

REPORT
OF
THE NATIONAL INSTITUTE ON AGING
PANEL ON THE EXPERIENCED PILOTS STUDY

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTES OF HEALTH
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PREFACE

On December 29, 1979, the United States Congress enacted Public Law 96-171, an Act to require a study of the desirability of mandatory age retirement for certain pilots, and for other purposes. The legislation (Appendix A) required the Director of the National Institutes of Health (NIH), in consultation with the Secretary of Transportation, to conduct a study to determine:

- (1) whether an age limitation which prohibits all individuals who are sixty years of age or older from serving as pilots is medically warranted;
- (2) whether an age limitation which prohibits all individuals who are older than a particular age from serving as pilots is medically warranted;
- (3) whether rules governing eligibility for first- and second-class medical certification, as set forth in part 67 of title 14 of the Code of Federal Regulations (as in effect on the date of enactment of this Act), are adequate to determine an individual's physical condition in light of existing medical technology;
- (4) whether rules governing the frequency of first- and second-class medical examinations, as set forth in part 67 of title 14 of the Code of Federal Regulations (as in effect on the date of enactment of this Act), are adequate to assure that an individual's physical condition is being satisfactorily monitored; and
- (5) the effect of aging on the ability of individuals to perform the duties of pilots with the highest level of safety.

A report on the results of the study was to be prepared and submitted to Congress within one year of enactment of the legislation.

In carrying out the requirements of P.L. 96-171, the Director of NIH assigned primary responsibility for implementing the legislation to the National Institute on Aging (NIA). As the first major step in assuming this responsibility, NIA established an Inter-Institute Committee, consisting of one representative each from NIA, the National Heart, Lung and Blood Institute (NHBLI), the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) and the National Institute of Mental Health (NIMH). The membership of the Inter-Institute Committee is shown in Appendix B.

The charge to the Inter-Institute Committee was to oversee implementation of P.L. 96-171 and the preparation of the statutorily mandated report. The Committee decided in favor of awarding a contract to the Institute of Medicine (IOM) of the National Academy of Sciences (NAS) to provide an

QUESTION 1

"Whether an age limitation which prohibits all individuals who are sixty years of age or older from serving as pilots is medically warranted."

RESPONSE

The Panel concluded, as did the expert committee assembled by the Institute of Medicine, that on purely medical grounds, age 60 is not an age of special significance with respect to the occurrence of either acute events (such as cardiovascular illness or stroke) or subtle changes (such as those in performance and intellectual function) that may adversely affect pilot performance.

The IOM report summarizes current information on the decline of physiologic and psychophysiologic function with age and the increased frequency of a number of medical disorders that occur with increasing age. These include cardiovascular disease (the leading cause of medical retirement among airline pilots); neurological and mental disorders; and changes in perceptual, psychomotor and intellectual functions. Although the report took cognizance of the fact that, at any given age, physiologic function can vary greatly--particularly among older individuals--it also recognized that an overall decline in function with aging is commonplace. For certain functions, such as hearing or vision, a decrement can now be adequately quantified. However, even for these measurable functions, this capability has been used to set only minimal standards for the pilot to satisfy if he or she is to be allowed to continue to fly. Moreover, criteria do not yet exist for adequate assessment of other complex functions that are also likely to deteriorate with advancing age. For example, as noted elsewhere in this report, performance of complex maneuvers under stress or in novel situations is more likely to be affected by aging than is the performance of well-learned, familiar tasks.

With respect to predicting disabling or life-threatening disease, considerable progress has been made in our ability to identify the presence of risk factors that predispose to the clinically important complications of atherosclerosis, i.e., heart attack, stroke, sudden incapacitation or death. (These risk factors and possible approaches to their detection are described in some detail in the IOM report, pages 59-64.) The risk factors used to determine the probability of developing coronary heart disease--and therefore the main elements of the risk factor profiles--are age, cholesterol, blood pressure, cigarette smoking, glucose intolerance and changes on a resting electrocardiogram. It should be emphasized that the concept of risk factors in predicting disease is based on statistical evaluation of populations. Therefore, it is not possible to single out with assurance the individual who will experience a heart attack or sudden cardiac death within a period of days, weeks, or even months in the future. Some individuals may be identified as being at high risk but will not be incapacitated by heart disease (false positives), whereas others who do not appear to be at high risk may be incapacitated by a heart attack or experience sudden cardiac death (false negatives).

The probability of developing coronary heart disease increases with increasing age. Average probabilities of developing coronary heart disease within 8 years in the Framingham Heart Study were 7 percent for 50- to 54-year-olds and 11 percent for 60- to 64-year-olds. But levels of risk overlap and were lower for some 60- to 64-year-old men than for some 50- to 54-year-old men (Figure 4).

Most medical disqualifications of older pilots are for cardiovascular disorders, and the frequency of these disqualifications increases dramatically with age, i.e., on the order of 54 times greater among pilots aged 55 to 59 than for pilots aged 35 to 45 (Orford and Carter, 1976). It seems reasonable to expect a further increase in the frequency of cardiovascular disorders if pilots are permitted to fly beyond age 60. Moreover, because even the full armamentarium of diagnostic procedures is not infallible with respect to anticipating cardiovascular crises, an increased number of incapacitations due to cardiovascular disorders would be expected as pilots grow older, thereby increasing the hazards to the flying public. However, it is likely that the morbidity and mortality of aging pilots would increase at a lower rate than that of the population at large since pilots have been demonstrated to be physically more fit than the general population at comparable ages.

Fortunately, cardiac incapacitation of a pilot-in-command has not been a major source of accidents under the present system. This happenstance is largely due to the mandatory retirement at age 60, the small number of cardiovascular accidents that the pilots have experienced, and the odds against a cardiovascular accident occurring during a critical period in flying, i.e., during takeoff, landing, or an in-flight emergency. If older pilots are permitted to continue flying as pilot-in-command or co-pilot, the frequency of cardiac incapacitation, and consequently of accidents, is likely to increase.

Relevant to the above considerations concerning commercial airlines is the fact that pilots flying for commuter airlines under Federal Aviation Regulations (FAR) part 135 are not covered by the age 60 rule. The National Transportation Safety Board has investigated three air taxi/commuter accidents that involved significant medical problems in pilots more than 60 years of age (Appendix E). Its investigations prompted recommendations that the FAA study the operating environment and working conditions of part 135 pilots to determine whether an age limitation is warranted and that, as an interim measure, an upper age limit be established for part 135 pilots that provides a level of safety equivalent to that of air carrier operations.

Decline in cognitive function (information processing and other intellectual functions) with age represents another category of impairment that, if undetected, could compromise pilot performance. Currently, this aspect of the medical appraisal is the least developed. Although the mental processing of information and mental functioning in general merit thorough evaluation in the medical appraisal, as noted in the IOM report (page 150), testing of cognitive function is currently not the responsibility of the aviation medical examiner. It is true that some cognitive functions are now tested implicitly, although not quantitatively, in proficiency checks conducted by pilot peers. However, this type of testing is not intended to detect subtle decrements in function. Instead, proficiency checks usually

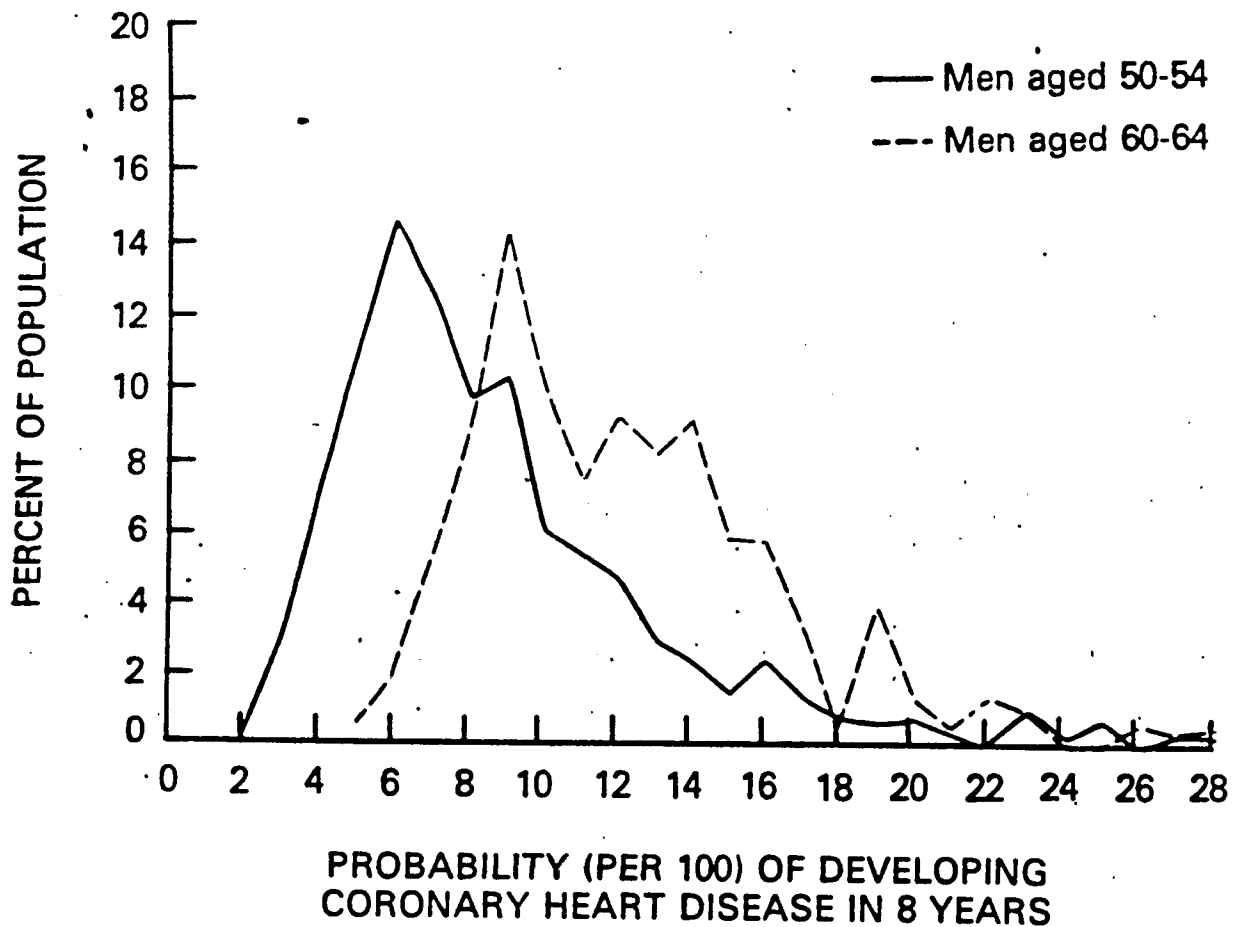


Figure 4. Risk of Developing Coronary Heart Disease in 8 Years in Men Aged 50-54 and 60-64.

Source: Biometrics Research Branch, the National Heart, Lung, and Blood Institute, June 1981.

are designed to train pilots to meet standards of proficiency under optimal testing conditions using known routines and maneuvers. Although the proficiency checks suffice for training purposes, they are not suitable for testing complex cognitive functions under actual conditions, such as fatigue and stress; nor are they used to determine at what rate the skills learned in the training sessions decline between two consecutive checks. Both the IOM Committee and this Panel conclude that, although the opportunity for testing (as well as for training) in a line-oriented flight training (LOFT)-type simulation is a promising avenue to pursue, much more study and development are required to ascertain the predictive value of this approach. The IOM Committee and this Panel also agree that certain important individual aspects of pilot performance cannot be quantified at present and that objective criteria for measuring overall pilot performance are not yet at hand.

REFERENCE

Orford, R. R. and Carter, E. T. Preemployment and Periodic Physical Examinations of Airline Pilots at the Mayo Clinic. Aviation, Space and Environmental Medicine 47(2): 180-184, 1976.

QUESTION 2

"Whether an age limitation which prohibits all individuals who are older than a particular age from serving as pilots is medically warranted."

RESPONSE

Just as there is no medical evidence to support age 60 as a breakpoint in the incidence or prevalence of disease states or in decrements in physiologic function that would produce sudden or subtle incapacitation sufficient to preclude the piloting of commercial aircraft, there is also no medical basis for singling out any other age below or above age 60 as that breakpoint. There is undoubtedly a minimal acceptable level of physiologic function and disease risk as well as freedom from threatening disease and disability for each individual. All individuals do not reach this functional and medical breakpoint at the same chronological age.

There is no doubt that advancing age is associated with a decline in physiologic function, as well as an increase in a number of disorders which, alone or in combination, could predispose to subtle or sudden incapacitation. However, individuals vary considerably and often remarkably, both in their rates of physiologic aging and in their vulnerability to potentially dangerous diseases and stress. As indicated with respect to Question 1, current medical tests and procedures do not have the precision, when applied to individuals, to identify reliably those at serious risk either below or above age 60. Just as there is no medical basis for selecting age 60 as the limit for piloting a commercial aircraft, so is there no medical justification for advocating any particular age. Age 60 has been a safe choice. This is not to say that age 61 or age 62 would have proved less safe but, because of the enforced retirement at age 60, no medical information is available to evaluate the safety of piloting beyond age 60. As the IOM report suggests, it would be advisable to develop a staged evaluation program, beginning around age 40, to document all types of risk. The evaluation program could introduce additional procedures over the years as more sophisticated diagnostic measures are indicated. With this longitudinal approach, a waiver system could be envisaged, one which would allow continued piloting activities beyond age 60 in selected individuals meeting well-defined criteria for medical fitness and performance.

QUESTION 3

"Whether rules governing eligibility for first- and second-class medical certification, as set forth in part 67 of title 14 of the Code of Federal Regulations (as in effect on the date of enactment of this Act), are adequate to determine an individual's physical condition in light of existing medical technology."

RESPONSE

In general, existing rules pertaining to medical certification have proved adequate for determining the physical condition of pilots. It is relevant that part 67 of title 14 of the Code of Federal Regulations operates within a system of medical evaluation that includes independent examinations by some air carriers and peer review of performance by check pilots. The medical examination should be improved, whether the age 60 rule is modified or not, to include procedures to assess risk and assure early detection of diseases and conditions which are related to aviation safety. The nature of the changes as well as the content and conduct of the medical examination should be determined by the Federal Air Surgeon after consultation with appropriate experts.

The excellent safety record of pilots who continue to fly to age 60 depends on a complicated interplay of independent assessments and safeguards in which the rules for medical certification are only one element. Among the safeguards built into this system are comprehensive medical examinations by some commercial airlines that are often more exhaustive and specialized than those required by law, periodic checks of performance by peers, and a system for early retirement for medical reasons.

Although this matrix has proved effective to date in protecting the pilot, the public and the airline, certain aspects of the current medical standards are not entirely consistent with contemporary medical knowledge and technology. These standards not only take into account most of the common disorders that relate to aviation safety and indicate acceptable levels of vision and hearing, but they also recognize less frequent disabilities in the form of "other organic, functional or structural defect or limitation which makes the applicant unable to safely perform or which may reasonably be expected within two years to make him unable to perform."

With respect to the common disorders affecting aviation safety, e.g., coronary heart disease, the current regulations could benefit from updating. For example, the IOM report stresses recent approaches to cardiovascular assessment, particularly the estimation of the risk of sudden incapacitation from cardiovascular disease. The report recommends the assessment of established risk factors, including blood pressure, blood cholesterol level, smoking habits, glucose intolerance, and the resting electrocardiogram. It also points out that additional procedures, such as the stress electrocardiogram, might be helpful in identifying those patients whose risk factor profiles indicate that they are particularly vulnerable to sudden incapacitation from coronary heart disease.

The use of risk factor profiles to identify persons with an unacceptably high level of risk for coronary heart disease and stroke and the use of additional tests in sequence, as necessary, holds the prospect of improving the prediction of sudden incapacitation without imposing excessive demands on most pilots and aviation medical examiners. This type of assessment seems particularly warranted if pilots are to fly beyond age 60. The concept of risk factors could also be usefully extended to other common diseases, including diabetes mellitus, chronic lung diseases and degenerative brain disease, e.g., by tests of glucose tolerance, pulmonary function, and cognitive functions, respectively.

Pilot error is the major threat to safety in flying. As indicated previously, the predominant cause of pilot error is impaired performance rather than overt cardiovascular or other disease. Inadequate performance may result from subtle changes in sensation, perception and cognitive function as well as from ill health. Unfortunately, medical data have not yet been related to pilot error. The present FAA examination is limited in its ability to detect gradual changes in sensory capability and is inadequate for the early detection of emotional disturbances which could lead to pilot disqualification. These subtle inadequacies in mentation may become operative at any age. However, as a general rule, changes in sensory capability and central processing are apt to pose difficulties at older ages whereas emotional disturbances are likely to dominate as a problem in younger individuals.

The Panel agrees with the IOM report's perception of a need for examiners to include a standardized mental status examination in their evaluation of pilots and for them to administer some standard screening test for the detection of symptoms of depression and/or other psychopathology. Conventional tests of vision and hearing should be refined and should include not only examination of visual acuity, tonometry and visual fields, but might include tests of dark adaptation and visual reaction times. Examination of hearing should include pure tone threshold audiometry and might include tests of speech discrimination with auditory masking of background noise and tests of central auditory processing. In contrast to these sensory functions, evaluation of complex behaviors such as reaction time, the speed of visual processing, vigilance, problem solving and complex decision-making might be included in augmented psychological testing, possibly as part of flight proficiency checks.

It is clear that modification of the current FAA examination as proposed above will impose new demands on the qualifications and training of the examiners. Currently, the qualifications of FAA-approved medical examiners vary: about 55 percent are general practitioners, 18 percent are specialists in internal medicine, and 3 percent are specialists in aviation medicine. To some extent, the procedures that make up the medical examination are standardized, using guidelines, training seminars, monitoring of junior examiners, and an appeals system. A system for referring applicants who need further investigations to the appropriate specialist is in effect. However, although annual checks are made on information provided by the aviation medical examiners, sufficient opportunity exists for variability in the quality of the examinations.

Mention has been made of the separate medical systems that are operated

by some airlines and the system of check pilot examinations that is operated by all airlines. These provide independent mechanisms for maintaining high standards of physical and mental well-being and for checking performance. No organized attempt has been made to relate medical assessments, pilot performance and information about accidents and errors made by pilots. These relationships should be determined for pilots of different ages. It is disturbing, with respect to the application of current knowledge and technology, that medical surveillance by air carriers is decreasing because of economic reasons.

Both the IOM Committee and this Panel have attempted, by every means available to them, to secure and utilize data directly relevant to the questions at hand. This undertaking met with only limited success for three reasons: 1) adequate data have not been collected; 2) in instances where data have presumably been gathered, they are not available; and 3) some relevant data--gathered for other purposes--have not been analyzed in line with the questions facing this Panel.

"Whether rules governing the frequency of first- and second-class medical examinations, as set forth in part 67 of title 14 of the Code of Federal Regulations (as in effect on the date of enactment of this Act), are adequate to assure that an individual's physical condition is being satisfactorily monitored."

RESPONSE

The frequency of first- and second-class medical examinations is probably greater than necessary to assure that the physical condition of the pilot is adequately monitored. Instead of a uniform rule for all pilots, the frequency and content of these examinations should be related to age and to the medical findings, i.e., more frequent and focused examinations for older persons and for those who demonstrate increased risk of developing disorders that predispose to sudden or subtle incapacitation.

The IOM report explains in some detail the need for adjusting the frequency of medical examinations in accord with likely predisposition to incapacitation. The suggestions made in the IOM report are endorsed by this Panel with particular reference to decreasing the number of examinations in younger pilots without evidence of disease. By exercising greater selectivity with respect to the frequency of examination, and by increasing the specificity of the examinations in older pilots who are at higher risk of incapacitating illness, the medical examinations will become more meaningful, particularly if the results of previous examinations are available to examiners and if provision is made for monitoring changes with age through sequential analysis of data on individual pilots. The need for more frequent and focused examinations would undoubtedly increase if the age limit were raised beyond age 60. As part of these proposed changes in the frequency and nature of the examinations, provision should be made for monitoring the system of medical evaluations and for introducing further modifications as necessary.

QUESTION 5

"[What is] the effect of aging on the ability of individuals to perform the duties of pilots with the highest level of safety[?]"

RESPONSE

Quantitative, objective, and longitudinal observations over the years of the performance of individual pilots with advancing age do not exist. Undoubtedly, the number of individuals experiencing substantial decline in performance does increase with advancing age. However, individuals vary greatly in this respect: some demonstrate serious performance decrements at an early age whereas others show no measurable decrements until much later. Although many performance tests which can be quantitatively scored in a laboratory setting do show statistical decrements with aging, they have not yet been shown to be predictors of piloting performance. As in the case of medical or physiological measurements, no sharp breaks in performance appear at any given age. Variability in performance appears to increase, and average performance to decrease, with increasing age. Unfortunately, objective tests of proficiency that would allow the characterization of levels of pilot performance according to age do not exist. Nonetheless, interpolating data from general experience with aging populations indicates that the risk of an accident increases in the later life of a pilot, and that such risk probably accelerates with advancing age.

The duties of pilots embrace not only maneuvering skill but also decision-making, crew coordination and resource management. Decline in cognitive and psychomotor performance, as well as in physiological performance, occurs with increasing age and will affect how these duties are executed. The health status of the pilot is apt to affect his/her flying performance. In this regard, subtle decrements in performance due to aging processes or subclinical functional impairment are more likely to pose a problem than is complete failure of performance due to sudden incapacitation. However, even though subclinical impairment of the pilot-in-command may be recognized by others in the cockpit, the co-pilot might hesitate to report it or to assume command of the aircraft. This uncertainty at a critical time in flying, e.g., on a final approach to landing, could cause a serious accident.

Although it might at first seem that each of the components of a pilot's task (e.g., visual-motor control, visual information processing, auditory signal detection, decision-making) could be tested and performance deficits used for the purposes of this evaluation, this capability is, in fact, unproven. The IOM report--particularly Chapter 10--points out the various age-related decrements in simple behavioral tasks, but is careful to avoid definitive statements about their correlations with piloting. Slowing of information processing, difficulty in resisting distracting stimuli and decreasing short- and long-term memory are all age-related findings relevant to pilot performance. Limited information now available about the effects of jet-lag and fatigue suggests that these, too, may be age-related.

Although the Panel could not obtain quantitative data concerning the

performance of well-learned, familiar tasks by pilots, relevant information was made available concerning failure rates of flight engineers during their conversion to new equipment (Jensen, 1981). Learning the systems in a complex aircraft involves complex cognitive processes using new and unfamiliar data. The results for 67 flight engineers converting to the L-1011 from other types of aircraft appear in Table 1.

Table 1. Failure Rates of Flight Engineers During Conversion to L-1011 Aircraft.

Outcome	AGE		Total
	Below 60 Years	60 Years & Above	
Pass	41	18	59
Fail	1 (<3%)	7 (28%) ³	8

The failure rate among the older flight engineers was 28 percent as compared to less than 3 percent in the younger age group ($p < .01$).

Although some simple tests to assess motor control and behavior do exist, and even though the results of these tests are easy to measure and seem attractive for providing a standard against which the performance of aging pilots might be measured, the relevance of these tests to actual piloting is uncertain. Since none of these partial tests appear adequate for judging overall pilot proficiency, it is reasonable to examine operational assessment of performance, which relies on check flights and on proficiency tests in simulators. However, standard maneuvers used in proficiency tests, as detailed in FAR 121 Appendix F, are inappropriate for measuring any but obvious decrements in pilot performance. Their inadequacy stems from the fact that the maneuvers are well-known in advance; they may be well-practiced and over-learned by experienced pilots; and they may give no indication of the pilot's ability to perform them under particular levels of stress, fatigue or unexpected decision-making requirements. Furthermore, the pass/fail nature of the testing program; the probable wide variability among testers (as discussed in the IOM report); and the "train-to-proficiency" nature of these tests make them inadequate as a screening mechanism.

The use of line-oriented flight training (LOFT) holds more promise. In this approach, air crews are presented with unexpected scenarios requiring appropriate coordinated responses. Testing the performance of the crew as a whole during these scenarios could afford the prospect of obtaining a reasonable measure of its proficiency. However, the current use of LOFT is for pilot qualification, i.e., for training to proficiency, rather than for assessment of overall ability or for detection of subtle, progressive deterioration. Moreover, as currently designed, LOFT assesses the performance of the entire crew rather than its individual members. Thus, the use of LOFT as a testing mechanism is complicated by difficulty in attributing a failure to a single member of the crew, including the pilot-in-command.

While piloting performance can be expected to decrease with advancing age, it is not possible at this time to identify those persons who will show particular decrements in performance in the future. In addition, our ability to detect small decrements in performance that may seriously interfere with piloting duties in a novel or critical situation is extremely limited.

If those individuals who will become unsafe as pilots in the future cannot be identified with assurance, the only recourse is for society to accept some level of risk. This is current practice in that pilots are permitted to fly until age 60 in the face of knowledge that the incidence of both incapacitating disease and decrements in performance is increasing. It seems certain that raising the age limit would further increase risk, probably accelerating as the cut-off age is increased. What is unclear is how much the risk will increase or whether a catastrophe will occur as a result of the increase in risk. The data to permit quantification of risk for a specific modification of the age 60 rule (e.g., 60 to 61-1/2 years of age) do not exist. As with the discriminability of current medical tests, the discriminability of proficiency tests must be made sharper as the age groups of interest increase because of the increasing variability in performance of individuals in older age groups. In effect, tests for discrimination of performance below age 60 are not likely to be adequate beyond age 60.

REFERENCE

Letter communication. Walter A. Jensen, Vice President, Operations and Engineering, Air Transport Association of America, June 24, 1981.