Accident Analysis and Prevention 72 (2014) 370–375

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Causes of fatal accidents for instrument-certified and non-certified private pilots

Bob Siyuan Shao[a], Michele Guindani[b], Douglas D. Boyd[c,*]

[a] University of California, Berkeley, CA, United States
[b] University of Texas Graduate School of Biomedical Sciences and MD Anderson Cancer Center, Houston, TX, United States
[c] University of Texas, Houston, TX, United States

ARTICLE INFO

Article history:
Received 23 January 2014
Received in revised form 6 June 2014
Accepted 12 July 2014
Available online 12 August 2014

Keywords:
Fatal accidents
General aviation accidents
Flight training
Instrument certification

ABSTRACT

Instrument certification (IFR) enhances a pilot's skills in precisely controlling the aircraft and requires a higher level of standards in maintaining heading and altitude compared with the less stringent private pilot certificate. However, there have been no prior studies to compare fatal accident causes for airmen with, and without, this rating, The NTSB accident database was queried for general aviation fatal accidents for private pilots with, and without IFR certification. Exact Poisson tests were used to calculate whether two rate parameters were equal (ratio of 1), normalized to the number of IFR-rated pilots and flight hours in the given time period. Proportion tests were used to determine whether there were significant differences in fatal accident causes between IFR-certified and non-certified pilots. A logistic regression for log-odds success was used in determining the trend and effect of age on fatal accident rates.

IFR certification was associated with a reduced risk of accidents due to failure to maintain obstacle/terrain clearance and spatial disorientation for day and night operations respectively. In contrast, the likelihood of fatal accident due to equipment malfunction during day operations was higher for IFR-certified pilots. The fatal accident rate decreased over the last decade for IFR-certified but not for non-IFR-certified private pilots. However, the overall accident rate for IFR-certified private pilots was more than double that of the cohort lacking this certification. Finally, we found a trend for an increased fatality rate with advancing age for both group of pilots.

Our findings informs on where training and/or technology should be focused. Both training for aerodynamic stalls, which causes over a quarter of all fatal accidents, should be intensified for both IFR-certified and non-certified private pilots. Similarly, adherence to minimum safe altitudes for both groups of pilots should be encouraged toward reducing the fatal accidents rate due to failure to maintain obstacle/terrain clearance. For night operations, the high percentage of accidents due to spatial disorientation for non-IFR certified airmen suggests that additional training be required for such operations or such flights carry restrictions for this subset of pilots.

1. Introduction

General aviation (14 CFR Part 91) is classified as all aviation excluding commercial passenger transport. Although accidents for the airlines (14 CFR Part 121) have dramatically declined over the last decade (Li and Baker, 2007), unfortunately this has not been evident with general aviation which now accounts for 94% of civil aviation fatalities in the United States (Kenny, 2012; Li and Baker, 2007). Indeed, the fatality rate for general aviation (1.31 per 100,000 flight hours) is 82 times higher than that of the air carriers (Li and Baker, 2007).

An instrument certificate (IFR) enhances a pilot's skills in precisely controlling the aircraft and requires a higher level of standards in maintaining heading and altitude as per the FAA Practical Test Standards (US Department of Transportation document FAA-S8081-4E) compared with the less stringent private pilot certificate. Additionally, it affords a higher safety level for flights in forecast and unanticipated reduced visibility. This latter point is important since while only 9% of general aviation crashes by non-IFR certified pilots are ascribed to flights where outside visual reference is lost (instrument meteorological conditions) such accidents account

* Corresponding author at: 1515 Holcombe Boulevard, Box 173, Houston, TX 77030, United States. Tel.: +1 713 563 4918.
E-mail addresses: bobshao@berkeley.edu (B.S. Shao), mguindani@mdanderson.org (M. Guindani), douglas.boyd@uth.tmc.edu (D.D. Boyd).

http://dx.doi.org/10.1016/j.aap.2014.07.013
0001-4575/

for 27% of fatalities (Li and Baker, 2007). Furthermore, there is a >4-fold increased probability of a general aviation crash for non-IFR certified pilots in degraded visibility in comparison with their IFR-certified counterparts (Groff and Price, 2006). Indeed, insurance companies will often discount rates for pilots upon addition of this rating.

A fundamental difference between visual and instrument meteorological conditions is the higher work load imposed on the airmen in the absence of visual cues requiring a complete reliance on information from the instrument panel for maintenance of heading, attitude and altitude. During flight in visual meteorological conditions, the eyes are the major orientation source and prevail over the somatosensory and vestibular systems the latter two which may create false sensations (Aeromedical Factor, 2008). Thus, in the absence of outside visual cues, airmen are prone to a variety of visual (e.g. "the leans", and coriolis, somatographic and inversion) and optical (e.g. runway width, slope, featureless terrain) illusions (Aeromedical Factor, 2008) which can lead to accidents. As part of training for IFR certification pilots wear a vision-limiting device thereby excluding outside visual references. Additionally, instruction also includes putting the trainee in a flight situation creating spatial disorientation from which the airman has to recover the aircraft to straight and level flight.

For the most recent year for which data are available (2012) of all FAA-certified non-commercial pilots aviators 52,604 (28%) held an instrument certificate (http://www.faa.gov/data_research/-aviation_data_statistics/civil_-airmen_statistics/2012). Hereafter, we use the term "private pilot" to refer to non-commercial aviators.

Although there have been several published studies on general aviation fatal crashes (Dambier and Hinkelbein, 2006; Grabowski et al., 2002; Li and Baker, 2007), to our knowledge few have compared fatal accident rate of pilots with, and without, the instrument certificate. A prior study did report that pilots without IFR certification carried an excess risk of an accident (odds ratio = 4.8) in degraded visibility in comparison with aviators holding this rating (Groff and Price, 2006). However the report aggregated pilots with various ratings e.g. private, commercial, airline transport pilot thus confounding the analysis. In fact, the majority of studies on general aviation accidents aggregate all 14 CFR Part 91 operations inclusive of pilots holding various licenses as well as trainees with little distinction given to the presence or absence of IFR-certification (Kenny, 2012). In a similar vein, accidents for single and multiple engine are grouped (Li and Baker, 1999) despite the fact that the latter carry an increased risk of fatality (Kenny, 2012). Another limitation of previous studies is that they may cite general (e.g. pilot error, pilot-related) (Dambier and Hinkelbein, 2006; Li et al., 2001; Shkrum et al., 1996) rather than specific causes. Knowing the specific causes is important since it informs on where training should be focused. Finally, some previous general aviation accident studies (Handel and Yackel, 2011; Li and Baker, 1999) cite a post-impact event (e.g. fire) or even a risk factor (e.g. off airport landing) (Li and Baker, 1999; Li et al., 2001) rather than the initiating event that led to the fatal crash.

Herein, we undertook the current study to compare the causes of fatal crashes for IFR-certified and non-IFR-certified private pilot operations and temporal changes over the last decade (2002–2011). Additionally, we determined whether indeed fatal accident rates are lower for IFR-certified pilots compared with a corresponding cohort lacking this rating. We report herein that while IFR certification is associated with a reduced risk of accidents due to failure to maintain obstacle/terrain clearance and spatial disorientation for day and night operations respectively, airmen with this certificate are more likely to incur a fatal crash due to equipment malfunction. Equally importantly, our findings reveal a disturbing trend in increase in fatality rate with advancing age for both groups of pilots. Our data inform where training should be focused.

2. Materials and methods

The study did not involve obtaining information from living individuals and as per the U.S. Department of Health and Human Services (http://www.hhs.gov/ohrp/policy/checklists/decisioncharts.html) therefore did not constitute research involving human subjects regulated under 45CFR Part 46. We queried the National Transportation Safety Board (NTSB) accident database (www.ntsb.gov/aviationquery) for fatal accidents occurring in aircraft with a single, reciprocating engine occurring between Jan 2002 and Dec 2012 and operating under 14 CFR Part 91-general aviation. Amateur built aircraft were excluded from the study.

Records were imported into a custom built database designed using the FileMaker Pro v11 software. We then searched our database for fatal accidents involving private pilots with, and without, instrument certification. We selected private pilots as a study cohort deliberately excluding commercial and airline transport pilots flying under 14 CFR Part 91 operations for two reasons (a) the majority of general aviation accidents involve private pilots (Kenny, 2012) (b) the different levels of flight training and currency requirements for the private, commercial and airline pilots would confound our analysis. Fatal accidents in the following categories were deleted from our analyses: instructional flights, aerobatics, non-certificated pilots, glider and banner-tows, aerial observation, sky-diving, flight tests, suicides and injury involving a pilot or passenger located external to the involved aircraft. Fatal accident causes were as per the NTSB determination in their final reports. Contributing factors stated by the NTSB were not cited as an accident cause. In cases where two certificated pilots were occupying the front seats in aircraft with dual controls we assumed that the pilot in the left seat was the one controlling the aircraft. The rationale for this was twofold: (a) we excluded instructional flights in our analysis (b) the instruments for altitude, direction, vertical speed and attitude in general aviation aircraft are most often located in front of the left-seat pilot. For temporal studies, we used 2011 as the most recent cut-off year since the typical fatal general aviation investigation takes approximately 390 days from assignment to release of probable cause (Fielding et al., 2011). Assignment of flights at night or day were as per the NTSB report. For accident airmen we extracted, where available several co-variants cited previously as accident risk factors: these were age (Shao et al., 2014) total flight times (Bazargan and Guzhva, 2011; Li and Baker, 1999; Li et al., 2001), overall currency (Weislogel, 1983), instrument currency (Bazargan and Guzhva, 2007; Groff and Price, 2006) and distance between departure and arrival airports (Groff and Price, 2006; O'Hare and Owen, 2002).

Aviation certification data were obtained from the publicly available FAA website (http://www.faa.gov/data-_research/aviation_data_statistics/civil_airmen_statistics/"year"/). General aviation flight hour data for single engine piston aircraft were from the FAA website (http://www.faa.gov/data_research/aviation_data_statistics/general_aviation/).

2.1. Statistics

Exact Poisson tests were used to calculate whether two rate parameters were equal (ratio of 1), normalized to the number of IFR-rated pilots and flight hours in the given time period. The first and last time periods were compared to see if there was a significant change in the difference in rates over time. Exact Fisher's test and proportion tests were used in comparing whether there were significant differences in fatal accident causes between IFR-certified and non-certified private pilots. Multiple comparisons adjustments were used when appropriate. A logistic regression for log-odds success was used in determining the trend and effect of age on fatal accident rates.