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MEASURING THE EFFICIENT UTILIZATION OF MEDICAL PERSONNEL AT NAVY MILITARY TREATMENT FACILITIES

by

Thomas G. Mihara

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Thesis Advisor L. Johnson

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The Military Health Services System (MHSS) has two fundamental objectives -- to augment the effectiveness of the military mission by providing medical support to active-duty personnel and secondarily to provide health care for dependents, survivors, and retirees on a space-available basis. Although the multiple objectives of the MHSS at times conflict with each other, the military has latitude in recommending and implementing health-care alternatives which can be observed in its composition and utilization of medical personnel. A measure of effectiveness (MOE) for utilizing manpower at a medical treatment facility (MTF) must be able to measure both medical and military inputs/outputs in terms of capacity and quality while including such diverse elements as budget, beneficiary population, technological capability, medical workload and case mix along with military contingency/augmentation readiness, training and retention. This study has developed a methodology to encompass multiple requirements and to measure technical efficiency for the production of health care. Technical efficiency can, in turn, be used as a relative measure of effectiveness.

The utilization of personnel at individual Naval hospitals is evaluated using a methodology classified as data envelopment analysis (DEA), which is a math programming technique that determines the efficiency of a facility from a set of variables that measure the utilization of a set of inputs which produce a set of outputs. Since manpower categories comprise the inputs that produce health care output, the utilization of medical personnel at a particular MTF can be compared to those facilities that are determined to be more technologically efficient.

The structural equations for personnel are calculated from the data of those hospitals that have above-average efficiency by means of a three-stage least squares procedure. First, physician requirements are determined from workload and beneficiary demand. The number of physicians then affect the numbers of professional support staff including other health-care officers, enlisted, and civilian personnel. In other words, the optimal composition of personnel in terms of output can be determined from the structural equations of hospitals that are efficient. Proposals are made to identify specific differences among MTFs in cross-sectional data.

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Measuring the Efficient Utilization of Medical Personnel at Navy Military Treatment Facilities

by

Thomas G. Mihara
Lieutenant, Medical Service Corps, United States Navy Reserve
M.S., University of Southern California, 1987
B.S., B.A., University of Montana, 1975

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Author: Thomas G. Mihara

Approved by: L. Johnson, Thesis Advisor

D. R. Whipple, Second Reader

Peter Purdue, Chairman,
Department of Operations Research

ABSTRACT

The Military Health Services System (MHSS) has two fundamental objectives -- to augment the effectiveness of the military mission by providing medical support to active-duty personnel and secondarily to provide health care for dependents, survivors, and retirees on a space-available basis. Although the multiple objectives of the MHSS at times conflict with each other, the military has latitude in recommending and implementing health-care alternatives which can be observed in its composition and utilization of medical personnel. A measure of effectiveness (MOE) for utilizing manpower at a medical treatment facility (MTF) must be able to measure both medical and military inputs/outputs in terms of capacity and quality while including such diverse elements as budget, beneficiary population, technological capability, medical workload and case mix along with military contingency/augmentation readiness, training and retention. This study has developed a methodology to encompass multiple requirements and to measure technical efficiency for the production of health care. Technical efficiency can, in turn, be used as a relative measure of effectiveness.

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THESIS DISCLAIMER

The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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Professor David Whipple must be recognized for his years of research on military healthcare. He suggested that I examine the data envelopment analysis methodology. My understanding of the health-care process has broadened significantly because of his enthusiastic encouragement to examine new processes for the delivery of medical care.

My family endured the time that their father spent on the computer during all hours of the day and night. Hopefully, they may some day benefit from our experiences in Monterey. My wife, Lenore, deserves full recognition for her role in facilitating the study.

I. INTRODUCTION

A. PROBLEM

Managers of medical treatment facilities (MTFs) lack reliable performance measures that capture, in a quantifiable way, the intensity of care being provided, level of resources consumed (human and material), or quality of the output [Ref. 1]. The Navy needs a measure to determine the best allocation of medical resources. As one of its recommendations, the Medical Blue Ribbon Panel Report specifies that measures of effectiveness (MOE) will be evaluated in order to describe performance and the responsiveness of the Navy health-care system. The significance of the issue is reinforced by the Surgeon General [Ref. 2] who states that "Navy Medicine presently has no means to measure individual or aggregate hospital or clinic performance." In addition, he emphasizes the need to implement MOEs in all aspects of Navy medicine. For the purposes of this study, the problem is limited to evaluating measures that identify the efficient utilization of manpower resources. The application of a technical MOE is necessary to allocate resources of medical personnel more efficiently as standards of medical care affect requirements, as changing force structure and military budgets alter constraints, and as the recruitment and retention of qualified personnel becomes more difficult.

Beyond the immediate concern, the need to determine efficiency is a Department of Defense (DOD) priority. The DOD instruction entitled ***Efficiency Review, Position Management, and Resource Requirements Determination*** states:

> "DOD components shall manage, provide resources, and evaluate activities based on output performance requirements and standards documented in performance work statements (PWSs). Resource requirements to accomplish the output(s) established in the PWS shall be determined based on the implementation of the most effective organization (MEO), structured to achieve economy, efficiency of operations, effective employee utilization, optimum mix of staffing, and proper classification of civilian positions. The process for determining and establishing the most efficient method and organization shall include the impact of labor-capital substitution programs (capital investments), excellent institution initiatives, work force motivation initiatives, value engineering and or value analysis, beneficial suggestions, position management; and other resource determination, productivity, and management improvement programs." [Ref.3]

The Chief of Naval Operations (OP-12) is responsible for efficiency reviews (ER) for the Navy. The Navy ER instruction reiterates the DOD guideline:

"The ER process reviews and assesses workload in terms of the activity's mission and duties; objectively reviews and determines the equipment, processes, and skills necessary for the activity to efficiently and effectively discharge those missions and duties; determines the number and defines the mix of military, civilian, and contractor manpower required; and implements a resulting plan to improve the activity's ability to accomplish its missions and duties." [Ref.]

In addition, the manpower-planning process can become a means to execute budgets by providing an incentive for managers to determine the size and grade structure of their civilian staffs. A proposed methodology should be congruent with total quality management and it should incorporate decision variables that can be altered by the decision maker in order to maximize the benefits of programs such as managing to payroll and contracting for civilian services, as well as to meet the requirements of a changing force structure.

An MOE for military health care has eluded analysts [Ref. 5]. The problem has become more pertinent as health-care expenditures have increased and as Congressional concern has addressed questions such as the utilization of MTFs and the responsiveness of the military health services system (MHSS) to provide for the needs of eligible beneficiaries. The need to contain medical costs within DOD has resulted in numerous initiatives, including the Civilian Health and Medical Program of the Uniform Services (CHAMPUS) Reform Initiative and issues concerning availability and utilization of MTFs. As the expense of DOD health care has increased over projected rates, the MHSS has come under close scrutiny during the last decade. Many recommendations have been suggested to meet some real and perceived deficiencies. Certain projects have been implemented, with varying degrees of success [Ref. 6]. The treatment of dependents and retirees at MTFs has been scrutinized and the increased cost of the CHAMPUS program has received considerable review from organizations both internal and external to DOD. In addition, the implementation of direct care varies from service to service. The various reviews by Congress of the MHSS recommend that the care provided by the components of the MHSS should be similar, but that is not the case since dependent services and care of survivors and retirees is neither consistent between services nor geographical areas.

The MHSS cares for about 2.2 million active duty (ACDU) personnel, 3 million dependents, and 4 million retired beneficiaries. In 1987, health care for ACDU personnel cost $1.9 billion, which averages to $863 per service person. In comparison the treatment of non-active beneficiaries cost $3 billion at MTFs plus $2 more billion for CHAMPUS, an average of $714 per individual. The funding for CHAMPUS has tripled, from about $710 million in 1980 to more than $2 billion in 1987. Dependents utilize medical facilities about seven times a year, which is one and one-half times more than the general utilization by the American population. The hospital days for dependents are 967 days/1000 patients at MTFs, whereas the civilian norm is 800 days/1000 patients and 450 days/1000 patients at health maintenance organizations [Ref. 6].

Costs cannot be contained unless each of the separate medical departments of the armed forces make service-specific requirements which are congruent with the overall objectives of the MHSS. Nevertheless, the cost of health care in this country will continue to increase, as will all technologically-specialized services. Since the number of health-care billets is limited, a framework is required for measuring the efficient utilization of personnel. The triage of medical resources may be necessary with decreasing total military budgets; at its very roots military health care is based on the concept of triage -- the incremental treatment with available medical resources to support the primary military mission.

Centralized medical planning is necessary for the coordination of the above activities. It provides the logistical components necessary for the acquisition and transfer of medical resources. The assumption which underlies a centralized medical coordinating body, such as the Naval Medical Department, supposes that it can organize the utilization of resources in a systematic manner in order to provide medical guidance and support for military missions. Although the MOE will be evaluated by a centralized system, it must provide a structure to encourage appropriate change at the MTF level.

B. LITERATURE REVIEW

Studies have shown that the MHSS can compete with civilian facilities in terms of cost and efficiency [Ref. 7]. The military has also historically utilized health-care providers other than physicians. It has developed alternative delivery systems, such as substance-abuse treatment facilities. No study has challenged the value or validity of providing health care to active duty personnel, although the MHSS is questioned about its ability to respond during a major conflict.

A variety of studies, which are listed in the Bibliography, examine the MHSS. Their primary focus concerns either containing cost and demand or improving productivity. The studies conclude that the MHSS is difficult to analyze because the data is either lacking or inconsistent. They recommend additional information systems to define the beneficiary population, workload and disaggregated costs.

The components of medical care are, in general, difficult to quantify for numerous social and economic reasons. The MHSS is even more difficult to analyze than its civilian counterpart because it does not associate a specific cost for individual treatment [Ref. 8]. In addition professional practice, tradition, and accreditation agencies define the standards of care -- or the type of services consumed -- rather than the patient population. The economics of health-care production suggest that physicians are the primary consumers of medical resources, since health care in the direct health-care system is free for beneficiaries. Thus, the MHSS does not respond according to the traditional economic model where supply and demand equilibrate at optimality.

C. THESIS PURPOSE

The thesis will evaluate measures of effectiveness (MOE) for utilizing manpower at a medical treatment facility by analyzing data from Navy hospitals. The MOE will be able to measure both medical and military inputs/outputs in terms of capacity and quality while including such diverse elements as budget, beneficiary population, technological capability, medical workload and case mix along with military contingency/augmentation readiness, training and retention. A methodology will be developed that encompasses multiple requirements and measures technical efficiency for the production of health care.

D. DATA RESOURCES

Can aggregate data be used to determine efficiency at the MTF level using a centralized or *top-down* approach? Various sources concerning medical care at Navy facilities will be used to compare alternative MOEs. The data resources are categorized into expenditures, Naval health-care statistics, and health-care manpower.

1. EXPENDITURES

The **Annual Budget of the United States Government** [Ref. 9] provides sequential, aggregate data of force structure and changes in expenditures. The **Monthly Labor Review** [Ref. 10] compares the change in the civilian price index for health care over a series of years. At the Office of the Chief of Naval Operations, OP-801 maintains financial data of medical budgets.

2. NAVAL HEALTH-CARE STATISTICS

The Navy Bureau of Medicine (BUMED) has published the **Statistics of Navy Medicine** since 1945. The Naval Data Services Center in Bethesda, Maryland has produced an annual Health Care Planning Matrix (HCPM) starting in 1986 that lists billets at individual Navy medical care units and concludes with data aggregated by

MTF. It also provides the Standard Element Activity Report, which is a monthly summary and comparative workload report of all Naval medical treatment facilities. The HCPM of 1987 (HCPM87) will form the basis of the current study. The supplement to the **Report of the Military Health Care Study**, also includes an analysis entitled ***Marginal Cost Analysis of the Military-Health Care Study*** [Ref. 11] that includes data for DOD MTFs.

3. HEALTH-CARE MANPOWER

A number of information systems maintain data concerning the MHSS. The Office of the Assistant Secretary of Defense (Health Affairs) provides the Health Manpower Statistics report. The Defense Manpower Data Center (DMDC) in Monterey, California supports the personnel information requirements for the Office of the Secretary of Defense and has summarized medical authorizations and staffing for the services [Ref. 12]. DOD also maintains the Medical Expense and Performance Reporting System (MEPRS). OP-931 represents the Navy medical department on the Manpower and Unit Data Technical Advisory Group. A monthly report of medical officers is available from the Personnel Plans and Analysis Branch at the Bureau of Medicine (BUMED) in Washington, D.C.

The Navy Occupational Development and Analysis Center, a detachment of the Navy Military Personnel Command in Washington, D.C., provides an occupational analysis report of responses from medical department officers that was also obtained in 1987. The data can be used to determine reasons for differences in efficiency by command for specific officer-designator codes.

The data to validate a model for a measure of effectiveness is not centralized. However, the HCPM does provide an outline for cross-sectional analysis and review. Data from the HCPM of 1988 can be used for validation of an MOE. Other medically-related data resources are listed in Appendix A. In addition the Naval Health Research Center in San Diego, California maintains an inpatient medical data file. Diagnosis after 1970 are in accordance with the Eighth Revision International Classification of Disease Adapted for Use in the United States.

E. FRAMEWORK

Operations research provides a general framework for assessing the problem of defining MOEs and evaluating alternative methodologies. The process requires a statement of objectives, a description of the environment, and constraints. The alternatives are then proposed and analyzed in terms of the constraints. The proposed methodology must then be implemented, validated, and reviewed [Ref. 13]. Effectiveness is the degree to which objectives have been fulfilled; in comparison, efficiency is the ratio of the actual output to the expected output.

A measure of effectiveness should have certain qualities in terms of its relationship to the system. The attributes should include the following:

> "It should be *operationally credible*. It should clearly relate to some benefit. It should have some predictive value. It should be sensitive to factors known to influence the value. It should be measurable." [Ref. 14]

An MOE should relate to a behavioral response that has variables that a decision maker can alter or use to forecast future requirements. A quantitative measure can be used by management to improve or anticipate the phenomenon in the model.

The selection of measures of effectiveness is incumbent on the viewpoint of the organization, given certain inputs. Depending on the perspective of the department, each MOE within an organization emphasizes different priorities and approaches which are listed below as examples:

- Fiscal -- cost and budget approach.
- Efficiency Review -- incremental partial measures of output.
- Manpower -- personnel utilization.
- Materials Management -- resource use per unit.
- Comptroller -- accounting ratios.

The MOE evaluates or estimates performance relevant to procedures or policy that can be altered by the system. It provides information for maintaining accountability between individual and organizational performance by linking personnel management with productivity. When the MOEs are compared between facilities, the methods for conducting individual operations can be analyzed to improve the utilization of manpower resources, for example.

1. OBJECTIVES

An MOE for the utilization of personnel for a MTF must be able to measure both medical and military inputs, outputs in terms of capacity and quality while including such diverse elements as budget, beneficiary population, technological capability, medical workload and case mix along with military contingency, augmentation readiness, training and retention. But the multiple objectives of the MHSS are complicated and at times are in conflict with each other. Basically, the MHSS has two fundamental objectives -- to augment mission effectiveness by providing medical support to active-duty personnel and secondarily to provide health care for dependents, survivors, and retirees on a space-available basis. The MHSS has a mandate to search for alternative methods in providing health care. It also has more latitude in recommending and implementing health-care alternatives than civilian counterparts. The application of optimization techniques can improve management procedures by evaluating the alternatives in terms of objectives.

The importance of defining the objectives cannot be overstated. The primary objectives for the MHSS were defined in the **Military Health Care Study** (MHCS) of 1975 and have maintained their validity over the last decade.

> The mission of the MHSS is to provide the health services necessary to support and maintain all military forces in fulfilling their approved missions, to create and maintain high morale in the uniformed Services by providing a comprehensive and high-quality program of health services for members and other eligible beneficiaries, and to be responsive to missions directed by the Executive Branch [Ref. 15]. According to the MHCS, the specific objectives of the MHSS include the following:
>
> a. To maintain a physically- and mentally-fit, combat- and operationally-ready military force, and further:
>
> i. To provide comprehensive and high-quality health services to active duty personnel.
>
> ii. To develop, implement, maintain, apply, and evaluate health standards for the initial selection, assignment, utilization and selective retention of physically- and mentally-fit military personnel, and for the disposition of those determined to be unfit.
>
> iii. To perform research, development and evaluation required to support military missions and forces.
>
> b. To ensure the timely availability of trained manpower and other health resources required to provide support to approved combat, mobilization, and contingency plans of the military forces, while maintaining a professionally viable and effective military health care system that is an incentive for the recruitment and retention of high-quality health professionals in an all-volunteer military force; specifically:
>
> i. To provide a full spectrum of medical diagnostic problems essential for the continuing education, training, development, and challenge of health professionals.
>
> ii. To conduct clinical investigation, training, and education functions essential to maintain qualified health service staffing and to provide health services.
>
> c. To provide a program of health services to all eligible beneficiaries as currently authorized by law, and which has developed through practice; specifically:
>
> i. To help create and maintain morale among active duty personnel by assuring that they, their dependents, and their survivors are provided comprehensive high-quality health services.
>
> ii. To encourage career commitment among active duty personnel by providing comprehensive high-quality health services for retirees, their dependents and their survivors.
>
> d. To maintain a system of health services that functions as effectively and efficiently as possible, and to assure the complete and efficient utilization of all Department of Defense health resources. [Ref. 16]

In addition the MHSS has a variety of other responsibilities, such as assistance in civilian disasters, assistance to Civil Defense and support to foreign nations in the event of natural disasters.

2. HEALTH-CARE CONSTRAINTS

The constraints for military health care are extensive. A partial list includes Federal law, DOD regulations, Service-specific requirements, military-mission support, programming, accreditation and licensing procedures, technology, professional standards of care, support of quality of life for beneficiaries, recruitment of qualified personnel, facilities, logistics, and medical training programs. An MOE operates within these limitations of the system. For the purposes of the study, the analysis is limited to Navy MTFs. The process of programming and budgeting for the Navy medical department has been clearly outlined previously [Ref. 17]. Specific criteria include the cost of system implementation, as well as the cost of calculating, maintaining, and analyzing the MOE. Other less tangible criteria are inclusiveness, comprehensibility, and flexibility.

Measures of effectiveness for medical services demonstrate the effects of either controlling demand or facilitating productivity. The factors affecting the patient's demand for medical care include the nature of the illness, cultural-demographic characteristics, and economic factors. Demand-based measures of effectiveness are difficult to implement and interpret. Methods of operations research, such as queuing theory, are used to analyze the pattern of demand. Applications of industrial engineering can be used to maximize patient flow and optimize staffing schedules [Ref. 18]. The current study focuses on the aggregate production of hospital services by the individual MTFs, although the control of demand or productivity at an individual MTF may be reflected in its MOE in relation to other hospitals in the system.

Economically, the consumption of medical resources by patients is not controlled by market mechanisms since the medical care at the MTF is essentially monetarily free to the beneficiary. Without the market control, military families use thirty percent more health-care resources than comparable civilian families [Ref. 19]. Also, the marginal benefit of additional medical care to the services with a healthy population results in the inefficient use of resources. In terms of allocation, the system has an incentive to shift costs to other accounts. However, the politics, marginal value, and programming of health care are not addressed in the thesis. MOEs categorized in terms of accounting and cost control are also not considered because the emphasis of the thesis concerns the utilization of personnel.

3. ENVIRONMENT

The environment is described in terms of legislative requirements, DOD policy, service-specific regulations, standards of care, eligible beneficiaries, fixed MTF installations, budget, and personnel. In Figure 1 on page 10 the MHSS operates within the DOD environment after it fulfills the requirements of the system of health care within the United States. The environment of the Navy medical department is as complicated as are its objectives. It spans the globe since military bases are located throughout the world. Its boundaries include not only physical and temporal limitations, but they also encompass extensive military and medical traditions. It functions within the guidelines of DOD, although it has specific mission requirements. The study will evaluate the treatment facilities listed in the HCPM, of which 24 are in the continental United States (CONUS) and 10 are outside the continental United States (OCONUS). Not all MTFs are classified as hospitals; the Navy unit-activity code lists 32 Navy hospitals.

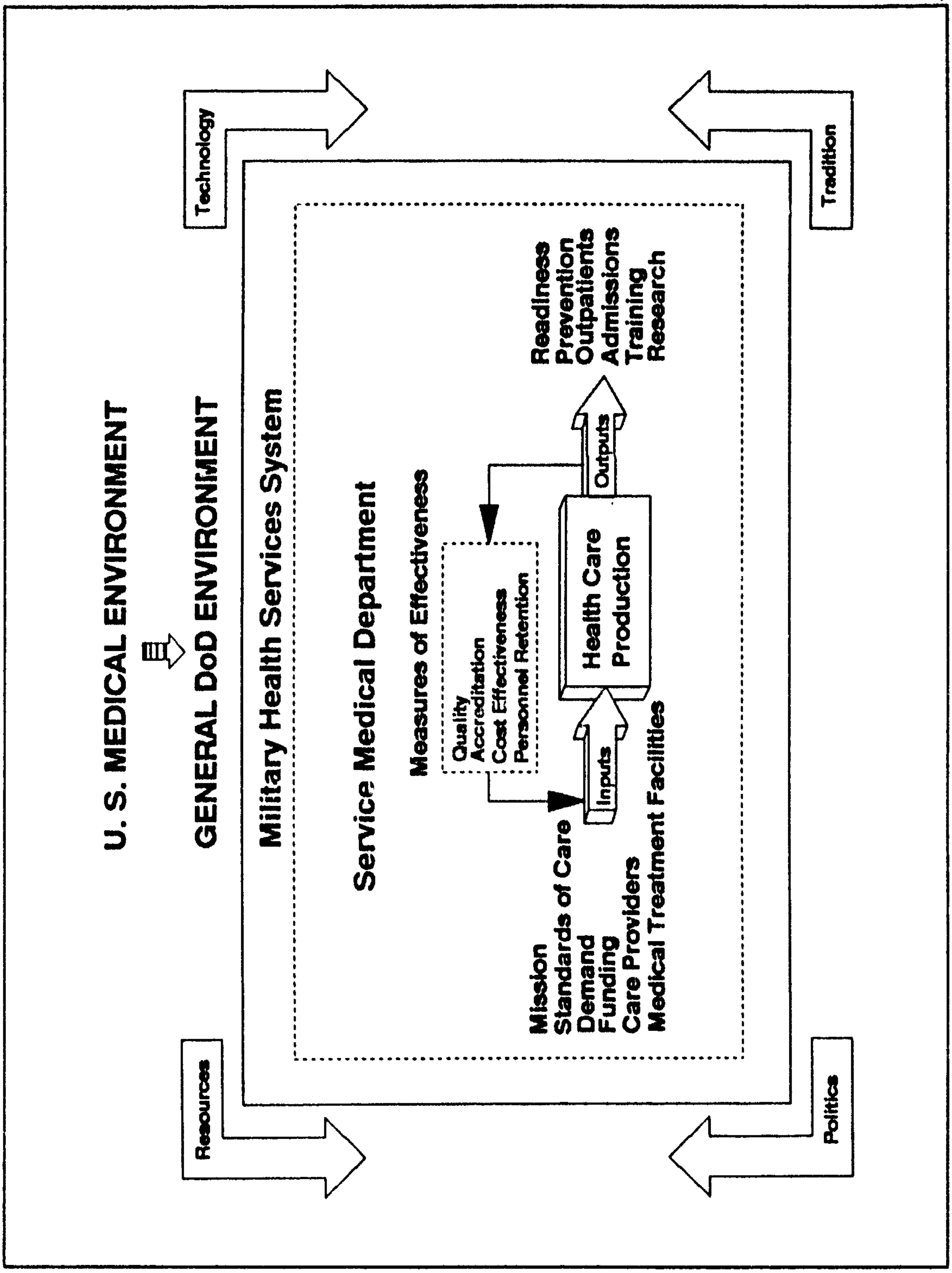


Figure 1. Environment of the Military Health Services System

II. MEASURES OF EFFECTIVENESS

Measures of effectiveness for health care are not well defined because of the differences between nonprofit, government, and profit organizations as well as private and group-practice physicians. The MOE may be too specific or an aggregated measure may not suggest a variable that can be changed by a decision maker. Aggregate measures tend to obscure variation and they lack incentives for change among individual production units. For example, an increase of a percentage in admissions for the total system does not indicate whether a particular MTF has increased its productivity. At the hospital level, a unit does not receive compensation for treating additional beneficiaries when it improves productivity. Generally, a tradeoff occurs between too large of a scope at a unit level or too much detail for the central agency.

A. ALTERNATIVES

Alternati measures of effectiveness can be categorized in terms of cost-based measures, ratio comparisons, parametric multivariate analysis, non-parametric analysis, and operation-effective measures. The categories of the alternatives are not inclusive and are meant to illustrate a variety of potential MOEs that may be applicable to a particular situation. After an alternative is selected, it is implemented and its effect is reviewed. The various alternatives are used in the thesis to support and confirm the values that are determined from a methodology classified as data envelopment analysis (DEA). The economic origins of technical efficiency and the DEA model is presented in Chapter III.

1. COST-BASED MEASURES

Most indices of labor productivity depend on a dollar value or a weighted man hour for a single-product output. For a single product the productivity of labor is the output divided by total man hours. Productivity occurs with the efficient utilization of resources for a given output, where production is simply the activity of producing health care. However, in the context of the MHSS manpower is composed of many military and civilian specialists; the multiple services provided by those personnel cannot be modelled as a single product.

The cost-based measures of aggregate care are described by the expenditures. However, MOEs based on budgets do not show relationships because they lack specific decision variables. The change in a budget does not indicate the amount or type of in-

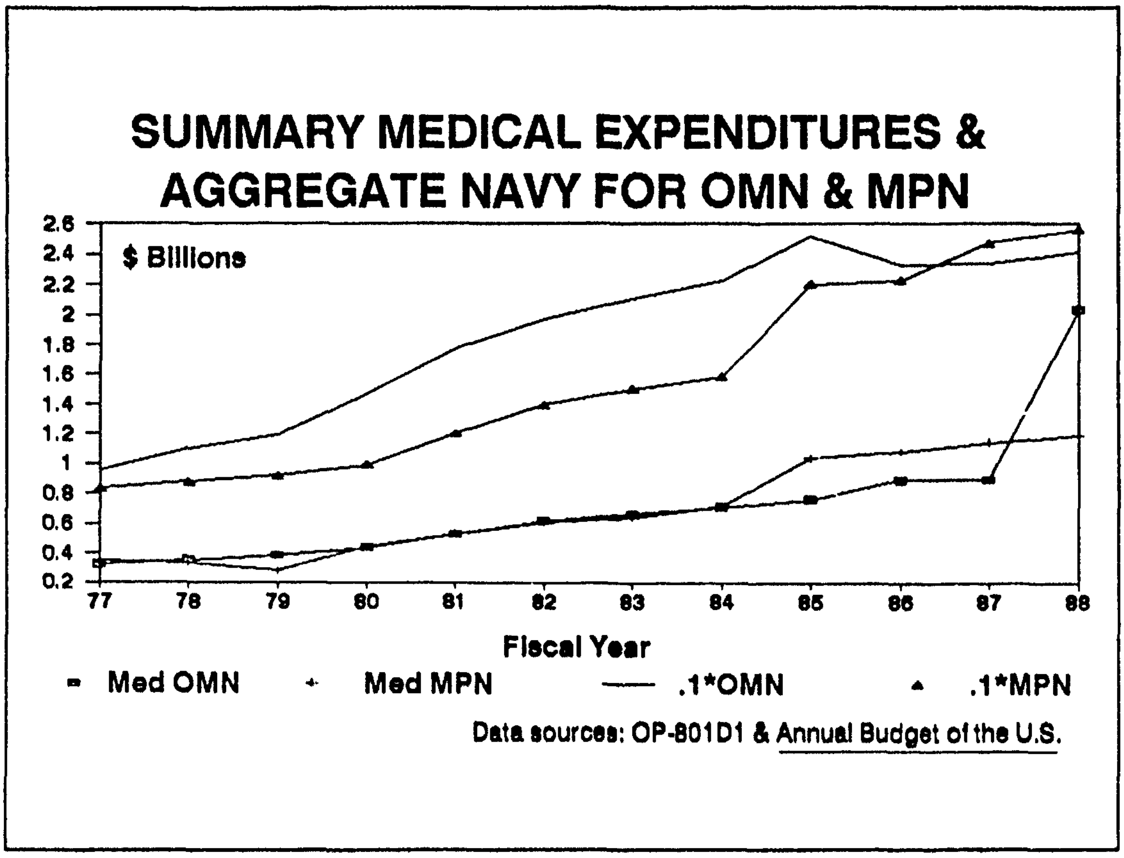


Figure 2. Navy Medical Expenditures Relative to Total Navy OMN

cremental change in the system that can improve performance. Surprisingly, expenditures for individual MTFs is unavailable because of differences in funding procedures between commands. This significant problem has not been solved and will become more inextractible under the reorganization of the Naval Medical Department; as MTFs become part of the line commands, financial accounting may become more difficult to analyze unless the Navy as a whole accounts for MTF expenditures in a uniform manner. However, the aggregated measure does not show if the utilization of personnel has changed or if the delivery of health care is more efficient.

Medical expenditures, shown in Figure 2, have increased from 3.7 percent in 1984 to 4.3 percent in 1987 as a proportion of total appropriations for manpower (manpower Navy or MPN), operation and maintenance (operation maintenance Navy or OMN), and other procurement (other procurement Navy or OPN). The 1988 fiscal-year budget for Naval Medical Department increased significantly, while most Navy components had a decrease in funding. Part of the justification for this change included the partial funding of Navy programs through CHAMPUS, which comprised 53 percent of the medical budget. The underlying justification for the action was based on the assumption that military facilities could provide less expensive care than civilian counterparts.

Although the efficiencies of the new programs have not been quantified, alternative delivery systems are being implemented and offer a significant alternative for providing out-patient health care [Ref. 20]. However, the new programs do not appear to have incentives to contain costs for either private or military health-care providers.

The difference in the change of the cost of Navy health care fluctuates more than that of consumer price index (CPI) for civilian health care, primarily because of the smaller variation which is associated with the larger civilian sample size. Figure 3 on page 14 shows that the change in the civilian CPI has been decreasing, whereas the change in Navy medical expenditures fluctuates with periods of decreases followed by abrupt increases. The change of Navy expenditures is not associated with the change in Marine and Naval personnel. Changes in age, composition, and case mix of the total beneficiary population may explain a portion of the fluctuation, but to prove this hypothesis additional data is required. Also, Navy medicine may be driven more by its budget resources whereas CPI is governed by numerous, other factors.

The problem of defining measures of effectiveness for medical care by cost is simultaneously symptomatic and directly related to a fundamental national incongruence of health-related goals pertaining both to the general population and civilian providers. The consumer believes that anything less than complete medical service is inadequate and that medical care is a right. However, the marginal benefit of additional medical care to a healthy beneficiary in the MHSS is close to zero and results in the inefficient use of resources. In fact the patient has an incentive to use the least cost-effective services.

An alternative approach would provide an incentive to physicians to use the most efficient combination of services, such as is the case in health maintenance organizations. In other words, it will be as difficult to contain costs in the military as it is in the civilian sector. Although the amount of hospitalization can be minimized and alternative delivery systems can be provided, this does not address the primary reason for increased costs of medical care in this country. The substantial change in national health-care costs will be directly related to higher expectations of care by patients and care providers. Changing professional requirements will also necessitate more training, more advanced technology, more interdisciplinary services, and more support facilities.

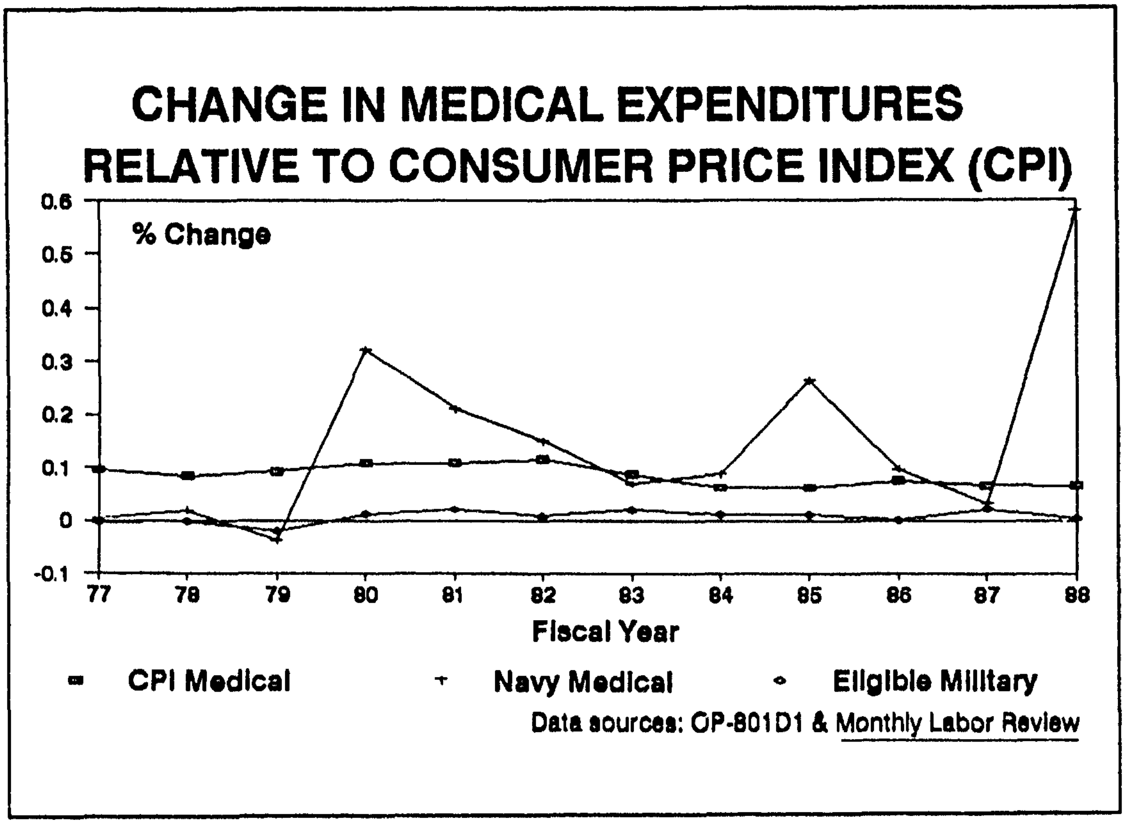


Figure 3. Change in Navy Medical Expenditures Relative to the CPI

The bottom line is that military personnel will continue to expect state of the art performance in their medical care.

2. RATIO COMPARISONS

Ratio studies generally compare the quantities of the individual components of medical services, such as the number of physicians and hospital beds per thousand population; by the utilization of medical services, such as the number of patient visits or hospital-patient days; or by aggregate measures, which include changes in prices, utilization of services, and differences in quality of services. The ratios can be compared to civilian institutions or between individual MTFs. Measurements of effectiveness for the Navy Medical Department are summarized in terms of utilization, productivity, financial, quality, and performance [Ref. 21]. Recommended measures and evaluation periods are listed in Table 1 on page 15.

Although many hospitals operate as nonprofit organizations, they can still use measures of efficiency such as industry cost per adjusted admission, routine cost per

Table 1. MEASUREMENTS OF EFFICIENCY AND FREQUENCY

MEASUREMENT	at MTF	at BUMED
UTILIZATION		
Patient Days	(C) daily, (R) monthly	(R) quarterly
Clinic Visits	(C) daily, (R) monthly	(R) quarterly
Occupancy of Staffed Beds	(C) monthly	(R) quarterly
% Non-available Time	(C) daily, (R) monthly	(R) as needed/annually
Pay or Mix	(C) monthly	(R) as needed/annually
ALOS By Nursing Type	(C) monthly	(R) quarterly
& Service Type	(C) daily, (R) monthly	(R) quarterly
PRODUCTIVITY		
Full Time Equivalent/ Weighted Patient Day	(C) monthly, (R) monthly	(R) quarterly
Required Nursing hours/ Patient Day	(C) daily, (R) daily	(R) as needed/quarterly
Actual Nursing hours/ Patient Day	(C) daily, (R) daily	(R) as needed/quarterly
Physician hours/ Clinic Visit	(C) monthly, (R) monthly	(R) as needed/quarterly
Support hours/ Clinic Visit	(C) monthly,(R) monthly	(R) as needed/quarterly
Pharmacy, Xray, Lab hours/Workload Unit	(C) monthly, (R) monthly	(R) as needed/annually
FINANCIAL		
Average Cost/Patient Day	(C) monthly, (R) monthly	(R) as needed/quarterly
QUALITY		
Unadjusted Mortality	(C) monthly, (R) monthly	(R) infrequently
Neonate Mortality	(C) monthly, (R) monthly	(R) infrequently
Nosocomial Infections	(C) monthly, (R) monthly	(R) infrequently
Surgical Wound Infection	(C) monthly, (R) monthly	(R) infrequently
Unplanned Surgical Returns	(C) monthly, (R) monthly	(R) infrequently
Re-admissions within 30 days	(C) monthly, (R) monthly	(R) infrequently
Anesthesia Mortality	(C) monthly, (R) monthly	(R) infrequently
C-section Rate	(C) monthly, (R) monthly	(R) infrequently
Special Care Returns	(C) monthly, (R) monthly	(R) infrequently
Hospital Injuries	(C) monthly, (R) monthly	(R) infrequently
PERFORMANCE		
Ancillary Workload/ Patient Day	(C) monthly, (R) quarterly	(R) as needed/annually
ALOS by DRG & Doctor Category	(C) monthly, (R) monthly	(R) as needed/quarterly
Case Mix Indices	(C) quarterly, (R)quarterly	(R) as needed/ quarterly
Market Share	(R) as needed	(C)(R) as needed
Labor Cost/Primary Statistic	(C) monthly, (R) quarterly	(R) as needed/annually
Direct Expense/Department Primary Statistic	(C) monthly, (R) monthly	(R) as needed/annually
Average Cost/DRG	(C) monthly, (R) quarterly	(R) quarterly
Supply Cost/Patient Day & By Primary Statistic	(C) monthly, (R) monthly	(R) quarterly

(C)=Collected (R)=Reviewed Source: American Management Systems, Inc.

patient day and admission, and cost per adjusted patient day. However, the only monetary assignment in the HCPM data occurred with CHAMPUS-related charges. Thus, another measurement of efficiency is needed for Naval hospitals. Other traditional measurements include occupancy (e.g., medical/surgical, pediatrics, obstetrics), average length of stay (actual and case mix-adjusted), workload by cost center, and personnel statistics in terms of full-time employees (per admission or patient day).

Workload measures are used for determining medical requirements. During World War II, the average workload for a surgeon was 1.62 cases per day; the maximum capacity for one surgeon was estimated at 10.5 cases per day for a period of one out of three days [Ref. 22]. Currently, the services must determine medical manpower requirements using the Medical Planning Module which uses historical rates to determine the number of medical personnel required to support medical casualties in theaters of operation. The wartime personnel requirements, in turn, define the peacetime personnel staffing level. The American Medical Association also publishes average workload rates for civilian physicians. But these rates do not encompass military operation, training, or readiness components.

The tri-service MHSS uses standard units of workload [Ref. 23], but the interpretation of these units in terms of efficiency is difficult when comparisons are made between MTFs or civilian hospitals. Also, the value of the units varies since an hour of physician service has a greater worth relative to an hour of output by an orderly.

Other proposed measures of efficiency are weights by diagnostic related groups (DRGs) which are used by civilian hospitals for reimbursement by Medicare [Ref. 24]. However, the DRG methodology does not measure outpatient workload or services such as laboratory tests which are required by Navy policy. Although it certainly does not measure military activities such as readiness or training, it does specify case mix and provides a mechanism to compare the number of cases with civilian hospitals. In Figure 3 on page 14 the decrease in the civilian consumer price index for medical care occurred because Medicare reimbursements after 1982 were based on DRGs. Hospitals had an incentive to reduce the amount of services provided to Medicare patients because they were reimbursed by each DRG admission, rather than by workload. Before 1983, Medicare basically paid for each service provided by the facility. Civilian providers then had an incentive to increase the amount of care given to a patient, which in turn required more resources.

Another proposed measure of manpower utilization determines manpower requirements in terms of the condition of the patient. This acuity index reflects the severity of a patient's health care needs and the quantities of nurses are determined by equations derived from ordinary least squares or OLS [Ref. 25]. The type of patient load of a hospital defines the type and numbers of physicians.

The information obtained from the measure could be used for simulating manpower requirements for wartime medical determinations. Basically, the acuity index would require costly information systems to monitor patient progress and would be difficult to implement for Navy MTFs and be biased to the training background of the personnel.

3. PARAMETRIC MULTIVARIATE TESTS

Econometric regression techniques are useful in understanding characteristics that impact on cost. For example, econometric regression analysis demonstrates the sizable impact that case mix has on hospital costs. The sum of elasticities for several inputs -- medical/drugs, medical/nurses, medical/catering, doctors/nurses, nurses/catering, medical/beds, doctors/beds, nurses/beds, catering/beds -- provide an estimate of the extent of decreasing or increasing returns to scale, but the results are closer to constant returns for larger hospitals. The coefficients of the production function are a linear function of hospital size. The elasticity with respect to medical staff increases substantially with hospital size, although one study noted that there is a low elasticity with respect to nursing staff [Ref. 26].

An aggregate measure called the composite workload unit (CWU) is parametrically estimated from admissions, births, bed days, and outpatient visits for Naval MTFs [Ref. 27]. In 1972, the coefficients were presented in the model as

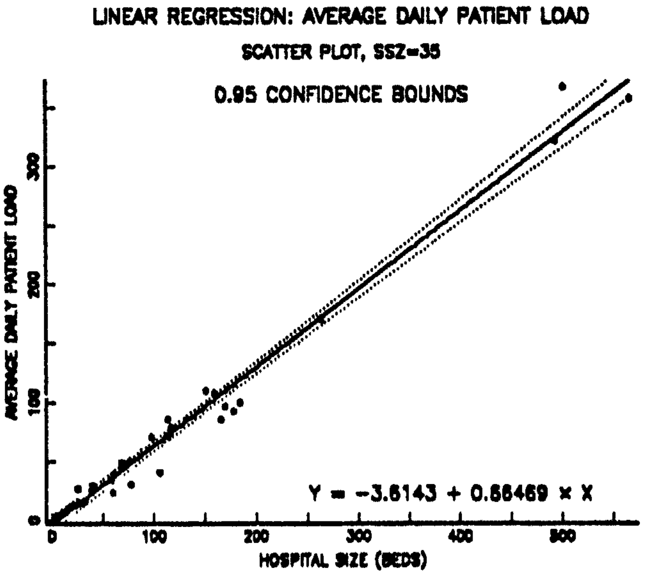
$$CWU = 141.6\ admissions - 1299.0\ births + 61.2\ bed\ day + 9.76\ outpatient\ visit. \quad (2.1)$$

The accepted CWU is reported in [Ref. 28] as

$$CWU = 10\ admissions + 10\ births + 1\ bed\ day + 0.3\ outpatient\ visit. \quad (2.2)$$

The coefficients of the CWU model change with each regression analysis of fiscal year data, which is a major problem with the approach.

The average daily patient load (ADPL) is related to hospital size, which is usually quantified by number of beds. A hospital with empty beds is usually considered less efficient since total hospital costs are directly proportional to the number of beds. The OLS estimation in Figure 4 on page 18 shows that the ADPL is directly related to the bed capacity of a hospital. It does not provide information about how to improve the utilization of personnel. As a note, Naval hospitals are categorized in terms of major



Data Source: HCPM87

COEF	ESTIMATE	STD ERR	T STAT	SIG LEVEL	95 PERCENT CONFIDENCE LIMITS LOWER	UPPER
INTERCEPT	3.6143	2.772	1.303	2.0130E1	9.2556	2.0269
BEDS	0.6646	0.015	43.564	8.3267E17	0.6336	0.6957

35 OBSERVATIONS R-SQUARED = 0.98291 STANDARD ERROR = 12.485
2 VARIABLES ADJ R-SQUARED = 0.98239

Figure 4. Average Daily Patient Load in Relation to Hospital Capacity

teaching hospitals, family practice, 98+ beds, 50-98 beds, and below 50 beds; the numbers of each category is insufficient to determine the variance of each set.

The ADPL, weighted by the number of beds, is a measure of productivity. A ratio of ADPL beds greater than 80 percent is a recognized measure of the effective utilization of hospital capacity. The percentage difference provides a buffer for transferring patients, emergencies, variation in case-load mix, and infection control.

The elasticity of health-care personnel with respect to hospital utilization demonstrates the effect that a percentage change in a personnel has on the variable APDL/BEDS. The log transformation of the variables estimates the elasticities directly; the calculation of elasticities from the Health Care Planning Matrix of 1987 (HCPM87) yields

$$ADPL/BEDS = -.2\ MC^{.50} Officer^{-1.61}\ Enlisted^{.89}. \qquad (2.3)$$

At the mean, a one percent increase in MC physicians will reduce ratio of ADPL to beds (ADPL BEDS) by .50 percent. A 1 percent increase in other officers will increase

ADPL/BEDS by 1.61 percent, whereas a 1 percent increase in enlisted personnel yields a 0.89 percent decrease. If the beta coefficient is normalized by the standard deviation of the dependent variable, the constant coefficient indicates that a one standard deviation change in a personnel category will lead to a 0.16 standard deviation change in the dependent variable. The estimated parameters are shown in Table 2.

Table 2. ELASTICITY OF ADPL/BEDS

Model fitting results for: Ln (ADPL/BEDS)

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	-0.204776	0.478042	-0.4284	0.6714
Ln MC	0.499036	0.141254	3.5329	0.0014
Ln Other Officer	-1.613733	0.375675	-4.2956	0.0002
Ln Enlisted	0.889165	0.30224	2.9419	0.0062

R-SQ. (ADJ.) = 0.3958 SE= 0.293848 MAE= 0.208956 DurbWat= 1.672
34 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

For Naval medical treatment facilities, the average daily patient load is 77 patients/day and the variable is characterized by a normal distribution. The peace-time bed capacity of the MTFs averages 121 with a utilization factor of 0.63 patients/bed. Although the summary statistics listed in Table 3 on page 20 show a large variation in the number of hospital beds, the variance in the occupancy ratio (ADPL/beds) is small. As an MOE, the occupancy ratio shows that Naval hospitals are similar in terms of utilization; however, it does not indicate whether personnel are being utilized effectively.

Table 3. COMPARISON OF THE ADPL/BEDS VARIABLES

Variable:	ADPL	BEDS	ADPL/BEDS
Sample size	34	34	34
Average	76.76	121.15	0.63
Median	44.50	74.50	0.63
Mode	86	114	0.56
Geometric mean	41.05	66.50	0.62
Variance	8963.88	19885.10	0.019

Basically, the Navy wants to know what it is getting for its health-care expenditure. Is it paying a higher than competitive price because of the influence of the medical staff [Ref. 29] or is staff expertise greater than that which is technologically necessary for a particular level and sophistication of the output? The general view is that "hospitals tend to be hoarders of labor and that the substitution of capital for labor, therefore, will most probably increase productivity and, *ceteris paribus*, reduce unit costs. A hospital may be operating with an optimum combination of input factors (land, capital, labor, and management) but because of supply-demand conditions in the market for such factors, its cost may be *high*. In fact, there is a relationship between technical and economic efficiency by the resources available to the management (the budget) and the prices of factors." [Ref. 30]

Econometric techniques, such as ordinary least squares, can indicate the relationships of inputs to outputs. For example, a relative measure of efficiency can be ascertained from a comparison of patient volume (an output) based on hospital size (an input). If a hospital has a larger output than other hospitals of its size, then it can be considered to be more efficient than others in its group. The ordering of hospitals by bed size can be criticized because of differences in location and operational functions, such as teaching and readiness training.

Other econometric procedures can be used to determine the production function of multiple inputs and outputs. For example, the parameters of the translog-cost function are estimated from the log of the cost regressed on the independent variables which are the logs of each of the outputs and inputs. The estimated parameters represent an average production function.

However, the econometric-regression studies that are traditionally used for hospital studies cannot specify the efficient scale size and efficient rates of transformation. Because they reflect the behavior of efficient and inefficient hospitals combined, the use of regression techniques does not provide insights into efficient hospital behavior.

4. NON-PARAMETRIC ANALYSIS

Non-parametric measures are not based on the assumption of an underlying probability distribution for the quantity being analyzed. For example, a short-run hospital production model can be structured as a linear programming model [Ref. 31]. In terms of efficient production, cost can be minimized subject to constraints such as resources and alternative products.

If the production function is estimated by fitting an envelope to the points nearest to the two input axes, then the approach is non-parametric since a convex hull is created from observed input-output ratios [Ref. 32]. Nonlinear programming methods, such as data envelopment analysis (DEA), establishes the concept of a relative efficiency measure based upon observed inputs and outputs of units which define the efficiency frontier. Since the frontier envelops less efficient units, the boundary provides a reference for measurement of relative efficiency and the efficiency of firms are ranked ordinally by their respective DEA value. The methodology is appropriate for evaluating the multiple resources used to produce services. The results is an overall evaluation of hospital technical efficiency. In addition, other hospital outputs -- such as teaching, research, and community education programs -- can be included in order to provide a comprehensive efficiency measure of hospital performance.

DEA is a subset of fractional programming, which is a mathematical programming technique that compares a set of actual inputs used to produce their actual output levels during a common time period. The DEA values measures the inefficiency compared with the efficient units in the set. Inefficient units are those with an efficiency ratio of less than 1 ($E < 1$) and those units are inefficient compared with other units in the set. Units with an efficiency ratio of 1 ($E = 1$) are not necessarily absolutely efficient but rather represent the best practice in a group, which means that they are not clearly inefficient compared with other units in the set [Ref. 33]. The advantages of DEA can be succintly stated in the following manner:

"The advantage of DEA is that it simultaneously considers the multiple outputs and inputs of an organization without the need to know the efficient relative weights as are needed for ratio analysis and most types of regression analysis. DEA is also unambiguous in its location of inefficient units. Beyond this, DEA conservatively measures the existing inefficiency and the amount of input reductions that would make inefficient units as efficient as other units in the set."[Ref. 34]

DEA results are then used along with ratio and regression analysis. Since the identity of the absolutely efficient hospital is not known due to lack of knowledge about efficient input- output relationships, a hospital that is found to be relatively efficient may also be able to improve its operating efficiency. A hospital that is found to be relatively inefficient will have true inefficiencies at least as large as the amount located with DEA. An inefficient hospital, as identified by DEA, is defined to have the ability to produce the same level of outputs (i.e., patient care and teaching) with fewer inputs based on the actual output-input levels of the hospitals. Moreover, DEA results actually increase the value of the subsequent use of ratio and regression analysis.

5. OPERATION-EFFECTIVE MEASURES

Operation-effective parameters include such diverse elements as patient satisfaction, retention of professional personnel, quality-control feedback, and personal development [Ref. 35]. Each of these can be analyzed at the command level. However, such measures are not improved by an increased in efficiency. Medical care is more than counting, for example, the number of sore throats at sick hall. The patient's perception of being recognized as an individual (rather than as a statistic) affects personal recovery and medical efficacy, as well as service-wide retention and readiness. In addition, medical personnel self select themselves for their vocation and their attitudes reflect a congruence with their self image. Perhaps a more efficient command will have higher morale and greater professionalism, but a tradeoff occurs when numbers indicate output. In this sense, the measure of effectiveness depends on the objective.

A global MOE for health care for the military might include an index of health status for the total force. In both peace and war, the objective of medical support should reduce morbidity and mortality. In both the civilian and military health care system, increased expenditures should improve an index of health status. If specialization or technology does not improve incremental health benefits, then another more valued need would be forgone. Also, an economic analysis should be able to quantify the value of the medical benefit in terms of enlistment and retention. Similar studies have been performed concerning the value of enlistment bonuses and retirement.

Measures of effectiveness for medical care are difficult to implement and often become convoluted in terms of quality and professional values, that are difficult to quantify. In order to make medicine accountable, an aggregate measure of effectiveness is required as a first step. The specification of an MOE based on an index of health for the military personnel is obvious because the primary function of the MHSS is medical support for service missions. Although health care for dependents, survivors and retirees is an entitlement, it encourages enlistment and retention of existing personnel.

The MHSS also places a value on utilizing the case mix provided by non-active duty beneficiaries in order to maintain proficiency and graduate medical education (such as residency programs). Economically, certain residencies provide a greater comparative advantage than others. The determination of the financial tradeoffs is complicated but would provide more cost-effective utilization of resources.

Both in concept and in practice, the military takes a holistic approach to medical care. It recognizes the value of education, attitude, devotion, diet, occupational safety, and standardization.

An index of health care is appropriate for the military. Such an index measures both the benefit of health care to a quality force and the cost effectiveness of the system. One simple, aggregate MOE for Navy medical activities is stated as the total amount of health-care expenditures divided by total hours minus the number of hours that active duty (ACDU) personnel are not available because of illness:

$$(S\ healthcare)/(total\ force\ hours - sick\ \ hours). \qquad (2.4)$$

Every additional hour that active duty personnel are sick would increase the relative cost of health care. The measure would require one data entry that corresponds to hours consumed for medical care. The MOE would then be compared against the number of hours spent by medical personnel for readiness activities plus the cost of contingency supplies. Every additional dollar spent on health care should return at least a dollar in total force capability.

The organizational structure of the medical department should be based on improving the measure of effectiveness. Structural requirements for readiness, for example, are necessary for the primary readiness objective and should be subtracted from the cost. If a decision by the medical planners was not optimal in terms of total force capability, then the MOE would show an increase in cost. If appropriate care is not timely or queuing is excessive, the MOE would reflect a problem because the active-duty member who would otherwise be engaged in their primary skill. Hospital commanders should be accountable for all costs of the command including maintenance, supplies, depreciation, and personnel. Cost shifting should be detected and any action should be accountable to that MTF. Thus, the MOE could be used to compare performance between MTFs.

The MOE would require that the division officer acknowledge that the ACDU member or dependent was going or had gone to medical. The MTF would stamp the member's medical request with time that the person entered the system. The MTF would state the care provided and stamp the time when the member left the facility. The MTF would keep a copy and the aggregate data would be sent to the Surgeon General, who could then monitor the duration and types of treatment at the MTFs. The division officer would forward a copy of the medical request to the line commander who could ascertain the extent of utilization of their personnel at MTFs. Health care for all service personnel and beneficiaries of a catchment area would be under a single organization.

If a physician places a service member on nonoptimal convalescent leave, the MOE would decrease. If quality decreases, the MOE would decrease because additional hospitalization or liability claims would be incurred. On the other hand, cost-effective technology should increase the MOE. Improvements in medical care should increase retention by improving the satisfaction of active duty personnel. The emphasis for military health care would be on quality of life as a means to retain a productive and trained force.

In order to encourage more efficiency at the MTF level, individual MTFs should be reimbursed at the etablished DRG rate from CHAMPUS or DOD. To encourage use of military facilities, eligible beneficiaries would not pay a deductible at MTFs. The funds should be used by the commanding officer of the MTF for personnel, equipment, or alternative production facilities in a manner that is cost effective. The MTF then would have an incentive to improve service to these beneficiaries. The MTF in turn would need to use management techniques to capture market share from competing civilian institutions and to accurately monitor the inputs necessary for a particular DRG. Specialized service would be encouraged only if it was cost effective in comparison with civilian and other military facilities.

B. SELECTION

The index of health status is an attractive alternative since additional demand is not inflated by the medical system, the producer of the service. However, implementation would be expensive and the measure would require a bureaucracy to monitor changes. It also would not identify the location of the inefficiency.

On the other hand, the DEA methodology provides a basis for determining efficient hospitals given any number of inputs and outputs. It is the only methodology which can indicate performance by MTF without being affected by the necessary requirements of parametric analysis, such as normality and homoscedasticity. When applicable, multivariate and econometric procedures are used to review and validate the methodology. The models evaluate the effective utilization of health care personnel based on productivity. The framework is then used as a decision support system to analyze manpower standards. The conceptual process is described in Figure 5 on page 26.

C. IMPLEMENTATION

The implementation of a single MOE will be difficult. The problem of instituting a MOE to an organizational problem is compounded by a number of factors including sociocultural attitudes, economics, politics, and technology. The implementation must be given enough time to equilibrate through the system; if abandoned too quickly because of initial problems, the alternative may be considered unfeasible when it is not. Naval medical personnel have undergone two major reorganizations in the last decade and they will be wary of methodologies that affect organizational behavior.

The implementation will fail if enough beneficiaries complain about their service, especially since the practice medicine is already subject to often unreasonable expectations concerning the capabilities of technology and the potential of scientific possibilities. In addition to the anxiety and uncertainty of medical treatment, unreasonable expectations will be exacerbated by the military because of the implicit assumption that health care is free and unlimited. Even though the medical treatment of eligible beneficiaries is an entitlement, dependents will not expected to be treated on a space-available basis at the MTF since families in general expect immediate and unconstrained care. An alternative then will be accepted if it appears that it provides more benefits than the existing system.

D. REVIEW

The necessary controls would include the monitoring and control of economic support, manpower resources, facilities, patterns of developing resources, patterns of distribution, regulation of resource use, and methods of administrative planning. The study emphasizes a top-down approach and analyzes aggregate data. Thus, the MOE is used together with a concept of the operation of the total system and available data. It

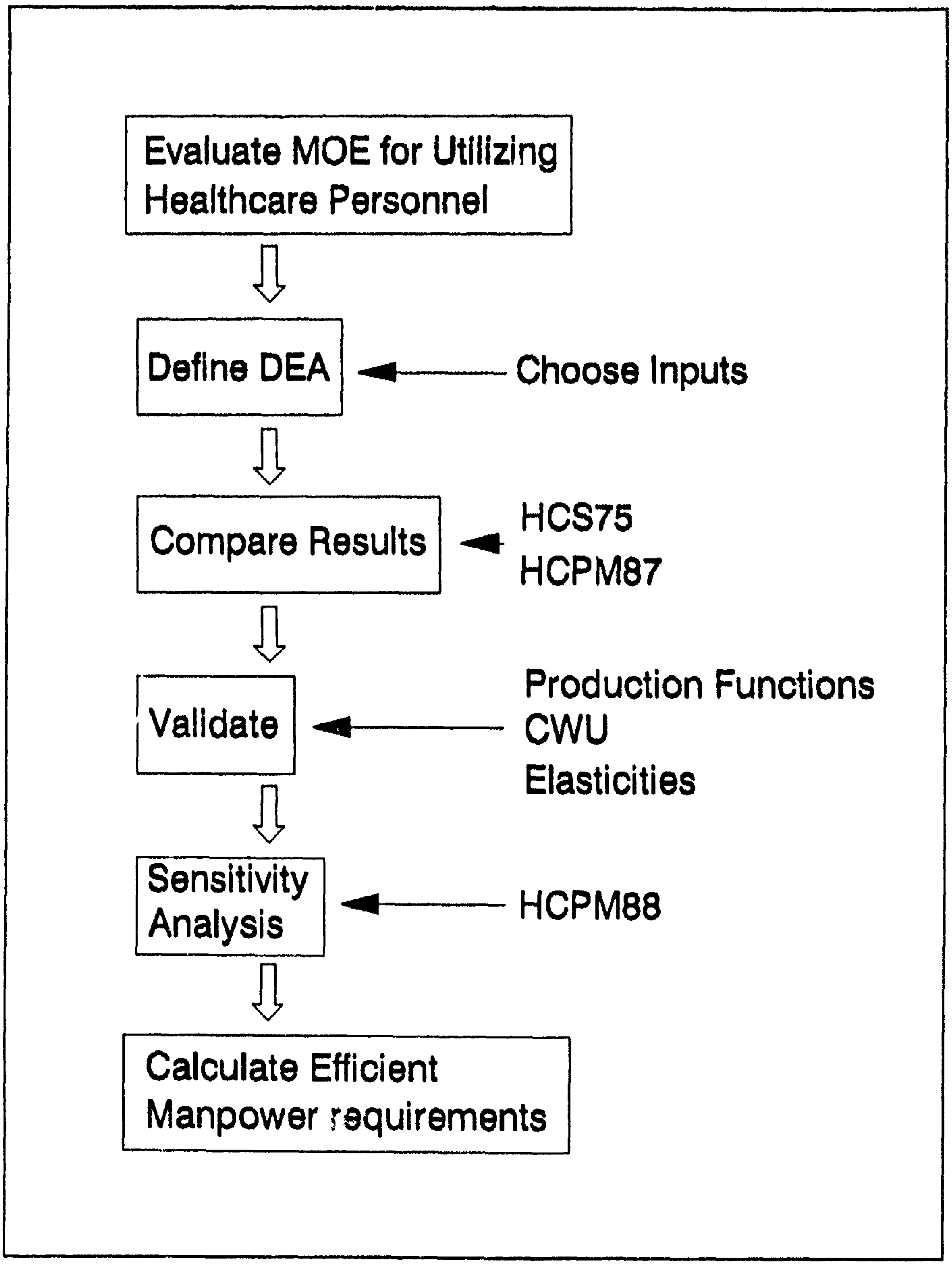


Figure 5. Study Organization and Plan

evaluates or predicts aspects of performance relevant to operational issues. Along with feedback, MOEs make an existing system work better or they can be used to design, select, and prepare for future systems.

E. SYNTHESIS

The cost of health care will continue to escalate as the standards of care require more specialization and technology. Certainly, alternative delivery methods can be implemented; however, medical care will inevitably increase significantly in cost, which can be calculated by various types of regression studies and forecasts.

Any analysis or recommendation depends on time and location and changing circumstances, institutions and relationships, the attitudes and behavioral characteristics of participants, the standards of care and technology, the traditions and expectations of the organization, and the goals and values of its members. In a dynamic environment both knowledge and prevailing attitudes are being constantly modified as well. Thus, choices reflect the structural and attitudinal changes that set the constraints on available options [Ref. 36].

To be effective incentives must be connected to the desired behavior, such as cost containment. As a prerequisite, the organizational goals must be congruent with organizational policies/objectives and with the perceived roles of its professional members. In turn, an MOE for allocative efficiency should be measured with respect to a particular objective. Politically implemented alternatives need to be phased in increments which are congruent with the existing system. The evaluation of the implementation of each phase must be guided by an understanding that the transitions will eventually meet the planned goal.

The analysis of measures for health care productivity has been difficult because medicine has not traditionally operated in a competitive environment. Physicians have ordered medical resources and secondary sources -- such as the federal government or private insurance -- often paid the bill. Since Naval facilties operate as nonprofit institutions, incremental studies have not been performed that examine the marginal cost of technology or personnel.

The first step to determine the performance of Navy medicine requires a measure of effectiveness. In particular, a measure of effectiveness for the utilization of Navy medical personnel is not defined except in terms of workload. Since the use of the DEA methodology provides a method which will allow for the identification of technological efficiency, the data from efficient MTFs determines the optimal combinations of physicians, officers and enlisted personnel. The various MOEs mentioned in this chapter are then used to validate or explain the DEA results.

III. MODEL DEFINITION

A. ECONOMIC EFFICIENCY

Efficient economic performance occurs when the marginal benefits of the last unit equal the marginal costs of the combination of inputs. The three basic choices which determine the production of medical services are (1) the amount and composition of health care, (2) the selection of the best method of producing those services and (3) the method for dispensing the medical services [Ref. 37]. Since the productivity of personnel is proportional to a production function, a structural change can be determined which will allocate resources among alternative programs to provide better health care for beneficiaries.

A production function gives the maximum possible output that can be produced from a given set of inputs; a cost function gives the minimum level of cost at some level of output, y given input prices, w. If the efficient transformation of inputs is characterized by the production function $f(x)$ and by the cost function $c(y,w)$ = $\min_x\{w'x \mid f(x) \geq y, x \geq 0\}$, then a vector of cost minimizing demands can be obtained as $x(y,w) = \nabla_w c(y,w)$. For a hospital (i), production is technically efficient if $y_i = f(x_i)$ and technically inefficient if $y_i < f(x_i)$. Thus, y_i is the maximum output produced from the vector of inputs x_i [Ref. 38]. Since the MHSS is a non-profit organization, it does not have a vector of profit maximization but it theoretically has a vector of cost minimization.

At the optimum a hospital will be technically, allocatively, and scale efficient. A measurement of relative economic efficiency would rank hospitals by some comparison of output in relation to a given amount of input. If similar inputs were allocated among hospitals, the ratio of the actual output to a theoretical maximum output would measure the efficiency with respect to an allocation of resources. An ability to minimize short-run costs is consistent with short-run efficiency, while the production function is commensurate with long-run efficiency. With a constant return to scale and a single output and two inputs of production, the production function would be a single isoquant on a graph with each of the inputs as an axis. An isoquant represents combinations of inputs such that the level of output is the same. Given constant returns to scale for the two inputs x_1 and x_2 and output y, the production frontier for a unit isoquant would be represented as $1 = f(x_1/y, x_2/y)$. In Figure 6 on page 30 an empirical isoquant for hospital

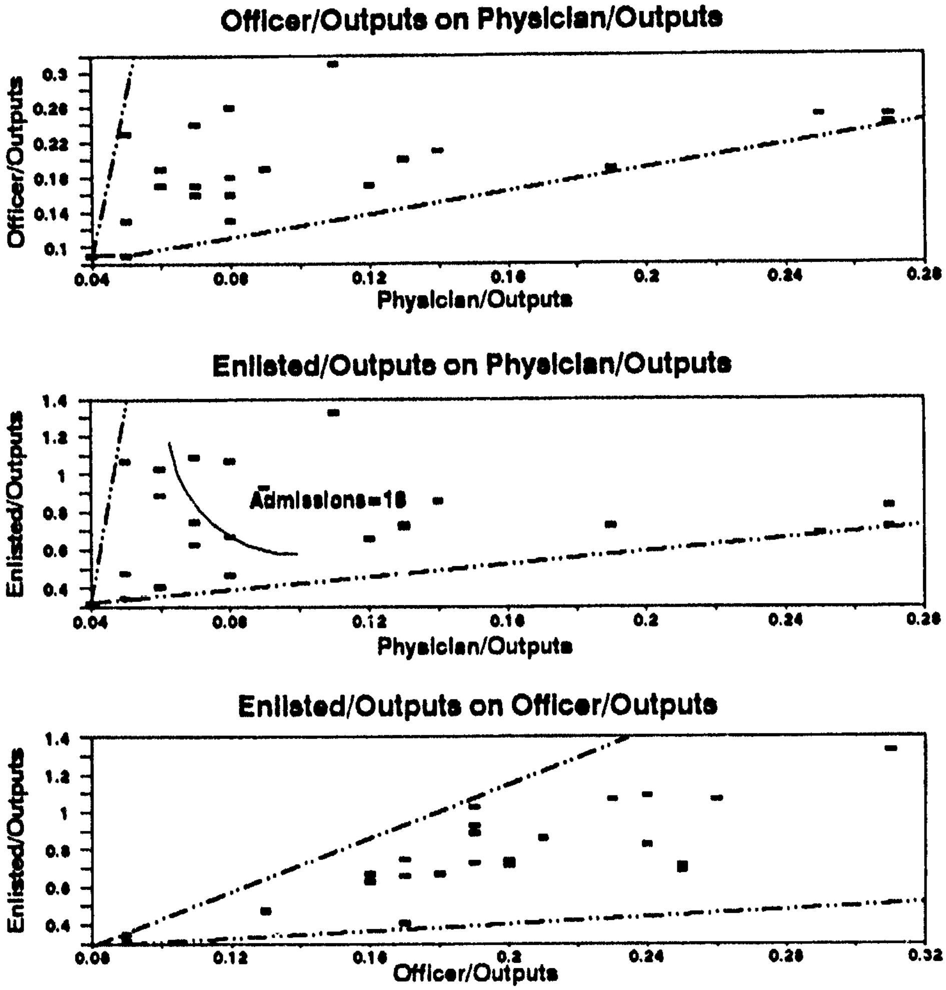


Figure 6. Components of Relative Efficiency for Naval MTFs

admissions is shown as the curve inside the cone for physicians and enlisted personnel. The three sets -- (1) physicians and other medical officers, (2) physicians and enlisted personnel, and (3) other medical officers and enlisted -- are the inputs which are normalized by dividing the component by the sum of the outputs. The inputs of the three sets can be controlled by the system and compose the largest components of medical personnel at the Naval MTFs listed in the HCPM87. The figure also illustrates that the normalized dispersion of the set called Officer/Outputs to Enlisted/Outputs is less than the other two sets because there is a linear relationship between the two inputs. The structure of these relationships will be explored further in a later chapter. The ratio of (distance from the origin of the production function)/(the distance of that line from the origin to the output) measures the extent to which the same output could be produced with fewer inputs used in the same proportion; the ratio represents technical efficiency. In other words, if a hospital could produce the same output with less of either input, then it could be more efficient in relation to the production function. When the frontier has a negative slope, an increase in the input per unit output of one factor will, *ceteris paribus*, imply lower technical efficiency.

The ratio of (distance from the origin to the intercept on the demand curve)/(distance from the origin to the intercept on the production function) measures the fraction of costs for which the output could be produced if the relative use of inputs were altered; the ratio represents technical efficiency. The concept of such a production possibilities set can be shown graphically for the single output, Admissions. If a normalized input -- such as Medical Corps (MC) -- is closer to the frontier (line a) in Figure 7 on page 32, then the facility will have a higher technological efficiency for that input. This can be shown graphically for three inputs. Figure 8 on page 33 shows three axes simultaneously from the HCPM87 data. The production cone is shown with a comparison to a point j, which represents a hospital which does not utilize personnel as efficiently as a hospital on the frontier.

B. DEA METHODOLOGY

An organization is technically efficient if it is operating on the best practice production frontier which is deterministically derived from all the organizations in the sample. The efficiency of an organization is relative to the frontier, which is derived from the combined production functions of the separate examples previously shown as two dimensional sets. The frontier represents the best technical capability of the system at that level of capacity and is simultaneously composed of all of the production functions. An organization on the production frontier is efficient, whereas an inefficient organization would have to reduce inputs proportionally for the given output.

DEA evaluates the multiple resources used to produce hospital services in terms of the outputs to gain an overall frontier or cone of hospital technical efficiency. The methodology locates those units that are relatively more or less efficient (E) and measures inefficiency compared to the more efficient units in the set. Inefficient units are those with an efficiency of less than 1 ($E < 1$). The analysis is run repetitively to derive

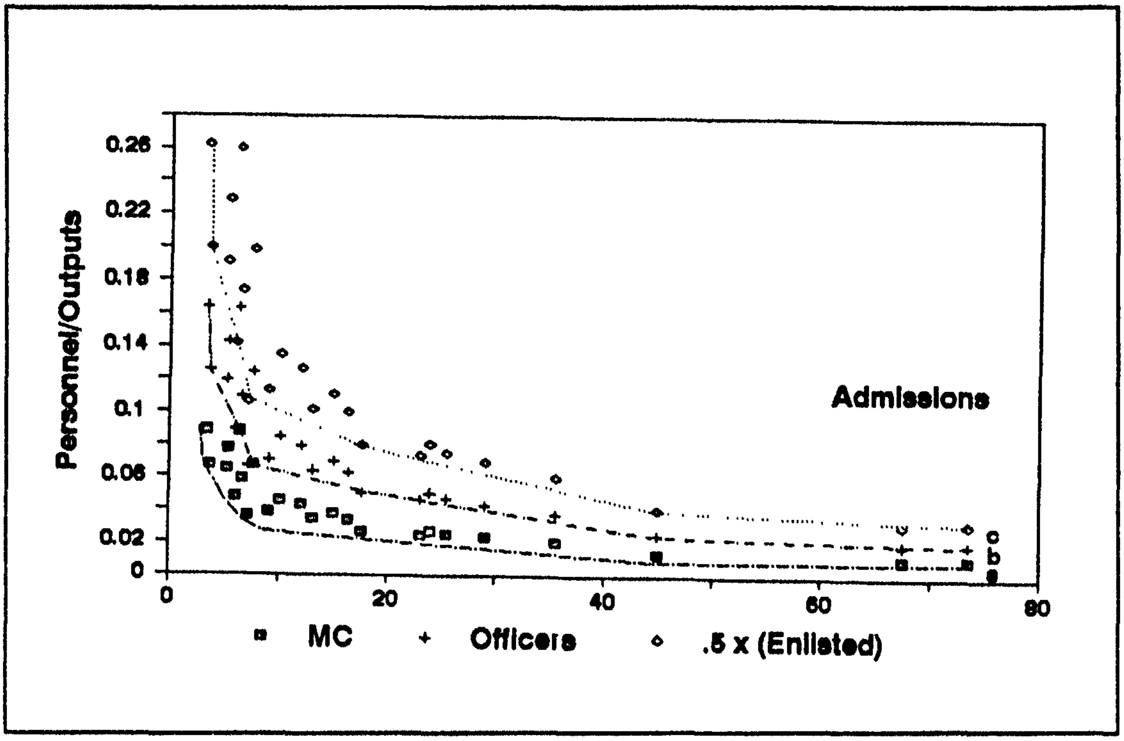


Figure 7. Technical Efficiency of Admissions for Single Inputs

the efficiency for each hospital. In addition, other military hospital requirements -- such as readiness, graduate-medical education, and training -- can be included in order to provide a comprehensive measure of MTF performance.

In terms of mathematical programming, technical efficiency can be defined as $K(u,x) = \min\{\lambda, \lambda x \in L^{*}(u)\}$, where the parameter λ represents the amount by which the observed inputs can be proportionally decreased if utilized efficiently and x is an element of $L^{*}(u)$ which is the minimal input combination that yields a given level of output, u [Ref. 39]. In Figure 7, $L^{*}(Admissions)$ represents the lower bound which is graphically represented as a non-solid line. If x is on the boundary, then λx is an element of $L^{*}(u)$. A hospital is technically efficient if $\lambda = 1$ and all slack values or weighting from the solution equal zero. Slack is the additional value of a variable that must be weighted in order to have an optimal efficiency of 1. Slack in one sense is a measure of excess or unused capacity, so that positive slack values represent inefficient use of inputs. In a graphical sense slack is seen as the distance of particular variable from the multidimensional cone previously shown in Figure 8 on page 33. In an organizational sense slack stabilizes the system in two ways: "(1) by absorbing excess resources, it retards upward

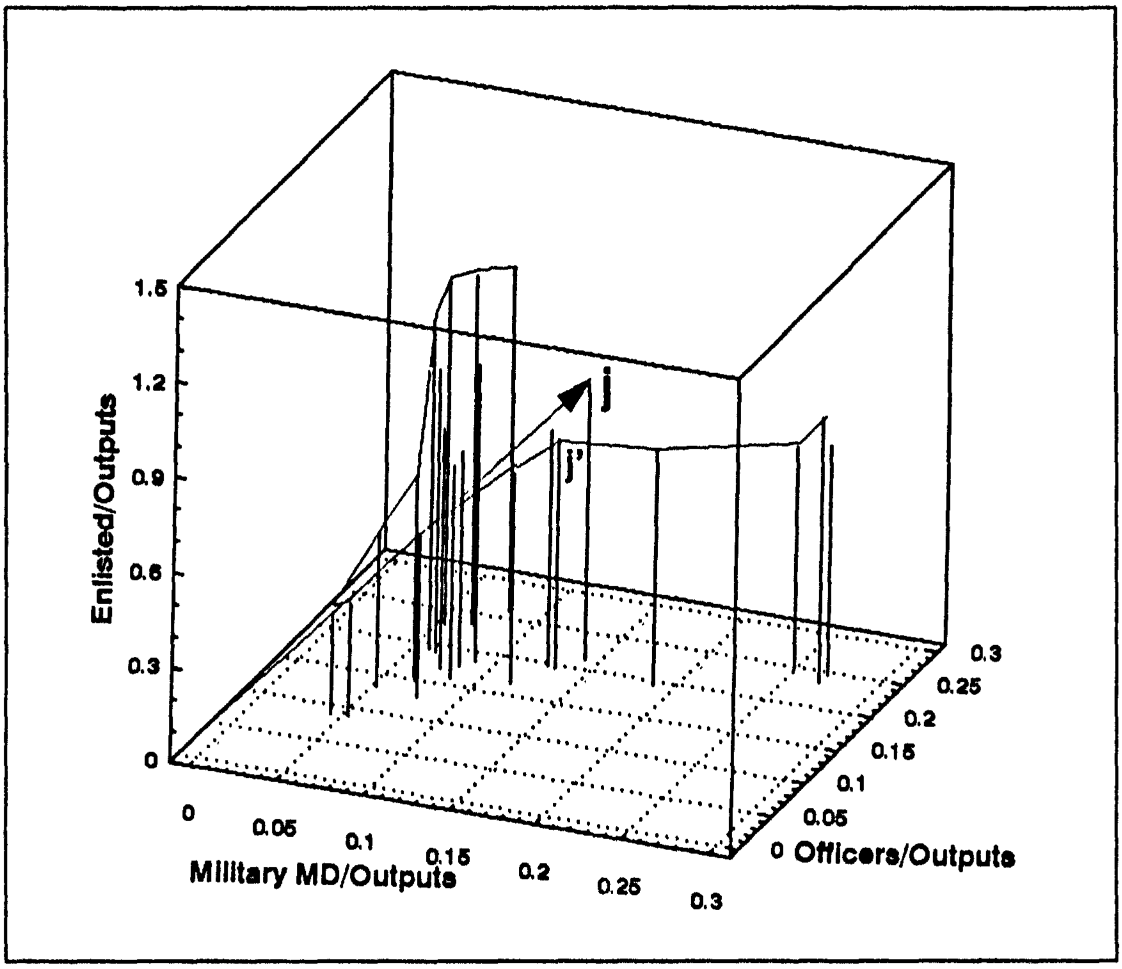


Figure 8. Cone of Efficiency Components for Three Manpower Inputs

adjustment of aspirations during relatively good times; (2) by providing a pool of emergency resources, it permits aspirations to be maintained (and achieved) during relatively bad times [Ref. 40]." Management can examine slack values to determine why the resources are not being used in a manner commensurate with the best practice. DEA is well suited as a method to measure hospital efficiency since best practice or standards of care are dynamic and are often driven by advances in technology or in medical research.

In the formulation, efficiency (E) is determined by mathematical programming techniques which operate on mainframe or personal computers. The formulation of DEA model is provided in a nonlinear format in Figure 9 on page 34 and a linear format in Figure 10 on page 35. The nonlinear and the linear programming (LP) versions of

INDICES

J	set of j = 1,...,n	hospitals where 0 is hospital being evaluated.
R	set of r = 1,...,s	outputs for a hospital
I	set of i = 1,...,m	inputs for a hospital

GIVEN DATA

y_{rj}	the observed value of output r for hospital j
x_{ij}	the observed value of input i for hospital j

DECISION VARIABLES

u_r	the weight for output r to maximize the efficiency value
v_i	the weight for input i to maximize the efficiency value

NONLINEAR DEA MODEL

maximize: $$E_0 = \sum_{r=1}^{s} u_r y_{r0} / \sum_{i=1}^{m} v_i x_{i0}$$

subject to:

$$\sum_{r=1}^{s} u_r y_{rj} \leq \sum_{i=1}^{m} v_i x_{ij} \qquad \text{for } j = 1,\ldots,n$$

$$u_r \geq 0 \qquad \text{for } r = 1,\ldots,s$$

$$v_i \geq 0 \qquad \text{for } i = 1,\ldots,m$$

Figure 9. Nonlinear DEA Formulation

DEA were implemented in the General Algebraic Modeling System (GAMS) [Ref. 41]; the nonlinear version is presented in Appendix D. A specific nonlinear model with MTF data for 1975 and a linear model [Ref. 42] with optimized personnel numbers are in Appendix D.

The decision variables for the procedure determine the weight of the summed outputs and the summed inputs. The efficiency is the ratio of the weighted sums. Units with an efficiency of 1 (E = 1) are not absolutely efficient but rather represent the *best practice* group of units. An inefficient hospital, as identified by DEA, has the potential to produce the same level of outputs with fewer inputs -- given current production methods.

The best way to describe the mechanics of the DEA application is to show an actual numerical example. In Figure 8 on page 33, Hospital j is clearly not on the efficient production frontier; thus, its efficiency will be less than one (E < 1). The DEA model

INDICES

J	set of j= 1,...,n	hospitals where 0 is hospital being evaluated.
R	set of r= 1,...,s	outputs for a hospital
I	set of i= 1,...,m	inputs for a hospital

GIVEN DATA

y_{rj}	the observed value of output r for hospital j
x_{ij}	the observed value of input i for hospital j

DECISION VARIABLES

u_r	the weight for output r to maximize the efficiency value
v_i	the weight for input i to maximize the efficiency value

LINEAR DEA MODEL

maximize: $E_0 = \sum_{r=1}^{s} u_r y_{r0}$

subject to:

$$0 \geq \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \qquad \text{for } j = 1,\dots,n$$

$$1 = \sum_{i=1}^{m} v_i x_{i0}$$

$$0 < u_r \qquad \text{for } r = 1,\dots,s$$

$$0 < v_i \qquad \text{for } i = 1,\dots,m$$

Figure 10. Linear DEA Formulation

calculates the weightings for each of the inputs and outputs for each hospital in the set and finds the maximum technical efficiency for Hospital j given its resources and production. Although Figure 8 on page 33 illustrates three inputs for the cone, the application has five inputs. Of course DEA can incorporate many variables; however, the technical component being measured requires an interpretation. The current model is restricted to the technical efficiency of manpower utilization and the model is as small as possible.

1. SELECTION OF INPUTS

Since the thesis is evaluating the efficiency of manpower utilization, the inputs were Medical Corps or military physicians (MILMDS), other officers including Medical Service Corps and Nurse Corps, corpsmen (ENLISTED), civilian physicians (CIVMDS), and other civilians (CIVOTH). The output variables were admissions

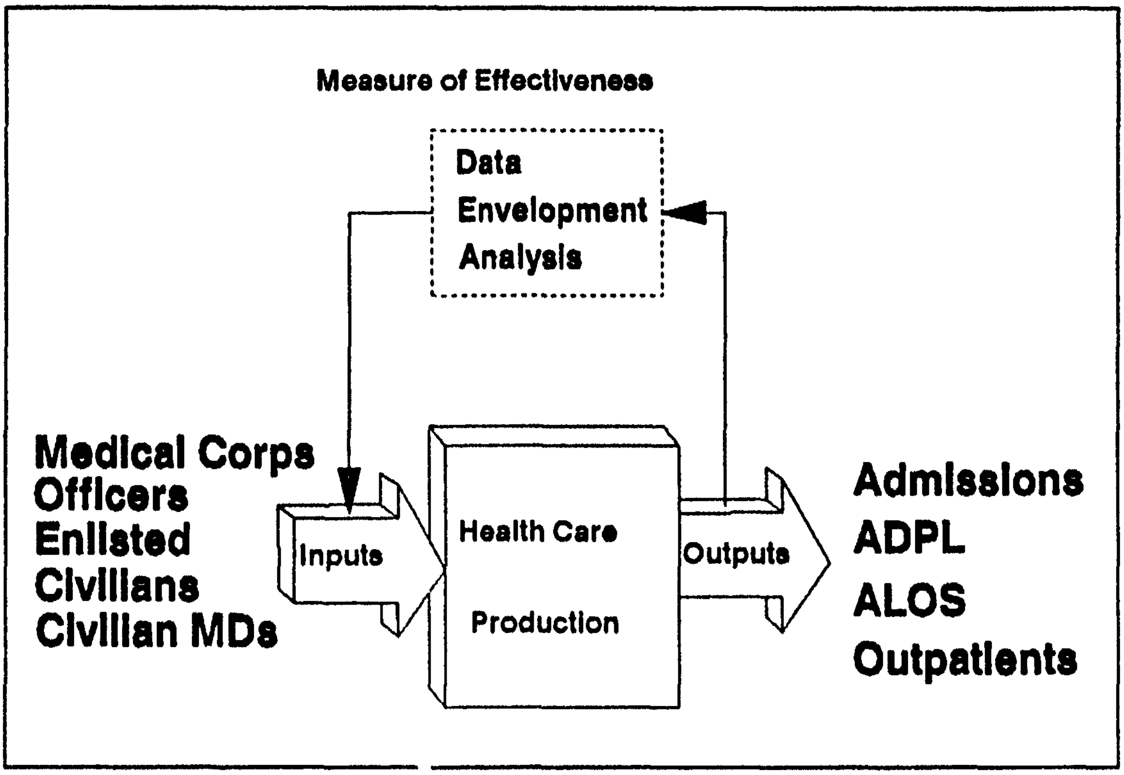


Figure 11. Selection of Inputs and Outputs for the MOE

(ADM), average length of stay (ALOS), average daily patient load (ADPL), and outpatient volume (OPV). The justification for the selection is based on the centralized approach of the study and the use of aggregated data. The relationship of the inputs and outputs in terms of the MOE is illustrated in [Ref. 42]. With these variables efficiency (E) is calculated in the following manner: (2.1)

$$E = \frac{u_1(ADM) + u_2(ALOS) + u_3(ADPL) + u_4(OPV)}{v_1(MILMDS) + v_2(OFFICERS) + v_3(ENLISTED) + v_4(CIVMDS) + v_5(CIVOTH)},$$

with variables shown as v_i for inputs and u_i for outputs. A weighting with a zero (0) value represents a technologically efficient solution for the input or output variable.

The weights calculated by the linear model for the set of all hospitals in Table 4 on page 37 include both the DEA value and the slack calculated by hospital number. The blank entries indicate no slack. Thus, the officer category is more efficient than the Medical Corp (MC) category. Nine hospitals are efficient and the average for the DEA values is 0.851.

Table 4. WEIGHTINGS OF INPUTS AND OUTPUTS AT MTFS

DEA	MILITARY MDS	OFFICERS	ENLISTED	CIVILIAN MDS	OTHER CIVILIAN	OPV	ADM	ALOS	ADPL
0.74			0.0080			0.0020	0.0110	0.0440	
0.84			0.0100	0.0380		0.0030		0.0650	
0.68	0.0170			0.0100	4.1150	0.0003	0.0130		0.0050
0.72	0.0280				0.0007	0.0010	0.0080		0.0040
0.75	0.0430					0.0020	0.0210	0.0200	
0.88	0.0340			0.0080	3.7950	0.0010	0.0110		0.0060
0.66	0.0270			0.0440		0.0010		0.0230	0.0020
0.86	0.0120	0.0030	0.0005				0.0280		0.0060
0.75	0.0390			0.0160			0.0500	0.0350	0.0060
0.96	0.0110	0.0030		0.0020		0.0000	0.0210		0.0050
0.68		0.0007	0.0020	0.0050		0.0003	0.0060		0.0050
0.62	0.0020	0.0001	0.0010				0.0110		0.0030
0.75	0.0020		0.0010		0.0000		0.0140		0.0040
0.93			0.0010			0.0001	0.0090		0.0030
0.78	0.0180			0.0180					0.0090
0.90			0.0010	0.1940	0.0005	0.0001			0.0070
0.83			0.0007	0.0020		0.0001	0.0030		0.0010
0.58	0.0670		0.0006	0.1160		0.0030		0.0650	
0.72	0.0070		0.0050				0.0520	0.0010	0.0150
0.96			0.0090		0.0020	0.0002		0.0550	0.0440
0.57	0.0050		0.0030	0.1230	0.0008		0.0090	0.0260	0.0160
0.77			0.0040	0.3730	0.0008		0.0040	0.0230	0.0160
COMPARISON OF AVERAGE WEIGHTINGS FOR EFFICIENT AND NONEFFICIENT MTFS									
E=1	0.0135	0.0006	0.0064	0.1601	0.1676	0.0011	0.0184	0 0511	0.0200
E<1	0.0223	0.0017	0.0033	0.1408	0.9893	0.0010	0.0169	0.0357	0.0087
ALL	0.0182	0.0015	0.0045	0.1493	0.6058	0.0010	0.0173	0.0421	0.0132

The optimal solution on the production frontier is compared to the actual data for the inputs and outputs. For Hospital j, the inputs and outputs result in the weightings listed in Table 5 on page 38.

The linear DEA model is generally presented in applications as the dual of the linear program. The optimal values of u_r^* and v_i^* are referred to as virtual transformation rates, which are similar to the concepts of marginal productivity and marginal rate of transformation which apply for the single output case [Ref. 43]. The linear model is compared with the results of the nonlinear model in the following chapter. The weights are observed in in Table 6 on page 38. Operationally, both models run equally fast which can be observed by the run time on a personal 80286-type of computer. The DEA values for 24 hospitals can be computed in approximately fifteen minutes.

An example of the linear model for Hospital j illustrates the affect of the variables on the weightings which are calculated by DEA. The weight of of an admission has twice the effect on efficiency as an extra patient in the ADPL, whereas the average

Table 5. WEIGHTS FOR THE NONLINEAR DEA MODEL

Given hospital production for Hospital j:

ADM	ALOS	ADPL	OPV
29.09	3.5	93	722.09

Given manpower resources for Hospital j:

MILMDS	OFFICERS	ENLISTED	CIVMDS	CIVOTH
120	195	717	5.7	269

The nonlinear DEA optimal weightings:

ADM	ALOS	ADPL	OPV
0	0	161292.011	5384.697

MILMDS	OFFICERS	ENLISTED	CIVMDS	CIVOTH
105348.571	0	22540.209	62753.113	3306.559

Efficiency:

$$E = \frac{0(29.09) + 0(3.5) + 161292.011(93) + 5384.697(722.09)}{105348.571(120) + 0 + 22540.209(717) + 62753.113(5.7) + 3306.559(269)}$$

$$E = .6286$$

Table 6. WEIGHTS CORRESPONDING TO THE LINEAR DEA MODEL

Given hospital production for Hospital j:

ADM	ALOS	ADPL	OPV
29.09	3.5	93	722.09

Given manpower resources for Hospital j:

MILMDS	OFFICERS	ENLISTED	CIVMDS	CIVOTH
120	195	717	5.7	269

The linear DEA weightings:

ADM	ALOS	ADPL	OPV
.009	0	.004	0

MILMDS	OFFICERS	ENLISTED	CIVMDS	CIVOTH
.004	0	.00080559	0	0

Efficiency:

$$E = \frac{.009(29.09) + 0 + .004(93) + 0}{.004(120) + 0 + .00080559(717) + 0 + 0} = .60$$

length of stay and outpatient visits have no effect on the locus of the production frontier. In Table 6 on page 38, the weight or output of a military physician is five times that of a corpsman for Hospital j.

With the given health-care production of Hospital j, efficiency is increased by two methods. The first requires an iterative alteration of the manpower inputs, such as decreasing the number of doctors or corpsman which will improve efficiency by increasing the ratio of outputs relative to inputs. The problem with improving the efficiency of one hospital is that the production frontier may then change, depending on the amount of slack; if the iteration exceeds the amount of slack, then the production frontier will change. A second method recalculates the manpower requirements for all the hospitals which represents a different production function. In Chapter Five, optimized manpower requirements are determined using three-stage least squares. The optimized resources produce the results presented in Table 7. If the inputs for manpower resources are decreased while keeping the outputs the same, the ratio has attained an efficiency of 1 or 100 percent.

Table 7. WEIGHTS CORRESPONDING TO INCREASED EFFICIENCY

```
Given hospital production for Hospital j:
 ADM            ALOS           ADPL           OPV
 29.09          3.5            93             722.09

Optimized manpower resources for Hospital j:
 MILMDS         OFFICERS       ENLISTED       CIVMDS         CIVOTH
 100            133            464            5.7            269

The linear DEA optimal weightings:
 ADM            ALOS           ADPL           OPV
 .011           0              0              .0003221

 MILMDS         OFFICERS       ENLISTED       CIVMDS         CIVOTH
 .004           .002           .00060051      0              .00024142

Efficiency:
     .011(29.09) + 0(3.5) + .005(93) + .0003221(722.09)
 E = ------------------------------------------------------------ = 1
     .004(100) + .002(133) + .00060051(464) + 0 + .00024142(269)
```

A number of parametric methods, as well as exploratory data analysis, are needed to show that the DEA values are the result of differences in technical efficiency. Although it is not necessary, a parametric analysis can verify the nature of the relationships between the variables before the inputs and outputs are chosen for the DEA model. In the next chapter, the variable for average length of stay (ALOS) cannot be explained by a variation in manpower; consequently, the ALOS variable may have a minimal affect on efficiency. In other words, it is important to have the outputs be a function of the inputs. The inputs and outputs must be related to a production function.

C. EFFECT OF INCREASING MODEL COMPONENTS

The input and output variables can be increased. The baseline shown with a mean efficiency of 80 percent in Figure 12 on page 41 decreases with the inclusion of the variable for readiness, which is listed in the HCPM87. If the operation/maintenance (OMN) budgets are included, then the efficiency increases to 84 percent. However, if the additional input and output are both included in the model then the overall system efficiency increases to 88 percent. Thus, a tradeoff between readiness and expenditures is observed which supports the concept of a systems approach when analyzing components of efficiency. The Navy hospitals have been ordered by bed capacity on the ordinate axis.

The DEA values which included the readiness and OMN variables were calculated for 1987 but the data was not available any other year. The validity of the data and the measure of readiness is also questioned. Thus, financial and readiness data will not be included in the analysis.

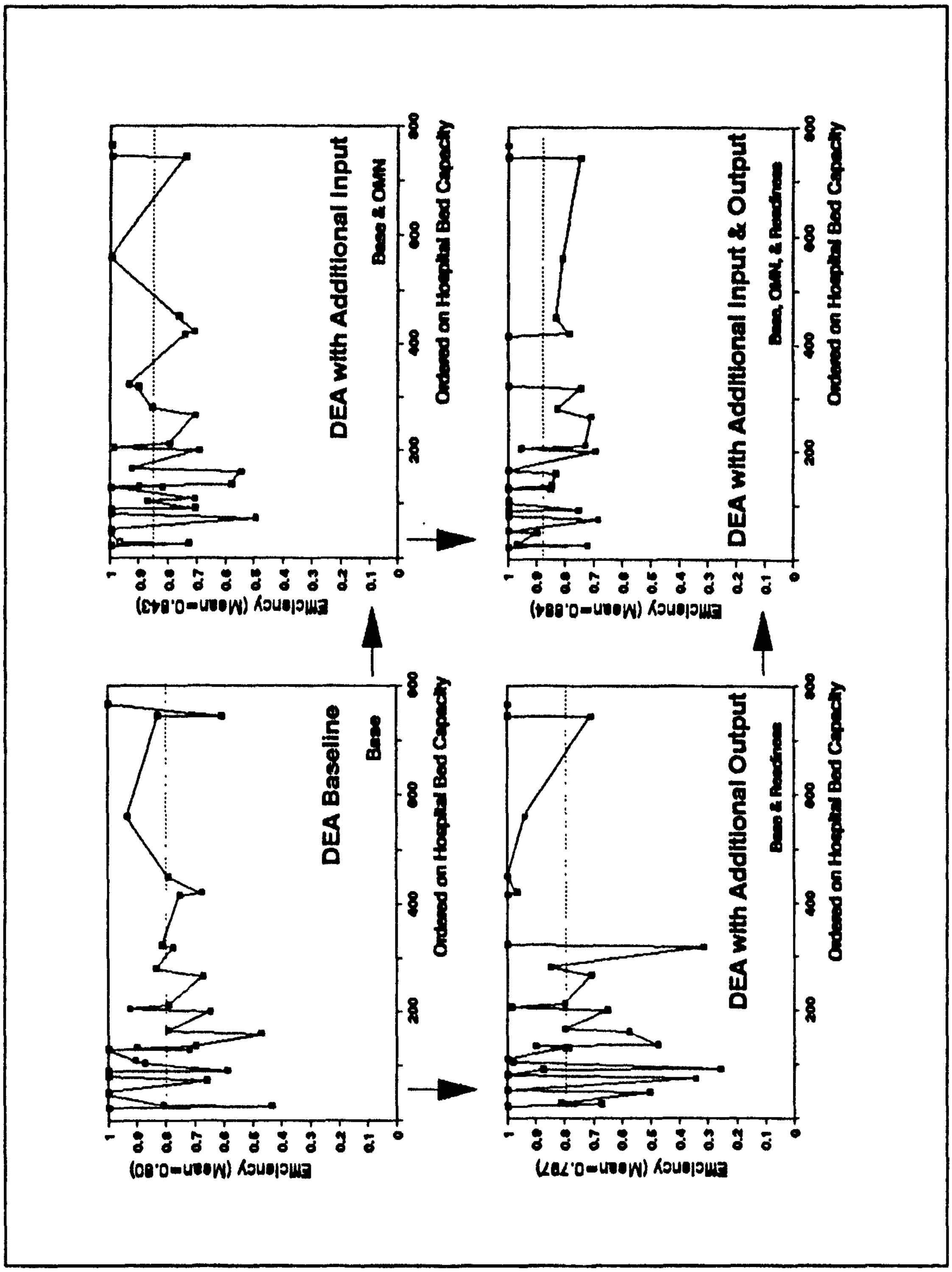


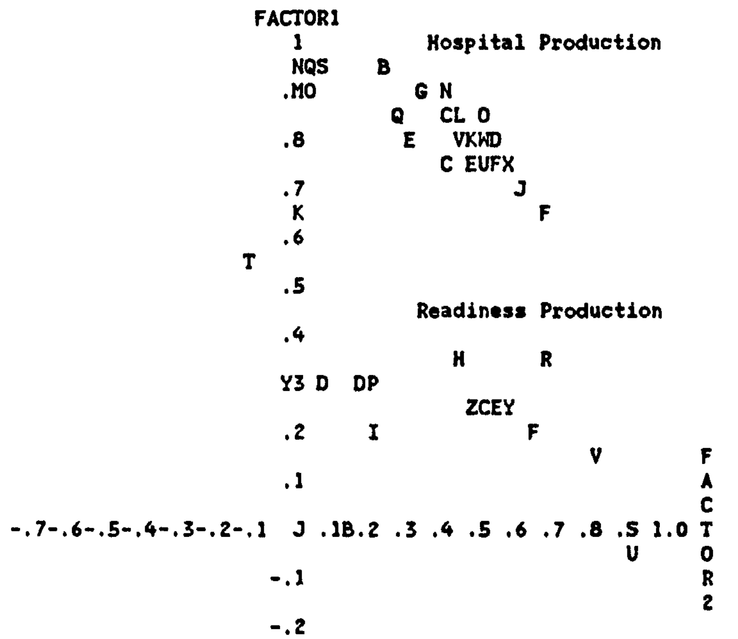
Figure 12. Effect of Readiness and Expenditures on Efficiency

IV. ANALYSIS OF THE EFFICIENCY OF MANPOWER UTILIZATION

A. FACTOR ANALYSIS

Factor analysis locates similarities between variables in a data set. Basically, medical care in the military is concerned with readiness and the production of medical care. The two-component factor analysis presented in Figure 13 uses the method of principal components to establish the patterns of similarities the two components.

ROTATION METHOD: VARIMAX



Abbreviations of Variables Presented in Factor1 and Factor2

Population=B	OPV =C	Beds =D	Peace Beds =E
War Beds =F	ADM =C	ALOS =H	ADPL =D
Lab =J	Xray =K	Pharmacy=L	Officers =D
Enlisted =N	Civilian=O	Contract=P	Nonavailability=Q
Readiness =R	Loaned =S	Borrow =T	MD =D
MC =U	DC =V	NC =W	MSC =X
Phy assist=Y	Oth Off =K	HM =N	DT =F
Enlist Oth=C	Civ MD =D	Civ RN =E	Civ tech =F
Civ other =G	Cont MD =W	Cont RN =I	Contract Hlth =J
Cont tech =K	Cont oth=J	Civ ADM =M	Civ Government =N
CivPatient=O	Civ Totl=N	Co visit=Q	Co Government =Q
Co Patient=S	DOD Beds=U	DOD Hosp=V	DOD MD =S
DOD RN =U	VA CARE =Y	VA Term =Z	Civ Hosp Beds =Y
EDS =B	Civ Hosp=C	Civ Oth =D	NPHY =E
Med School=F	CWU =C		Data: HCPM 1987

Figure 13. Plot of Hospital and DOD Factors

The decision for the selection of variables is based on the suitability of the parameter as an input/output. Medical Corps <U>, Medical Service Corps <X>, Nurse Corps <W>, and enlisted <N> cluster in a factor called hospital production. The second cluster includes readiness <R>, wartime beds and dental technicians <F>, Dental Corps and other DOD hospitals <V>, and ALOS <H> cluster in a factor called readiness production. For the purposes of the study, hospital production is specified as a frontier composed of inputs (manpower) and outputs (workload).

B. LONGITUDINAL CHANGES IN EFFICIENCY

The first empirical analysis is derived from the HCPM87 data set. Additional data samples were derived from the MHCS of 1975 and from the HCPM of 1988 (HCPM88) which was sequestered for further analysis. The DEA model was first run on the cross-sectional data of twenty-four CONUS MTFs with the values from the MHCS of 1975. The variables had to be transformed to units per day since the LP model requires daily amounts of inputs and outputs. The inputs were civilian physicians, Medical Corps (MC) physicians, other officers, enlisted personnel, civilian professionals. The outputs were out-patient volume (OPV), admissions per day (ADM), average length of stay (ALOS), and average daily patient load (ADPL). Although the number of variables that DEA can accommodate is only constrained by the software and computer system, the number of variables was limited to well-defined quantities. For this reason, the resource used for labor adjustments in the HCPM was not included in the model since the dimensions of the measures were absent. Readiness, a component of the labor adjustment, also appears to vary unconditionally regardless of the dimension. For example, Millington has a zero, Great Lakes has 32, San Diego has 896, and Oakland has 1921. The differences may be due to mission requirements and/or reporting bias.

The model evaluated the same hospitals with their respective variables from the HCS75 and HCPM87 data. In Figure 14 on page 44 the estimated Beta probability distributions and parameter estimates are presented to show the similarities between 1975 and 1987. The Kolmogorov-Smirnov two-sample test shows that the distributions are similar at a 7 percent significance level and the Mann-Whitney test indicates that the means are within one standard deviation of each other.

On the surface the most striking comparison is that average efficiency in Table 8 on page 45 has only changed 3 percent from 1975 to 1987. Although technology was different in 1975, the efficiency was confined by a production frontier or *best practice* for that time period. This suggests that the DEA methodology should be used with cross-

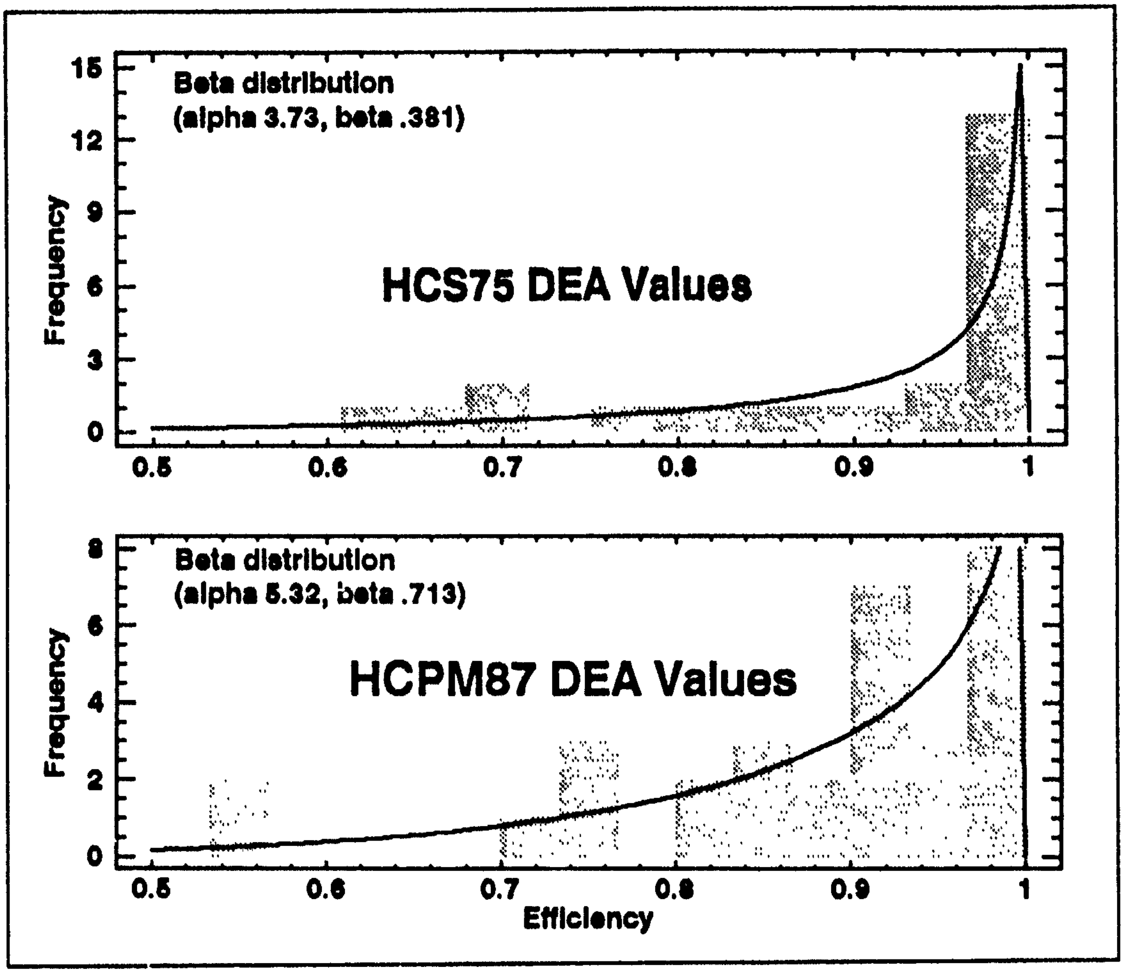


Figure 14. Comparison of Nonlinear DEA Results for 1975 and 1987

sectional or aggregate data, rather than with time-series data. Annual data between the two time periods is necessary to confirm the relationship.

The values of both the linear DEA (LDEA) and nonlinear DEA (NLDEA) models are also presented in Table 8 on page 45. Compared to the linear model, the nonlinear DEA solution method is more sensitive to differences between similar facilities and has a smaller value because the software solver uses a reduced-gradient algorithm. The production frontier is no longer piece-wise linear but curved and the function responsible for the nature of the curve has a lower value for a facet of a set of values. Graphically, the results from the nonlinear DEA model form a nonlinear lower bound on the frontier, rather than a linear production function. In the HCS75 set, the nonlinear-DEA value for the Cherry Point is interesting because it is efficient and then inefficient.

Table 8. COMPARISON OF DEA VALUES AND PROCEDURES

FACILITY	---1975--- LDEA	NLDEA	---1987--- LDEA	NLDEA	BUILT
OAK HARBOR	1	1	0.7563	0.7563	1969
PATUXENT RIVER	0.8993	0.8375	0.8835	0.8835	1969
TWENTYNINE PLM	1	1	1	1	1961
LEMOORE	1	0.9115	1	1	1961
CHERRY POINT	1	0.6791	1	1	1942
ORLANDO	1	1	0.8497	0.8497	1981
GROTON	1	1	0.7241	0.6428	1974
PHILADELPHIA	1	1	0.7094	0.5894	1935
MILLINGTON	0.7133	0.6393	0.92	0.8177	1972
NEWPORT	1	1	0.9357	0.9357	1913
BREMERTON	1	1	1	1	1980
CORPUS CHRISTI	1	0.8685	1	1	1974
BEAUFORT	1	0.9992	0.8177	0.7685	1969
CAMP LEJEUNE	1	1	1	1	1983
PENSACOLA	0.7771	0.7669	0.7855	0.7832	1975
JACKSONVILLE	0.8929	0.7094	0.6506	0.6286	1977
CHARLESTON	0.9792	0.9613	0.809	0.8039	1973
OAKLAND	0.7744	0.6505	0.93	0.774	1968
LONG BEACH	1	1	0.9057	0.7361	1967
CAMP PENDELTON	1	0.8201	1	0.8567	1974
PORTSMOUTH	0.9914	0.9321	1	1	1962
BETHESDA	1	1	1	1	1981
GREAT LAKES	1	1	1	1	1960
SAN DIEGO	1	1	0.8394	0.7611	1988
Average	0.9595	0.9073	0.8965	0.8578	
Standard deviation		0.1282		0.1350	
Skewness		-1.1072		-0.3979	

Since 1975, some of the hospitals have been rebuilt. Although a newer facility should have a higher productivity since the additional investment in capital should reduce the need for manpower, the hypothesized behavior could not be substantiated with ordinary least squares, logistic analysis or DEA.

C. COMPARISON OF CONUS WITH OCONUS NAVAL MTFS

The DEA values were obtained for twenty-four CONUS and ten OCONUS Naval MTFs. When the data is combined, the individual DEA values will change since the additional observations represent additional MTFs which may result in a different production function. Results for the combined MTFs and OCONUS MTFs are presented in Table 9 on page 46. The nonparametric Mann-Whitney test indicated that CONUS and OCONUS means are different at the 7.5 percent level of significance. The larger sample size will increase the degrees of freedom when OCONUS facilities are combined with CONUS MTFs. However, the two separate sets of hospitals have higher efficiency when they are not combined in the same analysis because some hospitals in one set are more efficient than others with similar inputs in the other set. In other words there are some OCONUS MTFs that are relatively more efficient than some CONUS MTFs for a certain level of inputs and vice versa.

Table 9. COMPARISON OF CONUS AND OCONUS SETS

Nonlinear DEA: HCPM87 Combined		CONUS	OCONUS
Sample size	34	24	10
Average	0.848544	0.900054	0.93292
Median	0.8683	0.925	0.98395
Mode	1	1	1
Geometric mean	0.836255	0.89358	0.928498
Variance	0.0202049	0.0114019	8.47299E-3
Standard deviation	0.142144	0.106779	0.0920489
Standard error	0.0243775	0.0217963	0.0291084
Minimum	0.5743	0.6506	0.7345
Maximum	1	1	1
Range	0.4257	0.3494	0.2655
Lower quartile	0.743	0.81335	0.8689
Upper quartile	1	1	1
Interquartile range	0.257	0.18665	0.1311

D. VALIDATION WITH HCPM88 DATA

The DEA results from the HCPM87 and HCPM88, shown in Table 10 on page 47, are juxtaposed to illustrate the sensitivity of the MOE. The aggregate mean efficiency of HCPM88 is 1.5 percent greater than that of HCPM87. However, the Kolmogorov-Smirnov test indicates a high probability that the two samples are from different probability distributions; DN in the table measures the maximum deviation between the cumulative distribution functions between the two data samples. The sets of aggregate data from 1987 and 1988 indicate that manpower decreased and that outputs increased which should have increased average system efficiency.

1. PRODUCTION ELASTICITIES BY PERSONNEL CATEGORY

The change in the elasticities for CWU and ALOS supports the DEA results which indicated higher efficiency in the HCPM88 data. The differences in efficiency can be explained by examining the differences in productivity and in the ALOS of the patient. Changes in the elasticities of production of the CWU and ALOS can also describe the differences. Separate OLS estimates of elasticity shown in Appendix E do indicate that more manpower is required for a CWU both in 1987 and 1988 than in 1975.

A homogenous production frontier [Ref. 44] can be writtten as the following: $\ln y = \ln f(x) - u = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln x_i - u_i, \quad u \geq 0,$ where $y \leq f(x)$. In principle productive

Table 10. COMPARISON OF HCPM87 AND HCPM88 DEA RESULTS

Variable: CONUS	LDEA87	LDEA88
Sample size	24	24
Average	0.9075	0.9249
Median	0.9323	1
Mode	1	1
Geometric mean	0.9011	0.9150
Variance	0.0112	0.0156
Standard deviation	0.1060	0.1249
Standard error	0.0216	0.0255
Minimum	0.6482	0.5409
Maximum	1	1
Range	0.3518	0.4591
Lower quartile	0.828	0.923
Upper quartile	1	1
Interquartile range	0.172	0.077

Mann-Whitney Comparison of Two Samples: Test Based on Pairs

Average rank of first group = 22.6667 based on 24 values.
Average rank of second group = 26.3333 based on 24 values.
Large sample test statistic Z = 0.950694
Two-tailed probability of equaling or exceeding Z = 0.341758
NOTE: 48 total observations.

Kolmogorov-Smirnov Two-Sample Test

Sample 1: Linear DEA HCPM87
Sample 2: Linear DEA HCPM88
Estimated overall statistic DN = 0.541667
Approximate significance level = 1.74934E-3

efficiency [Ref. 45] should be measured by the ratio of $y_i/[f(x_i; \beta) + v_i]$, rather than by the ratio of $y_i/[f(x_i; \beta)_i]$. If the input/output data only represents a cross section of hospitals at a single point in time, then relative economic efficiency cannot be estimated since independent estimates of v_i are not available for each hospital [Ref. 46].

As an alternative to productive efficiency, the elasticities were determined by log-log models using OLS. Approximately 95 percent of variation in the composite workload unit (CWU) mentioned in Chapter 1 could be explained by the MC, other officer, and enlisted personnel categories. Basically, the differences between the coefficients in 1975 and 1987 represent the change in the CWU. A 1 percent increase in physicians increases workload by 0.50 percent or a 1 percent increase in enlisted personnel increases workload by 0.21 percent. Officer productivity changed more, although the 1987 coefficient is not significant. MC and enlisted personnel are responsive to changes in workload, whereas other officers are not. The regression model is specified, as Ln CWU = f(Ln MC, Ln Officer, Ln Enlisted) plus an error term. The estimated functions are in Table 11 on page 48. The MC coefficient is significant in the three functions and consistently rounds to 0.4. Thus, an approximate 0.4 increase in MCs will increase the CWU by 1 percent. The sum of the manpower elasticities shows the response of output to a proportionate change in the inputs. A sum of one indicates a constant return to scale. The coefficients in the three models indicate a sum less than one; therefore, there is a decreasing return to scale and additional manpower will not increase the CWU at a one-to-one level.

Table 11. ELASTICITY OF THE COMPOSITE WORKLOAD UNIT

$CWU_{1975} = .93\ MC^{.37}\ Officer^{.50}\ Enlisted^{.19}$

(T-value) 2.18 2.06 2.56 1.37 n=24 Adjusted $R^2 = 0.95$.

$CWU_{1987} = 1.6\ MC^{.42}\ Officer^{.03}\ Enlisted^{.40}$

(T-value) 4.76 4.29 0.11 1.88 n=34 Adjusted $R^2 = 0.94$.

$CWU_{1988} = 4.3\ MC^{.39}\ Officer^{.23}\ Enlisted^{.13}$

(T-value) 11.92 4.58 2.04 2.84 n=34 Adjusted $R^2 = 0.94$.

CWU=10*ADM+ADPL+.3*OPV, where ADM=admissions+births,
ADPL=average daily patient load, OPV=outpatient volume, and MC=Medical Corps.

Ridge regression was also performed because of the collinear independent variables. The elasticities shown in Figure 15 on page 49 indicate that enlisted personnel in 1987 have higher levels of elasticity than their HCS75 counterparts which indicates that they contribute more directly in the CWU. Further study could establish a relationship to a variation in their training, for example, and the impact on the elasticity. As a comparison, Medical Corps and officers followed a similar ridge trace in 1975 while officers and enlisted followed a similar trace in 1987, even though there are higher initial elasticities for MC and officers. The nonlinear relationship of the officer category in terms of the enlisted category is seen as a diminishing marginal return even when calculated from the data of hospitals with above-average efficiency, as shown in Figure 16 on page 50. If the set included all DOD MTFs, then the additional values would determine empirical isoquant lines that would follow the direction of the regression plots. The substitution of the personnel categories have a similar functional form, which can be seen in Apendix D . Additional OLS and translog regressions were performed to

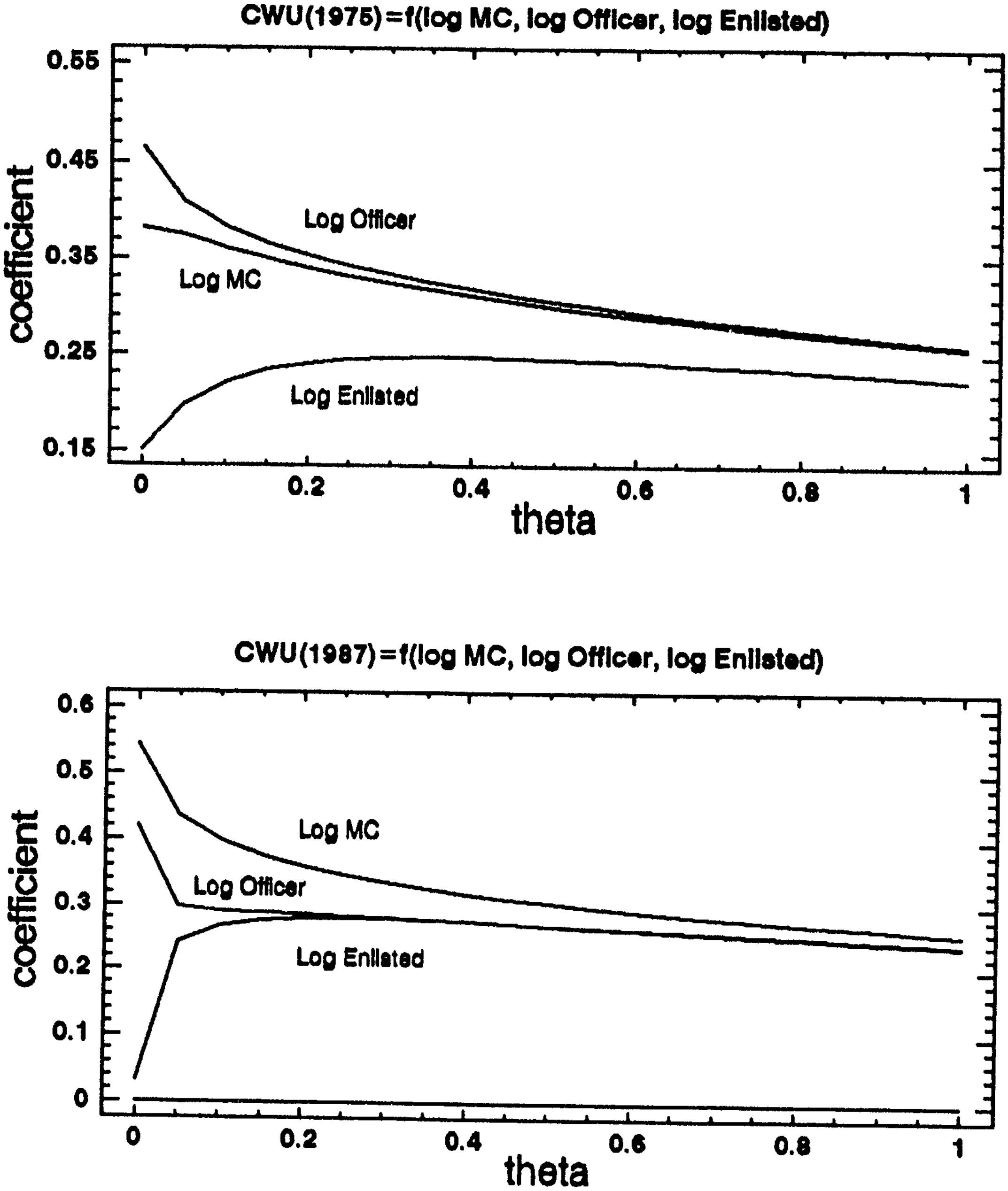
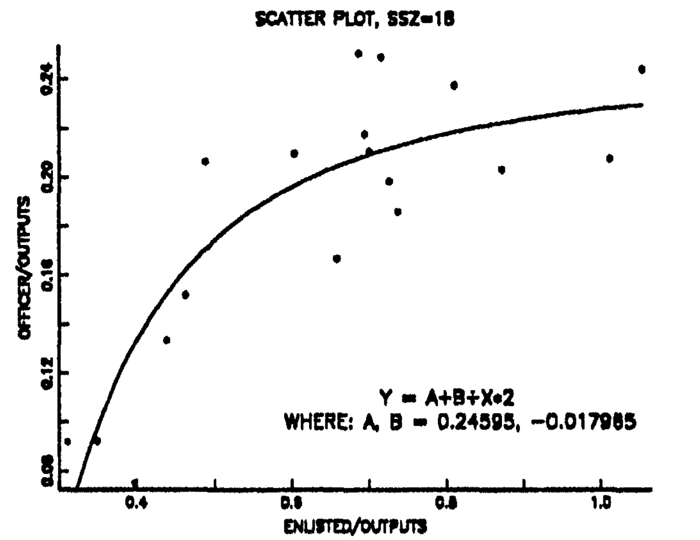


Figure 15. Ridge Regression for CWU with MHCS75 and HCPM87 data.



COEFFICIENT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	0.95 CONFIDENCE LIMITS LOWER	UPPER
CONSTANT	0.24595	0.011175	22.008	2.1788E-13	0.22226	0.26964
B	-0.017965	0.002632	-6.8236	4.0904E-6	-0.023546	-0.01238

18 OBSERVATIONS MEAN CORRECTED SS = 0.05191 STANDARD ERROR = 0.028805
2 COEFFICIENTS RESIDUAL SS = 0.013276 4 ITERATIONS R-SQUARED = 0.7442

Figure 16. Relationship of Efficient Officer and Enlisted Ratios for 1987

analyze the interaction terms for MC and Officer, MC and Enlisted, and Officer and Enlisted, but the estimated coefficients had t-values less than 2.0.

A similar analysis was attempted for average length of stay (ALOS). If ALOS can be decreased then system efficiency should also decrease since more patients can be treated in a given time for a constrained hospital capacity. When the elasticities were calculated, less variation was explained by the personnel categories than the previous estimations. The coefficients for the 1975 and 1987 regressions were not significant at the 5 percent level and the sign of the 1975 change was positive, which may indicate a fundamental change in the behavior being modeled. In 1988, a 1 percent increase in physicians increased ALOS by 0.04 percent and a 1 percent increase in enlisted personnel decreased ALOS by 0.03 percent. The functions are listed for purposes of comparison in Table 12 on page 51.

E. CHARACTERISTICS OF EFFICIENT HOSPITALS

A major reason for a measure of effectiveness is to optimize the best incremental change that will improve the efficiency of the system and to establish a mechanism to

Table 12. ELASTICITY OF AVERAGE LENGTH OF STAY

$ALOS_{1975} = 0.82\ MC^{.82}\ Officer^{.62}\ Enlisted^{-.22}$

(T-value)	1.43	0.24	0.26	1.83	n=24	Adjusted R^2 =.67

$ALOS_{1987} = -0.96\ MC^{-.27}\ Officer^{.20}\ Enlisted^{.44}$

(T-value)	-1.75	-1.53	0.39	1.20	n=24	Adjusted R^2 =.49

$ALOS_{1988} = -1.32\ MC^{-.39}\ Officer^{.58}\ Enlisted^{.28}$

(T-value)	-2.52	-3.25)	3.61	4.22	n=24	Adjusted R^2 =.57

explore the effect of varying structural components. The DEA methodology identifies the *best practice* hospitals. If certain characteristics of these MTFs can be quantifed, then the behavior may be useful for other facilities. Using DEA, system performance can be analyzed in terms of technical efficiency, structural efficiency, and allocative efficiency.

1. TECHNICAL EFFICIENCY

The major emphasis has been on the technical efficiency of inputs and outputs. Table 13 on page 52 juxtaposes efficient MTFs in terms of system averages and above-average ranges for ratios of input and output measures and also summarizes the differences.

A comparison of mean values shows that efficient MTFs use fewer manpower resources for a given amount of input. However, none of the means are different at a 0.05 percent significance level. The multiple ratios show specific relationships but they do not incorporate the effect of economic compliments and substitutes. As expected, hospitals with above-average efficiency have greater output for individual categories of health-care providers.

2. STRUCTURAL EFFICIENCY

The system can structure certain relationships that might account for differences in efficiencey. For example, if the number of doctors is based on the number of beneficiaries (doctors/thousand or Dr/M) or if the number of specialties or the number of surgeons is based on the average daily patient load, then a pattern of efficiency should develop in the system. A potential hypothesis is that a general medical officer (GMO) would treat more patients and thus be more efficient than a specialist. Using data from

Table 13. COMPARISON OF EFFICIENCY WITH INPUT/OUTPUT RATIOS

		MD per --------			Officer per ---			Enlisted per ---		
MTF	Efficiency	ADM	ADPL	OPV	ADM	ADPL	OPV	ADM	ADPL	OPV
Oak Harbor	74%	3.3	6.5	1.5	7.2	14.2	3.4	21.8	43.1	10.2
Patuxent River	84%	4.4	5.0	2.2	12.2	13.8	6.0	32.9	37.3	16.2
Twenty-Nine Palms	100%	2.6	6.4	1.3	4.9	12.0	2.5	17.7	43.2	9.0
Lemoore	100%	3.5	6.1	1.7	8.9	15.4	4.3	26.1	45.0	12.6
Cherry Point	100%	2.5	8.4	1.4	5.8	19.2	3.2	21.6	71.6	11.9
Orlando	68%	4.4	9.9	0.8	8.7	19.7	1.5	38.2	86.4	6.8
Groton	72%	5.0	11.3	1.8	11.9	26.8	4.4	48.1	108.1	17.6
Philadelphia	75%	7.1	10.8	1.8	14.8	22.6	3.8	59.4	90.3	15.3
Millington	88%	3.8	6.5	0.8	10.7	18.1	2.2	51.2	87.0	10.5
Newport	66%	4.8	4.5	0.7	12.6	12.0	1.9	42.6	40.5	6.4
Bremerton	86%	3.6	9.4	0.8	7.6	19.6	1.6	25.3	65.6	5.4
Corpus Christi	100%	4.4	2.3	0.6	16.1	8.6	2.1	56.3	30.0	7.5
Beaufort	75%	3.1	4.1	0.6	10.5	13.9	2.0	44.8	59.6	8.6
Camp Lejeune	96%	2.6	13.0	0.6	6.2	31.9	1.5	24.4	124.2	6.0
Pensacola	68%	6.2	17.8	1.3	9.9	28.4	2.2	33.9	97.2	7.4
Jacksonville	62%	4.6	34.1	1.4	6.8	50.8	2.0	25.8	192.4	7.7
Charleston	75%	4.0	25.7	1.1	5.6	36.2	1.5	20.4	131.0	5.4
Oakland	93%	7.1	50.2	1.5	6.4	45.1	1.3	17.6	124.5	3.7
Long Beach	78%	4.4	7.9	0.7	10.5	19.0	1.7	49.6	90.0	7.9
Camp Pendelton	90%	4.6	21.6	1.0	6.8	31.8	1.5	23.3	108.4	5.0
Portsmouth	100%	4.9	64.8	1.0	4.8	63.4	0.9	17.7	235.5	3.5
Bethesda	100%	9.0	53.2	1.2	7.5	44.2	1.0	22.9	135.8	3.1
Great Lakes	100%	4.9	12.5	0.8	8.0	20.6	1.2	37.0	95.4	5.7
San Diego	83%	7.8	90.4	1.5	6.4	73.8	1.2	23.0	266.2	4.4
Sigonella	100%	5.2	1.6	1.7	10.5	3.2	3.3	40.8	12.6	13.0
Keflavik	100%	2.6	1.3	0.8	2.6	1.3	0.8	29.3	14.7	9.3
Guantanamo Bay	58%	3.8	6.4	2.0	9.0	15.0	4.7	25.5	42.3	13.3
Naples	72%	3.3	6.2	1.1	8.1	15.5	2.7	23.9	45.8	7.9
Rota	96%	3.5	4.0	0.9	10.0	11.5	2.7	25.0	28.8	6.8
Roosevelt Roads	57%	4.0	5.6	1.1	11.3	15.6	3.0	38.4	53.2	10.4
Guam	77%	4.1	10.7	1.1	7.3	19.1	1.9	23.1	60.2	6.0
Yokosuka	92%	2.9	6.5	0.7	7.4	16.3	1.7	24.2	52.9	5.4
Subic Bay	100%	2.1	6.1	0.6	5.9	16.8	1.6	18.6	53.4	5.0
Okinawa	100%	2.2	9.3	0.5	6.0	26.1	1.5	23.1	100.4	5.7
	DAILY	OUTPUTS							Data:	HCPM88
EFFICIENT										
Average		4.0	15.6	1.1	7.4	21.0	2.1	28.3	76.1	7.9
Standard Error		0.5	5.1	0.1	0.8	4.3	0.3	2.8	15.3	0.8
LESS EFFICIENT										
Average		4.5	16.0	1.2	9.0	24.8	2.5	32.3	88.5	8.4
Standard Error		0.4	4.9	0.1	0.6	3.8	0.3	3.0	13.8	1.0
TOTAL										
Average		4.3	15.9	1.1	8.5	23.6	2.3	31.0	84.5	8.2
Standard Error		0.3	3.5	0.1	0.5	2.7	0.2	2.0	9.9	0.6

the Defense Manpower Data Center, the specialities of Medical Corps (MC) physicians were compared to the locations of Naval MTFs. The ratios from the HCPM88 were also included in Table 14 on page 54 to compare differences in ratios due to structural differences in the composition of physicians. If the hypothesis was substantiated, then the DEA model should include the physician specialties. Efficient MTFs have a larger number of GMOs and physicians in general, as well as fewer outpatients. However, the relationship is collinear with the average daily patient load and the differences between the efficient and less efficient hospitals in the table are less than one standard deviation.

Table 14. EFFICIENCY OF MEDICAL CORPS (MC) AT MTFS

MTF	ADPL	MC	Md*	Dr/M	OPV/Dr	Surgeon	GMO/Md	Efficiency
Oak Harbor	11	17	0	1.01	15.17	1	0.06	74%
Patuxent River	6	12	1	0.89	16.77	1	0.08	84%
Twenty-Nine Palms	12	16	0	0.80	13.32	0	0.56	100%
Lemoore	10	17	0	0.82	17.64	2	0.18	100%
Cherry Point	15	20	1	0.61	22.52	0	0.24	100%
Orlando	75	52	6.5	0.76	8.11	4	0.28	68%
Groton	19	33	2	0.76	13.11	0	0.74	72%
Philadelphia	23	31	11.3	0.59	6.55	3	0.60	75%
Millington	44	26	8.5	0.81	9.07	1	0.39	88%
Newport	42	28	2	0.83	10.91	3	0.17	66%
Bremerton	61	38	9	1.21	9.66	3	0.26	86%
Corpus Christi	31	15	3	0.78	12.78	0	0.56	100%
Beaufort	39	16	7	0.82	11.15	0	0.52	75%
Camp Lejeune	89	55	1	0.64	9.39	6	0.73	96%
Pensacola	66	86	3	1.41	6.48	6	0.76	68%
Jacksonville	92	121	5	1.24	5.34	7	0.22	62%
Charleston	102	101	7	1.14	5.58	8	0.18	75%
Oakland	172	241	15	2.20	2.98	20	0.27	93%
Long Beach	72	43	7	0.33	7.06	4	0.26	78%
Camp Pendelton	111	105	5	1.20	6.41	7	0.46	90%
Portsmouth	354	343	0.4	1.19	3.71	15	0.23	100%
Bethesda	328	398	6	3.82	2.66	23	0.24	100%
Great Lakes	112	32	52	1.02	5.33	4	0.74	100%
San Diego	332	489	8.4	1.63	2.81	29	0.26	83%
Sigonella	3	5	0	0.60	15.93			100%
Keflavik	6	5	0	0.90	21.48			100%
Guantanamo Bay	7	14	0	3.25	9.61			58%
Naples	19	20	0.6	2.76	6.22			72%
Rota	17	15	1	2.05	12.46			96%
Roosevelt Roads	21	22	1	0.94	8.53			57%
Guam	44	45	2	1.73	7.01			77%
Yokosuka	47	30	1	2.52	9.36			92%
Subic Bay	44	25	0	2.22	18.65			100%
Okinawa	81	43	0	1.29	8.68			100%
Sources:	------- HCPM88 -------				Defense Manpower Data Center			
EFFICIENT								
Average	85	79	6.0	1.4	11.00	5.31	0.34	0.97
Standard Error	24	28	2.9	0.2	1.44'	2.28	0.07	0.01
LESS EFFICIENT								
Average	61	71	4.0	1.26	8.77	5.50	0.34	0.72
Standard Error	13	30	0.6	0.13	0.65	2.33	0.06	0.01
TOTAL								
Average	73.7	75	4.9	1.32	10.07	6.13	0.37	0.85
Standard Error	15.8	20	1.6	0.14	0.90	1.60	0.05	0.02

Table 15. MTF EFFICIENCY AND NURSE CORPS ATTRIBUTES

Efficiency	MTF	Ed	Number in General Work Area ER	Ward	Co	OR	OP	Res	-Months in- Job	Grade	Work week	n
74%	Oak Harbor	1	5	0	3	2	3	0	16.3	6.4	50.3	12
84%	Patuxent River	2	3	0	1	2	0	0	26.0	17.3	56.8	8
100%	Lemoore	1	7	0	3	1	5	0	20.2	21.3	52.2	13
100%	Cherry Point	5	5	0	1	1	1	0	23.6	18.2	60.7	10
68%	Orlando	5	16	0	3	6	4	0	15.6	15.0	44.9	35
72%	Groton	3	12	0	4	7	6	1	21.5	10.1	54.0	21
75%	Philadelphia	1	3	0	1	4	1	0	9.4	29.6	40.7	10
88%	Millington	1	10	0	2	6	3	0	20.4	19.1	55.5	22
66%	Newport	2	10	0	2	5	1	0	16.8	23.8	64.8	23
86%	Bremerton	0	13	0	1	3	1	0	10.0	14.2	47.9	25
100%	Corpus Christi	2	2	0	1	1	1	0	15.0	20.0	39.0	6
75%	Beaufort	3	2	0	1	4	1	0	12.9	24.4	60.4	14
96%	Camp Lejuene	7	26	1	6	5	3	0	17.4	8.4	74.3	50
68%	Pensacola	3	30	0	6	1	2	1	17.8	10.0	56.3	47
62%	Jacksonville	3	10	0	6	6	3	0	22.0	13.0	55.6	33
75%	Charleston	5	12	1	3	0	2	0	21.2	13.6	47.4	27
93%	Oakland	7	38	0	12	6	7	2	15.9	14.9	46.1	80
78%	Long Beach	0	3	0	3	4	1	0	4.0	11.8	36.9	16
90%	Camp Pendelton	6	23	0	6	6	3	0	21.1	14.0	64.0	51
100%	Portsmouth	5	41	1	12	8	9	1	19.0	10.5	47.9	81
100%	Bethesda	6	49	0	7	2	4	0	19.1	11.7	45.5	81
100%	Great Lakes	4	13	0	3	3	3	0	12.4	15.8	50.5	24
83%	San Diego	2	14	0	3	2	1	0	13.8	17.0	46.0	33
100%	Keflavik	0	2	0	1	0	1	0	8.0	38.7	48.3	3
58%	Guantanamo Bay	1	5	0	1	1	2	0	10.2	23.4	55.8	10
72%	Naples	0	0	0	0	1	0	0	12	2.0	63.0	1
96%	Rota	2	4	0	1	2	1	0	20.3	9.4	74.3	8
57%	Roosevelt Roads	2	5	0	2	2	0	0	11.8	24.5	46.4	11
77%	Guam	2	12	0	1	3	3	0	10.1	19.3	45.2	21
92%	Yokosuka	1	10	0	4	1	2	0	15.6	13.6	42.6	16
100%	Okinawa	3	12	0	4	1	3	0	16.9	13.1	39.1	30
	Ed=education		ER=emergency room			Co=medical company						
	OR=operating room		OP=outpatient			Res=research						
n=number of respondents					Data: NODAC Medical Department Survey, 1988							
	(Sum of Category / Sum of Respondents by MTFs)											
	EFFICIENT	10%	53%	0%	13%	7%	11%	0%				
	Average								17	19	48	31
	Standard Error								1.3	2.3	1.8	8
	LESS EFFICIENT	10%	46%	0%	13%	14%	9%	1%				
	Average								16	15	53	25
	Standard Error								1.3	1.7	2.6	5
	TOTAL	10%	48%	0%	13%	12%	9%	1%				
	Average								16	16	52	27
	Standard Error								0.9	1.3	1.7	4

Another structural relationship is the type of work which is performed for a specific billet. In Table 15 on page 55 the general work areas of Nurse Corps (NC) officers is described in terms of MTFs. Behaviorally, efficiency should decrease with more levels or management or if health-care providers performed primarily administrative tasks. The majority of NC officers were in direct health-care work areas and no NC officer at a MTF in the survey worked as an administrator.

Table 16. EFFICIENCY OF HOSPITAL CORPSMEN

		----- HCPM88 -----			Months	%from	%from	
MTF	ADPL	HM	Civilian	LAB	LOS	1986	1985	Efficiency
Oak Harbor	11	112	48	3233	114	0.48	0.07	74%
Patuxent River	6	97	58	1781	107	0.37	0.02	84%
Twenty-Nine Palms	12	108	0	2121	107	0.40	0.03	100%
Lemoore	10	126	43	2059	109	0.45	0.05	100%
Cherry Point	15	179	73	4595	100	0.38	0.07	100%
Orlando	75	510	211	5961	103	0.47	0.06	68%
Groton	19	335	102	4596	138	0.20	0.02	72%
Philadelphia	23	352	213	3420	90	0.53	0.06	75%
Millington	44	461	112	5267	102	0.36	0.03	88%
Newport	42	267	159	4430	95	0.44	0.04	66%
Bremerton	61	328	261	5737	113	0.42	0.06	86%
Corpus Christi	31	231	88	3554	107	0.36	0.03	100%
Beaufort	39	334	143	3831	106	0.45	0.07	75%
Camp Lejeune	89	534	273	9455	99	0.19	0.02	96%
Pensacola	66	486	247	9109	103	0.42	0.05	68%
Jacksonville	92	712	274	11561	103	0.50	0.08	62%
Charleston	102	550	230	7491	99	0.42	0.06	75%
Oakland	172	635	347	19437	94	0.34	0.05	93%
Long Beach	72	567	357	6695	105	0.41	0.06	78%
Camp Pendelton	111	553	317	11731	96	0.34	0.03	90%
Portsmouth	354	1248	574	33346	99	0.38	0.07	100%
Bethesda	328	1032	563	44712	97	0.36	0.08	100%
Great Lakes	112	639	226	8348	114	0.41	0.06	100%
San Diego	332	1464	942	46101	100	0.33	0.05	83%
Sigonella	3	39	10	* 0	104	0.39	0.05	100%
Keflavik	6	56	0	939	* 9	0.08	0.02	100%
Guantanamo Bay	7	93	48	1655				58%
Naples	19	151	78	* 0				72%
Rota	17	115	18	4009				96%
Roosevelt Roads	21	218	88	2510				57%
Guam	44	265	114	4155				77%
Yokosuka	47	254	74	5314				92%
Subic Bay	44	219	239	7887				100%
Okinawa	81	462	99	8171				100%

* data excluded   Data compiled by Defense Manpower Data Center.

Corpsmen Length of Service (LOS) by months as of 1988 and % remaining.

<u>EFFICIENT</u>								
Average	85	401	184	9816	104.31	0.39	0.06	0.97
Standard Error	24	79	42	2759	1.58	0.01	0.01	0.01
<u>LESS EFFICIENT</u>								
Average	61	407	207	7283	103.90	0.39	0.05	0.74
Standard Error	20	84	54	2690	3.14	0.03	0.01	0.04
<u>TOTAL</u>								
Average	74	404	195	8624	100.39	0.38	0.05	0.85
Standard Error	16	57	33	1916	4.10	0.02	0.00	0.02

The relationship of certain attributes of hospital corpsmen (HM) and efficiency can also be examined. In Table 16 on page 56 the length of service (LOS) by months is juxtaposed with HCPM88 data and a comparison of the number corpsmen who remained at the MTF in 1988. Their social security numbers were matched by the zip code of the MTF and the percentages who were at the MTF after two years (1986) and three years (1985) were calculated. In terms of a system-wide attribute, there is no statistical difference at the five percent level of significance between the LOS or percentage remaining of efficient or nonefficient MTFs. The homogeneity is interesting: 95 percent of the corpsmen had left the facility after three years and 62 percent left after only two years.

3. ALLOCATIVE EFFICIENCY

In its broadest sense allocative efficiency addresses the equitable distribution of personnel resources. In a more limited context the study needs to determine if the allocation of personnel resources at individual MTFs affect efficiency. Does organizational climate and dynamics at a individual command affect performance? The data from the 1988 Medical Department Survey conducted by the Naval Occupational Data Analysis Center (NODAC) is analyzed by MTF. The results are inconclusive although trends are observed between Medical Corps (MC), Medical Service Corps (MSC), and Nurse Corps (NC) officers. For example, in Table 17 on page 57 MC and MSC officers at efficient hospitals have fewer average collateral duty hours per month than less efficient facilities. The homogeneity of the the attributes for individual facilities would suggest that organizational behavior is consistent within the Naval direct-care system. The NODAC summary stated, "Task performance by activity type did not play a significant part in the amount or type of tasks performed[Ref. 47]." In Table 18 on page 58 committee meetings are similar between facilities. The consensus for the hours spent with different type of patients in Table 19 on page 59, Table 20 on page 60, Table 21 on page 61, and Table 22 on page 62 is that all categories of officers in efficient MTFs perform more hours of healthcare per week than the less efficient facilities. The only category that is significant at the 0.05 level is the hours that NC officers provide in direct care for dependents. A table for MTF efficiency and watch duties is not included because of a wide range spent on watches by small number of repsondents. The other tables are included because they show attributes that affect personnel at individual MTFs and may be useful for additional analysis to evaluate characteristics of individual commands or MTFs.

Table 17. MTF EFFICIENCY AND COLLATERAL DUTIES

Average Collateral Duty hrs/month per Healthcare Provider

Beds	MTF	Efficiency	All	n	MC	n	MSC	n	NC	n
22	Oak Harbor	74%	18	25	15	8	27	6	15	11
28	Patuxent River	84%	21	23	35	6	20	9	13	8
36	Twenty-Nine Palms	100%	NA	NA	NA	NA	NA	NA	NA	NA
52	Lemoore	100%	21	25	19	5	22	8	22	12
80	Cherry Point	100%	15	26	6	8	20	9	17	9
104	Orlando	68%	NA	NA	NA	NA	NA	NA	NA	NA
109	Groton	72%	16	39	22	8	17	10	14	21
121	Philadelphia	75%	15	28	14	6	16	13	15	9
130	Millington	88%	17	35	12	9	19	7	18	19
130	Newport	66%	15	43	27	9	6	14	14	20
155	Bremerton	86%	NA	NA	NA	NA	NA	NA	NA	NA
165	Corpus Christi	100%	10	25	12	5	9	14	12	6
200	Beaufort	75%	19	34	17	6	17	14	21	14
205	Camp Lejeune	96%	14	80	18	14	16	19	12	47
212	Pensacola	68%	11	83	13	20	13	18	8	45
265	Jacksonville	62%	12	80	19	27	10	23	8	30
280	Charleston	75%	11	65	16	19	8	19	8	27
416	Oakland	93%	16	173	22	62	12	36	12	75
421	Long Beach	78%	12	37	23	5	9	15	11	16
450	Camp Pendelton	90%	15	102	17	32	19	23	12	47
555	Portsmouth	100%	12	170	13	54	13	39	11	77
560	Bethesda	100%	12	179	13	64	12	36	12	79
714	Great Lakes	100%	11	46	19	9	10	14	8	23
743	San Diego	83%	13	81	15	37	9	14	11	30
8	Sigonella	100%	1	4	30	2	5	1	100	1
17	Keflavik	100%	31	6	40	1	35	2	25	3
73	Guantanomo Bay	58%	20	24	21	6	26	9	12	9
26	Naples	72%	NA	NA	NA	NA	NA	NA	NA	NA
42	Rota	96%	1	18	4	3	18	8	7	7
91	Roosevelt Roads	57%	17	16	13	3	30	2	15	11
318	Guam	77%	16	55	16	23	11	10	18	22
136	Yokosuka	92%	20	35	33	11	18	9	12	15
90	Subic Bay	100%	18	2	NA	NA	18	2	NA	NA
323	Okinawa	100%	9	53	9	14	13	11	7	28

Data: NODAC Medical Department Survey, 1988

n = number of respondents NA = not available

		All	MC	MSC	NC
EFFICIENT	Average	17.1	17.9	15.4	23.8
	Standard Error	2.8	2.8	2.3	7.5
LESS EFFICIENT	Average	14.8	18.6	16.0	12.9
	Standard Error	1.2	1.9	1.7	1.0
TOTAL	Average	15.8	18.4	15.8	13.3
	Standard Error	1.3	1.5	1.3	0.8

Table 18. MTF EFFICIENCY AND COMMITTEE MEETINGS

Average Committee hrs/month per Healthcare Provider

Beds	MTF	Efficiency	All	n	MC	n	MSC	n	NC	n
22	Oak Harbor	74%	10	25	11	8	15	6	6	11
28	Patuxent River	84%	8	25	10	8	10	9	6	8
36	Twenty-Nine Palms	100%	NA	NA	NA	NA	NA	NA	NA	NA
52	Lemoore	100%	11	28	10	7	17	9	7	12
80	Cherry Point	100%	12	24	6	7	13	9	14	8
104	Orlando	68%	NA	NA	NA	NA	NA	NA	NA	NA
109	Groton	72%	1	44	10	9	13	11	7	24
121	Philadelphia	75%	9	30	9	7	12	13	4	10
130	Millington	88%	11	40	12	9	12	22	7	9
130	Newport	66%	8	46	7	10	7	14	8	22
155	Bremerton	86%	NA	NA	NA	NA	NA	NA	NA	NA
165	Corpus Christi	100%	5	25	7	5	5	14	5	6
200	Beaufort	75%	16	34	10	6	11	14	21	14
205	Camp Lejeune	95%	8	81	10	15	11	18	7	48
212	Pensacola	63%	9	83	13	19	6	18	8	46
265	Jacksonville	62%	7	84	7	28	8	24	7	32
280	Charleston	75%	10	64	7	19	7	19	15	26
416	Oakland	93%	8	172	10	66	9	34	6	72
421	Long Beach	78%	8	36	12	6	7	14	7	16
450	Camp Pendelton	90%	6	106	5	33	9	25	4	47
555	Portsmouth	100%	6	177	5	59	7	40	7	78
560	Bethesda	100%	8	181	7	70	7	36	10	75
714	Great Lakes	100%	7	47	6	10	9	16	7	21
743	San Diego	83%	7	82	6	39	7	14	7	29
8	Sigonella	100%	17	4	24	2	10	1	10	1
17	Keflavik	100%	17	6	40	1	17	2	9	3
73	Guantanomo Bay	58%	7	24	8	6	8	9	5	9
26	Naples	72%	NA	NA	NA	NA	NA	NA	NA	NA
42	Rota	96%	11	18	15	3	13	8	8	7
91	Roosevelt Roads	57%	13	16	16	4	15	1	12	11
318	Guam	77%	9	54	9	22	8	10	9	22
136	Yokosuka	92%	9	40	10	13	9	11	8	16
90	Subic Bay	100%	8	1	NA	NA	8	1	NA	NA
323	Okinawa	100%	7	50	7	14	8	11	5	25

Data: NODAC Medical Department Survey, 1988

n = number of respondents NA = not available

		All	MC	MSC	NC
EFFICIENT					
	Average	10.0	12.3	10.4	8.2
	Standard Error	1.1	3.1	1.1	0.7
LESS EFFICIENT					
	Average	8.6	9.7	9.9	8.1
	Standard Error	0.8	0.7	0.7	1.0
TOTAL					
	Average	9.1	10.5	10.0	8.2
	Standard Error	0.6	1.3	0.6	0.6

Table 19. MTF EFFICIENCY AND ACTIVE DUTY HEALTHCARE

Average Active Duty Healthcare hrs/week

Beds	MTF	Efficiency	All	n	MC	n	MSC	n	NC	n
22	Oak Harbor	74%	18	21	17	7	18	4	18	10
28	Patuxent River	84%	19	16	15	6	20	5	17	7
36	Twenty-Nine Palms	100%	NA	NA	NA	NA	NA	NA	NA	NA
52	Lemoore	100%	14	24	18	6	14	6	5	30
80	Cherry Point	100%	15	20	13	8	19	5	15	7
104	Orlando	68%	NA	NA	NA	NA	NA	NA	NA	NA
109	Groton	72%	21	35	23	7	18	7	21	21
121	Philadelphia	75%	15	20	13	5	12	8	20	7
130	Millington	88%	17	29	15	10	13	5	20	14
130	Newport	66%	21	37	24	10	23	8	19	19
155	Bremerton	86%	NA	NA	NA	NA	NA	NA	NA	NA
165	Corpus Christi	100%	13	25	16	5	6	14	28	6
200	Beaufort	75%	16	23	21	6	16	7	13	10
205	Camp Lejeune	96%	26	69	35	14	20	12	25	43
212	Pensacola	68%	16	68	19	19	12	12	16	37
265	Jacksonville	62%	10	72	14	28	7	16	9	28
280	Charleston	75%	19	51	23	18	13	10	19	23
416	Oakland	93%	17	154	21	60	14	25	15	69
421	Long Beach	78%	24	31	26	5	15	12	31	14
450	Camp Pendelton	90%	22	90	20	34	21	12	23	44
555	Portsmouth	100%	21	146	29	53	17	26	16	67
560	Bethesda	100%	17	160	18	69	14	21	17	70
714	Great Lakes	100%	23	45	26	10	19	13	24	22
743	San Diego	83%	15	72	15	36	15	11	15	25
8	Sigonella	100%	NA		30	2	NA	0	10	1
17	Keflavik	100%	19	4	27	1	NA	0	25	2
73	Guantanomo Bay	58%	21	17	28	6	8	3	21	8
26	Naples	72%	NA	NA	NA	NA	NA	NA	NA	NA
42	Rota	96%	NA		17	3	7	3	30	7
91	Roosevelt Roads	57%	15	15	25	4	20	1	11	10
318	Guam	77%	15	44	18	22	6	4	14	18
136	Yokosuka	92%	NA		28	10	8	9	29	15
90	Subic Bay	100%	NA		NA		NA		NA	
323	Okinawa	100%	25	44	31	13	22	5	23	26

Data: NODAC Medical Department Survey, 1988

n = number of respondents NA = not available

		All	MC	MSC	NC
EFFICIENT	Average	18.	23.1	15.9	18.0
	Standard Error	1.	1.8	1.3	1.9
LESS EFFICIENT	Average	16.48	20.8	14.3	19.3
	Standard Error	1.8	1.6	1.4	1.6
TOTAL	Average	18.3	21.5	14.5	18.9
	Standard Error	0.7	1.1	0.9	1.2

Table 20. MTF EFFICIENCY AND DEPENDENT HEALTHCARE

Average Dependent Healthcare hrs/week per Healthcare Provider

Beds	MTF	Efficiency	All	n	MC	n	MSC	n	NC	n
22	Oak Harbor	74%	26	23	28	8	7	4	31	11
28	Patuxent River	84%	19	17	17	6	11	4	25	7
36	Twenty-Nine Palms	100%	NA	NA	NA	NA	NA		NA	
52	Lemoore	100%	30	25	38	7	9	6	36	12
80	Cherry Point	100%	28	20	36	8	10	5	32	7
104	Orlando	68%	NA	NA	NA	NA	NA		NA	
109	Groton	72%	19	36	19	6	0	6	24	24
121	Philadelphia	75%	10	21	14	6	4	7	13	8
130	Millington	88%	22	29	24	10	6	4	25	15
130	Newport	66%	14	35	16	10	6	7	16	18
155	Bremerton	86%	NA	NA	NA	NA	NA		NA	
165	Corpus Christi	100%	13	25	14	5	5	14	33	6
200	Beaufort	75%	13	22	15	6	5	6	17	10
205	Camp Lejeune	96%	16	70	15	14	8	11	18	45
212	Pensacola	68%	20	70	24	20	8	12	16	38
265	Jacksonville	62%	20	73	25	29	8	16	23	28
280	Charleston	75%	17	50	14	17	7	10	23	23
416	Oakland	93%	19	166	21	65	10	23	22	72
421	Long Beach	78%	8	27	14	5	8	11	5	11
450	Camp Pendelton	90%	20	90	21	35	9	12	24	43
555	Portsmouth	100%	20	151	22	58	7	26	22	67
560	Bethesda	100%	19	165	19	71	8	21	18	73
714	Great Lakes	100%	15	42	21	9	0	12	18	21
743	San Diego	83%	16	73	21	38	7	12	14	23
8	Sigonella	100%	50	3	60	2	NA		30	1
17	Keflavik	100%	26	4	53	1	NA		25	2
73	Guantanomo Bay	58%	16	17	15	6	2	3	16	8
26	Naples	72%	NA	NA	NA	NA	NA		NA	
42	Rota	96%	20	13	15	3	7	3	28	7
91	Roosevelt Roads	57%	17	15	19	4	NA		18	10
318	Guam	77%	25	44	26	22	3	4	28	18
136	Yokosuka	92%	18	34	24	10	5	9	21	15
90	Subic Bay	100%	NA		NA		NA		NA	
323	Okinawa	100%	22	49	30	15	18	5	19	29

Data: NODAC Medical Department Survey, 1988

n = number of respondents NA = not available

		All	MC	MSC	NC
EFFICIENT					
	Average	24.8	32.6	8.1	26.0
	Standard Error	2.8	4.1	1.4	1.6
LESS EFFICIENT					
	Average	17.8	19.3	6.0	20.3
	Standard Error	1.2	1.2	0.8	1.7
TOTAL					
	Average	20.0	23.4	6.8	22.1
	Standard Error	1.4	2.1	0.7	1.3

Table 21. MTF EFFICIENCY AND RETIRED HEALTHCARE

Average Retired Healthcare hrs/week per Healthcare Provider

Beds	MTF	Efficiency	All	n	MC	n	MSC	n	NC	n
22	Oak Harbor	74%	12	21	10	7	7	4	16	10
28	Patuxent River	84%	13	17	24	4	8	4	12	7
36	Twenty-Nine Palms	100%	NA		NA		NA		NA	
52	Lemoore	100%	10	21	15	6	10	6	18	4
80	Cherry Point	100%	7	17	14	4	4	4	8	5
104	Orlando	68%	NA		NA		NA		NA	
109	Groton	72%	9	32	9	5	4	6	10	20
121	Philadelphia	75%	9	20	6	7	5	7	13	8
130	Millington	88%	12	27	14	10	4	4	14	13
130	Newport	66%	9	35	17	7	4	7	10	18
155	Bremerton	86%	NA		NA		NA		NA	
165	Corpus Christi	100%	14	25	12	5	5	14	35	6
200	Beaufort	75%	9	22	12	6	5	6	10	10
205	Camp Lejeune	96%	9	64	14	11	5	11	9	40
212	Pensacola	68%	15	66	19	19	5	12	18	35
265	Jacksonville	62%	12	71	13	28	10	16	13	27
280	Charleston	75%	12	48	14	10	4	10	19	21
416	Oakland	93%	16	150	17	58	11	23	17	69
421	Long Beach	78%	10	28	15	5	6	11	11	12
450	Camp Pendelton	90%	15	86	18	34	9	12	13	40
555	Portsmouth	100%	12	144	17	53	6	26	11	65
560	Bethesda	100%	18	157	64	21	10	21	18	68
714	Great Lakes	100%	9	40	6	12	7	12	10	20
743	San Diego	83%	12	69	12	33	8	12	14	24
8	Sigonella	100%	6	3	6	2	NA		5	1
17	Keflavik	100%	NA		NA		NA		NA	
73	Guantanomo Bay	58%	3	16	1	6	0	3	7	7
26	Naples	72%	NA		NA		NA		NA	
42	Rota	96%	11	13	3	3	7	3	17	7
91	Roosevelt Roads	57%	13	14	18	4	5	1	12	9
318	Guam	77%	14	42	17	21	3	4	13	17
136	Yokosuka	92%	6	33	8	9	2	9	7	15
90	Subic Bay	100%	NA		NA		NA		NA	
323	Okinawa	100%	4	39	4	12	3	5	4	22

Data: NODAC Medical Department Survey, 1988

n = number of respondents   NA = not available

		All	MC	MSC	NC
EFFICIENT	Average	9.9	17.2	6.4	13.7
	Standard Error	1.1	5.0	0.7	2.6
LESS EFFICIENT	Average	11	12.9	5.5	12.8
	Standard Error	0.9	1.5	0.7	0.9
TOTAL	Average	10.7	14.1	5.7	13.0
	Standard Error	0.7	2.1	0.5	1.1

Table 22. MTF EFFICIENCY AND AMOUNT OF OTHER HEALTHCARE

Average Other Healthcare hrs/week per Healthcare Provider

Beds	MTF	Efficiency	All	n	MC	n	MSC	n	NC	n
22	Oak Harbor	74%	2	11	2	3	5	3	1	5
28	Patuxent River	84%	4	13	4	4	9	4	0	5
36	Twenty-Nine Palms	100%	NA		NA		NA		NA	
52	Lemoore	100%	3	12	1	2	4	5	4	5
80	Cherry Point	100%	2	17	1	8	5	5	2	4
104	Orlando	68%	NA		NA		NA		NA	
109	Groton	72%	1	20	1	3	0	6	1	11
121	Philadelphia	75%	4	15	4	4	8	5	0	6
130	Millington	88%	2	18	4	4	1	4	2	10
130	Newport	66%	5	19	NA		11	5	4	10
155	Bremerton	86%	NA		NA		NA		NA	
165	Corpus Christi	100%	4	6	0	5	1	14	2	6
200	Beaufort	75%	1	17	2	3	0	5	0	9
205	Camp Lejeune	96%	1	42	0	8	0	8	2	26
212	Pensacola	68%	2	40	2	8	NA		3	23
265	Jacksonville	62%	2	49	0	16	1	12	3	21
280	Charleston	75%	4	29	3	6	2	8	6	15
416	Oakland	93%	3	87	2	23	2	16	3	48
421	Long Beach	78%	1	18	2	2	1	9	1	7
450	Camp Pendelton	90%	3	53	2	12	2	9	5	32
555	Portsmouth	100%	1	84	2	27	0	16	0	41
560	Bethesda	100%	3	111	2	44	1	20	4	47
714	Great Lakes	100%	4	30	4	7	7	10	2	13
743	San Diego	83%	3	42	3	19	0	8	4	15
8	Sigonella	100%	NA		NA		NA		NA	
17	Keflavik	100%	0	4	1	1	NA		NA	
73	Guantanomo Bay	58%	9	17	5	6	3	3	14	8
26	Naples	72%	NA		NA		NA		NA	
42	Rota	96%	2	9	1	3	3	3	2	3
91	Roosevelt Roads	57%	0	10	NA		NA		2	6
318	Guam	77%	5	31	6	13	2	3	4	15
136	Yokosuka	92%	3	27	3	8	1	7	4	12
90	Subic Bay	100%	NA		NA		NA		NA	
323	Okinawa	100%	2	32	3	8	1	4	2	20

Data: NODAC Medical Department Survey, 1988

n = number of respondents NA = not available

		All	MC	MSC	NC
MORE EFFICIENT	Average	2	2	3	2
	Standard Error	0.3	0.3	0.6	0.3
LESS EFFICIENT	Average	3	2	3	3
	Standard Error	0.5	0.4	0.9	0.9
TOTAL	Average	3	2	3	3
	Standard Error	0.3	0.3	0.6	0.5

F. SENSITIVITY ANALYSIS

As a procedure, DEA is more sensitive to multivariate differences than OLS and is more robust in that it is not affected by collinearity. Various ratios illustrate how DEA detects differences of one standard deviation in one variable. For example, the efficient MTF has .02 fewer physicians per thousand and 7.7 more admissions per thousand. It has 4.3 fewer outpatient visits per thousand, which may not be too surprising considering that inpatients are weighted heavier by DEA than outpatients. Admissions (ADM) have a greater effect than outpatients (OPV) which illustrates both the sensitivity of the DEA methodology and the need to fully understand the relationships between each and all the variables. In general hospitals with high efficiencies have higher ratios of outputs per inputs, but the number of MTFs makes interpretation of multiple ratios difficult. Although its dependent on the amount of slack, less than a 10 percent change in a single input or output will alter the MTF DEA value, which is shown Table 23 on page 64. The three hospitals that show the greatest change in DEA values from the HCPM87 data are Oakland which improved versus Newport and Orlando which did show a decrease in efficiency. The changes correspond to relative decreases in personnel or outputs. The efficiency for Oakland improved because of decreases in officers while outputs remained constant. On the other hand, additional enlisted personnel caused a change in the efficiency for the Orlando MTF. The change at the Newport MTF is more complicated. Although Newport had 6 fewer physicians, the hospitals with similar capacity increased their output in relationship to inputs.

In terms of sensitivity analysis, the DEA results indicate the the extreme inefficiency of the Philadelphia and Newport MTFs, both of which may be closed. The comparison of DEA values for the sets of CONUS and OCONUS hospitals also demonstrates that the methodology can detect differences in sets of MTFs in the same time period. The advantage of DEA is that it is sensitive to small changes in manpower and can detect differences in time to implement corrective measures. The sensitivity of the methodology also detect data outliers, which can then be analyzed and interpretted.

If the DEA methodology was used was used in an iterative manner and if MTFs improved the composition of their manpower, the system would become increasingly efficient and differences would become even more noticeable.

Table 23. SENSITIVITY ANALYSIS WITH SELECTED MTFS

HCPM87

	MILMD	OFFICER	ENLISTED	CIVMD	CIVOTH	ADM	ALOS	EFFICIENCY
ORLANDO	51	117	531	6	223	13.21	5.7	85%
NEWPORT	34	79	273	2	156	5.99	6.6	94%
OAKLAND	243	245	671	19	388	35.55	5	77%

HCPM88

	MILMD	OFFICER	ENLISTED	CIVMD	CIVOTH	ADM	ALOS	EFFICIENCY
ORLANDO	52	116	510	6.5	211	13.36	5.9	68%
NEWPORT	28	79	267	2	159	6.27	6.6	66%
OAKLAND	241	230	635	15	347	36.1	5.1	93%

DIFFERENCE = HCPM87 - HCPM88

	MILMD	OFFICER	ENLISTED	CIVMD	CIVOTH	ADM	ALOS
ORLANDO	-1	1	21	-0.5	12	-0.15	-0.2
NEWPORT	6	0	6	0	-3	-0.28	0
OAKLAND	2	15	36	4	41	-0.55	-0.1

PERCENT DIFFERENCE

	MILMD	OFFICER	ENLISTED	CIVMD	CIVOTH	ADM	ALOS
ORLANDO	-2.0%	0.9%	4.0%	-8.3%	5.4%	-1.1%	-3.5%
NEWPORT	17.6%	0.0%	2.2%	0.0%	-1.9%	-4.7%	0.0%
OAKLAND	0.8%	6.1%	5.4%	21.1%	10.6%	-1.5%	-2.0%

V. OPTIMIZING THE ALLOCATION OF PERSONNEL

A. CALCULATING EFFICIENT STRUCTURAL RELATIONSHIPS

Efficient hospitals operate with the *best practice* combination of manpower inputs. Once hospitals with efficient performance are identified, then ordinary least square regressions can estimate coefficients that represent higher levels of performance. If the coefficient of an indicator variable for efficiency is significant, then changes in efficiency explains variation in the dependent variable. Without the indicator variable, the regression coefficients are not significant at the 5 percent level. In Table 24 on page 66, both the 1987 and 1988 parameter estimates for the Officers and Enlisted variables are listed with a base case for below-average efficiency. Thus, as expected fewer officers and enlisted personnel are necessary for the case of the hospital with above-average efficiency. The Admissions (ADM) and Average Length of Stay (ALOS) variables are not always significant but they are presented to illustrate their relationship to the other outputs. Input parameter estimates for doctors are not significant which indicates that the variation in the output variables with the Efficiency indicator variable do not explain the variation in the Physician variable.

In Table 25 on page 67, the coefficients represent the amount of each category of personnel that are technologically efficient in terms of physicians (MDs) and Average Daily Patient Load (ADPL). The behavior being modeled assumes that the quantities of officers at a MTF is a function of the numbers of physicians and enlisted personnel. The coefficients for the officer model indicate that fewer officers were required per physician in 1988 as compared to 1987. Fewer numbers of enlisted and civilian personnel as a function of physicians and ADPL were needed 1988 as compared to 1987. The information supports the reason for improved DEA values in 1988 as compared to 1987 and suggests that the performance of Navy medicine improved in 1988.

B. IMPROVING SYSTEM PERFORMANCE

Since the hospitals with 100 percent efficiency represent the MTFs with best productivity, a regression using the data from them estimates efficient manpower composition for all MTFs. In order to maintain sufficient degrees of freedom a heuristic decision was made to identify those MTFs with above average efficiency, rather than just those with 100 percent efficiency. The data from hospitals with above average efficiency were

Table 24. COEFFICIENTS REPRESENTING EFFICIENT AMOUNTS OF INPUTS

Input Parameter Estimates for OFFICERS

Characteristic	1987	t-value	1988	t-value
Outpatient Volume	0.0005	2.230	0.1157	4.164
Admissions	-0.0090	-1.294	0.9139	1.092
Average Daily Patient Load	2.3006	5.585	0.4188	2.958
Average Length of Stay	-7.8265	-1.192	5.7773	2.503
Efficiency	-36.6212	-2.568	-20.9167	-4.297
Intercept	43.4800	1.295	2.1897	0.178
Adjusted R^2	96.35 percent		97.86 percent	
Durbin-Watson D	2.001		2.105	

Input Parameter Estimates for ENLISTED

Characteristic	1987	t-value	1988	t-value
Outpatient Volume	0.0009	2.513	0.3372	2.465
Admissions	0.0248	2.041	9.2053	2.235
Average Daily Patient Load	0.4981	0.695	0.4297	0.617
Average Length of Stay	43.7819	3.832	40.7421	3.586
Efficiency	-78.8392	-3.178	-113.3927	-4.733
Intercept	-88.9476	-1.522	-36.1993	-0.599
Adjusted R^2	95.70 percent		95.86 percent	
Durbin-Watson D	1.742		2.161	

analyzed using a three-stage least squares (3SLS) procedure [Ref. 48]. The behavioral model assumes the following structural relationships:

$$Physicians = f(CWU,\ ALOS\ ADPL) \qquad (5.1)$$

$$Officers = f(Physicians,\ Enlisted,\ Civilian)$$

$$Enlisted = f(Physicians,\ Officers,\ Civilian).$$

The second and third functions show simultaneous relationships with each other. When efficient hospitals are analyzed with 3SLS, the coefficients represent an optimized composition of manpower. The 3SLS model is listed in Appendix E.

Table 25. COEFFICIENTS FOR EFFICIENT AMOUNTS OF SUPPORT PERSONNEL

Input Parameter Estimates for OFFICERS

Characteristic	1987	t-value	1988	t-value
MD	1.4976	21.00	0.3774	6.305
Enlisted	0.1386	5.571	0.1630	7.620
Intercept	17.0211	2.829	16.8375	3.624
Adjusted R^2	99.63 percent		98.54 percent	

Input Parameter Estimates for ENLISTED

Characteristic	1987	t-value	1988	t-value
MD	-1.2790	-2.204	-1.7113	-3.532
Average Daily Patient Load	4.585	7.020	5.1042	9.141
Intercept	103.7333	4.133	98.8749	5.689
Adjusted R^2	95.00 percent		96.79 percent	

right 14

Input Parameter Estimates for CIVILIANS

Characteristic	1987	t-value	1988	t-value
MD	-0.0609	-0.107	-0.1788	-0.342
Average Daily Patient Load	1.7439	2.724	1.8226	3.027
Intercept	66.45	2.701	45.9521	2.452
Adjusted R^2	84.04 percent		86.66 percent	

Table 26. COMPARISON OF HCPM87 AND OPTIMIZED DEA VALUES

Nonlinear DEA Values for 1987:	Combined	Optimized 3SLS
Sample size	34	34
Average	0.8485	0.9300
Median	0.8683	0.9631

After efficient hospitals ar^ analyzed by 3SLS, the coefficients are entered into a spreadsheet as a function. The calculated values are in a print range that creates a text file that can be read by GAMS. The actual variables are outside the range. The resultant calculations are then analyzed by DEA. The process results in a 9 percent change in the over-all system average efficiency, which can be seen in Table 26. Figure 17 on page 68 displays the changes in personnel at the MTFs after the procedure.

Overall system efficiency is improved if personnel from certain categories are transferred between facilities. However, the staffing of physicians at teaching hospitals is reduced which would cause major disruptions in system productivity. The reason for the

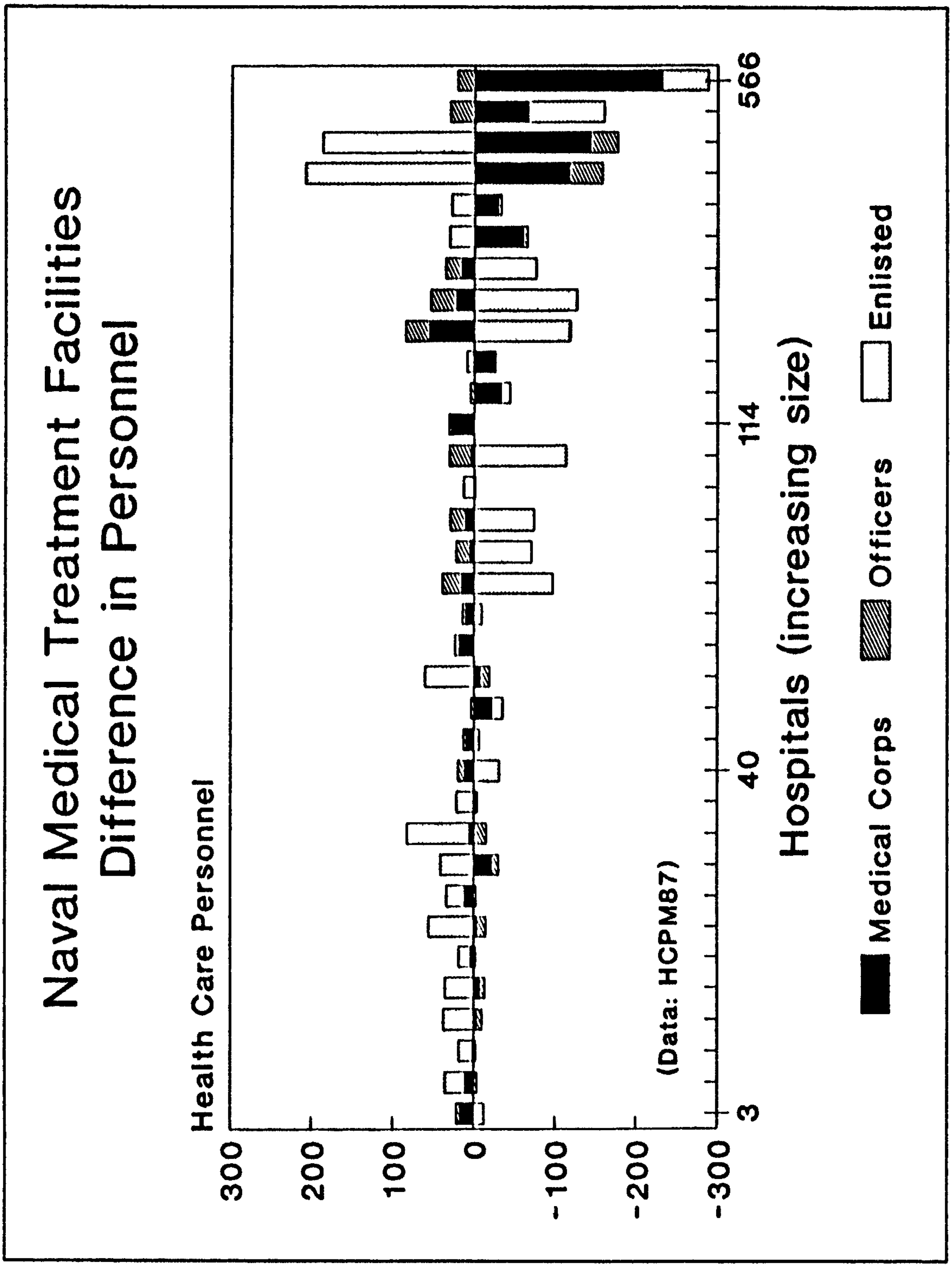


Figure 17. Changes in Personnel at MTFs

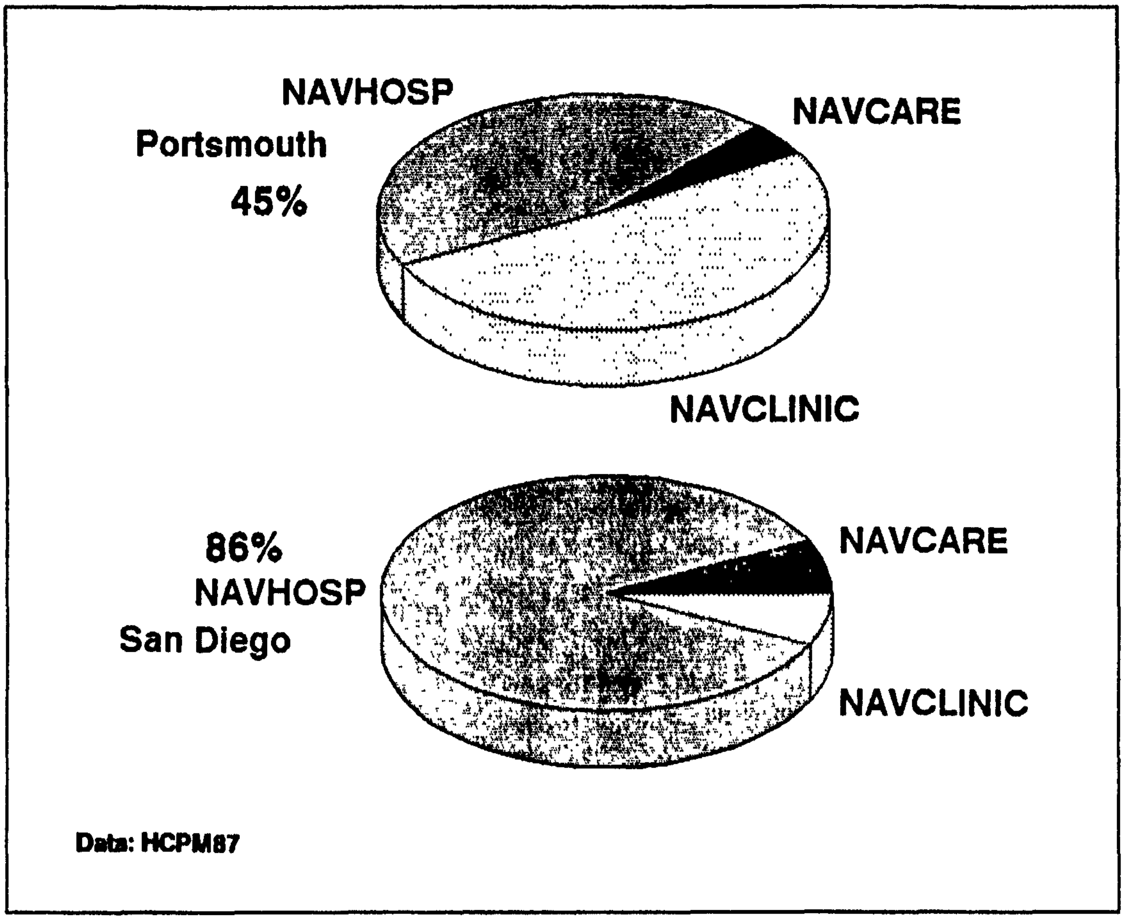


Figure 18. Percent Outpatient Volume at MTF for Catchment Area

difference may be explained in terms of graduate medical education (GME) and training programs. If GME, training, and readiness is included in the HCPM, then DEA measures effectiveness in terms of a larger mission and the recalculated manpower requirements reflect the effect of the programs on efficiency. The HCPM also needs measures which indicate case-load mix, such as DRGs, and the hours of practicing specialists.

The major reason for the discrepancy is due to the weighting of outpatients versus inpatients (e.g., ADPL and ADM). Since there are so many outpatients, the OPV variable has a small weight. Hospitals that have many outpatients compared with similar sized facilities will be less efficient. In Figure 18, Portsmouth has 100 percent efficiency, whereas San Diego has an efficiency of 84 percent. The proportion of outpatients who are treated at the Naval hospital (NAVHOSP) in San Diego is 86 percent, while more of the outpatient workload in Portsmouth is at Navy clinics (NAVCLINIC) and contractors (NAVCARE). The implication for policy analysis is that the implementation of alternative health care systems for outpatient care should have a greater incremental effect in San Diego than in a catchment area that already has extensive clinic support. The DEA results did not focus on the issue, but an analysis of the results does illustrate the relationship of inpatient and outpatient care in terms of efficiency.

A system of linear equations can also be used to estimate the number of support personnel necessary to optimize the utilization of physicians. The behavioral model now assumes the following structural relationships:

$$Civilians = f(Physicians) \qquad (5.2)$$

$$Officers = f(ADPL)$$

$$Enlisted = f(Physicians, ADPL).$$

Other combinations are more compelling in theory but the data for both 1987 and 1988 show excessive linear dependence for other combinations of the inputs and outputs. The numbers of officers required Figure 19 on page 71 requires an explanation because the results are unexpected.

Although previous models demonstrated a direct relationship between workload and enlisted personnel, the modified model for 1987 shows a need for 2693 more support officers and 1772 fewer enlisted personnel. The similarly modified model for 1988 proposes 1601 fewer enlisted personnel than officers. A full explanation requires a disaggregated model of the officer category which was composed of the following by percentage in 1988: Physician Assistants (5 percent), Nurse Corps (71 percent), and Medical Service Corps (24 percent). But conceptually, an exchange for more Nurse Corps officers instead of enlisted personnel indicates a need for more specialized nursing skills that are necessary for increasingly sophisticated medical procedures and certification requirements. The need for more advanced training is not unique to medicine since the problem is recognized in other technologically-advanced fields in the Navy [Ref. 49]. Two alternatives to alleviate the problem include the hiring additional specialized registered nurses or increasing the duration of duty at a MTF so that personnel could master more complicated specialized nursing requirements, along with placement in that speciality at the subsequent MTF. In 1988, only 5 percent of enlisted personnel remained at an MTF for a period longer than three years which is a short time to learn nursing skills -- let alone a specialty. Another complimentary alternative includes a

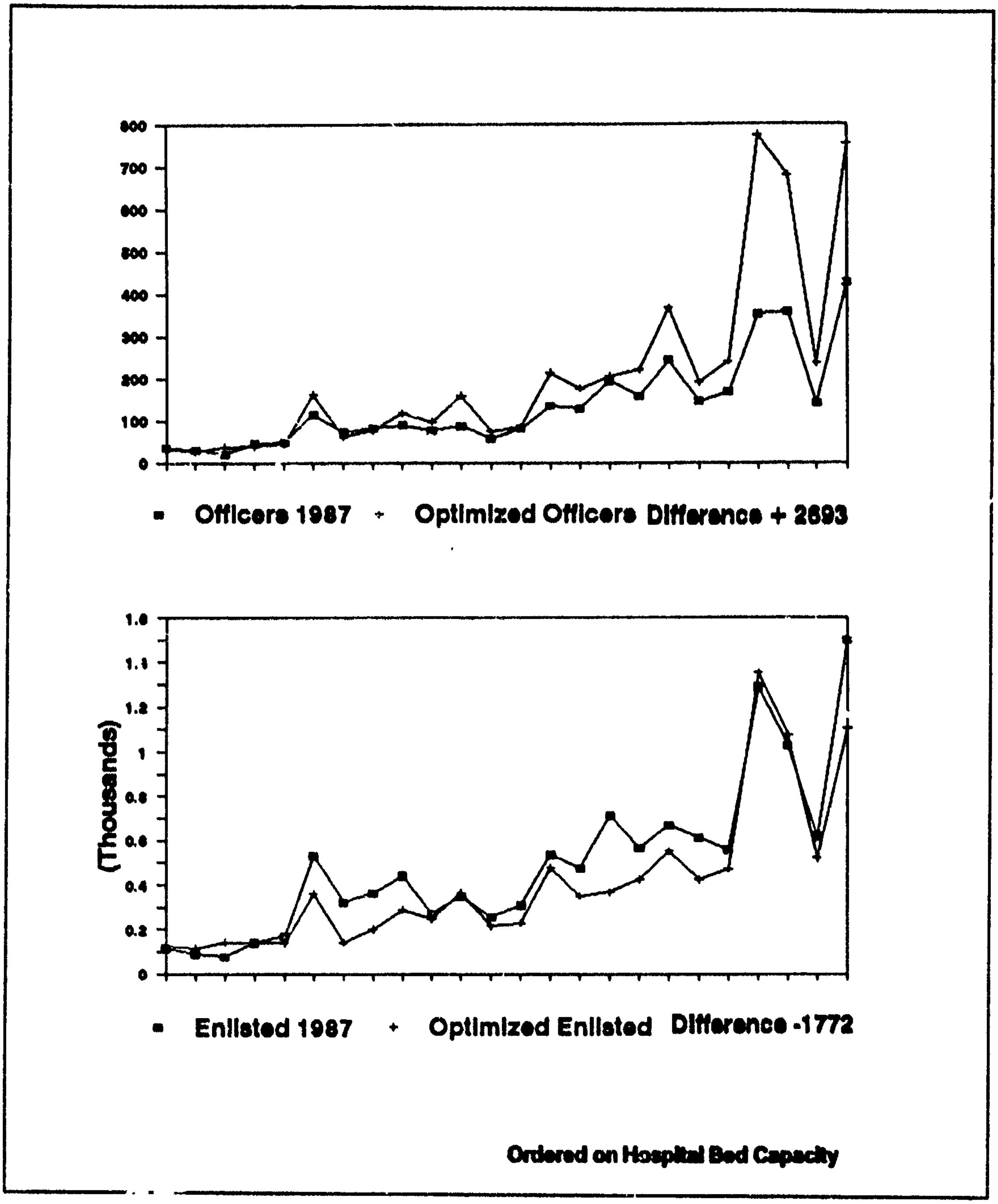


Figure 19. Personnel Necessary to Optimize the Efficiency of Physicians

military-sponsored nursing curriculum, which could increase the supply of registered nurses.

C. PHYSICIAN ALTERNATIVES

In order to compare the efficiency of the delivery of physician services, the changes in physician alternatives need to be monitored as innovative systems and methods are implemented. Examples of alternatives to Medical Corps (MC) doctors are civilian physicians, contract physicians, physician assistants, and independent-duty corpsmen. Also, the economics of manpower supply and demand suggests that there are substitutes and compliments for physicians. Using the HCPM87 and HCPM88 data, Table 27 illustrates these relationships for hospitals that have above-average efficiency. The negative sign of the coefficients for Civilian MD, Enlisted, and Civilian variables indicate that they are MC substitutes; the positive sign for the Officer variable indicates a compliment effect, in that officers increase along with the numbers of MC physicians. The weakness with the description is shown in the 1988 regression by the Durbin-Watson D value which is caused by the serial correlation of the residuals. The serial correlation of the errors is a serious violation of the linear regression assumptions and is caused by the increase in all manpower categories with increasing hospital size.

Table 27. PHYSICIAN ALTERNATIVES AT EFFICIENT MTFS

Model fitting results for: MC at Above-Average MTF, 1987

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	-29.94767	7.680861	-3.8990	0.0018
Civilian MD	-1.586435	0.747112	-2.1234	0.0535
Officers	2.312989	0.246194	9.3950	0.0000
Enlisted	-0.241832	0.064427	-3.7536	0.0024
Civilian	-0.265853	0.090362	-2.9421	0.0114

18 observations Adjusted R^2 = 0.9695 Durbin-Watson D = 2.121

Model fitting results for: MC at Above-Average MTF, 1988

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	-42.355903	9.895448	-4.2803	0.0007
Civilian MD	-0.888633	0.638015	-1.3928	0.1840
Officers	2.191416	0.412374	5.3142	0.0001
Enlisted	-0.265135	0.108705	-2.4390	0.0276
Civilian	-0.086207	0.128277	-0.6720	0.5118

20 observations Adjusted R^2 = 0.9358 Durbin-Watson D = 1 132

In order to utilize the Medical Corps physicians to their fullest extent, the proper composition of support personnel are necessary. Although the collinearity is caused by the billet authorizations which are predetermined, regressions of physician alternatives show the evolving nature of manpower substitutes. The guiding principle is that highly-trained personnel should not perform tasks that can be adequately performed by less costly methods or personnel.

A more important issue, however, is what is the number of support-personnel required to fully utilize the current number of physicians?

> "It has been argued within the military medical departments that performance is currently hindered by a shortage of support personnel in direct care facilities. An increase in the number of physicians without a comparable increase in the number of clinical and administrative personnel would exacerbate this problem." [Ref. 50]

An increase in the number of registered nurses at specific MTFs will improve the efficiency of the MTF. Not only will physicians become more productive, but also the amount of direct care given to beneficiaries will increase. Such an emphasis should improve the satisfaction of active-duty dependents and, in turn, their active-duty sponsors. As a quality-of-life issue, the incremental improvement in health-care as a benefit should increase the performance and retention of the active-duty force.

VI. CONCLUSION

A. RESULTS

The thesis evaluates various measures of effectiveness and compares alternatives with data from the Military Health Care Study of 1975 and the aggregate values from the Health Care Planning Matrix of 1987 and 1988.

DEA determines technical efficiency and identifies the *best practice* or technologically-efficient hospitals for a given set. The efficiency of CONUS and OCONUS hospitals are not compared as separate sets, but they are combined as a single set and analyzed by DEA. The values produced by DEA identify the relative efficiency for a set of hospitals in cross-sectional data; the efficiency of a hospital is compared to similar facilities. For the years of 1987 and 1988, the Naval hospitals at Bethesda, Cherry Point, Okinawa, Portsmouth, and Subic Bay more efficiently utilized personnel, than did competing hospitals.

Changes in personnel utilization over time are observed with elasticities for the composite workload unit and for average length of stay. The elasticities describe the relationship of incremental changes in personnel categories to output. The use of the composite workload unit as an MOE is not appropriate since the coefficients change over time.

Although Navy MTFs show differences in technical efficiency, they are homogenous in terms of organizational structure and policy. The differences in efficiency are based on non-optimal numbers of personnel and are not due to any one category of manpower. The only significant difference in the use of personnel at efficient hospitals involved Nurse Corps officers and active-duty dependents. In efficient hospitals, Nurse Corps officers provided additional hours of patient care to active-duty dependents.

Total system efficiency is improved by reallocating personnel within the system. Efficiency is increased at certain MTFs by increasing certain types of manpower. For example, more nursing staff is necessary in order to fully utilize the numbers of physicians at individual MTFs. Efficiency is usually not improved by simply removing or adding personnel at random. The average of the DEA values indicates a level of performance in the system, which includes all of the hospitals.

B. APPLICATION

Since the concepts of DEA are technical in nature, the central-planning authority may be reluctant to use a measure that is difficult to describe to its staff or MTF commanders. The decision maker might rely on present procedures or measures that are more common. The application and understanding of DEA, as a technique, would require a careful definition of the underlying concepts and perhaps a background in analytical procedures as well. If the DEA methodology was implemented, the procedure could be performed at the headquarters with monthly MTF data so that the DEA values could be associated with other indicators of efficiency. Along with continual review and with a comparison to other performance indicators, the DEA methodology might be accepted as a MOE. Also, similar inputs and outputs from civilian hospitals could be analyzed with DEA and compared to the Navy values; this would require the precaution that civilian institutions do not have same the military requirements.

Another possible objection with the analysis is that the hospitals that are identified as being efficient may have staff or workload that actually belong to another hospital or clinic. Thus, other well-managed hospitals may appear to be less efficient when they are compared with those facilities. The analysis also does not include or compensate for physicians who are undergoing residencies or other types of GME which may affect their productivity as producers of health-care outputs.

C. IMPROVING PRODUCTIVITY

Productivity is classified according to techniques associated with technology, employee, product, process, and material. In a multiple-regression analysis of productivity improvement, employee and task variables provide the greatest impact for ten companies [Ref. 51]. The most significant variable is communication which was in the employee category. Indeed, the hours that officers spent at committee meetings do not decrease MTF efficiency. In the task category, important variables are production scheduling and job evaluation. Other pertinent productivity variables are listed in Table 28 on page 76.

Plans to improve effectiveness require an examination of the structural efficiency for the system. For example, less than 60 percent of hospital corpsmen remain at a MTF for more than two years. In a study where the productivity was based on the subjective assessments of supervisors, the productivity for corpsmen out of advanced training school (A-school) increases from 27.8 percent initially to 86.9 percent after two years of on-the-job training [Ref. 52]. Thus, the service member leaves the MTF before becom-

Table 28. TECHNIQUES FOR IMPROVING PRODUCTIVITY

1. Technology-Oriented Techniques
   a. Computer-aided procedures
   b. New construction based on improving efficiency
   c. Maintenance management

2. Employee-Oriented Techniques
   a. Individual incentives
   b. Group incentives
   c. Promotion
   d. Job enrichment
   e. Job enlargement
   f. Job rotation
   g. Worker participation
   h. Skill enhancement
   i. Management by objectives
   j. Learning curve
   k. Communication
   l. Working condition improvement
   m. Training
   n. Education
   o. Role perception
   p. Supervisor quality
   q. Recognition

3. Product-Oriented Techniques
   a. Value Engineering
   b. Product diversification
   c. Product simplification
   d. Research and development
   e. Product standardization
   f. Reliability improvement

4. Task-Oriented Techniques
   a. Methods engineering
   b. Work measurement
   c. Job design
   d. Job evaluation
   e. Job safety design
   f. Human factors engineering
   g. Production scheduling
   h. Computer-aided data processing

5. Material-Oriented Techniques
   a. Inventory control
   b. Materials requirement planning
   c. Materials management
   d. Quality control
   e. Material handling systems improvement
   f. Material reuse and recycling

Source: Sumanth, 1984

ing completely productive and then must assimilate a new job role at the next duty station. Longer tours may increase structural efficiency. A similar case might be considered for NC officers who have an average of 16 months at their present duty station.

Efficiency increases in civilian hospitals where economic incentives are directed toward a group or department. In the military hospital the composition of medical personnel is constrained by a predetermined billet structure. Given the current organizational structure of the MHSS, merging small departments among hospitals may provide an additional economy of scale as long as "the cost of producing all outputs jointly is strictly less than the cost of producing the same levels of output in separate production units [Ref. 53]."

Incentives to improve the efficiency of the MHSS should first be targeted to the individual MTF [Ref. 54], which is a specific production unit. If the MTF was directly reimbursed for nonactive-duty care according to the DRG rate by CHAMPUS and allowed to use the funds for the best incremental benefit, then it would have an incentive to contain costs while managing resources in order to capture more CHAMPUS workload. Each MTF, or group, would meet its own interests since the funds could be used for additional manpower, supplies, equipment, or contracts. In addition, the group would have an incentive to implement the DRG as an operating concept, since reimbursement would be based on prospective payment and the MTF would want the associated financial compensation. The collection of DRGs for each hospital in the system could then be analyzed by DEA, so that the coordinating headquarters could identify those improvements that would lead to increased performance at selected MTFs.

D. IDENTIFYING COMPONENTS TO IMPROVE EFFICIENCY

Since efficiency as measured by DEA is ordinal by MTF, the set of efficient facilities (E = 1) can be separated from the set of less-efficient hospitals (E < 1). The probability that a hospital will be efficient (E = 1) given a set of explanatory variables can be modeled by the logistic procedure.[1]

Using the DEA values from the HCPM87 and HCPM88 data as the dichotomous explanatory variable, a logistic regression procedure estimates the log likelihood of efficiency in relation to the independent variables. Individual input and output variables used in the DEA model show no effect on the logistic R-statistic which is similar to the adjusted R^2. However, the workload of ancillary services does affect the proportion of log likelihood explained by the model. Support procedures from laboratory, X-ray, or pharmacy act as a constraint on over all health-care production and, therefore, limits the efficiency of health-care personnel. The parameters for laboratory, pharmacy, and X-ray

[1] The form of the logistic regression [Ref. 55] is written as Probability (Efficiency = 1) = $1/(1 + \exp(-\alpha - \beta_i x_i))$, where i represents a single hospital.

procedures are listed in Table 29 on page 78 and Appendix E for the fiscal years of 1987 and 1988.

Table 29. DETERMINANTS OF EFFICIENT UTILIZATION OF ANCILLARY SERVICES

Independent Variable	1987	P-value	1988	P-value
Lab Workload	0.93E-6	0.0570	1.18E-6	0.0683
Pharmacy Workload	-14.05E-6	0.0868	-19.69E-6	0.0418
X-ray Workload	1.87E-6	0.8727	5.40E-6	0.4036
Intercept	0.2727	0.6805	-0.6205	0.4521
R	0.269		0.175	
Log Likelihood	-16.855		-10.445	
X^2 with 3 degrees of freedom	9.10		6.84	

In both data sets, the coefficient for laboratory workload is positive whereas the coefficient for pharmacy workload is negative. The X-ray coefficient is not significant but the variable is added as a means to compare the three ancillary services; in fact, the R value actually increases for both years if the X-ray variable is removed from the logistic model. In terms of policy analysis, improving laboratory services has a higher probability of increasing efficiency. The negative sign on the Pharmacy variable indicates that pharmacy workload decreases efficiency. The behavior is not unexpected considering the negative effect of outpatient volume on efficiency; the amount of queuing of outpatients at MTF pharmacies is well known. On the other hand, physicians and other support personnel often wait for laboratory results before initiating a course of action. The sooner action is initiated, the sooner the inpatient is released; resources are then released which are available for the next patient.

E. SUMMARY

A model for military-personnel requirements is proposed for the production of efficient health care at Naval medical treatment facilities. The data envelopment model validates the effect of the optimization of personnel. These models are especially valuable in the measurement of best practice in hospitals where advancements in medical standards and medical technology demand quality personnel. However, a measurement of the efficient utilization of personnel is incomplete since the readiness objective and training objectives have not been measured. The DEA methodology can encompass the additional outputs if desired.

The paper began with an analysis of measures of effectiveness, which are difficult to implement. Data envelopment analysis was chosen because it provided a method to analyze technical efficiency. The efficiency value identified specific MTFs that required additional analysis in order to improve toward a goal of total quality management [Ref. 56]. Once efficient medical treatment facilities were identified, econometric analysis was used to evaluate characteristics of the data including the elasticities of the workload and average length of stay in terms of categories of military manpower. A comparison of 1975, 1987, and 1988 data suggested that more manpower is now required to generate a composite workload unit, although the elasticity for physician output is 0.4 in three annual data sets. For constant returns to scale, the elasticity implies that 60 percent of the workload requires non-physician personnel.

DEA can be used as an adjunct to other measurements of hospital efficiency. Other inputs such as dollar costs will make the interpretation of DEA relevant with production functions. Additional outputs, such as DRGs which would give diagnoses information, will incorporate the effect of case mix on productivity.

F. FUTURE STUDIES

DEA does provide an MOE for the efficient utilization of medical personnel at MTFs. The logistic analysis indicated that manpower affects less than 30 percent of the MOE. An analysis of different variables is required to identify the remaining 70 percent. The opportunities for future analysis include a number of topics which are listed below.

- The specification of separate case-mix categories and individual health-care personnel categories could show the effectiveness of MTFs in providing a particular service.
- If financial data was available by MTF, the Cobb-Douglas production functions could be calculated in order to estimate the tradeoff between additional personnel versus capital investment. Additional financial information such as capital improvements at MTFs could help explain longitudinal differences in efficiency.
- DEA values could be calculated with physician specialists as inputs and case mix as outputs to determine efficiency of medical specialty.
- DEA could model additional input variables for Dental Corps (DC), Nurse Corps (NC), Medical Service Corps (MSC) and others. The process would disaggregate the *other officer* category.
- Cumulative monthly data from individual MTFs can be analyzed on a monthly basis. For example, the combined set of January and February data can be sequentially accumulated and analyzed in terms of their ordinal relations [Ref. 57].
- Forecasts from the requirements models stated in the ***Joint Health care Manpower Standards*** could be analyzed in terms of DEA.

- DEA might help determine the effect of training if certain MTFs receive a disproportionate number of recent graduates of A-schools.
- DEA values of MTFs that receive more newly commissioned officers could be compared with those MTFs that receive less to show the capability of the screening by the commissioning source.
- Data on retention by Unit Identification Code could be obtained to determine if the amount of turnover at individual MTFs affects efficiency.

The application of operation-analysis techniques and economic theory improves the interpretation of results that affect manpower policy. In the future as the number of variables increase with better information systems, the amount of unexplained deviation in the current study can be decreased in order to make better predictions about the military health services system.

APPENDIX A. ABBREVIATIONS

ACDU__________Active Duty
ADPL__________Average Daily Patient Load
ALOS__________Average Length of Stay
BUMED_________Bureau of Medicine
CHAMPUS_______Civilian Health and Medical Program of the Uniformed Services
CNO___________Chief of Naval Operations
CONUS_________Continental United States
CPI___________Consumer Price Index
CWU___________Composite Workload Unit
DEA___________Data Envelopment Analysis
DEERS_________Defense Eligibility Enrollment Reporting System
DMDC__________Defense Manpower Data Center
DOD___________Department of Defense
DRG___________Diagnostic Related Group
ER____________Efficiency Review
GAMS__________General Algebraic Modeling System
GME___________Graduate Medical Education
HCPM__________Health Care Planning Matrix
LDEA__________Linear Data Envelopment Analysis
LP____________Linear Programming
MHCS__________Military Health Care Study
MC____________Medical Corps
MD____________Medical Doctor
MEPRS_________Medical Expense and Performance Reporting System
MHCS__________Military Health Care Study
MHSS__________Military Health Services System
MOE___________Measure of Effectiveness
MPN___________Manpower Navy
MSC___________Medical Service Corps
MTF___________Military Treatment Facility
NC____________Nurse Corps
NLDEA_________Nonlinear Data Envelopment Analysis
NODAC_________Navy Occupational Development and Analysis Center
OCONUS________Outside Continental United States
OLS___________Ordinary Least Squares
OMN___________Operation and Maintenance Navy
OPN___________Other Procurement Navy
OPV___________Out-Patient Volume
3SLS__________Three-Stage Least Squares

A. DEPARTMENT OF DEFENSE AND NAVY MEDICAL DATABASES

AQCESS_____	Automated Quality of Care Evaluation Support System	DOD/NAVY
CMF_______	Civilian Master File	DOD/NAVY
DIRS______	Dental Information Retrieval System	NAVY
MEPRS_____	Medical Expense & Performance Reporting System	DOD/NAVY
NAS_______	Nonavailability Statement	DOD/NAVY
OMF_______	Officer Master File	DOD/NAVY
RAPS______	Resource Analysis and Planning System	DOD/NAVY
OCHAMPUS___	Office of the Civilian Health and Medical Program of the Uniformed Service	DOD/NAVY
TRILAB_____	Tri-Service Laboratory System	DOD/NAVY
TRIMIS_____	Tri-Service Medical Information Systems	DOD/NAVY
WIPS______	Worldwide Inpatient Reporting System	NAVY
WORS______	Worldwide Outpatient Reporting System	NAVY

APPENDIX B. SUMMARY OF THE HCPM 1987 DATA

SUMMARY DATA FOR ALL FACILITIES BY GEOGRAPHIC COMMAND
NAVY HEALTH CARE PLANNING MATRIX
CORE HOSPITAL SUMMARY FOR: FY87

GEOCOM FACILITY	CATCHMENT POP	OPV	OP BEDS	PEACE CAP	WAR CAP	ADM	ALOS	ADPL	---- TOTAL INPATENT & OUTPATIENT ---- DIAGNOSTIC TREATMENT (WEIGHTED) LAB TESTS	X-RAY	PHARM
NMC, NEREG											
GREAT LAKES	82,623	167,254	159	744	970	6,017	6.6	108	3,930,354	157,150	296,285
GROTON	46,034	177,260	60	109	133	3,333	3.1	24	1,549,182	140,826	313,650
NEWPORT	36,054	131,918	106	130	190	2,187	6.6	41	1,450,261	105,325	187,463
PHILADELPHIA	72,122	108,117	78	159	291	2,412	4.8	31	1,241,095	71,593	202,237
T O T A L	236,833	584,549	403	1,142	1,584	13,949	5.4	204	8,170,892	474,894	999,635
NMC, NATCAPREG											
BETHESDA	105,715	389,135	494	560	1,008	16,400	7.4	322	17,004,045	496,910	977,399
PATUXENT RIVER	14,560	77,372	13	28	32	1,253	2.6	7	666,174	38,950	99,642
T O T A L	120,275	466,507	507	588	1,040	17,653	7.0	329	17,670,219	535,860	1,077,041
NMC, MIDLANTREG											
BEAUFORT	28,178	91,205	59	200	247	2,779	4.8	35	1,491,548	58,779	261,554
CAMP LEJEUNE	87,174	220,794	170	205	284	8,749	4.4	97	2,193,899	241,119	538,793
CHARLESTON	95,014	238,113	184	280	360	9,326	4.3	100	2,608,347	172,418	710,610
CHERRY POINT	34,340	192,962	27	80	129	2,641	2.7	15	1,472,305	69,073	186,498
GUANTANAMO BAY	4,314	47,563	11	73	128	1,238	2.2	7	597,772	25,992	54,163
KEFLAVIK	5,537	24,137	9	17	25	670	3.2	5	335,883	15,301	35,616
PORTSMOUTH	289,045	487,154	501	765	976	26,864	5.3	368	10,821,891	652,735	911,640
ROOSEVELT RDS	24,545	74,148	40	91	128	2,419	4.1	25	947,092	63,950	130,296
T O T A L	568,147	1,376,076	1,001	1,711	2,277	54,686	4.7	652	20,468,737	1,299,367	2,829,170
NMC, SEREG											
CORPUS CHRISTI	23,019	92,325	40	165	200	1,337	8.2	30	1,262,030	65,703	179,307
JACKSONVILLE	101,998	263,562	178	265	496	10,619	3.5	93	5,538,728	255,582	540,160
MILLINGTON	42,598	135,473	77	130	231	3,691	5.4	51	1,802,499	121,469	294,367
ORLANDO	77,128	178,392	114	104	134	4,822	5.7	72	2,401,332	215,710	382,187
PENSACOLA	63,046	231,409	117	212	342	6,460	4.8	79	3,764,005	192,984	582,384
T O T A L	307,789	901,161	526	876	1,403	26,929	4.7	325	14,768,594	851,448	1,978,405
NMC, NWREG											
ADAK	3,946	19,344	4	15	17	573	2.9	4	187,468	12,134	27,084
BREMERTON	38,828	161,147	98	133	209	5,501	5.1	71	2,895,745	179,751	277,596
LEMOORE	20,820	104,954	23	52	99	1,920	3.0	13	847,790	55,665	166,477
OAK HARBOR	16,779	87,344	17	22	38	1,962	2.6	11	1,160,281	78,687	226,831
OAKLAND	114,256	279,327	263	416	757	12,976	5.0	171	6,899,065	463,964	632,414
T O T A L	194,629	652,116	405	638	1,120	22,932	4.6	270	11,990,349	790,199	1,330,402
NMC, SWREG											
CAMP PENDELTON	91,984	241,980	151	450	595	8,445	5.1	110	3,877,929	293,042	547,600
LONG BEACH	149,343	131,545	166	421	692	4,418	7.0	86	2,145,905	78,201	433,805
SAN DIEGO	305,800	508,442	566	743	1,134	24,632	5.6	358	15,641,384	732,734	1,179,674
TWENTYNINE PLS	20,062	75,197	20	36	41	2,309	2.5	12	746,379	52,930	109,583
T O T A L	567,189	957,164	903	1,650	2,462	39,804	5.4	566	22,611,597	1,156,907	2,270,662
NMC, PACREG											
GUAM	27,123	107,366	61	318	389	4,318	3.9	39	2,084,005	86,233	155,350
OKINAWA	33,396	139,186	114	323	638	7,311	4.7	86	3,471,922	173,878	247,654
SUBIC BAY	11,282	156,668	72	90	119	4,376	4.2	48	2,461,946	56,588	136,141
YOKOSUKA	12,286	102,100	69	136	171	3,817	5.1	49	1,681,238	95,584	111,370
T O T A L	84,087	505,320	316	867	1,317	19,822	4.4	222	9,699,111	412,283	650,515
NMC, EURREG											
NAPLES	7,454	41,741	26	26	106	2,193	5.0	27	464,413	39,627	57,282
ROTA	7,786	68,774	33	48	68	1,661	4.1	16	746,041	35,597	81,680
SIGONELLA	8,391	28,254	3	8	13	358	2.7	3	147,539	7,580	31,847
T O T A L	23,631	138,769	62	82	187	4,212	4.4	46	1,357,993	82,804	170,809
T O T A L A L L	2,102,580	5,581,662	4,123	7,554	11390	199,987	5.0	2,614	106,737,492	5,603,762	11,306,639

GEOCOM FACILITY	TOTAL STAFF(ONBD) OFFICERS	ENLISTED	CIVIL	CONTRACT	LABOR ADJUSTMENTS(FTE) NON AVAIL	READINESS	LOAN	BORROW
NMC, NEREG								
GREAT LAKES	176	621	255	26.8	1,485.3	32.1	0.0	19.8
GROTON	119	324	104	1.0	800.5	108.8	0.0	0.0
NEWPORT	113	273	158	0.0	519.5	107.4	56.1	549.8
PHILADELPHIA	107	364	217	7.3	662.3	56.3	0.0	204.0
T O T A L	515	1,582	734	35.1	3,467.6	304.6	56.1	773.6
NMC, NATCAPREG								
BETHESDA	747	1,032	620	2.0	1,112.7	691.9	292.3	0.0
PATUXENT RIVER	47	92	63	0.0	0.0	0.0	0.0	0.0
T O T A L	794	1,124	683	2.0	1,112.7	691.9	292.3	0.0
NMC, MIDLANTREG								
BEAUFORT	107	311	157	2.5	366.0	29.0	3.0	1.0
CAMP LEJEUNE	190	539	304	0.0	275.3	0.0	0.0	1,282.8
CHARLESTON	262	568	237	0.0	121.9	19.7	4.5	1.1
CHERRY POINT	75	172	78	1.0	104.9	37.5	0.0	923.0
GUANTANAMO BAY	43	99	41	0.0	159.1	63.7	0.0	5.3
KEFLAVIK	22	46	0	0.0	0.0	0.0	0.0	0.0
PORTSMOUTH	689	1,293	561	4.0	2,367.6	421.5	23.3	380.5
ROOSEVELT RDS	87	205	86	0.0	343.0	30.4	0.0	0.0
T O T A L	1,475	3,233	1,464	7.5	3,737.8	601.8	30.8	2,593.7
NMC, SEREG								
CORPUS CHRISTI	79	257	93	1.0	988.7	103.8	1.0	314.6
JACKSONVILLE	315	717	273	1.7	1,739.0	86.2	0.0	0.0
MILLINGTON	117	443	127	5.0	0.0	0.0	0.0	0.0
ORLANDO	168	531	225	4.0	1,592.9	262.6	26.6	1.2
PENSACOLA	216	478	254	0.0	1,327.3	12.0	1.2	1.8
T O T A L	895	2,426	972	11.7	5,647.9	464.6	28.8	317.6
NMC, NWREG								
ADAK	16	31	0	0.0	0.0	0.0	0.0	0.0
BREMERTON	134	351	264	2.0	1,506.6	273.5	111.4	525.3
LEMOORE	63	143	43	0.0	0.0	34.6	2.0	83.3
OAK HARBOR	57	118	42	1.0	171.0	58.1	0.0	115.0
OAKLAND	488	671	404	3.0	1,747.3	1,921.2	322.0	37.7
T O T A L	758	1,314	753	6.0	3,424.9	2,287.4	435.4	761.3
NMC, SWREG								
CAMP PENDELTON	274	561	405	0.0	1,246.6	334.2	0.0	743.4
LONG BEACH	199	614	384	0.0	2,335.0	245.0	103.0	567.0
SAN DIEGO	920	1,506	844	8.4	4,192.0	896.4	0.0	1,367.8
TWENTYNINE PLS	33	79	0	0.0	0.0	0.0	0.0	0.0
T O T A L	1,426	2,760	1,633	8.4	7,773.6	1,475.6	103.0	2,678.2
NMC, PACREG								
GUAM	125	260	108	0.0	498.4	47.3	0.2	11.8
OKINAWA	160	399	239	0.0	949.6	93.5	36.0	548.6
SUBIC BAY	92	216	213	0.0	575.0	0.0	3.1	66.2
YOKOSUKA	102	239	204	0.0	398.6	64.4	66.0	127.1
T O T A L	479	1,114	764	0.0	2,421.6	205.2	105.3	753.7
NMC, EURREG								
NAPLES	71	157	77	3.0	26.9	12.4	0.2	0.6
ROTA	59	104	36	0.0	0.0	0.6	0.0	1.6
SIGONELLA	12	37	7	0.0	4.8	0.6	0.0	0.0
T O T A L	142	298	120	3.0	31.7	13.4	0.2	2.2
T O T A L A L L	6,484	13,851	7,123	73.7	27,617.8	6,044.5	1,051.9	7,880.3

GEOCOM FACILITY	MILITARY STAFF (ONBD) OFFICERS MC	DC	NC	MSC	PA	OTH	ENLISTED HM	DT	OTH	CIV STAFF (ONBD) PHY	RN	ALD HLTH	LPN/ TECH	OTH	CONTRACT STAFF (FTE) PHY	RN	ALD HLTH	LPN/ TECH	OTH
NMC, NEREG																			
GREAT LAKES	32	6	90	38	9	3	562	18	41	2	10	22	9	212	24.8	0.0	2.0	0.0	0.0
GROTON	34	1	57	22	4	1	317	2	5		20	10	7	67	1.0	0.0	0.0	0.0	0.0
NEWPORT	34	1	52	19	5	2	265	3	5	2	12	5	14	125	0.0	0.0	0.0	0.0	0.0
PHILADELPHIA	23	2	52	24	4	2	334	4	26	5	10	16	13	173	6.3	0.0	0.0	0.0	1.0
T O T A L	123	8	251	103	22	8	1,478	27	77	9	52	53	43	577	32.1	0.0	2.0	0.0	1.0
NMC, NATCAPREG																			
BETHESDA	388	5	257	81	4	12	968	18	46	2	67	47	88	416	2.0	0.0	0.0	0.0	0.0
PATUXENT RIVER	14		18	13	2		87		5	1	4	1	9	48	0.0	0.0	0.0	0.0	0.0
T O T A L	402	5	275	94	6	12	1,055	18	51	3	71	48	97	464	2.0	0.0	0.0	0.0	0.0
NMC, MIDLANTREG																			
BEAUFORT	24	2	43	29	6	3	296	3	12	1	9	3	11	133	2.5	0.0	0.0	0.0	0.0
CAMP LEJEUNE	54	2	81	39	11	3	502	8	29	1	28	12	34	229	0.0	0.0	0.0	0.0	0.0
CHARLESTON	99	3	111	37	8	4	509	4	55	7	18	20	40	152	0.0	0.0	0.0	0.0	0.0
CHERRY POINT	24		30	18	3		163	2	7	1	12	4	7	54	1.0	0.0	0.0	0.0	0.0
GUANTANAMO BAY	14		16	13			92		7		2	1		38	0.0	0.0	0.0	0.0	0.0
KEFLAVIK	6		10	6			46								0.0	0.0	0.0	0.0	0.0
PORTSMOUTH	335	10	264	60	7	13	1,228	29	36		80	24	98	359	4.0	0.0	0.0	0.0	0.0
ROOSEVELT RDS	28	2	39	18			198	5	2	1	6	3	12	64	0.0	0.0	0.0	0.0	0.0
T O T A L	584	19	594	220	35	23	3,034	51	148	11	155	67	202	1029	7.5	0.0	0.0	0.0	0.0
NMC, SEREG																			
CORPUS CHRISTI	19		30	24	4	2	238		19		8	6		79	1.0	0.0	0.0	0.0	0.0
JACKSONVILLE	120	2	126	49	14	4	676	5	36	4	28	17	40	184	1.7	0.0	0.0	0.0	0.0
MILLINGTON	26	2	62	21	6		419	5	19		10	3	5	109	5.0	0.0	0.0	0.0	0.0
ORLANDO	51	2	66	38	8	3	510	5	16	2	24	8	30	161	4.0	0.0	0.0	0.0	0.0
PENSACOLA	86	3	82	33	8	4	436	6	36	3	18	20	43	170	0.0	0.0	0.0	0.0	0.0
T O T A L	302	9	366	165	40	13	2,279	21	126	9	88	54	118	703	11.7	0.0	0.0	0.0	0.0
NMC, NWREG																			
ADAK	5		9	2			31								0.0	0.0	0.0	0.0	0.0
BREMERTON	45	2	53	27	4	3	332	5	14	3	54	24	26	157	2.0	0.0	0.0	0.0	0.0
LEMOORE	16		27	14	6		134		9		1	4	2	36	0.0	0.0	0.0	0.0	0.0
OAK HARBOR	20		19	14	4		109		9		11	2	1	28	1.0	0.0	0.0	0.0	0.0
OAKLAND	243	7	181	50	2	5	588	22	61		16	38	50	300	3.0	0.0	0.0	0.0	0.0
T O T A L	329	9	289	107	16	8	1,194	27	93	3	82	68	79	521	6.0	0.0	0.0	0.0	0.0
NMC, SWREG																			
CAMP PENDELTON	105	5	107	40	12	5	532	13	16		36	10	47	312	0.0	0.0	0.0	0.0	0.0
LONG BEACH	51	2	93	43	6	4	532	6	76	4	25	33	41	281	0.0	0.0	0.0	0.0	0.0
SAN DIEGO	490	10	335	71	1	13	1,391	29	86	2	96	42	155	549	5.4	0.0	3.0	0.0	0.0
TWENTYNINE PLS	12		12	8	1		76		3						0.0	0.0	0.0	0.0	0.0
T O T A L	658	17	547	162	20	22	2,531	48	181	6	157	85	243	1142	5.4	0.0	3.0	0.0	0.0
NMC, PACREG																			
GUAM	42	4	51	19	7	2	243	3	16		10	2	5	91	0.0	0.0	0.0	0.0	0.0
OKINAWA	43	2	75	35	2	3	372	4	23		30	6	4	199	0.0	0.0	0.0	0.0	0.0
SUBIC BAY	26	1	36	23	6		205	2	9			5		208	0.0	0.0	0.0	0.0	0.0
YOKOSUKA	27		44	23	6	2	229		10	1	6	5		192	0.0	0.0	0.0	0.0	0.0
T O T A L	138	7	206	100	21	7	1,049	9	56	1	46	18	9	690	0.0	0.0	0.0	0.0	0.0
NMC, EURREG																			
NAPLES	22		27	17	2	3	146		11		5	2	3	67	3.0	0.0	0.0	0.0	0.0
ROTA	15		24	17	3		102		2			2		34	0.0	0.0	0.0	0.0	0.0
SIGONELLA	5		5	2			37				1	1	1	4	0.0	0.0	0.0	0.0	0.0
T O T A L	42		56	36	5	3	285		13		6	5	4	105	3.0	0.0	0.0	0.0	0.0
T O T A L A L L	2578	74	2584	987	165	96	12,905	201	745	42	657	398	795	5231	67.7	0.0	5.0	0.0	1.0

CORE HOSPITAL USN/USMC CATCHMENT AREA CHAMPUS SUMMARY FOR: FY87

GEOCOM FACILITY	CHAMPUS ADMS	---- CHAMPUS INPATIENT CHARGES ---- GOVT	PATIENT	TOTAL	CHAMPUS VISITS	----- CHAMPUS OUTPATIENT CHARGES ----- GOVT	PATIENT	TOTAL
NMC, NEREG								
GREAT LAKES	2,757	$11,419,178	$2,542,404	$13,961,582	35,231	$2,742,972	$1,587,501	$4,330,473
GROTON	1,348	$3,441,880	$684,030	$4,125,910	24,366	$1,517,436	$862,267	$2,379,703
NEWPORT	1,420	$3,527,946	$1,400,554	$4,928,500	20,678	$1,588,422	$922,018	$2,510,440
PHILADELPHIA	2,759	$11,344,662	$2,574,377	$13,919,039	48,265	$3,921,268	$1,918,045	$5,839,313
T O T A L	8,284	$29,733,666	$7,201,365	$36,935,031	128,540	$9,770,098	$5,289,831	$15,059,929
NMC, NATCAPREG								
BETHESDA	920	$5,155,925	$1,754,493	$6,910,418	66,600	$4,003,103	$2,632,997	$6,636,100
PATUXENT RIVER	239	$1,174,151	$168,840	$1,342,991	6,028	$369,093	$229,390	$598,483
T O T A L	1,159	$6,330,076	$1,923,333	$8,253,409	72,628	$4,372,196	$2,862,387	$7,234,583
NMC, MIDLANTREG								
BEAUFORT	952	$2,877,357	$856,446	$3,733,803	12,239	$908,337	$451,205	$1,359,542
CAMP LEJEUNE	3,488	$9,277,221	$1,521,247	$10,798,468	66,681	$3,981,641	$1,810,401	$5,792,042
CHARLESTON	4,993	$15,046,064	$5,602,469	$20,648,533	81,915	$5,268,461	$2,630,693	$7,899,154
CHERRY POINT	1,383	$3,903,170	$1,109,029	$5,012,199	25,754	$1,709,725	$866,292	$2,576,017
GUANTANAMO BAY								
KEFLAVIK								
PORTSMOUTH	10,553	$32,347,136	$9,943,530	$42,290,666	241,135	$15,339,601	$7,616,261	$22,955,862
ROOSEVELT RDS								
T O T A L	21,369	$63,450,948	$19,032,721	$82,483,669	427,724	$27,207,765	$13,374,852	$40,582,617
NMC, SEREG								
CORPUS CHRISTI	1,467	$4,301,138	$1,487,856	$5,788,994	14,108	$1,100,687	$649,792	$1,750,479
JACKSONVILLE	6,360	$25,977,125	$8,842,985	$34,820,110	129,874	$9,925,972	$5,126,254	$15,052,226
MILLINGTON	2,029	$7,317,092	$4,791,041	$12,108,133	33,412	$2,206,006	$1,574,459	$3,780,465
ORLANDO	2,871	$10,378,015	$6,999,080	$17,377,095	66,221	$5,017,040	$3,494,839	$8,511,879
PENSACOLA	2,346	$10,202,050	$5,214,988	$15,417,038	62,236	$4,403,653	$2,467,425	$6,871,078
T O T A L	15,073	$58,175,420	$27,335,950	$85,511,370	305,851	$22,653,358	$13,312,769	$35,966,127
NMC, NWREG								
ADAK	11	$276,234	$1,529	$277,763	69	$9,990	$3,680	$13,670
BREMERTON	968	$2,588,460	$772,341	$3,360,801	19,887	$1,200,335	$759,111	$1,959,446
LEMOORE	721	$3,324,454	$1,037,135	$4,361,589	22,657	$1,584,032	$938,489	$2,522,521
OAK HARBOR	773	$2,194,488	$567,667	$2,762,155	23,882	$1,491,016	$694,115	$2,185,131
OAKLAND	1,204	$7,860,849	$3,215,058	$11,075,907	55,502	$3,713,216	$2,469,169	$6,182,385
T O T A L	3,677	$16,244,485	$5,593,730	$21,838,215	121,997	$7,998,589	$4,864,566	$12,863,153
NMC, SWREG								
CAMP PENDELTON	3,012	$15,107,954	$2,971,177	$18,079,131	103,192	$8,375,001	$3,619,662	$11,994,663
LONG BEACH	7,567	$37,896,670	$11,588,734	$49,485,404	239,798	$17,445,797	$10,151,110	$27,596,907
SAN DIEGO	9,686	$58,778,12	$13,622,608	$72,400,734	477,959	$32,757,100	$15,173,771	$47,930,871
TWENTYNINE PLS	448	$3,375,71	$702,580	$4,078,293	14,202	$1,305,033	$610,192	$1,915,225
T O T A L	20,713	$115,158,463	$28,885,099	$144,043,562	835,151	$59,882,931	$29,554,735	$89,437,666
NMC, PACREG								
GUAM								
OKINAWA								
SUBIC BAY								
YOKOSUKA								
T O T A L		$0	$0	$0	0	$0	$0	$0
NMC, EURREG								
NAPLES								
ROTA								
SIGONELLA								
T O T A L		$0	$0	$0	0	$0	$0	$0
T O T A L A L L	70,275	$289,093,058	$89,972,198	$379,065,256	1,891,891	$131,884,937	$69,259,138	$201,144,075

CORE HOSPITAL NON-NAVY AREA SUMMARY FOR: FY87

GEOCOM / FACILITY	OTHER DOD OP BEDS	OTHER DOD # HOSP	OTHER DOD # PHY	OTHER DOD # RNS	VA BEDS ACUTE CARE	VA BEDS LONG TERM	CIVILIAN OP BEDS	CIVILIAN # HOSP	CIVILIAN % OCC	CIVILIAN # PHY	MED SCHOOLS
NMC, NEREG											
GREAT LAKES					2,094	369	31,869	102	65	1,930	6
GROTON					186		5,417	27	72	273	
NEWPORT					311		5,674	22	73	2,235	1
PHILADELPHIA	190	1			636	60	33,736	133	73	12,452	5
T O T A L	190	1			3,227	429	76,696	284	69	16,890	12
NMC, NATCAPREG											
BETHESDA	1,456	4	110	229	1,082	163	28,251	91	75	5,817	6
PATUXENT RIVER							1,031	8	68	48	
T O T A L	1,456	4	110	229	1,082	163	29,282	99	74	5,865	6
NMC, MIDLANTREG											
BEAUFORT							1,852	9	63	85	
CAMP LEJEUNE							659	5	66	198	
CHARLESTON					280		2,263	12	64	513	1
CHERRY POINT							589	4	71	132	
GUANTANAMO BAY											
KEFLAVIK											
PORTSMOUTH	138	3	36	65	411	120	6,911	30	68	1,119	1
ROOSEVELT RDS										143	
T O T A L	138	3	36	65	691	120	12,274	60	66	2,190	2
NMC, SEREG											
CORPUS CHRISTI							1,845	12	55	616	
JACKSONVILLE							4,444	21	62	1,302	
MILLINGTON					886	120	7,188	21	62	1,261	1
ORLANDO							4,561	19	58	1,216	
PENSACOLA							1,853	7	55	524	
T O T A L					886	120	19,891	80	59	4,919	1
NMC, NWREG											
ADAK											
BREMERTON	330	1			778	136	9,413	45	63	212	1
LEMOORE					218	60	2,635	23	54	1,017	
OAK HARBOR							1,372	12	50	91	
OAKLAND	698	2	101	224	2,198	270	20,970	88	65	12,792	2
T O T A L	1,028	3	101	224	3,194	466	34,390	168	63	14,112	3
NMC, SWREG											
CAMP PENDELTON							7,115	35	66	3,286	1
LONG BEACH					2,664	590	44,232	206	62	13,182	4
SAN DIEGO					562	60	6,400	32	69	4,926	1
TWENTYNINE PLS							756	4	64		
T O T A L					3,226	650	58,503	277	63	21,394	6
NMC, PACREG											
GUAM										97	
OKINAWA											
SUBIC BAY	160	1	56	110							
YOKOSUKA	30	1	21	34						30	
T O T A L	190	2	77	144						127	
NMC, EURREG											
NAPLES											
ROTA											
SIGONELLA											
T O T A L											
T O T A L A L L	3,002	13	326	662	12,306	1,948	231,036	968	66	65,497	30

CORE HOSPITAL PRODUCTION RATIOS BY GEOGRAPHIC COMMAND FOR: FY87

GEOCOM FACILITY	CATCHMENT POP	OPV (CORE + BRCL *)	OP BEDS	ADM	ADPL	PHY	RN	LPN+ TECH**	PHY/ 1000	OPV/ 1000	ADM/ 1000	OPV/ PHY	ADM/ PHY	ADPL/ PHY	RN/ PHY	RN/ BED	TECH/ BED
NMC, NEREG																	
GREAT LAKES	82.623	582.843	159	6.017	108	58	100	571	0.7	7.054.2	72.8	10.049.0	103.7	1.9	1.7	0.6	3.6
GROTON	46.034	177.260	60	3.333	24	35	77	324	0.8	3.850.6	72.4	5.064.6	95.2	0.7	2.2	1.3	5.4
NEWPORT	36 054	131.918	106	2.187	41	36	64	279	1.0	3.658.9	60.7	3.664.4	60.8	1.1	1.8	0.6	2.6
PHILADELPHIA	72.122	213.878	78	2.412	31	34	62	347	0.5	2.965.5	33.4	6.290.5	70.9	0.9	1.8	0.8	4.4
T O T A L	236.833	1.105.899	403	13.949	204	163	303	1.521	0.7	4.669.5	58.9	6.784.7	85.6	1.3	1.9	0.8	3.8
NMC, NATCAPREG																	
BETHESDA	105.715	389.135	494	16.400	322	392	324	1.056	3.7	3.681.0	155.1	992.7	41.8	0.8	0.8	0.7	2.1
PATUXENT RIVER	14.560	77.372	13	1.253	7	15	22	96	1.0	5.314.0	86.1	5.158.1	83.5	0.5	1.5	1.7	7.4
T O T A L	120.275	466.507	507	17.653	329	407	346	1.152	3.4	3.878.7	146.8	1.146.2	43.4	0.8	0.9	0.7	2.3
NMC, MIDLANTREG																	
BEAUFORT	28.178	290.542	59	2.779	35	27	52	307	1.0	10.311.0	98.6	10.760.8	102.9	1.3	1.9	0.9	5.2
CAMP LEJEUNE	87.174	319.544	170	8.749	97	55	109	536	0.6	3.665.6	100.4	5.809.9	159.1	1.8	2.0	0.6	3.2
CHARLESTON	95.014	359.358	184	9.326	100	106	129	549	1.1	3.782.2	98.2	3.390.2	88.0	0.9	1.2	0.7	3.0
CHERRY POINT	34.340	192.962	27	2.641	15	26	42	170	0.8	5.619.2	76.9	7.421.6	101.6	0.6	1.6	1.6	6.3
GUANTANAMO BAY	4.314	52.605	11	1.238	7	14	18	92	3.2	12.194.0	287.0	3.757.5	88.4	0.5	1.3	1.6	8.4
KEFLAVIK	5.537	24.137	9	670	5	6	10	46	1.1	4.359.2	121.0	4.022.8	111.7	0.8	1.7	1.1	5.1
PORTSMOUTH	289.045	487.154	501	26.864	368	339	344	1.326	1.2	1.685.4	92.9	1.437.0	79.2	1.1	1.0	0.7	2.6
ROOSEVELT RDS	24.545	74.148	40	2.419	25	29	45	210	1.2	3.020.9	98.6	2.556.8	83.4	0.9	1.6	1.1	5.3
T O T A L	568.147	1.800.450	1001	54.686	652	602	749	3.236	1.1	3.169.0	96.3	2.990.8	90.8	1.1	1.2	0.7	3.2
NMC, SEREG																	
CORPUS CHRISTI	23.019	92.325	40	1.337	30	20	38	238	0.9	4.010.8	58.1	4.616.3	66.9	1.5	1.9	1.0	6.0
JACKSONVILLE	101.998	453.655	178	10.619	93	125	154	716	1.2	4.447.7	104.1	3.629.2	85.0	0.7	1.2	0.9	4.0
MILLINGTON	42.598	219.973	77	3.691	51	31	72	424	0.7	5.163.9	86.6	7.095.9	119.1	1.6	2.3	0.9	5.5
ORLANDO	77.128	363.846	114	4.822	72	57	90	540	0.7	4.717.4	62.5	6.383.3	84.6	1.3	1.6	0.8	4.7
PENSACOLA	63.046	282.666	117	6.460	79	89	100	479	1.4	4.483.5	102.5	3.176.0	72.6	0.9	1.1	0.9	4.1
T O T A L	307.789	1.412.465	526	26.929	325	322	454	2.397	1.0	4.589.1	87.5	4.386.5	83.6	1.0	1.4	0.9	4.6
NMC, NWREG																	
ADAK	3.946	19.344	4	573	4	5	9	31	1.3	4.902.2	145.2	3.868.8	114.6	0.8	1.8	2.3	7.8
BREMERTON	38.828	168.602	98	5.501	71	50	107	358	1.3	4.342.3	141.7	3.372.0	110.0	1.4	2.1	1.1	3.7
LEMOORE	20.820	104.954	23	1.920	13	16	28	136	0.8	5.041.0	92.2	6.559.6	120.0	0.8	1.8	1.2	5.9
OAK HARBOR	16.779	87.344	17	1.962	11	21	30	110	1.3	5.205.6	116.9	4.159.2	93.4	0.5	1.4	1.8	6.5
OAKLAND	114.256	279.327	263	12.976	171	246	197	638	2.2	2.444.7	113.6	1.135.5	52.7	0.7	0.8	0.7	2.4
T O T A L	194.629	659.571	405	22.932	270	338	371	1.273	1.7	3.388.9	117.8	1.951.4	67.8	0.8	1.1	0.9	3.1
NMC, SWREG																	
CAMP PENDELTON	91.984	342.800	151	8.445	110	105	143	579	1.1	3.726.7	91.8	3.264.8	80.4	1.0	1.4	0.9	3.8
LONG BEACH	149.343	205.663	166	4.418	86	55	118	573	0.4	1.377.1	29.6	3.739.3	80.3	1.6	2.1	0.7	3.5
SAN DIEGO	305.800	508.442	566	24.632	358	497	431	1.546	1.6	1.662.7	80.5	1.023.0	49.6	0.7	0.9	0.8	2.7
TWENTYNINE PLS	20.062	75.197	20	2.309	12	12	12	76	0.6	3.748.2	115.1	6.266.4	192.4	1.0	1.0	0.6	3.8
T O T A L	567.189	1.132.102	903	39.804	566	669	704	2.774	1.2	1.996.0	70.2	1.692.2	59.5	0.8	1.1	0.8	3.1
NMC, PACREG																	
GUAM	27.123	131.222	61	4.318	39	42	61	248	1.5	4.838.0	159.2	3.124.3	102.8	0.9	1.5	1.0	4.1
OKINAWA	33.396	195.693	114	7.311	86	43	105	376	1.3	5.859.8	218.9	4.551.0	170.0	2.0	2.4	0.9	3.3
SUBIC BAY	11.282	226.941	72	4.376	48	26	36	205	2.3	20.115.3	387.9	8.728.5	168.3	1.8	1.4	0.5	2.8
YOKOSUKA	12.286	107.234	69	3.817	49	28	50	229	2.3	8.728.1	310.7	3.829.8	136.3	1.8	1.8	0.7	3.3
T O T A L	84.087	661.090	316	19.822	222	139	252	1.058	1.7	7.862.0	235.7	4.756.0	142.6	1.6	1.8	0.8	3.3
NMC, EURREG																	
NAPLES	7.454	41.870	26	2.193	27	25	32	149	3.4	5.617.1	294.2	1.674.8	87.7	1.1	1.3	1.2	5.7
ROTA	7.786	68.774	33	1.661	16	15	24	102	1.9	8.833.0	213.3	4.584.9	110.7	1.1	1.6	0.7	3.1
SIGONELLA	8.391	28.254	3	358	3	5	6	38	0.6	3.367.2	42.7	5.650.8	71.6	0.6	1.2	2.0	12.7
T O T A L	23.631	138.898	62	4.212	46	45	62	289	1.9	5.877.8	178.2	3.086.6	93.6	1.0	1.4	1.0	4.7
T O T A L A L L	2.102.580	7.376.962	4123	199.987	2614	2685	3241	13.700	1.3	3.508.5	95.1	2.747.5	74.5	1.0	1.2	0.8	3.3

* INCLUDES OUTPATIENT VISITS FOR SELECTED BRANCH CLINICS WHERE STAFFING COULD NOT BE SEPARATELY IDENTIFIED FROM ITS CORE HOSPITAL

**INCLUDES HOSPITAL CORPSMEN, CIVILIAN LPNS, CIVILIAN TECHNICIANS, CONTRACT LPNS, AND CONTRACT TECHNICIANS

CORE HOSPITAL PRODUCTION RATIOS BY SIZE GROUP COMMAND FOR: FY87

SIZE GROUP FACILITY	CATCHMENT POP	OPV (CORE + BRCL *)	OP BEDS	ADM	ADPL	PHY	RN	LPN+ TECH**	PHY/ 1000	OPV/ 1000	ADM/ 1000	OPV/ PHY	ADM/ PHY	ADPL/ PHY	RN/ PHY	RN/ BED	TECH/ BED
MAJOR TEACHING HOSP																	
BETHESDA	105.715	389.135	494	16.400	322	392	324	1.056	3.7	3.681.0	155.1	992.7	41.8	0.8	0.8	0.7	2.1
OAKLAND	114.256	279.327	263	12.976	171	246	197	638	2.2	2.444.7	113.6	1.135.5	52.7	0.7	0.8	0.7	2.4
PORTSMOUTH	289.045	487.154	501	26.864	368	339	344	1.326	1.2	1.685.4	92.9	1.437.0	79.2	1.1	1.0	0.7	2.6
SAN DIEGO	305.800	508.442	566	24.632	358	497	431	1.546	1.6	1.662.7	80.5	1.023.0	49.6	0.7	0.9	0.8	2.7
T O T A L	814.816	1.664.058	1824	80.872	1219	1474	1296	4.566	1.8	2.042.3	99.3	1.128.9	54.9	0.8	0.9	0.7	2.5
FAMILY PRACTICE																	
CAMP PENDELTON	91.984	342.800	151	8.445	110	105	143	579	1.1	3.726.7	91.8	3.266.8	80.4	1.0	1.4	0.9	3.8
CHARLESTON	95.014	359.358	184	9.326	100	106	129	549	1.1	3.782.2	98.2	3.390.2	88.0	0.9	1.2	0.7	3.0
JACKSONVILLE	101.998	453.655	178	10.619	93	125	154	716	1.2	4.447.7	104.1	3.629.2	85.0	0.7	1.2	0.9	4.0
PENSACOLA	63.046	282.666	117	6.460	79	89	100	479	1.4	4.483.5	102.5	3.176.0	72.6	0.9	1.1	0.9	4.1
T O T A L	352.042	1.438.479	630	34.850	382	425	526	2.323	1.2	4.086.1	99.0	3.384.7	82.0	0.9	1.2	0.8	3.7
98+ BEDS																	
BREMERTON	38.828	168.602	98	5.501	71	50	107	358	1.3	4.342.3	141.7	3.372.0	110.0	1.4	2.1	1.1	3.7
CAMP LEJEUNE	87.174	319.544	170	8.749	97	55	109	536	0.6	3.665.6	100.4	5.809.9	159.1	1.8	2.0	0.6	3.2
GREAT LAKES	82.623	582.843	159	6.017	108	58	100	571	0.7	7.054.2	72.8	10.049.0	103.7	1.9	1.7	0.6	3.6
LONG BEACH	149.343	205.663	166	4.418	86	55	118	573	0.4	1.377.1	29.6	3.739.3	80.3	1.6	2.1	0.7	3.5
NEWPORT	36.054	131.918	106	2.187	41	36	64	279	1.0	3.658.9	60.7	3.664.4	60.8	1.1	1.8	0.6	2.6
OKINAWA	33.396	195.693	114	7.311	86	43	105	376	1.3	5.859.8	218.9	4.551.0	170.0	2.0	2.4	0.9	3.3
ORLANDO	77.128	363.846	114	4.822	72	57	90	540	0.7	4.717.4	62.5	6.383.3	84.6	1.3	1.6	0.8	4.7
T O T A L	504.546	1.968.109	927	39.005	561	354	693	3.233	0.7	3.900.8	77.3	5.559.6	110.2	1.6	2.0	0.7	3.5
50-98 BEDS																	
BEAUFORT	28.178	290.542	59	2.779	35	27	52	307	1.0	10.311.0	98.6	10.760.8	102.9	1.3	1.9	0.9	5.2
GROTON	46.034	177.260	60	3.333	24	35	77	324	0.8	3.850.6	72.4	5.064.6	95.2	0.7	2.2	1.3	5.4
GUAM	27.123	131.222	61	4.318	39	42	61	248	1.5	4.838.0	159.2	3.124.3	102.8	0.9	1.5	1.0	4.1
MILLINGTON	42.598	219.973	77	3.691	51	31	72	424	0.7	5.163.9	86.6	7.095.9	119.1	1.6	2.3	0.9	5.5
PHILADELPHIA	72.122	213.876	78	2.412	31	34	62	347	0.5	2.965.5	33.4	6.290.5	70.9	0.9	1.8	0.8	4.4
SUBIC BAY	11.282	226.941	72	4.376	48	26	36	205	2.3	20.115.3	387.9	8.728.5	168.3	1.8	1.4	0.5	2.8
YOKOSUKA	12.286	107.234	69	3.817	49	28	50	229	2.3	8.728.1	310.7	3.829.6	136.3	1.8	1.8	0.7	3.3
T O T A L	239.623	1.367.050	476	24.726	277	223	410	2.084	0.9	5.705.0	103.2	6.130.3	110.9	1.2	1.8	0.9	4.4
BELOW 50 BEDS																	
ADAK	3.946	19.344	4	573	4	5	9	31	1.3	4.902.2	145.2	3.868.8	114.6	0.8	1.8	2.3	7.8
CHERRY POINT	34.340	192.962	27	2.641	15	26	42	170	0.8	5.619.2	76.9	7.421.6	101.6	0.6	1.6	1.6	6.3
CORPUS CHRISTI	23.019	92.325	40	1.337	30	20	38	238	0.9	4.010.8	58.1	4.616.3	66.9	1.5	1.9	1.0	6.0
GUANTANAMO BAY	4.314	52.605	11	1.238	7	14	18	92	3.2	12.194.0	287.0	3.757.5	88.4	0.5	1.3	1.6	8.4
KEFLAVIK	5.537	24.137	9	670	5	6	10	46	1.1	4.359.2	121.0	4.022.8	111.7	0.8	1.7	1.1	5.1
LEMOORE	20.820	104.954	23	1.920	13	16	28	136	0.8	5.041.0	92.2	6.559.6	120.0	0.8	1.8	1.2	5.9
NAPLES	7.454	41.870	26	2.193	27	25	32	149	3.4	5.617.1	294.2	1.674.8	87.7	1.1	1.3	1.2	5.7
OAK HARBOR	16.779	87.344	17	1.962	11	21	30	110	1.3	5.205.6	116.9	4.159.2	93.4	0.5	1.4	1.8	6.5
PATUXENT RIVER	14.560	77.372	13	1.253	7	15	22	96	1.0	5.314.0	86.1	5.158.1	83.5	0.5	1.5	1.7	7.4
ROOSEVELT RDS	24.545	74.148	40	2.419	25	29	45	210	1.2	3.020.9	98.6	2.556.8	83.4	0.9	1.6	1.1	5.3
ROTA	7.786	68.774	33	1.661	16	15	24	102	1.9	8.833.0	213.3	4.584.9	110.7	1.1	1.6	0.7	3.1
SIGONELLA	8.391	28.254	3	358	3	5	6	38	0.6	3.367.2	42.7	5.650.8	71.6	0.6	1.2	2.0	12.7
TWENTYNINE PLS	20.062	75.197	20	2.309	12	12	12	76	0.6	3.748.2	115.1	6.266.4	192.4	1.0	1.0	0.6	3.8
T O T A L	191.553	939.286	266	20.534	175	209	316	1.494	1.1	4.903.5	107.2	4.494.2	98.2	0.8	1.5	1.2	5.6
T O T A L A L L	2.102.580	7.376.982	4123	199.987	2614	2695	3241	13.700	1.3	3.508.5	95.1	2.747.5	74.5	1.0	1.2	0.8	3.3

* INCLUDES OUTPATIENT VISITS FOR SELECTED BRANCH CLINICS WHERE STAFFING COULD NOT BE SEPARATELY IDENTIFIED FROM ITS CORE HOSPITAL
**INCLUDES HOSPITAL CORPSMEN, CIVILIAN LPNS, CIVILIAN TECHNICIANS, CONTRACT LPNS, AND CONTRACT TECHNICIANS

APPENDIX C. NONLINEAR MODEL

The optimal weightings are determined from a nonlinear model. Since the objective function is both pseudoconvex and pseudoconcave a point satisfying the Kuhn-Tucker conditions for a minimization problem is also a global minimum over the feasible region. Likewise, a point satisfying the Kuhn-Tucker conditions for a maximizing problem is also a global maximum over the feasible region [Ref. 58].

The GAMS model includes the data of the observations. The GAMS software uses a text file. The listing includes the following:

```
GAMS 2.04 PC AT/XT
* * * NONLINEAR DEA MODEL * * *

      Data Envelopment Analysis
      GAMS output
      Phase 1 -- Implementation of CONUS Model
      ANSWER Data for HCS75

      *------------------------------------------------------------------
      OPTIONS SOLPRINT = OFF, RESLIM = 60, ITERLIM = 100
      OPTIONS LIMCOL = 0, LIMROW = 0
      *------------------------------------------------------------------

      SET J  hospitals

      * NEREG
      / GREATLAKES 1,  GROTON 2,  NEWPORT 3,  PA 4,
      * NATCAPREG
       BETHESDA 5, PATUXENTR 6,
      * MIDALTREG
       BEAUFORT 7,  CMPLEJEUNE 8,  CHARLESTON 9,  CHERRYPNT 10,
       PORTSMOUTH 13,
      * SEREG
       CORPUSCHRI 15,  JACKSNVILL 16,  MILLINGTON 17,
       ORLANDO 18,  PENSACOLA 19,
      * NWREG
       BREMERTON 21,  LEMOORE 22,  OAKHARBOR 23,  OAKLAND 24,
      * SWREG
       CMPENDLTN 25,  LONGBEACH 26,  SANDIEGO 27,  TWENTYNPLM 28 /;


      SET I        inputs per day of manpower categories
      /  MILMDS    military doctors
         OFFICERS non-physician officers
         ENLISTED personnel
         CIVMDS    civilian doctors
         CIVOTH    other civilians / ;

      SET R     outputs per day
      /  OPV    outpatient volume per day
         ADM    admissions per day
         ALOS   average length of stay in days
         ADPL   average daily patient load / ;

      TABLE X(J,I)

      * hospital input

                          MILMDS OFFICERS ENLISTED   CIVMDS   CIVOTH
       GREATLAKES            105       161      592        0     88.6
       GROTON                 29        45      153        0       68
```

```
NEWPORT        57      79     235      0     151
PA            200     203     346      7     482
BETHESDA      277     212     555      0     935
PATUXENTR    14.8      21      91      0      43
BEAUFORT       37      66     273      4     157
CMPLEJEUNE   80.7   106.1   410.6      0   289.4
CHARLESTON     77     105     381      4     265
CHERRYPNT    22.1    22.1     346      7    38.4
PORTSMOUTH  290.5     304    1201     10     908
CORPUSCHRI     30      56     147      1     110
JACKSNVILL    111     165     530      0     249
MILLINGTON     44      77     351      0     144
ORLANDO        52      65     334      3     205
PENSACOLA      82     109     455      0     288
BREMERTON    31.9    45.3   180.7    4.8   168.1
LEMOORE        22      25     122      0      35
OAKHARBOR    19.8    16.3    71.6      0    25.2
OAKLAND       250     231     647      6     704
CMPENDLTN   115.9    89.2   637.7      0     301
LONGBEACH     100     132   486.6      6     407
SANDIEGO    456.3   333.2  1364.1      3   896.7
TWENTYNPLM      8      11      67      0      15     ;

TABLE Y(J,R)
* hospital output

             ADM        ALOS      ADPL      OPV
GREATLAKES   27.74      12.49     341.47    10.0713
GROTON        6.27      10.45      65.53     3.5964
NEWPORT      11.19      14.23     159.23     3.6102
PA           28.7       21.18     608.07    10.3328
BETHESDA     35.52      16.04     569.92     3.5884
PATUXENTR     4.41       4.23      18.66      .2126
BEAUFORT     16.63       7.89     131.19      .91792
CMPLEJEUNE   21.65      10.06     217.76    12.8953
CHARLESTON   23.28      10.12     235.55     8.7196
CHERRYPNT     6.68       5.54      37        4.1306
PORTSMOUTH   68.07      11.58     788.03     30.64
CORPUSCHRI    8.68       8.68      75.27     3.5306
JACKSNVILL   25.69       9.46     243.09     2.6849
MILLINGTON    9.32       8.68      75.27     3.5306
ORLANDO      24.75       6.04     149.5      7.9366
PENSACOLA    16.22      10.25     166.3      9.5661
BREMERTON     8.19      14.97     122.6      3.0387
LEMOORE       6.41       5.74      36.74     2.2633
OAKHARBOR     4          4.05      16.2      2.1406
OAKLAND      35.75      12.74     455.33    12.8137
CMPENDLTN    19.17      11.23     215.24    15.2113
LONGBEACH    18.22      18.82     342.91    14.0319
SANDIEGO     81.46      15.41     1255.49   34.7774
TWENTYNPLM    4.07       2.75      11.2      1.4799

POSITIVE VARIABLES
   V(I)    the weighting for input i to maximize efficiency value
   U(R)    the weighting for output r to maximize efficiency value ;
   V.L(I)=1;
   U.L(R)=1;

VARIABLE
   MAXEFF  maximize efficiency ;

EQUATIONS
   OBJ1    maximize efficiency of  hospital 1
   OBJ2    maximize efficiency of  hospital 2
   OBJ3    maximize efficiency of  hospital 3
   OBJ4    maximize efficiency of  hospital 4
   OBJ5    maximize efficiency of  hospital 5
   OBJ6    maximize efficiency of  hospital 6
```

```
     OBJ7    maximize efficiency of  hospital 7
     OBJ8    maximize efficiency of  hospital 8
     OBJ9    maximize efficiency of  hospital 9
     OBJ10   maximize efficiency of  hospital 10
     OBJ13   maximize efficiency of  hospital 13
     OBJ15   maximize efficiency of  hospital 15
     OBJ16   maximize efficiency of  hospital 16
     OBJ17   maximize efficiency of  hospital 17
     OBJ18   maximize efficiency of  hospital 18
     OBJ19   maximize efficiency of  hospital 19
     OBJ21   maximize efficiency of  hospital 21
     OBJ22   maximize efficiency of  hospital 22
     OBJ23   maximize efficiency of  hospital 23
     OBJ24   maximize efficiency of  hospital 24
     OBJ25   maximize efficiency of  hospital 25
     OBJ26   maximize efficiency of  hospital 26
     OBJ27   maximize efficiency of  hospital 27
     OBJ28   maximize efficiency of  hospital 28
     INOUT(J) ;


OBJ1..  (SUM(R,U(R)*Y('GREATLAKES',R))/SUM(I,V(I)*X('GREATLAKES',I)))
          =E=MAXEFF;
OBJ2.. (SUM(R,U(R)*Y('GROTON',R))/SUM(I,V(I)*X('GROTON',I)))
          =E=MAXEFF;
OBJ3.. (SUM(R,U(R)*Y('NEWPORT',R))/SUM(I,V(I)*X('NEWPORT',I)))
          =E=MAXEFF;
OBJ4.. (SUM(R,U(R)*Y('PA',R))/SUM(I,V(I)*X('PA',I)))
          =E=MAXEFF;
OBJ5.. (SUM(R,U(R)*Y('BETHESDA',R))/SUM(I,V(I)*X('BETHESDA',I)))
          =E=MAXEFF;
OBJ6.. (SUM(R,U(R)*Y('PATUXENTR',R))/SUM(I,V(I)*X('PATUXENTR',I)))
          =E=MAXEFF;
OBJ7.. (SUM(R,U(R)*Y('BEAUFORT',R))/SUM(I,V(I)*X('BEAUFORT',I)))
          =E=MAXEFF;
OBJ8.. (SUM(R,U(R)*Y('CMPLEJEUNE',R))/SUM(I,V(I)*X('CMPLEJEUNE',I)))
          =E=MAXEFF;
OBJ9.. (SUM(R,U(R)*Y('CHARLESTON',R))/SUM(I,V(I)*X('CHARLESTON',I)))
          =E=MAXEFF;
OBJ10.. (SUM(R,U(R)*Y('CHERRYPNT',R))/SUM(I,V(I)*X('CHERRYPNT',I)))
          =E=MAXEFF;
OBJ13.. (SUM(R,U(R)*Y('PORTSMOUTH',R))/SUM(I,V(I)*X('PORTSMOUTH',I)))
          =E=MAXEFF;
OBJ15.. (SUM(R,U(R)*Y('CORPUSCHRI',R))/SUM(I,V(I)*X('CORPUSCHRI',I)))
          =E=MAXEFF;
OBJ16.. (SUM(R,U(R)*Y('JACKSNVILL',R))/SUM(I,V(I)*X('JACKSNVILL',I)))
          =E=MAXEFF;
OBJ17.. (SUM(R,U(R)*Y('MILLINGTON',R))/SUM(I,V(I)*X('MILLINGTON',I)))
          =E=MAXEFF;
OBJ18.. (SUM(R,U(R)*Y('ORLANDO',R))/SUM(I,V(I)*X('ORLANDO',I)))
          =E=MAXEFF;
OBJ19.. (SUM(R,U(R)*Y('PENSACOLA',R))/SUM(I,V(I)*X('PENSACOLA',I)))
          =E=MAXEFF;
OBJ21.. (SUM(R,U(R)*Y('BREMERTON',R))/SUM(I,V(I)*X('BREMERTON',I)))
          =E=MAXEFF;
OBJ22.. (SUM(R,U(R)*Y('LEMOORE',R))/SUM(I,V(I)*X('LEMOORE',I)))
          =E=MAXEFF;
OBJ23.. (SUM(R,U(R)*Y('OAKHARBOR',R))/SUM(I,V(I)*X('OAKHARBOR',I)))
          =E=MAXEFF;
OBJ24.. (SUM(R,U(R)*Y('OAKLAND',R))/SUM(I,V(I)*X('OAKLAND',I)))
          =E=MAXEFF;
OBJ25.. (SUM(R,U(R)*Y('CMPENDLTN',R))/SUM(I,V(I)*X('CMPENDLTN',I)))
          =E=MAXEFF;
OBJ26.. (SUM(R,U(R)*Y('LONGBEACH',R))/SUM(I,V(I)*X('LONGBEACH',I)))
          =E=MAXEFF;
OBJ27.. (SUM(R,U(R)*Y('SANDIEGO',R))/SUM(I,V(I)*X('SANDIEGO',I)))
          =E=MAXEFF;
OBJ28.. (SUM(R,U(R)*Y('TWENTYNPLM',R))/SUM(I,V(I)*X('TWENTYNPLM',I)))
```

```
        =E=MAXEFF;
*          subject to
INOUT(J).. SUM(R,U(R)*Y(J,R)) - SUM(I,V(I)*X(J,I)) =L= 0 ;
*-------------------------------------------------------------
*-------maximize---------------------------------------------
MODEL HOSP1 /OBJ1,INOUT/;
SOLVE HOSP1 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP2 /OBJ2,INOUT/;
SOLVE HOSP2 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP3 /OBJ3,INOUT/;
SOLVE HOSP3 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP4 /OBJ4,INOUT/;
SOLVE HOSP4 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP5 /OBJ5,INOUT/;
SOLVE HOSP5 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP6 /OBJ6,INOUT/;
SOLVE HOSP6 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP7 /OBJ7,INOUT/;
SOLVE HOSP7 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP8 /OBJ8,INOUT/;
SOLVE HOSP8 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP9 /OBJ9,INOUT/;
SOLVE HOSP9 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP10 /OBJ10,INOUT/;
SOLVE HOSP10 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP13 /OBJ13,INOUT/;
SOLVE HOSP13 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP15 /OBJ15,INOUT/;
SOLVE HOSP15 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP16 /OBJ16,INOUT/;
SOLVE HOSP16 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP17 /OBJ17,INOUT/;
SOLVE HOSP17 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP18 /OBJ18,INOUT/;
SOLVE HOSP18 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP19 /OBJ19,INOUT/;
SOLVE HOSP19 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP21 /OBJ21,INOUT/;
SOLVE HOSP21 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP22 /OBJ22,INOUT/;
SOLVE HOSP22 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP23 /OBJ23,INOUT/;
SOLVE HOSP23 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
MODEL HOSP24 /OBJ24,INOUT/;
SOLVE HOSP24 USING NLP MAXIMIZING MAXEFF ;
DISPLAY U.L,V.L,MAXEFF.L;
```

```
257  MODEL HOSP25 /OBJ25,INOUT/;
258  SOLVE HOSP25 USING NLP MAXIMIZING MAXEFF ;
259  DISPLAY U.L,V.L,MAXEFF.L;
260  MODEL HOSP26 /OBJ26,INOUT/;
261  SOLVE HOSP26 USING NLP MAXIMIZING MAXEFF ;
262  DISPLAY U.L,V.L,MAXEFF.L;
263  MODEL HOSP27 /OBJ27,INOUT/;
264  SOLVE HOSP27 USING NLP MAXIMIZING MAXEFF ;
265  DISPLAY U.L,V.L,MAXEFF.L;
266  MODEL HOSP28 /OBJ28,INOUT/;
267  SOLVE HOSP28 USING NLP MAXIMIZING MAXEFF ;
268  DISPLAY U.L,V.L,MAXEFF.L;


COMPILATION TIME     =        0.158 MINUTES

SOLUTION REPORT     SOLVE HOSP1 USING NLP FROM LINE 198
**** OBJECTIVE VALUE                    1.0000

SOLUTION REPORT     SOLVE HOSP2 USING NLP FROM LINE 201
**** OBJECTIVE VALUE                    1.0000

SOLUTION REPORT     SOLVE HOSP3 USING NLP FROM LINE 204
**** OBJECTIVE VALUE                    1.0000

MODEL STATISTICS    SOLVE HOSP4 USING NLP FROM LINE 207
**** OBJECTIVE VALUE                    1.0000

SOLUTION REPORT     SOLVE HOSP5 USING NLP FROM LINE 210
**** OBJECTIVE VALUE                    1.0000

SOLUTION REPORT     SOLVE HOSP6 USING NLP FROM LINE 213
**** OBJECTIVE VALUE                    0.8375

SOLUTION REPORT     SOLVE HOSP7 USING NLP FROM LINE 216
**** OBJECTIVE VALUE                    0.9992

SOLUTION REPORT     SOLVE HOSP8 USING NLP FROM LINE 219
**** OBJECTIVE VALUE                    1.0000

SOLUTION REPORT     SOLVE HOSP9 USING NLP FROM LINE 222
**** OBJECTIVE VALUE                    0.9613

SOLUTION REPORT     SOLVE HOSP10 USING NLP FROM LINE 225
**** OBJECTIVE VALUE                    0.6791

SOLUTION REPORT     SOLVE HOSP13 USING NLP FROM LINE 228
**** OBJECTIVE VALUE                    0.9321

SOLUTION REPORT     SOLVE HOSP15 USING NLP FROM LINE 231
**** OBJECTIVE VALUE                    0.8685

SOLUTION REPORT     SOLVE HOSP16 USING NLP FROM LINE 234
**** OBJECTIVE VALUE                    0.7094

SOLUTION REPORT     SOLVE HOSP17 USING NLP FROM LINE 237
**** OBJECTIVE VALUE                    0.6393

SOLUTION REPORT     SOLVE HOSP18 USING NLP FROM LINE 240
**** OBJECTIVE VALUE                    1.0000

SOLUTION REPORT     SOLVE HOSP19 USING NLP FROM LINE 243
**** OBJECTIVE VALUE                    0.7669

SOLUTION REPORT     SOLVE HO  21 USING NLP FROM LINE 246
**** OBJECTIVE VALUE                    1.0000
```

```
SOLUTION REPORT     SOLVE HOSP22 USING NLP FROM LINE 249
**** OBJECTIVE VALUE                      0.9115

SOLUTION REPORT     SOLVE HOSP23 USING NLP FROM LINE 252
**** OBJECTIVE VALUE                      1.0000

SOLUTION REPORT     SOLVE HOSP24 USING NLP FROM LINE 255
**** OBJECTIVE VALUE                      0.6505

SOLUTION REPORT     SOLVE HOSP25 USING NLP FROM LINE 258
**** OBJECTIVE VALUE                      0.8201

SOLUTION REPORT     SOLVE HOSP26 USING NLP FROM LINE 261
**** OBJECTIVE VALUE                      1.0000

SOLUTION REPORT     SOLVE HOSP27 USING NLP FROM LINE 264
**** OBJECTIVE VALUE                      1.0000

SOLUTION REPORT     SOLVE HOSP28 USING NLP FROM LINE 267
**** OBJECTIVE VALUE                      1.0000

     M I N O S  ---  VERSION  5.0   APR  1984
     = = = = =
     courtesy of B. A. Murtagh and M. A. Saunders,
                 Department of Operations Research,
                 Stanford University,
                 Stanford   California   94305   U.S.A.


**** FILE SUMMARY

INPUT   D: GAMS204 HCS75NL.GMS
OUTPUT  D: GAMS204 HCS75NL.LST

EXECUTION TIME       =        0.081 MINUTES
```

APPENDIX D. LINEAR DEA MODEL

The linear DEA model has manpower data which has been calculated from the coefficients of the three-stage least squares. The coefficients for MDs, officers, and enlisted personnel have been optimized, while the rest of the data has not been altered.

The procedure for changing the GAMS input file is included with the calculation of the coefficients, which occurs in a spreadsheet. The formulas for the coefficients are entered in the appropriate cells and the spreadsheet calculates the values. The rest of the GAMS model is also in the spreadsheet. A print to file statement in the spreadsheet creates an ASCII file which is compatible with GAMS.

```
GAMS 2.04 PC AT/XT
GENERAL  ALGEBRAIC  MODELING  SYSTEM  COMPILATION

* * * LINEAR DEA MODEL * * *

*---------------------------------------------------------------
OPTIONS SOLPRINT = OFF, RESLIM = 60, ITERLIM = 100
OPTIONS LIMCOL = 0, LIMROW = 0
*---------------------------------------------------------------

SET J  HOSPITALS

/ OAKHARBOR 1, PATUXENTR 2,    TWENTYNPLM 3,  LEMOORE 4,
CHERRYPNT 5,   ORLANDO 6,      GROTON 7,      PA 8,
MILLINGTON 9,  NEWPORT 10,     BREMERTON 11,  CORPUSCHRI 12,
BEAUFORT 13,   CMPLEJEUNE 14,  PENSACOLA 15,  JACKSNVILL 16,
CHARLESTON 17, OAKLAND 18,     LONGBEACH 19,  CMPENDLTN 20,
PORTSMOUTH 21, BETHESDA 22,    GREATLAKES 23, SANDIEGO 24,
SIGONELLA 25,  KEFLAVIK 26,    GUANTBAY 27,   NAPLES 28,
ROTA 29,       ROOSRDS 30,     GUAM 31,       YOKOSUKA 32,
SUBICBAY 33,   OKINAWA 34 / ;

SET I       INPUTS PER DAY OF MANPOWER CATEGORIES
/  MILMDS   MILITARY DOCTORS
   OFFICERS NON-PHYSICIAN OFFICERS
   ENLISTED PERSONNEL
   CIVMDS   CIVILIAN DOCTORS
   CIVOTH   OTHER CIVILIANS / ;

SET R    OUTPUTS PER DAY
/  OPV   OUTPATIENT VOLUME PER DAY
   ADM   ADMISSIONS PER DAY
   ALOS  AVERAGE LENGTH OF STAY IN DAYS
   ADPL  AVERAGE DAILY PATIENT LOAD / ;

TABLE X(J,I)
* HOSPITAL INPUT

                 MILMDS OFFICERS ENLISTED  CIVMDS   CIVOTH
  OAKHARBOR        13       30      154        1       42
  PATUXENTR        11       26      130        1       62
  TWENTYNPLM       15       19       95        0        0
  LEMOORE          12       36      199        0       43
  CHERRYPNT         2       42      213        2       77
  ORLANDO          54      144      418        6      223
  GROTON           12       79      310       21       84
  PA               28      101      293     11.3      212
  MILLINGTON       42      114      346       10      122
  NEWPORT          34       78      286        2      156
  BREMERTON        56      108      278        5      261
  CORPUSCHRI       30       68      226        1       93
```

```
BEAUFORT        34       86      304      3.5      156
CMPLEJEUNE      70      156      463        1      303
PENSACOLA       53      134      467        3      251
JACKSNVILL      60      190      747      5.7      269
CHARLESTON      70      156      596        7      230
OAKLAND        126      203      879       19      388
LONGBEACH       73      179      487        4      380
CMPENDLTN       78      170      569        0      405
PORTSMOUTH     269      384     1198        4      561
BETHESDA       244      326     1220        4      618
GREATLAKES      88      173      503     26.8      253
SANDIEGO       258      451     1449      7.4      842
SIGONELLA       22       11       24        1        6
KEFLAVIK        16       12       71        0        0
GUANTBAY        15       26      117        0       41
NAPLES          34       46      179        3       77
ROTA            20       28      182        0       36
ROOSRDS         27       56      226        1       85
GUAM            35       71      320        0      108
YOKOSUKA        45       76      243        1      203
SUBICBAY        36       70      206        0      213
OKINAWA         71      120      399        0      239 ;

TABLE Y(J,R)
* HOSPITAL OUTPUT

               ADM       ALOS      ADPL  OPV
OAKHARBOR      5.38      2.6        11    239.3
PATUXENTR      3.43      2.6         7   211.98
TWENTYNPLM     6.33      2.5        12   206.02
LEMOORE        5.26        3        13   287.55
CHERRYPNT      7.24      2.7        15   528.66
ORLANDO       13.21      5.7        72   488.75
GROTON         9.13      3.1        24   485.64
PA             6.61      4.8        31   296.2
MILLINGTON    10.11      5.4        51   371.16
NEWPORT        5.99      6.6        41   361.42
BREMERTON     15.07      5.1        71    441.5
CORPUSCHRI     3.66      8.2        30   252.95
BEAUFORT       7.61      4.8        35   249.88
CMPLEJEUNE    23.97      4.4        97   604.92
PENSACOLA      17.7      4.8        79      634
JACKSNVILL    29.09      3.5        93   722.09
CHARLESTON    25.55      4.3       100   652.36
OAKLAND       35.55        5       171   765.28
LONGBEACH      12.1        7        86    360.4
CMPENDLTN     23.14      5.1       110   662.96
PORTSMOUTH     73.6      5.3       368  1334.67
BETHESDA      44.93      7.4       322  1066.12
GREATLAKES    16.48      6.6       108   458.23
SANDIEGO      67.48      5.6       358  1302.99
SIGONELLA      0.98      2.7        12    77.41
KEFLAVIK       1.84      3.2         5    66.13
GUANTBAY       3.39      2.2         7   130.31
NAPLES         6.01        5        27   114.36
ROTA           4.55      4.1        16   188.42
ROOSRDS        6.63      4.1        25   203.15
GUAM          11.83      3.9        39   294.15
YOKOSUKA      10.46      5.1        49   279.73
SUBICBAY      11.99      4.2        48   429.23
OKINAWA       20.03      4.7        86   381.33 ;


POSITIVE VARIABLES
   LVI(I)  INPUTS
   LVR(R)  OUPUTS
   V(I)    THE WEIGHTING FOR INPUT I TO MAXIMIZE EFFICIENCY VALUE
   U(R)    THE WEIGHTING FOR OUTPUT R TO MAXIMIZE EFFICIENCY VALU
```

```
VARIABLE
   MAXEFF  MAXIMIZE EFFICIENCY ;

EQUATIONS

   OBJ1    MAXIMIZE EFFICIENCY OF  HOSPITAL 1
   OBJ2    MAXIMIZE EFFICIENCY OF  HOSPITAL 2
   OBJ3    MAXIMIZE EFFICIENCY OF  HOSPITAL 3
   OBJ4    MAXIMIZE EFFICIENCY OF  HOSPITAL 4
   OBJ5    MAXIMIZE EFFICIENCY OF  HOSPITAL 5
   OBJ6    MAXIMIZE EFFICIENCY OF  HOSPITAL 6
   OBJ7    MAXIMIZE EFFICIENCY OF  HOSPITAL 7
   OBJ8    MAXIMIZE EFFICIENCY OF  HOSPITAL 8
   OBJ9    MAXIMIZE EFFICIENCY OF  HOSPITAL 9
   OBJ10   MAXIMIZE EFFICIENCY OF  HOSPITAL 10
   OBJ11   MAXIMIZE EFFICIENCY OF  HOSPITAL 11
   OBJ12   MAXIMIZE EFFICIENCY OF  HOSPITAL 12
   OBJ13   MAXIMIZE EFFICIENCY OF  HOSPITAL 13
   OBJ14   MAXIMIZE EFFICIENCY OF  HOSPITAL 14
   OBJ15   MAXIMIZE EFFICIENCY OF  HOSPITAL 15
   OBJ16   MAXIMIZE EFFICIENCY OF  HOSPITAL 16
   OBJ17   MAXIMIZE EFFICIENCY OF  HOSPITAL 17
   OBJ18   MAXIMIZE EFFICIENCY OF  HOSPITAL 18
   OBJ19   MAXIMIZE EFFICIENCY OF  HOSPITAL 19
   OBJ20   MAXIMIZE EFFICIENCY OF  HOSPITAL 20
   OBJ21   MAXIMIZE EFFICIENCY OF  HOSPITAL 21
   OBJ22   MAXIMIZE EFFICIENCY OF  HOSPITAL 22
   OBJ23   MAXIMIZE EFFICIENCY OF  HOSPITAL 23
   OBJ24   MAXIMIZE EFFICIENCY OF  HOSPITAL 24
   OBJ25   MAXIMIZE EFFICIENCY OF  HOSPITAL 25
   OBJ26   MAXIMIZE EFFICIENCY OF  HOSPITAL 26
   OBJ27   MAXIMIZE EFFICIENCY OF  HOSPITAL 27
   OBJ28   MAXIMIZE EFFICIENCY OF  HOSPITAL 28
   OBJ29   MAXIMIZE EFFICIENCY OF  HOSPITAL 29
   OBJ30   MAXIMIZE EFFICIENCY OF  HOSPITAL 30
   OBJ31   MAXIMIZE EFFICIENCY OF  HOSPITAL 31
   OBJ32   MAXIMIZE EFFICIENCY OF  HOSPITAL 32
   OBJ33   MAXIMIZE EFFICIENCY OF  HOSPITAL 33
   OBJ34   MAXIMIZE EFFICIENCY OF  HOSPITAL 34


   LINCON1 A MATRIX DOT PRODUCT Y LESS THAN OR EQUAL TO ZERO
   LINCON201 Q MATRIX DOT LV EQUAL ONE
   LINCON202 Q MATRIX DOT LV EQUAL ONE
   LINCON203 Q MATRIX DOT LV EQUAL ONE
   LINCON204 Q MATRIX DOT LV EQUAL ONE
   LINCON205 Q MATRIX DOT LV EQUAL ONE
   LINCON206 Q MATRIX DOT LV EQUAL ONE
   LINCON207 Q MATRIX DOT LV EQUAL ONE
   LINCON208 Q MATRIX DOT LV EQUAL ONE
   LINCON209 Q MATRIX DOT LV EQUAL ONE
   LINCON210 Q MATRIX DOT LV EQUAL ONE
   LINCON211 Q MATRIX DOT LV EQUAL ONE
   LINCON212 Q MATRIX DOT LV EQUAL ONE
   LINCON213 Q MATRIX DOT LV EQUAL ONE
   LINCON214 Q MATRIX DOT LV EQUAL ONE
   LINCON215 Q MATRIX DOT LV EQUAL ONE
   LINCON216 Q MATRIX DOT LV EQUAL ONE
   LINCON217 Q MATRIX DOT LV EQUAL ONE
   LINCON218 Q MATRIX DOT LV EQUAL ONE
   LINCON219 Q MATRIX DOT LV EQUAL ONE
   LINCON220 Q MATRIX DOT LV EQUAL ONE
   LINCON221 Q MATRIX DOT LV EQUAL ONE
   LINCON222 Q MATRIX DOT LV EQUAL ONE
   LINCON223 Q MATRIX DOT LV EQUAL ONE
   LINCON224 Q MATRIX DOT LV EQUAL ONE
   LINCON225 Q MATRIX DOT LV EQUAL ONE
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   LINCON226 Q MATRIX DOT LV EQUAL ONE
   LINCON227 Q MATRIX DOT LV EQUAL ONE
   LINCON228 Q MATRIX DOT LV EQUAL ONE
   LINCON229 Q MATRIX DOT LV EQUAL ONE
   LINCON230 Q MATRIX DOT LV EQUAL ONE
   LINCON231 Q MATRIX DOT LV EQUAL ONE
   LINCON232 Q MATRIX DOT LV EQUAL ONE
   LINCON233 Q MATRIX DOT LV EQUAL ONE
   LINCON234 Q MATRIX DOT LV EQUAL ONE ;

******** LINEAR MODEL****************************
*MAX
OBJ1.. (SUM(R,LVR(R)*Y('OAKHARBOR',R)))=E=MAXEFF;
OBJ2.. (SUM(R,LVR(R)*Y('PATUXENTR',R)))=E=MAXEFF;
OBJ3.. (SUM(R,LVR(R)*Y('TWENTYNPLM',R)))=E=MAXEFF;
OBJ4.. (SUM(R,LVR(R)*Y('LEMOORE',R)))=E=MAXEFF;
OBJ5.. (SUM(R,LVR(R)*Y('CHERRYPNT',R)))=E=MAXEFF;
OBJ6.. (SUM(R,LVR(R)*Y('ORLANDO',R)))=E=MAXEFF;
OBJ7.. (SUM(R,LVR(R)*Y('GROTON',R)))=E=MAXEFF;
OBJ8.. (SUM(R,LVR(R)*Y('PA',R)))=E=MAXEFF;
OBJ9.. (SUM(R,LVR(R)*Y('MILLINGTON',R)))=E=MAXEFF;
OBJ10.. (SUM(R,LVR(R)*Y('NEWPORT',R)))=E=MAXEFF;
OBJ11.. (SUM(R,LVR(R)*Y('BREMERTON',R)))=E=MAXEFF;
OBJ12.. (SUM(R,LVR(R)*Y('CORPUSCHRI',R)))=E=MAXEFF;
OBJ13.. (SUM(R,LVR(R)*Y('BEAUFORT',R)))=E=MAXEFF;
OBJ14.. (SUM(R,LVR(R)*Y('CMPLEJEUNE',R)))=E=MAXEFF;
OBJ15.. (SUM(R,LVR(R)*Y('PENSACOLA',R)))=E=MAXEFF;
OBJ16.. (SUM(R,LVR(R)*Y('JACKSNVILL',R)))=E=MAXEFF;
OBJ17.. (SUM(R,LVR(R)*Y('CHARLESTON',R)))=E=MAXEFF;
OBJ18.. (SUM(R,LVR(R)*Y('OAKLAND',R)))=E=MAXEFF;
OBJ19.. (SUM(R,LVR(R)*Y('LONGBEACH',R)))=E=MAXEFF;
OBJ20.. (SUM(R,LVR(R)*Y('CMPENDLTN',R)))=E=MAXEFF;
OBJ21.. (SUM(R,LVR(R)*Y('PORTSMOUTH',R)))=E=MAXEFF;
OBJ22.. (SUM(R,LVR(R)*Y('BETHESDA',R)))=E=MAXEFF;
OBJ23.. (SUM(R,LVR(R)*Y('GREATLAKES',R)))=E=MAXEFF;
OBJ24.. (SUM(R,LVR(R)*Y('SANDIEGO',R)))=E=MAXEFF;
OBJ25.. (SUM(R,LVR(R)*Y('SIGONELLA',R)))=E=MAXEFF;
OBJ26.. (SUM(R,LVR(R)*Y('KEFLAVIK',R)))=E=MAXEFF;
OBJ27.. (SUM(R,LVR(R)*Y('GUANTBAY',R)))=E=MAXEFF;
OBJ28.. (SUM(R,LVR(R)*Y('NAPLES',R)))=E=MAXEFF;
OBJ29.. (SUM(R,LVR(R)*Y('ROTA',R)))=E=MAXEFF;
OBJ30.. (SUM(R,LVR(R)*Y('ROOSRDS',R)))=E=MAXEFF;
OBJ31.. (SUM(R,LVR(R)*Y('GUAM',R)))=E=MAXEFF;
OBJ32.. (SUM(R,LVR(R)*Y('YOKOSUKA',R)))=E=MAXEFF;
OBJ33.. (SUM(R,LVR(R)*Y('SUBICBAY',R)))=E=MAXEFF;
OBJ34.. (SUM(R,LVR(R)*Y('OKINAWA',R)))=E=MAXEFF;

*          SUBJECT TO
LINCON1(J).. SUM(R,LVR(R)*Y(J,R)) - SUM(I,LVI(I)*X(J,I)) =L= 0 ;
LINCON201(J).. SUM(I,LVI(I)*X('OAKHARBOR',I)) =E= 1 ;
LINCON202(J).. SUM(I,LVI(I)*X('PATUXENTR',I)) =E= 1 ;
LINCON203(J).. SUM(I,LVI(I)*X('TWENTYNPLM',I)) =E= 1 ;
LINCON204(J).. SUM(I,LVI(I)*X('LEMOORE',I)) =E= 1 ;
LINCON205(J).. SUM(I,LVI(I)*X('CHERRYPNT',I)) =E= 1 ;
LINCON206(J).. SUM(I,LVI(I)*X('ORLANDO',I)) =E= 1 ;
LINCON207(J).. SUM(I,LVI(I)*X('GROTON',I)) =E= 1 ;
LINCON208(J).. SUM(I,LVI(I)*X('PA',I)) =E= 1 ;
LINCON209(J).. SUM(I,LVI(I)*X('MILLINGTON',I)) =E= 1 ;
LINCON210(J).. SUM(I,LVI(I)*X('NEWPORT',I)) =E= 1 ;
LINCON211(J).. SUM(I,LVI(I)*X('BREMERTON',I)) =E= 1 ;
LINCON212(J).. SUM(I,LVI(I)*X('CORPUSCHRI',I)) =E= 1 ;
LINCON213(J).. SUM(I,LVI(I)*X('BEAUFORT',I)) =E= 1 ;
LINCON214(J).. SUM(I,LVI(I)*X('CMPLEJEUNE',I)) =E= 1 ;
LINCON215(J).. SUM(I,LVI(I)*X('PENSACOLA',I)) =E= 1 ;
LINCON216(J).. SUM(I,LVI(I)*X('JACKSNVILL',I)) =E= 1 ;
LINCON217(J).. SUM(I,LVI(I)*X('CHARLESTON',I)) =E= 1 ;
LINCON218(J).. SUM(I,LVI(I)*X('OAKLAND',I)) =E= 1 ;
LINCON219(J).. SUM(I,LVI(I)*X('LONGBEACH',I)) =E= 1 ;
```

```
LINCON220(J).. SUM(I,LVI(I)*X('CMPENDLTN',I)) =E= 1 ;
LINCON221(J).. SUM(I,LVI(I)*X('PORTSMOUTH',I)) =E= 1 ;
LINCON222(J).. SUM(I,LVI(I)*X('BETHESDA',I)) =E= 1 ;
LINCON223(J).. SUM(I,LVI(I)*X('GREATLAKES',I)) =E= 1 ;
LINCON224(J).. SUM(I,LVI(I)*X('SANDIEGO',I)) =E= 1 ;
LINCON225(J).. SUM(I,LVI(I)*X('SIGONELLA',I)) =E= 1 ;
LINCON226(J).. SUM(I,LVI(I)*X('KEFLAVIK',I)) =E= 1 ;
LINCON227(J).. SUM(I,LVI(I)*X('GUANTBAY',I)) =E= 1 ;
LINCON228(J).. SUM(I,LVI(I)*X('NAPLES',I)) =E= 1 ;
LINCON229(J).. SUM(I,LVI(I)*X('ROTA',I)) =E= 1 ;
LINCON230(J).. SUM(I,LVI(I)*X('ROOSRDS',I)) =E= 1 ;
LINCON231(J).. SUM(I,LVI(I)*X('GUAM',I)) =E= 1 ;
LINCON232(J).. SUM(I,LVI(I)*X('YOKOSUKA',I)) =E= 1 ;
LINCON233(J).. SUM(I,LVI(I)*X('SUBICBAY',I)) =E= 1 ;
LINCON234(J).. SUM(I,LVI(I)*X('OKINAWA',I)) =E= 1 ;

**************************************************

MODEL HOSP1 /OBJ1,LINCON1,LINCON201/;
SOLVE HOSP1 USING LP MAXIMIZING MAXEFF ;
DISPLAY "OAKHARBOR",LVI.L,LVR.L;
**
MODEL HOSP2 /OBJ2,LINCON1,LINCON202/;
SOLVE HOSP2 USING LP MAXIMIZING MAXEFF ;
DISPLAY "PATUXENTR",LVI.L,LVR.L;
**
MODEL HOSP3 /OBJ3,LINCON1,LINCON203/;
SOLVE HOSP3 USING LP MAXIMIZING MAXEFF ;
DISPLAY "TWENTYNPLM",LVI.L,LVR.L;
**
MODEL HOSP4 /OBJ4,LINCON1,LINCON204/;
SOLVE HOSP4 USING LP MAXIMIZING MAXEFF ;
DISPLAY "LEMOORE",LVI.L,LVR.L;
**
MODEL HOSP5 /OBJ5,LINCON1,LINCON205/;
SOLVE HOSP5 USING LP MAXIMIZING MAXEFF ;
DISPLAY "CHERRYPNT",LVI.L,LVR.L;
**
MODEL HOSP6 /OBJ6,LINCON1,LINCON206/;
SOLVE HOSP6 USING LP MAXIMIZING MAXEFF ;
DISPLAY "ORLANDO",LVI.L,LVR.L;
**
MODEL HOSP7 /OBJ7,LINCON1,LINCON207/;
SOLVE HOSP7 USING LP MAXIMIZING MAXEFF ;
DISPLAY "GROTON",LVI.L,LVR.L;
**
MODEL HOSP8 /OBJ8,LINCON1,LINCON208/;
SOLVE HOSP8 USING LP MAXIMIZING MAXEFF ;
DISPLAY "PA",LVI.L,LVR.L;
**
MODEL HOSP9 /OBJ9,LINCON1,LINCON209/;
SOLVE HOSP9 USING LP MAXIMIZING MAXEFF ;
DISPLAY "MILLINGTON",LVI.L,LVR.L;
**
MODEL HOSP10 /OBJ10,LINCON1,LINCON210/;
SOLVE HOSP10 USING LP MAXIMIZING MAXEFF ;
DISPLAY "NEWPORT",LVI.L,LVR.L;
**
MODEL HOSP11 /OBJ11,LINCON1,LINCON211/;
SOLVE HOSP11 USING LP MAXIMIZING MAXEFF ;
DISPLAY "BREMERTON",LVI.L,LVR.L;
**
MODEL HOSP12 /OBJ12,LINCON1,LINCON212/;
SOLVE HOSP12 USING LP MAXIMIZING MAXEFF ;
DISPLAY "CORPUSCHRI",LVI.L,LVR.L;
**
MODEL HOSP13 /OBJ13,LINCON1,LINCON213/;
SOLVE HOSP13 USING LP MAXIMIZING MAXEFF ;
```

```
DISPLAY "BEAUFORT",LVI.L,LVR.L;
**
MODEL HOSP14 /OBJ14,LINCON1,LINCON214/;
SOLVE HOSP14 USING LP MAXIMIZING MAXEFF ;
DISPLAY "CMPLEJEUNE",LVI.L,LVR.L;
**
MODEL HOSP15 /OBJ15,LINCON1,LINCON215/;
SOLVE HOSP15 USING LP MAXIMIZING MAXEFF ;
DISPLAY "PENSACOLA",LVI.L,LVR.L;
**
MODEL HOSP16 /OBJ16,LINCON1,LINCON216/;
SOLVE HOSP16 USING LP MAXIMIZING MAXEFF ;
DISPLAY "JACKSNVILL",LVI.L,LVR.L;
**
MODEL HOSP17 /OBJ17,LINCON1,LINCON217/;
SOLVE HOSP17 USING LP MAXIMIZING MAXEFF ;
DISPLAY "CHARLESTON",LVI.L,LVR.L;
**
MODEL HOSP18 /OBJ18,LINCON1,LINCON218/;
SOLVE HOSP18 USING LP MAXIMIZING MAXEFF ;
DISPLAY "OAKLAND",LVI.L,LVR.L;
**
MODEL HOSP19 /OBJ19,LINCON1,LINCON219/;
SOLVE HOSP19 USING LP MAXIMIZING MAXEFF ;
DISPLAY "LONGBEACH",LVI.L,LVR.L;
**
MODEL HOSP20 /OBJ20,LINCON1,LINCON220/;
SOLVE HOSP20 USING LP MAXIMIZING MAXEFF ;
DISPLAY "CMPENDLTN",LVI.L,LVR.L;
**
MODEL HOSP21 /OBJ21,LINCON1,LINCON221/;
SOLVE HOSP21 USING LP MAXIMIZING MAXEFF ;
DISPLAY "PORTSMOUTH",LVI.L,LVR.L;
**
MODEL HOSP22 /OBJ22,LINCON1,LINCON222/;
SOLVE HOSP22 USING LP MAXIMIZING MAXEFF ;
DISPLAY "BETHESDA",LVI.L,LVR.L;
**
MODEL HOSP23 /OBJ23,LINCON1,LINCON223/;
SOLVE HOSP23 USING LP MAXIMIZING MAXEFF ;
DISPLAY "GREATLAKES",LVI.L,LVR.L;
**
MODEL HOSP24 /OBJ24,LINCON1,LINCON224/;
SOLVE HOSP24 USING LP MAXIMIZING MAXEFF ;
DISPLAY "SANDIEGO",LVI.L,LVR.L;
**
MODEL HOSP25 /OBJ25,LINCON1,LINCON225/;
SOLVE HOSP25 USING LP MAXIMIZING MAXEFF ;
DISPLAY "SIGONELLA",LVI.L,LVR.L;
**
MODEL HOSP26 /OBJ26,LINCON1,LINCON226/;
SOLVE HOSP26 USING LP MAXIMIZING MAXEFF ;
DISPLAY "KEFLAVIK",LVI.L,LVR.L;
**
MODEL HOSP27 /OBJ27,LINCON1,LINCON227/;
SOLVE HOSP27 USING LP MAXIMIZING MAXEFF ;
DISPLAY "GUANTBAY",LVI.L,LVR.L;
**
MODEL HOSP28 /OBJ28,LINCON1,LINCON228/;
SOLVE HOSP28 USING LP MAXIMIZING MAXEFF ;
DISPLAY "NAPLES",LVI.L,LVR.L;
**
MODEL HOSP29 /OBJ29,LINCON1,LINCON229/;
SOLVE HOSP29 USING LP MAXIMIZING MAXEFF ;
DISPLAY "ROTA",LVI.L,LVR.L;
**
MODEL HOSP30 /OBJ30,LINCON1,LINCON230/;
SOLVE HOSP30 USING LP MAXIMIZING MAXEFF ;
```

```
DISPLAY "ROOSRDS",LVI.L,LVR.L;
**
MODEL HOSP31 /OBJ31,LINCON1,LINCON231/;
SOLVE HOSP31 USING LP MAXIMIZING MAXEFF ;
DISPLAY "GUAM",LVI.L,LVR.L;
**
MODEL HOSP32 /OBJ32,LINCON1,LINCON232/;
SOLVE HOSP32 USING LP MAXIMIZING MAXEFF ;
DISPLAY "YOKOSUKA",LVI.L,LVR.L;
**
MODEL HOSP33 /OBJ33,LINCON1,LINCON233/;
SOLVE HOSP33 USING LP MAXIMIZING MAXEFF ;
DISPLAY "SUBICBAY",LVI.L,LVR.L;
**
MODEL HOSP34 /OBJ34,LINCON1,LINCON234/;
SOLVE HOSP34 USING LP MAXIMIZING MAXEFF ;
DISPLAY "OKINAWA",LVI.L,LVR.L;
**
```

```
* * * LINEAR DEA MODEL RESULTS * * *

SOLUTION REPORT     SOLVE HOSP1 USING LP FROM LINE 270
**** OBJECTIVE VALUE                0.8014
----     271 OAKHARBOR
----     271 VARIABLE  LVI.L        INPUTS
MILMDS        0.028,    OFFICERS    0.019,    ENLISTED 5.0560E-4
----     271 VARIABLE  LVR.L        OUPUTS
ADM  0.015,    ALOS 0.175,    ADPL 0.024

SOLUTION REPORT     SOLVE HOSP2 USING LP FROM LINE 274
**** OBJECTIVE VALUE                0.8348
----     275 PATUXENTR
MILMDS   0.023,    OFFICERS 0.002,    ENLISTED 0.005
OPV  9.5872E-4,    ADM      0.029,    ALOS     0.205

SOLUTION REPORT     SOLVE HOSP3 USING LP FROM LINE 278
**** OBJECTIVE VALUE                1.0000
----     279 TWENTYNPLM
MILMDS        0.061,    ENLISTED 8.1947E-4,    CIVMDS       0.374
CIVOTH        0.002
OPV  1.0165E-4,    ADM      0.082,    ADPL     0.038

SOLUTION REPORT     SOLVE HOSP4 USING LP FROM LINE 282
**** OBJECTIVE VALUE                1.0000
----     283 LEMOORE
MILMDS   0.048,    OFFICERS 0.009,    CIVMDS   0.202,    CIVOTH   0.002
ALOS 0.124,    ADPL 0.048

SOLUTION REPORT     SOLVE HOSP5 USING LP FROM LINE 286
**** OBJECTIVE VALUE                1.0000
----     287 CHERRYPNT
MILMDS   0.024,    ENLISTED 0.004,    CIVOTH   0.002
OPV  6.0330E-4,    ALOS     0.088,    ADPL     0.030

SOLUTION REPORT     SOLVE HOSP6 USING LP FROM LINE 290
**** OBJECTIVE VALUE                0.9165
----     291 ORLANDO
MILMDS        0.010,    ENLISTED 8.8291E-4,    CIVOTH   3.0203E-4
ALOS 0.027,    ADPL 0.011

SOLUTION REPORT     SOLVE HOSP7 USING LP FROM LINE 294
**** OBJECTIVE VALUE                0.9422
----     295 GROTON
MILMDS 0.034,    CIVOTH 0.007
ALOS 0.034,    ADPL 0.035
```

```
SOLUTION REPORT     SOLVE HOSP8 USING LP FROM LINE 298
**** OBJECTIVE VALUE                0.7604
----    299 PA
MILMDS   0.018,    ENLISTED 0.002
ALOS 0.054,    ADPL 0.016

SOLUTION REPORT     SOLVE HOSP9 USING LP FROM LINE 302
**** OBJECTIVE VALUE                0.9066
----    303 MILLINGTON
MILMDS       0.013,    ENLISTED 6.3388E-4,    CIVOTH       0.002
ALOS 0.036,    ADPL 0.014

SOLUTION REPORT     SOLVE HOSP10 USING LP FROM LINE 306
**** OBJECTIVE VALUE                0.9612
----    307 NEWPORT
MILMDS       0.011,    OFFICERS     0.007,    ENLISTED 1.9424E-4
ALOS 0.050,    ADPL 0.015

SOLUTION REPORT     SOLVE HOSP11 USING LP FROM LINE 310
**** OBJECTIVE VALUE                0.9973
----    311 BREMERTON
MILMDS   0.008,    ENLISTED 0.002
ALOS 0.030,    ADPL 0.012

SOLUTION REPORT     SOLVE HOSP12 USING LP FROM LINE 314
**** OBJECTIVE VALUE                1.0000
----    315 CORPUSCHRI
MILMDS       0.022,    ENLISTED 5.2755E-4,    CIVMDS       0.104
CIVOTH       0.001
OPV  9.2850E-5,    ALOS     0.047,    ADPL     0.020

SOLUTION REPORT     SOLVE HOSP13 USING LP FROM LINE 318
**** OBJECTIVE VALUE                0.7472
----    319 BEAUFORT
MILMDS       0.016,    ENLISTED     0.001,    CIVOTH   4.5054E-4
ALOS 0.041,    ADPL 0.016

SOLUTION REPORT     SOLVE HOSP14 USING LP FROM LINE 322
**** OBJECTIVE VALUE                1.0000
----    323 CMPLEJEUNE
MILMDS       0.011,    ENLISTED 1.3486E-4,    CIVMDS       0.063
CIVOTH   4.0210E-4
ADM  0.014,    ALOS 0.002,    ADPL 0.007

SOLUTION REPORT     SOLVE HOSP15 USING LP FROM LINE 326
**** OBJECTIVE VALUE                0.9309
----    327 PENSACOLA
MILMDS       0.011,    ENLISTED 8.4881E-4
ALOS 0.015,    ADPL 0.011

SOLUTION REPORT     SOLVE HOSP16 USING LP FROM LINE 330
**** OBJECTIVE VALUE                0.8909
----    331 JACKSNVILL
MILMDS 0.009,    CIVOTH 0.002
ADM  0.005,    ADPL 0.008

SOLUTION REPORT     SOLVE HOSP17 USING LP FROM LINE 334
**** OBJECTIVE VALUE                0.9154
----    335 CHARLESTON
MILMDS 0.008,    CIVOTH 0.002
ADM  0.005,    ADPL 0.008

SOLUTION REPORT     SOLVE HOSP18 USING LP FROM LINE 338
**** OBJECTIVE VALUE                0.9659
----    339 OAKLAND
MILMDS   0.003,    OFFICERS 0.003
ADM  0.002,    ALOS 0.014,    ADPL 0.005
```

```
SOLUTION REPORT     SOLVE HOSP19 USING LP FROM LINE 342
**** OBJECTIVE VALUE                    0.8418
----     343 LONGBEACH
MILMDS       0.008,    ENLISTED 6.7571E-4,    CIVOTH   2.3115E-4
ALOS 0.021,    ADPL 0.008

SOLUTION REPORT     SOLVE HOSP20 USING LP FROM LINE 346
**** OBJECTIVE VALUE                    1.0000
----     347 CMPENDLTN
MILMDS       0.010,    ENLISTED 1.0451E-4,    CIVMDS       0.045
CIVOTH   4.6955E-4
ALOS 0.016,    ADPL 0.008

SOLUTION REPORT     SOLVE HOSP21 USING LP FROM LINE 350
**** OBJECTIVE VALUE                    1.0000
----     351 PORTSMOUTH
MILMDS       0.002,    ENLISTED 3.3084E-4
ADM  0.008,    ADPL 0.001

SOLUTION REPORT     SOLVE HOSP22 USING LP FROM LINE 354
**** OBJECTIVE VALUE                    1.0000
----     355 BETHESDA
MILMDS       0.002,    OFFICERS    0.001,    ENLISTED 8.5576E-5
OPV  4.4043E-5,    ALOS     0.007,    ADPL     0.003

SOLUTION REPORT     SOLVE HOSP23 USING LP FROM LINE 358
**** OBJECTIVE VALUE                    0.9185
----     359 GREATLAKES
MILMDS       0.007,    ENLISTED 6.1358E-4,    CIVOTH   2.0989E-4
ALOS 0.019,    ADPL 0.007

SOLUTION REPORT     SOLVE HOSP24 USING LP FROM LINE 362
**** OBJECTIVE VALUE                    0.9650
----     363 SANDIEGO
MILMDS       0.003,    ENLISTED 1.6198E-4
ADPL 0.003

SOLUTION REPORT     SOLVE HOSP25 USING LP FROM LINE 366
**** OBJECTIVE VALUE                    1.0000
----     367 SIGONELLA
MILMDS       0.034,    OFFICERS    0.021,    ENLISTED     0.001
CIVOTH   5.7874E-4
OPV  1.3113E-4,    ADM      0.004,    ALOS     0.154,    ADPL      0.047

SOLUTION REPORT     SOLVE HOSP26 USING LP FROM LINE 370
**** OBJECTIVE VALUE                    1.0000
----     371 KEFLAVIK
MILMDS       0.021,    OFFICERS    0.037,    ENLISTED     0.003
CIVMDS       0.418,    CIVOTH   2.2821E-4
ALOS 0.209,    ADPL 0.066

SOLUTION REPORT     SOLVE HOSP27 USING LP FROM LINE 374
**** OBJECTIVE VALUE                    0.7416
----     375 GUANTBAY
MILMDS   0.049,    ENLISTED 0.002,    CIVMDS    0.393
ADM  0.043,    ALOS 0.270

SOLUTION REPORT     SOLVE HOSP28 USING LP FROM LINE 378
**** OBJECTIVE VALUE                    0.9041
----     379 NAPLES
MILMDS       0.014,    OFFICERS    0.010,    ENLISTED 2.5134E-4
CIVOTH   6.6080E-5
ADM  0.002,    ALOS 0.069,    ADPL 0.020

SOLUTION REPORT     SOLVE HOSP29 USING LP FROM LINE 382
**** OBJECTIVE VALUE                    1.0000
----     383 ROTA
```

```
MILMDS   0.034,    OFFICERS 0.009,    CIVMDS   0.127,    CIVOTH   0.001
ALOS 0.099,    ADPL 0.037

SOLUTION REPORT     SOLVE HOSP30 USING LP FROM LINE 386
**** OBJECTIV. VALUE                     0.7932
----     387 ROOSRDS
MILMDS        0.014,    OFFICERS     0.010,    ENLISTED 2.2868E-4
CIVOTH   8.0544E-5
ADM  0.003,    ALOS 0.068,    ADPL 0.020

SOLUTION REPORT     SOLVE HOSP31 USING LP FROM LINE 390
**** OBJECTIVE VALUE                     0.9651
----     391 GUAM
MILMDS 0.022,    CIVMDS 0.347,    CIVOTH 0.002
ALOS 0.020,    ADPL 0.023

SOLUTION REPORT     SOLVE HOSP32 USING LP FROM LINE 394
**** OBJECTIVE VALUE                     0.9203
----     395 YOKOSUKA
MILMDS        0.010,    OFFICERS     0.007,    ENLISTED 1.5190E-4
ADM  0.001,    ALOS 0.047,    ADPL 0.014

SOLUTION REPORT     SOLVE HOSP33 USING LP FROM LINE 398
**** OBJECTIVE VALUE                     1.0000
----     399 SUBICBAY
MILMDS        0.011,    OFFICERS     0.007,    ENLISTED 3.5743E-4
CIVOTH   1.9115E-4
OPV  4.3310E-5,    ADM      0.001,    ALOS     0.051,    ADPL     0.016

SOLUTION REPORT     SOLVE HOSP34 USING LP FROM LINE 402
**** OBJECTIVE VALUE                     1.0000
----     403 OKINAWA
MILMDS        0.008,    OFFICERS     0.002,    CIVMDS       0.156
CIVOTH   6.0465E-4
ALOS 0.015,    ADPL 0.011

**** FILE SUMMARY

INPUT    D: GAMS204 AGAIN1.GMS
OUTPUT   D: GAMS204 AGAIN1.LST

EXECUTION TIME       =       0.152 MINUTES
```

APPENDIX E. FUNCTIONAL RELATIONSHIPS

A. CALCULATIONS OF ELASTICITIES

1. CWU ELASTICITIES

$$CWU(1975)=.93(MC)^{.93}(officers)^{.37}(enlisted)^{.19}$$

Model fitting results for: ln CWU75

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	0.927602	0.425744	2.1788	0.0415
ln MC	0.371539	0.180386	2.0597	0.0527
ln Officers	0.498578	0.194697	2.5608	0.0186
ln Enlisted	0.18843	0.13705	1.3749	0.1844

R-SQ. (ADJ.) = 0.9530 SE= 0.219165 MAE= 0.162949 DurbWat= 2.453
24 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	22.5400	3	7.51335	156.420	.0000
Error	0.960663	20	0.0480332		
Total (Corr.)	23.5007	23			

R-squared = 0.959122 Stnd. error of est. = 0.219165
R-squared (Adj. for d.f.) = 0.95299 Durbin-Watson statistic = 2.45324

Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	DF	Mean Sq.	F-Ratio	P-value
ln MC	22.0297149	1	22.029715	458.64	.0000
ln Officers	.4195350	1	.419535	8.73	.0078
ln Enlisted	.0908000	1	.090800	1.89	.1844
Model	22.5400499	3			

Correlation matrix for coefficient estimates

	CONSTANT	MC	Officer	Enlisted
CONSTANT	1.0000	.4574	-.1228	-.8374
ln MC	.4574	1.0000	-.8202	-.3157
ln Officer	-.1228	-.8202	1.0000	-.2296
ln Enlisted	-.8374	-.3157	-.2296	1.0000

$$CWU(1987)=1.6(MC)^{.43}(officers)^{.03}(enlisted)^{.40}$$

Model fitting results for: ln CWU87

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	1.602814	0.336438	4.7641	0.0000
ln MC	0.426503	0.099412	4.2902	0.0002
ln Officer	0.031401	0.264394	0.1188	0.9063
ln Enlisted	0.40068	0.212712	1.8837	0.0693

R-SQ. (ADJ.) = 0.9417 SE= 0.206805 MAE= 0.153478 DurbWat= 1.588
34 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	22.9125	3	7.63751	178.578	.0000
Error	1.28305	30	0.0427684		
Total (Corr.)	24.1956	33			

R-squared = 0.946972 Stnd. error of est. = 0.206805
R-squared (Adj. for d.f.) = 0.941669 Durbin-Watson statistic = 1.58769

Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	DF	Mean Sq.	F-Ratio	P-value
ln MC	22.0813775	1	22.081377	516.30	.0000
ln Officer	.6794076	1	.679408	15.89	.0004
ln Enlisted	.1517532	1	.151753	3.55	.0693
Model	22.9125382	3			

Residual Summary

Number of observations = 34 (0 missing values excluded)
Residual average = 1.37145E-15
Residual variance = 0.0427684
Residual standard ~~or = 0.206805
Coeff. of skewness ~.484747 standardized value = 1.15393
Coeff. of kurtosis = -0.413613 standardized value = -0.492298

Correlation matrix for coefficient estimates

	CONSTANT	MC	Officer	Enlisted
CONSTANT	1.0000	.2464	.3959	-.7322
ln MC	.2464	1.0000	-.6076	.2163
ln Officer	.3959	-.6076	1.0000	-.8923
ln Enlisted	-.7322	.2163	-.8923	1.0000

$$CWU(1988)=4.3(MC)^{.39}(officers)^{.22}(enlisted)^{.13}$$

Model fitting results for: ln CWU88

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	4.343743	0.364471	11.9179	0.0000
ln MC	0.378676	0.082548	4.5873	0.0002
ln Officers	0.225877	0.110594	2.0424	0.0545
ln Enlisted	0.132014	0.046377	2.8465	0.0100

R-SQ. (ADJ.) = 0.9446 SE= 0.162879 MAE= 0.102226 DurbWat= 1.651
24 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	10.4851	3	3.49505	131.742	.0000
Error	0.530591	20	0.0265295		
Total (Corr.)	11.0157	23			

Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	DF	Mean Sq.	F-Ratio	P-value
ln MC	10.2212157	1	10.221216	385.28	.0000
ln Officers	.0489579	1	.048958	1.85	.1894
ln Enlisted	.2149630	1	.214963	8.10	.0100
Model	10.4851366	3			

2. ALOS ELASTICITIES

$$ALOS(1975) = .8(MC)^{.00}\ (officers)^{.62}\ (enlisted)^{-.22}$$

Model fitting results for: ln ALOS75

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	0.816016	0.569134	1.4338	0.1671
ln MC	0.002244	0.24114	0.0093	0.9927
ln Officer	0.615247	0.26027	2.3639	0.0283
ln Enlisted	-0.219319	0.183208	-1.1971	0.2453

R-SQ. (ADJ.) = 0.6685 SE= 0.292979 MAE= 0.212341 DurbWat= 1.738
24 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	4.23958	3	1.41319	16.4637	.0000
Error	1.71673	20	0.0858367		
Total (Corr.)	5.95631	23			

R-squared = 0.711779 Stnd. error of est. = 0.292979
R-squared (Adj. for d.f.) = 0.668546 Durbin-Watson statistic = 1.7382

Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	DF	Mean Sq.	F-Ratio	P-value
ln MC	3.72112504	1	3.7211250	43.35	.0000
ln Officer	.39544429	1	.3954443	4.61	.0443
ln Enlisted	.12300904	1	.1230090	1.43	.2453
Model	4.23957838	3			

$$ALOS(1987) = -1(milmds)^{-.3}\ (officers)^{.2}\ (enlisted)^{.4}$$

Model fitting results for: ln ALOS87

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	-0.964893	0.551782	-1.7487	0.0957
ln MC	-0.27086	0.177434	-1.5265	0.1425
ln Officers	0.204126	0.530139	0.3850	0.7043
ln Enlisted	0.436845	0.366221	1.1928	0.2469

R-SQ. (ADJ.) = 0.4862 SE= 0.253929 MAE= 0.169752 DurbWat= 1.758
24 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	1.59694	3	0.532313	8.25548	.0009
Error	1.28960	20	0.0644800		

Total (Corr.)	2.88654	23	
R-squared = 0.553237			Stnd. error of est. = 0.253929
R-squared (Adj. for d.f.) = 0.486222			Durbin-Watson statistic = 1.75848

Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	DF	Mean Sq.	F-Ratio	P-value
ln MC	.52596650	1	.5259665	8.16	.0098
ln Offices	.97922543	1	.9792254	15.19	.0009
ln Enlisted	.09174697	1	.0917470	1.42	.2469
Model	1.59693890	3			

Residual Summary

Number of observations = 24 (0 missing values excluded)
Residual average = -6.05997E-16 Residual variance = 0.06448
Residual standard error = 0.253929
Coeff. of skewness = 0.80352 standardized value = 1.60704
Coeff. of kurtosis = 1.35059 standardized value = 1.35059

$$ALOS(1988) = -1.3(milmds)^{-.4}(officers)^{.6}(enlisted)^{.3}$$

Model fitting results for: ln ALOS88

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	-1.321268	0.525149	-2.5160	0.0205
ln MC	-0.386688	0.118939	-3.2511	0.0040
ln Officers	0.575644	0.159349	3.6125	0.0017
ln Enlisted	0.281739	0.066822	4.2162	0.0004

R-SQ. (ADJ.) = 0.5738 SE= 0.234684 MAE= 0.162789 DurbWat= 1.999
24 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

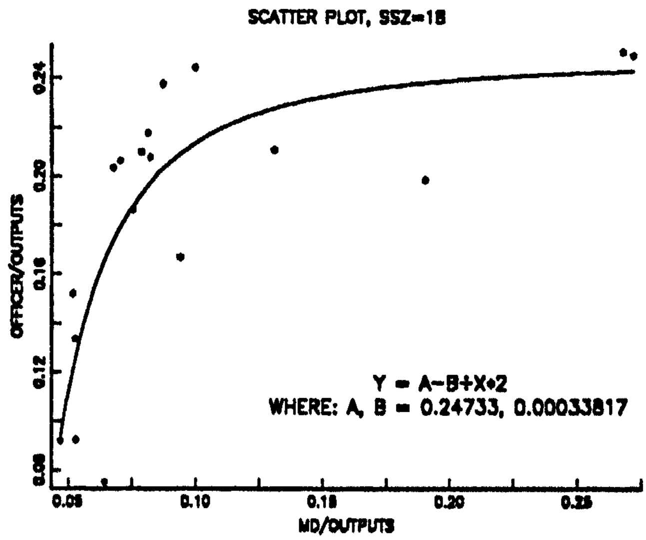
Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	1.87067	3	0.623557	11.3216	.0001
Error	1.10154	20	0.0550768		
Total (Corr.)	2.97221	23			

R-squared = 0.629388 Stnd. error of est. = 0.234684
R-squared (Adj. for d.f.) = 0.573796 Durbin-Watson statistic = 1.99922

Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	DF	Mean Sq.	F-Ratio	P-value
ln MC	.51360650	1	.5136065	9.33	.0063
ln Officers	.37798267	1	.3779827	6.86	.0164
ln Enlisted	.97908114	1	.9790811	17.78	.0004
Model	1.87067032	3			

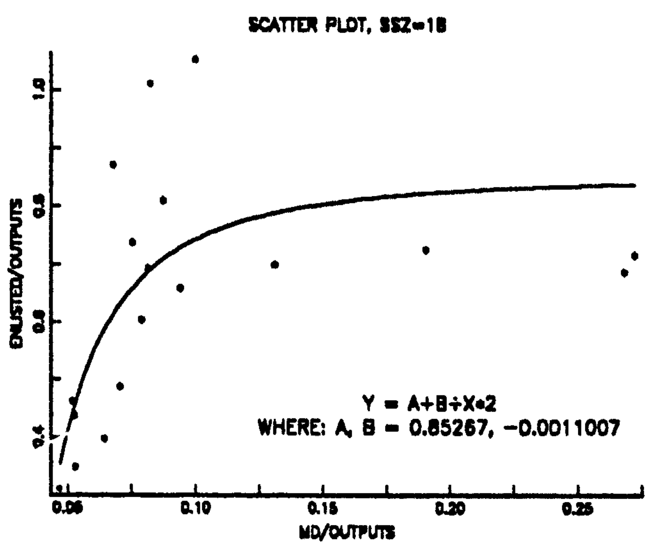
B. RELATIONSHIP OF EFFICIENT INPUT RATIOS FOR PERSONNEL



COEFFICIENT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	0.95 CONFIDENCE LIMITS LOWER	UPPER
CONSTANT	0.24733	0.014177	17.446	7.7753E-12	0.21728	0.27739
B	0.00033817	0.000063	5.316	6.9597E-5	0.00020331	0.00047

18 OBSERVATIONS MEAN CORRECTED SS = 0.05191 STANDARD ERROR = 0.034247
2 COEFFICIENTS RESIDUAL SS = 0.018765 5 ITERATIONS R-SQUARED = 0.6385

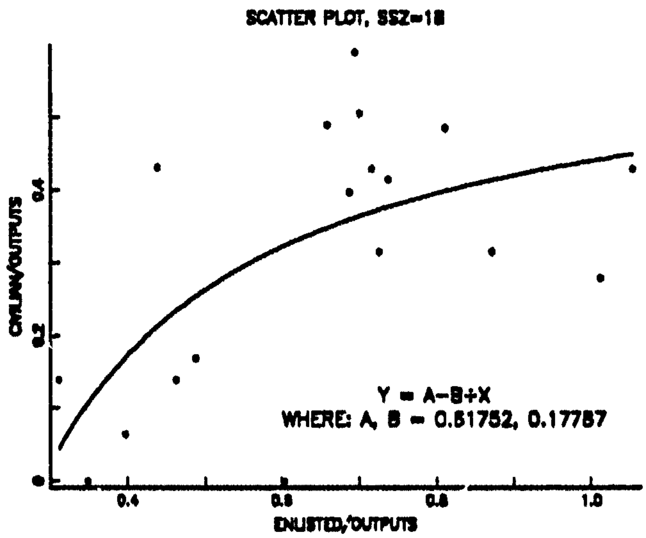
Figure 20. Relationship of Efficient MD and Officer Ratios for 1987



COEFFICIENT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	0.95 CONFIDENCE LIMITS LOWER	UPPER
CONSTANT	0.85267	0.067089	12.71	8.9112E-10	0.71044	0.99490
B	-0.0011007	0.00030	-3.6563	2.1303E-3	-0.0017389	-0.00046

18 OBSERVATIONS MEAN CORRECTED SS = 0.77134 STANDARD ERROR = 0.162067
2 COEFFICIENTS RESIDUAL SS = 0.420235 5 ITERATIONS R-SQUARED = 0.4552

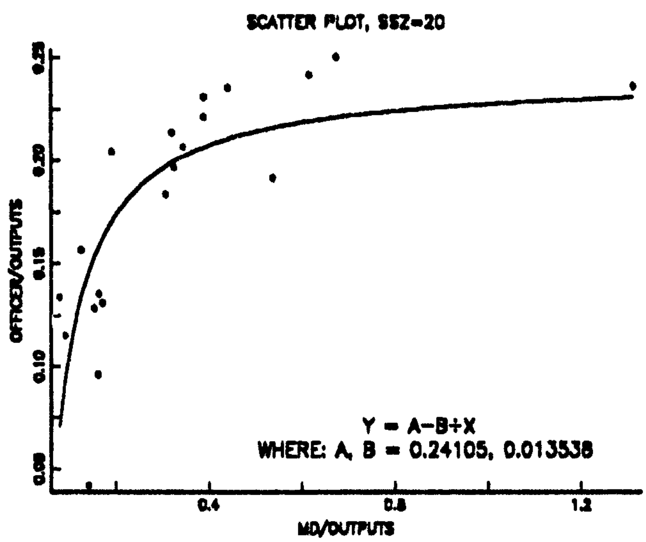
Figure 21. Relationship of Efficient MD and Enlisted Ratios for 1987



COEFFICIENT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	LOWER 95%	UPPER
CONSTANT	0.61752	0.10109	6.1084	0.0000151	0.4032	0.83183
B	0.17787	0.05505	3.2307	0.0052288	0.061151	0.29459

18 OBSERVATIONS MEAN CORRECTED SS = 0.57327 STANDARD ERROR = 0.14726
2 COEFFICIENTS RESIDUAL SS = 0.34694 5 ITERATIONS R-SQUARED = 0.3948

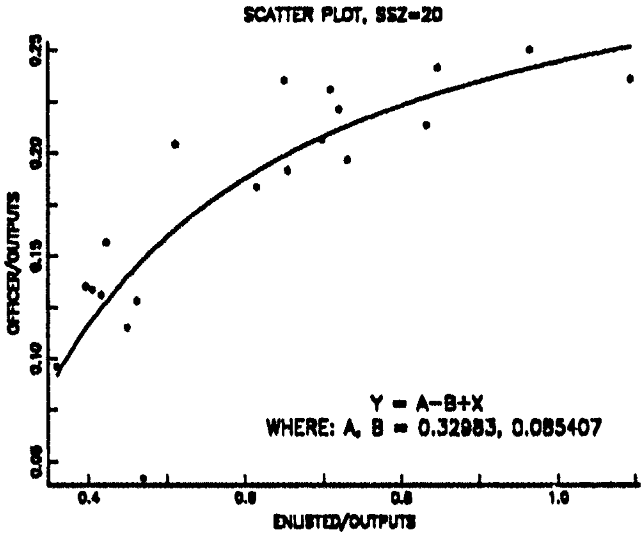
Figure 22. Relationship of Efficient Enlisted and Civilian Ratios for 1987



COEFFICIENT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	LOWER 95%	UPPER
CONSTANT	0.24105	0.015584	15.468	7.7025E-12	0.20831	0.2738
B	0.01353	0.002773	4.8812	1.2014E-4	0.0077106	0.0193

20 OBSERVATIONS MEAN CORRECTED SS = 0.062151 STANDARD ERROR = 0.038548
2 COEFFICIENTS RESIDUAL SS = 0.026747 5 ITERATIONS R-SQUARED = 0.4304

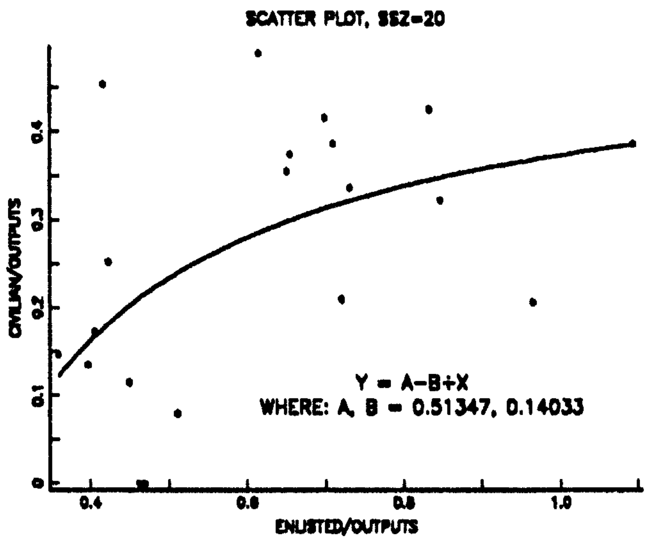
Figure 23. Relationship of Efficient MD and Officer Ratios for 1988



COEFFICIENT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	LOWER 95%	UPPER
CONSTANT	0.32983	0.024384	13.527	7.1753E-11	0.2786	0.38107
B	0.085407	0.013084	6.5277	3.8952E-6	0.057915	0.1129

20 OBSERVATIONS MEAN CORRECTED SS = 0.062151 STANDARD ERROR = 0.032022
2 COEFFICIENTS RESIDUAL SS = 0.018458 5 ITERATIONS R-SQUARED = 0.7030

Figure 24. Relationship of Efficient Officer and Enlisted Ratios for 1988



COEFFICIENT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	LOWER 95%	UPPER
CONSTANT	0.51347	0.10125	5.0715	0.00007	0.30073	0.72620
B	0.14033	0.05432	2.5832	0.01875	0.026186	0.25448

20 OBSERVATIONS MEAN CORRECTED SS = 0.43618 STANDARD ERROR = 0.13296
2 COEFFICIENTS RESIDUAL SS = 0.31821 5 ITERATIONS R-SQUARED = 0.2705

Figure 25. Relationship of Efficient Enlisted and Civilian Ratios for 1988

C. MANPOWER-REQUIREMENTS MODEL

The three-stage least squares methodology was provided as a SAS procedure [Ref 59] and the manpower categories were used as endogenous variables while workload was an endogenous variable called *charts.*

SAS STATEMENTS

MODEL: EQU 1
DEP VARIABLE: MD

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	3	148305.93	49435.30989	11.719	0.0001
ERROR	30	126551.67	4218.38914		
C TOTAL	33	274857.60			

ROOT MSE	64.94913	R-SQUARE	0.5396
DEP MEAN	59.25588	ADJ R-SQ	0.4935
C.V.	109.6079		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	14.74080651	47.66368638	0.309	0.7593
CHARTS	1	-0.05241853	0.10062087	-0.521	0.6062
ALOS	1	0.23441092	8.82917290	0.027	0.9790
ADPL	1	0.87994119	0.37770778	2.330	0.0267

MODEL: EQU 2
DEP VARIABLE: ENLISTED

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	3	3728869.26	1242956.42	317.342	0.0001
ERROR	30	117503.24	3916.77452		
C TOTAL	33	3846372.50			

ROOT MSE	62.58414	R-SQUARE	0.9695
DEP MEAN	406.5	ADJ R-SQ	0.9664
C.V.	15.39585		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	20.45335318	16.50430824	1.239	0.2249
MD	1	-0.49858975	0.17229718	-2.894	0.0070
CIVOTH	1	0.03764852	0.21676393	0.174	0.8633
OFFICER	1	3.57163494	0.45105189	7.918	0.0001

MODEL: EQU 3
DEP VARIABLE: OFFICER

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	3	326414.66	108804.89	523.916	0.0001
ERROR	30	6230.28483	207.67616		
C TOTAL	33	332644.94			

ROOT MSE	14.41097	R-SQUARE	0.9813
DEP MEAN	114.1765	ADJ R-SQ	0.9794
C.V.	12.62167		

PARAMETER ESTIMATES

	PARAMETER	STANDARD	T FOR H0:

VARIABLE	DF	ESTIMATE	ERROR	PARAMETER=0	PROB >]T]
INTERCEP	1	-1.12084399	3.89105959	-0.288	0.7753
MD	1	0.15833465	0.03431816	4.614	0.0001
CIVOTH	1	0.13975635	0.04292760	3.256	0.0028
ENLISTED	1	0.18937609	0.02391578	7.918	0.0001

MODEL: EQU 1 SECOND STAGE
DEP VARIABLE: MD

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	3	148305.93	49435.30989	11.719	0.0001
ERROR	30	126551.67	4218.38914		
C TOTAL	33	274857.60			

ROOT MSE	64.94913	R-SQUARE	0.5396
DEP MEAN	59.25588	ADJ R-SQ	0.4935
C.V.	109.6079		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB >]T]
INTERCEP	1	14.74080651	47.66368638	0.309	0.7593
CHARTS	1	-0.05241853	0.10062087	-0.521	0.6062
ALOS	1	0.23441092	8.82917290	0.027	0.9790
ADPL	1	0.87994119	0.37770778	2.330	0.0267

MODEL: EQU 2 SECOND STAGE
DEP VARIABLE: ENLISTED

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	3	3669644.85	1223214.95	280.138	0.0001
ERROR	30	130994.36	4366.47882		
C TOTAL	33	3846372.50			

ROOT MSE	66.07934	R-SQUARE	0.9655
DEP MEAN	406.5	ADJ R-SQ	0.9621
C.V.	16.25568		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB >]T]
INTERCEP	1	13.39602386	18.72519836	0.715	0.4799
MD	1	-0.69391788	0.44807113	-1.549	0.1319
CIVOTH	1	-0.33104183	0.38478213	-0.860	0.3964
OFFICER	1	4.40334235	0.94845188	4.643	0.0001

MODEL: EQU 3 SECOND STAGE
DEP VARIABLE: OFFICER

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	3	324106.49	108035.50	492.882	0.0001
ERROR	30	6575.74670	219.19156		
C TOTAL	33	332644.94			

ROOT MSE	14.80512	R-SQUARE	0.9801
DEP MEAN	114.1765	ADJ R-SQ	0.9781
C.V.	12.96687		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB >]T]
INTERCEP	1	-0.97322905	4.38826553	-0.222	0.8260
MD	1	0.20256909	0.07009796	2.890	0.0071
CIVOTH	1	0.13299182	0.06450227	2.059	0.0483
ENLISTED	1	0.18601002	0.04367556	4.259	0.0002

THREE STAGE LEAST SQUARES

CROSS MODEL COVARIANCE

SIGMA	MD	ENLISTED	OFFICER
MD	4218.389	299.4467	-289.376
ENLISTED	299.4467	4366.479	-915.821
OFFICER	-289.376	-915.821	219.1916

CROSS MODEL CORRELATION

CORR	MD	ENLISTED	OFFICER
MD	1	0.06977189	-0.300938
ENLISTED	0.06977189	1	-0.936123
OFFICER	-0.300938	-0.936123	1

CROSS MODEL INVERSE CORRELATION

INV CORR	MD	ENLISTED	OFFICER
MD	1.830757	3.137433	3.487968
ENLISTED	3.137433	13.46256	13.54679
OFFICER	3.487968	13.54679	14.73113

CROSS MODEL INVERSE COVARIANCE

INV SIGMA	MD	ENLISTED	OFFICER
MD	0.0004339943	0.0007310305	0.003627332
ENLISTED	0.0007310305	0.003083163	0.0138471
OFFICER	0.003627332	0.0138471	0.06720665

SYSTEM WEIGHTED MSE IS 16.3541 WITH 90 DEGREES OF FREEDOM
SYSTEM WEIGHTED R-SQUARE IS 0.978165

D. MODEL TO DETERMINE AMOUNT OF MILITARY PERSONNEL FOR PHYSICIANS

SAS STATEMENTS

```
PROC SYSLIN 3SLS;
    ENDOGENOUS MD OFFICER ENLISTED;
    INSTRUMENTS CIVOTH ADM ALOS ADPL OPV;
    MODEL MD = CHARTS ALOS ADPL;
    MODEL ENLISTED = MD CIVOTH OFFICER;
    MODEL OFFICER =  MD CIVOTH ENLISTED;
```

MODEL: EQU 1 3SLS
DEP VARIABLE: MD

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	12.68785032	42.54557829	0.298	0.7676
CHARTS	1	-0.01931457	0.08268614	-0.234	0.8169
ALOS	1	-0.89422509	7.82707804	-0.114	0.9098
ADPL	1	0.77398936	0.31505693	2.457	0.0200

MODEL: EQU 2 3SLS
DEP VARIABLE: ENLISTED

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	12.08437354	17.74559209	0.681	0.5011
MD	1	-0.76718610	0.34202806	-2.243	0.0324
CIVOTH	1	-0.35046917	0.26123306	-1.342	0.1898
OFFICER	1	4.48808182	0.62373446	7.196	0.0001

MODEL: EQU 3 3SLS
DEP VARIABLE: OFFICER

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	-1.95246396	4.04096186	-0.483	0.6325
MD	1	0.20620755	0.05802643	3.554	0.0013
CIVOTH	1	0.07586912	0.04154076	1.826	0.0778
ENLISTED	1	0.21698102	0.02669027	8.130	0.0001

E. LOGISTIC REGRESSION PROCEDURE

Efficiency as measured by DEA is ordinal by MTF; thus, efficient facilities (E = 1) can be separated as a separate set. The probability that a hospital will be efficient (E = 1) given a set of explanatory variables can be modeled by the logistic procedure over the feasible region [Ref. 55]. The form of the logistic regression is Probability (Efficiency = 1) = $1/(1 + \exp(-\alpha - \beta_i x_i))$. The logistic model is analyzed with both 100% and above-average hospitals.

LOGISTIC REGRESSION PROCEDURE, DEPENDENT VARIABLE: EFFICIENCY 1987
34 OBSERVATIONS, 23 EFF=0, 11 EFF=1, 0 OBSERVATIONS DELETED

VARIABLE	MEAN	MINIMUM	MAXIMUM	S. D.
LAB	3133824	147539	17004032	3978664
PHARM	331752	31847	1179674	286420
XRAY	164460	7580	732734	176357

```
 -2 LOG LIKELIHOOD FOR MODEL CONTAINING INTERCEPT ONLY=   42.81
MODEL CHI-SQUARE=    6.76 WITH   3 D.F.   (SCORE STAT.) P=0.0799.
CONVERGENCE IN  6 ITERATIONS WITH  0 STEP HALVINGS        R= 0.269.
MAX ABSOLUTE DERIVATIVE=0.2772D+01.               -2 LOG L=   33.71.
MODEL CHI-SQUARE=    9.10 WITH   3 D.F.   (-2 LOG L.R.) P=0.0280.
C=0.777, SOMER DYX=0.553, GAMMA=0.556, TAU-A=0.250
```

VARIABLE	BETA	STD. ERROR	CHI-SQUARE	P	R
INTERCEPT	0.27274405	0.66226695	0.17	0.6805	
LAB	0.00000093	0.00000049	3.62	0.0570	0.195
PHARM	-0.00001405	0.00000820	2.93	0.0868	-0.148
XRAY	0.00000187	0.00001165	0.03	0.8727	0.000

LOGISTIC REGRESSION PROCEDURE, DEPENDENT VARIABLE: EFFICIENCY 1988
32 OBSERVATIONS, 27 EFF=0, 5 EFF=1, 2 OBSERVATIONS DELETED

VARIABLE	MEAN	MINIMUM	MAXIMUM	S. D.
LAB	2842766	342749	16319922	3334001
PHARM	320074	32020	1180234	264369
XRAY	165585	13354	754708	165632

```
 -2 LOG LIKELIHOOD FOR MODEL CONTAINING INTERCEPT ONLY=   27.74
MODEL CHI-SQUARE=    4.25 WITH   3 D.F.   (SCORE STAT.) P=0.2356.
CONVERGENCE IN  6 ITERATIONS WITH  0 STEP HALVINGS        R= 0.175.
MAX ABSOLUTE DERIVATIVE=0.1367D+02.               -2 LOG L=   20.89.
MODEL CHI-SQUARE=    6.84 WITH   3 D.F.   (-2 LOG L.R.) P=0.0770.
C=0.819, SOMER DYX=0.637, GAMMA=0.642, TAU-A=0.173
```

VARIABLE	BETA	STD. ERROR	CHI-SQUARE	P	R
INTERCEPT	-0.62050229	0.82519692	0.57	0.4521	
LAB	0.00000118	0.00000065	3.32	0.0683	0.218
PHARM	-0.00001969	0.00000968	4.14	0.0418	-0.278
XRAY	0.00000540	0.00000647	0.70	0.4036	0.000

1. COEFFICIENTS FOR ANCILLARY SERVICES, 1987

DEP VARIABLE: MD

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	4	429462.13	107365.53	278.264	0.0001

ERROR	29	11189.37739	385.84060		
C TOTAL	33	440651.51			
ROOT MSE		19.64283	R-SQUARE	0.9746	
DEP MEAN		78.90294	ADJ R-SQ	0.9711	
C.V.		24.89492			

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	-10.39683893	7.19339296	-1.445	0.1591
LAB	1	0.000017826	.00000224347	7.946	0.0001
XRAY	1	0.000279558	0.000063208	4.423	0.0001
PHARM	1	-0.000012198	0.000034602	-0.353	0.7270
EFFBAR	1	-16.04063780	7.25886536	-2.210	0.0352

DURBIN-WATSON D 1.672, (FOR NUMBER OF OBS.) 34
1ST ORDER AUTOCORRELATION 0.164

DEP VARIABLE: OFFICERS

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	5	1477664.78	295532.96	511.260	0.0001
ERROR	28	16185.34	578.05		
C TOTAL	33	493850.12			
ROOT MSE		24.04263	R-SQUARE	0.9892	
DEP MEAN		190.2353	ADJ R-SQ	0.9872	
C.V.		12.63836			

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	13.38129	9.189709980	1.456	0.1565
LAB	1	0.000021131	0.000003485	6.064	0.0001
XRAY	1	0.000357943	0.000094389	3.792	0.0007
PHARM	1	0.000082690	0.000043019	1.922	0.0648
ADPL	1	0.49569334	0.21378512	2.319	0.0279
EFFBAR	1	-25.91357304	9.05509735	-2.862	0.0079

DURBIN-WATSON D 1.724, (FOR NUMBER OF OBS.) 34
1ST ORDER AUTOCORRELATION 0.134

DEP VARIABLE: ENLISTED

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	5	3661610.57	732322.11	110.605	0.0001
ERROR	28	185389.90	6621.06782		
C TOTAL	33	3847000.47			
ROOT MSE		81.36994	R-SQUARE	0.9518	
DEP MEAN		406.4706	ADJ R-SQ	0.9432	
C.V.		20.01865			

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	112.62669	31.10168634	3.621	0.0012
LAB	1	-0.000016817	0.000011794	-1.426	0.1649
XRAY	1	0.000154293	0.000319450	0.483	0.6329
PHARM	1	0.000445975	0.000145593	3.063	0.0048
ADPL	1	2.63746622	0.72353509	3.645	0.0011
EFFBAR	1	-55.24334926	30.64610289	-1.803	0.0822

DURBIN-WATSON D 1.997, (FOR NUMBER OF OBS.) 34
1ST ORDER AUTOCORRELATION 0.001

2. COEFFICIENTS FOR ANCILLARY SERVICES, 1988

DEP VARIABLE: MD

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	4	233526.72	58381.68114	7.612	0.0003
ERROR	29	222427.79	7669.92379		
C TOTAL	33	455954.51			
ROOT MSE		87.5781	R-SQUARE	0.5122	
C.V.		109.2437			

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	39.98230973	34.06337183	1.174	0.2500
LAB	1	0.000025543	0.000012220	2.090	0.0455
XRAY	1	0.000070084	0.000209827	0.334	0.7408
PHARM	1	-0.000032977	0.000154281	-0.214	0.8322
EFFBAR	1	-49.39110297	35.69592301	-1.384	0.1770

DURBIN-WATSON D 1.942, (FOR NUMBER OF OBS.) 34
1ST ORDER AUTOCORRELATION 0.023

DEP VARIABLE: OFFICERS

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	4	177326.39	44331.59867	11.574	0.0001
ERROR	29	111082.34	3830.42554		
C TOTAL	33	288408.74			
ROOT MSE		61.89043	R-SQUARE	0.6148	
DEP MEAN		111.9118	ADJ R-SQ	0.5617	
C.V.		55.30288			

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	74.37708206	24.07219113	3.090	0.0044
LAB	1	0.000012418	.00000863606	1.438	0.1612
XRAY	1	0.000213633	0.000148282	1.441	0.1604
PHARM	1	0.0000044481	0.000109029	0.041	0.9677
EFFBAR	1	-51.57102556	25.22589619	-2.044	0.0501

DURBIN-WATSON D 2.047, (FOR NUMBER OF OBS.) 34
1ST ORDER AUTOCORRELATION -0.027

DEP VARIABLE: ENLISTED

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	4	2120243.25	530060.81	10.274	0.0001
ERROR	29	1496184.28	51592.56130		
C TOTAL	33	3616427.53			
ROOT MSE		227.14	R-SQUARE	0.5863	
DEP MEAN		403.8824	ADJ R-SQ	0.5292	
C.V.		56.23914			

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	307.94242	88.34574864	3.486	0.0016
LAB	1	0.000030366	0.000031695	0.958	0.3459
XRAY	1	0.001074982	0.000544201	1.975	0.0578
PHARM	1	-0.000057035	0.000400138	-0.143	0.8876
EFFBAR	1	-230.34759	92.57988488	-2.488	0.0188

```
DURBIN-WATSON D            2.083, (FOR NUMBER OF OBS.)        34
1ST ORDER AUTOCORRELATION -0.044
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