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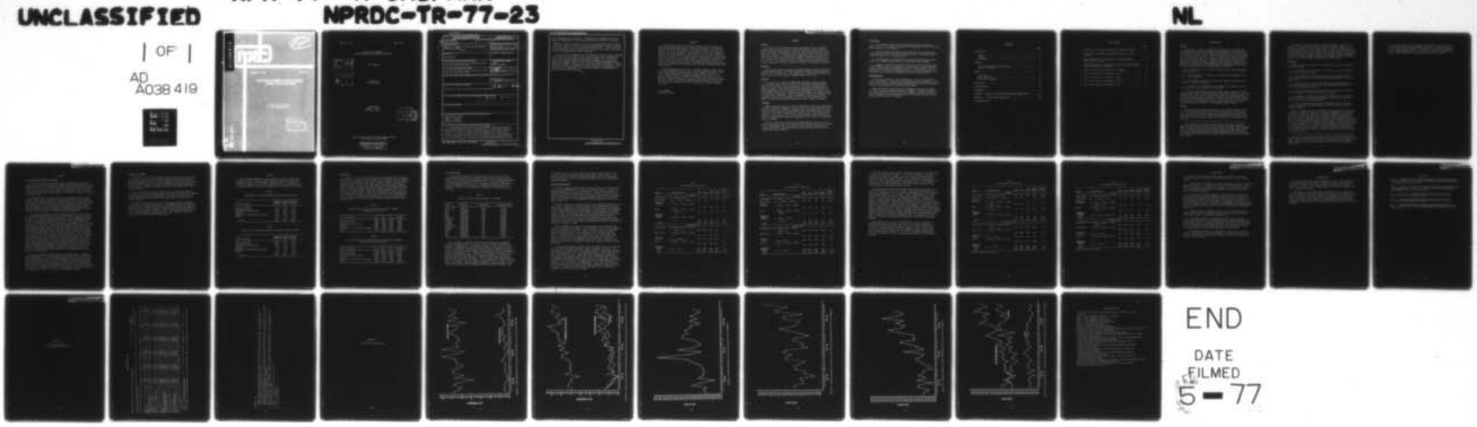

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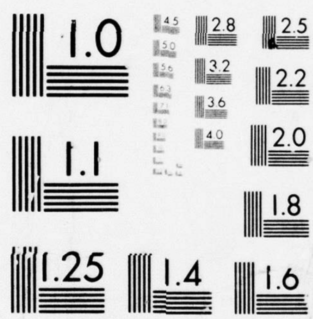

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ANALYSIS OF DEMANDS ON NAVAL REGIONAL MEDICAL CENTER, SAN DIEGO

Mark Chipman

Reviewed by
Joe Silverman

Approved by
James J. Regan
Technical Director

Navy Personnel Research and Development Center
San Diego, California 92152

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In developing a system for allocating manpower resources in the Navy, major emphasis has been placed on the design of an input-output model to forecast the workload of shore activities, based on the size and distribution of the fleet. To determine the feasibility of an input-output analysis for operational use, a full-scale model of the 11th Naval District is being developed. The structure of the input-output analysis requires data on the work output of each shore activity and its destination in the

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) fleet and other shore activities. In addition, the demands by the fleet must be disaggregated by ship type/aircraft model, movement, and status.

A major effort is underway to collect and organize data and to conduct an empirical analysis of the fleet-shore workload demand network, focusing on 12 major shore activities in the 11th Naval District. This report provides an analysis of the workload demands on one of these shore activities--the Naval Regional Medical Center, San Diego.

The structure of demands on the Naval Regional Medical Center, San Diego was analyzed by using inpatient and outpatient data obtained monthly for FY74, FY75, and FY76; Master Loading Plans for FY74, FY75, and FY76 prepared by the Bureau of Medicine and Surgery (BUMED); and Enlisted Data Verification Reports supplied by the Enlisted Personnel Management Center, New Orleans (EPMAC). The data were used to determine distribution of total workload, as well as differences in demand among retired personnel, active duty personnel, dependents of active duty personnel, and dependents of retired and deceased personnel.

FOREWORD

The effort described in this report supports the Fleet Impact on Shore Requirements subproject, an advanced development under Z0109-PN, Requirements Development Systems. The overall objective of this subproject is to test and evaluate technologies directed toward improved manpower resources management. The main effort of FY77 is an empirical study of the fleet and shore demands placed on major shore activities in the 11th Naval District, with the objective of developing an input-output model of the fleet support demand network. This report focuses on one of the major shore activities, the Naval Regional Medical Center, San Diego. Three previous reports were concerned with the Naval Supply Center, San Diego, Long Beach Naval Shipyard, and the Naval Air Rework Facility, North Island.

Acknowledgments are due to LT D. Waldroupe (Data Processing Branch) of the Naval Regional Medical Center, San Diego (NRMCSD); CAPT C. Arnold of the Enlisted Personnel Management Center (EPMAC), New Orleans; Mr. W. Evans (Automatic Data Processing Operations Division) of the Bureau of Naval Personnel (BUPERS); and LCDR R. Turco (Facilities Requirements Planning Branch of the Bureau of Medicine and Surgery (BUMED)). The entire staff of the NRMCSD, EPMAC, BUPERS, and BUMED were helpful and cooperative throughout the data collection and analysis stages of this study.

J. J. CLARKIN
Commanding Officer

SUMMARY

Problem

A system for determining Navy manpower requirements and allocating manpower resources must be based on the workload and economic relations among individual shore-support activities. The demand network that links shore activities to one another, and to the fleet, constitutes the economic system of the Navy. To represent this network structure, an input-output (I/O) model of the 11th Naval District (11ND) is being developed to forecast the workload of shore activities, based on the size and distribution of the fleet. An I/O model of this size requires a significant effort to collect, organize, and analyze data on the source and intensity of demands.

Objective

This study provides an analysis of workload demands placed on the Naval Regional Medical Center, San Diego (NRMCSD) by various military subpopulations in the San Diego area. The results will be used in developing a full-scale model of the fleet support demand network of the 11ND.

Approach

The structure of demands on NRMCSD was analyzed by using inpatient and outpatient data monthly for FY74, FY75, and FY76; Personnel Loading Plans for FY74, FY75, and FY76 prepared by the Bureau of Medicine and Surgery; Enlisted Data Verification Reports supplied by the Enlisted Personnel Management Center, New Orleans; and monthly manpower figures from the Personnel Diary Section, Bureau of Naval Personnel. The data were used to determine distribution of total workload and differences in demand among the six patient categories: retired personnel, active duty personnel, dependents of active duty personnel, other active duty personnel, dependents of retired and deceased personnel, and other eligible personnel.

Findings

NRMCSD produces output that can be classified into two major categories: inpatient visits and outpatient visits. While total demand increased during the years studied, the number of inpatient and outpatient visits per person in each patient category remained fairly stable, thus permitting reasonable estimates to be made for both outputs, given the size of the patient categories. Further analysis for the active duty patient category revealed no significant correlation between the magnitude of that sector and its monthly demand at NRMCSD.

Further, time series analyses of the demand data for five of the six patient categories proved to be useless in forecasting either type of demand 3 or 4 months ahead. The extent of the current data base permits only 1-month forecasts at best, and these forecasts were more accurate for the "outpatient visits" category.

Conclusions

1. Navy medical workload data are available to measure demands on NRMCs in terms of the number of inpatient and outpatient visits. This data will conform to an I/O framework.

2. Because demand rates were relatively stable for all six patient categories in FY74, FY75, and FY76, coefficients for these NRMCSD sectors of the I/O model can be developed easily.

3. Further data are required before time series analysis can become beneficial to NRMCSD administrators in forecasting future demands.

4. Because the size of the patient categories affects the total workload at NRMCSD, changing the homeport of several ships to San Diego would certainly contribute to subsequent deviations in that workload. It is hoped that the I/O model will have the ability to determine quantitatively the change in the workload at NRMCSD and at other 11ND activities.

Recommendations

The analysis relating to the determination of the I/O coefficients should be extended to include all or most Navy hospitals and medical centers. Close contact should be maintained with BUMED when the entire Navy medical system is incorporated into the Navy-wide I/O model.

Additional study of admissions and outpatient visits data is needed to further clarify staffing requirements at NRMCSD. Studying characteristics associated with the data, such as the number of bed days and medical service rendered, will give more insight into the amount and type of personnel required to meet the demands.

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INTRODUCTION

Problem

The design of a system to determine Navy manpower requirements and allocate manpower resources has emphasized development of an input-output (I/O) model to forecast the workload of shore activities based on the size and configuration of the fleet. Manpower requirements then may be derived from these workload forecasts. The I/O structure can link the activities of the fleet to individual shore-support activities and indicate linkages among shore-support activities. With the interconnections among fleet and shore activities identified, methods can be developed to quantitatively measure the relationship of workload demand between the operating forces and shore activities as well as among support activities.

The I/O model may be able to answer a wide variety of Navy management questions, such as:

1. What is the impact of changes in the shore establishments on the level of fleet support?

2. For changes in fleet size or mix, what changes in workload can be expected at each shore activity?

3. If ships are transferred from one homeport to another, what will be the effect on shore activities at each port?

An I/O model representing the fleet support demand network of the 11th Naval District (11ND) is being developed for test and evaluation. This model requires data on the output of each shore activity and its destination in the fleet and other shore activities. Demands by the fleet must be broken cut by ship type, movement, and status. A large data base for an I/O model is essential, so current efforts are devoted to collecting, organizing, and analyzing data to describe a fleet support demand network.

Purpose

This data analysis effort concentrates on the workload demands placed on 12 shore activities in the 11ND.[1] These activities were selected for their wide range of functions and outputs, data problems, their manpower intensities, and their direct and indirect linkages to the fleet. Furthermore, the activities comprise nearly 45 percent of the total workforce in the 11ND.

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[1]The activities are the Naval Supply Center, San Diego; Long Beach Naval Shipyard; Naval Air Stations, North Island and Miramar; Naval Regional Medical Center, San Diego; Naval Training Center, San Diego; Naval Station, San Diego; Public Works Center, San Diego; Naval Electronics Laboratory Center, San Diego; Naval Electronic Systems Engineering Center, San Diego; Development and Training Center, San Diego; and the Naval Air Rework Facility, North Island.

This report provides an analysis of workload demand on one of these activities--the Naval Regional Medical Center, San Diego (NRMCSD).[2] The primary geographical region served by NRMCSD includes San Diego County, the southern most part of Indo County, and the area within a 40-mile radius of Yuma, Arizona. This region includes all zip codes headed by 920 and 921 except 92003, 92008, 92024-28, 92054-55, 92059, 92061, 92069, and 92082-3, which are attributed to NRMC Camp Pendleton. NRMCSD is also the referral hospital for the naval bases and ships at sea in the Pacific.

Background

NRMCSD is directly responsible for the medical care of the following patient categories:

1. Active Duty Navy (including all personnel on active duty status) located in the San Diego region.

2. Other Active Duty (including personnel in the Army, Air Force, Coast Guard, and Marine Corps on active duty status) located in the San Diego region.

3. Dependents of Active Duty (including the legal dependents of an active duty serviceman of any branch of the Armed Forces) residing or visiting in the San Diego region.

4. Retired (including retired personnel of any branch of the Armed Forces) residing or visiting in the San Diego region.

5. Dependents of Retired and Deceased (including those legal dependents of any retired or deceased serviceman of any branch of the Armed Forces) located in the San Diego region.

6. Other (including authorized U.S. Government civilian employees and their dependents, Veterans Administration beneficiaries, and other authorized groups).

Thus, the demand population of NRMCSD can be classified into these six categories. However, the output or workload of NRMCSD can be restricted to two major categories--admissions (to Balboa Hospital) and outpatient visits (to the hospital and various outpatient clinics throughout the San Diego region). Admissions are technically restricted by the number of beds at the Balboa Hospital complex, although full occupancy rarely occurs. They are more likely to be restricted by the number of attending physicians and nurses, although this situation is also uncommon. However, when such a situation does arise, all but obstetrics and gynecology patients are referred to other local hospitals. Outpatient visits are restricted only by the number of clinics and by the hours of operation, which vary from 8 to 24 hours per day.

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[2] This is the fourth in a series of reports on the empirical study of demands placed on 11ND shore activities. The first three concerned the Naval Supply Center, San Diego (Blanco, 1976), the Long Beach Naval Shipyard (Rowe, 1976), and the Naval Air Rework Facility, North Island (Blanco & Rowe, 1977).

To project manpower requirements for a particular fiscal year, the Bureau of Medicine and Surgery (BUMED) publishes a Personnel Loading Plan for the region served by NRMCSD. Included in this report are estimates of the population totals for the six patient categories. From these estimates, BUMED determines an appropriate staff size for NRMCSD.

APPROACH

Data Sources and Initial Processing

Analysis of the workload demands placed on NRMCSD requires several groups of data. First, to measure workload, data on NRMCSD admissions and outpatient visits for the six patient categories were obtained on a monthly basis for FY74, FY75, and FY76. Thus, the workload data base consisted of 36 points, one for each month studied. Workload data before FY74 were considered inconsistent and unreliable due to the data collection procedures used at that time.

The number of admissions was chosen as the workload measure for the hospital rather than average daily patient load (ADPL) for two reasons: First, a policy change occurred at the hospital near the end of FY75 that caused ADPL to drop significantly and made comparisons between FY74, FY75, and FY76 impractical. Second, hospital administrators expressed belief that admissions is a better indicator of hospital workload than ADPL. It should also be noted that the number of outpatient visits is the only practical workload measure available for NRMCSD dispensaries.

As stated above, BUMED's Personnel Loading Plans supply the data for the estimated demand populations on a regular basis. (A partial listing of the Plan for FY76 is given in Appendix A.) Because monthly estimates for most of the demand populations were not available, only three points in time are represented--FY74, FY75, and FY76. One demand population sector, Active Duty Navy, can be broken down into monthly totals. Because this category contains the largest monthly demand variation of all patient classifications, these monthly totals were derived to help clarify the relationship between the size of this sector and its demand upon NRMCSD. This involved categorizing Active Duty Navy personnel into three groups--those stationed on ships, on shore, and with squadrons. Thus, the daily logs for FY74, FY75, and FY76 from Naval Station, San Diego were examined to determine which Navy ships were in port each month and for how long. The same information was obtained for all squadrons based in San Diego. Finally, after compiling a list of all the Unit Identification Codes (UICs) for the appropriate ships, squadrons, and shore activities in the San Diego region, monthly manpower data were obtained from the Enlisted Personnel Management Center (EPMAC) in New Orleans for enlisted men, and from the Personnel Diary Section, PERS 3614, in Washington, D.C. for officers. These data were only available for the 16-month period from March 1975 to June 1976.

Initial processing involved summing the monthly figures to generate yearly demand figures for NRMCSD, although the monthly data are also used for other analyses. Also, the monthly manning data for Active Duty Navy were converted into man-days in port per month by multiplying the monthly manpower levels for each activity by the number of days per month each activity was "in port" and by summing over all activities for each month. This provided a measure of Active Duty Navy strength in the San Diego region for each of the 16 months and allows for statistical comparison with the corresponding 16 months of data for the two demand categories.

Analysis of Demands

The analysis of demands at NRMCSD concentrated on three areas: First, the primary goal was to derive hospital sector coefficients relating admissions and outpatient visits to their driving factors; namely, the six patient categories. This was done by examining the data in its yearly form, since no monthly measures of the size of five of the demand populations were available. Methods for analysis were thus restricted by the lack of a large data base.

Second, Active Duty Navy data for the last 16 months were examined to further test the relationship between that sector's size and its demands. It was hoped that, with this breakdown of the data, the variance of the monthly admissions and outpatient visits for Active Duty Navy could be better explained.

Finally, the demand data for all 36 months were studied independently of the size of the demand populations to help NRMCSD predict its future workload levels. Standard time series analysis techniques were applied to five of the six patient categories' demand histories (excluding "Other") for both admissions and outpatient visits. Four additional months of data (July, August, September, and October 1976) were obtained to test the accuracy of the various models' predictions.

RESULTS

Total demand at NRMCSD has risen steadily from FY74 to FY76 with a 20 percent increase in total annual admissions (24,586 to 29,583) and a 22 percent increase in total annual outpatient visits (1,269,375 to 1,550,343). Tables 1 and 2 show that the proportion of the workload, as distributed among the six patient categories, has remained fairly stable.

Table 1

Distribution of Workload (Admissions) by Patient Category

Patient Category	Proportion of Workload (%)		
	FY74	FY75	FY76
Active Duty Navy	31.0	29.7	27.3
Other Active Duty	6.7	6.4	6.8
Dependents of Active Duty	34.6	35.7	35.3
Retired	13.3	13.3	13.7
Dependents of Retired and Deceased	13.5	14.0	16.1
Other	0.9	0.9	0.8
Total	100.0	100.0	100.0

Table 2

Distribution of Workload (Outpatient Visits) by Patient Category

Patient Category	Proportion of Workload (%)		
	FY74	FY75	FY76
Active Duty Navy	39.0	41.4	36.8
Other Active Duty	10.0	9.9	10.6
Dependents of Active Duty	31.8	29.9	31.9
Retired	7.2	6.6	7.6
Dependents of Retired and Deceased	8.4	8.7	10.1
Other	3.6	3.5	3.0
Total	100.0	100.0	100.0

Yearly Data

To arrive at the coefficients (which must link demand with the demand populations) to be used in the I/O model, ratios relating yearly admissions per person and outpatient visits per person were computed for each patient category in each of the 3 study years. Cursory analysis revealed little change from year to year in the demand rates for each patient category (Tables 3 and 4), although those for Dependents of Active Duty and Dependents of Retired and Deceased depicted a slight increasing trend. The decision was therefore made to use as the I/O coefficients the average of each group of three ratios. These were considered to be better estimates for the demand rates than, say, the ratios for FY76 alone, realizing that it is difficult to establish the existence of a trend using three data points. Because of the lack of data, no further analysis was carried out in this area.

Table 3

Yearly Demand Rates for Admissions by Patient Category
(Admissions per Person)

Patient Category	FY74	FY75	FY76	Average
Active Duty Navy	.0902	.0873	.0891	.0889
Other Active Duty	.1596	.1205	.1257	.1353
Dependents of Active Duty	.0684	.0785	.0863	.0778
Retired	.1084	.1105	.1143	.1111
Dependents of Retired and Deceased	.0402	.0412	.0472	.0428
Other	.0113	.0103	.0105	.0107

Table 4

Yearly Demand Rates for Outpatient Visits by Patient Category
(Outpatient Visits per Person)

Patient Category	FY74	FY75	FY76	Average
Active Duty Navy	5.848	6.500	6.282	6.210
Other Active Duty	12.256	10.053	10.380	10.896
Dependents of Active Duty	3.255	3.526	4.090	3.624
Retired	3.059	2.935	3.341	3.112
Dependents of Retired and Deceased	1.286	1.356	1.546	1.396
Other	2.238	2.173	1.948	2.120

Active Duty Navy

For the period from March 1975 through June 1976, the Active Duty Navy population (expressed in man-days in port) was calculated for each month. Associated with these population data are the corresponding numbers of admissions and outpatient visits (Table 5). To determine the relation between demand and the size of the demand population, simple Pearson *r*'s were computed for the number of admissions and outpatient visits, yielding -.133 and -.265 respectively. Neither *r* is significant at the .05 level.

Table 5

Monthly Active Duty Navy Man-Days vs. Demands

Month	Man-Days	Admissions	Outpatient Visits
March 1975	1,869,731	660	42,589
April	1,765,950	646	43,538
May	1,816,904	627	47,135
June	1,782,377	633	54,102
July	1,863,061	681	53,735
August	1,855,648	712	50,198
September	1,812,185	672	52,100
October	1,848,649	632	48,645
November	1,852,638	695	48,289
December	2,012,794	546	42,534
January 1976	1,996,637	735	48,866
February	1,831,892	641	44,244
March	1,821,899	722	48,275
April	1,839,437	675	45,077
May	1,893,165	655	42,463
June	1,839,635	724	46,224

Thus, instead of observing a positive correlation between man-days in port and demand, which was expected, just the opposite occurred (although not significantly). An analysis of Table 5 reveals that data for the month of December in particular, contributes to the negative correlations. Although this month accounted for the largest number of man-days in port, it had the smallest demand for admissions, and the next-to-smallest demand for outpatient visits. This is due to the fact that many Active Duty Navy personnel are home on leave during December but do not wish to use that time for medical purposes. January is also viewed by hospital administrators as an atypical month. This is supported by looking again at Table 5, which shows that the number of man-days in port is nearly as large as that in December, although demand increased in both categories. Thus, computation of additional correlation coefficients ignored December 1975 and January 1976. The results--.265 for admissions and -.229 for outpatient visits--while showing improvement, remain insignificant. Consequently, based on 16 months of data, there appears to be no significant relationship between Active Duty Navy man-days in port and the respective demands at NRMCSD.

Time Series Analyses

Whereas the analyses above looked at the 16 months of Active Duty Navy data as being independent over time, this section attempts to view the 36-month demand data base as time-dependent. Thus, the demand data--both admissions and monthly outpatient visits--were plotted over time for all patient categories. The resultant 12 time series are provided in Appendix B. The standard procedures found in Box and Jenkins (1970) were used to fit models to this data. (A less mathematical interpretation can be found in Nelson (1973).)

A number of steps were taken to find the most appropriate model for each time series. First, plots of the raw data, first differences of the raw data, and, if necessary, second differences of the raw data, were obtained. Second, sample correlograms and the partial autocorrelations were examined to aid in the selection of an initial model. After expanding the initial model in either the autoregressive or moving-average direction and testing for significance of the added parameter, the final model was chosen. Finally, a Gaussian white noise test was performed on the one-step forecasting errors to check for excessive autocorrelation among those errors. Forecasts for one period ahead were then computed along with the appropriate 95 percent confidence limits.

Table 6 presents the results of fitting models to the 36-month time series for all patient categories except "Other," as well as the projected and actual values for July 1976. Due to the small size of the data base and the irregular patterns of the raw data, the 95 percent confidence range is relatively large. Even though the totals for admissions come very close to the actual totals for July 1976, it should be noted that this was partly due to forecasting errors cancelling each other out. However, all forecasts for outpatient visits are, in this instance, very good predictors, with the largest forecast error being 3 percent for Active Duty Navy.

To forecast the demand for August 1976, the models were fitted to data for 37 months including July 1976. Results are shown in Table 7. The parameters for the models were recalculated because of additional information available by July 1976. When working with such a small data base (for time series purposes), any further data can be very useful, especially when forecasting. However, August 1976 was an exceptional month in that the number of admissions were at record levels for all patient categories. All forecasts for admissions and outpatient visits underestimated the actual demands. A further analysis of NRMCSD data for this month revealed no epidemiological cause for this sudden surge; rather, all types of patient care at the hospital experienced an increase in workload. This points out a weakness in linear time series models in general--the inability to forecast a sudden deviation in the data.

Table 6

Time Series Models for 36 Months of Data

Category	Undifferenced Model	Lower Limit	Forecast	Upper Limit	July 1976 Actual	Percent Forecast Error
	Admissions					
Active Duty Navy	$Z_t = -.25902Z_{t-1} + 829.586 + \varepsilon_t$	527	642	757	681	-6.02
Other Active Duty	$Z_t = Z_{t-1} - .64635\varepsilon_{t-1} - .42058\varepsilon_{t-2} + \varepsilon_t$	121	159	197	163	-2.45
Dependents of Active Duty	$Z_t = .82798Z_{t-1} + .17202Z_{t-2} - .62240\varepsilon_{t-1} + \varepsilon_t$	784	874	964	843	+3.68
Retired	$Z_t = .77545Z_{t-1} + .39732Z_{t-2} - .17277Z_{t-3} - .80310\varepsilon_{t-1} + \varepsilon_t$	274	332	390	375	+11.47
Dependents of Retired and Deceased	$Z_t = 1.52019Z_{t-1} - .5209Z_{t-2} - .88993\varepsilon_{t-1} + \varepsilon_t$	346	416	485	410	+1.46
TOTALS		2248	2423	2598	2472	-1.98
	Outpatient Visits					
Active Duty Navy	$Z_t = .83681Z_{t-1} + 7528.4361 - .46714\varepsilon_{t-1} - .27097\varepsilon_{t-2} + \varepsilon_t$	35963	46657	57351	45276	3.05
Other Active Duty	$Z_t = .56492Z_{t-1} - .02911Z_{t-2} + .46420Z_{t-3} + \varepsilon_t$	15173	17122	19071	17654	-3.01
Dependents of Active Duty	$Z_t = Z_{t-1} - .82817\varepsilon_{t-1} + \varepsilon_t$	36405	41199	45993	40109	+2.72
Retired	$Z_t = .76854Z_{t-1} + .23146Z_{t-2} - .67121\varepsilon_{t-1} + \varepsilon_t$	8211	9990	11769	10077	-0.86
Dependents of Retired and Deceased	$Z_t = Z_{t-1} - .66997\varepsilon_{t-1} + \varepsilon_t$	11732	13726	15720	13868	-1.02
TOTALS		116082	128694	141306	126984	+1.35

Table 7

Time Series Models for 37 Months of Data

Category	Undifferenced Model	Lower Limit	Forecast	Upper Limit	August 1976 Actual	Percent Forecast Error
		Admissions				
Active Duty Navy	$Z_t = -.23990Z_{t-1} + 817.73 + \varepsilon_t$	540	654	768	735	-11.02
Other Active Duty	$Z_t = Z_{t-1} - .63052\varepsilon_{t-1} - .40311\varepsilon_{t-2} + \varepsilon_t$	100	137	174	197	-30.46
Dependents of Active Duty	$Z_t = .80282Z_{t-1} + .19718Z_{t-2} - .60250\varepsilon_{t-1} + \varepsilon_t$	782	872	962	980	-11.02
Retired	$Z_t = .78658Z_{t-1} + .36132Z_{t-2} - .14790Z_{t-3} - .78691\varepsilon_{t-1} + \varepsilon_t$	318	348	378	380	-8.42
Dependents of Retired and Deceased	$Z_t = 1.47183Z_{t-1} - .47183Z_{t-2} - .83318\varepsilon_{t-1} + \varepsilon_t$	337	407	477	465	-12.47
TOTALS		2242	2418	2594	2757	-12.30
		Outpatient Visits				
Active Duty Navy	$Z_t = .83623Z_{t-1} + 7551.33 - .46932\varepsilon_{t-1} - .26430\varepsilon_{t-2} + \varepsilon_t$	35118	45677	56236	50491	-9.53
Other Active Duty	$Z_t = .56891Z_{t-1} - .03541Z_{t-2} + .46650Z_{t-3} + \varepsilon_t$	11921	15688	19455	17847	-12.10
Dependents of Active Duty	$Z_t = Z_{t-1} - .78100\varepsilon_{t-1} + \varepsilon_t$	36440	41321	46202	41535	-0.52
Retired	$Z_t = .76731Z_{t-1} + .23269Z_{t-2} - .66998\varepsilon_{t-1} + \varepsilon_t$	8313	10069	11825	10300	-2.24
Dependents of Retired and Deceased	$Z_t = Z_{t-1} - .66204\varepsilon_{t-1} + \varepsilon_t$	11809	13781	15753	14713	-6.33
TOTALS		114027	126536	139045	134886	-6.19

The same procedures were used to forecast the demand for September 1976 (Table 8) and October 1976 (Table 9). (In three instances, the number of parameters in the models change.) As can be seen, the demand rates for September returned to a more "normal" level, although the forecast for Active Duty Navy admissions remained very much in error, significantly contributing to the underestimation of total admissions. For the October predictions, the most extreme error occurred in forecasting Active Duty Navy and Other Active Duty outpatient visits.

Some general observations can be made concerning the applicability of time series analysis to this set of data. First, much less faith can be placed in forecasts for two (or more) periods ahead because of the scarcity and irregular variability of the data. This is especially true for the admissions category, in which the largest percentage of forecast errors occur. To use a forecast for 1 month ahead to forecast an addmissions demand 2 or more months ahead would only compound the errors. Also, outpatient visits are more accurately forecasted due to their relative stability compared to admissions. Indeed, many of the forecasts for outpatient visits differ by less than 2 percent from the actual figures. However, for both demand categories, the Active Duty Navy and Other Active Duty classifications remain the most difficult to assess. Although there appears to be a 12-month seasonal cycle in this data, analysis revealed that time series models using twelfth differences offered no improvement over those subsequently chosen. Thus, the data itself and the population levels, as examined in the previous section, fail to explain the variability in active duty personnel demands.

These models, then, in their present state, are nearly useless for NRMCSD administrators because a time period of at least 3 months is necessary to act upon the forecasts. At best, the models can cnly give a 1 month's advance warning of possible demands to come. Several more years of data would be helpful in establishing a longer warning period. With these additional figures, the 95 percent confidence ranges should decrease and forecasts for more than one period ahead should become more reliable.

Table 8

Time Series Models for 38 Months of Data

Category	Undifferenced Model	Lower Limit	Forecast	Upper Limit	September 1976 Actual	Percent Forecast Error
	Admissions					
Active Duty Navy	$Z_t = -.22628Z_{t-1} + 811.183 + \varepsilon_t$	530	645	760	776	-16.88
Other Active Duty	$Z_t = Z_{t-1} - .55743\varepsilon_{t-1} - .32803\varepsilon_{t-2} + \varepsilon_t$	133	172	211	199	-13.57
Dependents of Active Duty[a]	$Z_t = 1.07308Z_{t-1} + .20087Z_{t-2} - .27394Z_{t-3} - .85833\varepsilon_{t-1} + \varepsilon_t$	792	883	974	917	-3.71
Retired	$Z_t = .81299Z_{t-1} + .36275Z_{t-2} - .17574Z_{t-3} - .79722\varepsilon_{t-1} + \varepsilon_t$	298	356	414	372	-4.30
Dependents of Retired and Deceased	$Z_t = 1.53579Z_{t-1} - .53579Z_{t-2} - .92257\varepsilon_{t-1} + \varepsilon_t$	362	431	500	376	+14.63
TOTALS		2310	2487	2664	2640	-5.80
	Outpatient Visits					
Active Duty Navy[a]	$Z_t = .41357Z_{t-1} + .58643Z_{t-2} + .07031\varepsilon_{t-1} - .72199\varepsilon_{t-2} + \varepsilon_t$	36263	47047	57831	46270	+1.68
Other Active Duty	$Z_t = .57520Z_{t-1} + .00690Z_{t-2} + .41790Z_{t-3} + \varepsilon_t$	14287	18045	21803	18254	-1.14
Dependents of Active Duty	$Z_t = Z_{t-1} - .80816\varepsilon_{t-1} + \varepsilon_t$	36569	41348	46127	39478	+4.74
Retired	$Z_t = .76917Z_{t-1} + .23083Z_{t-2} - .67250\varepsilon_{t-1} + \varepsilon_t$	8360	10091	11823	9964	+1.27
Dependents of Retired and Deceased	$Z_t = Z_{t-1} - .67586\varepsilon_{t-1} + \varepsilon_t$	12129	14076	16023	14503	-2.94
TOTALS		117956	130607	143258	128469	+1.66

[a]Number of parameters in the model changed.

Table 9

Time Series Models for 39 Months of Data

Category	Undifferenced Model	Lower Limit	Forecast	Upper Limit	October 1976 Actual	Percent Forecast Error
Admissions						
Active Duty Navy	$Z_t = -.15637Z_{t-1} + 768.331 + \epsilon_t$	526	647	788	670	-3.43
Other Active Duty	$Z_t = Z_{t-1} - .53075\epsilon_{t-1} - .35465\epsilon_{t-2} + \epsilon_t$	135	174	213	166	+4.82
Dependents of Active Duty	$Z_t = 1.12678Z_{t-1} + .13088Z_{t-2} - .25766Z_{t-3} - .94784\epsilon_{t-1} + \epsilon_t$	819	907	995	854	+6.21
Retired	$Z_t = .78420Z_{t-1} + .36356Z_{t-2} + .14956Z_{t-3} - .75534\epsilon_{t-1} + \epsilon_t$	305	363	421	373	-2.68
Dependents of Retired and Deceased[a]	$Z_t = Z_{t-1} - .55241\epsilon_{t-1} - .03252\epsilon_{t-2} + \epsilon_t$	335	407	479	378	+7.67
TOTALS		2318	2498	2678	2441	+2.34
Outpatient Visits						
Active Duty Navy	$Z_t = .39409Z_{t-1} + .60591Z_{t-2} + .07992\epsilon_{t-1} - .74026\epsilon_{t-2} + \epsilon_t$	35852	46466	57080	42695	+8.83
Other Active Duty	$Z_t = .57523Z_{t-1} + .00722Z_{t-2} + .41756Z_{t-3} + \epsilon_t$	14294	18001	21708	14399	+25.02
Dependents of Active Duty	$Z_t = Z_{t-1} - .75822\epsilon_{t-1} + \epsilon_t$	36138	40990	45842	39175	+4.63
Retired	$Z_t = .76427Z_{t-1} + .23573Z_{t-2} - .66524\epsilon_{t-1} + \epsilon_t$	8419	10133	11847	9951	+1.83
Dependents of Retired and Deceased	$Z_t = Z_{t-1} - .67058\epsilon_{t-1} + \epsilon_t$	12300	14224	16148	13522	+5.19
TOTALS		117301	129814	142327	119742	+8.41

[a]Number of parameters in model changed.

CONCLUSIONS

An analysis of demands on NRMCSD permits some general conclusions on the feasibility of building an I/O model of the fleet support demand network.

1. Data exist in the NRMCSD to measure its demands in terms of admissions and outpatient visits. The data will fit into an I/O framework, with updating performed on a yearly basis, as long as a close working relationship is maintained with members of the NRMCSD's Data Processing Division and key personnel in BUMED.

2. The results from this study can be used to develop input-output coefficients for the I/O model's NRMCSD sectors, which would consist of the six patient categories. Demand rates were relatively constant in all six categories for FY74, FY75, and FY76. These results can be used in conjunction with the results from analyses of demands of other major activities. For example, the I/O coefficient between NRMCSD and the Naval Supply Center, San Diego might be measured in units of requisitions per number of admissions.

3. Further analysis of monthly Active Duty Navy strength in the San Diego region (in terms of man-days in port) and the respective demands revealed no inherent relationship between the two.

4. Time series analyses of the demand data for five of the six patient categories proved to be somewhat useless to NRMCSD administrators in forecasting demand 3 or more months ahead. With the current data base, only 1-month forecasts were deemed feasible, and these were more accurate for the "outpatient visits" demand category. Many more months of data are required before reliable long-term forecasts can be made.

5. Changing the homeport of several ships to San Diego will almost certainly influence the workload at NRMCSD. An I/O model must have the ability to quantitatively determine the change in that workload and those at other 11ND activities.

RECOMMENDATIONS

The analysis relating to the determination of the input-output model coefficients should be extended to include all or most Navy hospitals and medical centers. Close contact should be maintained with BUMED in evaluating the feasibility of incorporating the entire Navy medical system into a Navy-wide I/O model.

Furthermore, to allow NRMCSD administrators to more ably determine staffing standards, additional analysis of admissions and outpatient visits data is required. A correlative study should examine the various parameters associated with the two, such as the number of bed-days and the particular medical service rendered. Reliable estimates of the various population sectors will help to establish staffing requirements for medical personnel.

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APPENDIX A

PARTIAL LISTING OF FY76 PERSONNEL LOADING PLAN

PERSONNEL LOADING PLAN

Average strength data for: San Diego, CA
As of: 17 May 1976
(MASTER LOADING PLAN)

AVERAGE STRENGTH SERVED BY FISCAL YEAR FOR EACH PROGRAMMED YEAR

The average strength sata listed below is provided for planning purposes. These data should form the basis for all local and regional health care planning and programming documents.

		FY76	FY77	FY78	FY79	FY80	FY81
Army	1/	530	530	530	530	530	530
Air Force	2/	138	138	138	138	138	138
Coast Guard	3/	238	238	238	238	238	238
OTHER STU LESS THAN 20 WKS	4/	475	475	475	475	475	475
Marine Corps - Total	5/	14,518	14,518	14,518	14,518	14,518	14,518
Officer Enlisted							
Ashore		4,639	4,639	4,639	4,639	4,639	4,639
Afloat FMF		1,654	1,654	1,654	1,654	1,654	1,654
RECRUITS & STU LESS THAN 20 WKS		8,225	8,225	8,225	8,225	8,225	8,225
Navy - Total	6/	90,837	92,950	92,578	92,084	91,635	90,840
Ashore		22,141	21,720	22,048	22,048	22,132	22,077
Afloat		51,365	53,899	53,199	52,705	52,172	51,432
RECRUITS & STU LESS THAN 20 WKS		14,894	14,894	14,894	14,894	14,894	14,894
STUDENTS MORE THAN (20) WKS		2,437	2,437	2,437	2,437	2,437	2,437
Uniformed Services - Total		106,736	108,849	108,477	107,983	107,534	106,739
Dependents of Active Duty	7/	120,866	124,036	123,477	122,737	122,061	120,870
Retired Personnel	8/	35,444	35,444	35,444	35,444	35,444	35,444
Dep. of retired & deceased	8/	101,046	101,046	101,046	101,046	101,046	101,046
Other authorized treatment	9/	23,445	23,445	23,445	23,445	23,445	23,445
Total		387,537	392,820	391,889	390,655	389,530	387,544

1/ SOURCE: ARMY REPORT USADSC-39 AS OF 31 DEC 75. "ACTIVE ARMY STRENGTH BY UNIT AND STATION." NOTE FY77-81 DATA BASED ON FY76. NO PROJECTED DATA AVAILABLE.

2/ SOURCE: AIR FORCE REPORT HAF-DPX(M)7104 AS OF 29 FEB 76. "AIR FORCE MILITARY PERSONNEL BY OPERATING LOCATION." NOTE: FY77-81 DATA BASED ON FY76. NO PROJECTED DATA AVAILABLE.

3/ SOURCE: FONECON OF 30 APR 76 BETWEEN BUMED CODE 0211A AND USCG LCDT FOLCE. NOTE FY77-81 DATA BASED ON FY76. NO PROJECTED DATA AVAILABLE.

FOOTNOTES (CON'T)

4/ SOURCE: FONECON OF 3 MAY 1976 BETWEEN BUMED CODE 0211A AND NAVFACENGCOM CODE 0812B1 MR. R. B. SYKES. NOTE: STUDENTS LESS THAN (20) WEEKS ARE NOT USED IN COMPUTATION OF DEPENDENTS. TOTAL EQUALS SUM OF ENCLOSED PRIMARY LOADING PLANS. FIGURE REPRESENTS ARMY, AIR FORCE, COAST GUARD, AND FOREIGN MILITARY STUDENTS.

5/ SOURCE: MARCORPS REPORT DD-COMP(A)659 AS OF 30 JUN 75, FONECON OF 3 MAY 76 BETWEEN BUMED CODE 0211A AND HDQ MC CODE LFF-1 CAPT NARCRELLI, AND FONECON OF 3 MAY 76 BETWEEN BUMED CODE 0211A AND NAVFACENGCOM CODE 0812B1 MR. R. B. SYKES. NOTE: RECRUITS AND STUDENTS LESS THAN (20) WEEKS ARENOT USED IN COMPUTATION OF DEPENDENTS.

6/ SOURCE: BUPERS REPORT (MAPMIS) R31610B AS OF 31 MAR 76 AND FONECON OF 3 MAY 76 BETWEEN BUMED CODE 0211A AND NAVFACENGCOM CODE 0812B1 MR. R. B. SYKES. NOTE: STUDENTS LESS THAN (20) WEEKS ARE NOT USED IN COMPUTATION OF DEPENDENTS. NOTE: SEE ATTACHMENT (A) FOR ABBREVIATED ACTIVITIES LISTING.

7/ SOURCE: TOTAL EQUALS SUM OF ENCLOSED PRIMARY LOADING PLANS.

8/ SOURCE: SEE ATTACHMENT (B).

9/ SOURCE: SEE ATTACHMENT (C).

APPENDIX B

PLOTS OF TIME SERIES DATA

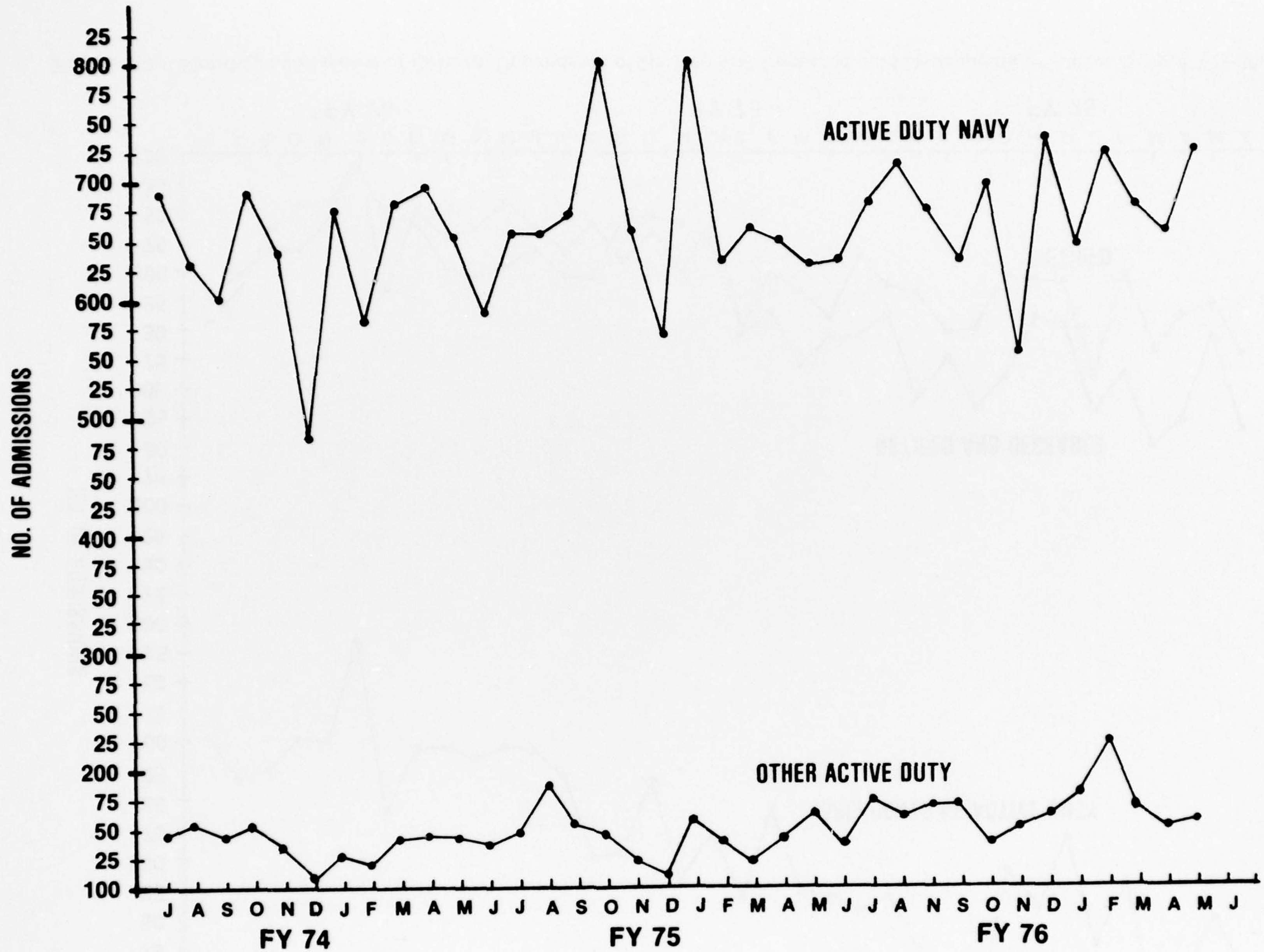

Figure B-1. Monthly admissions of Active Duty Navy and Other Active Duty, FY74-76, NRMCSD.

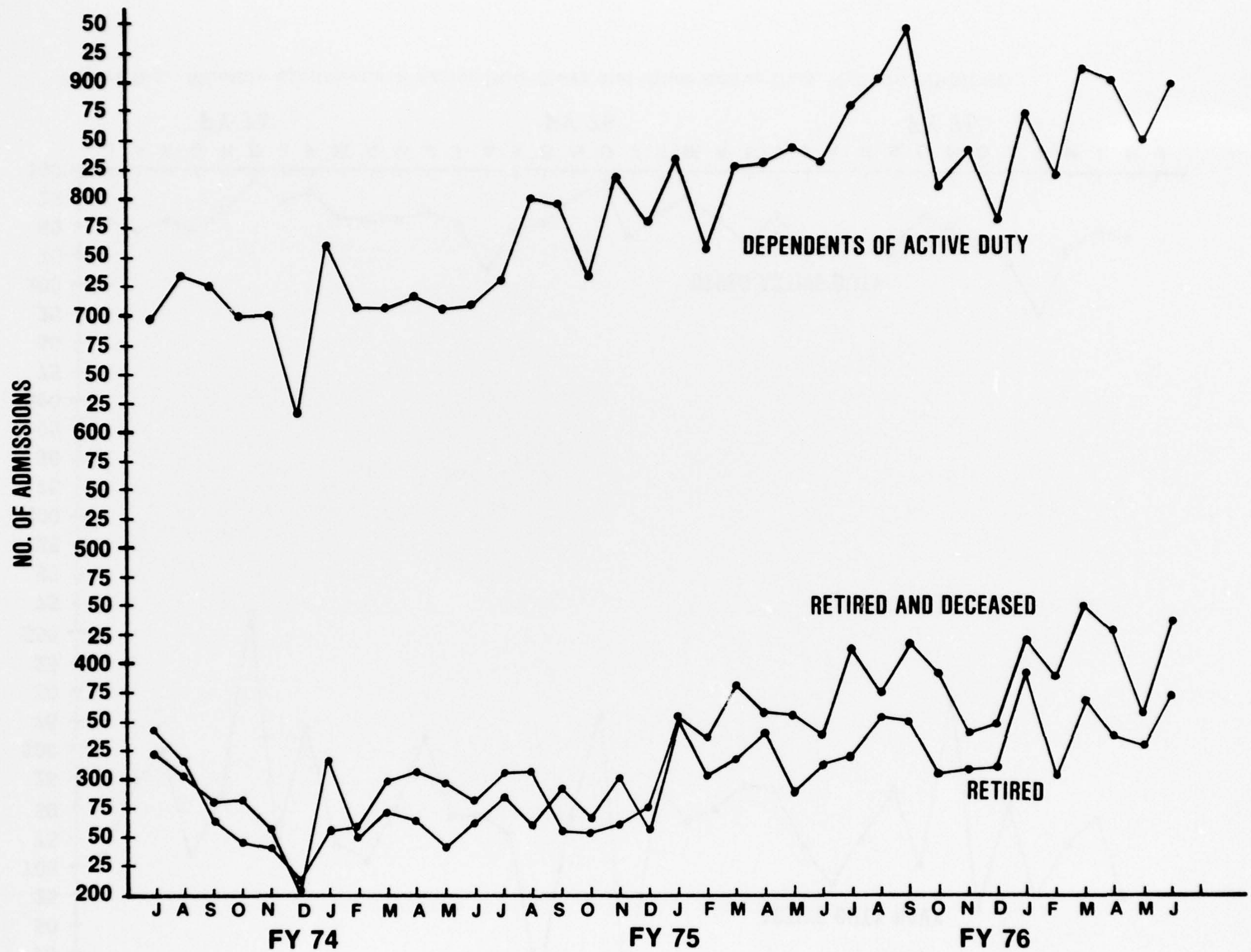

Figure B-2. Monthly admissions of Retired, Dependents of Retired and Deceased, and Dependents of Active Duty, FY74-76.

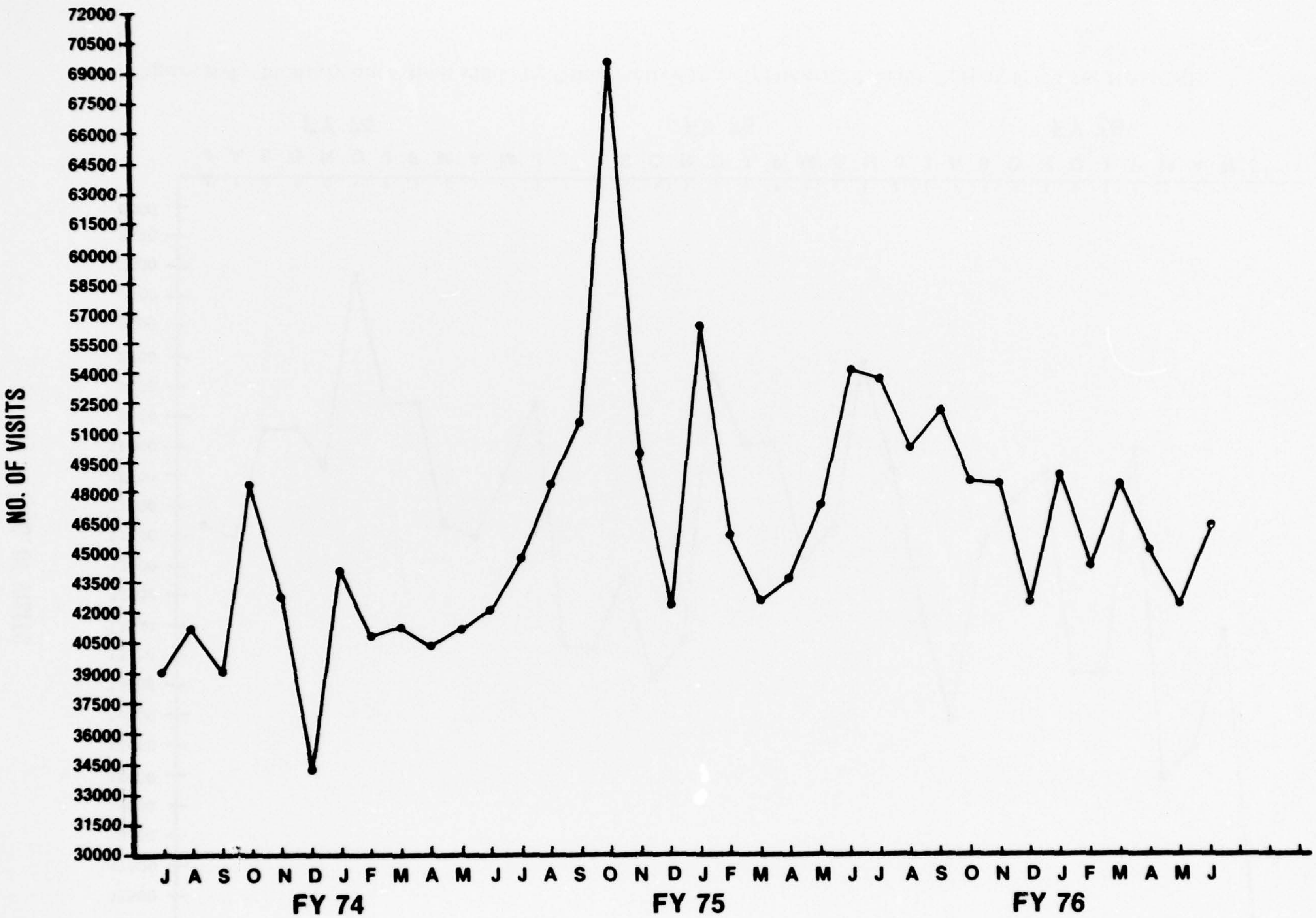

Figure B-3. Monthly outpatient visits by Active Duty Navy, FY74-76, NRMCSD.

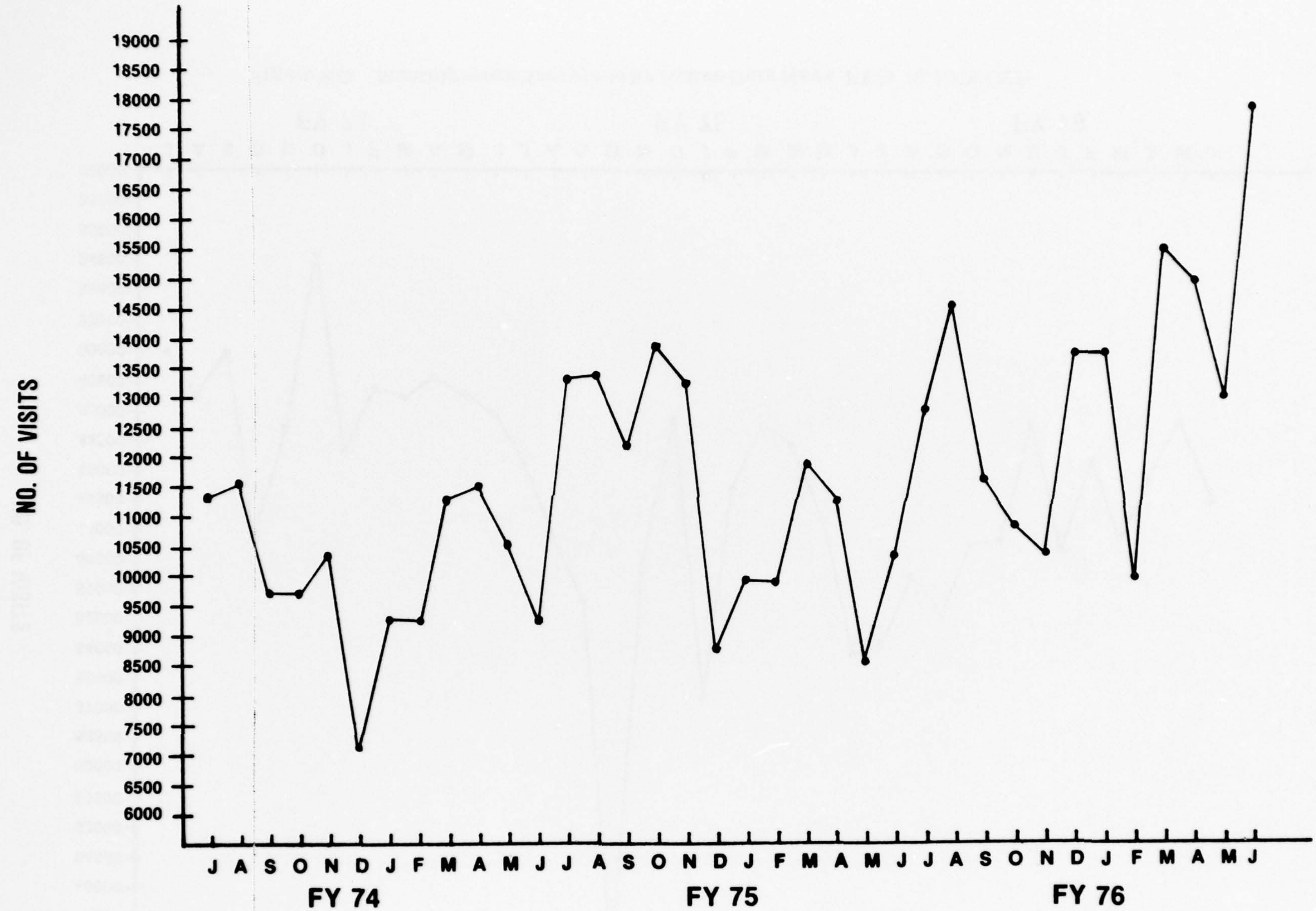

Figure B-4. Monthly outpatient visits by Other Active Duty (primarily Marine Corps), FY74-76, NRMCSD.

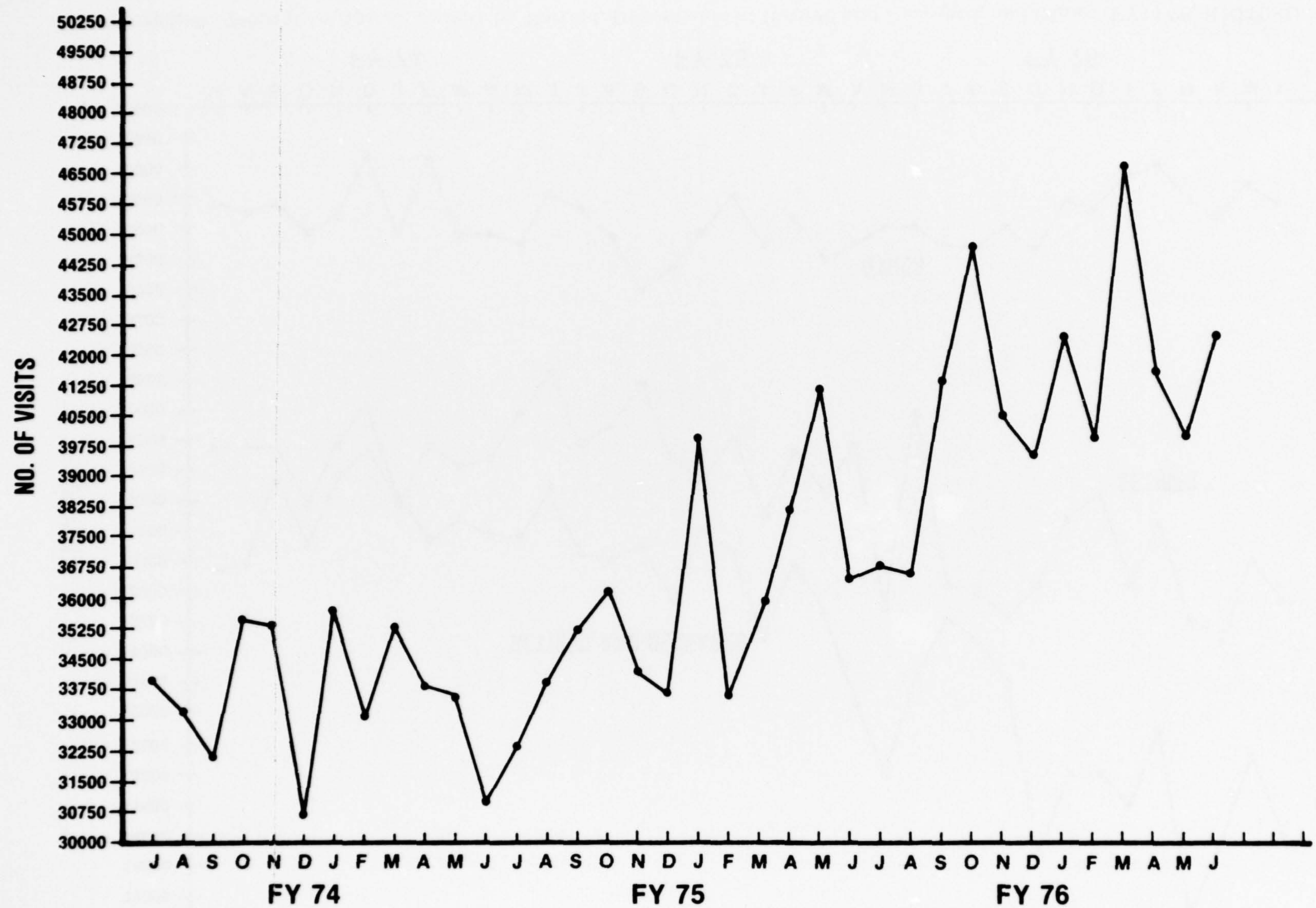

Figure B-5. Monthly outpatient visits by Dependents of Active Duty, FY74-76, NRMCSD.

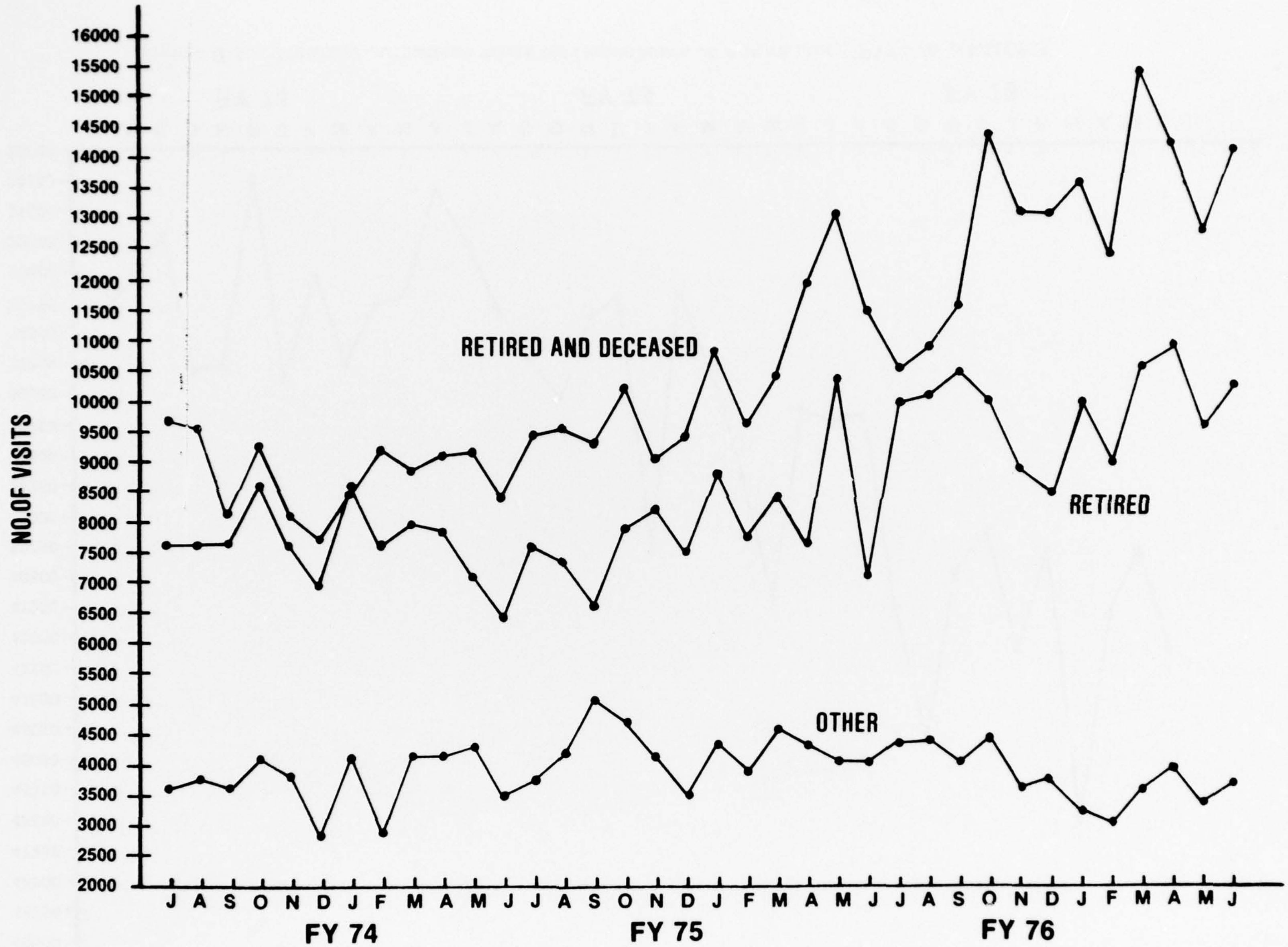

Figure B-6. Monthly outpatient visits by Retired, Dependents of Retired and Deceased, and Other, FY74-76, NRMCSD.

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