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# NAVAL POSTGRADUATE SCHOOL

## Monterey, California



# THESIS

AN APPLICATION OF CASE-MIX ADJUSTED LENGTHS
OF STAY IN NAVAL MEDICAL TREATMENT
FACILITY'S OUTPUT MEASUREMENT

by

David Howard Hofflinger

September 1980

Thesis Advisor: D. R. Whipple

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# AN APPLICATION OF CASE-MIX ADJUSTED LENGTHS OF STAY IN NAVAL MEDICAL TREATMENT FACILITY'S OUTPUT MEASUREMENT

by

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Submitted in partial fulfillment of the
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## ABSTRACT

The absence of a meaningful measure of hospital output is widely recognized. Common measures such as inpatient length of stay, discharges, or Composite Work Units do not fully consider the mix of patients hospitalized and are at best rough partial indicators of output.

The intent of this study is to determine whether length of stay, a common output measure, which is adjusted for case-mix, is a better partial indicator than non-adjusted length of stay. This hypothesis was tested with three analyses, using the inpatient admission/disposition records for 24 selected naval medical treatment facilities for calendar year 1978, and found to be correct. For each analysis two indices are developed to evaluate the overall change in length of stay: the first index evaluating changes due to differences in case-mix; the second index evaluating changes due to differences in length of stay for each case-mix type.

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## I. INTRODUCTION

There is considerable alarm over the increasing rate of growth and absolute levels of health care costs in private and public sector delivery systems. For example, Federal budget outlays for health have grown from 6.6 percent of the Federal budget in 1970 to 9.7 percent in 1978 [U.S. President 1979, p. 264-5]. Many factors have been cited as causes for this growth in costs such as advances in technology, expansion of hospital beds, service availability and intensity, and growth in third party reimbursements.

In response to this rapid growth in health care costs a proliferation of legislation and administrative guidelines have been developed which attempt to limit hospital costs by review and control of capital expansion, rate structure, and utilization. This movement towards centralized external review posits that hospitals exhibit sufficient homogenity to allow for inter-hospital comparisons and that adequate evaluation standards are known to make meaningful comparisons possible.

This review and control process is a difficult task since hospitals are multiproduct firms where inputs, outputs, and related costs are influenced by a larger number of factors than is the case for a single product firm. The nature of hospital care is such that it is a highly specialized production entity. Even though every hospital patient requires hotel and social services, there are few outputs beyond these which are common to all patients. Therapeutic and diagnostic services demanded by physicians in treatment of their patients are dependent upon the complexity of the case and make up this unique combination of labor, material, and equipment outputs.

Historically, hospital output has been described by average or homogeneous measures such as patient days, hospital services, episodes of illness, levels of health, intermediate inputs, or combinations of the above. When these average measures are presented out of the context of the types of cases treated within a medical facility, their usefulness as a decision-making tool is limited. These measures ignore the fact that there are distinct differences in the medical nature of the average output over time and place.

This paper will examine this output measurement problem as it exists in health care delivery systems and the need for supplementary output information. Specifically, a composite statistical index model will be applied to Navy inpatient data in order to construct a measure of the heterogeneous nature of one segment of Navy health care delivery.

Chapter II will examine the literature that has dealt with the problem of hospital output measurement. The major approaches that have addressed this issue will be discussed. The hospital workload indices which are currently used by the

Navy for evaluating and comparing its medical facilities will also be examined. In Chapter III the methodology of the Laspeyres type statistical index model will be presented and discussed. The sample, its essential characteristics, and assumptions of the model and sample will be identified. Chapter IV will present the results of the indices, followed by a discussion of their meaning and how the values relate to the model. Finally, Chapter V will present the conclusion of the study, the applications and limitations of the index for the Navy, and the implied direction of future research as a result of this study.

## II. HOSPITAL OUTPUT

The need for meaningful output measures is basic to all sectors of society that require its limited resources be used in an efficient and effective manner. Within the health care sector, it is held by most researchers, that hospital output cannot be adequately quantified because of its multi-product nature. This diverse and varied output gaurentees difficult interpretation of cost and performance information. Anthony [1972] views this problem as the primary reason why management decisions have been more difficult in the health sector than in organizations with identifiable outputs.

Historically, there has been a tendency to evaluate hospital output as a unidemensional proxy or measure such as patients discharged per specific time period. This approach is at best a crude indicator of output and is meaningless as a decision-making tool. For example, to compare a small non-teaching hospital that discharged 200 patients in a month with a large medical center that discharged 1500 patients during the same period says very little. The number of patients discharged is influenced by many factors such as patient case complexity, occupancy rates, or physician specialities. Thus, the heterogeneous nature of hospital output cannot be expressed in a single valued measure but better expressed as a multidimensional measure [Petru 1975, p. 57].

Because of these reasons, regulatory agencies, established to monitor and control health care costs and assure quality of care, and hospital administrators and clinicians in their hospital operational roles, find it difficult to determine the full costs of most management decisions.

The first half of this chapter will examine a sample of the literature attempting to develop approaches which would quantify the elusive hospital output. The remainder of the chapter will examine and evaluate the key workload indices that are currently used within the Navy to evaluate and compare its medical facilities.

## A. LITERATURE REVIEW

One approach taken in the literature is to identify hospital output by patients or patient days, adjusting for diagnosis, length of stay, or type of hospital service. Berry [1967] attempted to standardize hospitals by the types of services they can produce. He was primarily concerned with the specific problem of measuring interhospital cost differences to identify economies of scale. His hypothesis was that hospitals which provided the same types of services as identified by his groups were more likely to produce a homogeneous product than hospitals in different groups. In a later study [1973] he developed a method to determine whether there exists a relationship between a hospital's facilities, and its capacity to provide specific services. Within this context, a facility is an organizational element within a hospital that has the capability of providing a specific service. A service is the product that is supplied to the consumer from the facility. As in the earlier article, he grouped hospitals by services provided. Starting with a "basic service" hospital, hospitals appear to add facilities and services that can be characterized as "quality-enhancing." The third group, "complex," is created when the scope of the facilities and services which transform it into a "community" medical center.

By fitting the hospitals into his groupings, resource relationships began to emerge. For example, community service hospitals employed more labor and capital. Thus, he found that mean cost per patient day was directly related to the hospital category. The basic problem with both approaches is that they do not address the extent the facilities are used nor the interhospital differences between services. For example, two hospitals may have an identical grouping mix but have completely different final outputs.

In the literature it is generally agreed that the lack of hospital homogeneity can be indicated by variations in case-mix. One of the most frequent methods used to correct for product heterogenity is to group hospitals by facility/service complexity [Berki 1972, p. 39].

Feldstein [1967] examined hospital output by patients or patient days adjusted for case-mix by service unit. In an attempt to estimate marginal costs of a case, he divided patients into eight mutually exclusive categories according to the medical departments into which they were admitted. A relationship was assumed to exist between patient days and service activity thus implying a homogeneity of case types. The shortcoming of this approach was the difficulty in distinguishing the serverity and complexity of the case. Hospitals with facilities that are similar may still produce different products. For example, a hospital that specializes in maternity care might have facilities that are similar to an accute care community hospital however their products are obviously different.

Using a similar technique (proportioning the inpatient population into categories) Evans [1971] developed two measures of case-mix. The first was based on the total cases, the second on the total number of days. Proportions were generated for each measure, one based on 41 diagnostic categories, the other on 40 age-sex categories. Factor analysis was used to group the diagnostic categories in an effort to reduce multicollinearity problems. Although this study does develop a more meaningful definition of case-mix effects on output, it fails to consider other relevant hospital characteristics.

Lave and Lave [1971] developed a technique to distinguish the differences in case-mix and hospital specialization. They analyzed 249,696 patient records from sixty-five hospitals in Western Pennsylvania. The forty-eight most commonly occurring medical diagnosis and the thirty-five most common procedures were evaluated. They concluded that a small subset of the diagnoses and surgical procedures accounted for a large proportion of the total case types. Moreover, teaching medical centers not only have more surgical cases than non-teaching facilities, but more complex and fewer simple procedures than the average hospital. While the size, number of facilities and services, and whether the hospital is a teaching facility are shown to be correlated with case-mix, they further concluded that they cannot be used as meaningful proxies for case-mix. Thus, any cost analysis of homogeneous groupings by characteristics requires reliance on an output measure which varies over time.

In another study, Lave and Lave and Silverman [1973] reaffirmed the importance of case-mix in relation to variation in hospital costs. In a proposed incentive reimbursement model, they made an initial approach to examine the relationship between institutional output and resource consumption by grouping their variables based on the first two digits of the International Classification of Diseases, Adapted for Use in the U.S. (ICDA). (For a general description of the ICDA see Appendix A.)

Feldstein and Shuttinga [1977] attempted to develop a method of adjusting hospital costs for interhospital differences in case-mix. Their analysis provides a potentially useful tool for health service management. Their statistical analysis specifically provides:

"1. A measure of the general impact of case-mix on hospital costs, i.e., an estimate of the fraction of the variation in hospital case costs that is a reflection of case-mix;

2. A costliness rating for each individual hospital, i.e., a measure of each hospital's cost after purging the effects of case-mix." [p. 22].

They concluded that more than half of the observed variation in cost per case can be explained by the principal components measure of case-mix, yet low correlation values were observed for both cost per case and cost per patient day, thus, neither can be considered an adequate measure of hospital performance. The case-mix adjusted measure of costliness nevertheless provides a method for grouping hospitals into cost levels so that comparisons with predicted levels can be made and management attention directed to areas that are significantly out of line.

Another approach for providing a basis for comparison of hospital output and costs are indices. Indices may take a variety of forms depending upon the data it was developed from or the purpose it will serve. An index under optimal conditions would provide an accurate measure of output, however indices are affected by the same difficulties in measuring hospital costs and output as other techniques. Because of the heterogeneous nature of the health care industry, indices generally rely on proxy measures as input values for making comparisons.

Cohen [1966] attempted to recognize output as the sum of the weighted services in measuring interhospital cost differences for similar services. Output was defined as:

$$S_j = \Sigma w_i Q_{ij}$$

Where $W_i$ = quantity of ith service

$Q_{ij}$ = quantity of ith service in the jth hospital

$S_j$ = service output of the jth hospital

Cohen evaluated thirteen intermediate services that included operations, deliveries, physical therapy treatment, diagnostic X-rays, and adult and pediatric days. These services $Q_{ij}$ were weighted by their respective average cost $W_i$. The basic problem with this technique lies in determining the appropriate weighting factor since there exists a high degree of autocorrelation between output weighted by cost and cost itself.

In another weighted value method, Rafferty [1972] used a statistical composite index to measure variations in hospital output. This was an attempt to allow for the comparison of case-mix in a given hospital with the case-mix of the total sample of hospitals. Diagnostic cases within hospital j were divided into i groups on the basis of some criteria such as primary diagnosis, age, surgical procedure, etc. The proportion of cases in each group $P_{ij}$ is then multiplied by the appropriate weight $W_i$ such as patient length of stay or costs.

Summing these products for all groups results in a unique case-mix value for hospital j. This index is then compared with the case-mix of any other patient population n by using the same weights $W_i$ but with the case-mix proportion $P_{in}$ of the population. This results in a Laspeyres type index where:

$$\text{Index} = \frac{\Sigma W_i P_{ij}}{\Sigma W_i P_{in}} (100)$$

The index value will vary from 100 if the case-mix of hospital j differs from the case-mix of population n.

The index allows for a wide variety of comparative analyses because of the flexibility in choosing the population, weights, diagnostic groupings and evaluation period. Rafferty, as was found in Cohen's analysis, points out that the most difficult obstacle in using the index is the selection of appropriate weights.

The Commission of Professional and Hospital Activities (CPHA) developed two indices to adjust for case-mix by using output proxies. Ament and Loup [1974] applied the relative value principle to gross hospital charges. Their index, the Appendicitis Equivalent Value Index (AEV), was designed to evaluate the extent to which differences in case-mix account for differences in average gross charges. The index is the ratio of the average gross charges for hospitalization with a particular diagnosis type to the average gross charge of an operated patient under 20 years of age who has a final diagnosis of acute appendicitis without peritonitis. If a patient had the same average charge as the appendicitis patient the AEV would be 1.00. On the other hand, if a patient had an average charge that was 125 percent of the average charge for an appendicitis patient, the AEV would be 1.25.

To build an AEV Index for a hospital, each patient is matched to a case-mix cell an assigned the respective AEV. This process continues until all patients have been assigned an AEV. The AEVs are then summed and divided by N. The resulting average is the AEV index for the hospital. The normal charges for the index were compiled from a CPHA table entitled the Study of Patient Charges (SPC). The SPC is based upon 1.1 million case abstracts that were assigned to one of 3,510 cells defined by 351 diagnosis groups, five age groups, and whether surgery occurred. The AEV index can be used to evaluate the change in average charges per patient from period to period due to a change in case-mix within and between hospitals. The index can also be used to evaluate the case complexity between hospitals as reflected in the value of materials and services required.

In another application of the relative value principle to gross charges, Ament [1976A, 1976B] attempts to isolate the effect of case-mix in comparisons to average charges betwen patient groups, hospitals, or time periods. The two key values in the study are the Resource Need Unit (RNU) and the Resource Need Index (RNI). RNUs reflect the relative value of resources needed in treating grouped patients. A RNU value of one would represent the average patient cost. Likewise, a patient cost that was less (more) than the average would represent a lower (higher) RNU value. A RNU for each patient category is defined by the CPHA and is equal to the average charge of matched patients divided by the average charge for all patients in the data base. A RNI is calculated as the average number of RNUs per patient for any group of patients.

## B. NAVY MEDICAL WORKLOAD INDICES

As previously mentioned, a number of proxy measures of hospital output have been developed to measure hospital productivity. Despite their limitations and because of their simplicity these measures tend to be the most popular indicators used to evaluate and compare hospital output. This section will discuss and evaluate key medical workload indices that are used by the Navy and presented in Medical Statistics U.S. Navy [U.S. Department of the Navy 1980].

Admission and Discharges are defined as those patients accepted by a hospital to receive medical services while occupying a hospital bed established for inpatients and the termination of the granting of lodging and the formal release of an inpatient by the hospital [American Hospital Association 1960, p. 6]. The use of these measures can provide an indication of the trend in overall hospital activity. By varying the sample, different comparisons may be made. For example, patterns of patient types could be examined by subclassifying the measures into adult, child, sex, age, etc., or an analysis of admission/discharge patterns could be developed by determining the percentage of patients admitted or discharged by the day of the week. Generally, these measures when combined with other indices can provide a more relative measure of activity, e.g., the cost per admission, admission rate for specific diagnosis types, etc. Currently, several tabulation type indicators and one ratio are used to provide a more specific indicator or activity. The admission rate (diagnostic) index identifies the number of patients admitted from duty status by specific diagnosis for a given calendar year multiplied by 1000 and divided by the average strength for the calendar year [U.S. Department of the Navy 1980, p. 252]. Further, tabulations are done on the beneficiary class of patients admitted, e.g., active-duty, retired, etc., and the number of admissions by type of facilities.

The Average Daily Patient Load is defined as the number of occupied bed days for a given calendar year divided by the number of days in the given calendar year [Ibid.]. The difficulties in measuring output with this index are related to the fact that the value is a gross aggregate. The heterogeneity of the patient load and the varying amounts of services and resources cannot be captured. One approach to measure the heterogeneity aspects would be to adjust for case-mix variations.

Average Length of Stay is the average number of days of service rendered to each inpatient discharged during a given period [American Hospital Association 1960, p. 21]. As with the other measures, the average length of stay is influenced by many variables. It may vary with the type of case-mix a hospital treats and with innovations in specific treatments. The Medicare program was the major impetus in the use of this measure. Length of stay was easy to measure, report and analyze, and was also believed that the value would be able to identify hospital misutilization [Goldberg 1975]. Studies have since indicated that this is not the case and that no unique relationship exists between length of stay and the need for acute hospital care.

In evaluating length of stay, it is important to note that a major portion of medical resources are consumed by a small group of patients. On the average, 13 percent of all patients consume as much of the medical resources as the remaining 87 percent [Zook and Moore 1980]. The average length of stay does not take this grouping of patients into consideration with respect to resource consumption. The value provides no indication of what was done to the patient, his condition upon discharge, or the effectiveness of the treatment [Prims and Delesie 1975]. Nor does length of stay properly measure the effect the individual patient has upon resource utilization occurring in the early stages of hospitalization. Typically, resources are used at a very high rate at first and then approach an average consumption rate. This pattern indicates that the effect of length of stay on resource consumption is not linear [Lave and Leinhardt 1976].

Length of stay does provide a rough indication of physician screening and discharge practices. If improved by classifying length of stay by diagnosis type it would allow for a case-mix/ length of stay evaluation indicating the extent to which variations in diagnosis types explain variations in average length of stay. This approach is a primary concern that will be further developed in the study.

An outpatient visit (or an occasion of service) occurs when a patient receives treatment, examination, or consultation from a clinical service on an ambulatory basis. Outpatient visits can be used to give an indication of the trend in overall hospital acitivity. Currently, an outpatient visit rate (daily) is evaluated. This index is calculated by taking the number of active-duty outpatient visits for a given calendar year multiplied by 1000, and dividing by the average active-duty strength, multiplied by the days in the calendar year [U.S. Department of the Navy 1980, p. 253]. As with the indices already discussed, other variants of the basic outpatient visit aggregate may provide more specific information for further trend analysis, e.g. categorizing each visit by reason for encounter, findings, diagnosis, procedures, etc.

This indicator has particular importance when evaluating the average length of stay for inpatients. It has been argued that the average length of stay and cost of illness episode may be reduced if alternatives to long-term facilities such as outpatient clinics exist [Berki 1972, p. 162]. However, others present evidence that the availability of extended care facilities and ambulatory services reduce hospital utilization but do not change the total cost of care.

The Navy began using the Composite Work Unit (CWU) in the mid-sixties as a measure of hospital activity. The CWU was first dveloped by the Army and involves assigning numerical values to different aspects of patient care performed by the hospital. The equation is currently:

$$CWU = \frac{10\ (A + B)\ +\ 0.3\ (OPV)\ +\ OBD}{\text{Number of days in given calendar year}}$$

Where: A = number of admissions for a given calendar year

B = number of live births for a given calendar year

OPV = number of outpatient visits for a given calendar year

OBD = number of occupied bed days for a given calendar year

This index is based on the assumption that the outpatient visit and a patient day represent a homogeneous output mix in terms of service intensity. Thus, a true indication of hospital output is not provided from the index. Also levels of service quality nor differing economies of scale between facilities cannot be considered in an evaluation process.

## C. SUMMARY

The preceding pages have discussed the difficulty of measuring hospital output. As noted, there is a general tendency for hospital output to be measured as a unidimensional proxy measure or a function of several proxy measures. These measures continue to be used even though they are at best rough indicators of hospital output because they are relatively easy to develop, less costly to maintain, and provide a wide basis for comparison with other facilities because, in effect, they have been institutionalized by various regulatory agencies.

Other more innovative approaches that attempt to include, for example, the effect of case-mix proportions tend to be more successful from an empirical standpoint at attempting to measure hospital activity. Generally, these have been motivated by an attempt to capture an explanation for cost variations among diagnosis types and hospitals.

Chapter III will present a method to study the extent to which case-mix proportions explain variations in patient lengths of stay. Length of stay was chosen as the primary indicator of output for investigation by the study because of its clear relationship with case-mix variations and its popularity as a measure of output.

# III. METHODOLOGY

The previous chapter reviewed the literature relevant to research attempting to measure hospital output, and identified and discussed a sample of the key hospital workload indices that the Navy is currently using to evaluate its facilities. This chapter will present: A brief background of the problem of output measurement as it relates to inpatient length of stay (LOS); A statement of the hypotheses and objectives; The specific statistical method of the study; The sample, noting its essential characteristics and assumptions made in adapting it for use; And finally, a description of the diagnostic groupings used in the method.

## A. BACKGROUND

As already noted, the absence of a meaningful measure of hospital output is widely recognized. Standard hospital utilization measures such as inpatient days, admissions and discharges, or percent occupancy, assume that the mix of patients hospitalized does not vary, or if there is a variance, that it does not effect the validity of the particular measure. These values do provide a rough indication of output. However, if they are presented out of context of the types of cases treated by the hospital, they have no useful meaning for internal or external management in assessing efficiency and effectiveness.

To illustrate this situation, consider inpatient LOS, an aggregate measure that has been widely used to measure trends in admission and discharge policies within or between medical facilities. A change in LOS is a result of the interaction of many variables. However these variables tend to become obscured in the aggregate measure. An example of this problem can be found in the Report of the Military Health Care Study (MHCS), 1975. This was a joint study by DOD, OMB, and HEW that was formed to review and evaluate the miliatry health care system. Nine recommendations were made to affect a more efficient and effective military health care system. Recommendation number eight specifically addressed the inpatient utilization of military medical facilities [p. 88]. The evaluation compared 13 selected diagnoses and held that the military medical facilities LOS was excessive when compared with stays in civilian facilities under the Civilian Health and Medical Program of the Uniformed Services (CHAMPUS), with stays for Kaiser enrollees,[1] and with stays for patients in hospitals which participated in the Professional Activity Study (PAS).[2]

In response to this specific recommendation the Navy increased its emphasis on LOS evaluation and reduction, affecting a decrease in LOS from 12.1 days in 1972, to 7.5 days in 1976. These decreases are seen by the Navy as a result of "cessation of hostile action in southeast Asia; early discharges from inpatient medical treatment facilities

[1]Kaiser Foundation Health Plan, Inc. is a prepayment group health plan.

[2]The Professional Activity Study is a medical record information system in which 1,576 short-term non-Federal hospitals in the U.S. participated during calendar year 1973.

to medical holding companies; outpatient diagnosis and treatment; and preventive and health maintenance efforts" [U.S. Department of the Navy 1980, p. 12].

Although a reduction in LOS was affected, there may be other causes for its occurence. LOS is typically a function of case-mix, prevailing medical practices, and admission/ discharge policies, which can be influenced (manipulated) by decision-makers under various scenarios. For example, to reduce LOS from a 1972 base period value, several methods might be employed without adversely affecting the quality of care. First, administrative procedures might be streamlined to shorten the discharge process. Patient categories might be switched from an inpatient to a "medical holding" status, thus reducing the number of accountable patient days. Second, physicians could adopt medical techniques more effective and efficient from the standpoint of reducing inpatient days without reducing quality. Third, the case-mix could be modified to reflect more diagnoses types that are less complex and generally represent less patient days per treatment. That is, by holding the number of complex cases constant and increasing the number of less complex cases, the effect would be an increase in patients treated but a reduction in total length of stay. Fourth, the case-mix could be modified to reflect a total diagnosis shift to less complex case types, thus fewer patient days.

The intention is not to confuse or dispute the stated reasons the overall LOS was reduced in the Navy during 1972-1976 time period, but rather to emphasize the complexity of evaluating aggregate LOS measures. A technique will be introduced in the following section in an attempt to define a more meaningful measure of LOS.

## B. STATEMENT OF HYPOTHESIS AND OBJECTIVES

It is the hypothesis of this study that length of stay which is adjusted for case-mix is a better partial indicator of hospital output than non-adjusted length of stay. Specifically, the study will address the aggregate LOS value and attempt to devise a method that will isolate causes for changes in this measure over time. The mechanism for accomplishing this goal is to categorize patients into diagnostic groupings, determine their respective lengths of stay, and evaluate these values with other time periods or medical treatment facilities.

The steps involved in testing the hypothesis are:

1. A survey of the literature to determine the feasible output identification models which have been tested and are statistically relevant;

2. Construction of a statistical composite index that will provide a meaningful measure of hospital output in terms of inpatient length of stay/case-mix relationships;

3. Collection of Navy medical inpatient data that is commonly available on admission/disposition abstracts in a medium that would be compatible with the electronic data processing capabilities at the Naval Postgraduate School;

4. Selection of a scheme for categorizing patients into diagnostic groupings. It should be extensive enough so that any pathological condition can be accurately recorded, be congruent with the available data set, yet still be a manageable number of categories to facilitate the study;

5. Application of the statistical composite index to the Navy inpatient data set;

6. Creation of a length of stay/case-mix relationship for a longitudinal analysis of the total population and selected medical facilities, and a cross-sectional analysis of all medical facilities in the population;

7. Draw conclusions from the analyses in objective 6.

## C. METHODOLOGY

The technique developed by Rafferty [1972], as briefly described in Chapter II, will be the model for the study. In developing his technique, Rafferty considered the effect case-mix plays in changing a hospital's rate of occupancy and the average length of stay. Various scenarios were developed to isolate reasons for changes in these values. For example, if an increase in a hospital's rate of occupancy is accompanied by an increase in average length of stay, Rafferty held that the longer the length of stay likely can be attributed to the discharge policy of the medical staff. However, the increase could also represent a change in the complexity of cases where more serious/complex patients are being treated.

Rafferty examined similar models of case-mix and how it effects hospital costs. Because case-mix changes occur in the individual hospital and have a bearing on variations in average cost [Lave and Lave 1970A, 1970B], it is likely that case-mix will differ among hospitals and result in costs that are not comparable, making cost comparisons subject to qualification. Rafferty holds that this heterogeneous measurement problem could be best measured as a composite statistical index. The index procedure would first require that cases be categorized into diagnostic groupings based on some criteria such as primary diagnosis, surgical procedure, etc. The changes in the proportions of the diagnostic groupings to the total population are then multiplied by an appropriate weight such as cost, length of stay, etc. Finally, the sum of the diagnostic products is the composite value, based on the unique case-mix proportions in that population.

The base period composite value uses the same format in which the previous weight values and the unique case-mix proportions of the base population are multiplied and summed.

An index is created when the former value is divided by the later value and multiplied by 100. If the index value differs from 100 it indicates that the case-mix proportions of the given patient population differ from those of the base patient population. Rafferty views the selection of appropriate weights as the most difficult problem. This is primarily because one must determine the appropriate criteria for the case-mix comparison. The procedure that will be used in this study will attempt to interpret variations in average length of stay by employing average lengths of stay as the weights for the respective case-mix categories. It is hoped that this approach will provide a means of identifying case-mix variations but also indicate the extent to which variations in case-mix proportions explain variations in the overall length of stay. The index will be of the following format and identified as CM1:

$$CM1 = \frac{\Sigma P_{ij} \; los_i}{\Sigma P_i \; los_i} (100)$$

Where $P_{ij}$ = proportion of cases of hospital or evaluated population j in category i.

$P_i$ = proportion of cases of the base population in category i (case type).

$los_i$ = average length of stay for the base population in category i (weight).

In addition to the above index, a supplementary variant will also be examined. This application will use the case-mix proportions for category i as the weights, and the length of stay for category i as the case type proportion. It is hoped that this index value will indicate the degree to which differences in overall average stay could be attributed to differences in length of stay for specific illnesses. This index will be identified as CM2 and be of the format:

$$CM2 = \frac{\Sigma P_i \; los_{ij}}{\Sigma P_i \; los_i} (100)$$

Where $P_i$ = proportion of cases of the base population in category i.

$los_i$ = average length of stay for the base population in category i.

$los_{ij}$ = average length of stay for hospital or evaluated population j in category i.

Specific interpretations of the indices and the values that were calculated from the sample will be discussed in Chapter IV.

## D. THE SAMPLE

The sample consisted of 231,594 patient discharges from land based (fixed) and afloat (non-fixed) naval medical inpatient treatment facilities for calendar year 1978. This includes all continental United States (CONUS) including Alaska and Hawaii, and overseas medical treatment facilities. The data is based on the Inpatient Admission/Disposition Record, NAVMED 6300/5, copies of which are submitted monthly by each required medical facility to the Naval Medical Data Services Center (NMDSC), Bethesda, Maryland for inclusion in a master record for all facilities. An EDP magnetic tape copy of the master record was provided by NMDSC for this study.

The record was modified to conform to Privary Act requirements where all identifiable characteristics to specific patients, e.g. name, social security number, and the medical treatment facilities registry number were deleted.

Upon receipt of the magnetic tape, the first step was to construct the subset of data that would actually be examined. Sought was a grouping of medical facilities that would represent a homogeneous population where all categories of eligible beneficiaries would be treated. It was decided that fixed CONUS hospitals and regional medical centers, less Alaska and Hawaii, would satisfy this requirement. Non-fixed CONUS and fixed and non-fixed overseas medical facilities were not considered in the study because they would not be indicative of the total population since they generally treat active-duty members and their dependents, who are more likely to be younger and less prone to the wide spectrum of disease categories exhibited by the retired groups. This reduced the population to 24 medical treatment facilities.

The next process was to further refine the subset. Cases with patients who died were removed from the sample since their lengths of stay were probably atypical of the disease category under consideration. A further refinement was made by excluding all patients from the population whose lengths of stay were "zero" days. This situation would occur when a patient was admitted and discharged on the same day. As briefly discussed above, this has an affect of reducing the average length of stay for a facility by generally treating more less-complex cases. Finally, all patients who were discharged because they were transferred to another medical facility were also removed. It was decided that if the patient was transferred, the present facility most likely lacked the medical capabilities for treating the patient, thus the length of stay was probably atypical of its normal diagnoses types. By eliminating these groupings, it was hoped that a more accurate measure of length of stay could be evaluated for each facility and the total population. These refinements reduced the subset population to 172,087 cases.

## E. DIAGNOSTIC GROUPINGS

In testing the hypothesis it is essential that a diagnostic grouping be selected to identify unique patient characteristics that would provide a quantitative and valid measure of length of stay. Within the literature, many methods have been used to categorize patients. Some appear to be arbitrary selections while others are well-researched and justified. Lave and Lave [1971] studied how much case-mix varies across different types of hospitals and analyzed these variations. In this study three approaches to classifying patients were proposed. The first was to categorize patients by the principle diagnosis, defining case-mix in terms of the proportions of patients in each category. Second was to aggregate patients by the hospital service, e.g., pediatrics, obstetrics, etc. and define case-mix in terms of the proportions of patients in each service. Finally, patients were aggregated into the 17 broad ICDA diagnostic categories where case-mix was defined in terms of the percentage of patients in each major grouping. The authors favored the third approach because they felt it provided a more consistent approximation to an isoresource classification and more likely to be consistent across hospitals.

Lee and Wallace [1972] presented five patient classification schemes to study the effect of variation in case-mix on hospital costs. The first classification was based on the duration and the extent of disability because of the illness. It consisted of five groups from long-term severe to short-term not severe. The second scheme was based on the risk of dying, subclassified into five groups from high to low. Third was a scheme based on the cellular processes of the body and consisted of six groups, e.g. "generative" related to the production of new tissue. The fourth scheme classified patients by the 17 major groups of the ICDA. The last scheme classified patients according to their hospital services. The authors attained higher $R^2$ for classification four and five, .522 and .577 respectively. They felt they were more detailed and thus had a higher explanatory power. The remaining three schemes represented low $R^2$. The authors felt that by combining several schemes it would perhaps increase the explanatory power of the case-mix variable.

A more complete approach to classifying patients was developed by the Professional Activity Study (PAS) of the Commission on Professional and Hospital Activities (CPHA) [1976]. Patients are divided into 349 mutually exclusive diagnostic categories then further subdivided into whether surgery was performed, presence or absence of a secondary diagnosis, and five age categories. This totals nearly 7000 patient classes which are used extensively by Professional Standards Review Organizations (PSRO) as part of their concurrent review process. This approach has a tendency to over or underspecify according to the existence or absence of utilization variables.

Generally, the most frequent diagnostic grouping of patients by case-mix is based upon the patients primary diagnosis using the major ICDA disease categories. The Navy, in its Medical Statistics, U.S. Navy, has developed several methods to describe its population by using the ICDA groupings. The first is to group patient types, e.g., active-duty Navy, Marine Corps, recruits, etc., by their primary diagnosis by the 17 major disease classifications. Within these groups, the patients are subdivided by the major disease types within each category. Another method is to group patients who had undergone surgery into the 17 major ICDA surgery classifications. These groupings are also further subdivided into major surgical procedures within each classification. Several other approaches are used by the Navy, such as admissions due to injuries, a noneffective ratio where the number of active-duty sick days is divided by the average active-duty strength, medical separations, dental procedures, deaths, and births. Generally, all of these techniques are incidence frequencies which provide a rough description of the population. However they cannot be considered adequate measures for defining cases with respect to length of stay.

This study investigates the existence and characteristics of a method to identify classes of patients by their primary diagnosis which have the same clinical attributes and require similar processes of care. The patient classification scheme chosen was the Diagnosis-Related Groups (DRGs) method as defined by Fetter, et al. [1980]. The classification scheme under DRGs is to identify a set of case types that represent a class of patients requiring similar processes of care and denotes a predictable product from an institution. The groups are first partitioned into 83 major diagnostic categories and further subdivided into DRGs based on those variables which demonstrated an effect in predicting output as a measure of length of stay. This process resulted in 383 DRGs that were interpretable medically and were similar with respect to their patterns of length of stay.

Because of time and resource constraints, the diagnostic groupings which were used in the study were the 83 major diagnostic categories as discussed above. It was felt that this grouping would be superior to the present 17 major ICDA classifications in explaining variations in length of stay, yet provide a manageable number of categories. The 83 categories were defined using ICDA secondary diagnostic codes. The groupings were formed by a committee of physicians who followed these general principles:

"1. Major diagnostic categories must have consistency in terms of their anatomic, physiopathologic classification, or in the manner in which they are clinically managed.

2. Major diagnostic categories must have a sufficient number of patients.

3. Major diagnostic categories must cover the complete range of codes (ICDA codings) without overlap." [Ibid. p. 8].

A listing of the 83 Major Diagnostic Categories is at Appendix B.

## F. SUMMARY

This chapter has discussed the relationship of LOS to case-mix, and posited that the use of LOS as a partial indicator of hospital output can become more definitive when LOS is adjusted for case-mix. The statistical indices presented will provide the framework for analysis of the sample data in Chapter IV. The data will be evaluated based on the primary diagnoses of patients that were discharged from the 24 selected fixed CONUS medical facilities for a longitudinal and cross-sectional analysis, and six selected fixed CONUS facilities for an interhospital longitudinal analysis.

# IV. APPLICATIONS OF THE MODEL

The objective reported on in this chapter is a test of the methodology that was stated in the previous chapter. This chapter will first provide the reader with a simplified application of the indices using a hypothetical data set. This illustration will hopefully allow the reader the opportunity to gain an understanding of the intricacies of the indices, thus allowing easier interpretation of this data and the following Navy data set. The remainder of the chapter will apply the Navy inpatient data set to the indices. Three analyses will be done. First, a monthly longitudinal analysis of the total population, which is then followed by a cross-sectional analysis of the 24 facilities within the data set. This application will evaluate the yearly values for each facility to the total population. Finally, a longitudinal analysis of six selected facilitites will be presented. This analysis will provide for the measurement of interhospital trends on a quarter-by-quarter basis.

## A. HYPOTHETICAL APPLICATION

The Navy data set, it will be recalled, was made up of inpatient admission/discharge records for calendar year 1978 from 24 CONUS hospitals and regional medical centers. The data was further refined to eliminate patients who died, were transferred, or had a LOS of zero days. The remaining records were then grouped by primary diagnosis categories. In applying the data set to the indices, each diagnostic category with its unique LOS and proportion of the total population is multiplied and summed according to the indice equation. To gain an understanding of the indices a hypothetical example will be developed. The example will be a longitudinal study of a facility over four quarters and, for simplicity will have two diagnostic categories with respective average lengths of stay (ALOS) and proportions of total cases. The example input data will be sufficiently changed for each quarter to explain the causes of most variances in ALOS in the Navy data set. Table I provides the input data that is used in the example.

TABLE I.

HYPOTHETICAL INPUT DATA

| Diagnostic Category | Number of Observations | Proportion of Total Observations | Average Length of Stay for Category | Average Length of Stay for Period |
|---|---|---|---|---|
| Quarter 1 | | | | 5.20 |
| 1 | 12 | 0.60 | 6 | |
| 2 | 8 | 0.40 | 4 | |
| Quarter 2 | | | | 5.12 |
| 1 | 8 | 0.33 | 6.5 | |
| 2 | 16 | 0.66 | 4.5 | |
| Quarter 3 | | | | 6.30 |
| 1 | 15 | 0.60 | 7.5 | |
| 2 | 10 | 0.40 | 4.5 | |
| Quarter 4 | | | | 5.26 |
| 1 | 19 | 0.68 | 5.9 | |
| 2 | 6 | 0.32 | 3.9 | |

By examining the input values it should be noted that ALOS for the period varies as a result of the changes in proportion or the ALOS of the diagnostic categories. A feel for this change is essential to later comprehension of the index values. The calculations of the indices values from the above input data are contained in Appendix C. The results of these calculations are presented below in Table II.

TABLE II.

HYPOTHETICAL RESULTS

| Quarter | ALOS | ALOS Index | CM1 | CM2 | Total Observations |
|---|---|---|---|---|---|
| (Base Period) 1 | 5.20 | 100.0 | 100.0 | 100.0 | 20 |
| 2 | 5.12 | 98.5 | 88.8 | 109.6 | 24 |
| 3 | 6.30 | 121.2 | 100.0 | 121.2 | 25 |
| 4 | 5.26 | 101.2 | 103.1 | 98.1 | 25 |

In evaluating the CM1 values above, any value that is different from the base period is a result of changes in the proportions of cases treated. Thus, if there is a rise (drop) in the index value it could result from an increase (decrease) in the proportion of longer-staying cases or a decrease (increase) of shorter-staying cases or a combination of the two. For example, in Quarter 2 there was a decrease in CM1 to 88.8. From the input data in Table I for this period, it is apparant that this was a result of the changes in the proportion of the cases treated. Diagnosis category 1 (longer-staying case type) dropped to 33 percent while category 2 (shorter-staying cases) increased to 66 percent. In Quarter 3, the proportion of cases was purposely left the same as the base, thus the value of 100 for CM1. Quarter 4 represents an increase in the CM1 to 103.1. This is caused by the increase in Diagnosis Category 1 (longer-staying case types) to 68 percent and the drop in Category 2 (shorter-staying cases) to 38 percent.

CM2 reflects the percentage the evaluation period varied from the base, had its case-mix proportions remained unchanged. Thus, the defined value represents a true case-mix measure to evaluate LOS. A value greater (less) than 100 would indicate an increase (decrease) in LOS even though the ALOS may have declined (increased). In Quarter 2, the ALOS decreased to 98.5, however CM2 increased to 109.6. This indicates a true increase in ALOS that was masked by the greater proportions of shorter-staying cases. Quarter 3 shows a CM2 value of 121.2, representing a true increase in LOS for the categories. The proportions of the diagnostic categories were kept constant, as seen in Table I, to emphasize this effect. Quarter 4 represents the inverse of Quarter 2. Here the ALOS has increased to 103.9 but CM2 has decreased to 98.1. This represents a true reduction in LOS for the categories, even though the ALOS has gone up, and is a result of treating a greater proportion of longer-staying cases.

Rafferty [1972] holds that the index values represent the percentage change in the ALOS. Quarter 2 will be used to evaluate his assumption. During this period raw (unadjusted) ALOS decreased 1.5 percent from the base, CM1 was 11.2 percent less than the base, and CM2 9.6 percent greater than the base. By subtracting CM1 from CM2, the ALOS change is captured, i.e., 11.2 percent less 9.6 percent equals 1.6 percent which is approximately equal to the change in ALOS. Thus in this evaluation period, the 1.5 percent decrease in ALOS is primarily the effect of a case-mix change to shorter-staying cases.

His assumption appears reasonable, however the validity is based upon the requirement for a sufficient frequency of paitents in all diagnostic categories between the base and evaluation period or facility. As will be seen in later analyses, CM1 and CM2 percentage differences are not always approximately equal to the percentage change in ALOS. It appears that this is due primarily to the presence of all diagnostic categories being used in the base, but an incomplete presence of diagnostic categories in the evaluation period of facility. Even in view of this shortcoming, the decrease in unadjusted ALOS for Quarter 2 can still be identified as a result of two distinct and separable effects by CM1 and CM2. Specifically, CM1 has decreased in the direction of cases which normally require shorter LOS, offsetting the LOS increase as noted by CM2.

The indices provide a relative feel for the changes in the proportions of case-mix and the LOS for each diagnostic category, however the relative magnitude of the proportions is not addressed. If an index value was equal to 100, it would not guarantee that the proportions are identical to the base period, but that they can be considered equivalent. For example, if Diagnostic Categories 1 and 2 had respective LOS of 6 and 4, a case-mix proportion of 40 percent under Category 1 would be equivalent to 60 percent under Category 2.

## B. LONGITUDINAL ANALYSIS OF THE TOTAL POPULATION

A summary of the total population of the Navy data set by month is provided below in Table III. As previously defined, the first evaluation period, January, is considered the base period for the analysis.

Examination of the ALOS shows a general increase between January and December. However this trend may be more seasonal than secular. For example, fluctuations of the value from a high of 110.1 for March to a 100.2 value in April, 103.1 for June to 100.7 for July, and 103.2 for October to 100.3 for November. Upon the examination of the CM1 values, there is a general increase from the January base period of 100.0 to 103.1 in December. This represents a probable increase in the proportions of cases that can be associated with longer-stays. The CM2 values, with the exception of three months, generally

TABLE III.

LONGITUDINAL SUMMARY OF THE TOTAL POPULATION DATA

| Month | ALOS | ALOS Index | CM1 | CM2 | Number of Dispo-sitions |
|---|---|---|---|---|---|
| (Base Period) | | | | | |
| Jan | 6.132 | 100.0 | 100.0 | 100.0 | 14,814 |
| Feb | 6.406 | 104.5 | 100.1 | 103.9 | 14,459 |
| Mar | 6.750 | 110.1 | 102.7 | 106.8 | 15,878 |
| Apr | 6.143 | 100.2 | 102.8 | 97.6 | 14,526 |
| May | 6.531 | 106.5 | 103.4 | 103.3 | 15,092 |
| Jun | 6.320 | 103.1 | 104.5 | 98.6 | 14,487 |
| Jul | 6.176 | 100.7 | 102.8 | 99.0 | 13,630 |
| Aug | 6.268 | 102.2 | 103.2 | 99.4 | 14,435 |
| Sep | 6.229 | 101.6 | 102.8 | 99.1 | 13,763 |
| Oct | 6.331 | 103.2 | 103.3 | 100.8 | 14,106 |
| Nov | 6.152 | 100.3 | 103.0 | 98.4 | 13,408 |
| Dec | 6.254 | 102.0 | 103.1 | 99.8 | 13,489 |
| Total | | | | | 172,087 |

remained close to the base period of 100 indicating that the true LOS was relatively constant. Thus, the general increase in ALOS stems from the increased proportion of longer-staying cases.

## C. CROSS-SECTIONAL ANALYSIS OF FACILITIES

The following analysis will compare each medical treatment facility within the data set to the total population. The format will be the same as previous analyses where the base period will be expressed as 100. In viewing the indice values, there may be a tendency to compare one facility with another. However, before comparisons between facilities are made, the unique characteristics of the facilities should be known and the limitations of the indices considered. Table IV provides the results of the data tabulations.

The ALOS ranged from a low of 59.1 for NH Lemoore to a high of 165.0 for NNMC Bethesda. The average deviation for ALOS differed by 17.1 percent from the mean value. Further interpretations of the ALOS are possible when used in conjunction with CM1 and CM2. CM1 ranged from a high of 115.2 for NNMC Bethesda to a low of 79.3 for NH Cherry Point. The average deviation for this measure was 6.7 percent from the mean value. The CM2 index showed a wider range than CM1, where the high was 142.7 for NNMC Bethesda, to a low of 59.3 for NH Lemoore.

To evaluate the results, three facilities were chosen as an example: NNMC Bethesda (highest indice values); NH Lemoore (lowest indice values); and NRMC San Diego (closest to indice value means). When viewing NNMC Bethesda, the ALOS is 65 percent greater than the population value. CM1 and CM2 will be used to interpretate the causes for the difference.

TABLE IV.

CROSS-SECTIONAL TABULATION OF FACILITIES

| Facility | ALOS | ALOS Index | CM1 | CM2 | Number of Dispositions |
|---|---|---|---|---|---|
| (Base Period) Total Population | 6.314 | 100.0 | 100.0 | 100.0 | 172,087 |
| NH Annapolis | 4.034 | 63.9 | 93.7 | 69.7 | 1,577 |
| NNMC Bethesda | 10.421 | 165.0 | 115.2 | 142.7 | 12,621 |
| NRMC LeJeune | 7.024 | 111.1 | 94.9 | 117.8 | 8,390 |
| NRMC Pendleton | 5.692 | 90.1 | 92.8 | 97.6 | 10,116 |
| NRMC Charleston | 4.897 | 77.6 | 91.3 | 86.5 | 10,122 |
| NH Cherry Point | 5.714 | 90.5 | 79.3 | 114.2 | 2,356 |
| NRMC Corpus Christi | 8.160 | 129.2 | 106.1 | 118.7 | 1,889 |
| NRMC Great Lakes | 5.666 | 89.7 | 98.9 | 94.2 | 8,053 |
| NRMC Jacksonville | 5.939 | 94.0 | 96.2 | 100.0 | 8,688 |
| NH Key West | 4.213 | 66.7 | 96.0 | 65.7 | 993 |
| NH Lemoore | 3.731 | 59.1 | 80.8 | 59.3 | 1,739 |
| NRMC Long Beach | 5.541 | 87.8 | 102.2 | 87.8 | 7,089 |
| NRMC Memphis | 5.058 | 80.1 | 93.2 | 86.3 | 3,982 |
| NSMC New London | 4.097 | 64.9 | 90.1 | 68.1 | 3,222 |
| NRMC Newport | 6.582 | 104.2 | 104.8 | 95.7 | 2,953 |
| NRMC Oakland | 6.561 | 104.0 | 109.6 | 97.0 | 12,262 |
| NRMC Orlando | 6.993 | 110.8 | 91.8 | 115.8 | 3,964 |
| NH Patuxent | 5.361 | 84.9 | 81.1 | 98.6 | 1,278 |
| NARMC Pensacola | 5.708 | 90.4 | 98.5 | 90.6 | 6,351 |
| NRMC Philadelphia | 7.978 | 126.4 | 103.1 | 123.4 | 5,382 |
| NRMC Portsmouth | 6.370 | 100.9 | 104.2 | 96.8 | 24,494 |
| NH Quantico | 4.622 | 73.2 | 93.7 | 69.7 | 1,144 |
| NRMC San Diego | 5.990 | 94.9 | 100.3 | 94.5 | 29,748 |
| NH Bremerton | 5.443 | 86.2 | 98.5 | 89.2 | 3,674 |

The CM1 value of 115.2 indicates that the facility is most likely taking on a more demanding case-mix which tends to be associated with longer-stays. CM2 is shown to be 42.7 percent higher than the total population indicating that the treatment processes take considerably longer at this facility. This great variance in LOS identifies possible areas for review where reductions in LOS may be affected. Again, with any type of review process, the unique characteristics of the facility must be understood to make a meaningful analysis.

In contrast, NH Lemoore had the lowest index values. The ALOS was 40.9 percent below the population base, the CM1 value was 19.2 percent below the base, and likewise, the CM2 value was 40.7 percent below the base. The CM1 value indicates that the facility is generally treating a less complex case-mix and the CM2 value indicates that it generally takes less time at this facility to treat similar types of cases. This is consistent with the fact that NH Lemoore is a small medical facility that generally treats less complex case-mix types.

NRMC San Diego had values closest to the indices mean. ALOS was at 94.9, CM1 at 100.3, and CM2 at 94.5. These values indicate that the ALOS is less than the total population, that the case-mix treated is closely representative of the total population and that the facility is experiencing a lower LOS in treating its patients when compared to the total population.

## D. LONGITUDINAL ANALYSIS OF SELECTED FACILITIES

The final analysis will be a quarterly evaluation of six selected medical facilities within the Navy data set. The facilities were chosen on the basis of being mid-sized regional medical facilities having similar numbers of dispositions for the calendar year. Table V presents the results of the analysis.

In evaluating NRMC LeJeune, the ALOS appears to be subject to seasonal fluctuations. The second quarter shows a rise of 13.2 percent, the third quarter a 12.9 percent drop, and the fourth quarter a 0.5 percent increase. When viewing the CM1 there are values greater than the base during each quarter. This generally represents a shift to case types that require longer stays. The CM2 value rises during the second quarter and then exhibits values less than the base period for the remaining quarters. The rise during quarter two would indicate a true increase in LOS while the decrease in quarter three and four indicates true decreases in LOS.

NRMC Pendleton experienced a continual decrease in ALOS with an ending value of 91.6. CM1 rose indicating a shift to cases that require longer stays, while CM2 shows a decrease in the true LOS. This is a favorable trend where ALOS is reduced, case-mix complexity is increased, and true LOS is reduced.

The ALOS for NRMC Charleston decreased during the second and third quarters and then increased during the fourth quarter. This is a result of the general increase in CM1,

TABLE V.

LONGITUDINAL COMPARISON OF SELECTED FACILITIES

| Facility & Quarter | | ALOS | ALOS Index | CM1 | CM2 | Number of Dispositions |
|---|---|---|---|---|---|---|
| NRMC LeJeune | 1 | 6.790 | 100.0 | 100.0 | 100.0 | 2,276 |
| | 2 | 7.683 | 113.2 | 108.0 | 106.8 | 2,016 |
| | 3 | 6.813 | 100.3 | 104.4 | 92.2 | 2,062 |
| | 4 | 6.864 | 100.8 | 104.5 | 95.3 | 2,036 |
| NRMC Pendleton | 1 | 5.914 | 100.0 | 100.0 | 100.0 | 2,494 |
| | 2 | 5.794 | 98.0 | 101.8 | 97.4 | 2,586 |
| | 3 | 5.635 | 95.3 | 107.2 | 91.2 | 2,585 |
| | 4 | 5.419 | 91.6 | 104.4 | 89.7 | 2,451 |
| NRMC Charleston | 1 | 5.035 | 100.0 | 100.0 | 100.0 | 2,629 |
| | 2 | 4.739 | 94.1 | 101.5 | 93.5 | 2,558 |
| | 3 | 4.732 | 94.0 | 100.0 | 95.0 | 2.490 |
| | 4 | 5.081 | 100.9 | 102.1 | 100.3 | 2.445 |
| NRMC Great Lakes | 1 | 5.720 | 100.0 | 100.0 | 100.0 | 2,414 |
| | 2 | 5.370 | 93.9 | 107.4 | 92.4 | 1,951 |
| | 3 | 5.520 | 96.5 | 105.2 | 92.3 | 1,901 |
| | 4 | 6.070 | 106.1 | 108.5 | 102.4 | 1,787 |
| NRMC Jacksonville | 1 | 5.926 | 100.0 | 100.0 | 100.0 | 2,365 |
| | 2 | 5.878 | 99.2 | 104.1 | 95.7 | 2,288 |
| | 3 | 6.017 | 101.5 | 104.2 | 99.0 | 1,946 |
| | 4 | 5.948 | 100.4 | 99.3 | 100.4 | 2,071 |
| NRMC Long Beach | 1 | 6.153 | 100.0 | 100.0 | 100.0 | 1,943 |
| | 2 | 5.662 | 92.0 | 98.3 | 94.8 | 1,886 |
| | 3 | 5.304 | 86.2 | 99.4 | 87.9 | 1,580 |
| | 4 | 4.922 | 80.0 | 98.0 | 82.0 | 1,680 |

which indicates a trend in treating more longer-staying case types, while CM2 dropped for the second and third quarter and then increased during the fourth quarter. This indicates that the true LOS had been reduced or kept constant, compared with the base, while treating more longer-staying cases for quarters two and four and equivalent case types during quarter three.

NRMC Great Lakes appears to exhibit a trend similar to NRMC Charleston in that ALOS falls during quarter two and three and then rises in quarter four. This appears to have occurred due to the increase in longer-staying cases as represented by CM1 and the general decrease in quarter two and three and increase in quarter four of CM2. Here the true LOS has generally been reduced, as identified by CM2, while treating more longer-staying cases.

NRMC Jacksonville shows little change in ALOS from the base period. When viewing CM1 the index value increases during quarter two and three and then decreases to a value slightly less than the base. CM2 drops 4.3 percent during the second quarter and then increases to values that are close to the base period for quarters three and four. In evaluating these results, it appears that during quarter two a true reduction in LOS was affected while treating a generally more serious case-mix. True LOS during quarter three is slightly less than the base while still treating a more complex case-mix. Quarter four represents a true LOS that is slightly above the base while treating a case-mix that is slightly less difficult than the base.

The ALOS for NRMC Long Beach is steadily declining from the base. This is due to a general decrease in CM1 and CM2. In quarter four the case-mix, as indicated by CM1, is 98 percent of the base period noting a less serious case-mix, while the true LOS has been reduced 18 percent, as shown by CM2. This represents a favorable situation where similar cases are treated (compared to the base) but require fewer patient days for treatment.

## E. SUMMARY

This chapter has presented the results of the application to the Navy inpatient data set of the methodology described in Chapter III. Three analyses were done in testing the data set: a longitudinal analysis of the total population; a cross-sectional analysis where each facility was compared with the total population; and a longitudinal analysis of six selected medical treatment facilities.

The longitudinal study of the total population showed a general increase in ALOS. This increase can be attributed to a shift in case-mix that requires generally longer-stays. The cross-sectional analysis, illustrated the differences in ALOS among facilities when compared to the total population. The longitudinal analysis of six selected facilities evaluated quarterly changes in ALOS that were a result of changes in case-mix and LOS. Five of the facilities were generally treating more case types that required longer-stays while maintaining relatively stable LOS and ALOS. The sixth facility experienced a reduced ALOS. This appears to be a result of a decrease in the longer-staying case types and a reduced LOS.

The following chapter will present the conclusions of the study, the applications and limitations of the indices for the Navy and the implied direction of future research as a result of the study.

# V. CONCLUSIONS

This chapter will provide a brief summary of the important conclusions of this study. In addition it will include several comments on the applications and limitations of the indices for the Navy. Finally, it will discuss the implied direction of future research as a result of this study.

## A. CONCLUSIONS

The intent of this study was to determine whether length of stay, a common output measure, which is adjusted for case-mix, is a better partial indicator than non-adjusted length of stay. This hypothesis was tested with three analyses and found to be correct. For each analysis two indices were used to evaluate the overall change in length of stay, the first index evaluating changes due to differences in case-mix, the second index evaluating changes due to differences in length of stay for each case-mix type. It was posited that the overall effect of both indices would be approximately equal to the overall change in length of stay. Empirically, this assumption appeared valid, however this relationship did not always occur in the analyses. It is believed that this was a result of the diagnostic groupings that were used, where several categories did not have a consistent frequency of cases between the base period and evaluation period. Even in view of this shortcoming, it is held that the index values allow for a wider intrepretation of what causes changes in length of stay.

B. APPLICATIONS AND LIMITATIONS

These composite statistical indices could be easily applied to any medical facility or regulatory organization that maintains or has access to admission/disposition statistics. The three analyses in the study provided for the two most common uses: a longitudinal analysis where an evaluation period's (month, quarter, year) case-mix and respective lengths of stay are compared to the base period (year); or a cross-sectional analysis where a unique population's (facility's) case-mix and respective lengths of stay are compared with other populations and the aggregate of the populations. The index values for either application may be used to interpret differences in admission-discharge practices or differences in a population's case-mix types due to more (less) complex cases.

By modifying the index weights from average length of stay for each diagnostic grouping to, for example, average cost per patient for each diagnostic group, the financial picture of the costs of treating specific types of patients could be traced. This application of a case-mix accounting system would be useful in cost control programs or in the development of budgets.

Several limitations exist that are related to these indices: First, the indices do not provide for measurement of outpatient or preventive medicine activity; Second, the diagnostic categories that were used did not have a sufficient frequency of cases in all groupings. This had an effect of reducing the strength of the values; Third, the case-mix categories did not examine the presence of secondary diagnoses, age, sex, or indication of surgery; Fourth, the indices cannot capture all the unique characteristics of a facility such as its demographic or environmental differences, whether a facility has a large teaching or research mission, or the prevailing medical practices at a facility. These unique characteristics must be recognized before any comparison between facilities is attempted.

## C. EXTENSIONS FOR FUTURE RESEARCH

An additional extension for research would be to study a patient population for more than one year. This would allow for identification of seasonal trends in the data.

The specificity of the index values could be improved if diagnostic categories were developed that maximized variance reduction or minimized the predictive error of the dependent variable (length of stay). This technique, as discussed in Chapter III, would examine the effect of the many independent variables such as age, sex, presence of secondary diagnoses, surgical procedures, etc., on length of stay.

A final extension would be to use the basic format of the indices, but to change the weights from the average length of stay for each diagnostic category to, for example, the average cost for each diagnostic category. This would allow for an analysis of cost/case-mix relationships.

# APPENDIX A

## DESCRIPTION OF THE EIGHTH REVISION INTERNATIONAL CLASSIFICATION OF DISEASES ADAPTED FOR USE IN THE U.S. (ICDA-8)

The coding system consists of two separate sections. The first is for the classification of disease entities, the second for the classification of surgical procedures. Theoretically, every patient who is admitted into a hospital will be assigned one or more diagnostic categories. However, only those individuals who have had one or more surgical procedures will be assigned a surgical category.

The classification system uses a etiological framework. There are seventeen primary classes comprising the broadest groupings of disease entities. These seventeen are subdivided into ninety-seven secondary classifications. An even further refinement of the disease entities is attained by a tertiary classification which is the three digit code. A still further refinement is achieved by the addition of a decimal point and a single digit to the three digit code. The following is an example of a diagnostic category, Malignant Neoplasm of Respiratory System (160-163) under primary class II Neoplasms.

## II NEOPLASMS (140-239)

### MALIGNANT NEOPLASM OF RESPIRATORY SYSTEM (160-163)

160 Malignant neoplasm of nose, nasal cavities, middle ear, and accessory sinuses

- 160.0 Nose (internal and nasal cavities
- 160.1 Eustachian tube and middle ear
- 160.2 Maxillary sinus
- 160.8 Other sinus
- 160.9 Unspecified sinus

161 Malignant neoplasm of larynx

- 161.0 Glottis, true vocal cord
- 161.8 Other specified parts
- 161.9 Part unspecified

162 Malignant neoplasm of trachea, bronchus, and lung

- 162.0 Trachea
- 162.1 Bronchus and lung

163 Malignant neoplasm of other and unspecified respiratory organs

- 163.0 Pleura
- 163.1 Mediastinum
- 163.9 Site unspecified

# APPENDIX B

## MAJOR DIAGNOSTIC CATEGORIES LISTING

| Major Category | Group Names | ICDA-8 Codes |
|---|---|---|
| 1 | Infectious Diseases | 0000-0689, 0710-1360 |
| 2 | Malignant Neoplasm of Digestive System | 1400-1590 |
| 3 | Malignant Neoplasm of Respiratory System | 1600-1635 |
| 4 | Malignant Neoplasm of Skin | 1720-1739 |
| 5 | Malignant Neoplasm of Breast | 1740 |
| 6 | Malignant Neoplasm of Female Genital Organ | 1800-1849, 2340, 6211, 6291 |
| 7 | Malignant Neoplasm of Male Genital Organ | 1850-1879 |
| 8 | Malignant Neoplasm of Urinary System | 1880-1899 |
| 9 | Malignant Neoplasm of Other and Unspecified Sites | 1700-1719, 1900-1991 |
| 10 | Neoplasm of Lymphatic and Hemopoietic Tissue | 2000-2090 |
| 11 | Benign Neoplasm of Female Genital Organ | 2180-2219 |
| 12 | Benign Neoplasm of Other Sites | 2100-2169, 2220-2330, 2341-2399, 2552, 7434, 7571 |
| 13 | Diseases of Thyroid and Other Endocrine Glands | 2400-2460, 2510-2551, 2559-2589 |
| 14 | Diabetes | 2500-2509 |
| 15 | Nutritional and Other Metabolic Diseases | 2600-2790 |
| 16 | Diseases of Blood and Blood Forming Organs | 2800-2890, 2894-2899, 6345 |
| 17 | Psychoses Not Attributed to Physical Conditions | 2950-2990 |
| 18 | Neuroses | 3000-3029 |
| 19 | Alcoholic Mental Disorder and Addiction | 2910-2919, 3030-3039 |

| Major Category | Group Names | ICDA-8 Codes |
|---|---|---|
| 20 | Other Mental Disorders | 2900-2901, 2920-2949 3040-3159 |
| 21 | Diseases of Central Nervous System | 3200-3499 |
| 22 | Diseases of Peripheral Nervous System | 3500-3580, 3589 |
| 23 | Diseases of Eye | 3600-3789 |
| 24 | Diseases of Ear and Mastoid Process | 3800-3879 |
| 25 | Hypertensive Heart Diseases | 4000-4040 |
| 26 | Acute Myocardial Infarction | 4100-4109 |
| 27 | Ischemic Heart Diseases except AMI | 4110-4149 |
| 28 | Arrhythmia and Slowed Conduction | 3581, 4272-4279 |
| 29 | Heart Failure | 4270-4271, 7824 |
| 30 | Carditis, Valvular, and Other Diseases | 3900-3980, 4200-4260, 4280-4299 |
| 31 | Cerebrovascular Diseases | 4300-4389 |
| 32 | Diseases of Vascular System | 2891-2893, 4400-4431, 4438-4480, 4520-4549, 4560-4589 |
| 33 | Pulmonary Embolism | 4500 |
| 34 | Phlebitis and Trombophlebitis | 4510-4519 |
| 35 | Hemorrhoids | 4550 |
| 36 | Hypertrophy of Tonsil and Adenoid | 5000 |
| 37 | Acute URI and Influenza | 4600-4650, 4700-4741 |
| 38 | Other Diseases of Upper Respiratory Tract | 5010-5089 |
| 39 | Pneumonia | 4800-4860 |
| 40 | Bronchitis | 4660, 4900-4910 |
| 41 | Asthma | 4930 |
| 42 | Other Lung and Pleural Diseases | 4920, 5100-5199 |
| 43 | Diseases of Oral Cavity, Salivary Glands and Jaws | 5200-5299 |
| 44 | Gastric and Peptic Ulcer | 5310-5349 |
| 45 | Upper GI Diseases except Gastric and Peptic Ulcer | 5300-5309, 5350-5379 |

| Major Category | Group Names | ICDA-8 Codes |
|---|---|---|
| 46 | Appendicitis | 5400-5430 |
| 47 | Hernia of Abdominal Cavity | 5500-5539 |
| 48 | Enteritis, Diverticula, and Functional Disorder of Intestine | 5610-5649 |
| 49 | Diseases of Anus | 5650-5660, 6850 |
| 50 | Miscellaneous Diseases of Intestine and Peritoneum | 5600-5609, 5670-5699 |
| 51 | Diseases of Liver | 0700, 0705-0709, 9992, 5700-5739 |
| 52 | Diseases of Gallbladder and Bile Duct | 5740-5769 |
| 53 | Diseases of Pancreas | 5770-5779 |
| 54 | Diseases of Kidney and Ureter | 5800-5910, 5930-5935, 7920 |
| 55 | Urinary Calculus | 5920-5940 |
| 56 | Cystitis and Other Urinary Diseases | 5950-5999 |
| 57 | Diseases of Prostate | 6000-6020 |
| 58 | Diseases of Male Genital Organs | 6030-6050, 6070-6079 |
| 59 | Diseases of Female Genital Organs | 6120-6210, 6212-6270, 6290, 6292, 6294, 6296-6299 |
| 60 | Diseases of Breast | 2170, 6100-6119 |
| 61 | Abortion | 6400-6459 |
| 62 | Obstetrical Diseases of Antepartum and Puerperium | 6300-6344, 6346-6399, 6700-6730, 6739-6780 |
| 63 | Normal Delivery | 6500 |
| 64 | Delivery with Complication | 6510-6620, 6731 |
| 65 | Diseases of Skin and Subcutaneous Tissue | 6800-6840, 6860-7099 |
| 66 | Arthritis | 7100-7150 |
| 67 | Derangement and Displacement of Intervertebral Disc | 7250-7259 |
| 68 | Diseases of Bone and Cartilege | 7171-7180, 7200-7249 |
| 69 | Other Diseases of Musculo-Skeletal System | 7160-7170, 7260-7389 |

| Major Category | Group Names | ICDA-8 Codes |
|---|---|---|
| 70 | Congenital Anomalies | 7400-7433, 7438-7570, 7572-7599 |
| 71 | Normal Mature Born | Y200-Y209, Y220-Y239, Y260-Y279 |
| 72 | Certain Diseases and Conditions Peculiar to Newborn Infants | Y210-Y219, Y240-Y259, Y280-Y299, Y005, 7600-7799 |
| 73 | Symptoms and Signs Referable to Nervous, Respiratory, and Circulatory Systems | 4432, 7800-7808, 7814-7815, 7817-7823, 7825-7834, 7836-7837 |
| 74 | Symptoms and Signs Referable to GI and Urinary System | 7840-7865 |
| 75 | Miscellaneous Signs, Symptoms, and Ill-defined Conditions | 6060, 6280, 6293, 6295, 7810-7813, 7816, 7835, 7866-7889, 7900-7910, 7930-7969 |
| 76 | Fractures | 8000-8299 |
| 77 | Dislocation and Other Musculo-Skeletal Injury | 8300-8480 |
| 78 | Internal Injury of Cranium, Chest, and Other Organs | 8500-8699, 9500-9599, 9953, 9954 |
| 79 | Open Wound and Superficial Injury | 8700-9390, 9960-9969 |
| 80 | Burn | 9400-9499 |
| 81 | Complication of Surgical and Medical Care | 9970-9991, 9993-9999 |
| 82 | Adverse effects of a Certain Substance | 9600-9952, 9955-9959 |
| 83 | Special Admissions and Examinations Without reported Diagnosis | Y000-Y004, Y006-Y159, 3790-3793, 3880-3899, 7890-7899 |

# APPENDIX C

## HYPOTHETICAL INDEX CALCULATIONS

$$CM1 = \frac{\Sigma p_{ij}\ los_i}{\Sigma p_i\ los_i}(100) \qquad CM2 = \frac{\Sigma p_i\ los_{ij}}{\Sigma p_i\ los_i}(100)$$

Period Two

$$CM1 = \frac{(.33)(6) + (.66)(4)}{(.6)(6) + (.4)(4)}(100) = 88.8$$

$$CM2 = \frac{(.6)(6.5) + (.4)(4.5)}{(.6)(6) + (.4)(4)}(100) = 109.6$$

Period Three

$$CM1 = \frac{(.6)(6) + (.4)(4)}{(.6)(6) + (.4)(4)}(100) = 100.0$$

$$CM2 = \frac{(.6)(7.5) + (.4)(4.5)}{(.6)(6) + (.4)(4)}(100) = 121.2$$

Period Four

$$CM1 = \frac{(.68)(6) + (.32)(4)}{(.6)(6) + (.4)(4)}(100) = 103.1$$

$$CM2 = \frac{(.6)(5.9) + (.4)(3.9)}{(.6)(6) + (.4)(4)}(100) = 98.1$$

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