Suicide and Murder-Suicide Involving Aircraft

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BACKGROUND: This is a systematic review of suicide and homicide-suicide events involving aircraft. In aeromedical literature and in the media, these very different events are both described as pilot suicide, but in psychiatry they are considered separate events with distinct risk factors.

METHODS: Medical databases, internet search engines, and aviation safety databases were searched in a systematic way to obtain relevant cases. Relevant articles were searched for additional references.

RESULTS: There were 65 cases of pilot suicide and 6 cases of passengers who jumped from aircraft found. There were also 18 cases of homicide-suicide found involving 732 deaths. Pilots perpetrated 13 homicide-suicide events. Compared to non-aviation samples, a large percentage of pilot suicides in this study were homicide-suicides (17%).

DISCUSSION: Homicide-suicide events occur extremely rarely. However, their impact in terms of the proportion of deaths is significant when compared to deaths from accidents. There is evidence of clustering where pilot suicides occur after by media reports of suicide or homicide-suicide. Five of six homicide-suicide events by pilots of commercial airliners occurred after they were left alone in the cockpit. This, along with a sixth incident in which active intervention by a Japan Air crew saved 147 lives, suggests that having two flight members in the cockpit is potentially protective. No single factor was associated with the risk for suicide or homicide-suicide. Factors associated with both events included legal and financial crises, occupational conflict, mental illness, and relationship stressors. Drugs and/or alcohol played a role in almost half of suicides, but not in homicide-suicides.

KEYWORDS: mental health, intentional crash, substance abuse.

Kenedi C, Friedman SH, Watson D, Preitner C. *Suicide and murder-suicide involving aircraft*. Aerosp Med Hum Perform. 2016; 87(4):388–396.

Aviation safety is rarely impacted by the intentional destruction of aircraft by pilots. Events that do occur are often shrouded in uncertainty as to the pilot's motivation or even their role in the loss of the aircraft. However, in the last 60 yr of aviation, there have been crashes with clear evidence of suicidal intent or in which elements strongly suggest that pilots had a role in intentionally destroying the aircraft.

The most important distinction is to separate events in which the pilot uses the aircraft to commit suicide from incidents of murder-suicide in which the pilot kills others. While aviation literature, the public, and media synthesize these events into a single category, there is an extensive psychiatric literature which demonstrates that suicide and homicide-suicide are distinct forms of pathology, with unique risk factors that should be recognized and considered separately.

This review considers recognized differences between suicide and homicide-suicide in the general population and, systematically, evaluates available sources for reports on suicide and homicide-suicide involving aircraft. The instigators of suicide or homicide-suicide involving aircraft are not always the aircraft's pilot: there are reports of passengers using the aircraft (and the pilot) as a means of suicide or else causing the destruction of the aircraft through violence.

METHODS

The PRISMA statement and checklist were used to provide the structure for this review. Because of the nature of the subject, our search extended beyond traditional medical databases. We searched Medline using the terms: airline OR aviation OR

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This manuscript was received for review in September 2015. It was accepted for publication in January 2016.

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DOI: 10.3357/AMHP.4474.2016

aircraft OR aviator OR aerospace AND suicide OR suicidal OR self-destruction OR intentional. This resulted in 106 articles. Of those, 22 were evaluated as relevant based on their titles and/or abstracts. Pilot as a search term produced many additional articles, but were not relevant to suicide or homicide-suicide involving aircraft. PsychINFO was searched with 58 results and 2 additional papers which were applicable. The search in EmBase produced 122 results and 19 were evaluated as relevant based on their titles/abstracts. There were 10 found to be applicable to the research question.

Google Scholar produced three additional relevant articles. Google Web Search was also used and specific websites, including the Federal Aviation Administration, National Transport Safety Board (NTSB), the Center for Disease Control and Prevention, National Institute of Mental Health, Aircraft Owners and Pilots Association, Flight Safety Foundation, Aviation Safety Network (ASN), Air Safety Institute, and AvWeb, were also searched. This resulted in 27 additional useful reports. One additional conference presentation was found from the citations of papers.

The focus of this research was on the civilian aviation system. We specifically did not include articles that investigated the September 2001 terrorist attacks involving four aircraft or other forms of politically or religiously motivated terrorism involving aircraft. The psychopathology and socio-cultural events around organized terrorism are vastly different and outside the bounds of this study.

We did not include articles exploring the use of Kamikaze pilots or other military personnel induced to use aircraft as weapons, or to fly missions in which aircraft were unlikely to survive in a combat setting. Finally, we did not include related cases of attempted suicide, such as by a flight student who landed the plane with assistance after he requested help. The search is up to date through 17 April 2015.

RESULTS

There were 71 incidents involving aircraft and suicide described by 11 authors in the medical literature as well as data from reports of the NTSB, confirmed and well described reports in the media and aviation safety websites. Three of the incidents involved pilots who killed themselves using commercial airliners (**Table I**). Six of the incidents involved passengers who jumped to their death from single engine or multiengine aircraft (**Table II**) as opposed to the remaining 62 that involved general aviation aircraft (online supplementary **Table A**; 10.3357/amhp.4474sd.2016).

There were 18 incidents that the authors judged were consistent with strong evidence suggesting homicidal and suicidal intent by the pilot or passenger (**Table III**, **Table IV**, and **Table V**). These acts resulted in the deaths of 732 people. Of those, 13 involved homicide-suicides in which the pilot was the perpetrator. One case only resulted in the death of the student pilot, but he crashed into a 42-story building office that had been vacated 1 h prior for a meeting. Because there was the expectation of significant fatalities, we classified this as a homicide-suicide attempt and included it with the other 17 reports. Six cases occurred when the pilots of passenger-carrying commercial airliners were perpetrators. In one case (the 1982 Japan Air flight), the pilot perpetrator survived what was a homicide with an associated (attempted) suicide that killed 24 crew and passengers. However, he only survived due to the efforts of the First Officer and the Flight Engineer who wrestled the controls from him.

DISCUSSION

Data on suicides involving aircraft can be found in Tables I and II. Suicide in the general population of the United States occurs at a rate of 13 per 100,000 people. It is the 10th leading cause of death in the United States.[6] Risk factors for suicide in the general population include previous attempts, underlying mental illness, substance abuse, and family history of completed suicide, impulsive or aggressive tendencies, and the diagnosis of progressive and debilitating physical illness such as cancer, multiple sclerosis, or Huntington's disease.[6] Protective factors include engagement in care, family and community support, cultural and religious beliefs against suicide, and skills in problem solving and managing distress.

Active pilots should have a lower rate of suicide than the general public because they are screened for mental illness, monitored for significant physical illness and substance abuse, required to demonstrate problem solving skills, and usually do not have prior suicide attempts. In addition most pilots will be part of a sense of community involving other pilots and air staff. This reduction in risk factors and exposure to protective elements are not universally protective; they only reduce the risk. They also do not apply if pilots have deceived air medical examiners during medical exams. Pilots may develop difficulties throughout their careers, such as mental illness, substance abuse problems, stress leading to deterioration in coping skills and problem solving, or the threat of isolation if they are in danger of losing their position within a professional or family community.

Almost all accidents involving aircraft are investigated by a national authority such as the NTSB in the United States. In theory this should provide a stable denominator of events; all that is required is to establish the numerator of how many events were due to suicidal or homicide-suicide activity. In many cases these events are known if there is written evidence (a suicide note) or voice data from the cockpit voice recorder. But in many cases, there is uncertainty about the motivations of pilots involved in fatal aircraft events. Reviewing the NTSB reports alone, there is a strong sense that suicide is only identified when there is incontrovertible data for investigators. To some extent this is understandable as a finding of suicidal actions by the pilot has significant legal, financial, and interpersonal implications for survivors, families, organizations, aircraft owners/operators, companies, airports, and media. There are cases in which the cause is unexplained and the NTSB report

Table I. Pilot Suicide Involving Large Aircraft.

DATE	EVENT	CONTRIBUTING FACTORS
13 July 1994	A Russian Air Force engineer stole an Antonov 26 aircraft at the Kubinka AFB. According to media reports he had indicated that he intended to commit suicide. He circled the city repeatedly until the airplane ran out of fuel and crashed.	No data
11 October 1999	Air Botswana captain grounded for medical reasons stole an ATR-42 aircraft. He initially made demands, then stated his intention to crash and did so into two parked planes. At Gaborone Airport, Botswana.	Possibly occupational; he had been refused reinstatement of his medical certificate.
20 July 2012	Pilot wanted by police on charges of murder; the victim had been his girlfriend. He was placed on administrative leave by the airline. He then tried to steal a Canadair RJ-200, crashed on taxiing, and then shot himself.	Legal. Relationship.

does not mention suicide, but where local law enforcement or media reports suggest that it should be a consideration. The result is that the identified cases (the numerator) are the lowest limit of the possible events that occur. Presumably there are cases in which the pilot acted alone and in which family, coworkers, and other interested parties do not provide the data that would be required to recognize a pattern consistent with suicidal intent.

In Bills et al. analysis of 37 crashes determined by the NTSB to be suicide, 51% were reported to have left a note.[3] This is higher than in the general population, in which 15–38% of people who have completed suicides left notes.[5] Since there is nothing to suggest that pilots should differ from the general population in this regard, it has to be considered that the lack of a note may be incorrectly biasing NTSB investigators against the determination of suicide.

Ranges of the rate of crashes attributable to suicide in the United States started with Gibbons' article examining six cases in which he estimated that "<2%" of aircraft crashes were due to suicide.[9] Ungs's report reviewing 6000 NTSB reports from 1979-1989, which reported 10 confirmed and 20 "possible but not proved" suicides, gave a rate of suicide involving aircraft crashes at 0.17%–0.51%.[22] Since then there have been two reports by Lewis et al.; one in 2007 that covered 1993-2002, in which he estimated that the rate of suicide as a cause of airplane crashes was 0.44%.[13] The 2014 report covered the period 2003-2012 and suggested a rate of 0.29% of crashes were attributable to suicide.[12] Again this was based on confirmed suicides as noted by the NTSB and does not include most of the incidents noted in this systematic review. A more recent review by Vuorio et al. suggested that the rate in the United States from 1993-2012 was 0.33%, but this was still primarily based on NTSB reports and the authors argue that this is most likely an under-estimation.[23]

Articles have reported estimates of suicide by pilots involving aircraft in other countries. In Germany, Maeulen reported in his paper titled "An Aeronautical Suicide Attempt—Suicide and Self-Destructive Behavior in Aviation" that: "Approximately 2%-3% of all fatal general aviation accidents in Germany may be attributed to suicide, and in many other accidents in aviation there are grounds for inferring that self-destructive and suicidal behavior was involved."[16] The source of this estimate was unclear. Schwark described nine cases reported by forensic pathologists over 34 yr; he stated that this rate of confirmed suicide as noted by the German Federal Bureau of Aircraft Accidents Investigation (similar to the U.S. NTSB) establishes a minimum rate of 0.6% of fatal aircraft crashes as being due to suicide cases, but obviously misses cases in which suicide was not suspected or where the pilot's body was not recovered.[21]

Analysis of data from the United States, the United Kingdom, and Germany revealed the rate of aviation crashes thought to be due to suicide ranged from 0.17 to 3% (**Table VI**). In the United Kingdom, Cullen stated that, based on their case series, 0.72% of fatal crashes were considered definite suicides and 1.69% were probably suicide or involved some degree of self-destructive behavior.[7] Based on this, the authors estimate that the rate of fatal crashes attributable to suicide in general aviation in the UK is around 2.4%.

Assuming the U.S. data follows the British pattern illustrated by Cullen, the confirmed rate of suicide involving aircraft in the United States of 0.17–0.44% represents less than a third of

Table II. Passengers Who Have Jumped from Aircraft in Flight.

	NATION	DATE	SOURCE	ALCOHOL OR DRUGS	MENTAL ILLNESS	NOTES	GENDER	AGE
1.	UK	<1998	Cullen	yes	Anxiety, depression	Jumped from 15-seat airliner	F	42
2.	USA	28 October 1983	Media/ASN			Jumped out at 3,500 ft. Gender unknown. 27-seat airliner	unknown	
3.	USA	1994	Media/NTSB		Personality disorder?	2nd attempt to jump from plane. Female. Single-engine light aircraft.	F	26
4.	USA	14 December 2000	Media/NTSB			Jumped from corporate jet.	F	31
5.	Canada	14 April 2009	Media		Under Mental Health Act one day prior	Jumped from medical transport aircraft.	M	20
6.	USA	2013	Media			Jumped from helicopter. Severe reflux disease he could not get treatment for.	M	61

Table III. Homicide-Suicide Where the Aircraft Passenger Was the Perpetrator.

DATE	DEATHS	NATION	EVENT	NOTES	AGE
6 January 1960	34	USA	National Airlines Flight 2511. A passenger was believed to have carried a dynamite bomb on board.	Under criminal investigation.	32
5 July 1964	44	USA	Pacific Air Lines Flight 773. A passenger shot the pilot and copilot.	Financial.	27
1984	5	Germany	A passenger stabbed 4 others including pilot.	No data	52
7 December 1987	43	USA	Pacific Southwest Airlines Flight 1771. An airline employee shot his supervisor, the pilot, and copilot and crashed the plane.	Occupational.	35
1996	4	Germany	A passenger shot 3 others including the pilot.	No data	48

actual crashes attributable to suicide. This still compares favorably to estimates of fatal car crashes due to suicide. Ahlm et al. suggested that 2.5–4.5% of car accidents in Sweden were suicides.[1] Schmidt et al. considered 300 single-vehicle accidents over 6 mo, in Baltimore, MD, and estimated that 2–7% were due to suicide.[20]

The publicity of other suicides may have an impact as well. Data on single-car crashes reported by Phillips shows that the number of motor vehicle fatalities increase by 9% in the week after a suicide is publicized in the media.[18] This phenomenon is well documented: that exposure to the suicide of others has a real impact on an individual's risk of suicide and can result in "clusters" of suicide in a community. Phillips found that the greater the degree of publicity, the higher the rate of motor vehicle deaths in the following period. The 62nd pilot suicide involving aircraft in Table A occurred 2 wk after the reported disappearance of Malaysian Airlines Flight MH370, which was speculated to be a possible pilot homicide-suicide in the media. The pilot in the 62nd incident we report turned off his transponder and then flew his aircraft out over the water.

Pilot background data was a focus of the analysis. In our review of 65 single occupant aircraft (including 3 commercial airliners) which were suspected to be suicides, the average age at death was 40. Of the 65 pilots who killed themselves using aircraft, 63 were men. It is not clear if this is due to the lower absolute number of female pilots, the data that women are less likely to use lethal means to attempt suicide, or if there is a bias against considering suicide as a cause of a crash among female pilots.

Alcohol and drugs were known to be involved in almost half of pilot suicides. Of the 43 suicides in which the pilot was in control of the aircraft and in which authors reported information on alcohol and recreational drugs, 20 (47%) of the cases had 1 or more substances. There were 11 (26%) who had alcohol in their system or opened bottles of alcohol in the plane were reported. Of the pilots, 7% were noted to have the sedating antihistamine diphenhydramine on autopsy. Alcohol or drugs were noted in 12% of reports, but which agent was not specified. Of the pilots, 14% had both alcohol and another banned substance and 9% had drugs only but no alcohol.

The study by Bills et al. of 37 pilots over 21 yr who attempted or completed suicide found that 24% were positive for alcohol, 22% for prescription drugs, including selective serotonin reuptake inhibitors (SSRIs) and benzodiazepines, and 14% had evidence of illicit drugs.[3] This is consistent with what we found in our larger and comprehensive sample size. This follows patterns in the general population in which the use of disinhibiting agents is a risk factor for suicide. However, it may also reflect a bias that suicide may have been more likely to be considered by investigators if a banned substance was detected on autopsy.

Mental illness was not found to be a defining contributor to pilot suicide based on available data. Of the 44 (36%) pilot suicides in which background information was provided, 16 had a history of mental illness or were presumed to because antidepressants were found in their system. One additional pilot suicide was known to have a history of a traumatic brain injury. Three of the cases in which the pilot had alcohol or illicit drugs in their system also had selective serotonin reuptake inhibitors

Table IV. Homicide-Suicide with an Aircraft Pilot as Perpetrator.

DATE	DEATHS	NATION	EVENT	NOTES	AGE
26 September 1976	12 (11 on the ground)	USSR	A pilot stole an Antonov 2 airplane and flew it into an apartment block where his ex-wife lived.	Relationship	Unknown
22 August 1979	4 (3 on the ground)	Colombia	A mechanic who had recently been fired stole a military transport plane. He took off and immediately crashed the plane in a residential area.	Occupational	23
1987	2	Germany	"Suspected suicide."	No data	61
1988	2	Germany	"Suspected Suicide."	No data	44
June 5, 2002	1 (attempted homicide)	USA	Student sent to preflight an aircraft, took off. Intercepted by Coast Guard helicopter but ignored it and flew into an occupied 42-story office building with offices vacated 1 h prior.	Mental Illness	15
March 5, 2007	2	USA	Student pilot in a custody dispute crashed into his mother-in-law's house, killing himself and his 5 y/o daughter.	Relationship, Legal	47
Feb 18, 2010	2 – 1 killed on the ground (13 wounded)	USA	A pilot flew his Piper Dakota into an Internal Revenue Service Office Building.	Legal	53

Table V. Homicide-Suicide with an Airline Pilot as Perpetrator.

DATE	DEATHS	NATION	EVENT	NOTES	AGE
9 February 1982	24 – while 147 survived, including the pilot	Japan	Japan Air DC8 Ditched in Tokyo Bay by flight's captain. First Officer and the Flight Engineer worked to restrain him and fly the aircraft. Found Not Guilty by Reason of Insanity.	Mental illness.	35
21 August 1994 (probable)	44	Morocco	A Royal Air Maroc ATR-42 crashed in the Atlas Mountains after takeoff. The captain apparently disconnected the autopilot and deliberately flew into the ground. Copilot was locked out of the cockpit.	Possible relationship.	32
19 December 1997 (probable)	104	Indonesia	Silk Air Flight 185, a Boeing 737 en route from Jakarta, Indonesia, to Singapore crashed following a rapid descent. Indonesian authorities were not able to determine the cause of the accident. The NTSB suggested the captain may have committed suicide by turning off both flight recorders and intentionally putting the aircraft in a dive after the first officer left the flight deck.	Occupational conflict, financial.	41
31 October 1999 (probable)	217	USA (Egyptian pilot)	Egypt Air Flight 990, a Boeing 767, crashed moments after the captain had left the flight deck. No mechanical scenario modeled by the NTSB could modify the plane's behavior. The NTSB reported the crash was a "result of the relief first officer's flight control inputs. The reason for the relief first officer's actions was not determined."	Possible occupational.	59
29 November 2013	33	Namibia	LAM Flight 47, an Embraer ERJ-190. Early investigation results suggest the crash was intentional based on the captain's control inputs after the first officer had left the flight deck.	Mental illness, bereavement of son.	Unknown
24 March 2015	150	France (German pilot)	Germanwings Flight 9524 Airbus A320. Pilot crashed after locking the copilot out of the flight deck.	Mental illness reported. Relationship issues.	28

detected. Two additional cases with no reported alcohol or recreational drugs had other antidepressants in their system.

Pilots with a history of mental illness or with psychotropic agents in their system may be more likely to be classified as suicide if they die in a plane crash. Therefore, this study is ill-equipped to offer any comment on the role of mental illness in pilots beyond what is known in the general population. Gibbons et al. and others reported evidence that some suicidal pilots in crashes conceal their mental illness history on medical forms.[9]

A study by Akin reviewed 4184 fatal accidents from 1991-2001 with serum samples available.[2] In 61 of the 4184 incidents, the pilot's post mortem samples tested positive for SSRIs.[2] Two involved air taxi/commuter planes, two were agricultural, one was an ultralight, and the rest were general aviation. Per their report, the NTSB found that in 9/61 accidents the SSRI was noted to have a contributory role (and no other drug was noted to be present), although the pathophysiology of this mechanism was not described and is contrary to data in the psychiatric literature. There were 39 samples from the 61 fatal incidents which had other drugs such as analgesics, antihistamines, benzodiazepines, sympathomimetics, and/or alcohol present in post mortem samples.

Mental illness, including prior suicide attempts, are not always disqualifying for pilots. The Civil Aviation Authorities in New Zealand and in Australia, among other nations, consider pilots' background, engagement, insight, treatment, sustained remission, support system, comorbidities, and other

Table VI. Reported Percentage of Fatal Aircraft Crashes Attributable to Suicide Listed by Nationality/Author/Year.

SOURCE	PERCENTAGE
USA	
Gibbons 1967[9]	<2%
Ungs 1994[22]	0.17% -0.51%.
Lewis 2007[13]	0.44%
Lewis 2014[12]	0.29%
Vuorio 2014[23]	0.33%
Germany	
Maeulen 1993[16]	2–3%
Schwark 2008[21]	0.6%
UK	
Cullen 1998[7]	2.4% (0.72% confirmed)

factors in granting aeromedical certification. Therefore, a previous suicide attempt or episode of depression is not automatically disqualifying and many pilots have been able to fly or return to flight under medical supervision without negative consequence. In a study by Patterson et al. of U.S. Air Force pilots, 79% who had attempted suicide were able to return to flight duties following aeromedical assessment after treatment.[17]

Legal or financial issues played a significant but not major role in pilot suicides. Of the 59 (36%) reports with background information, 21 included details suggesting that the pilot had ongoing legal or financial difficulties. This included a pilot wanted for murder who crashed a commercial airliner while taxiing and then killed himself. This is consistent with the human factors analysis by Bills that suggested that 41% of pilots in their sample who committed suicide had legal difficulties.[3] These problems ranged from impending arrest or grand jury investigation to business failure and bankruptcy.

Relationship conflict was involved in almost half the pilot suicides where we have data. Of the 60 (43%) incidents with supplied information, 26 suggested that the suicidal pilot had relationship difficulties. This includes two of the suicidal pilots who were at the helm of large commercial airliners or transport aircraft. Of these 26, 6 (23%) incidents also included pilots who were having concomitant legal or financial problems and were included in the above numbers. This is consistent with Bills' sample that estimated that 38% of the pilots they analyzed had marriage or relationship difficulties.

Bills' detailed analysis demonstrated four issues not brought up in other studies.[3] First, October-March (winter months) showed higher rates of pilot suicide, with 62% of incidents and an odds ratio of 2.84 (1.2–6.72); this is similar to the general population. Second, they found that 9/37 (24%) of pilot suicides involved stolen aircraft. Third, compared to controls, they reported that crashes were more likely to occur away from the airport with an OR of 10.46 (3.09–35.39). And, finally, they noted that pilots committing suicide using aircraft were 2.45 (1.05–5.72) times more likely to be under the age of 40 yr old. It is not clear from this age differential whether being older than 40 is protective against pilot suicide or if it is less likely to involve aircraft as compared to traditional means such as firearms.

Passengers who jumped from aircraft are listed in Table II. As part of this study we included passengers who purposely jumped from functioning aircraft with no parachute. There were six reports. Four incidents occurred from commercial airliners or corporate jets, one from a helicopter, and one was from a four-seater aircraft. In the last two cases the passenger had rented the aircraft and pilot from a commercial flight school and reports suggested that both pilots were traumatized by the events. The average age of the four suicides for which data was reported was 36 yr. Three of the six suicidal passengers were women, which is in contrast to homicide-suicide events in which all the perpetrators were men and pilot suicide events. Included in the pilot suicides are two pilots who intentionally jumped from aircraft when they were the sole occupant.

The analysis of homicide-suicide data refers to Tables III, IV, and V. Because of both their rarity and the difficulty of meaningful study because the perpetrator and victim(s) are dead, homicide-suicides are difficult to both predict and prevent. Research demonstrates that homicide-suicide is most commonly committed by a man against his female intimate (or ex-intimate) in the context of relationship strife, often on a backdrop of intimate partner violence.

In a recent study of 408 American homicide-suicides from the National Violent Death Reporting System, only 10% of cases were extra-familial, in which someone outside the perpetrator's family was the victim.[15] Even among the extra-familial homicide-suicide perpetrators in the same study, a history of intimate partner conflict was quite common, occurring in 36%. In 'adversarial' type homicide-suicides, the perpetrator perceives that his employer or a person in authority has wronged him. Though he may target a single person whom he perceives as the source of his distress, others may be killed as well. This is in distinction to a 'pseudo-commando' homicide-suicide, where a crowded public place is chosen so that the perpetrator can kill as many people as possible, people with whom he does not usually have any relationship and who happen to be there.

Homicide-suicide events from passengers are less likely in the post-9/11 world of airport security and none were reported. Also less likely post-9/11 is airplane theft. In one subanalysis of 37 pilot suicides before 2001, 24% of planes used in the suicide event were stolen.[3]

Motives for homicide-suicide are complex and multifactorial. It is critical to consider homicide-suicides separately from either entity alone. Homicide-suicide can arise from a primary homicidal motive or a primary suicidal motive. A primary homicidal motive would include killing a partner out of anger or revenge, then committing suicide because of guilt or to avoid punishment. Alternatively, a primary suicidal motive, also known as 'extended suicide,' would include a depressed mother who loves her infant, but feels that suicide is her only escape from what she sees as a terrible world and would not leave her infant motherless. Psychological autopsy studies strongly suggest consideration should be given to depression or other psychopathology.[11,19] Family pressures and social stressors, including work difficulties, legal issues, and separations, are also common. Further, homicide-suicide can be either planned

or impulsive, and this may impact choice of weapon and lethality.

In the March 2007 incident, a father in a custody dispute flew a plane with himself and his child into his mother-in-law's house. This is referred to as filicide-suicide and it is a subtype of homicide-suicide in which a parent kills their child and then themselves.[10] Similar to men's higher rates of suicide, if they kill their children, men are more likely to also kill themselves than women are.

Of these events, 13 involved pilots at the controls. The others were due to passengers who disabled the pilots or destroyed the aircraft. Compared to non-aviation samples, a relatively large percentage of pilot suicides in this study were actually homicide-suicides (17%). Rates of completed homicide-suicide in the general U.S. population are $<0.001\%$.[8] The rate of homicide-suicide events is extremely rare as 1998 alone had 18 million commercial flights; by 2014 there were more than 36.5 million. Neither of these includes general aviation flights.[4,14] Although the rate of events is low, the impact is not negligible; 732 people died from homicide-suicide events. Since 1945 there have been between 224-2429 deaths per year from all causes of commercial airliner crashes. There were 572 deaths from homicide-suicide among commercial airliners reported for that period. In 2013, where there were few aircraft crashes for other reasons, 13% of people killed in commercial airliner crashes were due to a pilot homicide-suicide.

There were too few events to clearly see patterns in specific background factors. Five cases had no personal background data available. Of the 13 cases in which the perpetrator's age was available, the average age was 33 yr old. Among the nine pilot perpetrators for whom ages were available, the average age was 37 yr old. All the perpetrators for whom we have data were men. Among the five incidents involving the pilot as the perpetrator of passenger-carrying commercial airliner crashes in which data was available, the average pilot age was 39 yr old.

Of the 14 homicide-suicide incidents in our study with background data (including pilot perpetrators), 3 of the perpetrators had ongoing legal issues or impending criminal investigations. Two had financial problems. Four had relationship conflict. Four appeared to have occupational or workplace conflict. Four of the perpetrators who destroyed aircraft in flight had reports of mental illness and all were pilots. All the perpetrators were men. Of 18 incidents, 13 involved the pilot in control of the aircraft as perpetrator, but 5 of the incidents occurred when passengers shot (3 incidents) or stabbed (1 incident) the pilot(s) and 1 case in which the passenger detonated an explosive. One case was difficult to classify as the pilot in control was an aircraft mechanic who stole a military transport plane and almost immediately crashed after takeoff into a residential area; because he was technically (albeit briefly) in command of the aircraft and because he caused it to take off, we classified him as a pilot perpetrator.

In five out of six cases in which the pilot of a commercial jetliner was the perpetrator, the pilot appeared to wait for the copilot to leave the flight deck before destroying the aircraft. Three of these cases had pilot perpetrators who may have suffered from mental illness. Two of them had occupational issues and two had relationship issues (one pilot had both relationship issues related to a recent break-up as well as a history of mental illness). It is important to note that these sample sizes are too small to draw any significant conclusions.

In our sample, 29% of the 14 cases of homicide-suicide for which we have at least some background information had reports that suggested the presence of mental illness. This compares to 36% of the 43 pilot suicides. Both numbers are smaller than we would expect for similar behavior in the general population; however, the data is clearly incomplete and the sample sizes have no statistical power due their low numbers.

Homicide-suicide by airplane affords the perpetrator a high likelihood of lethality compared to many other methods, as well as the possibility of killing a large number of people all at once. Consistent with research with other methods, men were more likely perpetrators of homicide-suicide. Pilots were most likely to be the perpetrators of the homicide-suicides by aircraft, but several passengers were able to cause a large number of deaths. There was an unexpected trend noted: of the six cases in which the pilot of a passenger airliner was the perpetrator, all of the fatalities were passengers on board the aircraft—the pilot did not crash the aircraft into residential areas. In both cases involving military transport aircraft, the crash did occur in a dense residential area and there was no one else on board; one was apparently a deliberate attempt by a pilot to kill his ex-wife and the other was a mechanic with no flight experience. Of the 18 cases of homicide-suicide, 4 involved a single occupant in the aircraft who committed homicide (or in one case, attempted homicide) by deliberately flying the plane into a building or house.

The homicide-suicides in our sample occurred with motives and victimology similar to events described in the psychiatric literature. In two cases, a family member was the murder victim. Anger appeared as a prominent emotion in multiple homicide-suicides: in four cases in which there had been occupational strife, the boss or supervisor was targeted, and in another case the IRS was targeted. Many perpetrators were under stress at the time, be it financial/work-related, romantic, or legal issues. Unlike the vast majority of homicide-suicide cases with other methods/weapons such as guns, family members were only rarely the victims when aircraft were involved.

While suicide and homicide-suicide events both involve the death of the perpetrator, they are not identical events and should not be confused by the media or regulators. Just as we would not equate someone who shot himself in a car outside a movie theater with a person who entered a mall and shot others before taking his own life, we should not equate pilots who kill themselves with pilots who choose to kill others. Flying a plane is a technically sophisticated act and most pilots who commit homicide-suicide appear to have had some premeditation beforehand. Our study shows that in five out of six events, the perpetrator pilot of commercial airliners waited for the copilot to leave the flight deck. In the remaining event, the 1982 Japan

Air crash, the flight crew was able to save 147 lives when they wrestled the controls away from the pilot.

Both suicide and homicide-suicide involving aircraft are extremely rare events. With more than 8 million people flying each day who depend on pilots and the air transport system for their safety, the concern of the flying public is based less on statistical risk analysis than a perceived fear of giving control of their lives to another person. It is notable that aviation holds a unique place in society for this concern. In a nonsystematic review of PubMed and Google, we found one study evaluating suicide in commercial bus drivers and no studies looking at homicide-suicide in commercial bus drivers.

There does not seem to be a clear pattern of background factors or motivations which could suggest a recognizable pattern of which pilots would be more likely to commit suicide or homicide-suicide. There is not enough data to suggest that mental illness plays a significant role in either suicide or homicide-suicide by pilots. Rather perpetrators were often noted to have other stressors, such as relationship or financial problems. Patterns similar to other cases of homicide-suicide (including multiple stressors) emerged.

In New Zealand and Canada any clinician (general practitioner, emergency room doctor, or psychiatrist) who treats a pilot for any condition that may impair him/her is required to report it to the relevant national authority. These laws circumvent privacy restrictions on the sharing of information to further public safety and public confidence in the aviation system. Due to the disparate patterns of motivations and background factors we found in this study for both suicide and homicide-suicide, this form of mandatory reporting requirement would not provide a total shield against these events, but could help to reduce them and possibly reinforce public confidence. With high rates of depressive episodes occurring in the general population, it is likely that many people in any field will experience symptoms at some time in their career. It is critical that stigma and fear of loss of livelihood do not prevent treatment, as help-seeking mitigates the risk of suicide and homicide.

Mandatory reporting would not impact the majority of cases in which financial, occupational, or legal factors appeared to be in the background. Airlines may want to review thresholds for suspending pilots who have ongoing occupational conflict. A more practical approach may be the one recently put in place by many regulatory authorities in 2014 whereby two crewmembers must be on the flight deck at all times. Bills' analysis of general aviation suicides[3] suggested that when compared to controls, the odds of a suicide were 34.8% lower when a second person was present. This is also supported by the data from our study that shows that in four of six homicide-suicides involving pilots of passenger airliners, the pilot perpetrator waited for the copilot to leave the flight deck before the crash.

Introducing another person into the cockpit (the rule of two people in the cockpit at all times) means more flow, more distractions, and the addition of a flight crewmember (flight attendant) who will generally have had little or no screening for mental illness and a less rigorous medical evaluation. Flight attendants also do not have ongoing annual medical evaluations. Flight attendants in the cockpit while only one pilot is present sit behind the pilot in the jump seat in many aircraft configurations. In some aircraft they would have access to an axe which is stored across from the jump seat and behind the pilot-in-command. It is also unclear that a single flight attendant could prevent a determined pilot from engaging in a controlled flight into terrain. In the Japan Air event in 1982 it took two male crewmembers to wrest partial control away from the pilot attempting homicide-suicide. Therefore, introducing a flight attendant into the cockpit on a routine basis could also conceivably introduce a new element of risk as well as offer protective factors against homicide-suicide.

ACKNOWLEDGMENTS

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