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16. Abstract

The U.S. Federal Aviation Administration (FAA) is committed to establishment of airman physical standards and certification policies that are as liberal as possible without compromising aviation safety. Through the years, medical flight test results, research, and consultant opinions have resulted in relaxation of medical standards and policies and current FAA certification of 4,704 pilots with blindness or absence of one eye, 14,421 who wear contact lenses, 15,779 with deficient color vision, 15,543 with deficient distant vision and smaller, but significant, numbers with paraplegia, deafness, and amputations. Limitations are placed on flying activities when appropriate. Routine aircraft accident investigations seek to determine the presence of physical problems in the involved airmen and any probable association of the defect with the accident cause. The FAA experience with these civilian pilots who have static physical defects was examined and accident rates were calculated for several categories of pathology for comparison with the overall accident rates in general aviation activities. Three categories exceeded expectations significantly: blindness or absence of one eye, deficient color vision with a waiver, and deficient distant vision. However, these groups reported much higher median flight times than a non-accident airman population and accident airmen without any of the pathology selected for this study. Analyses of available data proved inconclusive but increased exposure may account for most or all of the increased accidents observed for airmen with these three pathologies. None of the accidents was related to the pilots' physical condition in the reports.

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Medical participation in aircraft accident investigation, an active program in which 78 percent of FAA-designated Aviation Medical Examiners participate voluntarily, helps the National Transportation Safety Board (NTSB) determine accident causes and thus identify the significant problems in aviation safety; checks on the adequacy of medical standards, the certification process, and medical flight tests; and provides information to improve human engineering and crash survivability design of aircraft.

II. METHOD.

Growth of the civil airman population to 762,604 at the end of 1974 with application of the established medical standards, medical flight or practical tests results, judgments about the applicant's operational experience, consultants' opinions, and research findings have resulted in the following numbers of active airmen with static physical defects (pathology categories) of concern for this study. There were 4,704 airmen with blindness or absence of either eye (includes uncorrectable distant visual acuity of 20/200 or worse, one eye); 14,421 airmen who wear contact lenses; 5,157 with deficient color vision who have taken a signal light gun test and passed and have no operational restriction; 10,622 with deficient color vision and the restriction: not valid for night flight or color signal control; 15,543 with deficient distant vision (uncorrected distant vision poorer than 20/100 for first or second class, or does not correct to standards for any class); 154 with paraplegia; 87 with deafness (restriction: not valid for flying where radio is required); and 745 with amputation (restriction: must wear artificial limb while flying, or requires special controls on airplane).

This study was designed as a first effort using readily available information to compare the accident experience of the airmen in each of these eight static physical defect categories with expectations based upon their representation within the active airman population. The 762,604 airmen who held current medical certificates on December 31, 1974, and the records of 4,600 airmen who were involved in aircraft accidents during 1974 were used in the analysis.

In an effort to consider exposure to risk, reported flying times for the 6-month period immediately preceding the latest physical examination before the accident were analyzed for the 416 accident airmen with a selected handicap, for each of the three significant categories, for the 4,184 other airmen who had accidents, and for a sample of 1,020 from the active airman population. Hours flown during the 24 hours and 90 days preceding each aircraft accident are contained in FAA aircraft accident investigation reports but these data are not readily available nor are they available for the airman population sample.

The FAA reports of these accidents (which are unofficial; the NTSB determines the official cause) were examined to determine the time of day and phase of flight for each. Mid-air collisions, landing accidents, and nighttime and special operations were of particular concern. The preliminary determination of the probable cause of each accident was also checked.

III. RESULTS.

Table I shows the airmen and accident frequencies and rates for the eight selected pathology categories.

Three categories stand out as exceeding expectations based on the observed to expected ratios as well as chi-square results. These categories are blindness or absence of either eye, deficient color vision with a waiver, and deficient distant vision. The other categories were either not significant or could not be calculated because of small expected values.

For the categories without increased accident rates, either corrective devices were required or operational limitations were imposed. This is true for only one of the significant categories (deficient distant vision).

The distribution of 6-month flight times for accident airmen were significantly different (greater) than those for the active population sample and the flight times for airmen with selected handicaps were significantly greater than for the other accident airmen. Table II shows the increased proportion of handicapped airmen who reported higher levels of flying activity.

TABLE I

AIRMEN AND ACCIDENT FREQUENCIES AND RATES FOR SELECTED PATHOLOGY CATEGORIES

Pathology Category	Freq. Active Airmen Pop.	Rate/ 1,000	Expected Accident Airmen--1974	Observed Accident Airmen--1974	No. Observed / No. Expected	Observed Accident Rate/1,000	Chi-Square Test
Blindness or Absence of Either Eye	4,704	6.17	28.4	45.0	1.58	9.78	9.86**
Contact Lenses (Path. Code 161)	14,421	18.91	87.0	99.0	1.14	21.52	1.70*
Deficient Color Vision (waiver cause Code F)	5,157	6.76	31.1	52.0	1.67	11.30	14.21***
Deficient Color Vision (Restrict. 17)	10,622	13.93	64.1	53.0	0.83	11.52	1.95*
Deficient Color Vision (Total)	15,779	20.69	95.2	105.0	1.10	22.82	1.04*
Deficient Distant Vision (waiver cause Code D less Path. Code 162)	15,543	20.38	93.7	165.0	1.76	35.87	55.60***
Paraplegia (Path. Code 639)	154	0.20	0.9	--	--	--	+
Deafness (Restrict. 22)	87	0.11	0.5	1.0	2.00	0.22	+
Amputations (Restrict. 10 or waiver cause Code 1)	745	0.98	4.5	5.0	1.11	1.09	+

+ Expected value too small--cannot run X^2
* Not significant at 0.05
** Significant at 0.01
*** Significant at 0.001

The separate defect categories were further compared and analyzed using the chi-square test, trend analysis, and other standard parametric techniques with inconclusive results as to the potential contribution of exposure to the experience realized.

Median flight times are considered more representative than other summary statistics due to reporting problems and extreme influences which affect other measures. These were found to be 13.9 hours for an active airman population sample, 38.4 hours for the 4,184 accident airmen without selected pathology, 74.9 hours for those with blindness or absence of one eye, 61.7 hours for those with deficient color vision without restriction, and 107.8 hours for airmen with deficient distant vision.

It seems possible that increased exposure may account for a large part or all of the increased accident rates observed for these pathologies. If so, it is most likely in the case of defective distant vision (107.8 hours) and possible also for blindness or absence of one eye (74.9 hours) and deficient color vision without restriction (61.7 hours) when these are compared to the other accident group exposure of 38.4 hours. Calculation of accident rates per 100,000 flying hours for each category would be ideal, if possible, and could change the relationships observed here.

The results of the analysis of time of day and phase of flight are presented in Table III. Because of small numbers and the obvious trends reflected in Table III, no statistical treatment was considered appropriate.

TABLE II

FLIGHT TIME DATA

Airman Category	Preceding 6 Months Flight Time (Hours) 0	1-10	11-50	51-200	200+	Total
With Selected Handicap	33	48	117	140	78	416
Percent	7.9	11.5	28.1	33.6	19.0	100.1
Other Accident Airmen	656	707	1,066	1,047	708	4,184
Percent	15.7	16.9	25.5	25.0	16.9	100.0
Total Accident Airmen--1974	689	755	1,183	1,187	786	4,600
Percent	15.0	16.4	25.7	25.8	17.1	100.0
Active Population Sample	220	273	236	152	139	1,020
Percent	21.6	26.8	23.1	14.9	13.6	100.0

X^2 (total accident airmen vs. active population sample) = 121.24   4 d.f.   Sig. @ 0.001

X^2 (airmen with selected handicap vs. other accident airmen) = 34.62   4 d.f.   Sig. @ 0.001

Pilots with only one eye and those with deficient color vision without any operational limitations had more (33 and 50 percent, respectively) than the usual (9.4) percent of their fatal accidents at night. All three categories had more (89, 67, and 74 percent) than the expected 27 percent of their fatal accidents during the cruise phase of flight and more (53, 52, and 47 percent) than the expected (21 percent) of the non-fatal accidents during landing. There were only two mid-air accidents but 31 of the accidents involved agricultural operations where accidents which occurred during spray runs and turns were counted as "cruise." Agricultural operations accounted for 15 percent of the non-fatal accidents for the monocular and deficient distant vision groups. (Aerial application usually accounts for about 10 percent of all general aviation accidents.) Two-thirds of the ag accidents occurred during actual spray operations but only one ag accident was fatal so this operation did not contribute to the high percent of fatal accidents during cruise nor to the high percent of non-fatal landing accidents which was observed for all three of the visually handicapped groups.

Human factors causes were cited in 60 percent of accidents with blindness or absence of either eye and of those with deficient color vision without restriction, and in 48 percent of those with deficient distant vision—all below the usual finding of about 85 percent of general aviation accidents due to human factors causes. None of the accidents was related to the pilot's physical condition in the reports. Four of the monocular pilots struck objects (one collided with another aircraft in flight, two struck wires, and one hit a calf on takeoff) as did five of those with deficient distant vision (three struck the ground during turns and one hit power lines and another struck cattle on takeoff).

IV. DISCUSSION.

Relatively few studies have been performed over the years to compare airmen physical standards and deficiencies with accident experience. Fewer still examples are known where the findings in such studies have influenced medical standards and policies. An exception is the Harper study,[4] which probably influenced the FAA (in 1965) to relax the distant visual acuity standards for first- and second-class medical

TABLE III

TIME OF DAY AND PHASE OF FLIGHT OF ALL ACCIDENTS AND THOSE IN THREE SIGNIFICANT PATHOLOGY CATEGORIES

	All Accidents	Blindness or Absence of either eye (1)		Deficient Color Vision (2)		Deficient Distant Vision (3)	
		9 Fatal	34 Non-fatal	12 Fatal	40 Non-fatal	19 Fatal	146 Non-fatal
Time of Day							
Day	85%	67%	88%	50%	85%	84%	85%
Night	9.4%	33%	6%	50%	2.5%	11%	6%
Dawn	1.1%	--	--	--	2.5%	--	3%
Dusk	4.3%	--	3%	--	10%	--	3%
Unknown	0.2%	--	3%	--	--	5%	3%
Phase of Flight							
Takeoff	19%	--	29%	25%	23%	5%	21%
Cruise	27%	89%	12%	67%	20%	74%	24%
Approach	23%	--	--	8%	2.5%	5%	3%
Landing	21%	11%	53%	--	52%	16%	47%
Ground Operation	3%	--	3%	--	2.5%	--	1%
Unknown	3%	--	3%	--	--	--	3%

(1) Includes 1 mid-air (day), 6 ag (1 fatal)

(2) Includes 1 mid-air (day), 4 ag (0 fatal)

(3) No mid-air, 21 ag, (0 fatal)

certificates (from 20/50 to 20/100) and establish a more liberal policy on waivers for poorer acuity, before correction, and for contact lens acceptance. The Rohde and Ross study, the most thorough of those referenced and reported here, has influenced medical standards and policies for several conditions including monocularity.

Few studies have been conducted of inflight performance of pilots with static physical defects. Roman[8] and Lewis[6] did not find any significant increase in landing errors by pilots flying jet aircraft after the loss of binocular vision.

Because all U.S. civilian medical certification and aircraft accident data are now contained in the same computer system in Oklahoma City, analyses of the data to determine the effects of static physical defects and known active diseases on pilot performance and aviation safety are now more feasible despite the large numbers of airmen and accidents involved. Inflight performance research should be conducted when appropriate. Increased future attention to landing and ag accident reports is indicated to determine if there is any obvious operational/physical defect relationship.

In this preliminary analysis of the accident experience of pilots in eight categories of static physical defects, there is evidence that handicapped pilots fly significantly more hours than do accident and non-accident pilots without known defects. Where devices or operational limitations are available to compensate for physical deficiencies, the accident rate usually was not found to be significantly higher than for pilots without physical problems. The extra interest, effort, and determination required to learn to fly and to obtain medical certification with a significant physical handicap may result in an increased number of actual flying hours as found reported. Overreporting is, of course, possible and, except for the agricultural operations, we know very little about the type of aircraft, weather, time of day, congestion, or other risks typically encountered by the handicapped groups. The general dependability and the will to compensate for serious handicaps is frequently recognized for those in several of the pathology categories considered here.

V. CONCLUSIONS.

Analyses of the data that were available for this study have proved very interesting but inconclusive with regard to a final explanation for the higher accident experience of these three groups. There is a strong likelihood that increased exposure to flight accounts for the increased accidents. Further future examination of individual accident reports may identify specific operational problems or important missing information which warrant additional emphasis in accident investigation, data analysis, and research. The findings of expanded studies such as this can influence medical standards and policies, clinical examination procedures, flight test content and reliability, limitations, educational materials, research priorities, and the use of color in aviation. These analyses should continue on a regular basis and should be extended to common active diseases such as diabetes treated by diet alone and hypertension which are of current professional interest and concern. Our workload and available resources have not permitted these studies as frequently or as profoundly as we feel they are indicated.

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