

A widely used tool for predicting cardiovascular problems failed to identify more than half of the 15 pilots who experienced cardiovascular events within five years of being evaluated, according to a study by a team of New Zealand researchers.¹

The team's report on the study of 16 years of data, published in the May

issue of *Aviation, Space, and Environmental Medicine*, said that during that time frame, they identified 15 cases involving cardiovascular events in pilots working for an operator identified only as an Oceania-based airline.

Of the 15, six were detected during a routine cardiovascular screening involving use of a risk calculator that considered the pilot's age and sex, cholesterol

levels, blood pressure and whether he or she was diabetic or smoked tobacco. The remaining nine cases were classified as sudden clinical presentations that had not been foreseen.

Of the 15 cases, only one occurred during flight, and it did not incapacitate the pilot, the report said.

"While the number of incapacitations that may occur is low, the potential

BY LINDA WERFELMAN

A common method of identifying pilots at risk of cardiovascular problems missed about half those who soon experienced trouble.

Off the Mark



consequences are so significant that this remains a high risk area,” the report said.

The report noted that civil aviation authorities consider cardiovascular disease a serious medical condition not only because it presents the risk of a pilot’s sudden incapacitation but also because of its association with long-term disability and loss of a pilot’s license. Other researchers have found that nearly half of all pilots who are found to be “long-term unfit” for flight duty have cardiovascular disease.

The study focused on the New Zealand Civil Aviation Authority’s (CAA’s) method of evaluating the cardiovascular risk of anyone over age 35 who applies for medical certification. The CAA’s five-year risk evaluation is conducted using guidelines based on the Framingham Heart Study risk calculator,² adjusted by the New

Zealand Guidelines Group (NZGG), an independent organization that aids in the development of health care guidelines.

“The existing NZGG methods apply Framingham’s risk prediction tools, which are based on data collected more than 30 years ago,” the report said, noting that questions have developed “regarding the accuracy of the NZGG risk chart in the current era.”

An earlier study found that the Framingham approach was “fairly valid” for the general population, the report said. Nevertheless, it added, “very little evidence has been found on the accuracy of this method in occupational groups, especially in the airline pilot population.”

In the authors’ study, the pilots who experienced cardiovascular events were considered relatively young — between the ages of 43 and 63 — and half were diagnosed with premature ischemic heart disease (defined as occurring before age 55 in men and before age 65 in women). The cardiovascular events reported were unstable angina, revascularization, myocardial infarction and ischemic stroke (see “Cardiovascular Conditions”).

The study indicated that the current aeromedical screening process “is not effective at identifying clinically significant disease.”

Other data on in-flight cardiovascular incapacitation are limited, the report said, and those limitations hindered the researchers’ ability to make safety recommendations on the matter.

Correct Emphasis

In an earlier report on a study of a similar issue, two British researchers said that their analysis of all incapacitations occurring among U.K. commercial pilots in 2004 concluded that the aeromedical community is correct in its continuing emphasis on minimizing cardiovascular risk and monitoring pilots’ mental health.³

The study, published in the January 2012 issue of *Aviation, Space, and Environmental Medicine*, identified 16,145 licensed professional pilots with Class 1 medical certificates in the United Kingdom in 2004. Of that number, 36 experienced events that year — including six events that occurred in flight or in a simulator

Cardiovascular Conditions

The following are among the cardiovascular conditions associated with pilot incapacitation, impairment and unfitness:¹

- Angina is chest pain associated with poor flow of blood through the heart’s blood vessels. Stable angina is associated with stress or activity; unstable angina, which can be more severe, occurs with or without activity or stress.
- Revascularization is a medical procedure in which new channels are created through the heart in the hope that, as they heal, they cause the formation of new blood vessels. Such procedures include coronary bypass surgery and coronary angioplasty. For purposes of the study, the procedure was classified as a cardiovascular event in cases in which a pilot’s condition was detected during medical screening.
- A myocardial infarction, more commonly called a heart attack, occurs when a blood clot interrupts blood flow through a coronary artery leading to the heart.
- Stroke is an interruption of blood flow to the brain. Most strokes are ischemic strokes, caused by a blockage in an artery carrying blood to the brain. Less common are hemorrhagic strokes, which occur if an artery in the brain ruptures or leaks blood.
- Subarachnoid hemorrhage — a type of hemorrhagic stroke — is bleeding between the brain and the tissues that cover it.

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Note

1. U.S. National Library of Medicine. *A.D.A.M Medical Encyclopedia*. <www.ncbi.nlm.nih.gov/pubmedhealth>.

— that were characterized as incapacitations; half of the 36 events involved cardiac or cardiovascular problems. When the researchers examined only in-flight incapacitations, however, they found that the causes typically were psychiatric issues.

“The emphasis placed on the prediction of sudden cardiac and vascular events by aviation regulators by screening for underlying coronary artery disease and predisposing factors for stroke appears to be well founded,” the report said. “The increased risk of incapacitation from these disorders with age is clearly demonstrated, although it is noteworthy that the youngest pilot to have a stroke was only 33.”

Of the 36 events classified as incapacitations, cardiovascular events were most frequent, cited in 13 events. Four events were attributed to stroke and 18 were classified as stemming from “other” causes (Table 1).

The youngest pilots involved in the 36 events were two 24-year-old men. One suffered a perforated appendix and the other was incapacitated because of epilepsy, the report said. The oldest were two 64-year-olds, one of whom had a heart attack and the other, a panic attack.

Determining Risk

Regulatory authorities determine what level of risk is acceptable, and that level varies, depending on the type of flight operation and the existence of mitigating factors. The U.K. CAA, for example, has established a maximum incapacitation risk level of 1 percent per year for a commercial pilot in a multi-pilot operation — the so-called 1 percent rule.

The 1 percent rule was developed by aeromedical specialists who said that the likelihood that a pilot would suffer cardiovascular incapacitation could be predicted through an evaluation of his or her risk factors, including hypertension, elevated cholesterol and age. Typically, if the evaluation determines there is less than a 1 percent chance of cardiovascular incapacitation within the year, the certificate is approved; if there is a greater than 1 percent chance, the certificate is denied.

Professional Pilot Incapacitations in 2004

Cause of Incapacitation	Number of Events	Ages of Pilots
Cardiovascular		
Acute myocardial infarction	6	39, 52, 54, 58, 59, 64
Chest pain	2	48, 60
Arrhythmia	3	42, 50, 66
Pulmonary embolus	2	45*, 49
Cerebrovascular		
Stroke	4	33, 42, 50, 59
Subarachnoid hemorrhage	1	48
Other		
Panic attack	3	34*, 35*, 64*
Spontaneous pneumothorax	4	30, 40, 44, 62
Gastric ulcer	1	47
Perforated appendix	1	24
Syncope	1	54
Bowel obstruction	1	48
Biliary colic	1	51*
Migraine	1	47
Prolapsed intervertebral disc	1	52
Epilepsy	2	24, 55
Vestibular disturbance	1	39*
Spontaneous abortion	1	40
Total	36	

* Occurred in flight or in the simulator

Note: Data were compiled in a study of 16,145 licensed U.K. professional pilots who had Class 1 medical certificates in 2004.

Source: Evans, Sally; Radcliffe, Sally-Ann. “The Annual Incapacitation Rate of Commercial Pilots.” *Aviation, Space, and Environmental Medicine* Volume 83 (January 2012): 42–49.

Table 1

‘Unfit Notifications’

As part of their effort to determine the actual incapacitation rate, the researchers gathered data that showed that the 16,145 professional pilots with U.K. CAA/European Joint Aviation Authorities Class 1 medical certificates had received a total of 720 “unfit notifications” during 2004. The 720 notifications involved 700 pilots — 20 of whom had been involved in two episodes apiece of unfitness — or 4.3 percent of the total.

The major cause of temporary unfitness was some type of accident, the report said, noting that 131 of the 720 episodes were

Episodes of Temporary Unfitness, 2004

Causes	Number	Percentage
Accidents	131	18
Pregnancy related	24	3
Cardiovascular	103	14
Cerebrovascular	8	1
Dermatologic	3	<1
Diabetes	8	1
Ear, nose and throat	46	6
Endocrine	5	<1
Gastrointestinal	59	8
Genitourinary	30	4
Hematologic	2	<1
Infectious disease	9	1
Information not received	5	<1
Miscellaneous	12	2
Musculoskeletal	126	18
Neurologic	21	3
Neoplasms	25	3
Ophthalmologic	17	2
Psychiatric	71	10
Respiratory	15	2
Total	720	100

Note: Data were compiled in a study of 16,145 licensed U.K. professional pilots who had Class 1 medical certificates in 2004.

Source: Evans, Sally; Radcliffe, Sally-Ann. "The Annual Incapacitation Rate of Commercial Pilots." *Aviation, Space, and Environmental Medicine* Volume 83 (January 2012): 42–49.

Table 2

attributed to accidents. Of the medical (non-accident) issues, musculoskeletal problems were most common, involved in 126 episodes of unfitness. Of the other leading causes of medical unfitness, 103 were cardiovascular, 71 were psychiatric and 59 were gastrointestinal (Table 2).

Because only 26 episodes involved female pilots, the study focused on the 539 male pilots who experienced temporary medical unfitness. Older

pilots were affected most frequently, the study found.

"The number of episodes demonstrated a plateau between the late thirties and late fifties, with a marked drop after age 59, reflecting the usual retirement age [at that time] of 60," the report said. "The increased risk of experiencing an episode of unfitness with increasing age is clearly demonstrated."

In-Flight Medical Events

The U.K. study identified 16 medical events that occurred either during flight — while a pilot was part of the flight crew or a passenger — or during simulator sessions (Table 3).

Of the 16 events, six were psychiatric issues, and five others stemmed from "nonspecific symptoms that may have had psychiatric contributing factors," the report said.

Two episodes of panic attacks were experienced by the same pilot during two flights that were six months apart. The pilot was 34 years old when the first event occurred and 35 by the time of the second.

"The high proportion of in-flight events attributed to panic disorder ... serves to emphasize the truly incapacitating nature and threat to flight safety presented by this condition," the report said. "Noteworthy is the fact that two of the episodes occurred to the same pilot, indicating the need for careful assessment and monitoring of individuals with a history of this condition."

Self-Reporting

Reviewing reports filed under the U.K. Mandatory Occurrence Reporting System (MORS), the report's authors identified 25 in-flight medical events involving flight crewmembers.⁴ Of the 25 events, only four were considered likely to also have been

included in the "unfit notifications" examined by the authors.

In two of the 25 events, flight crews declared an urgent situation in an effort to get help quickly for the ailing pilots — a Boeing 747 pilot with an inner ear problem associated with severe dizziness and a 777 pilot with nausea.

Only one of the 25 MORS events was classified as "sudden and overt" — a situation in which the single pilot of a Britten-Norman Islander experienced vertigo soon after takeoff but "managed to join the circuit and landed successfully," the report said.

14 Deaths

Fourteen of the 16,145 professional pilots with Class 1 medical certificates died in 2004, the report said. Four of the deaths presumably were sudden, the results of two heart attacks, a subarachnoid hemorrhage and a gastrointestinal hemorrhage.

Considering data from all sources — the unfit notifications, MORS reports and notifications of sudden death — the authors calculated that 40 pilots were incapacitated in 2004 and that the annual incapacitation rate was 0.25 percent.

They measured a steady increase in the annual incapacitation rate as male pilots aged through their 60s.⁵ Those who were ages 17–19 had an annual incapacitation rate of zero. Pilots from 20–29 had an annual incapacitation rate of 0.11 percent; those from 30–39, 0.12 percent; 40–49, 0.23 percent; 50–59, 0.42 percent; and 60–69, 1.20 percent. The number of pilots over age 70 was considered "too small for meaningful analysis."

"Pilots in their 40s have approximately the same number of incapacitations that would be expected with an even distribution of age," the report

said. “Pilots in their 50s have a 1.5- to 2.0-fold increase, compared with the number of expected incapacitations. “Pilots in their 60s account for 15 percent of all incapacitations but only 3 percent of all male pilots. A pilot in his 60s has five times the risk of incapacitation of a pilot in his 40s.”

The report’s authors characterized their findings as “consistent with the view that the greatest risk factor for incapacitation is age.”

The authors also calculated that the annual rate of a medical event “with the potential to affect flight safety” was 0.8 percent, based on 76 unfit notifications, 14 MORS reports, 36 incapacitations and four sudden deaths.

Low Risk

In-flight medical impairments and incapacitations are rare and, in multi-pilot

crews, typically are mitigated by the presence of another pilot, the report said, noting that an earlier study by researchers for the U.S. Federal Aviation Administration (FAA) found that, from 1993 through 1998, two non-fatal accidents could be attributed to in-flight incapacitations involving U.S. airline pilots.⁶

The flight risk presented by an incapacitation is mitigated in multi-pilot crews because another pilot can take over for the incapacitated colleague; nevertheless, the additional workload, distraction and stress also contribute to increased risk.

Regular aeromedical exams aid in risk mitigation for individual pilots, the report said, because medical examiners are able to identify each pilot’s greatest health risks. Pilots under age 40 are likely to reap the greatest benefits from these exams, the report added.

These pilots are those “least likely to experience an incapacitation [in the near future] but for whom prevention of future incapacitation would provide the most benefit for flight safety in the future,” the report said. “Ongoing monitoring of incapacitating events is essential to understand which type of medical conditions present the greatest flight safety risk and to focus efforts on reducing those risks.”

Notes

1. Wirawan, I. Made Ady, et al. “Cardiovascular Risk Score and Cardiovascular Events Among Airline Pilots: A Case-Control Study.” *Aviation, Space, and Environmental Medicine* Volume 83 (May 2012): 465–471.
2. The risk calculator was developed during the course of the Framingham Heart Study, a multi-year study that began in 1948, involving about 5,200 men and women from ages 30 through 62 from Framingham, Massachusetts, U.S., to identify common factors in cardiovascular disease.
3. Evans, Sally; Radcliffe, Sally-Ann. “The Annual Incapacitation Rate of Commercial Pilots.” *Aviation, Space, and Environmental Medicine* Volume 83 (January 2012): 42–49.
4. MORS is designed for the reporting, collection, storage, protection and dissemination of information about incidents that “if not corrected, would endanger an aircraft, its occupants or any other person.” Crew incapacitation is among the occurrences that must be reported.
5. Because female pilots accounted for only 4 percent of the total, the study did not examine the relationship of their age to incapacitation events.
6. DeJohn, Charles A.; Wolbrink, Alex M.; Larcher, Julie G. “In-Flight Medical Incapacitation and Impairment of U.S. Airline Pilots: 1993 to 1998,” DOT/FAA/AM-04/16. FAA Office of Aerospace Medicine. October 2004.

In-Flight Medical Events Resulting in Notification of Unfitness, 2004

Cause of Unfit Episode	Number	Age of Pilot (years)	Situation
Panic attacks (same pilot)	2	34/35	In flight
Anxiety attack	1	50	Simulator
Panic attack	1	64	Passenger
Panic disorder	1	36	In flight
Stress	1	44	Simulator
Lightheaded/visual disturbance	1	54	In flight
Paresthesia in arm	1	42	In flight
Vestibular disturbance	1	39	In flight
‘Unwell’/visual symptoms	1	43	In flight
Dizziness/blurred vision	1	35	In flight
Acute sinusitis/vertigo	1	47	In flight
Perforated tympanic membrane	1	48	In flight
Transient ischemic attack	1	50	In flight
Pulmonary embolus	1	45	Heavy crew
Biliary colic	1	51	Simulator

Note: Data were compiled in a study of 16,145 licensed U.K. professional pilots who had Class 1 medical certificates in 2004.

Source: Evans, Sally; Radcliffe, Sally-Ann. “The Annual Incapacitation Rate of Commercial Pilots.” *Aviation, Space, and Environmental Medicine* Volume 83 (January 2012): 42–49.

Table 3