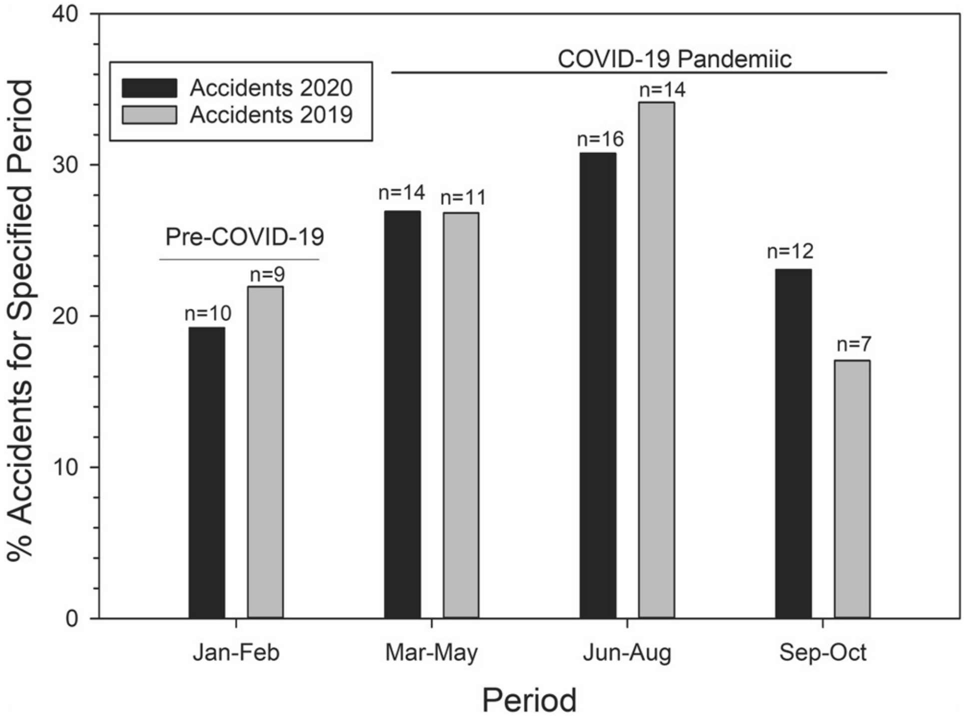

Fig. 2. A proportional analysis of accidents in 2020 and 2019 for selected airplane make/models/U.S. states. The proportional distribution of accident counts (expressed as a percentage) across the Jan.–Oct. period for 2019 and 2020 is shown for airplanes as specified in Fig. 1 with the sum of proportions equaling 100% for each year. A Chi-squared test was used to determine if proportional changes were significantly different for the 2 yr. n: accident count.

Proportional Analysis of Accidents in 2020 and 2019

As a separate approach, a proportional analysis of accidents was also undertaken for the airplane cohort described above comparing the January–October periods of 2020 with the corresponding months in 2019. If indeed pandemic-related flight safety was compromised, this should be evident by over-representation of accident counts during the months of the pandemic relative to the prior year (2019) using the January–February period of the corresponding year as referent. For 2020, the accident count progressively increased from the January–February period through June–August, after which a decrease was evident (**Fig. 2**). However, more importantly, this trend was paralleled for the prior nonpandemic year (2019). Moreover, there was no evidence of over-representation of accidents during the pandemic (March–October 2020) relative to the corresponding months in 2019. A Chi-squared test indicated a nonstatistical difference ($P = 0.920$) in proportions between the 2 yr.

To address the possibility that the absence of statistical difference in the proportion and rate analyses was due to a small number of events, an additional strategy was undertaken. Specifically, the proportional accident analysis was extended to include those involving all individually owned, single-piston engine airplanes (inclusive of all make/models) registered across the United States. However, again, accidents in this extended set of light aircraft (**Fig. 3**) were not disproportionate ($P = 0.345$) over the pandemic months in comparison with the corresponding times in 2019. Taken together, these findings show little evidence, at least using accidents as an outcome, of inferior safety for light aircraft operating under 14CFR Part 91 during the pandemic period.

Accident Injury Severity During the COVID-19 Pandemic

While accident rates/proportions were unaffected, the possibility of a greater injury severity during the COVID-19 pandemic was entertained. Accordingly, the highest occupant injury severity (per airplane) for the select cohort of aircraft described per Fig. 1 was compared for the pandemic period (March–October 2020) with the corresponding months of 2019. Although a trend to a higher injury severity (43% vs. 34% serious/fatal injuries) was evident for the pandemic year (**Table II**), this difference in proportions was not statistically significant ($P = 0.482$).

A Comparison of Flight Histories for Accident Pilots and Fleet Airmen

The number of ASRS reports (Table I) expressing a concern as to degraded flying skills as a consequence of fewer flight hours during the pandemic appeared inconsistent with the observations of an accident rate/proportions comparable with that for the period preceding it. Two separate avenues were undertaken to address this conflict.

First, were flight hours accrued by pilots involved in airplane accidents in fact less than that for airmen in the corresponding fleet? Toward answering this question but to address the issue of accidents occurring across the entire pandemic period rendering a comparison of flight histories between mishap aircraft and the fleet difficult, the analysis was restricted to accidents

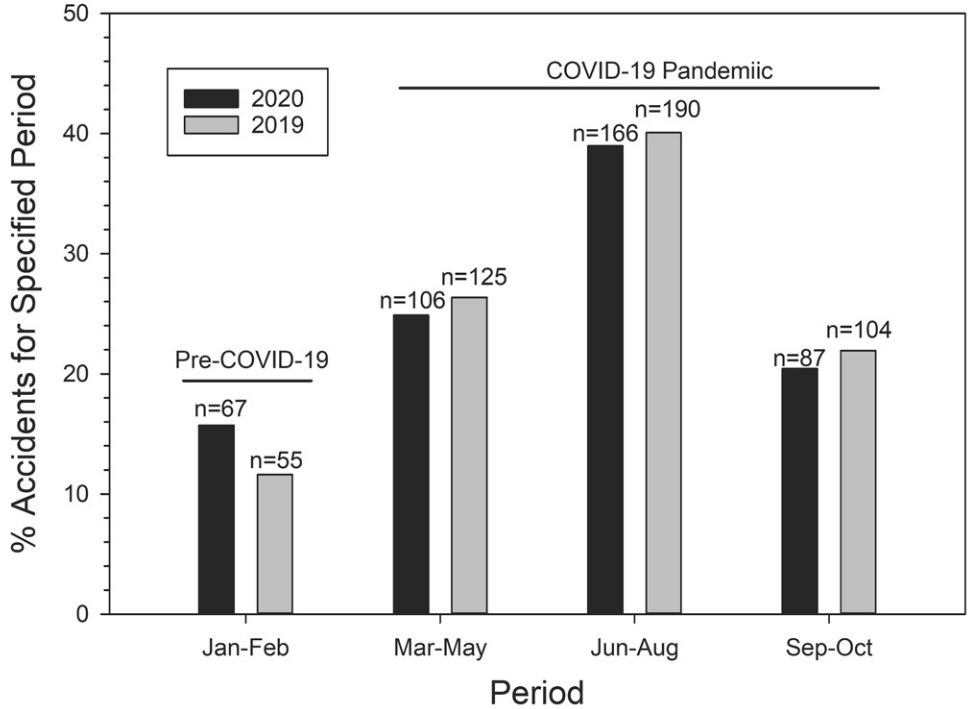

Fig. 3. A proportional analysis of accidents in 2020 and 2019 for all airplane make/models across the United States. The proportional distribution of accidents (expressed as a percentage) across the Jan.–Oct. period for 2019 and 2020 is shown for individually owned, single piston engine airplanes across the United States. For each year, the sum equals 100%. A Chi-squared test was used to determine if proportional changes were significantly different for the 2 yr. n: accident count.

occurring over the August–October 2020 period with flight times for both cohorts constrained to the preceding pandemic months (March–July). Interestingly and contrary to the ASRS data, the median value of accident airman flight times accumulated during these pandemic months (**Fig. 4**) was higher (34 vs. 13 h) than that for pilots of the corresponding fleet, a difference which was statistically significant (P = 0.048). Note that the lower count of accident aircraft (compared with Fig. 1) reflects: 1) the shorter accident capture period used (August–October); and 2) aircraft for which flight histories were unavailable due to either N-registration-blocking or incomplete data per the tracking web-application.

TABLE II. Comparison of Occupant Injury Severity for Accidents Involving a Cohort of Make/Model Airplanes in Selected U.S. States.

	YEAR				CHI-SQUARED 2-SIDED *P*-VALUE
	2020		2019		
	ACCIDENT COUNT (*N*)	%	ACCIDENT COUNT (*N*)	%	
Injury Severity					
None/Minor	24	57.1	21	65.6	0.482
Serious/Fatal	18	42.9	11	34.4	
Total	42	100	32	100	

For the cohort of aircraft described per Fig. 1, accidents were scored by the highest occupant injury severity and binned (Non-Minor and Serious-Fatal) according to the period (March–Oct. periods of 2020 and 2019, respectively) in which they occurred. Data are expressed as a percentage and for each year the sum of percentages for the two injury severity categories equals 100. Significant difference in proportions between the 2 yr was tested for using a Pearson Chi-Squared test. *N*: accident count.

Second, for the aforementioned fleet, monthly flight hours were computed and compared. For the prepandemic months (January–February 2020), the fleet accrued 2256 h/mo. While the fleet time was marginally (10%) lower over the March–May period (2066 h/mo), 50% more flight time (3276 h/mo) was apparent for the June–August period. Flight time accrued by the fleet for the September–October time span was only 5% lower than the referent prepandemic period (2142 h/mo).

Taken together, these data provide little evidence that the accident aircraft flew fewer hours than the corresponding fleet over 5 mo of the pandemic. In a similar vein, the findings herein argue against the contention that the corresponding fleet accrued few hours during the pandemic months relative to the prepandemic period.

DISCUSSION

Contrary to initial expectations, the study herein showed little evidence of diminished flight safety (albeit using accidents as an outcome) for light aircraft operations during the first 8 mo of the COVID-19 pandemic and prior to the approval of a vaccine.[22] These findings were surprising based on anecdotal reports, per filed ASRS reports, by general aviation airmen citing degraded flight proficiency as a consequence of a lesser frequency of flying.

What reasons might account for an uncompromised flight safety evident in the current report despite the pandemic

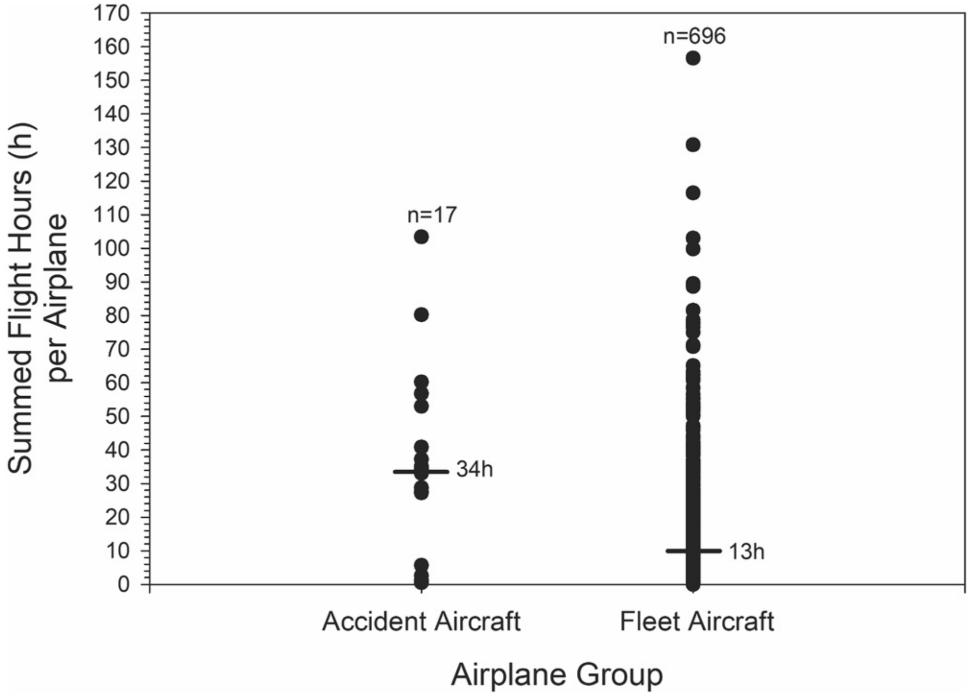

Fig. 4. Accident and fleet flight histories for a selected group of make/model airplane in specified U.S. states. Data shown are the ADS-B flight times summed for each aircraft (a filled circle representing a single airplane) in the specified group (accident and fleet) across the period spanning March–July 2020. The horizontal bars represent the median values for each population. The difference in the median values between the two groups was tested for significance using a Mann-Whitney *U*-test. n: airplane count.

fostering a more unsafe flight environment? Three possibilities merit discussion. The first regards an important distinction between an accident, which must be reported to the NTSB, and an incident, which does not.[11] An accident is defined,[11] in part, as an occurrence associated with the operation of an aircraft in which any person suffers death or serious injury, or in which the aircraft receives substantial damage. In contrast, an incident refers to an occurrence other than an accident.[11] So, for example, in an event involving an airplane incurring damage which does not require major repair or replacement[11] as a consequence of a pilot's COVID-19-related diminished flight proficiency would constitute an incident, go unreported, and hence would be absent from the NTSB database. Second, it is well recognized that accidents are the culmination of several, rather than a result of a single causal/contributing factor(s).[30] However, in all likelihood, multiple defenses per the oft cited "Swiss-cheese model"[30] effectively blocked the trajectory of opportunity for such causal/contributing factors, abrogating an increase in accident rate. Third, an increased emphasis on aeronautical decision-making in flight reviews[15,18] required for pilots operating under 14CFR Part 91 regulations in alternate years[13] may have played a role. Thus, airmen affected by the nonphysical impact of COVID-19 (i.e., in mental health domains that could impair cognitive function)[8,23,28] may have elected to restrict their operations to less challenging conditions (for example by eschewing flights in instrument conditions).

Two divergent observations merit discussion. Specifically, despite the filed ASRS reports of reduced flight frequency by airmen operating under general aviation regulations (14CFR Part 91), this was not evident for the cohort of accident pilots in the current study when compared with the corresponding fleet comprised of identical make/model airplanes registered in the same states. Why this discrepancy? It should be emphasized that ASRS reports are not mandatory, are filed at the discretion of the airman, and may be biased toward events where the airman is concerned that he/she has incurred an Federal Aviation Administration regulatory infraction. Thus, ASRS reports, at least in context of the current study, may not be representative of the pilot population.

Several limitations of the current investigation require mention. First, and as discussed above, accident count was used as an outcome measure of safety. A second was a relatively small number of events in some instances. Nevertheless, the proportional analysis of accident counts (comparing those occurring in March–October 2020 with those during the corresponding months in 2019) for the extended set of single-piston engine-powered light aircraft inclusive of all make/models and registered across the United States would argue otherwise. Third, an assumption was made that the adverse psychological impact of COVID-19[23,28,32] reported for the population-at-large also applied to airmen, thus interfering with the latter's cognitive engagement required for safe flight operations. Fourth, the possibility that accidents occurring during the study period which extended through October 2020 were not published in the NTSB database (at least in a factual/preliminary form) should be considered. However, a comparison of the NTSB database releases from most recent issue (February 2, 2021) revealed no further additions to the accident cohort captured in the December 31, 2020, release, countering this contention. Finally, since not all general aviation airplanes required ADS-B-out equipage (e.g., those whose operations were restricted to Class D/E/G airspace), exposure data may have been under-represented and, as a result, accident rates over-estimated.

In conclusion, this early study provides little foundation for the initial conjecture that general aviation safety in the United States was compromised to the extent that caused an elevated accident rate. That said, it is possible that the accident causes (relating more to impaired cognitive function) during the COVID-19 pandemic were at variance with those occurring prior to the pandemic, a question which should be addressed in future research upon issuance of the final reports (commonly requiring in excess of 12 mo[21]).

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