Recent Trends of Pneumonia Morbidity in US Naval Personnel

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Currently, respiratory diseases account for 25-30 per cent of the total infectious and parasitic disease admissions among active duty Navy and Marine Corps (henceforth naval) personnel. Among these admissions, the greatest medical cause of lost workdays is pneumonia, due both to its frequency of diagnosis and to the relatively long hospitalization period associated with this disease.

Because of the diversity of pathogens associated with the pneumonia syndrome, pertinent epidemiological information is difficult to extract from clinical observation or health surveys, except in the most general sense. A closed system of health care, such as that provided by the Navy, offers an opportunity to evaluate the significance of this disease in terms of its epidemiology, and to identify new areas for research which will further our understanding of factors contributing to patterns of pneumonia occurrence.

The data available for study were hospital admission records of active duty naval personnel with primary diagnoses of pneumonia. By calculating and comparing specific admission rates for pneumonia, we identified high risk groups within the population and the temporal trends associated with morbidity.

Methods

The admission records included all active duty Navy and Marine Corps patients for whom inpatient care was carried to completion at a naval medical treatment facility, or who were discharged from the facility without intent of transfer for continued inpatient care at another Armed Forces facility. Pneumonia admissions were categorized according to the *Eighth Revision International Classification of Diseases Adapted for Use in the United States* (ICDA-8).

The period of study for age, race, and sex adjusted admission rates was 1974-1978, and 1970-1979 for unadjusted rates. The data base for this project was established from information retrievals done with the computer system files of the NMDSC. Admission records were retrieved for specific diagnoses along with the selected variables of race, sex, age at admission, and branch of Service. Overall annual admissions rates by disease category, and selected age, race, and sex specific rates were computed. When appropriate, admission rates were ad-

justed to compensate for differences in age, race, or sex distributions in comparison groups. Rate adjustments were accomplished by means of a standardized rates computation computer program developed by NMDSC. Denominator values for calculation of rates were based on annual average personnel strengths. Comparisons were made between selected disease categories and among demographic subgroups.

Diagnostic categories were grouped into two broad classes, based on whether or not specific etiology was recorded in the diagnosis. The "specific pneumonia" class included the ICDA-8 categories† *pneumococcal pneumonia, other specified bacterial pneumonia,* and *pneumonia due to other specified organisms,* because diagnoses falling into these categories must have included some reference to a specific pathogen. Although a specific diagnosis may exist in hospital medical records, this information is sometimes "lost" in the coding process when all of the available information is not passed on in the recording system. For example, although *Klebsiella* may have been isolated from a pneumonia patient, only the preliminary diagnosis of "bacterial pneumonia" may find its way to the coder's desk. The result is an entry into the *bacterial pneumonia not otherwise specified* category and a loss of specific etiologic information. "Non-specific pneumonias" included the ICDA-8 categories *viral pneumonia, bacterial pneumonia not otherwise specified, acute interstitial pneumonia, unspecified bronchopneumonia,* and *unspecified pneumonia.* In these categories, the specific etiology was either unrecorded or, if recorded, the ICDA-8 classification scheme did not permit its separate classification. These groupings enabled us to make comparisons of changing diagnostic specificity over time.

Results

Demographic Comparisons

Adjusted total pneumonia admission rates by sex, race, and age are presented in Table I. When the overall adjusted pneumonia admission rate for whites was compared with that for blacks, whites had 20 per cent more admissions than blacks (whites/blacks = $318.2/264.3$ = 1.20; $P < .0001$). Further breakdowns showed that this difference was principally due to the higher admission rates of whites for *unspecified pneumonia* and *viral pneumonia,* being admitted 32 per cent and 77 per cent more often, respectively. Although overall adjusted admission rates for females were higher than for males, this trend was not consistent from year to year. Admission rates for

† ICDA-8 categories are italicized and are not to be confused with the authors' classification scheme allocating these categories into broader groups of either "specific pneumonias* or "non-specific pneumonias."

TABLE I

AVERAGE ANNUAL ADMISSION RATES FOR ALL TYPES OF PNEUMONIA, BY AGE, RACE, AND SEX, ACTIVE-DUTY NAVY AND MARINE CORPS
PERSONNEL. 1974-1978 (RATES PER 100,000 AVERAGE STRENGTH)*

Age, Race, Sex Category	Navy and Marine Corps			Navy			Marine Corps		
	Total	Officer	Enlisted	Total	Officer	Enlisted	Total	Officer	Enlisted
All Personnel[1]	307.6	210.4	311.9	322.0	227.0	326.8	277.5	152.7	281.3
Sex									
male[2]	306.0	185.0	311.1	318.4	196.2	324.2	280.7	149.3	284.7
female[2]	349.6	694.7	323.7	402.5	738.8	374.5	100.7	246.2	95.4
Race									
white[3]	318.2	216.1	323.2	333.7	233.4	339.2	283.2	155.1	287.7
black[3]	264.3	141.0	265.4	271.3	131.0	272.9	257.0	159.3	257.6
Age									
17-19	922.5	—[4]	922.5	974.7	—[4]	974.7	834.5	—	834.5
20-24	208.8	103.1	213.3	218.1	114.8	222.6	186.3	70.6	190.7
25-29	116.5	72.0	128.1	122.2	71.6	135.0	95.3	73.1	102.0
30-34	94.5	100.2	92.9	98.0	110.5	94.8	74.5	60.0	80.6
35-39	80.7	64.2	85.6	86.5	74.3	89.8	50.3	27.2	60.5
40-44	60.7	41.4	75.5	64.0	42.6	79.4	46.4	37.1	55.8
45-49	63.7	72.0	52.7	69.2	82.6	51.5	38.2	22.6	58.4
50-54	112.0	83.4	148.2	99.2	78.0	126.7	182.6	115.5	257.4
55 and over	146.4	139.5	154.1	158.9	156.6	161.3	—	—	—

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[1] Adjusted for age, race, sex using the indirect method with the total Navy/Marine Corps Rates as the standard

[2] Adjusted for age and race using the indirect method with the total Navy/Marine Corps Rates as the standard

[3] Adjusted for age and sex using the indirect method with the total Navy/Marine Corps Rates as standard

[4] Too few cases for a meaningful rate

enlisted personnel were found to be 48 per cent higher than for officers (P < .0001). Admissions due to *unspecified pneumonias* showed the greatest consistent differences between officers and enlisted personnel when data were grouped by specific ICDA-8 categories, with enlisted personnel averaging twice the admission rate of officers in this category. Although Navy personnel were found to have 16 per cent more overall pneumonia admissions than Marine Corps personnel and differences in rates were statistically significant (P < .0001), comparisons of rates for single years varied widely when analyzed for individual diagnostic categories by branch of Service.

Recruits vs Non-Recruits

Admission rates for the 17-19 year old age groups were found to be far higher than other age groups (Table I). Because of the likelihood that a large proportion of the admissions in this age group were associated with recruit training, we analyzed recruit admission data separately. Specific rates for recruits showed that, although recruits represent less than five per cent of naval personnel, they accounted for almost 65 per cent of the pneumonia admissions during the period studied.

We compared the Navy and Marine Corps recruit populations with the non-recruit naval population under 25 years of age. As seen in Table II, annual recruit admission rates varied from 20.2 to 157.5 per 1,000 during the period 1970-1979 while non-recruits, aged 24 and under,‡

‡ Age 24 was chosen as the cutoff for the non-recruit comparison group, because the small number of non-recruits aged 19 and under does not allow meaningful comparisons.

ranged from 1.2 to 3.7 per 1,000 over the same period. The ratio of recruit to non-recruit admissions among these groups varied from 14.5 to a remarkable 62.0. This indicates that, in equal size populations of naval recruit and non-recruit personnel of approximately the same age, recruits have an average of more than 29 times the admissions found in non-recruits. Comparing Navy recruits to Marine Corps recruits, annual admission rates for pneumonia were consistently higher for Navy compared with Marine personnel. The high rates of pneumonia admissions for recruits undoubtedly had an influence on the relatively higher rates seen for enlisted personnel as a whole compared with officers.

Specificity off Pneumonia Reporting

The relative contributions of each diagnostic category by number and per cent of total pneumonia admissions are presented in Table III. For the period studied, the *unspecified pneumonia* category was responsible for the largest number of pneumonia admissions (61.5 per cent), followed by *pneumococcal pneumonia* (19.7 per cent), and *viral pneumonia* (10.3 per cent).

Of special interest in this study were those major diagnostic categories of pneumonia for which the specific etiologic organism was either unknown or unrecorded (non-specific pneumonias). These categories accounted for 75.8 per cent of the total pneumonia admissions for the period 1970-79, and are compared with the admission rates for pneumonia of known and recorded etiology (specific pneumonias) in Fig. 1. Per cent contributions for these two classes, by year, are shown in Fig. 2.

During the period 1970-1973, there was an overall

trend of increasing pneumonia admission rates in naval personnel (Fig. 1). This upward trend was most consistent for "non-specific pneumonias." Rates during this period for "specific pneumonias" are somewhat erratic from year to year, but appear to be two to three times higher than rates for later years. Although admission rates were high for all pneumonias during this period, the difference between admission rates for these two broad classes of pneumonia widened until 1974, when the difference became greatest. This trend can easily be seen by analyzing the per cent contributions, by year, of pneumonia admission classes (Fig. 2). "Specific pneumonia" admissions declined from 37 per cent of the total pneumonia admissions in 1970 to just over 15 per cent in 1974. Conversely, 'non-specific* admissions rose from 63 per cent in 1970 to 85 per cent of the total pneumonia admissions in 1974. Since 1974, the proportionate contributions of these major diagnostic classes to the overall pneumonia admission rate has remained relatively stable, with a slight tendency toward increased specificity in pneumonia reporting (Fig. 2). Whether this is a result of changing patterns of disease or changing patterns of pneumonia diagnosis and reporting cannot be known, without more detailed information on the etiology of pneumonia admissions as they occur.

Discussion

Demographic Comparisons

When pneumonia admission data were analyzed by demographic subgroups, adjusted admission rates were found to be higher for whites than blacks, higher for females than males, higher for enlisted than officers, and higher for Navy than Marine Corps personnel. Previous research has shown the same relationships to exist for hospital admissions of naval personnel due to enteric diseases.[a] These differences may reflect unnecessary health risks associated with certain population subgroups. They could be attributable to differing socio-environmental experiences of these groups prior to their entry into the military, conferring some population subgroups with increased immunity to many pneumonia pathogens because of greater prior exposure. Other explanations are that differences in admission rates may be occupationally related or associated with the relative ease with which one can have access to health care facilities. The variability in admission criteria associated with command size and function, or an individual's rank or occupational status, could have had a significant effect on whether a given pneumonia case is treated as an admission or an outpatient; e.g., since these data represent only admissions, rate differences such as those seen between officers and enlisted personnel may be the result of differing admission criteria for these two groups.

Recruit vs Non-Recruit

The dramatic excess of pneumonia admissions in naval recruits leaves little doubt that pneumonia is still a signif-

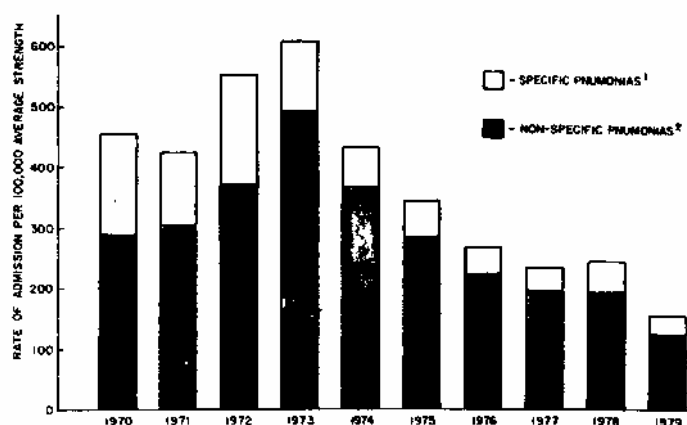[a] Based on average admission rates 1970-1979.

Fig. 1. Annual admission rates for pneumonia in active duty Navy and Marine Corps personnel by reported specificity of etiology, 1970-1979. (1) Includes the ICDA-8 diagnostic categories *poeumococcal pneumonia, other specified bacterial pneumonia,* and *pneumonia due to other specified organisms.* (2) Includes the ICDA-8 diagnostic categories *viral pneumonia, bacterial pneumonia not otherwise specified, acute interstitial pneumonia, unspecificed bronchopneumonia,* and *unspecified pneumonia.*
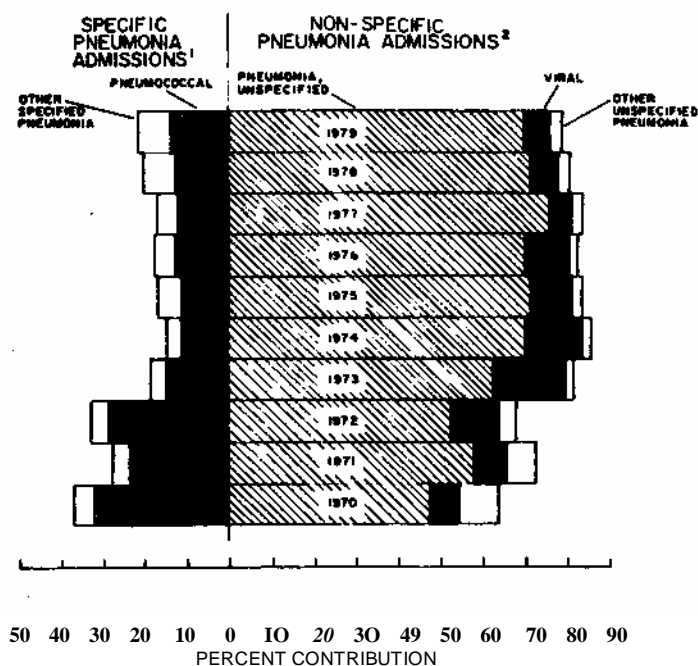

Fig. 2. Relative per cent contributions for selected pneumonia admission categories, 1970-1979. (1) Includes the ICDA-8 diagnostic categories *pneumococcal pneumonia, other specified bacterial pneumonia,* and *pneumonia due to other specified organisms.* (2) Includes the ICDA-8 diagnostic categories *viral pneumonia, bacterial pneumonia not otherwise specified, acute interstitial pneumonia, unspecified bronchopneumonia,* and *unspecified pneumonia.*

icant cause of lost manpower, and that this disease contributes to the financial and manpower burden of the military health care system. We estimate that, if the pneumonia admission rate for naval recruits were brought down to the level of that seen in non-recruits of approximately the same age, more than 14,500 lost work-days could be eliminated annually,[a] saving about 2.7 million dollars per year in hospital care costs alone.[b] Since non-

[b] Based on a cost of $255.00 per bed day.

recruit admission rates now approximate those found in a comparable US civilian population, this is a reasonable and attainable goal.

Pneumonia and the Adenovirus Vaccine

Extensive studies at the Great Lakes Naval Training Center, the Naval Training Center at San Diego, and the Marine Corps Recruit Depot at San Diego established adenovirus as one of the predominant pathogens causing acute respiratory disease among recruits.[2] This led to the routine prophylactic administration of adenovirus vaccine for all Navy and Marine Corps recruits since 1974. Although an association of adenovirus with adult pneumonia incidence has been reported,[3-5] the assumption of cause and effect has not been confirmed.[6] If adenovirus is causally associated with pneumonia, either directly or in a helper role, the apparent decrease in pneumonia since a peak in 1973 (Fig. 1) may be a result of the use of the adenovirus vaccine.[7]

Data in this study provide additional evidence of the association between administration of adenovirus vaccine and reduced pneumonia incidence. In 1974, the first year of administration of the adenovirus vaccine, the pneumonia admission rate per 1,000 average strength among Navy and Marine Corps recruits fell to 69.9 from the rate of 124.1 in the previous year (Table II). The rate continued to decline each subsequent year to a rate of 20.2 per 1,000 average strength in 1979. For active-duty Navy and Marine Corps personnel under the age of 25 who were not recruits, the pneumonia admission rate also declined substantially from 2.0 per 1,000 average strength in 1973 to 1.2 in 1979.

These data suggest the need for further study to determine if in fact there is a cause and effect relationship between the administration of adenovirus vaccine and a reduced incidence rate of pneumonia and, if so, renewed attention should be given to the study of other viruses known to be associated with acute respiratory disease, but that have not been strongly linked to pneumonia.

Specificity of Pneumonia Reporting

Hospital admission records of active duty naval personnel could provide epidemiologists with the clues necessary to untangle the complicated network of organism, host, and environmental factors which result in the broad disease category of pneumonia. With a closed system of health care, computerized record keeping and detailed personal histories for each individual, the only necessary factor missing from the medical records used in these analyses is an accurate, unbiased, and comprehensive system of disease classification. This position is supported by the results of our current study of active duty naval personnel, which shows that, in 61.5 per cent of all pneumonia admissions (1970-1979), there was no computer record of specific pathogen or any other characterization of the disease which would allow meaningful risk analysis. An additional 14.3 per cent of the admission diagnoses reported offered little more information than whether the pneumonia was interstitial or bronchial, or whether the predominant pathogen was bacterial or viraL

TABLE II

ADMISSION RATES FOR PNEUMONIA IN ACTIVE DUTY NAVY AND MARINE CORPS PERSONNEL, 1971-1979 (ANNUAL RATES PER 1,000 AVERAGE STRENGTH)

Year	Marine Corps Recruits	Navy Recruits	Total Recruits	Non-Recruits <25 years of age	Ratio of Total Recruits/Non-Recruits
1970	45.4	59.5	53.5	3.7	14.4
1971	70.5	60.0	66.0	2.4	27.5
1972	54.6	110.3	85.9	2.1	40.9
1973	86.7	157.5	124.1	2.0	62.0
1974	67.1	71.8	69.9	1.6	43.7
1975	48.1	55.8	52.4	1.6	32.8
1976	39.4	39.5	39.4	1.4	28.1
1977	13.5	49.4	35.5	1.3	27.3
1978	13.2	45.3	34.7	1.5	23.1
1979	9.4	26.5	20.2	1.2	16.8
Average	47.6	66.5	58.8	2.0	29.4

Our ability to retrospectively analyze admission data, for factors which may have influenced the occurrence of disease in certain subpopulations of naval personnel, is severely limited by this lack of specificity in the recorded diagnoses.

Many of the ICDA-8 classification difficulties are caused by the complex etiologic nature of the pneumonia syndrome. Although our ability to identify specific pathogens of pneumonia has increased dramatically in recent years, classification systems are slow to reflect improved technology. This, in a large part, is due to the differing needs of medical practitioners who provide the data, and medical researchers who compile and analyze the data. Because the clinician has little need for medical records beyond the patient level of recording, a more concise and comprehensive system of reporting would only add additional burdens on the physician's and staff's time. Infectious disease investigators, on the other hand, have a need for information that provides meaningful insight into disease occurrence and causation. They are, however, often insensitive to the time and manpower required to support such a system at the information management level.

Beginning in 1980, a new diagnostic classification system (ICD-9) was adopted by the Armed Forces and is currently being used by the NMDSC for gathering medical statistics. The ICD-9 system incorporates a number of improvements over the old system that should significantly reduce the number of non-specific diagnoses for pneumonia and other infectious diseases. The previous classification system (ICDA-8) made no provisions for the separate classification of pneumonia due to adenovirus, respiratory syncytial virus, parainfluenza virus, cytomegalovirus, measles virus, rhino virus, coxsackie virus, echo virus, *Pseudomonas, Chlamydia, Francisella tularensis, Bordetella pertusis, Bacillus anthracis, Escherichia coli, Proteus, Salmonella, Histoplasma, Coccidioides, Candida, Pneumocystis,* or *Legionella.* A new system of secondary codes in the ICD-9 makes these distinctions possible and should greatly improve the quality of the NMDSC data system. However, this improvement does not come without a

price. The major changes in pneumonia and other infectious disease classifications will result in problems of comparability between admission diagnoses in the two classification periods; i.e., diagnoses recorded by the ICDA-8 will not always have a comparable counterpart in the ICD-9 system. As an example, comparing the rates of unspecified viral pneumonia for each time period will show an artificial decline beginning in 1980, because the ICD-9 system allocates many viral diagnoses to specific categories whereas ICDA-8 groups all viral pneumonia diagnoses, whether specified or not, into a single class.

The ICD, with revisions occurring about every ten years, is a classification scheme designed for international use. Although the ICD fulfills the classification needs of most countries in the world, its application, without frequent modification, to a military health care system is less than ideal. The extreme geographic distribution and atypical living and working conditions of military populations expose this group to a unique set of health hazards. This, coupled with the rapidly growing knowledge of infectious disease etiology, warrants a more frequent review of existing classification schemes, in order to tailor the system to fit military research needs. More frequent reviews of the system could go far in explaining the differences in admission rates among sub-populations of military personnel. If a separate classification for pneumonia due to adenovirus had been included in ICDA-8, we might now know unequivocally whether or not the adenovirus vaccine was responsible for the recent decrease in recruit pneumonia admissions.

It is within our grasp to solve many of the complex epidemiological problems associated with pneumonia if classification systems continue to improve. There is no need, however, to stand idly by and await the next revision in the ICD which may, or may not, include changes relevant to studying disease problems in a well defined military population with a closed system of health care. Military populations are ideally suited for population based studies utilizing existing medical records; a closer scrutiny of records through the use of a more comprehensive and frequently updated classification system could clarify specific military research questions. More frequent modification of ICD system to incorporate new diseases, new pathogens, changes in nomenclature, and infrequent

but militarily relevant diseases would be an important advance in medical data gathering. Continued surveillance of broad diagnostic categories such as *unspecified bacterial pneumonia* or *viral pneumonia* is of little help in determining which of the possibly hundreds of pathogens that fall into these categories are important as objects of research. Identification of risk factors is limited to those factors which enhance the disease process for the majority of the pathogens in a given diagnostic category. As long as many diverse pathogens continue to be grouped broadly in data resources, we are severely limited in the number and types of improvements that can be made in the health status of our personnel.

Summary

In this paper, we describe pneumonia morbidity data derived from admission records of the computer files of the Naval Medical Data Services Center (NMDSC), Bethesda, Maryland. By calculating and comparing specific incidence rates for pneumonia admissions in active duty Navy and Marine Corps personnel, we sought to identify high risk groups within the population and the temporal trends associated with morbidity.

Overall, there has been a significant decline in pneumonia admission rates for naval personnel since 1973. Adjusted rates, however, showed higher rates of pneumonia admissions for whites compared with blacks, for females compared with males, for enlisted personnel compared with officers, and for Navy personnel compared with Marine Corp personnel. Specific rates for naval personnel under 25 years of age showed that, for individual years, recruits had about 30 times the rate of pneumonia admissions compared with the non-recruit population in this same age range. Diagnostic categories for which the specific etiologic agent was either unknown or unrecorded (non-specific pneumonias) accounted for 75.8 per cent of the total pneumonia admissions for the period 1970-1979.

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TABLE III

ADMISSIONS FOR PNEUMONIA BY PRIMARY DIAGNOSIS, ACTIVE DUTY NAVY AND MARINE CORPS PERSONNEL, 1970-1979

Primary Admission Diagnosis (ICDA-8)	Number of Admissions	Per Cent Contribution
Viral pneumonia	3,030	10.3
Pneumococcal pneumonia	5,777	19.7
Other specified bacterial pneumonia	241	0.8
Bacterial pneumonia, NOS	154	0.5
Pneumonia due to other specified organism	1,074	3.7
Acute interstitial pneumonia	44	0.2
Bronchopneumonia, unspecified	957	3.3
Pneumonia, unspecified	18,004	61.5
Total	29,281	100.0