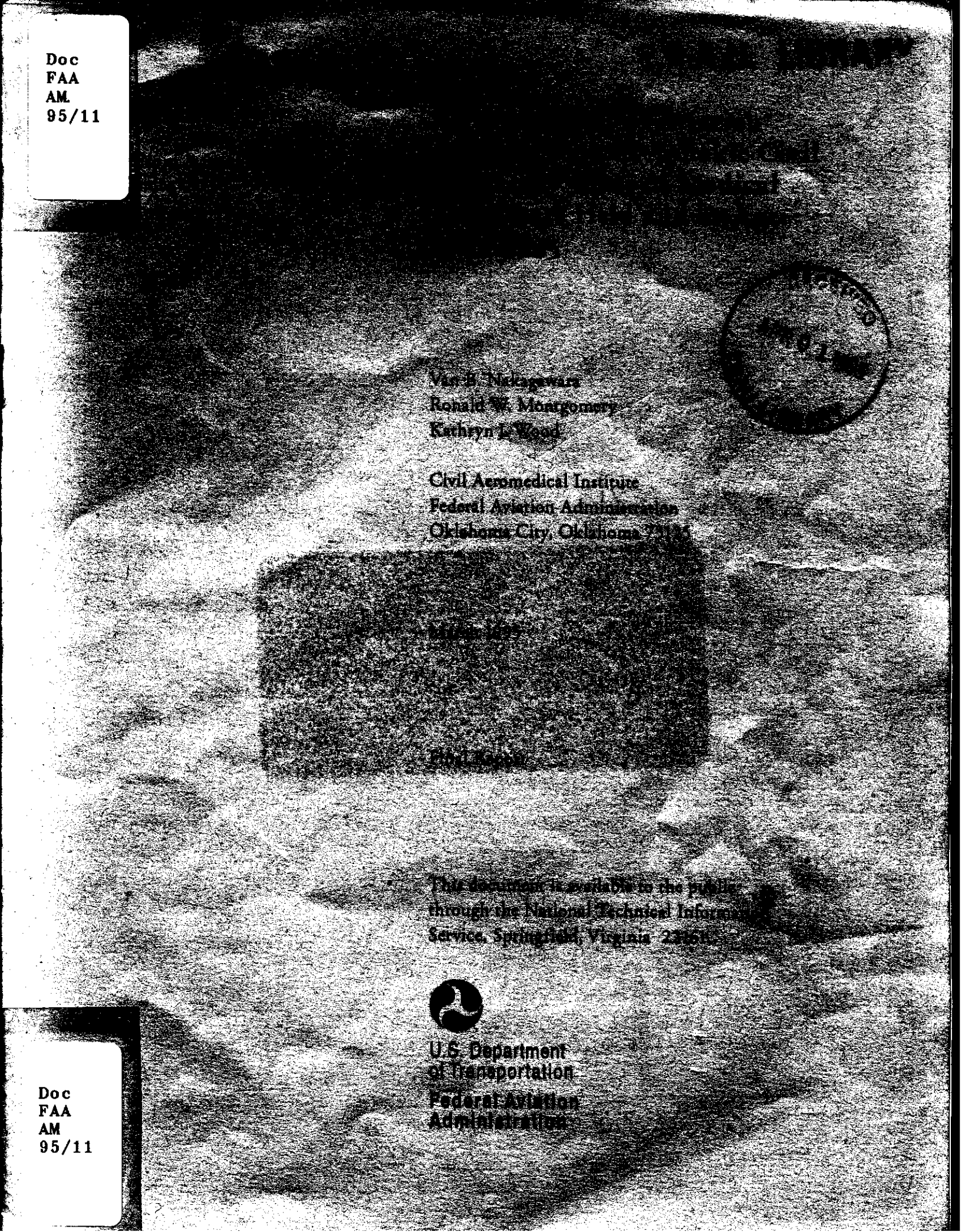

Van B. Nakagawara
Ronald W. Montgomery
Kathryn L. Wood

Civil Aeromedical Institute
Federal Aviation Administration
Oklahoma City, Oklahoma 73125

Final Report

U.S. Department of Transportation
Federal Aviation Administration

Doc
FAA
AM
95/11

AN ASSESSMENT OF AVIATION ACCIDENT RISK OF APHAKIC CIVIL AIRMEN BY CLASS OF MEDICAL CERTIFICATE HELD AND BY AGE: 1982-1985

INTRODUCTION

Cataract, a condition where there is a loss of transparency of the crystalline lens or its capsule, is the third leading cause of blindness in the United States (1) and is normally associated with the aged. Aphakia, a condition where the crystalline lens has been extracted, is usually a result of the removal of a cataractous lens. There are three ophthalmic devices normally employed to correct aphakia: spectacles, contact lenses, and artificial or intraocular lens (IOL) implants.

Aphakic spectacles have many optical and aesthetic disadvantages, including extreme degrees of anisometropia and internal reflections that produce a ring scotoma, which seriously affects the field of vision (2,3). Although superior to spectacles, contact lenses to correct for aphakia have their own deficiencies. Patient compliance in contact lens wearers is poor, especially with rigid lenses (4). Soft contact lenses are difficult to locate when misplaced and poorly handled by older aphakics. Soft lens wearers are more prone to infections and more often develop sensitivities to contact lens solutions.

Implantation of an IOL has become the primary therapeutic modality for the correction of aphakia in the United States. In 1980, approximately 396,000 cataract procedures were performed in the United States and 30% of these surgeries included the implantation of an IOL (5). By 1990, there were approximately 1.385 million cataract procedures and 98% of these included the implantation of an IOL (6). Cataract surgery accounts for about 40% of all eye operations in the United States (7). During the last decade, there have been notable advances in surgical procedures and in IOL designs and materials that have provided the impetus for earlier medical intervention for individuals with cataract.

In the Federal Aviation Administration's (FAA's) Guide for Aviation Medical Examiners (AMEs), the examining physician may issue a medical certificate to a third-class (private pilot) aphakic applicant who meets designated visual criteria and is otherwise healthy. However, first- (air transport pilot) and second-class (commercial pilot) airman applicants who have had cataract surgery are deferred issuance of a certificate, and their applications are submitted for further review by the FAA. A waiver can be issued for such applicants (8), on a case-by-case basis, after review of a completed ophthalmological evaluation.

Dille & Booze (9), in a 1979 study of aviation accidents involving airmen with vision pathologies, found that aphakia and artificial lens implant populations had significantly higher accident rates when compared to the total airman population. In a follow-up study of 1980-81 airman accidents, Dille and Booze (10) found that pilots with aphakia and artificial lens implants, when compared to the total airman population, had higher rates in two categories of exposure: accident rates per 1,000 airmen per year and accident rates per 100,000 hours of recent flight time. A more recent FAA investigation (11) reported significantly higher accident rates for aphakia and IOL airmen, compared to non-aphakic airmen during the period 1982-85. When the populations were sorted by age, significantly higher accident rates were reported in the aphakia and IOL airmen < 50 years of age, compared to non-aphakic airmen in the same age category. Similar comparison found no significant differences in accident rates for older (≥ 50 years of age) aphakia and IOL airmen.

There have been no previous statistical studies of aviation accident risk by aeromedical certificate held. The objective of this report is to present an analysis of aviation accidents for pilots with aphakia and IOL by class of FAA medical certificate held (first-, second-, and third-class) and by age (< 50 and ≥ 50 years) during the study period 1982-85.

METHODS

1. A list was generated identifying civil airmen who were issued airman medical certificates between January 1, 1980, and December 31, 1985, and who carried one or both of the FAA-specific pathology codes 134 (aphakia) and 160 (artificial lens implant) from FAA computer files.
2. The medical records of these airmen were reviewed and a Vision Defect Database, that included known demographic and medical data on these aphakic airmen, was constructed from the medical examination records and FAA computer files.
3. The Aviation Standards National Field Office, Operations Systems Branch (AVN-124), generated a list from the Accident/Incident Data Systems for the period January 1, 1982, to December 31, 1985, of all airmen who were involved in civil aviation aircraft accidents, which included fatal and non-fatal accidents. (Note: An aviation accident is defined as an occurrence in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.)
4. A list of known aphakic airmen (n = 3460) during the study period was provided to AVN-124. The list was matched against the Accident/Incident Data Systems for the time period January 1, 1982, to December 31, 1985, which identified those aphakic airmen involved in civil aviation aircraft accidents (i.e., Aphakic Accident Database).
5. The Aphakic Accident Database was compared with the Vision Defect Database to ensure all the identified aphakic airmen with accidents were aphakic at the time of their accident and active at the end of the accident year. (Note: Active refers to the current status of the airman's medical certificate. Airmen are considered active until their certificate expires. FAA aeromedical certification guidelines consider an airman to be active for a period of 24 months after the month in which the certificate was issued. A certificate remains active even with the death of the airman from aviation-related or nonaviation-related causes.)
6. The FAA's Data Services Division (AAC-300) extracted information from the Comprehensive Airman Information System (CAIS), Vision Defect Database and the Accident/Incident Data System to:
   a) Stratify all active civil airmen by effective class of medical certificate (Note: FAA aeromedical regulations stipulate that an airman may be first- or second-class medically certified and the time lapse since the physical examination would reduce the "effective status" to a lesser class.) and age (< 50 and ≥ 50 years) as of the end of each study year;
   b) Stratify all airmen with accidents by effective class of medical certificate and age as of the end of each study year;
   c) Stratify all aphakic airmen by pathology (aphakia and IOL) and by effective class of medical certificate and age as of the end of each study year; and
   d) Stratify all aphakic airmen with accidents by pathology and by effective class of medical certificate and age as of the end of each study year.
7. Accident rates per 1,000 airmen were calculated for the three major populations: total airman (aphakic and non-aphakic), aphakic airman (aphakia with or without IOL), and IOL airman (aphakia with IOL). These populations were further sorted by age and by effective class of medical certificate. Accident rates were calculated for each calendar year and for the 4-year study period. Significance ($p < 0.05$) was determined by using the Chi-Square (χ^2c) or the Fisher Exact 2-Tailed Tests, as appropriate.
8. The aphakic airmen accident reports were reviewed to determine the ascribed causal role in the accident and the likelihood of vision or eye pathology being a factor.

RESULTS

There were 12,883 aviation accidents that occurred during the study period. When these accident records were cross-referenced to the CAIS database, 1,889 (14.7%) were deleted due to non-readable information in the pilot certificate number field, incorrect pilot certificate or social security numbers, and changes in the control data, leaving a total of 10,994 identified accidents. When the airmen involved in these 10,994 accidents were stratified by effective class of medical certificate held at the end of each year of the study, 1,832 (14.2%) airmen were deleted for the following reasons: not active at the time of the accident or at the end of the year; active at the time of the accident but not at the end of the year; not active at the time of the accident but active at the end of the year; and doubtful determination of effective class of medical certificate and age, leaving a total of 9,162 (71.1%) airmen with aviation accidents.

Airmen from the Vision Defect Database (n = 3460) were cross-referenced to the CAIS database. A total of 43 airmen were deleted due to error messages in one of the identification fields (e.g., social security number, pilot certification number, etc.), leaving a total of 3,417

TABLE 1: THE POPULATION FREQUENCY OF THE APHAKIA, IOL, AND TOTAL AIRMAN POPULATIONS BY CLASS OF MEDICAL CERTIFICATE AND BY AGE

		1982	1983	1984	1985
APHAKIA POPULATION:					
CLASS I	< AGE 50	42	49	43	47
	≥ AGE 50	87	79	94	109
CLASS II	< AGE 50	93	116	113	117
	≥ AGE 50	282	348	352	389
CLASS III	< AGE 50	330	323	360	352
	≥ AGE 50	915	1,030	1,174	1,277
TOTAL APHAKIA	< AGE 50	465	488	516	516
	≥ AGE 50	1,284	1,457	1,620	1,775
IOL POPULATION:					
CLASS I	< AGE 50	14	19	20	25
	≥ AGE 50	47	48	66	82
CLASS II	< AGE 50	33	40	54	57
	≥ AGE 50	138	199	239	279
CLASS III	< AGE 50	59	76	105	135
	≥ AGE 50	373	538	691	845
TOTAL IOL	< AGE 50	106	135	179	217
	≥ AGE 50	558	785	996	1,206
AIRMAN POPULATION:					
CLASS I	< AGE 50	50,106	51,397	54,579	58,830
	≥ AGE 50	11,183	11,722	12,483	13,464
CLASS II	< AGE 50	164,149	157,926	142,067	137,355
	≥ AGE 50	36,862	38,141	36,745	36,520
CLASS III	< AGE 50	394,705	376,966	377,100	354,976
	≥ AGE 50	111,337	112,153	116,326	115,332
TOTAL AIRMEN	< AGE 50	608,960	586,289	573,746	551,161
	≥ AGE 50	159,382	162,016	165,554	165,316

known aphakia and IOL airmen during the study period.

Aphakic airmen with accidents during the study period were cross-referenced to the CAIS database. One airman was deleted from the study (active at the time of accident, but not at the end of the year), leaving a total of 41 aphakic airmen involved in accidents and active at the end of the accident year.

The population frequencies of the aphakia, IOL, and total airman populations by class of medical certificate and by age are presented in Table 1. As expected, in the aphakia and IOL airman populations there are substantially more airmen ≥ 50 years of age. In the total airman population, there are substantially more airmen < 50 years of age. Total aphakia and IOL population frequencies increased each year of the study period. In contrast, the total airman population decreased each year of the study and by seven percent from 1982-85.

The accident frequencies of the aphakia, IOL, and total airman populations by class of medical certificate and by age are presented in Table 2. In the aphakia and IOL airman populations, there are generally more accidents in the ≥ 50 years of age category. There are substantially more accidents in the < 50 years of age category in the total airman population.

TABLE 2: THE ACCIDENT FREQUENCY OF THE APHAKIA, IOL, AND TOTAL AIRMAN POPULATIONS BY CLASS OF MEDICAL CERTIFICATE AND BY AGE

		1982	1983	1984	1985
APHAKIA POPULATION:					
CLASS I	< AGE 50	0	0	0	1
	≥ AGE 50	0	0	0	0
CLASS II	< AGE 50	0	0	1	1
	≥ AGE 50	4	3	1	4
CLASS III	< AGE 50	2	1	2	5
	≥ AGE 50	3	5	4	4
TOTAL APHAKIA	< AGE 50	2	1	3	7
	≥ AGE 50	7	8	5	8
IOL POPULATION:					
CLASS I	< AGE 50	0	0	0	1
	≥ AGE 50	0	0	0	0
CLASS II	< AGE 50	0	0	1	1
	≥ AGE 50	2	1	0	4
CLASS III	< AGE 50	1	0	1	2
	≥ AGE 50	1	2	4	3
TOTAL IOL	< AGE 50	1	0	2	4
	≥ AGE 50	3	3	4	7
AIRMAN POPULATION:					
CLASS I	< AGE 50	182	179	179	171
	≥ AGE 50	24	27	22	21
CLASS II	< AGE 50	790	715	753	611
	≥ AGE 50	177	199	197	170
CLASS III	< AGE 50	913	836	790	796
	≥ AGE 50	337	336	384	353
TOTAL AIRMEN	< AGE 50	1,885	1,730	1,722	1,578
	≥ AGE 50	538	562	603	544

TABLE 3: THE ACCIDENT RATE PER 1,000 AIRMEN OF THE APHAKIA, IOL, AND TOTAL AIRMAN POPULATIONS BY CLASS OF MEDICAL CERTIFICATE AND BY AGE

		1982	1983	1984	1985	PERIOD
APHAKIA POPULATION:						
CLASS I	< AGE 50	0.00	0.00	0.00	21.28	5.52
	≥ AGE 50	0.00	0.00	0.00	0.00	0.00
					TOTAL	1.82
CLASS II	< AGE 50	0.00	0.00	8.85	8.55	4.56
	≥ AGE 50	14.18	8.62	2.84	10.28	8.75
					TOTAL	7.73
CLASS III	< AGE 50	6.06	3.10	5.56	14.20	7.33
	≥ AGE 50	3.28	4.85	3.41	3.13	3.64
						4.51
TOTAL APHAKIA	< AGE 50	4.30	2.05	5.81	13.57	6.55
	≥ AGE 50	5.45	5.49	3.09	4.51	4.56
					TOTAL	5.05
IOL POPULATION:						
CLASS I	< AGE 50	0.00	0.00	0.00	40.00	12.82
	≥ AGE 50	0.00	0.00	0.00	0.00	0.00
					TOTAL	3.12
CLASS II	< AGE 50	0.00	0.00	18.52	17.54	10.87
	≥ AGE 50	14.49	5.03	0.00	14.34	8.19
					TOTAL	8.66
CLASS III	< AGE 50	16.95	0.00	9.52	14.81	10.67
	≥ AGE 50	2.68	3.72	5.79	3.55	4.09
					TOTAL	4.96
TOTAL IOL	< AGE 50	9.43	0.00	11.17	18.43	10.99
	≥ AGE 50	5.38	3.82	4.02	5.80	4.80
					TOTAL	5.74
AIRMAN POPULATION:						
CLASS I	< AGE 50	3.63	3.48	3.28	2.91	3.31
	≥ AGE 50	2.15	2.30	1.76	1.56	1.92
					TOTAL	3.05
CLASS II	< AGE 50	4.81	4.53	5.30	4.45	4.77
	≥ AGE 50	4.80	5.22	5.36	4.65	5.01
					TOTAL	4.82
CLASS III	< AGE 50	2.31	2.22	2.09	2.24	2.22
	≥ AGE 50	3.03	3.00	3.30	3.06	3.10
					TOTAL	2.42
TOTAL AIRMEN	< AGE 50	3.10	2.95	3.00	2.86	2.98
	≥ AGE 50	3.38	3.47	3.64	3.29	3.44
					TOTAL	3.08

The accident rates per 1,000 airmen of the aphakia, IOL, and total airman populations by class of medical certificate and by age are presented in Table 3. In the total aphakia and IOL airman populations, there were 5.05 and 5.74 accidents/1,000 airmen, respectively, for the study period. Accident rates were highest for second-class (7.73 and 8.66/1,000 airmen, respectively) and lowest for first-class (1.82 and 3.12/1,000 airmen, respectively) certificate holders. In the total airman population, there were 3.08 accidents/1,000 airmen for the study period. Accident rates were highest for second-class (4.82/1,000 airmen) and lowest for third-class (2.42/1,000 airmen) certificate holders.

The statistical test results are presented in Table 4. Total aphakia ($p = 0.00193$) and IOL ($p = 0.00303$) airman populations had significantly higher ($p < .05$) accident rates than that of the total non-aphakic airman population. When sorted by class of medical certificate held, only third-class aphakia ($p = 0.00194$) and IOL ($p = 0.01053$) airman populations had significantly higher accident rates than that of the corresponding non-aphakic airman population. When further sorted by age, only the < 50 years of age third-class aphakia ($p = 0.00115$) and IOL ($p = 0.010197$) airman populations had significantly higher accident rates than that of the corresponding non-aphakic airman population.

Upon review of the FAA accident reports of airmen with aphakia or IOL, neither the presence of aphakia or IOL was ascribed a causal role, nor was any association to vision problems ascribed to any accident.

DISCUSSION

When sorted by class of medical certificate held, the accident rates for first-class aphakia (1.82/1,000) and IOL (3.12/1,000) populations were approximately equivalent or less than the total airman population (3.05/1,000) of the same class. However, accidents in the aphakia and IOL populations were so infrequent that an accurate risk analysis was not possible. The highest accident rates for the period were for second-class airmen. Second-class aphakia (7.73/1,000) and IOL (8.66/1,000) accident rates were higher, although not statistically so, than the total airman population (4.82/1,000) of the same class. These overall higher accident rates may be due to substantial flight exposure, with less aircraft maintenance, pilot training, and human resource cockpit support compared to scheduled air carrier flights.

Only third-class aphakia (4.51/1,000) and IOL (4.96/1,000) airman populations had significantly higher accident rates when compared to the non-

TABLE 4: SUMMARY OF STATISTICAL TESTS OF ACCIDENT FREQUENCY

CATEGORY	ODDS RATIO	95% CONFIDENCE INTERVAL	CHI-SQ (Yates)	P-Value	FISHER 2-TAILED TEST
APHAKIA	1.64	(1.19<OR<2.26)	9.61	0.001930	
IOL	1.87	(1.22<OR<2.85)	8.79	0.003030	
CLASS III APHAKIA	1.87	(1.25<OR<2.79)	9.60	0.001940	
CLASS III IOL	2.06	(1.17<OR<3.56)	6.54	0.010530	
CLASS III APHAKIA <AGE 50	3.33	(N/A)	(N/A)		0.001150
CLASS III IOL <AGE 50	4.86	(N/A)	(N/A)		0.010197

Note: Above populations are compared to like non-aphakic populations.

aphakic airman population of the same class. When stratified by age, although for both age categories the accident rates for aphakia and IOL populations were substantially higher, statistical tests indicated that only the < 50 years of age third-class aphakia and IOL populations (7.33 and 10.67/1,000, respectively) had significantly higher accident rates when compared to the non-aphakic airman population of the same age and class.

Vision requirements for civil airmen differ between classes of medical certification (Note: Table 5). The standards are not only more stringent for professional pilots, but they also have more frequent medical examination requirements (first-class every 6 months, second-class every 12 months) than private pilots (third-class every 24 months). With lenient standards and less frequent medical certification examinations, third-class pilots would more often fly with known incipient or undiagnosed medical impairments.

Medical impairment may be defined as an alteration of a patient's health status assessed by medical means, while a disability may be defined as an alteration of the patient's capacity to meet personal, social, or occupational demands, or to meet statutory or regulatory requirements, which are assessed by non-medical means (12). An airman who is visually impaired, due to a refractive condition or eye disease, can often meet the occupational or regulatory requirements to pilot an aircraft, and, for this task, is considered not functionally disabled. Aphakia and the use of an IOL are examples of medical impairments. Aphakia - with or without an IOL correction - is considered a visual impairment weighted by the American Medical Association with a 50% decrease in value of the remaining corrected central vision for unilateral conditions; while with bilateral conditions, the corrected central vision decreases an additional 25% (Note: Corrected visual acuity of 20/20 carries an impairment value = 0%, 20/25 = 5%, etc.) (12). Multiple impairments, although not disqualifying, may lower physiological capabilities to a disabling level in stressful environments or activities. The extent to which these physiological capabilities are lowered varies among individuals.

Third-class airman medical certificate holders have higher prevalence of medical impairment than either first- or second-class holders (13,14). Additionally, the prevalence of aphakia and IOL is higher in third-class airman medical certificate holders for the period 1982-85, partially as a result of third-class certificate

TABLE 5: SUMMARY OF VISION REQUIREMENTS FOR CIVIL AIRMEN BY CLASS OF MEDICAL CERTIFICATE

CLASS OF MEDICAL CERTIFICATE	FIRST-CLASS (AIRLINE TRANSPORT)	SECOND-CLASS (COMMERCIAL)	THIRD-CLASS (PRIVATE)
Distant Vision	20/20 in each eye separately without correction or at least 20/100 in each eye separately corrected to 20/20 or better with corrective lenses (glasses or contact lenses).		At least 20/50, without correction or if vision is poorer than 20/50, must correct to 20/30 or better with corrective lenses (glasses or contact lenses).
Near Vision	At least 20/40 with each eye separately with or without correcting glasses.		At least 20/60 with each eye separately with or without correcting glasses.
Hyperphoria	Maximum of 1 diopter.		No standard.
Esophoria & Exophoria	Maximum of 6 diopters of esophoria or exophoria.		No standard.
Color Vision	Normal color vision.	Ability to distinguish aviation signal red, green and white.	

holders being older on average than either first- or second-class airmen (15,16). Since the accident rates for the < 50 years of age third-class aphakia and IOL airman populations were significantly higher, this may suggest these visual impairments are important risk factors and are not necessarily associated with the physiological impairments that often accumulate with age. Similar conclusions were reported by Dougherty and Harper (17) in their study of accident risk. It is therefore possible that the visual symptoms of incipient cataract may be less impairing than the end result of cataract surgery. If true, our findings may have added clinical significance since medical intervention for cataracts and the implantation of IOLs, in the United States, is being done on progressively younger patients, with perhaps milder forms of cataract.

The significant difference in accident rates of the < 50 years of age pilot populations may be related to psychological as well as physiological factors. Older pilots usually have grown accustomed to slowly developing cataract and reduced vision capabilities over time and have a better understanding of their over-all physiological deficiencies. This experience may make the older airmen more likely to limit their exposure and avoid unknown or potentially dangerous flying situations. On the other hand, younger airmen, even with physiological impairments, may be more aggressive with an actual or perceived limitation and be less cautious in hazardous situations than older pilots with similar conditions. Such behavior may expose these younger airmen to situations where the physiological capabilities of their condition(s) are exceeded. This may be especially true for an airman with a cataract corrected early with surgery, that results in little physical evidence of an impairment due to the inconspicuousness of an IOL. The presence of physiological impairment, together with psychological differences in adapting behavior to that impairment, may be an important risk factor for aviation accidents.

Alternative analyses of the accident data may more precisely define aphakia and IOL relative risk. For example, accident rate per exposure period (person-time) for the various populations (class, age, pathology); accident rate by class of medical certificate held at accident date; and accident rate by class of medical certificate issued prior to the accident event were considered for analysis. However, these were not performed at the recommendation of both the computer program support staff and aeromedical certification personnel, due to limitations in the data that restricts coordination between the databases. These analyses are being considered in an ongoing follow-up study (1986-89) of accident risk for aphakic airmen.

Aviation accidents are rare events. In the total airman population, there were approximately 3.1 accidents per 1,000 airmen during the study period (0.014 accidents/1,000 airmen contributed by aphakic airmen). The limited number of aviation accidents makes statistical analysis suspect, especially when small populations, such as aphakia and IOL, are further stratified (by class of medical certificate, by age) and evaluated relative to the substantially larger non-aphakic airman populations. Additionally, the fact that neither the presence of aphakia or IOL was ascribed a causal role to any of the accidents in our study, further weakens our findings that suggest an association between these medical conditions and aviation accidents. Regardless of these considerations, the fact that aphakia and IOL have been found to have higher accident rates in all previous FAA epidemiologic studies supports the need for continued research. The improvements in cataract surgery techniques and IOL designs and materials since 1985 have been remarkable. It is possible that these technological advances may reduce the visual impairment for aphakic pilots and lessen the risk of aviation accidents.

Improved aeromedical certification practices and the implementation of other safety programs may enhance the performance of aphakia and IOL airmen. These considerations, include:

1) Since medical impairment may be a factor in accident risk, prior to initiating a waivered certificate, a system that weighs the relevance of multiple medical impairments for an applicant relative to flight safety may be applied.
2) Current methods to evaluate vision performance in the clinical environment may not provide an accurate assessment of functional vision capabilities in the aviation environment. Research to identify more effective assessment procedures for visually impaired pilot applicants should be ongoing.

3) The higher accident rates of aphakia and IOL airmen suggests that additional clinical studies on the effects of aviation stressors to these airmen be initiated.
4) Aircraft design and maintenance need to consider the capabilities and limitations of pilots with medical impairments in supporting reasonable accommodations for these airmen.
5) Specialized training and education of airmen with medical impairments, that could potentially affect their ability to fly an aircraft, may improve aviation safety.

In summary, the major findings of this study are:
1) Third-class aphakia and IOL airman populations had significantly higher accident rates than third-class non-aphakic airmen; and
2) Less than 50 years of age third-class aphakia and IOL airman populations had significantly higher accident rates than < 50 years of age third-class non-aphakic airmen.

Our findings suggest that visual impairment in aphakic and IOL airmen may be an important factor in aviation accident risk. Age stratification focused the risk on the younger pilot populations and brings into question the practice of early surgical intervention and correction of incipient cataracts. Ophthalmic surgeons may need to postpone surgery until the cataract is more mature, and the benefits of surgery unequivocally outweigh the disadvantages. Specific education, particularly for younger aphakia and IOL airmen, is recommended since the elevated risk observed for the < 50 years of age populations may be a product of a lack of psychological conditioning to the physiological limitations of their impairments.

Until subsequent study further validates these findings, with more powerful statistical tests on larger populations with higher accident frequencies, no change in present certification standards or waiver processes is recommended at this time. Easy access to the newly created consolidated airman health information and accident database system at the FAA's Civil Aeromedical Institute in Oklahoma City should facilitate future studies of correlations between aviation accidents and medical conditions. Additionally, a more detailed medical certification database would facilitate extraction of information on a pilot involved in an aviation accident such that the initial investigation could focus on any medical impairment(s) that could have contributed to accident causation. However, education and training that create awareness of the extent to which the impairment(s) can limit an individual's ability to perform, particularly in complex aviation environments and modes of flight, may be a good place to focus initial efforts that can improve aviation safety.

REFERENCES

1. Goodman DF, Stark WJ, Gottsch JD. Complications of cataract extraction with intraocular lens implantation. Ophthalmic Surgery. 1989; 20:132-140.
2. Roper-Hall MJ. Intraocular Lenses. In: Duane TD, ed. Clinical Ophthalmology Vol. 5. Hagerstown: Harper & Row, 1979:1-5.
3. Dhenin G. Ophthalmological conditions and eye examination. In: Aviation Medicine: Health and Clinical Aspects. London: Tri-Med Books Limited, 1978:264-302.
4. Boyd BF. Highlights of Ophthalmology. 1974-1975 Series; 3:1-6.
5. Boyd BF. Highlights of Ophthalmology. 1980 Series; 8:1-3.
6. Carr M. Cataract, intraocular lens, and refractive surgery in 1987 with a forecast to 1995. J Cataract Refract Surg. 1988; 14:664-7.
7. Alexander LJ. Aphakia and pseudophakia. In: Amos JF, ed. Diagnosis and Management in Vision Care. Boston: Butterworths, 1987:639-69.
8. Department of Transportation/Federal Aviation Administration. Guide for aviation medical examiners. Washington, DC:1992; FAA Office of Aviation Medicine.
9. Dille JR, Booze CF Jr. The prevalence of visual deficiencies among 1979 general accident airmen. Washington, DC: Department of Transportation/ Federal Aviation Administration. 1981; FAA Report No. FAA-AM-81-14. Available from: National Technical Information Service, Springfield, VA 22161. Order #ADA106489/8.

10. Dille JR, Booze CF Jr. The 1980 and 1981 accident experience of civil airmen with selected visual pathology. Washington, DC: Department of Transportation/Federal Aviation Administration. 1983; FAA Report No. FAA-AM-83-18. Available from: National Technical Information Service, Springfield, VA 22161. Order #ADA134898.

11. Nakagawara VB, Wood KJ. Aviation accident risk for airmen with aphakia and artificial lens implants. Washington, DC: Department of Transportation/Federal Aviation Administration. 1993; FAA Report No. DOT/FAA/AM-93/11. Available from: National Technical Information Service, Springfield, VA 22161. Order #ADA268389.

12. American Medical Association. Guides to the evaluation of permanent impairment. 4th Edition. June 1993.

13. Booze CF Jr. Prevalence of selected pathology among currently certified active airmen. Washington, DC: Department of Transportation/Federal Aviation Administration. 1981; FAA Report No. FAA-AM-81-9. Available from: National Technical Information Service, Springfield, VA 22161. Order #ADA103397/6.

14. Booze CF Jr. Prevalence of diseases among active airmen. Washington, DC: Department of Transportation/Federal Aviation Administration. 1988; FAA Report No. DOT/FAA/AM-89/2. Available from: National Technical Information Service, Springfield, VA 22161. Order #ADA206050.

15. Nakagawara VB, Loochan FK, Wood KJ. The prevalence of artificial lens implant in the civil airman population. Washington, DC: Department of Transportation/Federal Aviation Administration. 1992; FAA Report No. DOT/FAA/AM-92/14. Available from: National Technical Information Service, Springfield, VA 22161. Order #ADA249126.

16. Nakagawara VB, Loochan FK, Wood KJ. The prevalence of aphakia in the civil airman population. Washington, DC: Department of Transportation/Federal Aviation Administration. 1991; FAA Report No. DOT/FAA/AM-91/14. Available from: National Technical Information Service, Springfield, VA 22161. Order #ADA241032.

17. Dougherty JD, Harper CR. Physical defects of civilian pilots related to aircraft accidents: a new look at an old problem. Aerospace Med. 1968; 39:521-7.

☆U.S. GOVERNMENT PRINTING OFFICE: 1995 - 660-067/00098