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THE MORBIDITY EXPERIENCE OF AIR TRAFFIC CONTROL PERSONNEL, 1967--ETC(U)
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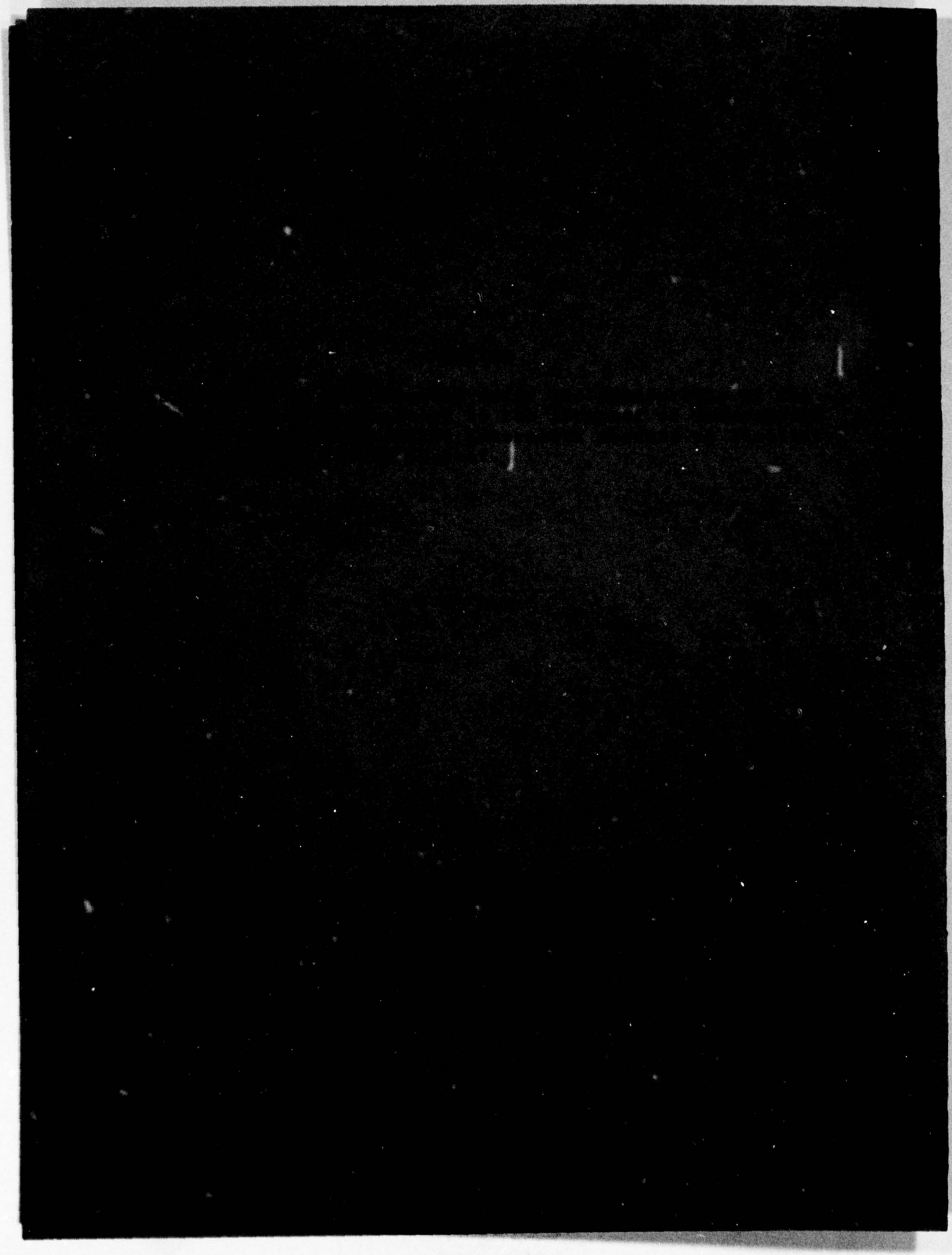

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7. Author(s)
C. F. Booze, Charles F. Booze

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16. Abstract
The morbidity experience of 28,086 air traffic controllers has been examined from 1967-77 with particular emphasis given the potential effects of job demands on ATC Health. The morbidity experience of air traffic controllers does not appear excessive when compared with the experience of other outside groups studied, except for psychoneurotic disorders. Additionally, a lack of association between disease occurrence and occupation is observed in the data correlating disease occurrence with length of service and age. While some isolated trends found in these data are supportive of an occupation disease relationship, they are neither impressive nor consistent, as would be expected if the association were a strong one. Although anticipated empirically, one of the more interesting results of the study was quantification of the substantial differences found to exist in the incidence of disease before and after the second-career legislation. While job and salary protection considerations obviously explain some of the difference, the importance of examination and screening techniques, which are not as dependent on reliable medical history, are emphasized for both air traffic control personnel and the general airman population in an environment in which a major justification for the periodic health examination is the protection of individuals other than the examinee.

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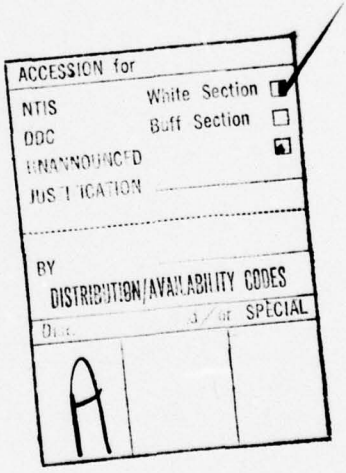

# THE MORBIDITY EXPERIENCE OF AIR TRAFFIC CONTROL PERSONNEL 1967-1977

## I. Introduction and Background.

Several years ago the Federal Aviation Administration (FAA) recognized the need for a program of health maintenance based upon a periodic medical examination for air traffic control personnel. Basically, three options exist in air traffic control. Air route traffic control centers provide cross-country airways control, while tower controllers provide control in the immediate vicinity of the terminal, and flight service station personnel provide a variety of flight assistance ranging from flight planning to emergency assistance.

Prior to 1966, air traffic control specialists (ATCS) working in towers were required by regulation to meet second-class airman medical standards on an annual basis. However, other ATCS employed by the agency before 1966 were administratively required, as a condition of initial employment only, to possess valid second-class airman medical certificates without any further requirement for periodic examinations.

Since neither of these two groups of specialists had the benefit of continuing medical observations oriented toward the maintenance of both employee health and system safety, the institution of an improved health program for agency air traffic controllers became a recognized necessity. The program was established in 1965 following publication by the Civil Service Commission of medical qualification standards for the Air Traffic Control job series. Flight service station (FSS) personnel did not, however, come under the provisions of this program until March 1974.

System safety and the application of medical requirements especially designed to assure the most effective selection of ATCS as employees of the agency and to preserve the useful working life of air traffic controllers by periodic medical assessment and by health counseling as appropriate are the basic program objectives.

The medical qualification levels established by the Civil Service Commission must be met by all applicants at the time of initial employment. Medical qualification levels shall thereafter be maintained according to the duties of the specific position held. Considerable latitude exists under waiver provisions for retention of

controllers. Further, what is significant pathology for one option may not be as significant for another.

The agency currently has approximately 10 years of medical history for tower and center personnel under the ATCS Health Program and about 3 years of experience for FSS personnel on computer files in Oklahoma City.

Certainly, this represents sufficient longitudinal data for center and tower personnel to begin appraisal of program experience. However, the limited data available for FSS personnel was found to be longitudinally insufficient for specific analyses.

## II. Methods.

Air traffic control personnel must obtain second-class medical certification on an annual basis. Controllers at air route traffic control centers are examined by FAA medical officers stationed at the center. Most ATCS in towers and flight service stations are examined by private physicians designated by the agency as aviation medical examiners (AMEs). The ATCS examination is more extensive than a second-class pilot examination, particularly with respect to laboratory requirements. Some differences in the extent of examination, but not standards, and laboratory requirements existed between regions until recently standardized by the Office of Aviation Medicine. An FAA medical officer located at the facility is more likely to have access to significant interim history than the AME. Naturally, some variety of interpretation of standards and emphasis exists between centers and regions reflecting specialty and personal interests among medical officers. Additionally, since the regions are primarily involved in the certification of controllers and the Oklahoma City certification facility is performing only a records repository function, sometimes incomplete data are reflected on the examination form reaching Oklahoma City, e.g., the omission of laboratory results, used by the regions in determining qualification.

A total of 28,086 controllers receiving medical examination for employment during or subsequent to 1967 were selected for the study (25,517 center/tower, 2,569 FSS). All had at least one examination after the initial (entry) examination for disease incidence determinations.

The limited longitudinal data available for flight service station personnel was found to be inadequate and misleading due to the small number of observations for many of the categories being analyzed. Results among this group are thus omitted from further discussion.

Prevalence of disease was determined as of the entry examination during or subsequent to 1967. Age at entry was also ascertained for classification and presentation of findings. Person years of observation were recorded for each study group member for use in disease incidence determination, i.e., new disease occurring after entry into the study. This approach was considered to be the most appropriate given various entry and exit dates by study group members.

Certain medical diseases are recognized as being of more importance with regard to potential for sudden incapacitation. These diseases are differentiated as "critical pathology" in subsequent presentations and discussions (see appendix B). The study design was essentially historically prospective in nature, in that groups were identified and followed from some past point in time to observe outcome, i.e., incidence of disease.

## III. Results and Discussion.

### A. Prevalence of Disease

For ages less than 30 years, cardiovascular and visual problems are the most frequently observed existing conditions among air traffic personnel and appear to be of approximately equal magnitude.

Between ages 30-49 abdominal then cardiovascular disease are the most frequent conditions existing among air traffic personnel.

For ages 50 and above, cardiovascular disease prevalence is most common with abdominal diseases next.

The most frequently observed existing pathologies at entry into the study group for all ages are shown in Figures 1 and 2.

### B. Incidence of Disease

Cardiovascular, neuropsychiatric, and abdominal diseases were the most frequently occurring new diseases among air traffic personnel regardless of age at entry into the study group. The most frequently occurring new pathologies during the study period are shown in Figures 3 and 4.

The potential effects of job demands on ATCS health is a matter of current and continuing interest to the FAA. Certain diseases have historically and classically been associated with life events, either occupational or otherwise. It was not possible to study some of these

Table 1
AGE ADJUSTED INCIDENCE OF SELECTED
PATHOLOGY FOR ATCS
RATES PER 1,000 PERSON YEARS

| Pathology | Age-Adjusted Rates Center/Tower |
|---|---|
| Myocardial infarction | 1.4 |
| Coronary artery disease | 1.1 |
| Hypertension only | 5.4 |
| Hypertension with medication | 5.4 |
| Uncomplicated ulcer | 5.0 |
| Complicated ulcer | .5 |
| Asthma | .3 |
| Migraine | .8 |
| Psychoneurotic disorders | 8.0 |
| Psychophysiologic disorders | 1.1 |
| Transient situational disturbances | .8 |
| Hyperthyroidism | .1 |
| Diabetes, controlled by diet | 2.0 |
| Diabetes, controlled by insulin | .1 |
| Diabetes, controlled by hypoglycemic drugs | .9 |

diseases, e.g., colitis and rheumatoid arthritis, due to combining of several diseases in the coding system utilized by FAA. The incidence of the selected pathologies are presented in Table 1.

Very little, if any, information exists in the literature concerning the incidence of many of the selected diseases frequently associated with life events. Additionally, appropriate comparison data for those selected diseases found in the literature are complicated by methodologic, diagnostic, and population differences. Some relevant comparison data are presented for the cardiovascular diseases and psychiatric diseases; which are by far the most frequently occurring diseases in the ATCS population.

The prevalence of definite hypertension among U. S. adults has been estimated to be approximately 18 percent by both the National Health Survey of 1971-74 and results of the Framingham Study (4,8,9).

At entry into this study, 369 of 25,517 ATCS had a diagnosis of hypertension for a prevalence rate of 1.4 percent. This rate is low due to pre-screening of ATC personnel, elimination of high risk individuals by recurrent examination, and a younger average age of ATCS.

A more realistic view of the occurrence of hypertension is obtained by considering the experience of the remaining 25,148 ATCS without a diagnosis of hypertension at entry into the study. Of this 25,148 ATCS, 1,385 were subsequently diagnosed as hypertensive for end of study prevalence of 5.5 percent among the group entering the study without a diagnosis of hypertension. It is doubtful that the factors previously mentioned in connection with the lower prevalence rate among ATCS could have accounted for the approximately three times higher rate observed in the U. S. and Framingham population.

The incidence of other cardiovascular diseases among center/tower personnel is likewise substantially less than would have been expected based on the findings of the Framingham studies, the Los Angeles heart studies, or other well known large scale studies of cardiovascular disease (1,2,7,8,9).

Age and sex specific incidence of coronary heart disease was compared for ATCS, airline pilots, and Framingham males (5,9). Rates for ATCS are intermediate between lower rates for airline pilots and higher rates for the Framingham males through ages 45-49. After ages 45-49 the morbidity experience of ATCS was lower than either the airline pilots or the Framingham group (see Figure 5).

The same pattern was also found when the ATCS incidence of myocardial infarction was compared with that of the airline pilots; airline pilots have lower rates through ages 45-49 and higher rates above age 50 (5).

For the psychiatric diseases, incidence rates for the ATCS group before the second-career legislation was enacted were similar to incidence of psychiatric illness among U. S. Navy personnel (6). However, incidence of psychiatric illness among ATCS for the entire study period, and especially subsequent to the second-career legislation, was substantially higher than the morbidity experience of U. S. Navy personnel (see Figure 6).

C. Source of Examination

During the 10 years covered in this study, ATCS personnel received a total of 131,217 physical examinations, of which 88,968 (68 percent) were performed by AMEs and the remainder by FAA physicians (42,249). An analysis of pathology discovered, by major body system and source of examination, was conducted in an effort to determine differences in disease detection rates. Prevalence and incidence of disease were higher among ATCS personnel examined by FAA physicians for 8 of 12 categories studied (see Table 2). Prevalence and incidence rates overall were significantly different at probability level 0.05.

The fact that FAA physicians find more pathology among examinees than do their AME counterparts, however, is not unexpected for several reasons. First, the FAA physician is more likely to be aware of significant history as a result of consultations with controller or supervisory personnel. Second, the FAA physician is likely to see more problem cases on a referral basis. Third, the FAA physician is a specialist in this area and thus is more sensitive to the importance of certain pathology in the ATC environment and more familiar with the latest diagnostic techniques. Overall, the FAA physician probably has better facilities for diagnosis at his disposal and spends more time in patient contact and examination per case than does the AME, to whom the air traffic controller health examination program may represent only a small part of his private practice.

D. Length of Service

The prevalence of critical pathology among all ATCS personnel was examined by age, length of service, and major body system. Age and length of service are obviously related variables which must be separately defined to observe outcome. Some trends are observed in the age-specific and age adjusted details of Table 3 and Figure 7.

Table 2
PREVALENCE AND INCIDENCE OF CRITICAL DISEASE BY SOURCE OF EXAMINATION AND BODY SYSTEM-ALL ATCS
RATES PER 1,000 EXAMINATIONS

| Body System | Source of Examination AME | FAA |
|---|---|---|
| Eye | | |
| Prevalence* | 9.4 | 19.8 |
| Incidence** | 2.4 | 3.9 |
| ENT | | |
| Prevalence | + | + |
| Incidence | + | + |
| Respiratory | | |
| Prevalence | + | + |
| Incidence | + | + |
| Cardiovascular | | |
| Prevalence | 13.0 | 15.8 |
| Incidence | 8.1 | 9.2 |
| Abdominal | | |
| Prevalence | 2.5 | 1.3 |
| Incidence | 0.8 | 0.5 |
| Neuropsychiatric | | |
| Prevalence | 1.1 | 0.8 |
| Incidence | 0.6 | 0.6 |
| Bones and Joints | | |
| Prevalence | 3.2 | 5.0 |
| Incidence | 0.5 | 1.2 |
| Muscles | | |
| Prevalence | + | + |
| Incidence | + | + |
| Miscellaneous (Endocrinopathies, Drugs, etc.) | | |
| Prevalence | 4.2 | 6.1 |
| Incidence | 3.5 | 3.1 |
| Total Pathology | | |
| Prevalence++ | 34.7 | 49.7 |
| Incidence++ | 16.3 | 18.6 |

*Prevalence of disease on entry into study exam (1967 or after).

**Incidence of disease subsequent to entry exam.

+Data considered unreliable due to small frequencies.

++Difference in overall rates by source of exam significant at 0.05.

Table 3
PREVALENCE OF CRITICAL PATHOLOGY
BY AGE AND LENGTH OF SERVICE AS OF
LAST EXAMINATION PER 1,000 PERSON YEARS

| Body System And Length of Service | Age At Last Exam | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <20 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | >64 | TOTAL |
| Eye | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 52.4 | 26.1 | 27.3 | 22.7 | 6.4 | 16.7 | 32.1 | 23.5 | 55.5 | 0.0 | 26.3 |
| 5-9 years | 0.0 | 0.0 | 21.5 | 21.6 | 26.7 | 17.7 | 8.1 | 66.2 | 23.8 | 0.0 | 0.0 | 22.5 |
| 10-14 years | 0.0 | 0.0 | 23.8 | 2.4 | 15.8 | 35.7 | 36.3 | 32.5 | 69.4 | 0.0 | 0.0 | 22.0 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 0.0 | 11.8 | 17.8 | 25.1 | 34.3 | 58.6 | 71.4 | 0.0 | 21.7 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 100.0 | 7.3 | 8.0 | 33.4 | 39.8 | 34.1 | 74.1 | 200.0 | 32.6 |
| Unknown | 0.0 | 0.0 | 47.6 | 11.9 | 28.8 | 13.4 | 25.8 | 20.2 | 0.0 | 0.0 | 0.0 | 21.2 |
| TOTAL | 0.0 | 47.9 | 24.7 | 21.4 | 19.3 | 17.0 | 25.3 | 37.4 | 38.9 | 64.5 | 125.0 | 24.5 |
| Ears, Nose, Throat, and Mouth | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.8 | 0.0 | 0.0 | 0.1 |
| 5-9 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 47.6 | 0.0 | 0.0 | 0.2 |
| 10-14 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 0.8 | 1.0 | 1.4 | 0.0 | 0.0 | 0.0 | 1.0 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 1.3 | 0.0 | 0.0 | 0.5 |
| Unknown | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.7 | 0.3 | 3.0 | 0.0 | 0.0 | 0.4 |
| Respiratory System | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5-9 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 6.6 | 0.0 | 0.0 | 0.0 | 0.2 |
| 10-14 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | 0.0 | 4.6 | 0.0 | 0.0 | 0.0 | 0.8 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 1.4 | 3.4 | 0.0 | 0.0 | 0.5 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 1.3 | 0.7 | 0.0 | 7.4 | 0.0 | 1.3 |
| Unknown | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.6 | 0.4 | 1.4 | 0.8 | 4.6 | 0.0 | 0.4 |

Table 3 (Continued)
PREVALENCE OF CRITICAL PATHOLOGY
BY AGE AND LENGTH OF SERVICE AS OF
LAST EXAMINATION PER 1,000 PERSON YEARS

| Body System And Length of Service | Age At Last Exam | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | < 20 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | > 64 | TOTAL |
| Cardiovascular System | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 4.5 | 5.0 | 8.0 | 27.9 | 45.0 | 50.0 | 142.2 | 258.8 | 166.7 | 0.0 | 20.5 |
| 5-9 years | 0.0 | 0.0 | 8.8 | 9.5 | 22.8 | 49.3 | 78.2 | 152.3 | 190.5 | 0.0 | 0.0 | 21.2 |
| 10-14 years | 0.0 | 0.0 | 0.0 | 21.5 | 32.6 | 92.4 | 124.3 | 209.3 | 180.5 | 250.0 | 0.0 | 69.1 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 0.0 | 46.3 | 57.6 | 94.3 | 131.6 | 148.3 | 261.9 | 0.0 | 74.7 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 0.0 | 36.8 | 62.3 | 127.2 | 160.0 | 149.6 | 163.0 | 200.0 | 130.5 |
| Unknown | 0.0 | 0.0 | 9.5 | 11.9 | 32.9 | 35.7 | 64.5 | 85.8 | 166.7 | 0.0 | 500.0 | 48.4 |
| TOTAL | 0.0 | 4.2 | 6.4 | 10.0 | 32.9 | 58.5 | 98.1 | 150.0 | 160.2 | 179.7 | 250.0 | 52.9 |
| Abdominal | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 0.0 | 1.7 | 1.3 | 0.0 | 6.4 | 4.2 | 9.2 | 23.5 | 0.0 | 0.0 | 2.3 |
| 5-9 years | 0.0 | 0.0 | 1.1 | 3.1 | 3.2 | 5.9 | 8.1 | 19.9 | 0.0 | 0.0 | 0.0 | 3.4 |
| 10-14 years | 0.0 | 0.0 | 0.0 | 2.4 | 6.5 | 14.7 | 5.2 | 23.2 | 13.9 | 0.0 | 0.0 | 8.8 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 0.0 | 5.1 | 7.3 | 9.4 | 11.4 | 10.3 | 0.0 | 0.0 | 7.7 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 0.0 | 7.3 | 6.4 | 9.0 | 14.2 | 10.5 | 22.2 | 0.0 | 11.1 |
| Unknown | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.4 | 12.9 | 5.0 | 50.0 | 0.0 | 0.0 | 7.6 |
| TOTAL | 0.0 | 0.0 | 1.4 | 2.4 | 4.1 | 8.0 | 8.5 | 13.5 | 13.0 | 13.8 | 0.0 | 5.8 |
| Neuropsychiatric | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 0.0 | 1.7 | 2.0 | 3.5 | 2.1 | 4.2 | 13.8 | 0.0 | 0.0 | 0.0 | 2.3 |
| 5-9 years | 0.0 | 0.0 | 1.1 | 2.8 | 2.6 | 0.0 | 2.7 | 6.6 | 0.0 | 0.0 | 0.0 | 2.2 |
| 10-14 years | 0.0 | 0.0 | 0.0 | 7.2 | 4.6 | 6.3 | 10.4 | 13.9 | 0.0 | 0.0 | 0.0 | 6.4 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 0.0 | 4.4 | 4.2 | 4.2 | 8.6 | 17.2 | 0.0 | 0.0 | 5.3 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 100.0 | 7.3 | 6.4 | 3.8 | 5.7 | 5.2 | 14.8 | 0.0 | 5.9 |
| Unknown | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.4 | 0.0 | 16.7 | 0.0 | 0.0 | 1.7 |
| TOTAL | 0.0 | 0.0 | 1.4 | 3.0 | 3.6 | 3.9 | 4.4 | 7.3 | 7.6 | 9.2 | 0.0 | 3.8 |

Table 3 (Continued)
PREVALENCE OF CRITICAL PATHOLOGY
BY AGE AND LENGTH OF SERVICE AS OF
LAST EXAMINATION PER 1,000 PERSON YEARS

| Body System And Length of Service | Age At Last Exam | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <20 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | >64 | TOTAL |
| **Bones and Joints** | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 9.1 | 5.7 | 6.0 | 10.5 | 6.4 | 8.3 | 4.6 | 0.0 | 0.0 | 0.0 | 6.4 |
| 5-9 years | 0.0 | 0.0 | 4.9 | 4.2 | 8.5 | 2.0 | 8.1 | 19.9 | 23.8 | 0.0 | 0.0 | 5.6 |
| 10-14 years | 0.0 | 0.0 | 0.0 | 0.0 | 7.4 | 6.3 | 5.2 | 9.3 | 0.0 | 0.0 | 0.0 | 5.6 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 19.2 | 2.2 | 7.7 | 6.3 | 20.0 | 6.9 | 0.0 | 0.0 | 7.7 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 0.0 | 7.3 | 8.0 | 5.1 | 12.8 | 11.8 | 7.4 | 0.0 | 9.8 |
| Unknown | 0.0 | 0.0 | 9.5 | 11.9 | 4.1 | 0.0 | 0.0 | 5.0 | 33.3 | 0.0 | 0.0 | 5.9 |
| TOTAL | 0.0 | 8.3 | 5.4 | 4.7 | 6.5 | 6.5 | 5.9 | 13.5 | 10.7 | 4.6 | 0.0 | 6.8 |
| **Muscles** | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 0.0 | 1.0 | 0.7 | 1.7 | 0.0 | 4.2 | 0.0 | 23.5 | 0.0 | 0.0 | 1.2 |
| 5-9 years | 0.0 | 40.0 | 1.6 | 2.2 | 3.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 |
| 10-14 years | 0.0 | 0.0 | 0.0 | 4.8 | 0.9 | 2.1 | 0.0 | 13.9 | 0.0 | 0.0 | 0.0 | 2.8 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 1.2 | 0.0 | 2.9 | 6.9 | 0.0 | 0.0 | 1.3 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.8 | 2.6 | 2.8 | 5.2 | 0.0 | 0.0 | 3.4 |
| Unknown | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 0.0 | 0.0 | 0.8 |
| TOTAL | 0.0 | 2.1 | 1.2 | 1.9 | 1.6 | 1.4 | 1.1 | 3.1 | 6.9 | 0.0 | 0.0 | 1.9 |
| **Other Miscellaneous Conditions** | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 2.3 | 3.3 | 3.3 | 12.2 | 10.7 | 12.5 | 32.1 | 58.8 | 0.0 | 0.0 | 6.6 |
| 5-9 years | 0.0 | 0.0 | 1.6 | 7.6 | 9.1 | 17.7 | 21.6 | 13.2 | 23.8 | 0.0 | 0.0 | 8.0 |
| 10-14 years | 0.0 | 0.0 | 0.0 | 12.0 | 13.6 | 46.2 | 129.5 | 51.2 | 83.3 | 0.0 | 0.0 | 35.6 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 0.0 | 23.5 | 20.9 | 36.7 | 58.6 | 41.4 | 47.6 | 0.0 | 29.3 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 0.0 | 29.4 | 27.1 | 47.5 | 48.4 | 66.9 | 44.4 | 0.0 | 47.3 |
| Unknown | 0.0 | 0.0 | 0.0 | 11.9 | 4.1 | 17.8 | 32.2 | 30.3 | 33.3 | 0.0 | 0.0 | 17.0 |
| TOTAL | 0.0 | 2.1 | 2.6 | 6.8 | 15.8 | 22.7 | 42.0 | 46.8 | 58.7 | 36.9 | 0.0 | 20.5 |

Table 3 (Continued)
PREVALENCE OF CRITICAL PATHOLOGY
BY AGE AND LENGTH OF SERVICE AS OF
LAST EXAMINATION PER 1,000 PERSON YEARS

| Body System And Length of Service | Age At Last Exam | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <20 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | >64 | TOTAL |
| GRAND TOTALS | | | | | | | | | | | | |
| Less than 5 years | 0.0 | 68.3 | 44.4 | 48.7 | 78.5 | 77.1 | 100.0 | 233.9 | 400.0 | 222.2 | 0.0 | 65.8 |
| 5-9 years | 0.0 | 40.0 | 40.7 | 51.1 | 76.9 | 92.7 | 126.7 | 284.8 | 309.5 | 0.0 | 0.0 | 65.6 |
| 10-14 years | 0.0 | 0.0 | 23.8 | 50.2 | 86.6 | 205.9 | 310.9 | 358.1 | 347.2 | 250.0 | 0.0 | 151.1 |
| 15-19 years | 0.0 | 0.0 | 0.0 | 19.2 | 96.3 | 117.5 | 177.1 | 270.4 | 293.1 | 380.9 | 0.0 | 149.2 |
| More than 19 years | 0.0 | 0.0 | 0.0 | 200.0 | 95.6 | 126.2 | 231.4 | 284.5 | 284.8 | 333.3 | 400.0 | 242.5 |
| Unknown | 0.0 | 0.0 | 66.7 | 47.6 | 69.9 | 80.3 | 141.9 | 146.5 | 316.7 | 0.0 | 500.0 | 102.8 |
| TOTAL | 0.0 | 64.6 | 43.2 | 50.3 | 84.7 | 119.1 | 186.5 | 273.3 | 299.8 | 313.4 | 375.0 | 117.0 |

Generally, prevalence of critical cardiovascular pathology is found to increase with length of service up to 15 years for the high risk ages 40-55.

No other consistent patterns exist in age/length of service specific, age adjusted or total rates based on length of service only. Much clearer patterns of increase with age exist within several length of service categories and for total age specific rates, demonstrating the familiar pattern of disease increase with age.

E. Disease Incidence Before and After Second-Career Legislation

Disease incidence increased substantially for all but two major body system categories following the implementation of second-career legislation, as seen in Figure 8. Rates increased from 20 to 150 percent for all major body system categories except respiratory and muscle diseases. Neuropsychiatric diseases increased by 150 percent and cardiovascular diseases by 47 percent. Part of these increases are, no doubt, due to masking of significant history and symptoms prior to the second-career legislation in order to protect salary levels or employment. It seems doubtful, however, that psychiatric disorders could have been successfully masked to the extent reflected by the increase from before to after second-career legislation.

F. Disqualifications by Cause

In the approximately 5 years since enactment of second-career legislation, a total of 1,759 ATCS have been medically disqualified. Cause and ranking by importance are presented in Table 4 (3).

Table 4
MEDICAL CAUSE AND RANK FOR 1,759 MEDICAL DISQUALIFICATIONS AMONG AIR TRAFFIC CONTROL PERSONNEL 1972-1977

| Medical Cause | Frequency | Rank |
|---|---|---|
| Psychiatric/psychological | 912 | 1 |
| Cardiovascular | 269 | 2 |
| Defective hearing | 131 | 3 |
| Gastrointestinal disorders | 130 | 4 |
| Bone and joint disease | 36 | 5 |
| Diabetes mellitus | 29 | 6 |
| Defective vision | 26 | 7 |
| Pulmonary disease | 23 | 8 |
| Malignancy | 17 | 9 |
| All other causes | 186 | 10 |
| Total | 1,759 | |

Source: FAA Personnel Management Information System.

## IV. Summary.

The morbidity experience of 28,086 ATCS personnel has been examined for the time period 1967 to 1977. Significant findings and conclusions are as follows:

A. Hypertension and psychoneurotic disorders were the most frequently occurring new diseases among air traffic control personnel.

B. Although an ideal comparison group is not available, the morbidity experience of ATCS does not appear excessive when compared with the experience of other outside groups studied with the exception of psychoneurotic disorders, which is substantially higher among controllers. Additionally, a lack of association between disease occurrence and occupation is observed in the data correlating disease occurrence with length of service and age. While isolated trends found in these data are supportive of an occupation/disease relationship, they are neither impressive nor consistent, as would be expected if the association were a strong one.

C. Although anticipated empirically, one of the more interesting results of the study was quantification of the substantial differences found to exist in the incidence of disease before and after the second-career legislation. Substantial increases were seen for most all diseases after second-career legislation was implemented. While job and salary protection considerations obviously explain some of the difference, the importance of examination and screening techniques, which are not as dependent on reliable medical history, are emphasized in an environment in which a major motivation for the periodic health examination is the protection of individuals other than the examinee.

D. On the basis of incidence findings of this study, ancillary techniques designed to detect latent cardiovascular disease or predisposition are obviously indicated. Psychoneurotic disorders and ulcers also occur frequently, but no convenient mass-screening technique is available for detection. However, with the apparent increased incidence of psychoneurotic disorders among air traffic controllers, an agency effort to better understand etiology and the sensitivity and specificity of current procedures is clearly in order.

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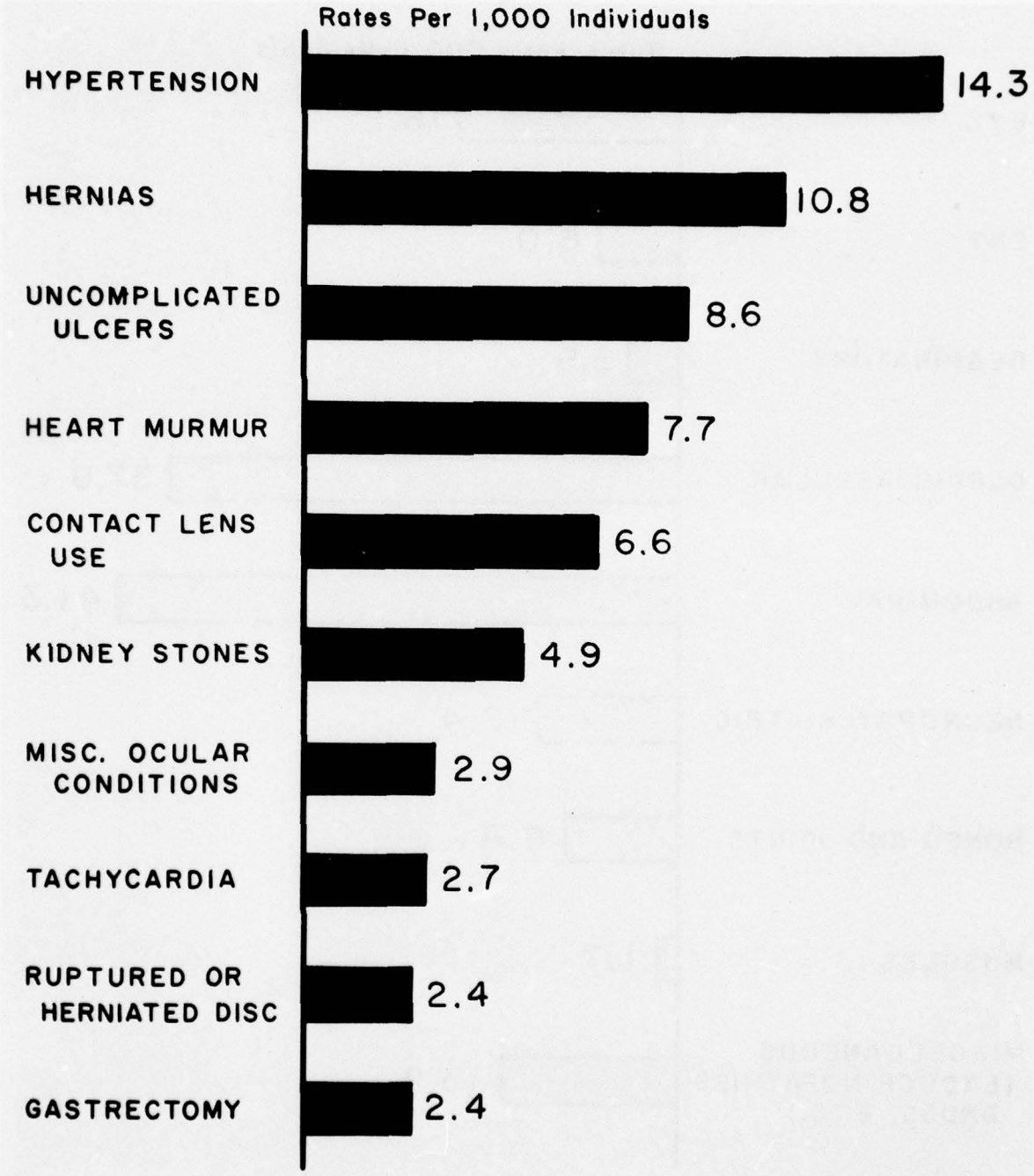


Figure 1. MOST FREQUENTLY OBSERVED PATHOLOGY AMONG ATCs AT ENTRY INTO STUDY

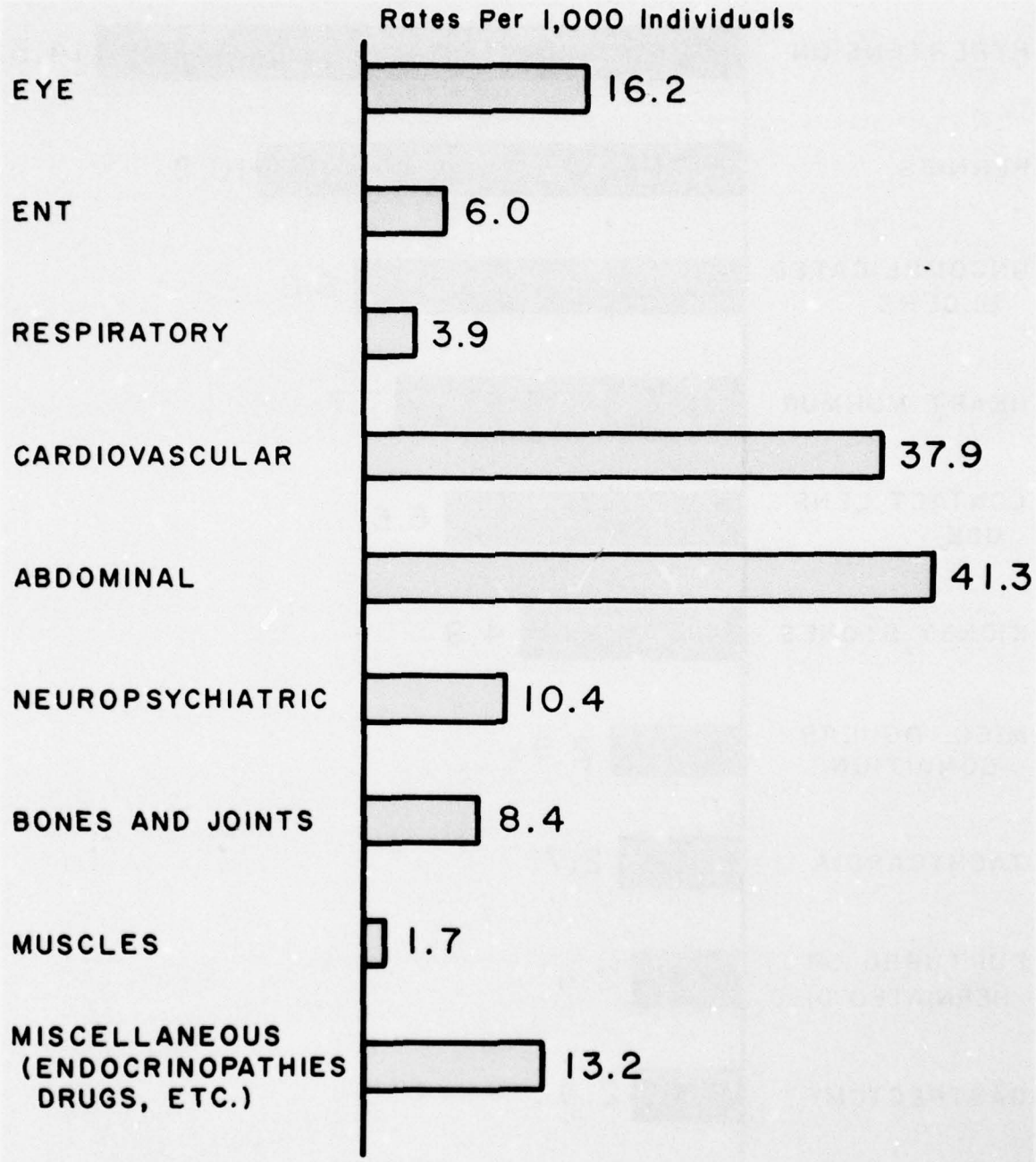


Figure 2. AGE ADJUSTED DISEASE PREVALENCE AMONG ATCs BY BODY SYSTEM

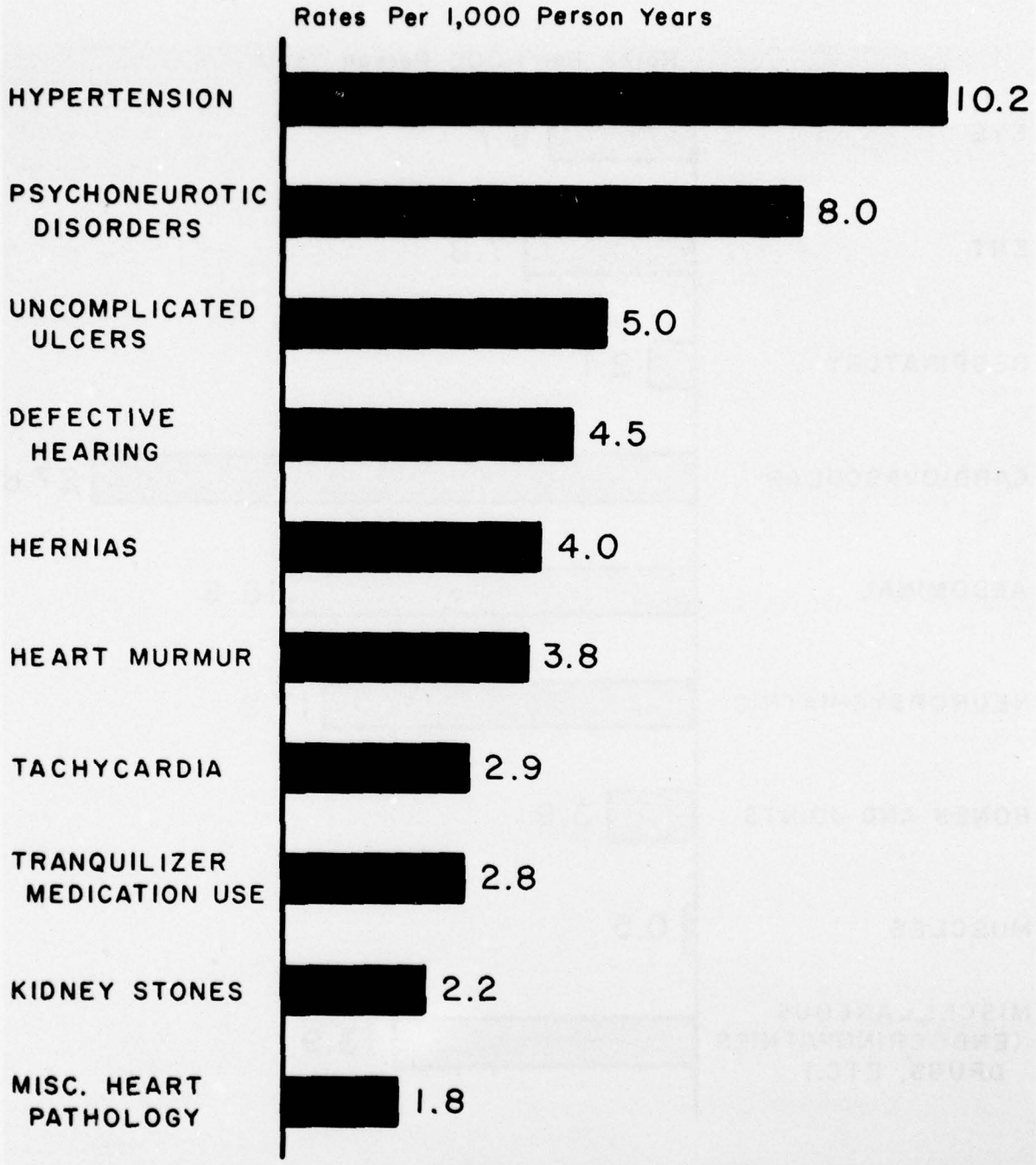


Figure 3. MOST FREQUENTLY OCCURRING NEW PATHOLOGY AMONG ATCs DURING STUDY PERIOD

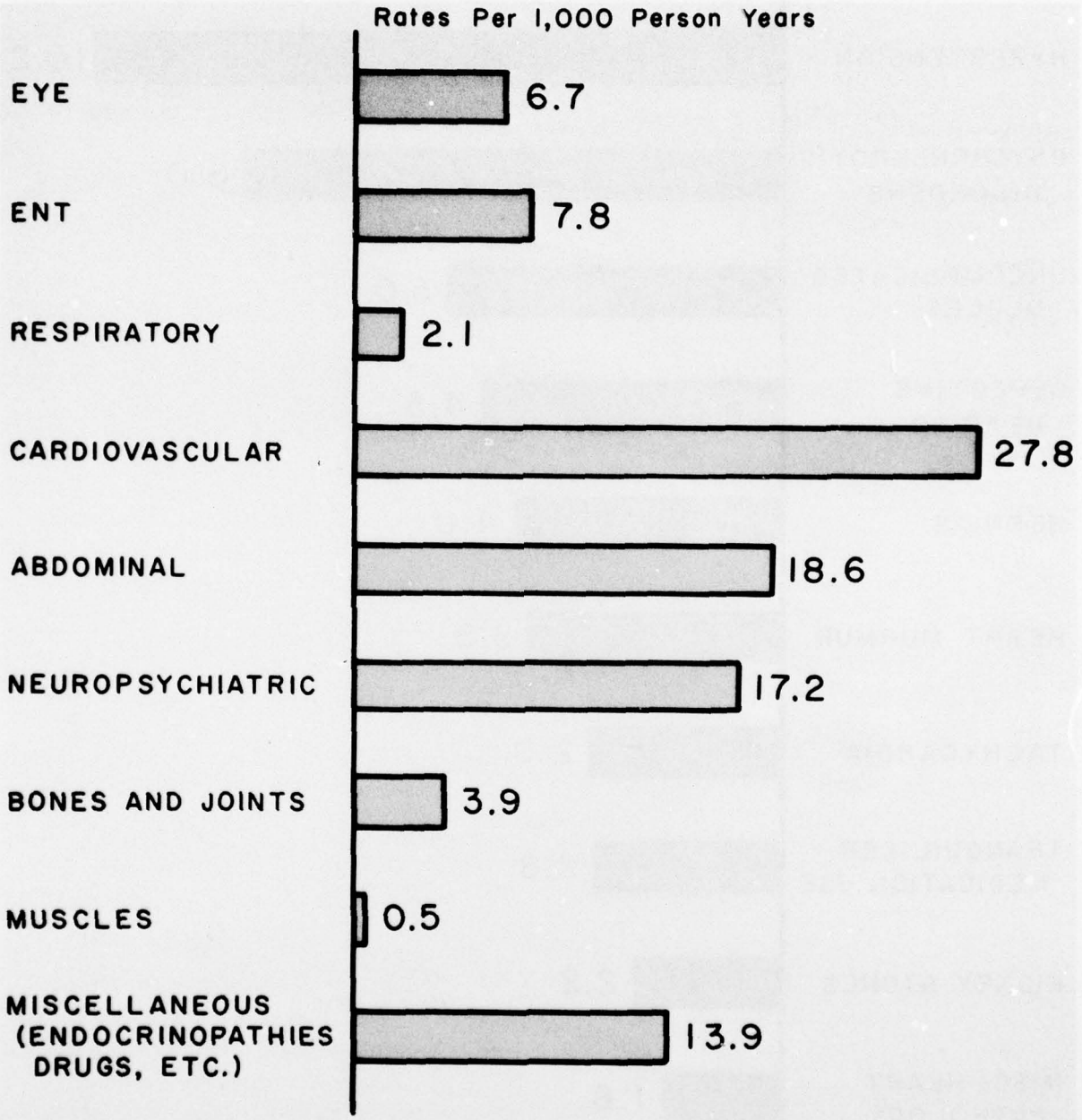


Figure 4. AGE ADJUSTED DISEASE INCIDENCE AMONG ATCs BY BODY SYSTEM

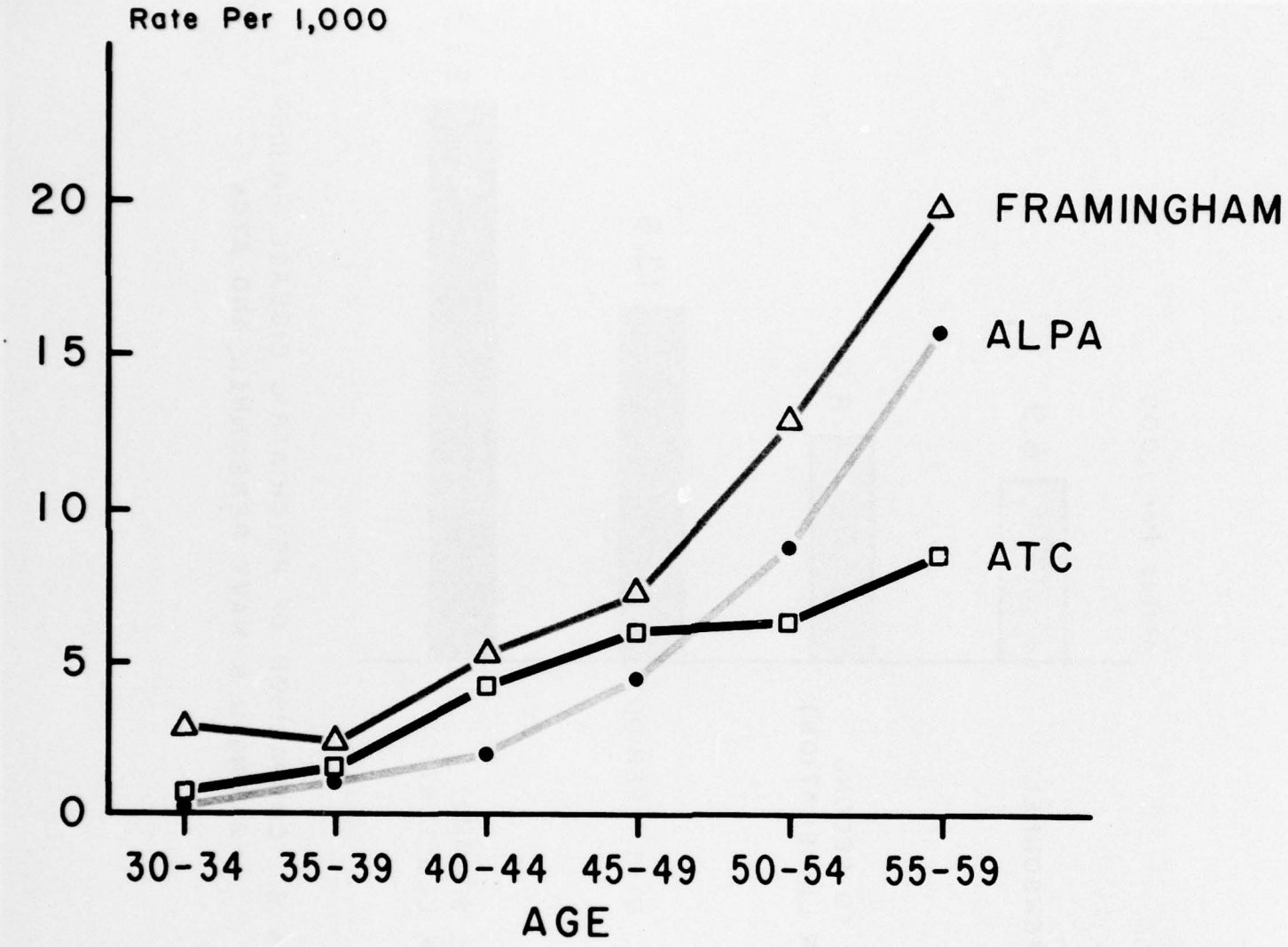


Figure 5. INCIDENCE OF CORONARY HEART DISEASE PER 1,000 MEN, — COMPARISON OF ATC, ALPA AND FRAMINGHAM DATA.

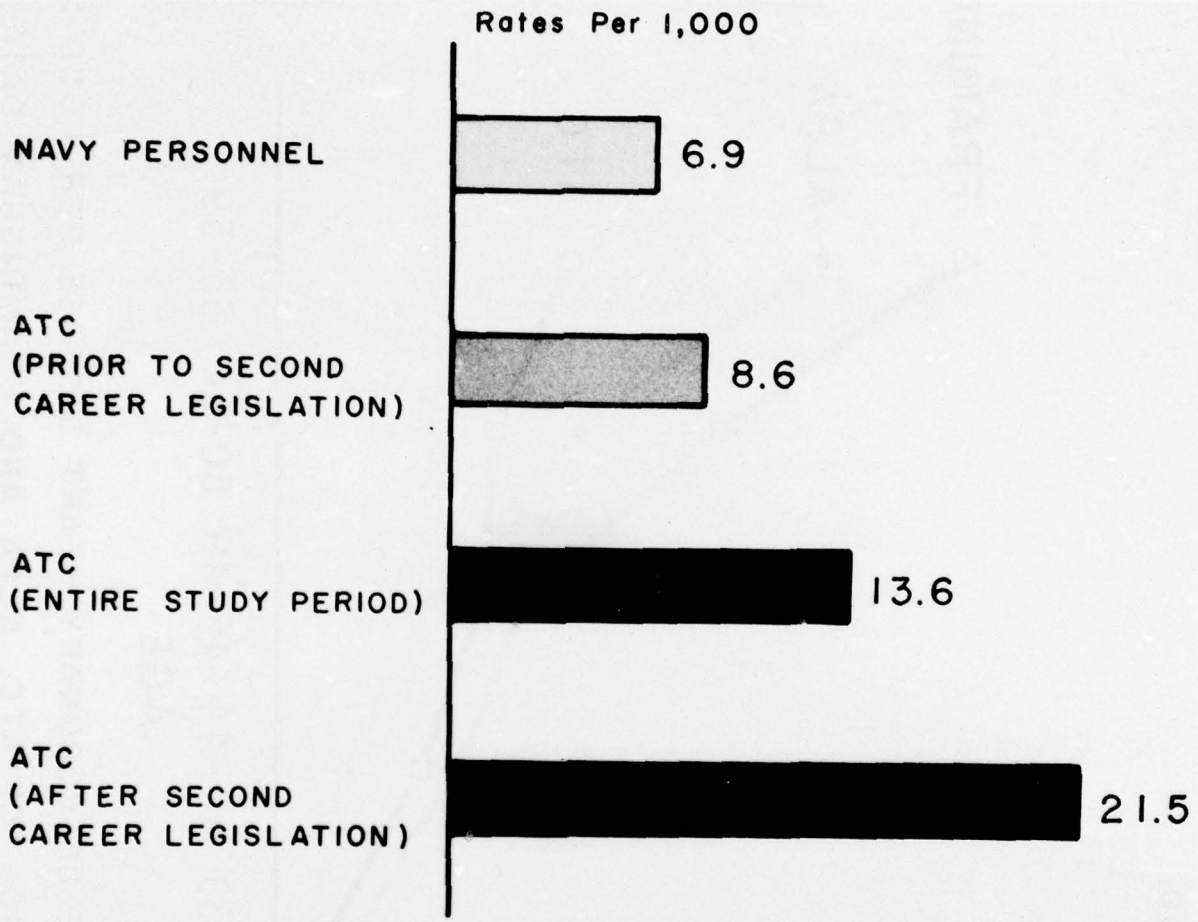


Figure 6. COMPARISON OF PSYCHIATRIC DISEASE INCIDENCE AMONG U. S. NAVY PERSONNEL AND ATCs

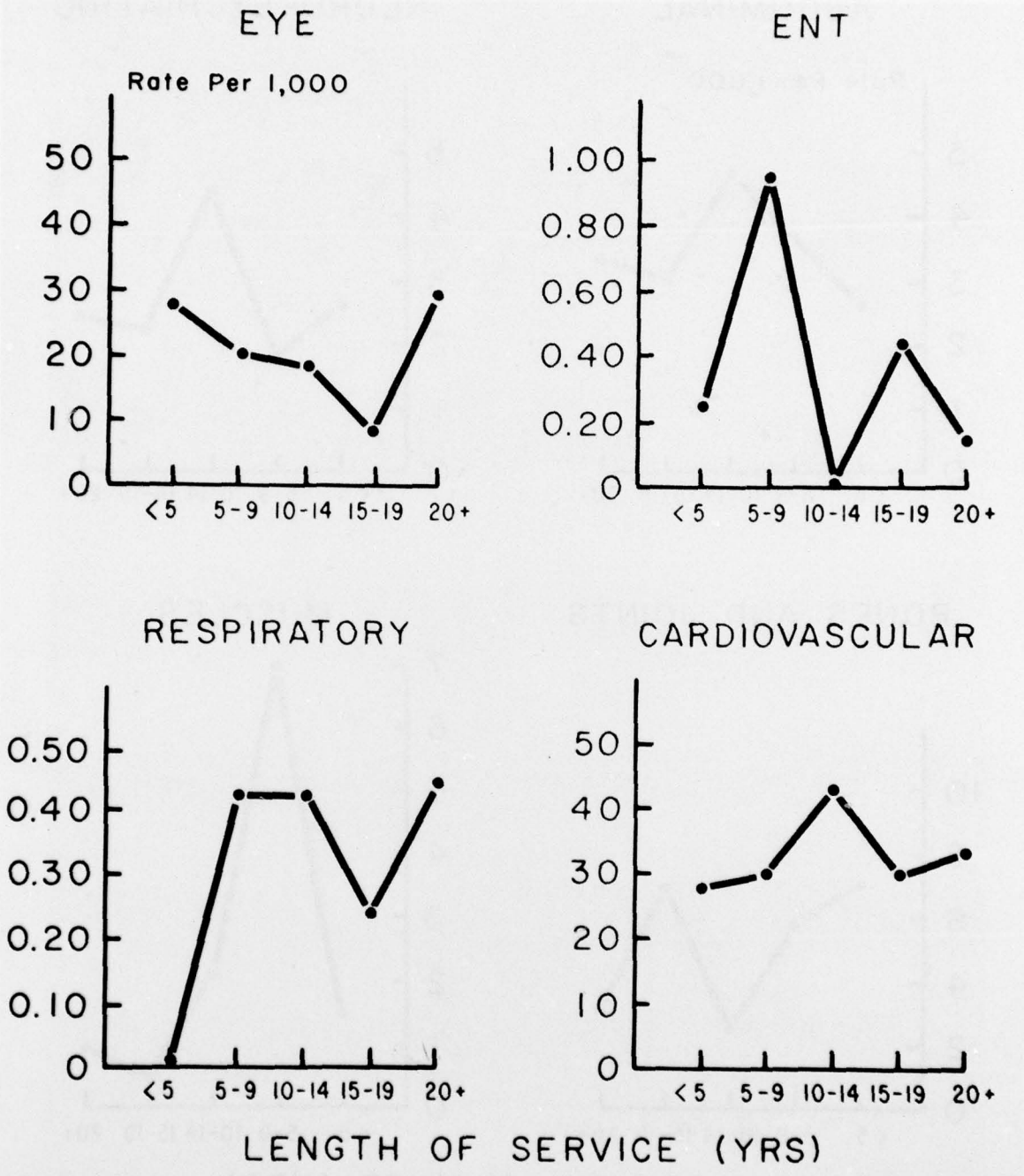


Figure 7. AGE ADJUSTED PREVALENCE OF CRITICAL PATHOLOGY BY LENGTH OF SERVICE – RATES PER 1,000

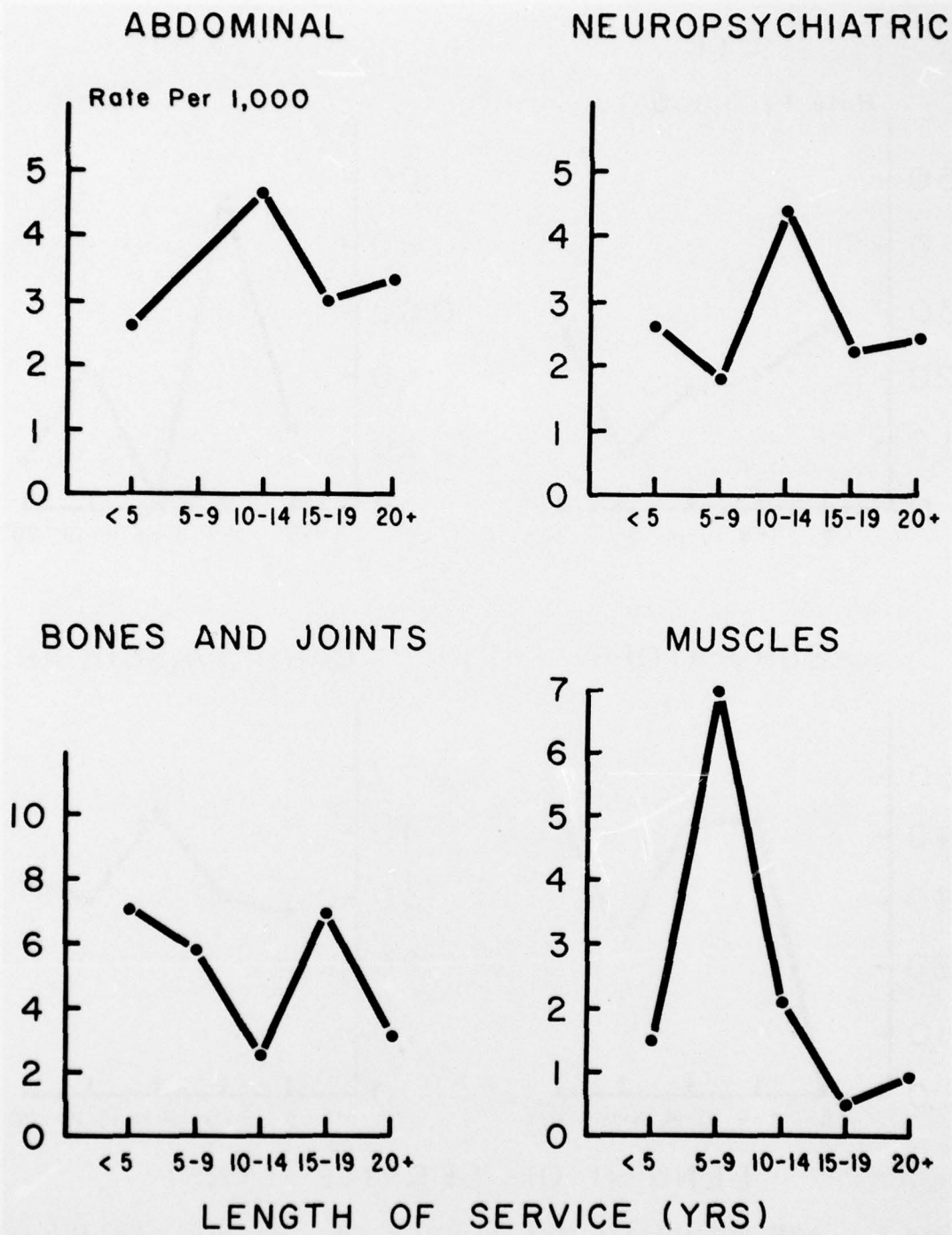


Figure 7. CONTINUED

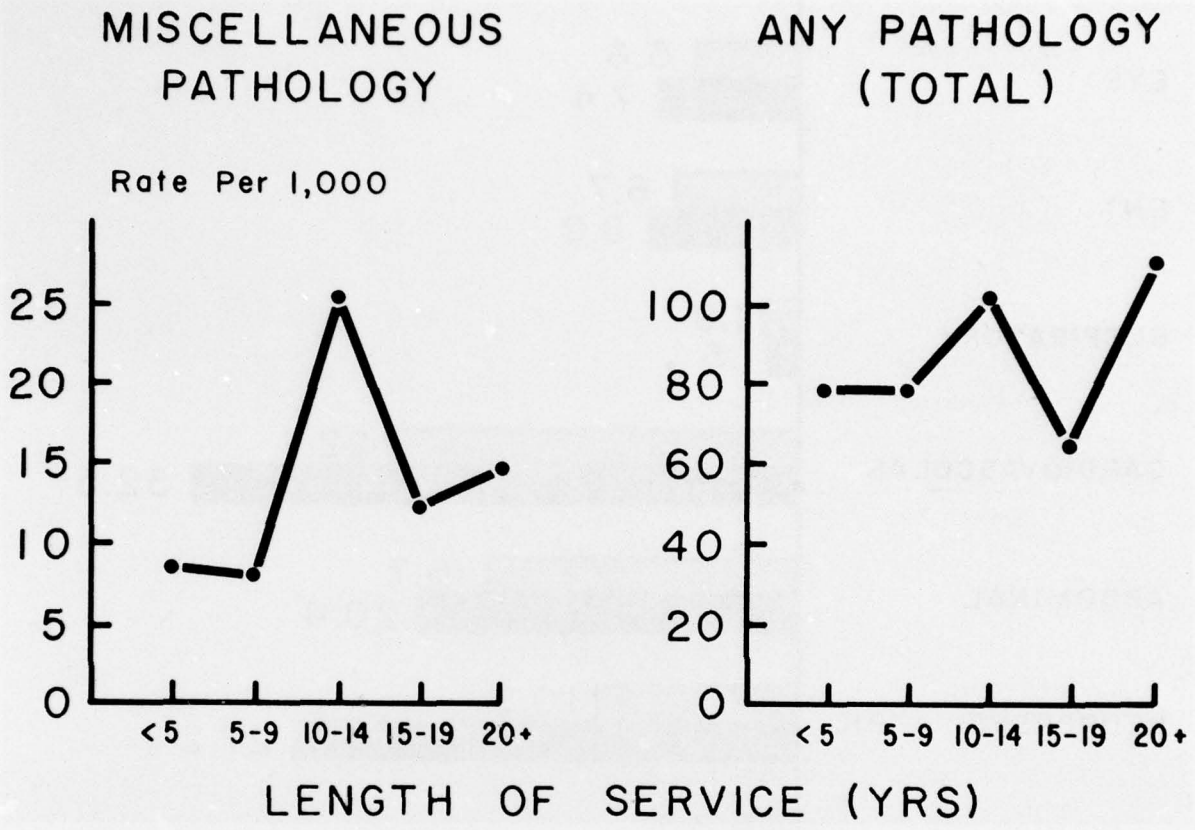


Figure 7. CONTINUED

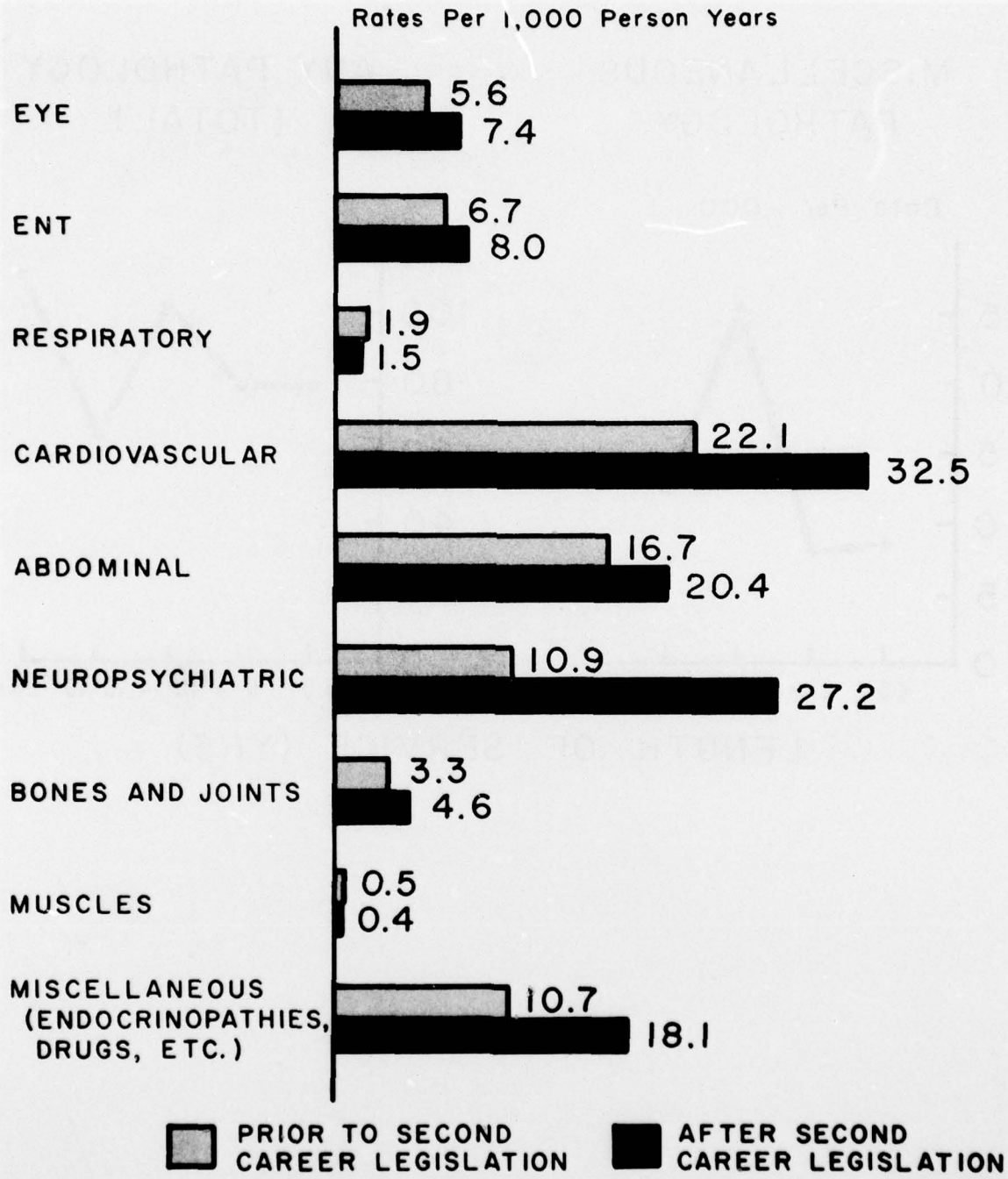


Figure 8. INCIDENCE OF DISEASE AMONG ATCs PRIOR TO AND AFTER SECOND CAREER LEGISLATION

Appendix A

PREVALENCE OF DISEASE AMONG ATCS BY AGE
AT ENTRY-RATES PER 1,000

| Body System And Group | Age At Entry <20 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | >64 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eye | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 12.5 | 10.9 | 8.0 | 5.2 | 6.0 | 15.4 | 14.3 | 5.4 | 0.0 | 1000.0 | 9.8 |
| Non-Critical Pathology | 0.0 | 6.3 | 3.1 | 7.5 | 4.3 | 8.5 | 8.9 | 14.3 | 5.4 | 0.0 | 0.0 | 6.0 |
| TOTAL | 0.0 | 18.8 | 14.0 | 15.4 | 9.6 | 14.6 | 24.2 | 28.5 | 10.8 | 0.0 | 1000.0 | 15.8 |
| Ears, Nose, Throat, and Mouth | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Non-Critical Pathology | 0.0 | 1.3 | 2.2 | 5.4 | 7.5 | 9.5 | 10.3 | 14.3 | 21.6 | 0.0 | 0.0 | 5.3 |
| TOTAL | 0.0 | 1.3 | 2.2 | 5.4 | 7.8 | 10.0 | 10.3 | 14.3 | 21.6 | 0.0 | 0.0 | 5.4 |
| Respiratory System | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Non-Critical Pathology | 0.0 | 1.8 | 1.1 | 2.7 | 4.9 | 5.0 | 10.3 | 4.7 | 21.6 | 55.5 | 0.0 | 3.5 |
| TOTAL | 0.0 | 1.8 | 1.1 | 2.7 | 4.9 | 5.5 | 10.3 | 4.7 | 21.6 | 55.5 | 0.0 | 3.5 |
| Cardiovascular System | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.8 | 0.8 | 3.2 | 11.3 | 20.6 | 36.4 | 59.4 | 70.3 | 55.5 | 0.0 | 9.8 |
| Non-Critical Pathology | 0.0 | 21.4 | 15.9 | 18.3 | 29.3 | 29.1 | 40.6 | 49.9 | 86.5 | 111.1 | 0.0 | 23.9 |
| TOTAL | 0.0 | 22.2 | 16.8 | 21.6 | 40.7 | 49.7 | 76.9 | 109.4 | 156.7 | 166.7 | 0.0 | 33.7 |
| Abdominal | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 1.0 | 0.7 | 1.2 | 2.6 | 5.5 | 4.2 | 4.7 | 5.4 | 55.5 | 0.0 | 2.0 |
| Non-Critical Pathology | 0.0 | 9.1 | 12.2 | 35.3 | 48.5 | 63.3 | 84.4 | 93.9 | 108.1 | 55.5 | 0.0 | 35.4 |
| TOTAL | 0.0 | 10.2 | 12.9 | 36.5 | 51.1 | 68.8 | 88.6 | 98.7 | 113.5 | 111.1 | 0.0 | 37.4 |

Continued
PREVALENCE OF DISEASE AMONG ATCS BY AGE
AT ENTRY-RATES PER 1,000

| Body System And Group | Age At Entry <20 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | >64 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neuropsychiatric | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.0 | 0.7 | 0.7 | 0.6 | 4.0 | 0.5 | 1.2 | 5.4 | 0.0 | 0.0 | 0.9 |
| Non-Critical Pathology | 0.0 | 3.6 | 5.2 | 8.5 | 12.5 | 16.1 | 13.1 | 19.0 | 16.2 | 0.0 | 0.0 | 8.7 |
| TOTAL | 0.0 | 3.6 | 5.9 | 9.2 | 13.1 | 20.1 | 13.5 | 20.2 | 21.6 | 0.0 | 0.0 | 9.6 |
| Bones and Joints | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 2.3 | 3.6 | 1.9 | 2.6 | 4.5 | 5.1 | 3.6 | 0.0 | 0.0 | 0.0 | 3.0 |
| Non-Critical Pathology | 0.0 | 1.8 | 1.8 | 4.9 | 6.1 | 7.5 | 8.9 | 9.5 | 32.4 | 55.5 | 0.0 | 4.7 |
| TOTAL | 0.0 | 4.2 | 5.4 | 6.8 | 8.7 | 12.0 | 14.0 | 13.1 | 32.4 | 55.5 | 0.0 | 7.7 |
| Muscles | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 1.0 | 0.4 | 1.3 | 0.0 | 0.5 | 0.9 | 0.0 | 21.6 | 0.0 | 0.0 | 0.9 |
| Non-Critical Pathology | 0.0 | 0.5 | 0.4 | 0.0 | 0.6 | 0.5 | 0.9 | 1.2 | 5.4 | 0.0 | 0.0 | 0.5 |
| TOTAL | 0.0 | 1.6 | 0.8 | 1.3 | 0.6 | 1.0 | 1.9 | 1.2 | 27.0 | 0.0 | 0.0 | 1.3 |
| Other Miscellaneous Conditions | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.3 | 0.6 | 1.7 | 4.1 | 8.5 | 13.5 | 9.5 | 16.2 | 0.0 | 0.0 | 3.4 |
| Non-Critical Pathology | 0.0 | 3.4 | 3.8 | 12.4 | 12.8 | 11.5 | 16.8 | 7.1 | 21.6 | 55.5 | 0.0 | 8.9 |
| TOTAL | 0.0 | 3.6 | 4.3 | 14.1 | 16.8 | 20.1 | 30.3 | 16.6 | 37.8 | 55.5 | 0.0 | 12.3 |
| SUMMARY GRAND TOTAL | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 18.0 | 17.8 | 18.0 | 26.7 | 50.7 | 76.0 | 92.7 | 124.3 | 111.1 | 1000.0 | 29.9 |
| Non-Critical Pathology | 0.0 | 49.3 | 45.8 | 95.1 | 126.7 | 151.2 | 194.0 | 214.0 | 318.9 | 333.3 | 0.0 | 96.9 |
| GRAND TOTAL | 0.0 | 67.4 | 63.5 | 113.1 | 153.4 | 201.9 | 270.0 | 306.8 | 443.2 | 444.4 | 1000.0 | 126.8 |

INCIDENCE OF DISEASE AMONG ATCS BY AGE
AT ENTRY-RATES PER 1,000

| Body System And Group | Age At Entry < 20 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | >64 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eye | | | | | | | | | | | | |
| Critical Pathology | 8.8 | 3.8 | 2.2 | 1.7 | 2.2 | 3.2 | 3.6 | 5.2 | 8.5 | 0.0 | 0.0 | 2.6 |
| Non-Critical Pathology | 0.0 | 2.0 | 2.7 | 3.7 | 3.7 | 5.7 | 4.9 | 8.7 | 8.5 | 0.0 | 0.0 | 3.7 |
| TOTAL | 8.8 | 5.8 | 4.9 | 5.5 | 5.9 | 8.9 | 8.5 | 13.9 | 17.0 | 0.0 | 0.0 | 6.3 |
| Ears, Nose, Throat and Mouth | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 1.7 | 0.0 | 0.0 | 0.0 |
| Non-Critical Pathology | 0.0 | 2.1 | 3.6 | 5.1 | 7.3 | 14.2 | 16.6 | 24.0 | 20.4 | 22.2 | 0.0 | 7.1 |
| TOTAL | 0.0 | 2.1 | 3.6 | 5.2 | 7.3 | 14.3 | 16.6 | 24.6 | 22.1 | 22.2 | 0.0 | 7.2 |
| Respiratory System | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.8 | 0.0 | 0.0 | 0.0 | 0.1 |
| Non-Critical Pathology | 0.0 | 0.9 | 0.8 | 1.4 | 1.6 | 2.6 | 3.5 | 4.4 | 17.0 | 0.0 | 0.0 | 1.7 |
| TOTAL | 0.0 | 0.9 | 0.8 | 1.5 | 1.7 | 2.7 | 3.7 | 5.2 | 17.0 | 0.0 | 0.0 | 1.7 |
| Cardiovascular System | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 1.6 | 2.2 | 5.4 | 8.9 | 15.8 | 22.1 | 24.8 | 23.8 | 66.7 | 0.0 | 7.8 |
| Non-Critical Pathology | 17.7 | 12.5 | 12.9 | 13.8 | 19.9 | 27.7 | 33.2 | 41.2 | 47.5 | 66.7 | 0.0 | 18.3 |
| TOTAL | 17.7 | 14.1 | 15.1 | 19.3 | 28.9 | 43.6 | 55.3 | 66.1 | 71.3 | 133.3 | 0.0 | 26.1 |
| Abdominal | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.3 | 0.3 | 0.7 | 0.9 | 1.1 | 1.2 | 1.9 | 1.7 | 0.0 | 0.0 | 0.7 |
| Non-Critical Pathology | 0.0 | 10.5 | 12.9 | 18.4 | 17.6 | 22.2 | 26.9 | 27.3 | 42.4 | 22.2 | 0.0 | 17.4 |
| TOTAL | 0.0 | 10.8 | 13.2 | 19.0 | 18.5 | 23.4 | 28.1 | 29.2 | 41.4 | 22.2 | 0.0 | 18.1 |

Continued
INCIDENCE OF DISEASE AMONG ATCS BY AGE
AT ENTRY-RATES PER 1,000

| Body System And Group | Age At Entry <20 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | >64 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neuropsychiatric | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.3 | 0.4 | 0.4 | 0.7 | 0.5 | 1.1 | 1.1 | 1.7 | 0.0 | 0.0 | 0.5 |
| Non-Critical Pathology | 0.0 | 11.1 | 12.6 | 17.1 | 18.3 | 24.1 | 24.1 | 16.4 | 17.0 | 22.2 | 0.0 | 16.7 |
| TOTAL | 0.0 | 11.4 | 13.0 | 17.4 | 19.0 | 24.6 | 25.2 | 17.5 | 18.7 | 22.2 | 0.0 | 17.2 |
| Bones and Joints | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.3 | 0.3 | 0.5 | 0.9 | 1.1 | 1.0 | 1.6 | 1.7 | 0.0 | 0.0 | 0.7 |
| Non-Critical Pathology | 0.0 | 1.6 | 2.0 | 2.7 | 3.3 | 5.5 | 6.5 | 3.5 | 8.5 | 0.0 | 0.0 | 3.1 |
| TOTAL | 0.0 | 2.0 | 2.3 | 3.2 | 4.2 | 6.7 | 7.5 | 5.2 | 10.2 | 0.0 | 0.0 | 3.8 |
| Muscles | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.3 | 0.1 | 0.1 | 0.1 | 0.3 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| Non-Critical Pathology | 0.0 | 0.1 | 0.2 | 0.2 | 0.3 | 0.1 | 0.8 | 0.0 | 3.4 | 0.0 | 0.0 | 0.3 |
| TOTAL | 0.0 | 0.4 | 0.3 | 0.4 | 0.5 | 0.4 | 1.3 | 0.0 | 3.4 | 0.0 | 0.0 | 0.5 |
| Other Miscellaneous Conditions | | | | | | | | | | | | |
| Critical Pathology | 0.0 | 0.6 | 1.4 | 2.6 | 3.3 | 6.8 | 7.7 | 9.3 | 8.5 | 22.2 | 0.0 | 3.2 |
| Non-Critical Pathology | 0.0 | | 5.9 | 6.0 | 10.4 | 15.9 | 20.1 | 16.4 | 13.6 | 0.0 | 1000.0 | 10.4 |
| TOTAL | 0.0 | 6.5 | 7.4 | 12.9 | 13.9 | 22.7 | 27.8 | 25.7 | 22.1 | 22.2 | 1000.0 | 13.6 |
| SUMMARY GRAND TOTAL | | | | | | | | | | | | |
| Critical Pathology | 8.8 | 7.2 | 7.0 | 11.6 | 17.1 | 29.3 | 37.4 | 45.3 | 47.5 | 88.9 | 0.0 | 15.8 |
| Non-Critical Pathology | 17.7 | 46.7 | 53.7 | 73.0 | 82.7 | 118.1 | 136.6 | 142.0 | 178.3 | 133.3 | 1000.0 | 78.7 |
| GRAND TOTAL | 26.5 | 53.9 | 60.7 | 84.5 | 99.8 | 147.4 | 174.0 | 187.3 | 225.8 | 222.2 | 1000.0 | 94.6 |

## Appendix B
## CRITICAL MEDICAL CONDITIONS

- Eye
  - Diplopia with 35° (homonymous, vertical heteronymous)
  - Aphakia (absence of the lens)
  - Cataract (opacity of lens)
  - Glaucoma
  - Fails color signal test
  - Wears contact lenses
  - Blindness or absence of either eye (light perception only)
- Ear, Nose, Throat & Mouth
  - Mute
  - Deaf Mute
- Cardiovascular
  - Myocardial infarction (heart attack, coronary occlusion or thrombosis)
  - Coronary artery disease--heart disease, includes angina pectoris
  - Special heart pathology
  - Fibrillation (auricular)
  - Hypertension with heart pathology
  - Hypertension with medication
- Abdominal
  - Complicated ulcer--bleeding, perforation, obstruction, severe pain
- Neuropsychiatric
  - Brain
    - Vascular--thrombosis, occlusion, stroke, embolism, aneurysm, spasm, hematoma, sub-dural or epidural hemorrhage, CVA etc.
    - Convulsive Reactions--epilepsy, grand mal, petit mal
    - Degenerative--atrophy, multiple sclerosis, chronic brain disease
  - Spinal Cord
    - Degenerative--tabes, disseminated sclerosis, ascending paralysis, amyotrophic lateral sclerosis, etc.
    - Psychotic Disorders (Not Attributed to Physical Condition)
      - Schizophrenia
      - Major Affective Disorders
      - Paranoid States
      - Other Psychoses
    - Personality Disorders and Certain Other Non-Psychotic Mental Disorders
      - A personality disorder that is severe enough to have repeatedly manifested itself by overt acts.
      - Chronic Alcoholism
      - Drug Addiction
    - Mental Deficiences
      - Mental Deficiency--congenital or acquired
- Miscellaneous Conditions
  - Diabetes, controlled by diet
  - Diabetes, controlled by insulin
  - Diabetes, controlled by hypoglycemic drugs (other than insulin)
  - Collagenous Diseases
- Neoplasm
- Deformed by Amputation
- Deformed by Limitation of Motion