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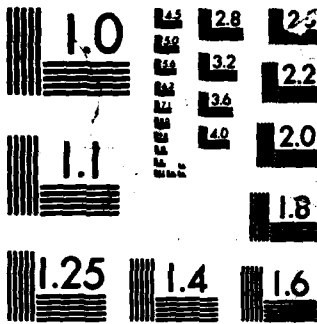
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PHYSICIAN PRACTICE PATTERNS
WITHIN AN ACUTE CARE FACILITY

by
Timothy Cross McKee

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Health Services Organization and Policy)
in The University of Michigan
1986

Doctoral Committee:

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An Ancient Chinese Classification of Animals

Animals are divided into (a) those that belong to the Emperor, (b) embalmed ones, (c) those that are trained, (d) suckling pigs, (e) mermaids, (f) fabulous ones, (g) stray dogs, (h) those that are included in this classification, (i) those that tremble as if they were mad, (j) innumerable ones, (k) those drawn with a very fine camel's hair brush, (l) others, (m) those that have just broken a flower vase, and (n) those that resemble flies from a distance. (Jorge Luis Borges, Other Inquisitions: 1937-1952)

To Susan who appreciates
that difficulty builds minds
as labor builds bodies.

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TABLE OF CONTENTS

DEDICATION	ii
ACKNOWLEDGEMENTS	iii
LIST OF FIGURES	vi
LIST OF APPENDICES	vii
CHAPTER	
1. THE PROBLEM AND THE APPROACH	1
Opportunities for Containing Costs	4
Nature of the Hospital's Product	7
Cost Minimization Approach	8
Research Agenda	15
2. CONCEPTUAL AND ANALYTICAL DEVELOPMENT OF PRODUCTIVITY MEASURES	18
Productivity Measures	18
Intermediate Product Productivity	20
Case Productivity	23
Enrollment Productivity	26
Relationship Among Productivity Measures	29
Matrix Relationships	33
3. LITERATURE REVIEW	37
Physician Induced Variation	38
Variation in Admission and Surgical Rates	38
Variation in Intermediate Product Use	46
Relationship of Variation in Admission/ Surgical Rates to Ancillary Services	51
Limitations of Past Studies	54
Summary	58
Patient Classification Systems	59
Diagnosis-Related Groups (DRG)	59
Patient Management Categories (PMC)	61
Patient Severity of Illness Index (PSI)	63
Disease Staging	64
Acute Physiology and Chronic Health Evaluation (APACHE II)	65
Medical Illness Severity Grouping System (Medisgps)	66
Cost/quality Relationship	67
Definition of Quality	68
Quality Assessment with Process And Outcome	69
Relationship Between Volume and Quality	70
Statistical Techniques	74

4. METHODOLOGY	77
Overview of Methodology	77
Formation of Practice Patterns	78
Identification of Pattern Characteristics	80
Association of Specific Physicians with Patterns	82
Issues	82
Selection of Diagnosis-Related Groups	82
Selection of Severity Measure	86
Statistical Method of Forming Patterns	93
Data	98
5. APPLICATION/RESULTS	100
Formation of Practice Patterns	100
Determination of Intermediate Products	101
Formation of Practice Patterns	105
Financial Significance of Clusters	108
Validity of the Cluster Solution	111
Development of Predictive Model	120
Association with Individual Physicians	126
Explanation of Detailed Statistics	128
Application of Detailed Statistics	130
Summary	132
6. IMPLEMENTATION AND FUTURE WORK	136
Implementation Issues	136
Magnitude of Potential Cost Reduction	136
Institution Specific Issues	140
Medical Staff Environment	142
Future Work	144
Wider Application	145
Improvements in Methodology	146
Investigation of Reimbursement Effect of Clinical and Facility Productivity	150
Conclusions	152
APPENDICES	154
BIBLIOGRAPHY	322

LIST OF FIGURES

Figure

1.1	COST REDUCTION POTENTIAL	14
2.1	RELATIONSHIP AMONG PRODUCTIVITY MEASURES . . .	30
2.2	ORIGIN OF INPUT COSTS	32
2.3	MATRIX RELATIONSHIPS OF IPP TO CP	34
3.1	PHYSICIAN EFFECT ON FP AND CP	53
3.2	INDEPENDENT DETERMINATION OF PRACTICE PATTERNS	57
3.3	SIMULTANEOUS DETERMINATION OF PRACTICE PATTERNS	57
3.4	RELATIONSHIP BETWEEN VOLUME AND QUALITY	72
4.1	DIAGNOSIS-RELATED GROUP DESCRIPTIONS	85
4.2	CLASSIFICATION OF CASE-MIX STRATEGIES	89
4.3	AGGREGATE COST CENTERS	94
5.1	SELECTION OF INTERMEDIATE PRODUCTS	104
5.2	FRACTION OF VARIANCE EXPLAINED BY CLUSTERS . .	110
5.3	SUMMARY OF BIVARIATE TABLES	115
5.4	SUMMARY OF CLUSTER EXTERNAL VALIDATION	117
5.5	SUMMARY OF FINANCIAL SIGNIFICANCE - COMBINED .	119
5.6	SUMMARY OF EFFECTIVENESS OF MNA MODEL	124
5.7	DETAILED PHYSICIAN MNA STATISTICS	128
5.8	ASSOCIATION OF SINGLE PHYSICIANS WITH PATTERNS	131
6.1	RANGE OF POTENTIAL COST REDUCTIONS	138
6.2	REIMBURSEMENT IMPLICATIONS OF PATTERNS	151

LIST OF APPENDICES

Appendix

1. STAGING RESULTS	155
2. DESCRIPTION OF DATA ELEMENTS	179
3. SELECTION OF RESOURCES	183
4. MEAN VALUES FOR 1983/1984	191
5. GRAPH OF PRACTICE PATTERNS 1983/1984	199
6. FINANCIAL SIGNIFICANCE OF CLUSTERS	207
7. MEAN VALUES FOR COMBINED PATTERNS	215
8. GRAPH OF COMBINED PRACTICE PATTERNS	223
9. COMPARISON OF CLUSTERS	231
10. EXTERNAL VALIDATION OF CLUSTERS	253
11. FINANCIAL SIGNIFICANCE OF COMBINED CLUSTERS . .	261
12. MNA OVERALL STATISTICS	269
13. CLUSTER PREDICTIONS VS ACUTAL MEMBERSHIP . . .	277
14. PREDICTIVE EFFECT OF INDIVIDUAL VARIABLES . . .	285
15. PHYSICIAN PERCENTAGES AND COEFFICIENTS	293
16. ASSOCIATION OF MD WITH PATTERNS	314

CHAPTER 1

THE PROBLEM AND THE APPROACH

Under cost-based reimbursement, the traditional form of payment in the U.S. until 1984, hospitals were paid a fee based upon expenses incurred during a patient's hospital stay. There was little incentive for hospitals to operate efficiently since all allowable costs were fully reimbursed. In fact, inefficiency was rewarded, because the larger a hospital's costs, the larger its payment. This lack of efficiency incentives was viewed as one of the major reasons for rising hospital expenditures. During 1982, costs in the hospital sector increased three times faster than the overall rate of inflation (Hospital Prospective Payment, 1983). Perhaps a more focused effect was that Medicare expenditures for hospital care increased 19 percent per year from 1979 to 1982. The inability to control these rapid increases in costs caused serious concern within the Federal government regarding its long term ability to continue to support the Medicare program.

In response, Congress passed the Tax Equity and Fiscal Responsibility Act of 1982 (TEFRA, PL 97-248) which, in addition to addressing other tax reform issues, directed the

Secretary of Health and Human Services (HHS) to develop a legislative proposal for reforming the Medicare hospital reimbursement system. In recognition that a major reason for the rising cost of hospital care was the lack of efficiency incentives within a cost-based reimbursement scheme, the objective was to develop a reimbursement formula which both financially rewarded efficient behavior and which provided financial disincentives for inefficient behavior.

In response to TEFRA, the Social Security Amendments of 1983, PL 98-21, implemented a case-based Prospective Payment System (PPS), with cases defined by a patient's membership in a Diagnosis Related Group (DRG) (Thompson, 1975). DRGs represent a patient classification scheme that forms patient groups which are relatively homogenous with respect to resource use. For each of the 470 DRGs, a rate is set by HHS that reflects the total payment the hospital will receive for providing inpatient services. By 1985 in Michigan, DRG-based PPS had expanded beyond Medicare recipients to include Medicaid and some Blue Cross patients.

Although the proportion of private pay patients continued to decline relative to those patients whose hospital stay was insured by third party intermediaries, the cost-based reimbursement mechanism had remained relatively stable for the twenty years preceding 1984. Since TEFRA, however, the reimbursement environment has been characterized by rapid change. While hospitals are in the process of adjusting to the present DRG-based system, other

methods of defining and refining case groups have been proposed (Brewster 1984, Horn 1983, Gonnella 1984, Young 1983). In addition, a shift to capitation-based payment systems has gained in momentum with a steady growth in Health Maintenance Organization (HMO) membership. Presently, the federal government is experimenting with an HMO voucher system for its Medicare insured population in several states (Friedman 1983, Luft 1984, U.S. Accounting Office 1985). The reimbursement environment will continue to be dynamic as the shift to both case and capitation-based systems accelerates. Hospitals that learn to prosper financially in the next few years should have less difficulty in adjusting to future changes.

Hospital management can select from a number of possible strategies to protect financial viability. Assuming that "profitable" case types (or DRGs under the Medicare system) can be identified, one scenario might involve actions to encourage a more profitable mix of DRGs. Realignment of medical staff and more focused marketing efforts are examples of institutional responses which may be effective in changing DRG case-mix, but such responses represent long term solutions for an immediate problem. A second possible response is for the institution to assure that it is maximizing its allowable revenues by tightening-up 1) physician-related documentation and attestation procedures; and 2) Medical Record Department record handling and coding procedures. While such activities, which can be

viewed as encouraging "DRG Creep" (Simborg, 1981), are desirable and appropriate as long as they are performed legally, the financial rewards will likely plateau quickly. A third strategy, which is the focus of the research reported here, is based on the contention that financial viability rests on an institution's ability to minimize costs.

Opportunities for Containing Costs

Under a prospective case-based payment system, the revenue available to hospitals for each treated case is essentially fixed at a pre-determined level. Hospitals will make a profit for a particular case if their costs fall below the prospective payment level and will absorb a loss when costs exceed it. Financial viability of the institution depends on its ability to produce its overall case load at total costs which are less than total payments. While the hospital may lose on some individual cases and gain on others, on average it must be profitable to remain financially sound.

Opportunities to contain costs can be grouped into two broad categories. The first involves the control of overhead expenditures that are not directly related to the hospital's production process. In particular, these opportunities relate to the level of administrative staffing, the cost of maintaining and operating the general plant and equipment, the deferment of new services and

technologies, and the control of planning and other strategic activities. While these efforts represent opportunities to reduce cash expenditures and therefore to reduce the total cost of hospital operations, they do not directly address the efficiency of the hospital's production process.

The second broad opportunity to contain costs lies in affecting the basic hospital production process. Since the majority of hospital costs are incurred in directly supporting patient treatment, increasing the efficiency of the treatment process itself provides considerable potential to contain costs. These opportunities relate to increasing the efficiency with which hospital services are produced and combined in the treatment process.

Two basic approaches that reflect the extremes of possible actions in order to achieve productivity improvement can be characterized as "implicit" and "explicit". The implicit approach is not concerned with impacting the production process directly, but instead relies on indirect actions, such as altering incentives, in order to encourage efficient behavior. It assumes that physicians, for example, know what is appropriate in terms of resource use and will behave accordingly when given the proper incentives. The introduction of case-based Medicare reimbursement is an example of this approach and its effectiveness is substantiated by the remarkable reduction in length of stay nationally since its adoption (Freko,

1985).

The explicit approach, on the other extreme, relies on direct intervention in the production process by focusing on specific areas in the process where it is believed that productivity or efficiency can be improved. Such an approach requires an understanding of the treatment process in enough detail to be able to define the hospital's products and further, to affect the relationship between the cost of the inputs and the quality of the outputs. The requirement to be explicit in articulating the nature of the hospital product and the cost/quality relationships within the hospital's production processes makes this approach difficult to implement.

While not ignoring the efficacy of the implicit approach in improving the productivity of the treatment process, the research reported herein employed the explicit approach of direct intervention in the treatment process thru identification of potentially less productive patterns of resource use among the hospital's provider staff. The research was conducted in a large Midwestern tertiary care facility with the direct support of the medical staff leadership. In the remainder of this chapter, the nature of the hospital's products is discussed, an approach to cost minimization is provided, and a research agenda is established.

Nature of the Hospital's Product

While a hospital is a multi-product firm involved in producing inpatient care, outpatient care, research, education, and various community services, the present focus of concern, due to reimbursement changes, is on inpatient care. In the traditional role as the "physician's workshop", the hospital product was defined in terms of the various hospital services or "intermediate products" produced by its departments (i.e. radiology, laboratory, nursing, dietary, etc.). There was a clear distinction between the hospital's responsibility to produce its various intermediate products and the physician's responsibility to combine the intermediate products in order to produce an episode of patient care. This rather sharp distinction was reflected 1) in the governance of the hospital, which had separate administrative and professional organizational structures; 2) in various reimbursement systems, which had separate methods of payment for the hospital and physicians; and 3) in the legal system, which had a clear delineation between corporate and professional liability. The sharpness of the distinction between the hospital and its medical staff began to erode in 1965 when the Darling case recognized that the administrative and medical staff shared jointly the responsibility for standards of patient care (Southwick, 1982). This legal decision should not be

interpreted as imposing lay control over the clinical practice of medicine --only that the "hospital" was to be considered legally one organization.

The introduction of the case-based PPS financially enforced this single organizational view of the hospital. With the output product of the hospital defined as a completed episode of inpatient treatment, the financial viability of the institution depends on the joint ability of the administration to be efficient in producing its intermediate products and the medical staff to be efficient in combining intermediate products in producing a completed case. With the definition of the hospital's product as a completed case, the hospital has a vested interest in affecting the physician's use of intermediate products as a means of reducing its operating costs.

Cost Minimization Approach

The total cost of a completed case is a function of the cost and quantity of hospital services (intermediate products) consumed in its production. This can be expressed in matrix notation as:

$$\begin{bmatrix} \$/\text{DRG}_1 & \dots & \$/\text{DRG}_j \end{bmatrix} = \begin{bmatrix} \text{IPCost}_1 & \dots & \text{IPCost}_n \end{bmatrix} \begin{bmatrix} \text{QIP}_{11} & \dots & \text{QIP}_{1j} \\ \vdots & \ddots & \vdots \\ \text{QIP}_{n1} & \dots & \text{QIP}_{nj} \end{bmatrix} \quad (\text{Eq. 1.1})$$

Where $\$/\text{DRG}_j$ = The unit cost of $\text{DRG}(j)$

$IPCost_i$ = The unit cost of Intermediate
product(i)

QIP_{ij} = The quantity of Intermediate
product(i) consumed in DRG(j)

i = Intermediate Product Index

j = DRG Index

n = Total Number of
Intermediate Products

The cost of a DRG can be minimized by reducing the production cost of each intermediate product ($IPCost_i$ - in Equation 1.1). Reducing the cost of each intermediate product should be a constant focus of effort within individual hospital departments, and these efforts can result in a significant reduction in DRG costs across all DRGs. However, since the intermediate product costs are constant for all DRGs within a single institution, they are not helpful in identifying which DRGs should be the focus for cost reduction efforts. This idea can be further articulated by examining the matrix notation of DRG cost in Equation 1.1, where the $IPCost$ row vector is identical for all DRG_j . The QIP column vector, however, is specific for each DRG_j . Therefore, within a single institution, the differentiating characteristic among DRG costs is not the cost per intermediate product, but is the quantity and types of intermediate products selected to produce a patient treatment classified in a DRG.¹

¹Reduction of institution costs by changing the volume of intermediate products depends on the capability of the hospital departments to be responsive in reducing the

Under a fixed fee case-based PPS, cost reduction depends on shifting the mean of the cost distribution of treated cases since a shift demonstrates that the average cost per case has been reduced. A shift in the mean of the cost distribution can result from a change in the volume and/or type of intermediate products consumed within some or all of the individual patient cases. Following traditional control theory, the initiative for change is brought about by identifying a variance (difference) in actual performance from an expectation of performance. Two basic approaches to determining the expectation of performance exist --with these approaches reflecting the difference between measuring "efficiency" or "productivity".

An "efficiency" approach determines whether the correct volume and/or type of intermediate products were consumed in each patient's treatment.² Thus, explicit standards and criteria of acceptable performance must exist. An efficiency evaluation results in a judgement of the "goodness" of the actual intermediate product use by comparing the variability in actual performance to predetermined standards. Unfortunately, the standards and criteria required to evaluate the clinically efficient use of intermediate products do not yet exist. Consequently,

primary labor and capital inputs when faced with a decline in intermediate product demand. This concept is further elaborated in Chapter 2.

²Donabedian (1983) and Wyszewski (1983) first used the term "clinical efficiency" which is identical to the way the concept is used here.

clinical efficiency cannot be measured presently.

A productivity approach focuses on variability in quantity and/or type of intermediate product use among individual patient cases. This approach compares the relative clinical productivity of treated cases, with the expectation that less clinically productive cases can be changed to more closely resemble more highly productive cases. Without standards of clinical performance, however, it cannot be assumed that higher clinical productivity is necessarily preferable, since the increased intermediate product use could have been the result of the medical need of the patient. Therefore, if productivity comparisons are to be used in a cost reduction strategy, then it is necessary to determine the reason for the variation in intermediate product use before encouraging changes in the quantities of intermediate products consumed.

Three major sources of variation within the treatment process affect intermediate product use --institutional differences, physician differences, and patient differences. Institutional differences include factors such as size, teaching affiliation, organization of the administration and medical staffs, multi-institutional relationships, sophistication of information system support, and profit/nonprofit status. Given a single institution clinical productivity focus, this source of variation was not considered in the analysis reported here. The two remaining sources of variation --the patient and the physician --were

considered.

A completed case might be thought of as an individually defined product, with the medical need of the patient determining the quantity and type of intermediate products consumed in the treatment process. Therefore, the need for a specific input resource and the intensity with which the resource is applied might be thought to be determined by factors beyond the immediate control of the physician. Simply put, the expectation would be that the amount of care provided to a patient is proportional to the quantity of illness present in the patient. Studies related to the volume of various intermediate products which are utilized in treating similar patients, however, indicate that the use of intermediate products seems to correlate more strongly with differences among physicians than with differences among patients (Daniels, 1977; Freeborn, 1972; Linn, 1984; Lyle, 1976; Schroeder; 1973,1974).

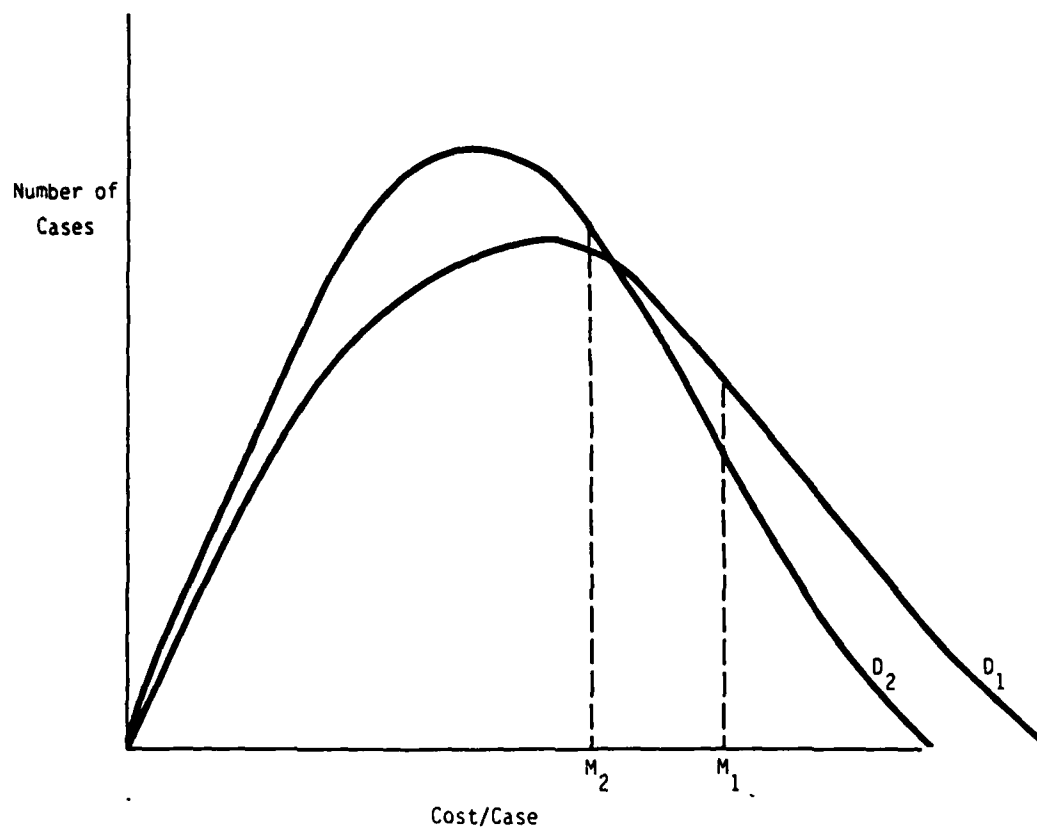
While it is appropriate in both a productive and quality sense for the volume of intermediate products to be correlated with the medical need of the patient, it may not be appropriate for the volume of intermediate products to be highly correlated with a physician's style of practice. Therefore, in order to achieve improvements in clinical productivity, variations in the quantity or mix of intermediate products consumed in the production of an episode of care must be better understood. In particular, the variation in intermediate product use that is deemed

appropriate and hence beyond the control of the physician (e.g. that due to the patient's medical need) must be differentiated from variation that may be more inappropriate and, conceptually at least, more controllable (e.g. that due to physician style differences).

While physician and patient differences affect variation in the quantity and/or types of inputs, an additional source of variation -- quality of the outputs -- should also be considered. Differences in the medical care process (intermediate product use) may result in differences in the health outcome from the care process. However, in order to provide a valid comparison of productivity measures among the treated cases, the definition of the outputs must remain constant. Therefore, while not a source of variation in the inputs (medical process), variation in outcome must be monitored to detect changes in the output definition.

If, when comparing clinical productivities, 1) the source of variation in intermediate product use can be attributed largely to physician practice style differences, and 2) physicians with a higher cost pattern of intermediate product use can be influenced to use a lower cost cost pattern, then the mean of the overall cost distribution can be shifted downward. Under such circumstances, the shift in the mean would result from a change in the shape of the distribution caused by a reduction in the distribution's variance. The direction of the shift is based on the assumption that the higher cost patterns would be reduced

FIGURE 1.1
Cost Reduction Potential



successfully. In Figure 1.1, the distribution of costs (D_1) has been changed to a different distribution (D_2) by transforming higher cost cases to lower cost cases. This results in a downward shift in the mean of the distribution from M_1 to M_2 .

In Figure 1.1, it has been assumed that a comparison of clinical productivities would result in a reduction in variation by reducing the volume or by utilizing a lower cost combination of input resources. In fact, this may not be the case and the comparison of clinical productivities may indicate that a higher intensity or more costly combination of inputs would be more clinically appropriate. While a higher cost combination of inputs may result in some instances (thereby increasing the mean of the overall cost distribution), the existence of wide physician induced variation supports the contention that a reduction in the variation will reduce, rather than increase, the quantity of input services.

Research Agenda

Given the material presented, it is believed that cost reduction is possible in a case-based PPS environment through altering the volume and/or changing the mix of input intermediate products. Lacking standards and criteria required to evaluate Clinical Efficiency, however, excessive use of input resources must be identified by investigating variation in the use of intermediate products (Clinical

Productivity). Rather than investigating gross variation in intermediate product use, the variation must be differentiated into its two major sources relating to the patient and the physician. Variation in the volume and type of input resource use resulting from physician differences is probably inappropriate and, although outcome of care must be monitored, it is believed that intermediate product use can be reduced without affecting quality. A reduction in intermediate product use by altering high cost physician practice patterns will result in a reduction in the mean of the overall cost distribution. However, before a cost reduction strategy based on improvements in clinical productivities can be implemented, the feasibility of such a Clinical Productivity approach must be demonstrated. This demonstration is the topic of the research reported herein.

Three major steps were followed in the research:

a. In order to investigate variation in the use of intermediate products by comparing clinical productivities, methods of comparison must first be established. Patients within a DRG need to be further classified into different groups based on the homogeneous use of intermediate products. These different groups, or practice patterns, should reflect differences in the volume and/or type of intermediate products consumed in the treatment process. The identification of different practice patterns provides the means for comparing relative clinical productivities.

b. Variation in clinical productivities among

different practice patterns have to be differentiated with respect to patient, physician, and outcome differences. If the differences in clinical productivities among the practice patterns can be attributed largely to differences in physician practice styles, then potentially inappropriate intermediate product use can be identified.

c. In order to identify specific physicians whose use of intermediate products may be inappropriate, individual physicians have to be associated with the different practice patterns.

The successful completion of these three steps within several types of DRGs demonstrates the feasibility of implementing a cost reduction strategy based on improving the clinical productivity of intermediate product use. In the following chapters 1) the relationships among different productivity measures are developed; 2) the literature pertinent to completing the research agenda is reviewed; 3) the research methodology is presented; 4) the application and results of the current research effort is discussed; and finally 5) thoughts relating to implementation of the cost reduction strategy and to future research opportunities are provided.

CHAPTER 2

CONCEPTUAL AND ANALYTICAL DEVELOPMENT OF PRODUCTIVITY MEASURES

As established in Chapter 1, the research reported here focuses on demonstrating the feasibility of implementing a cost reduction strategy based on identifying inappropriate intermediate product use through comparison of clinical productivity measures. In this chapter, 1) the productivity measures are developed further, both conceptually and analytically; 2) the cost reduction implications resulting from the relationships among the productivity measures are discussed; and 3) a matrix representation of the organizational cooperation and communication required to achieve cost reduction using this clinical productivity strategy is presented.

Productivity Measures

Productivity is defined as the ratio of output produced to a given level of input resources consumed in the production process.

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}} \quad (\text{Eq. 2.1})$$

Productivity is expressed as units of output for a given level of input resources. Its inverse, 1/productivity, provides an expression of input resources per unit of output.

For example:

$$\begin{aligned} \text{Productivity} &= \text{units of output/hour} \\ \text{Productivity} &= \text{units of output/dollar} \end{aligned}$$

or if the inverse is used

$$\begin{aligned} 1/\text{Productivity} &= \text{hours/unit of output} \\ 1/\text{Productivity} &= \text{dollars/unit of output} \end{aligned}$$

While it is common for productivity to be expressed as cost/unit, to be mathematically precise, cost/unit is actually the inverse of productivity.

In Chapter 1, the matrix equation for cost per DRG was presented.

$$\begin{bmatrix} \$/\text{DRG}_1 & \dots & \$/\text{DRG}_j \end{bmatrix} = \begin{bmatrix} \text{IPCost}_1 & \dots & \text{IPCost}_n \end{bmatrix} \begin{bmatrix} \text{QIP}_{11} & \dots & \text{QIP}_{1j} \\ \vdots & \ddots & \vdots \\ \text{QIP}_{n1} & \dots & \text{QIP}_{nj} \end{bmatrix} \quad (\text{Eq. 1.1})$$

The cost per DRG case can be represented as the inverse of case productivity.

$$\frac{1}{\text{CaseP}_j} = \$/\text{DRG}_j \quad (\text{Eq. 2.2})$$

where CaseP_j = Productivity of Producing DRG(j)

$\$/\text{DRG}_j$ = Cost of Producing DRG(j)

Since the current research effort focuses on establishing the feasibility of effecting a reduction in cost, the productivity measures are represented as an inverse to

provide mathematical validity for the cost equations.

Intermediate Product Productivity

Labor and capital can be thought of as Primary Resource (PR) inputs in producing intermediate products, and their unit cost is the price negotiated through external markets. Therefore, both the hourly cost of labor and the unit cost of input supplies depends on regional supply and demand factors. The price of each primary resource (P_r) is the negotiated unit cost.

$$P_r = \text{Unit Cost of } PR_r \quad (\text{Eq. 2.3})$$

where P_r is the unit cost of each primary resource(PR_r).

The quantity of primary resource inputs to produce intermediate product(i) can be referred to a Primary Resource Productivity (PRP) and expressed as a productivity ratio. In the current research, $1/PRP_{ri}$ is expressed as the productivity per unit of output, therefore, IP_i always equals one.

$$\frac{1}{PRP_{ri}} = \frac{QPR_{ri}}{IP_i} = QPR_{ri} \quad (\text{Eq. 2.4})$$

where PRP_{ri} = Primary Resource Productivity
for primary resource(r) for
intermediate product(i)

IP_i = Intermediate product(i)

QPR_{ri} = Quantity of primary resource(r)
consumed in producing each
intermediate product(i)

Intermediate Product Productivity (IPP) for each

intermediate product(i) is a function of the unit cost of its labor and capital inputs and the quantity of the labor and capital inputs consumed in its production. The cost per intermediate product($IPCost_i$) is the inverse of Intermediate Product Productivity (IPP) for product (i) and can be expressed as follows when $IP_i = 1$.

$$\frac{1}{IPP_i} = IPCost_i = [P_1, P_2 \dots P_m] \begin{bmatrix} QPR_{1i} \\ QPR_{2i} \\ \vdots \\ QPR_{mi} \end{bmatrix} \quad (Eq. 2.5)$$

The cost of intermediate product(i) is the result of a matrix multiplication of a row vector (1 x M) whose elements are the unit cost of the input resources(m) and a column vector (M x 1) whose elements are the quantities of resource inputs consumed in producing each intermediate product.

If the column vector represents the quantity of input primary resources consumed in producing the complete set of intermediate products ($i=1$ to n), then the result is a row vector (1 x N) with the elements representing the individual $1/IPP_i$ for all intermediate products(i). For example:

$$[IPCost_1 \dots IPCost_n] = [P_1 \dots P_m] \begin{bmatrix} QPRP_{11} & \dots & QPRP_{1n} \\ \vdots & & \vdots \\ QPRP_{m1} & \dots & QPRP_{mn} \end{bmatrix} \quad (Eq. 2.6)$$

The $IPCost_i$ row vector contains the unit/costs of producing each IP_i .

Insight into the potential for cost reduction can be gained from Equation 2.6. A decrease in the price of each primary resource (P_r) through lower negotiated prices for the primary resource inputs would decrease $IPCost_i$. The cost per intermediate product ($IPCost_i$) could also be affected by altering the quantities of primary resource inputs in two different ways. First, the elements in the QPRP matrix can be changed by reducing the quantities of the primary resources consumed in producing each intermediate product. Simply, reducing the quantities across the matrix will reduce $IPCost_i$. Second, a new matrix (CostPR) could be formed by introducing the primary resource costs (P_r). Therefore, in Equation 2.7, the elements of the new matrix are product of P_r and QPR_{ri} which represent the cost of the total volume of each primary resource consumed in producing each intermediate product.

$$CostPR = \begin{bmatrix} CostPR_{11} & . & . & CostPR_{1n} \\ . & . & . & . \\ . & . & . & . \\ CostPR_{m1} & . & . & CostPR_{mn} \end{bmatrix} \quad (Eq. 2.7)$$

In this case, each column of the matrix can be optimized by selecting the least costly combination of primary resource inputs to produce each intermediate product. Rather than an across the board reduction in quantities of primary resources, this view of the matrix substitutes lower cost combinations of inputs for the higher cost combinations. Therefore, changing the mix of primary resource inputs will

also reduce $IPCost_i$.

Case Productivity

The introduction of the case-based PPS emphasized a different output product for an institution. With the output product defined in a different manner, a new productivity measure can be established to relate a completed case to its input resources. Similar to Intermediate Product Productivity (IPP), Case Productivity (CaseP) depends on the cost of its intermediate product ($IPCost_i$) inputs and the quantity of intermediate product inputs (QIP_i) consumed in producing a completed case. The latter is referred to as Clinical Productivity (CP - see Chapter 1, pg. 11).

High clinical Productivity (CP) of producing a case depends on minimizing the volume of input intermediate products and thus, is a parallel measure to PRP (Eq. 2.4). Again, it is expressed as productivity per DRG_j where the quantity of DRG_j always equals one.

$$\frac{1}{CP_{ij}} = \frac{QIP_{ij}}{DRG_j} = QIP_{ij} \quad (\text{Eq. 2.8})$$

The clinical productivity of the j th DRG for the i th intermediate product is a function of the quantity of intermediate products (QIP_i) consumed in producing DRG_j . Since there is not a common metric, dollars for example, to allow combining the individual CPs, clinical productivity is only defined for a specific intermediate product for a

specific DRG. When $DRG_j = 1$, the clinical productivity matrix is simplified to the quantity of intermediate products consumed in producing each DRG.

$$\begin{bmatrix} 1 \\ CP_{ij} \end{bmatrix} = \begin{bmatrix} QIP_{11} & \dots & QIP_{1,470} \\ \vdots & \ddots & \vdots \\ QIP_{n1} & \dots & QIP_{n,470} \end{bmatrix} \quad (\text{Eq. 2.9})$$

The individual QIP_{ij} in the matrix can be defined depending on the level of patient aggregation that is required in the measure. For example, if the QIP_{ij} for a single patient is required, then the elements represent the quantity of intermediate product(i) for a single patient classified into DRG_j . However, if the QIP_{ij} for all patients treated in a specific DRG is required, then QIP_{ij} represents the total quantity of intermediate product(i) consumed in treating all patients classified into DRG_j . The same logic is applied if QIP_{ij} is required for patients of a specific severity level or patients treated by a specific specialty or physician.

The relationship between IPP and CP has important implications for the total cost of producing a completed case. The cost of a case or $1/\text{CaseP}$ can be expressed as:

$$\frac{1}{\text{CaseP}_j} = \$/\text{DRG}_j = \begin{bmatrix} \text{IPCost}_1 & \dots & \text{IPCost}_n \end{bmatrix} \begin{bmatrix} QIP_{1j} \\ \vdots \\ QIP_{nj} \end{bmatrix} \quad (\text{Eq. 2.10})$$

Where the cost of DRG_j is a function of the unit cost of intermediate product(IPCost_i) and the volume and types of

intermediate products selected (QIP_{ij}). The inverse of $\$/\text{DRG}_j$ provides case productivity (CaseP_j).

Of course, as presented previously in Eq. 1.1, the cost per case for all DRGs can be expressed in matrix notation.

$$\begin{bmatrix} \$/\text{DRG}_1 & \dots & \$/\text{DRG}_{470} \end{bmatrix} = \begin{bmatrix} \text{IPCost}_1 & \dots & \text{IPCost}_n \end{bmatrix} \begin{bmatrix} QIP_{11} & \dots & QIP_{1,470} \\ \vdots & \ddots & \vdots \\ QIP_{n1} & \dots & QIP_{n,470} \end{bmatrix} \quad \text{Eq. 2.11}$$

The matrix result produces row vector (1 x 470) with the elements representing the individual cost per case for all DRGs.

Cost minimization opportunities for a completed case are logically identical to those associated with intermediate products. Cost per case ($\$/\text{DRG}_j$) is a function of the intermediate product unit cost (IPCost_i), and the volume and types of intermediate products selected (QIP_{ij}). While reductions in the cost per intermediate product (IPCost_i) and quantity of intermediate products (QIP_{ij}) can be investigated independently of each other, the determination of the least cost combination of intermediate products depends on the determination of total intermediate product cost and therefore on the relationship between the cost (IPCost_i) and quantity (QIP_{ij}) of the intermediate products used. Therefore, in Equation 2.12 elements of a new matrix (CostIP) are the product of IPCost_i and QIP_{ij}

which result in the cost of the total volume of each intermediate product consumed in producing each DRG_j .

$$CostIP = \begin{bmatrix} CostIP_{11} & \dots & CostIP_{1,470} \\ \vdots & \ddots & \vdots \\ CostIP_{n1} & \dots & CostIP_{n,470} \end{bmatrix} \quad (Eq. 2.12)$$

Similar to selecting the least cost combination of primary resources to produce each intermediate product (Eq. 2.7), each column of the CostIP matrix can be optimized by selecting the least costly combination of intermediate products to produce each DRG_j .

Enrollment Productivity

A third set of productivity measures can be identified if the product of the hospital is defined in terms of a capitated reimbursement system. In this case, the concern is not only limited to the productivity of producing an intermediate product or of a treated case, but also includes an interest in the productivity of the institution in the utilization of costly inpatient services when providing medical care to a defined population. Facility Productivity(FP) can be expressed as:

$$\frac{1}{FP_j} = \frac{QDRG_j}{Population} \quad (Eq. 2.13)$$

Where $1/FP$ for DRG_j is the ratio of the quantity of DRGs produced to the population.

The matrix notation is straightforward.

$$\begin{bmatrix} 1 \\ \text{FP}_1 \\ \vdots \\ 1 \\ \text{FP}_{470} \end{bmatrix} = \begin{bmatrix} \frac{\text{QDRG}_1}{\text{Pop}} \\ \vdots \\ \frac{\text{QDRG}_{470}}{\text{Pop}} \end{bmatrix} = \begin{bmatrix} \text{QDRG}_1 \\ \vdots \\ \text{QDRG}_{470} \end{bmatrix} * \frac{1}{\text{Pop}} \quad (\text{Eq. 2.14})$$

The three measures of productivity (IPP, CP, FP) are interrelated depending on the product focus. The measures can be investigated independently in order to improve the productivity of producing an intermediate product, a completed case, or inpatient care for a population. However, since they represent a series of input/output relationships, the total effect is cumulative. If one wished to measure the cost of inpatient care within a capitation system, the three measures would have to be expressed together as the inverse of Enrollment Productivity (1/EP).

$$\frac{1}{\text{EP}_j} = [\text{IPCost}_1 \dots \text{IPCost}_n] \begin{bmatrix} \text{QIP}_{1j} \\ \vdots \\ \text{QIP}_{nj} \end{bmatrix} * \text{QDRG}_j \quad (\text{Eq. 2.15})$$

Therefore, $1/\text{EP}_j$ represents the cost of producing a volume of specific inpatient treatments (DRGs) for a defined population.

The cost for all DRGs can be expressed.

$$\begin{bmatrix} \frac{1}{EP_1} & \dots & \frac{1}{EP_{470}} \end{bmatrix} =$$

$$\begin{bmatrix} IPCost_1 \dots IPCost_n \end{bmatrix} \begin{bmatrix} QIP_{11} \dots QIP_{1,470} \\ \vdots \\ QIP_{n1} \dots QIP_{n,470} \end{bmatrix} \begin{bmatrix} QDRG_1 \\ \vdots \\ QDRG_{470} \end{bmatrix} \quad (Eq. 2.16)$$

Total inpatient costs for a population can be affected in three ways similar to cost per intermediate product ($IPCost_i$) and cost per case ($\$/DRG_j$) by 1) reducing the cost of producing an inpatient DRG_j (CaseP); 2) reducing the quantity of DRGs produced (FP); or 3) providing a more optimal mix of inpatient treatments by substituting lower cost outpatient care. A reduction in the volume of DRGs could be encouraged by examining the individual FP_j s for all DRG_j . In other words, there would need to be an evaluation of whether the rates at which various DRGs are produced for the population are too high. The determination of how to provide a more optimal mix of inpatient treatments would involve the development of parallel sets of productivity relationships for a variety of outpatient services which could be substituted for inpatient care. While the development of parallel productivity relationships is not provided, the determination of a least cost combination among these services would be similar to those discussed for cost per intermediate product and cost per case.

Relationship Among Productivity Measures

The symmetrical relationship among these measures (intermediate products, completed cases, and total inpatient care for a population) in affecting the cost per unit of output should be emphasized. All are cost times quantity relationships and can be affected by reducing the costs (P_r , $1/IPP$, $1/CaseP$) or the quantities of inputs ($1/PRP$, $1/CP$, $1/FP$). Quantities can be affected by an across-the-board reduction or by substituting least cost combinations of input quantities in producing the output products.

The relationship among these levels of product emphasis is described in Figure 2.1.

The cost of inpatient care to a population ($1/EP$) can be reduced by affecting the quantity of DRGs produced ($1/FP$ - across-the-board or change the mix) or by reducing the cost of its DRG input ($1/CaseP$). Of course, the cost per DRG ($1/CaseP$) is reduced by affecting the quantity or mix of intermediate products inputs ($1/CP$ - across-the-board or change the mix) or reducing the cost of its input intermediate products ($1/IPP$). The cost of an intermediate product ($1/IPP$) is reduced by affecting the quantity of primary resource inputs ($1/PRP$ - across-the-board or change the mix) or by reducing the cost of its primary resource inputs (P). In order to determine the cost reduction potential within a productivity framework utilizing the explicit approach, the complete set of interrelationships must be understood.

FIGURE 2.1
Relationship Among Productivity Measures

	P	PRP	CP	FP
IPP	P	PRP		
CaseP	IPP		CP	
EP	CaseP			FP

The focus of the research reported here is to determine the feasibility of reducing the cost of producing completed cases by affecting the quantity of intermediate products consumed (clinical productivity). This strategy is portrayed in Figure 2.1 by showing that a reduction in cost per case ($1/\text{CaseP}$) will occur when the quantity of intermediate products is reduced ($1/\text{CP}$) only if the cost per intermediate product ($1/\text{IPP}$) remains unchanged. As noted in chapter 1, a fixed cost for each intermediate product assumes that the quantity of primary resource inputs employed within the hospital departments is variable with respect to the quantity of intermediate products demanded. In Figure 2.2, the quantities of primary resource inputs per intermediate product ($1/\text{PRP}$) must remain constant in the face of a decrease in the quantity of intermediate products ($1/\text{CP}$) demanded to result in a decrease in cost per case ($1/\text{CaseP}$).

For example, if the number of staff within the laboratory is fixed, then a reduction in the total quantity of laboratory services demanded will actually increase the quantity of primary resource inputs ($1/\text{PRP}$) per unit of output since the same labor inputs are spread over a reduced volume of output. Therefore, a reduction in the cost per case achieved by changing the volume of intermediate products consumed in producing the case depends on the capability of the institution to reduce the quantity of its primary resource inputs when faced with a decrease in intermediate

FIGURE 2.2
Origin of Input Costs

	P	PRP	CP	FP
IPP	P	PRP		
CaseP	PP	PRP	CP	
EP	PP	PRP	CP	FP

product demand.

Matrix Relationships

The relationship between intermediate product and clinical productivity, and the coordination that is required within an institution to bring about cost reduction can be expressed in a matrix diagram (Figure 2.3) (Mckee, 79). The columns of the matrix represent different intermediate products and the rows delineate the defined patient case types. In this example, the patients are grouped into cases according to DRGs, although other methods such as CPHA List A groups, ICD-9-CD codes, or other case mix systems (Horn, 1983; Young, 1983; Gonnella, 1984; Brewster, 1984) could also be used.

With total quantities of intermediate product(i) as the entries in each cell, the matrix shown in Figure 2.3 is the $1/CP$ matrix of Equation 2.9. The aggregation of the quantities within each cell depends on the user's view. The quantities in each cell could represent individual patients, groups of patients, or the total for all patients treated within a specific DRG_j .

The summation of each column provides the total intermediate products produced by the institution for each product type while the sum of each row provides the total intermediate products consumed in each DRG_j . Dividing the sum of each column by the total costs of the input primary resources recovers Intermediate Product Productivity(IPP_i).

FIGURE 2.3
Matrix Relationships of IPP to CP

DRGs	IP ₁	IP ₂	IP ₃	IP ₄	IP ₅	IP ₆	IP ₇	IP ₈	IP ₉	IP _n	Tot Qty/	
1	1100	230	140	69	250	130	0	35	450	300	2340	
2												
3												
4												
469												
470												
Total	Qty/IP											

CP

← IPP →

Of course, the sum of the columns must equal the sum of the rows since the total intermediate products produced must equal the total intermediate products consumed in treating completed cases.

If the quantities of intermediate products in each cell are multiplied by the cost of each intermediate product ($IPCost_i$), the total costs of the institution are provided. Of course, the total costs of producing the intermediate products must equal the total costs of producing the treated cases. Therefore, the sums of the row and column costs must equal the operating costs of the institution.

One method of reducing total institutional costs is to reduce the $IPCost_i$ multiplier. If the cost of producing the intermediate products is reduced, then the total costs of the institution will be lowered. Therefore, the individual hospital departments which produce the intermediate products (columns) can independently investigate reducing the cost of each intermediate product. As discussed in relation to Figure 2.1, such reductions are accomplished by negotiating a lower price and/or by reducing the quantity and/or changing the mix of the primary resource inputs.

A second method of affecting institutional costs is to change the quantities of intermediate products within the cells, either by reducing the volume or changing the mix of intermediate products consumed in producing the completed cases. Therefore, the medical staff, who largely determine the quantity of intermediate products consumed in a

completed case, can independently investigate changing intermediate product use. However, cost reductions resulting from changes in intermediate product use cannot be achieved independently.

The provider staff (rows) are responsible for minimizing the volume and/or selecting the least cost combination of intermediate products to be consumed in a completed case. The hospital departments (columns) are responsible for minimizing the cost of each intermediate product and for being responsive to changes in the volume of intermediate products demanded by the provider staff. Therefore, rather than being independent, the effectiveness of cost reduction efforts through changes in intermediate product use rests on the interdependence among the hospital departments and medical staff. As discussed in Chapter 1, the introduction of a case-based PPS clearly enforces a single organization view of the hospital with the success of cost reduction efforts dependent on the joint effectiveness of both the administration and the medical staff.

CHAPTER 3

LITERATURE REVIEW

The major thrust of the research reported here was to determine the feasibility of a cost reduction approach based on identifying variation in input intermediate products within a single institution. As discussed in Chapter 1, in order to determine the clinical appropriateness of intermediate product use, it is necessary to differentiate the variation in intermediate product use according to its two major sources -- physician and patient. It was also recognized in chapter 1 that, in addition to variation in the medical process (intermediate product use), a third source of variation should be considered --outcome.

While there is an extensive body of literature which addresses organizational, financial, and demographic affects on the use of medical services, the focus of the present review is on the three sources of variation. First, the literature that addresses physician induced variation in the level and type of input resource use is discussed. Second, a review of different patient classification systems is provided. While severity of a patient's medical condition is difficult to measure, a severity measure had to be

selected in the development of the research methodology. The review of the major classification systems provides the background for determination of the selection criteria. Third, a selected review of the literature relating change in the process of care (intermediate product use) to change in health outcome of care is provided. Finally, different statistical techniques that were considered as methods to identify practice patterns are reviewed.

Physician Induced Variation

The literature relating to physician practice patterns falls neatly into two categories that address either 1) variations in admission and surgical rates; or 2) variations in intermediate product use. Variations in admission and surgical rates affect the volume and type of patient cases treated within the hospital, and therefore, relate to inputs into the Facility Productivity (FP) relationship. While this category does not directly address variation in inputs to clinical productivity (CP), the related literature has important implications for understanding how physician practice patterns affect cost. The relationship between the physician effect on FP and CP is developed further following the literature review.

Variation in Admission and Surgical Rates

Differences in surgical rates have been reported among numerous countries. Upon examining case loads of short term

hospital's in England, Sweden and the United States, Pearson (1968) found marked variations in the rates for common surgeries including appendectomy, cholecystectomy, hysterectomy, and prostatectomy. For example, the sex and age adjusted surgical rates were twice as high in New England as in England. In a classic study, Bunker (1970) reported that for common surgical procedures, there were twice as many surgeons per capita in the United States as in England and Wales, and, as a group, they performed twice as many operations. Due to imprecise indicators of surgery, it could not be determined whether surgeons in the United States operated too often or surgeons in Great Britain operated too infrequently. Using improved data that were age and sex adjusted as well as employing common definitions of procedures, a comparison of surgical rates in Canada and in England and Wales demonstrated similar results (Vayda, 1973). Comparison of the rates for common surgical procedures showed that rates in Canada were 1.8 times greater for men and 1.6 times greater for women than in England and Wales. Rather than using average surgical rates, McPherson (1982) examined relative variation in rates for seven common surgical procedures among New England, England, and Norway. Although the average population adjusted surgical rates were higher in New England than in England and Norway, the degree of variation with which the operations were performed generally appeared to be more characteristic of the physician than due to the country in

which it was performed. Therefore, while the surgical rates were different among countries, due to differences in the organizing, financing, and availability of manpower and facilities, the degree of variation in surgical rates among physicians within each country was fairly consistent.

The disparity among countries in rates of surgery suggests that the differences are due to factors other than the incidence and prevalence of disease. Age-specific and sex-specific mortality rates either showed no difference or higher rates for the countries with higher surgical rates. It is suggested that differences in the organization and financing of health services which affect the supply of (manpower, beds) and the demand for care are more important factors than the medical need of patients in determining surgical use rates.

While recognizing the differences in average rates of surgeries among countries, McPherson's study indicates that a pattern of variation in surgical rates is fairly consistent across international borders and is independent of the national method of organizing and financing medical care. Therefore, it can be concluded that while the organizing and financing of health care have significant impact on the average rates of surgery among countries, differences among physicians in either their diagnostic style or belief in the efficacy of the treatment contribute substantially, in an independent fashion, to the observed variation in rates within countries.

When major differences in organizing and financing of health care are eliminated by limiting investigations within national borders, differences in surgical rates persist. In studying appendectomy rates in New York, Lembcke (1952) found that the age and sex adjusted surgical rates among hospital areas ranged from 2.9 to 7.1 per 1,000 population. He found no association between low rates of appendectomies and higher death rates. He inferred that in areas served by hospitals where operations are not controlled strictly, the simple fact of greater accessibility to hospitals and medical care is a deciding factor.

Lewis (1969), in an analysis of the records of the Kansas Blue Cross Association, discovered a three to four fold variation in regional rates for the occurrence of six common surgical procedures. In order to control for access differences, he selected a study population that had the same type of insurance coverage for surgical care and equal geographical availability of health resources. He concluded that the number of physicians, board certification, and availability of hospital beds were the best predictors of surgical care.

In studying surgery in Ontario, there was a variation of five to eight times in the rates with which tonsillectomies, hysterectomies, cholecystectomies, and appendectomies were performed (Stockwell 1979). Over fifty percent of the variation could be explained by the number of

acute beds and physicians. An interesting finding was that in counties with teaching centers, the rates were the lowest even in the face of higher resource availability.

Roos (1977,1978) found significant variation in surgical rates in Manitoba, Canada. She could not correlate the five fold difference in hysterectomy rates (e.g fifteen per thousand compared to three per thousand) with the availability of hospitals or physicians, and there appeared to be no barriers to access in the low rate areas. High rate areas had a larger proportion of the population who were Catholic and/or a larger proportion of physicians who were "hysterectomy prone". She concluded that a combination of patient and physician characteristics could explain the variation in hysterectomy rates better than the medical need of the patient.

Wennberg (1973) investigated the incidence of tonsillectomies and other common surgical procedures in Vermont. He found that the rates with which adenotonsillectomies (TA) were performed in different counties varied between four and forty-one cases per thousand children. The associated risk of TA by age 20 within these counties varied between nine and sixty percent. Over 80% of the total TA procedures in Vermont were performed by less than two dozen physicians, with 50% of the procedures performed by ten physicians. Since TAs are not normally referred (with over 90% performed by local physicians), variation in the rate with which TAs are

performed is the result of the clinical decisions of a small number of physicians. Wennberg suggested that this "localization" of a particular physician's practice is the key to understanding the wide variation in tonsillectomy rates. The similarity of these counties in terms of demographic characteristics, medical insurance coverage, and physician visit rates further support the hypothesis that variation in physician attitudes is the major factor in rate differences.

In a follow-up study, Wennberg (1982) examined the rates with which six common surgical procedures were performed in six New England states. General health level of the population, access to physicians, income, and level of insurance could not explain the wide variation in surgical rates. The number of hospital beds and supply of physicians were disproportionate to the population and did correlate with the overall surgical rate. While the total rate of surgery was dependent on the supply of beds and physicians in the area, wide variations in the individual procedural rates were physician dependent. For example, while the overall surgical rate would be similar between two areas, hysterectomy might be the most common in one and the least common in another. Wennberg labeled this phenomenon a "surgical signature" that may persist within an area over many years unless physicians leave or enter it. Therefore, the most important factor in determining the rate of specific surgical procedures seems to be the physician style

of practice.

When examining geographic variation in general admission rates, compared to surgical admissions alone, findings parallel the results of surgical studies. After adjusting for medical need and demographic characteristics, the cause of variation in rates seems to point to a combination of supply (i.e. manpower, beds) and physician practice pattern differences.

One of the earliest studies dealing with admission rates was conducted by Moorehead in examining the quality of hospital care provided to teamster families in New York City (Moorhead 1961, 1964). She utilized panels of physician experts to judge the quality of the medical care rendered and the necessity of hospitalization through an implicit review of the medical record. Physicians managing the patient cases were divided into three classes: 1) Class I - Board Certified in their specialty; 2) Class II - not Board Certified, but holding staff positions in voluntary or municipal hospitals; and 3) Class III - neither Board Certified nor maintaining an active hospital appointment. Forty-four percent of the patients admitted to proprietary hospitals by Class III physicians were considered inappropriate admissions by the expert panel.

Since the Medicare program began in 1966, striking variations in hospital use across the country have been observed. An examination of the national PSRO areas revealed a two fold difference between the lowest rate of

257 admissions per 1000 enrollees in the Medicare program in Hawaii and the highest admission rate of 468 admissions per 1000 in Texas (Deacon, 1979). The conclusion of the authors after utilizing regression techniques to explain the reasons for the variation was that supply variables, changes in occupancy rates, and differences in physician practice patterns should be the focus of the PSROs in any attempt to reduce utilization rates. Extensive research conducted in Michigan on a state-wide basis showed wide variation in discharge rates among communities (Griffith 1981, Wilson 1984). Differences were demonstrated to be highly associated with differences in the supply of medical resources (beds, physicians), but not necessarily due to physician style differences.

Studies conducted in the State of Washington found wide variation in admission rates among 14 small area subdivisions, ranging from 65.3 to 161.7 per 1000 population (Cornell, 1981). Analysis indicated that these differences were associated neither with medical need nor demographic factors, disease patterns, physician or bed supply, severity of disease, or access barriers. One hypothesis for the variation in admission rates was that the results reflected differences in community practice styles, where in certain areas physicians are more prone to admit. In a follow-up study, Cornell (1984) found four fold variation in small area admission rates for diabetes. He concluded that the differences were related to differences in clinical practice

decisions to admit patients to the hospital.

Variation in Intermediate Product Use

Variation in the use of certain ancillary services has been studied both among geographic areas and within single institutions. A study of the use of diagnostic services by community physicians showed that the use of laboratory services was correlated with characteristics of the prescribing physicians (Eisenberg, 1981). An adjustment for case-mix was accomplished by a pre-selection of various ICD-9-CM codes. The results were correlated with specialty, years since graduation, and whether the physician graduated from a public, private, or foreign medical school. Although not case-mix adjusted, a study by Childs (1972) showed similar results for the effect of physician characteristics on x-ray use.

In the evaluation of the New Mexico Peer Review System, Brook and Williams (1976) examined the effects of the PSRO over a two year period (1971-1973) on the cost and quality of care provided to Medicare recipients. The most important findings related to the characteristics of providers in explaining the variation in the use of injections. Brook evaluated the "inappropriate" use of injections by evaluating the clinical justification for the demand for payment. The three important physician characteristics that were correlated with inappropriate use of injections were type of provider (D.O.), specialty Board Certification (not

certified), and specialty (OB/GYN).

Although there was early academic interest in excessive use of certain ancillary tests within an institution (Peabody, 1922), only in the last 10-15 years has there been an empirical interest in the micro focus on resource variation within single institutions.

Investigating the utilization patterns of internist's in a clinical setting, Schroeder (1973) showed wide variation in lab (17 fold) and drug use (4 fold). The author attributed this variation to different patterns of practice among similarly trained physicians. Although there were potential problems with the compatibility of the patients selected in terms of demography (age, sex, race) and clinical (case-mix, severity) characteristics, the extreme differences discovered could be explained only by variation in physician practice. In a follow-up study, Schroeder (1974) investigated whether the variations discovered in his earlier study could be related to differences in the quality of physician performance. In an effort to insure maximum compatibility of patients, he selected patients with diagnoses of uncomplicated acute myocardial infarction or uncomplicated chest pain. Clinical competence was measured by the implicit judgements of five faculty internists who ranked the interns on overall clinical capability. While there was a strong correlation between the number of tests and individual physicians, there was a negligible correlation between the number of tests and

clinical competence.

In a companion study to the Schroeder studies, Daniels (1977) tried to control in a more precise manner for severity and case-mix when studying variation in lab use among thirteen internists. He was also interested in correlating the variation in lab use with variations in clinical productivity and clinical outcomes. In controlling for case-mix and severity, only hypertensive patients who satisfied pre-determined criteria were selected. Cost profiles of the internists were expressed as mean cost per patient year for each internist. Clinical productivity was determined in two ways: 1) the total patient load for each internist divided by the weekly scheduled clinic sessions; and 2) subjective estimates of clinical productivity by the clinic administrator in evaluating the speed of practice, number of patients treated, and average length of clinic sessions. Outcome measurement was limited to assessment of blood pressure control of the hypertensive patients. The results paralleled earlier findings (Schroeder, 1973) with extreme degree of variation in lab cost (20 fold) for patients with comparable diagnoses cared for by similarly trained physicians. The study did not demonstrate that increased lab use was associated with improvements in either clinical outcomes or efficiency of practice. Daniels concluded that, at least in his particular study setting, physicians with greater lab use were merely more expensive, not more efficient.

In a study of eight internists who practiced in the same setting and who admitted to the same hospital, wide variation in patient charges were found (Lyle, 1976). These differences could not be explained by age, sex, or diagnoses of the patients. It was concluded that differences in the physician's practice patterns were responsible for the efficiency of delivering treatment and for the resulting cost of care.

Freeborn (1972) examined laboratory utilization in a pre-paid group practice. Within the Kaiser-Portland Health Plan, physicians are paid a fixed portion of capitation revenue so there is no financial incentive to use lab or other services unnecessarily. Utilizing a ratio of lab procedures to doctor office visits (DOV), the data indicated considerable variation in the way individual internists use the lab. The author assumed that most Kaiser internists, each of whom had adult general medical case loads, saw a similar diagnostic mix of patients and had comparable case loads. A second finding important to the current research effort was the indication of a consistent pattern of practice over time. Each physician's lab/DOV ratio was divided by the overall mean and scored for each time period. The internists were then ranked by these scores and Spearman's Rank Correlation was used to test the degree of association between the rankings from one time period to another. The degree of correlation ranged from 0.62 between 1967 and 1970 to 0.84 between 1968 and 1969. It was

concluded from these relatively high correlations that physicians tended to be consistent in their relative lab use over time. A general conclusion of the study was that variation in lab use found among physicians raises the question of the degree to which there is variation in other areas of practice and suggests the need for investigations to identify factors that account for these differences. A second observation was the need to understand the implications of these differences for the cost and quality of care.

In an article that addressed excessive use of laboratory tests, Wong (1983) suggested that physicians determine what tests to order by following informal test-ordering protocols rather than by following protocols that have been determined to be clinically appropriate. Therefore, much of the variation in the use of lab tests among physicians can be traced to a set pattern of practice rather than to the clinical needs of the patient.

Linn (1984) found wide variation among medical specialties in the number and type of tests and procedures that were suggested for two hypothetical cases. He concluded that there is little consensus among physicians as to the types of tests and procedures to order and that individual habits and rituals may account for much of the variation in ordering patterns.

Two general conclusions can be drawn from the above literature review: 1) there exists significant variation in

resource use whether measured by surgical rates, admission rates, or use of ancillary services; and 2) differences in physician's styles of practice are an important factor in explaining the variation.

Relationship of Variation in Admission/Surgical Rates to Ancillary Services

Although the current research is directed at identifying physician induced variation in intermediate product use as a potential area to contain costs under a case-based reimbursement scheme, a broader scope of literature addressing variation in physician practice patterns was presented to demonstrate a particular point. When addressing variation in physician practice patterns, there is no link made in the literature between 1) a physician's effect on the utilization of the facility (admission/surgical) rates; and 2) on the utilization of ancillary services. There are no linkages made between these effects in articles that address the effect of differences in physician practice patterns on the cost or appropriate use of services. In the equation for Total Inpatient Cost (EP) (Eq. 2.16), however, it is clear that Facility Productivity (FP) and Clinical Productivity (CP), although separate measures of different products, are interrelated in their effect on total cost.

The decision to admit, whether surgical or medical, determines the type and volume of inpatient cases (FP) utilized in producing the output of an enrolled inpatient

population (EP). The decision concerning the volume and type of intermediate products (CP) to use in a patient treatment is the major factor in determining how productively a completed case is produced (CaseP). While the physician effect on the productivity of producing each product is supported in the literature, for a particular physician or group of physicians the relationship between FP and CP has never been established empirically. The hypothetical relationship between FP and CP is presented in Figure 3.1.

The literature supports the conclusion that, depending on the case type, FP can range from high to low reflecting the propensity of physicians to admit or perform surgery. It also supports the conclusion that, depending on the intermediate product type, CP can range from high to low reflecting the amount and type of intermediate products ordered by a physician in managing the case. It has not been demonstrated, however, that a physician who performs surgery at a high rate, and is therefore less productive with respect to FP, is necessarily clinically less productive in the selection of intermediate product inputs. In fact, it might be hypothesized that a physician who is less productive with respect to FP, and therefore a high admitter, could be very productive with respect to CP due to the increased diagnostic and/or therapeutic skill gained from the greater number of cases that are treated.

While the practice pattern literature dealing with

FIGURE 3.1
Physician Effect on FP and CP

		CP	
		High	Low
FP	High		
	Low		

admission/surgical rates and ancillary use support each other indirectly --in that the existence of variation in one gives credence that variation may exist in the other --their linkage has not been demonstrated. Fortunately, the literature supporting physician induced variation in intermediate product use can stand on its own. Only those studies which directly address variation in inputs to CP are used as examples to guide methodological improvements for the present research.

Limitations of Past Studies

Two major limitations of past studies are directly related to the research reported here. One limitation is the imprecision with which case-mix and severity were controlled. Case-mix is defined as the diagnostic-specific makeup of a hospital's admitted population while severity refers to the probability of death or disfunction resulting from a patient's medical condition (Discursive Dictionary, 1976). Both case-mix and severity adjustments must be accomplished in a more precise manner in order to differentiate variation in intermediate product use due to patient differences from that due to physician differences. The other limitation involves defining practice patterns in a clinically incomplete manner.

In a few past studies, it was assumed that like physicians treated like patients (Lyle 1976, Freeborn 1972); therefore, no specific adjustment for case-mix or severity

differences were included. In the early studies conducted by Schroeder, patients were selected if they exhibited a diagnosis from a pre-determined list (Schroeder, 1973), but no attempt was made to adjust for the mix of diagnoses treated by different physicians. In another study (Schroeder, 1974), general disease processes were selected that were not diagnosis-specific. Severity of the patient's medical condition was not considered in either study. In some studies (Daniels 1977, Wong 1983), selection criteria used were diagnosis-specific, but no explicit adjustment was made for severity.

It is believed that the validity of the current research findings would be enhanced if adequate adjustment for both case-mix and severity could be incorporated into the study's methodology. On the one hand, desired change in a physician's pattern of practice might be difficult to achieve if the physician believed that differential resource use were due to inadequate adjustment for severity and/or case-mix. On the other hand, if resource use were successfully altered when such change was in fact inappropriate (due to patient differences), then the quality of care might suffer. Consequently, the research findings could encourage both acts of commission (change resource use when it is inappropriate) and acts of omission (do not change when such change is appropriate). Unless variation in resource use attributable to differences in the patient's disease process or the level of clinical severity within the

disease process could be adjusted for, the selection of dissimilar patients would remain a major threat to internal study validity (Cook, 1979).

As previously noted, a second limitation of past studies is the manner in which practice patterns were identified. In all studies, the resource use patterns were limited to only one or two ancillary services. If two services were utilized, the relationship between high use in both was not established for the same physician. In other words, uses of different intermediate products were treated as independent events rather than as belonging to an interrelated bundle of services consumed during a patient treatment. A physician does not make clinical decisions regarding intermediate product use in an isolated or independent fashion and therefore, practice patterns should not be defined independently of other intermediate products. In order for identified variations in intermediate product use to be clinically useful in changing physician's patterns of behavior, they should be a result of practice pattern comparisons that reflect the clinical environment in which physicians make clinical decisions. Therefore, the interrelationships among a more complete set of intermediate products should be included.

An example of the necessity to recognize the interrelationships of intermediate products in identifying clinical useful variation is described in Figures 3.2 and 3.3. In Figure 3.2, patients could be divided into high and

FIGURE 3.2
Independent Determination of Practice Patterns

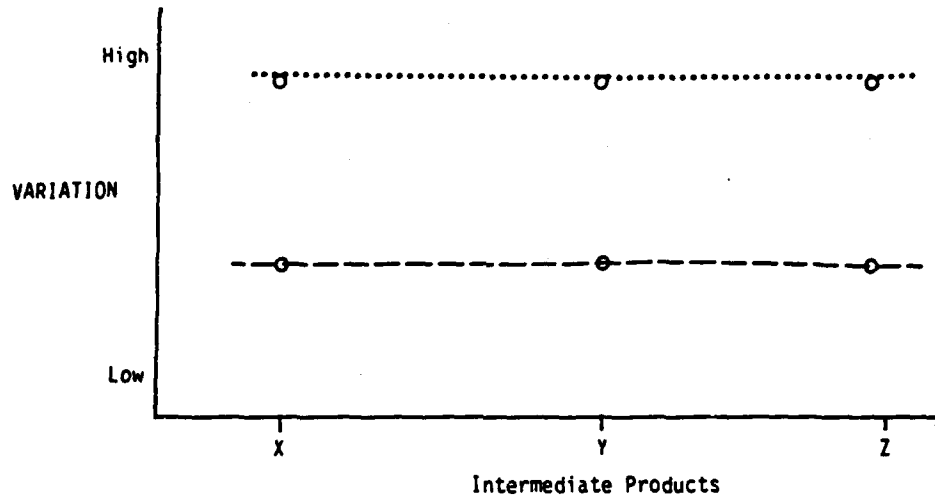
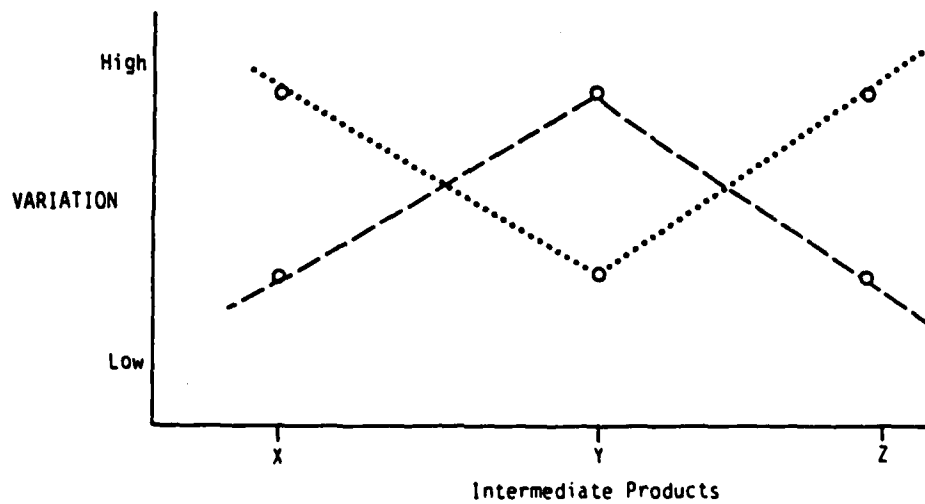


FIGURE 3.3
Simultaneous Determination of Practice Patterns



low use patterns, based on the level of intermediate products (X, Y, and Z) consumed in a treatment process, through an independent investigation of variation in use within each intermediate product. However, since the patients were classified independently with respect to the different intermediate products, the high and low use groups probably would not represent a patient cohort. In Figure 3.3, however, when the variation in the patient's consumption of intermediate products are considered simultaneously in the classification process, two entirely different patterns might emerge. The two patterns in Figure 3.3 would represent a patient cohort reflecting an interrelationship in the levels of use among the different intermediate products. Therefore, Figure 3.3 represents valid practice patterns which reflect the interrelationships in the level of intermediate product use resulting from physicians clinical decisions.

Summary

The literature addressing variation in inputs resulting from physician practice differences provided two contributions. First, a firm empirical foundation was established for the research contention that variation in resource use is related to factors other than patient medical need. Justification was thus provided for the hypothesis that physician induced variation is not only inappropriate, but is also a proper focus for cost

containment efforts. Second, an understanding of the limitations of past studies helped to improve the methodological design of the research reported here. In order to identify accurately patterns and reasons for the pattern differences, it became clear that the methodological design of the current research should measure case-mix and severity more precisely and define practice patterns more meaningfully.

Patient Classification Systems

In Chapter 1, the patient was viewed as an appropriate source of variation in intermediate product use. It was just established, however, that an improved method of measuring both case-mix and severity should be incorporated into the current research. Therefore, a review of the major patient case-mix and severity-related classification systems is provided. While many different classification strategies have been proposed¹, six classification strategies enjoy broad popularity. Many hospitals have either implemented or demonstrated a high interest in implementing one or more of these classification systems.

Diagnosis-Related Groups (DRG)

The original Diagnosis-Related Group (DRG) system was

¹ Of course, Other existing classification strategies are not discussed here because they are specific to resource use or quality (ICD-9CM - CPHA 1978; CPHA List A - CPHA 1966); relate to ambulatory care (Hurtado and Greenlick, 1971); or relate to injuries and burn cases (Gustafson and Holloway 1975).

developed at Yale University by Thompson and Fetter (Thompson, 1975). Under a grant from the Health Care Financing Administration, the Health Systems Management Group at The Yale School of Organization and Management developed a revised version of DRGs based on ICD-9-CM codes (Fetter et al, 1980). Of course, DRGs are now used by Medicare and other payors as a basis for reimbursement and therefore are the starting point for a discussion of classification systems.

The DRG classification system utilizes data from the Uniform Hospital Discharge Data Set (UHDDS).² Assignment of a patient into a DRG depends on partitioning into groups based on the following logic:

1. Mutually exclusive classification of the ICD-9-CM codes into 23 major diagnostic categories (MDCs) based on organ system involvement of the principal diagnosis.
2. Initial split within the MDCs on the presence or absence of an operating room procedure.
3. Further splits on the presence or absence of specific complications and/or co-morbidities.
4. Final splits on patient age and whether the patient died.

A total of 470 DRGs were defined which identify clinically

² The UHDDS is a set of data elements found on the cover sheet of most medical records of an inpatient stay. The UHDDS includes age, sex, discharge diagnoses, procedures performed, discharge status (location, i.e. home, short term hospital, nursing home), and whether discharged alive, dead, or against medical advice. Within the UHDDS, the diagnosis listed first is the "principal" diagnosis which is determined to be the diagnosis principally responsible for the admission - not necessarily the most resource intensive diagnosis.

coherent groups based on consumption of resources.

A limitation of DRGs that is specific to the research effort reported here is that they represent observed treatment patterns rather than clinical or ideal patterns. For example, an appendectomy DRG does not require that appendicitis was present, only that the patient was treated as if he/she had appendicitis. A further limitation is that DRGs might not identify patients with homogeneous disease processes or severity levels. In order to use DRGs as an output measure, the assumption must be made that the indications for surgery and the selection of resources were correct. DRGs assume that the observed patterns of care upon which the classifications were based were both effective and appropriate. While DRGs may represent a valid method of reimbursement, they are not well suited, by themselves, to either quality or efficiency/productivity assessment. An objective of the current research was to identify a methodology to overcome these limitations.

Patient Management Categories (PMC)

Patient Management Categories were developed by Young (1982) in conjunction with Blue Cross of Western Pennsylvania. Young's case-mix system was designed to overcome the inconsistencies in predicting resource use based only on ICD-9-CM diagnosis and procedure codes. Within a primary discharge diagnosis of breast cancer with metastases, for example, many different types of cases

requiring different diagnostic and therapeutic strategies might be represented (Hornbrook 1982). Young and her colleagues developed a three step procedure for classifying patients into groups that provide a recommended treatment modality.

First, patients were grouped into clinically homogeneous patient management categories (PMCs) based on multiple diagnoses and procedures available in the UHDDS. These PMCs were developed by physician panels based on clinical experience --rather than on an analysis of actual input resource data. Second, for each PMC, the physician panel specified patient management paths (PMPs) which describe the essential components of the diagnostic and therapeutic regimen. A PMP represents the key intermediate products that the average patient within the PMC is expected to receive. While PMPs do not provide criteria for optimal care for each individual case, they do represent a standard of comparison. Since they were developed without actual data, however, they do not represent a norm of care provided in any particular hospital. In the third step, the vector of services within each PMP was converted to a scalar resource value by assigning dollar costs to each intermediate product.³

PMC is intended to be an improvement over the DRG classification system, with the improvements achieved by

³ This is identical in concept to the determination of CaseP discussed in Chapter 1. If a PMP did represent an optimal standard of resource use, then it would imply CaseE.

introducing clinically preferred treatment patterns to predict the cost of care. No attempt was made directly to quantify severity affects on the cost of care, although this is accomplished indirectly through the clinical specificity of the patient management categories (Young 1984).

Patient Severity of Illness Index (PSI)

The Patient Severity of Illness Index (PSI) was developed by Horn (1981) at John Hopkins University with the purpose of measuring the severity of a patient's illness in order to predict the cost of the inpatient stay (Horn,1981). A patient's severity score is assigned from a review of the patient's medical record using implicit synthesis of seven sub-measures: 1) stage of principal diagnosis; 2) complications of principal condition; 3) concurrent interacting conditions affecting hospital care; 4) dependency on hospital staff; 5) extent of non-operating room life support procedures; 6) rate of response to therapy or rate of recovery; and 7) impairment remaining after therapy for the acute aspect of the hospitalization (Horn 1984). At discharge, the patient's medical record is reviewed and the patient is rated on a four point scale for each of the seven sub-measurements. The rater then subjectively integrates the separate scores into an overall score of one-to-four.

PSI is the most ambitious and the most controversial case-mix technique. It has provided, when applied to

specific diseases, more homogeneous groups of patients with respect to resource use than DRGs, Staging, or PMC (Horn 1981, Horn 1984). Although Horn (1984) reports high (90%) inter-rater reliability, the major criticism of the technique relates to the subjectiveness of the rating process and the confounding of severity with resource use. The rater may assume that high resource use is an indication of severity in which case, as Hornbrook (1982) points out, the correlation between resource use and severity is tautological. PSI assumes that the patient's treatment was both appropriate and effective, and it is labor intensive since it requires a manual review of the patient's chart.

Disease Staging

Disease Staging was developed by Gonnella (1983) at Jefferson Medical College and was further refined at SysMetric Inc. (Hornbrook, 1982). The purpose of staging is to provide a severity classification of the patient's illness so that in a case-mix application, differences in a patient's medical condition will not be confounded with resource use or response to therapy.

Staging assigns each diagnosis from the UHDDS into one of approximately 400 Major Disease Categories (MDC) and then to one of four stages representing progression of the disease within an MDC. The clinical logic of staging within each MDC is as follows

- Stage 0 - No Disease or diagnosis unknown
- Stage 1 - No complications present, either local or systemic
- Stage 2 - Disease is limited to an organ or system; significantly increased risk of complication
- Stage 3 - Multiple organ or system involvement; generalized systemic involvement
- Stage 4 - Death

The staging criteria for each MDC were defined by specialists from clinical experience with no reliance on resource use data. The stage assignment is automated using the UHDDS elements of diagnosis and procedural codes, sex, and discharge status (alive or dead). Studies have demonstrated a relationship between stage and resource use (Butler and Bently 1982, Garg 1978, Conklin, 1984). However, since the stage is defined within a single MDC, the stage assignment may not relate between MDCs. It should be noted that the methodology of staging is similar to Young's PMC, except it emphasizes the quantification of severity rather than the determination of treatment cost.

Acute Physiology and Chronic Health Evaluation (APACHE)

The Acute Physiology and Chronic Health Evaluation system was developed by Wagner (1984) and Knaus at George Washington University. A simplification of the APACHE severity of illness classification system, APACHE II is based on 12 common physiologic measures and includes: vital signs (heart rate, mean blood pressure, respiratory rate, temperature, and Glasgow Coma Score); variables derived from

routine venous blood tests (hematocrits and white blood cell count, serum potassium, serum sodium, and sodium creatinine); and two variables derived from arterial blood gas tests (serum pH and PaO₂) (Wagner, 1984). Each of the 12 variables is translated into weights resulting in a single integer score - Acute Physiology Score (APS). APACHE II has been used extensively with ICU patients, but not on general inpatients. There is evidence that the APS has a strong and stable relationship with resource cost of intensive care (Hornbrook, 1982). Since it relies on physiologic measures, it may be less successful in discriminating among elective or non-acute patients. It also requires information which is not available from the UHDDS or other common computerized abstracts.

Medical Illness Severity Grouping System (Medisgps)

The Medical Illness Severity Grouping System (Medisgps) was developed under the direction of Brewster (1984) in conjunction with Interqual Inc. It was developed as a quality assessment tool to measure the attainment of expected results from medical treatments. Patients are classified at the time of admission into severity groups based on key clinical findings (KCF) (clinical laboratory, radiology, pathology and physical examination findings). The effectiveness of the medical treatment is measured by changes in the severity assignment over the course of the hospital stay. Medisgps is in the early stages of

development as a reimbursement tool to measure the efficiency of resource use as well as improvement in health status (Brewster, 1984). It examines the efficiency of resource only within severity groups to prevent the confounding of efficiency issues with severity. Preliminary results show a statistical relationship between admission severity group assignment and total charges (Brewster 1984), although Brewster admits that the relevance of the relationship between severity and resource use for reimbursement is questionable since other factors in addition to severity (e.g. physician practice pattern variation) affect resource use. The major difficulty of utilizing this system for productivity /efficiency analysis is the emphasis on key clinical findings rather than on diagnoses. Therefore, there is no homogeneous or identifiable disease process in which to compare the volume and/or types of intermediate products utilized. Medisgps provides a measure of marginal change in outcome and therefore is useful for quality assessment. It does not, however, identify a production process which is of course required for productivity/efficiency analysis. A present limitation to widespread adoption of Medisgps is the reliance on data not available within the UHDDS.

Cost/Quality Relationship

The dilemma facing hospitals, when considering a cost reduction strategy based on changing physician's practice

patterns, is how to alter the volume and/or type of intermediate products consumed in the process of care without negatively affecting the quality of the patient care. In Chapter 1, outcome was identified as a source of variation that must be monitored when using clinical productivity comparisons to alter physician practice patterns. In order to investigate the inherent cost/quality relationship within a productivity measurement, a selected literature review is provided that covers the definition of quality, the relationship between the process of care and its outcome in assessing quality, and the relationship between the volume of intermediate products consumed in the treatment process and the quality of care.

Definition of Quality

Quality of medical care can be thought of as having three major components: technical, patient-physician relationship, and amenities of care (Donabedian, 1985 pg 4). Technical quality is concerned with the application of science and technology, and primarily addresses the selection and sequencing of the diagnostic and therapeutic services resulting from physician's decisions. The non-technical aspects of quality (patient-physician relationship and amenities) focus on the comfort and ease of the interpersonal relationship between the patient and physician, as well as on the patient's satisfaction with the environment within which the care is delivered. In addition

to the non-technical aspects of quality affecting the outcome of care (Donabedian, 1980 pg 29), one can extend the effects further and theorize that the effects are not only additive, but also involve an interaction term between technical and non-technical care (Brook and Williams, 1975). It can be concluded that patient comfort with the amenities, and patient satisfaction with the physician relationship, may affect the volume and type of resources consumed in the course of treatment. However, due to the difficulty of measuring non-technical aspects and to the degree of complexity introduced into the cost relationship, the current research was only considered the technical component.

Quality Assessment with Process and Outcome

While other authors have developed conceptual models of quality assessment that include process and outcome variables (Sheps 1955, Dror 1968, DeGeyndt 1970, Williamson 1971), Donabedian (1966, 1969, 1980) developed the structure-process-outcome paradigm which is widely accepted as a useful way to view quality assessment. Donabedian defines the assessment of process broadly as the evaluation of the activities of physicians and other health providers in the management of patients (Donabedian, 1969). Within the technical definition of quality established for this research effort, process is defined more narrowly as the selection of the type and quantity of intermediate products

used in the management of an inpatient episode of care. The assessment of outcome can be left broadly defined as the evaluation of the end results of care in terms of health and satisfaction (Donabedian, 1969). While quality can be assessed independently by examining either process or outcome, it is the interrelationship between process and outcome that is important to the present research effort. If changes in the process of care are encouraged within a cost reduction strategy, then it is important to be able to determine what the related effects will be on health outcome. A cost reduction strategy that considers only reductions in the quantity of intermediate products without concern for changes in quality (measured by outcome changes) is unethical and probably untenable.

Relationship Between Volume and Quality

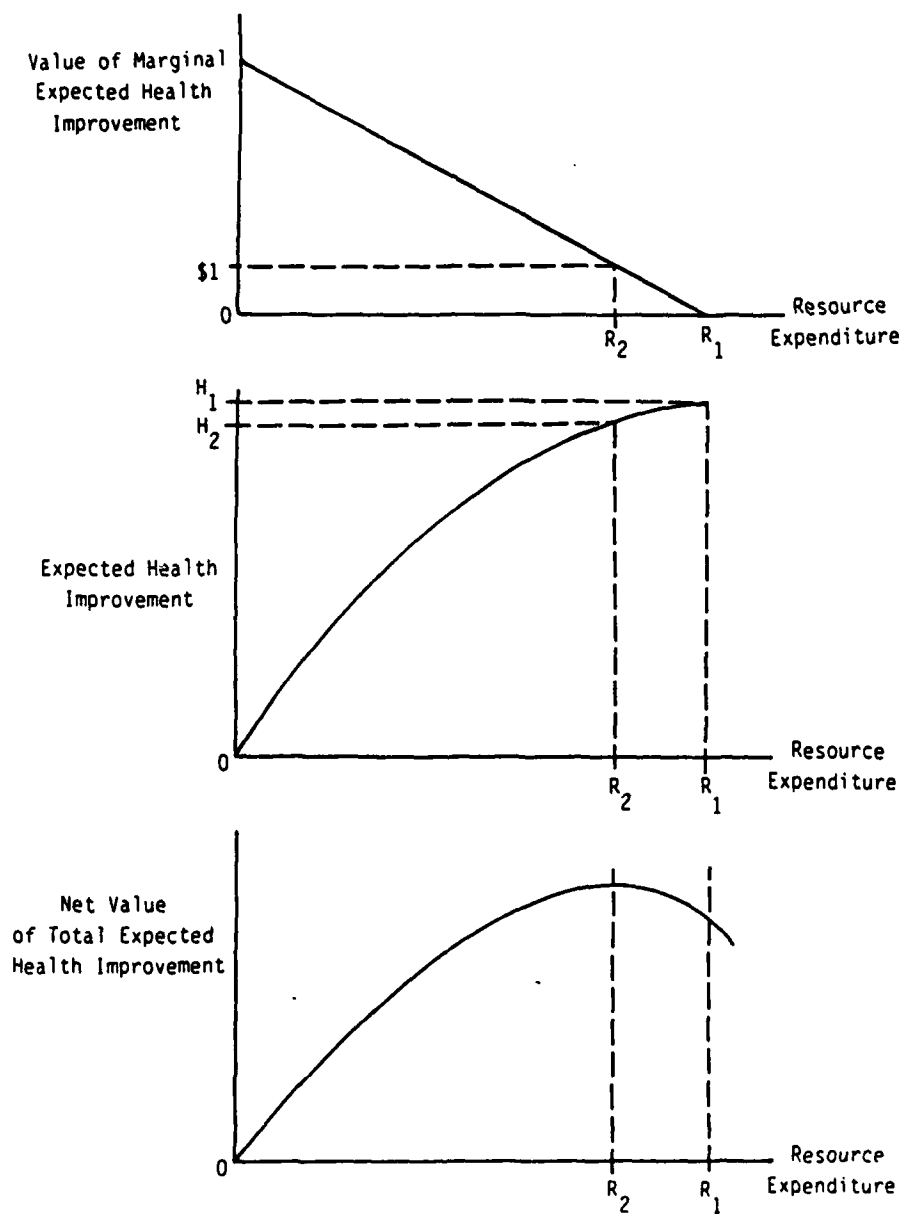
The argument was developed in Chapter 1 that without explicit standards controlling the volume and type of input intermediate products, it was necessary to focus on the variability of inputs. Of course, it was recognized that variation in the volume and type of resources utilized by physicians in the management of a patient's treatment episode does not necessarily indicate inappropriate utilization of resources. Variation can be expected to occur due to 1) the differential response of an individual patient to a disease process; and 2) the probabilistic nature of a physician's decisions regarding diagnosis and

treatment; and 3) the quantify and type of resources available to the physician. A certain amount of variation is appropriate and even desirable when recognizing that the medical care process should be responsive to the unique clinical needs of the individual patient.

Variation, however, may also indicate mis-utilization of resources. High resource variation supports the hypothesis that some physicians may be over utilizing services while others may be under utilizing them. As Donabedian points out, "The high incidence of unnecessary or unjustified diagnostic tests, therapeutic interventions, surgical procedures, hospital admissions, and hospital stays suggests that there is a large potential for cost reductions that would leave quality of care certainly unimpaired and very probably much improved" (Donabedian, 1985 pg 25).

There clearly exists a relationship between the volume and type of services consumed during an episode of treatment and the effect on health status. It is also highly probable that this relationship reflects diminishing returns-to-scale as the marginal improvement in quality resulting from added services diminishes as the volume of services increases (Donabedian, 1982 pg 985). Therefore, there is a direct relationship between increasing cost and improvements in quality until an optimal point is reached where the marginal increase in cost equals the marginal improvement in quality. After this point, costs continue to increase with a corresponding diminishing improvement in quality (Figure

FIGURE 3.4
Conceptual Relationship Between Cost and Quality



3.4) (Donabedian, 1982 pg 985). Without resource constraints, a rational decision process would lead to additional resource consumption until the marginal benefit equaled zero.

In a resource constrained environment, however, the decision must be made to halt the consumption of further resources before the maximum benefit to health improvement is achieved. Donabedian has suggested that this decision involves a "trade-off" between quality and monetary cost. While present outcome measures are imprecise and insensitive to quality of life changes, an ethical cost reduction strategy should strive to continually improve the articulation of this trade-off between cost and quality.

Two important conclusions can be drawn from the literature addressing the cost/quality relationship. First, the necessity of differentiating the variation in intermediate product use has firm support in the literature. While variation in resource use in response to medical need is appropriate, physician induced variation holds a large potential for reducing the cost of care without affecting its quality. Second, while cost attention is focused on the selection and volume of inputs into the productivity relationship, the potential effects on the quality of the output cannot be ignored. Therefore, in addition to physician and patient variables required to differentiate resource variation in the process of care, outcome variables must also be included to detect any change in the output

(quality). If the quality of the output changes significantly in response to changes in the inputs, then the comparison of productivity measures to identify potential cost reduction opportunities is invalid. The determination of the "significance" of the change in quality is the result of the capability to articulate the cost/quality trade-off.

Statistical Techniques

A variety of statistical techniques was considered for potential use in partitioning patients according to variation in intermediate product use. The techniques that are reviewed for the current research include Q-mode Factor Analysis, Regression analysis, Grade of Membership analysis, and Clustering (Manton, 1984). Unfortunately, all the techniques have limitations for use in this research effort.

Factor analysis is normally considered a data reduction technique that can be a powerful tool in reducing the number of variables to consider in explaining differences between groups when there is a high degree of inter-correlation among the variables. It can also be "turned on its side", with the information provided from the covariance matrix helpful in understanding how the entities (patients) are grouped together. This is in contrast to its more normal application of explaining differences among groups. Even accepting that the matrix is difficult to interpret, the main limitation of factor analysis for the current analysis was that it assumes a linear model (Bentler, 1976). In the

research reported herein, it could not be assumed that the resource variables relate to each other in a linear manner; therefore, an alternative technique had to be utilized.

Regression is also a powerful tool, especially when considering a single dependent variable, for explaining the variation in a dependent variable through analytic relationships with the independent variables. When a bi-variant relationship exists, it may be useful in explaining differences between categorical groups. However, it is not particularly useful in forming the groups themselves (Manton, 1984).

Grade of Membership, a relatively new technique, was also considered. Utilizing maximum likelihood estimates, it has some statistical advantages over other techniques (e.g., clustering) (Manton, 1984). The groups that are formed with this technique are not, however, mutually exclusive. Such non-exclusivity presents a problem in attempting to assign a patient to a practice pattern, since an individual patient cannot relate to more than one practice pattern group.

Cluster analysis is a generic name for a wide variety of procedures that can be used to create a classification. Generally, clustering procedures are multivariate statistical techniques that attempt to classify separate entities (patients) into relatively homogeneous groups using certain information known about these entities. Clustering has some limitations, the most important being that no statistical test exists for the correctness or validity of

the cluster solution (Aldenderfer, 1984). Clustering, however, possesses certain advantages, the foremost being great intuitive appeal and conceptual ease of comprehension. If variation in practice patterns is to serve as a basis to encourage behavioral change, then physicians should feel comfortable, at least conceptually, with the methodology used to identify the patterns.

CHAPTER 4

METHODOLOGY

The methodology developed for the research reported herein is complex because it involves a series of interrelated procedures -- with the latter steps built on the results of the previous steps. In order to present the methodology and its application in as clear and concise a manner as possible, the methodology and its application are treated separately. This chapter describes an overview of the steps in the methodology, some general methodological issues, and the data and system support used in the methodology's application. Chapter 5 provides the specifics of the application and results.

Overview of Methodology

As previously noted, the research methodology was developed to determine the feasibility of implementing a cost reduction strategy based on improving clinical productivity. Specifically, the research effort is directed towards determining the potential to reduce intermediate product use by changing high cost physician practice patterns to lower cost patterns in order to reduce the mean

of the overall cost distribution of treated cases within a DRG. As discussed at the end of Chapter 1, the methodology includes three basic objectives: 1) classification of patients into different groups based on the homogeneous use of intermediate products; 2) differentiation of the variation among the different groups according to physician, patient, and outcome characteristics; and 3) association of single physicians with the different patient groups. The methodology was developed sequentially so that each step builds on past results. If the outcome of any step was "unsatisfactory", then further analysis might not be justified.

Formation of Practice Patterns

In order to investigate variation in the use of intermediate products by comparing clinical productivities, a basis of comparison first had to be established. This comparison development began by classifying patients within each DRG into different groups based on the homogeneous use of intermediate products. The different groups, or practice patterns, must reflect differences, when all intermediate products are considered simultaneously, in the volume and/or type of intermediate products consumed in the treatment process. Five steps were followed in the formation of practice patterns.

- a. First, the sub-set of intermediate products to be considered in defining the practice patterns was determined.

It was hypothesized that many of the intermediate products contribute little in terms of total cost and/or are highly correlated with the medical need of the patient --rather than with physician practice style. Therefore, investigation of the complete set of intermediate products was deemed unnecessary. It was also felt that inclusion of all intermediate products would complicate the analysis significantly.

b. Second, patients within DRGs were grouped into different practice patterns. To allow testing of the validity of these groups, the patients were classified separately for 1983 and 1984. The determination of the statistical technique used in forming the practice patterns is discussed in the "Issues" section of this chapter.

c. Third, the financial significance of the differences in the patterns was determined. The cost reduction potential associated with shifts in practice patterns depends on the amount of variation in costs that was explained by the different patterns. Therefore, single Analysis of Variance (ANOVA) analyses were performed to determine if the potential cost savings justified the expense of further analysis.

d. Forth, although practice patterns for the individual data sets (1983 and 1984) had been identified, it was unclear, at this point, if the patterns represented true differences in intermediate product use. Such differences could, of course, be the result of aberrations in the two

data sets. Therefore, the validity of the practice patterns was tested 1) by investigating the internal consistency of the pattern differences to repeat across the two data sets; and 2) by association of the pattern differences with patient, physician, and outcome variables. The result of this step is the definition of practice patterns for the complete data set which represent valid differences in intermediate product use.

e. The final step was to determine if the practice patterns defined for the complete data set were financially significant. Again, while the patterns might represent valid differences in the way intermediate products were combined in the treatment process, the pattern differences must offer significant cost reduction potential to justify further analysis.

The completion of Step 1 should result in the identification of financially significant practice patterns that are consistent in their ability to detect different patterns of intermediate product consumption across the two years. Although different practice patterns had been identified across the two years, the characteristics of the patterns that explain the differences in intermediate product use had not been identified.

Identification of Pattern Characteristics

The variation in clinical productivities among the practice patterns were differentiated with respect to

physician, patient, and outcome characteristics. If the differences in clinical productivities among the practice patterns could be attributed largely to differences in physician practice style, then potentially inappropriate intermediate product use will have been identified. Three steps were involved in identifying pattern characteristics.

a. First, to determine the effect of the different characteristics on patient membership in a pattern, a predictive model was developed. If pattern membership could be predicted with improved accuracy, then the importance of the different patient, physician, and outcome characteristics in affecting intermediate product use could be determined.

b. Second, the model's accuracy in predicting pattern membership was determined.

c. Finally, the specific patient, physician, and outcome characteristics that were important in contributing to the model's predictive accuracy was determined.

Step Two determined if understanding how the practice patterns was related to different patient, physician, and outcome characteristics lead to an improved ability to predict pattern membership and hence intermediate product use. If one can predict resource use with an increased accuracy, then the potential to control intermediate product use is enhanced. While physicians as a group may be important in determining intermediate product use differences, the identification of individual physicians in

their relationship to specific resource use must be clarified if practice patterns are to be modified.

Association of Specific Physicians with Patterns

In order to identify specific physicians whose use of intermediate products may be inappropriate, individual physicians must be associated with different patterns. If a specific physician can be associated with differences in intermediate product use, then potentially inappropriate variation in clinical productivity will have been identified. Physician review of the appropriateness of clinical productivity differences is the mechanism best suited to reducing the volume and/or type of intermediate products used.

Issues

This section addresses three topics that require further development before the methodology can be presented logically. First, the criteria used in selecting the DRGs that were included in the study are provided. Second, the severity measure used to differentiate intermediate product use due to differences in the patient's medical condition is described. Third, the method of statistically forming practice patterns is discussed.

Selection of Diagnosis-Related Groups

The goal of differentiating variation in intermediate

product use is crucial to the attempt to reduce the cost of a treated case without affecting its quality. It was hypothesized, however, that the clinical precision of a case-type's definition will affect the ability to differentiate such variation. From previous research investigating variation in total cost within DRGs, it was known, at least within the particular study institution, that variation in total costs varied widely among DRGs (Martin 1984). Utilizing measures of standard deviation and kurtosis, DRGs were classified into four cells representing high and low standard deviation and high and low kurtosis. Standard deviation provided a measure of gross variation in costs while kurtosis provided insight into the shape of the cost distribution relative to a normal distribution.

It is recognized from Martin's (1984) research that all DRGs are "not created equal" and that some are more homogeneous with respect to resource use than others. However, it was not the amount of gross variation that was of concern --rather it was the ability to differentiate the variation with respect to patient and physician characteristics. Gross variation may reflect, among other factors, the heterogeneity of the disease processes and of the patient's medical condition, both of which are beyond the control of the individual institution (administrative and medical staffs). Therefore, while the amount of gross variation is of concern in a macro-structural sense in addressing the fairness of the reimbursement scheme based

upon the classification system, it is not pertinent to the identification of cost reduction opportunities within the control of the institution (i.e. patient and physician). However, the shape of the distribution, regardless of its gross standard deviation, may have important cost reduction implications.

In the previous research effort (Martin, 1984), DRGs were divided into two groups based on the relative kurtosis of the different DRG cost distributions. The result of this analysis produced a split of surgical and medical cases, with surgeries demonstrating a higher kurtosis relative to medical cases. It can be hypothesized that surgery cases have a higher degree of clinical agreement in the selection of the type and volume of intermediate products than the more heterogeneously defined medical cases. If this hypothesis is true, then it would be more difficult to identify practice pattern differences in surgical than in medical cases.

In order to test the capability of the methodology to identify practice pattern differences for different case types, it was decided to select an even number of surgical and medical DRGs. The final DRGs were selected with advice from the institution's Chairman of the Department of Surgery with the following criteria:

1. Professional judgement that physicians were utilizing resources differently.
2. Attention to adequate sample size with at least 100 patients treated in each selected DRG for both 1983 and 1984.

FIGURE 4.1
DRG Descriptions

DRG	TYPE	Description
14	Medical	Specific Cerebrovascular Disorders Except TIA
82	Medical	Respiratory Neoplasms
88	Medical	Chronic Obstructive Pulmonary Disease
127	Medical	Heart Failure and Shock
198	Surgical	Total Cholecystectomy W/O C.D.E. age <70 W/O C.C.
209	Surgical	Major Joint Procedures
215	Surgical	Back and Neck Procedures Age <70 W/O C.C.
355	Surgical	Non-Radical Hysterectomy Age <70 W/O C.C.

A total of eight DRGs were selected - four surgical and four medical (Figure 4.1).

Selection of Severity Measure

As noted in Chapter 3, case-mix is defined as the classification of an inpatient hospital stay in order to predict the resources consumed during the stay, while severity of illness refers to the probability of death or loss of function over the natural history of a disease (Hornbrook 1982). The need for a severity measure arises from the inability of DRGs to classify patients into clinically homogeneous groups. The need to accomplish a severity adjustment is a result of the indirect relationship between case-mix and severity classification systems. Although severity of illness is certainly related to the level of resource use, there are intervening variables (e.g., physician induced variation) which confound the relationship. Thus, while a case-mix system might classify patients who consume like resources together, it might not at the same time classify patients according to the severity of the disease process. In order to select a severity measure that met the needs of the current research, a framework which compares the six systems described in Chapter 3 is presented.

The six case-mix strategies share common characteristics. Although not necessarily supported by the UHDDS, all utilize discharge abstract data for

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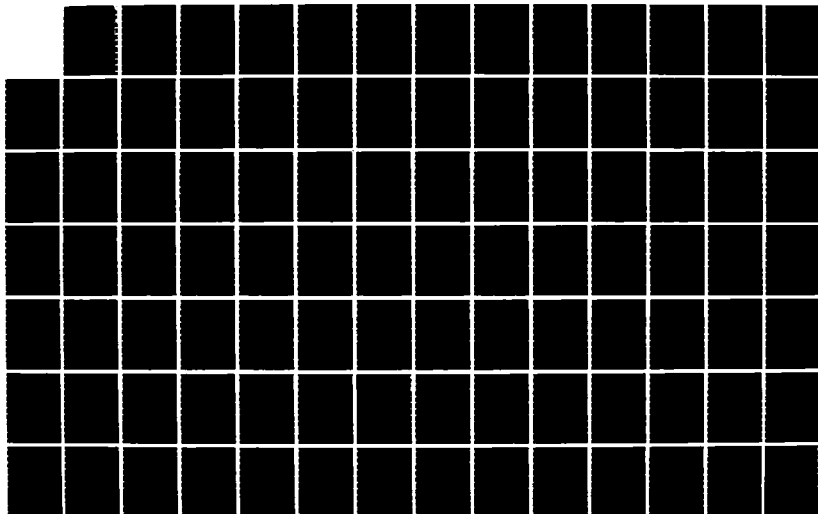
PHYSICIAN PRACTICE PATTERNS WITHIN AN ACUTE CARE
FACILITY(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB
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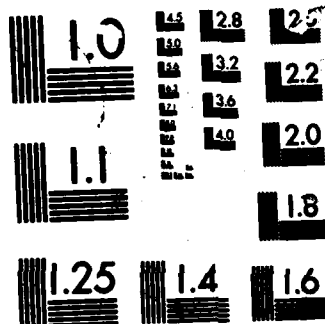
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classification, with five using objective classification criteria. Three of the strategies can be supported from only the UHDDS, and all the systems rely on accurate recording and coding of the medical record. While these strategies share common characteristics, there are also important differences.

Two discriminating characteristics can be used to develop a framework to relate the different strategies. One discriminating characteristic among the different systems is which dimension, severity or resource use, is used to classify patients. The relationship between severity and resource use is not direct since factors other than severity (i.e. physician variation) affect resource use. With one exception, only one or the other (e.g., severity or resource use) is the focus of the classification strategy. The exception is Horn's PSI and one of the major conceptual difficulties with this strategy is that it contends to classify patients with respect to both severity and resource use. However, since the relationship is not direct, it is unclear how this can be accomplished. PMC and DRGs classify patients by resource use, while Staging, APACHE II, and Medisgrps quantify severity of illness. PSI is considered to classify patients by both severity and resource use.

A second discriminating characteristic (Hornbrook, 1982) is whether a normative or empirical approach is used to classify patients. The normative approach (used in PMC, staging, APACHE II, and Medisgrps) attempts to identify

patient characteristics which are hypothesized to differentiate treatment patterns. How the patients were actually treated or what resources were actually used does not affect how the patients are classified. The empirical approach (used in DRGs and PSI) assigns patients based on what occurred during the patient treatment. The empirical approach usually provides a more precise explanation of actual hospital behavior. However, because this approach confounds the actual or observed treatment pattern with the hypothesized clinical or ideal pattern, it is more difficult to assess the appropriateness and/or productivity/efficiency of the performance of hospitals and physicians. The framework which compares the six classification strategies is described as in Figure 4.2.

a. Selection Criteria for Severity Measure

To accomplish the desired severity adjustment, the selected system must satisfy certain criteria. First, the classification system must be severity rather than resource oriented since it will be employed within a resource oriented system (DRGs). Second, the system must be based on normative rather than empirical selection criteria to prevent a confounding of resources used in the treatment with the severity assignment. Third, the system must be able to assign a severity score utilizing an automated application supported from the UHDDS data set. The time and expense of manually abstracting the medical record was considered prohibitive for the current research effort. The

FIGURE 4.2
Classification of Case-mix Strategies

	Resource Use	Severity
Normative	PMC	Staging APACHE II Medisgrps
Empirical	PSI DRG	PSI

only severity classification strategy which satisfies these criteria is Gonnella's Staging.

b. Staging

For the current research, an automated version of the staging algorithm was utilized. The staging software was developed under the direction of Gonnella in conjunction with Systemetrics and the National Center for Health Services Research (Louis, 1983 vol 1). In order to test the accuracy of the automated version, a re-abstracting study was conducted (Louis, 1984 vol 5). This study 1) compared the outcomes of the application of disease staging using the complete medical record and the medical staging criteria; with 2) the results using coded, automated UHDDS discharge abstract and the staging software. The performance of the software was improved when the input data were coded in ICD-9-CM rather than in ICDA-8 or H-ICDA-2 reflecting the increased clinical precision of the ICD-9-CM coding scheme. When the outcomes were compared for ICD-9-CM coding system, no significant differences were found between those staged by hand and those staged by machine (Louis, 1984 vol 5).

The staging software considers all diagnostic and procedural codes, sex, and discharge status (alive or dead) as input data. The staging criteria have been established so that a patient record will always be staged in at least one disease category and often can be staged in many. Accordingly, the program assigns the highest stage level that can be justified within each disease category (MDC).

For each MDC within which a patient is staged, a "staging triple" is formed which includes three pieces of information: 1) MDC number; 2) the stage number; and 3) whether the principal diagnosis was used in making the stage assignment. The set of all staging triples for a patient is called the "staging vector". Once the staging vector has been formed, the MDC with the highest stage assignment in which the principal diagnosis was involved is the stage assignment and is selected as the "primary staged condition" (Louis, 1983 vol 4).

As an example, consider a female patient with diagnoses of Diabetes Mellitis and Cystitis who was discharged alive, the discharge abstract would provide the following information.

Principal Diagnosis	250.80	Diabetes Mellitis with other complications
Secondary Diagnosis	595.00	Cystitis
Sex	Female	
Discharge Status	Alive	

The staging software would search a table of MDCs and, based on the diagnosis information, determine that the patient should be staged in two MDCs.

DX0901	Urinary Tract Infection
DX1214	Diabetes Mellitis

The software would then select the highest stage within each MDC for which the patient can be assigned, and determine if

the primary diagnosis was considered or not --thereby producing the staging vector.

Diagnostic Category	Stage	Primary Flag
DX0901	1.1	Secondary
DX1214	2.1	Primary

It would then search the staging vector and select the triple with the highest stage assignment for which the primary flag is on as the primary staged condition.

Diagnostic Category	Stage	Primary Flag
DX1214	2.1	Primary
DX0901	1.1	Secondary
DX1214	2.1	Primary

Only the primary staged condition would be returned for inclusion in the data set. In this example, the patient's primary staged condition was in DX1214 at level 2.1.

The results of staging patients in the eight DRGs selected for the current research study are presented in Appendix 1. Appendix 1 includes the stage assignment, clinical description of the stage, number of patients in that stage for 1983 and 1984, and the clinical evidence for the stage assignment.

Definition and Statistical Method of Forming Practice Patterns

One of the weaknesses of previous studies which investigated variation in intermediate product use was the lack of clinical meaningfulness when defining a practice pattern. As discussed in Chapter 3, the weakness pertains to the inability to identify a patient cohort when intermediate product use is investigated independently. In order to identify the differences in volumes and types of intermediate products used in treating the same group of patients, the variations in intermediate product use must be considered simultaneously.

For the research reported here, the dependent variables used to define a practice pattern were the costs of the intermediate products consumed in each of the institution's 21 aggregate financial cost centers (Figure 4.3). The use of a common metric such as cost to measure variability in the volume and type of intermediate products presents some analytic problems. Specifically, variation in either the volume or type of intermediate product use may not be detectable, especially within an aggregate cost center. For example, if lab test A costs half as much as lab test B, but twice as much of A is used, then the total cost of the two lab tests would be identical. Therefore, variation in the practice patterns might not be detected when variation in cost is used as the measure.

FIGURE 4.3
Aggregate Cost Centers

COST CENTERS	
1.	Adult/pediatrics
2.	Ambulatory Surgery
3.	Anesthesiology
4.	Cardiac Care Unit
5.	Clinics
6.	Delivery Room
7.	Drugs
8.	Electrocardiogram
9.	Electroencephalogram
10.	Emergency Room
11.	Surgical Intensive Care Unit
12.	Laboratory
13.	Medical Intensive Care Unit
14.	Medical Supplies
15.	Nursery
16.	Operating Room
17.	Physical Therapy
18.	Radiology
19.	Renal Dialysis
20.	Respiratory Therapy
21.	Speech Therapy

A second potential problem in using cost to measure variation in intermediate product use is that cost variation may reflect a difference in intermediate product productivity (IPP) rather than clinical productivity (CP). This could be a serious problem and a threat to the validity of the study design if costs were to be compared across institutions. Since, however, the present study is restricted to a single institution, IPP can be assumed to be constant, at least in the short run. Therefore, variation in cost should reflect differences in clinical Productivity (Equation 1.1).

While cost is not an ideal measure because of the potential to obscure variation in resource use, the inability to combine clinical productivity measures (Equation 2.9) forces its use. It would be statistically complex to examine the relationships of variation in the hundreds of different intermediate products consumed within a specific DRG. The collapsing of intermediate products into the aggregate cost centers requires that a common metric such as cost be used. Even with a collapsed set of intermediate products, the statistical task of identifying a pattern of variation is not insignificant.

Cluster Analysis was chosen for the current research due to its advantages of intuitive appeal and conceptual ease of comprehension. If variation among practice patterns is to serve as the basis to encourage physician's behavioral change, then physicians must feel comfortable with the

technique use to identify the patterns.

Cluster analysis is a multivariate statistical technique that attempts to classify separate entities (i.e. patients) into relatively homogeneous groups using information known about these entities. The choice of the measure of homogeneity or similarity is therefore crucial in determining which groups will be formed (Adenderfer, 1984).

The similarity measure chosen for the current study was the relative variability of cost across the aggregate resource cost centers. Therefore, patients grouped together should exhibit similar cost variation patterns. For example, patients who consumed a higher level of lab and lower level of pharmacy services as measured by their cost variation from the overall group mean would be grouped differently than patients who consumed a lower level of lab and a higher level of pharmacy services.

A second important decision was how to measure the relative similarity among patients. The selection of the distance measure was crucial since different measures include inherent assumptions concerning the relationship among the variables. Two distance measures were considered.

The Minkowski(k) distance measures were used. This family of distance measures is the kth root of the sum of the kth power of variable distances between two units.

$$d_{ij} = \left(\sum_{r=1}^{21} (X_{ri} - X_{rj})^k \right)^{1/k} \quad (\text{Eq. 3.1})$$

Where r = Aggregate Cost Center

X_{ri} = Value of Aggregate Cost Center (r)
for patient (i)

X_{rj} = Value of Aggregate Cost Center (r)
for patient (j)

d_{ij} = Distance between patient (i) and (j)

If $k=1$, the distance measure is sometimes called the City-Block Metric. It sums the absolute differences between patients on all cost centers. The argument for this method is that the estimation of distance should be the same whether the patients are two units apart on each cost center or they are one unit apart on one and three units apart on the other.

If $k=2$, the distance measure is called the Squared Euclidian Distance Measure. This measure is affected by the magnitude of the differences between the cost centers considered. Therefore, this method will record a larger distance if patients are three units apart on one cost center and one unit apart on another than if the patients are two units apart on each cost center. The Minkowski(2) (Squared Euclidian Distance Measure) was utilized for the present study to emphasize the differences between physician practice patterns.

The specific clustering technique chosen was hierarchical clustering, in which entities (patients) were grouped into clusters and the clusters in turn were merged into successive levels to form a tree-structure. The computer program that was utilized was from the MIDAS

statistical package developed by the Statistical Research Laboratory at the University of Michigan(Fox, 1976).

Data

A case mix management system was available with data for fiscal years 1983 and 1984 for the demonstration hospital. Two major sources of data were involved - medical record abstract data and billing system data. While the abstract data were obtained from an internal computer system of the subject hospital, they were similar in content to those in the PAS system (Mullnor, 1982). All UHDDS elements were available, including diagnostic and procedural data (ICD-9-CM codes), payor, discharge disposition, age, and DRG group number.

The financial data provided resource and associated cost information. Individual charge records for each billable service rendered to each patient were obtained from the hospital's billing system. These individual charge records were aggregated into 21 unique cost centers (Figure 3.2), cost center specific full cost-to-charge ratios were applied to obtain approximated cost, and these costs were then added to the abstract data to form a combined record for each of the approximately 25,000 patients represented within each fiscal year. Specific detailed resource data for each billable service were also available within each of the 21 aggregate cost centers. A description of the data elements and permissible values for each element are

included in Appendix 2. All the data manipulation was performed on the Michigan Terminal System (MTS), the major research computer facility at the University of Michigan.

CHAPTER 5

APPLICATION/RESULTS

To increase the presentation clarity, specifics of the methodological steps and the corresponding results of the methodology's application to the eight DRGs selected for the current research are presented together. This chapter, which is organized in the same manner as the methodology presented in Chapter 4, has three major sections that discuss 1) the formation of practice patterns; 2) the identification of pattern characteristics; and 3) the association of specific providers with different practice patterns.

Formation of Practice Patterns

The first critical step in analyzing variation in intermediate product use involved identification of difference patient treatment resource consumption patterns. If differences in the volume and/or type of intermediate products consumed could be identified, then intermediate product variation is available as the basis for further analysis. If differences in practice patterns could be identified, then a second concern was whether the different

practice patterns were stable over time. If the differences in practice patterns represented an aberration, rather than differences in patient treatments, then any action taken to alter the practice patterns would be unproductive. Finally, it was necessary to determine the financial significance of the pattern differences. If there is little cost reduction potential to be gained from altering the patterns, then further analysis may not be worth the effort.

Determination of Intermediate Products used

The mechanics of attempting to define practice patterns across 21 aggregate cost centers using a Minkowski distance measure would be computationally complex and difficult to interpret. Therefore, the number of aggregate cost centers that defined intermediate product use had to be reduced. The reduction in aggregate cost centers was accomplished through two separate processes which actually selected those aggregate cost centers determined to be the "most important" in defining practice patterns.

The first selection process identified categories of intermediate products (aggregate cost centers) in which the variation in cost among patients could be attributed more to physician differences than to patient differences. In this process, individual cost centers were selected for inclusion in a practice pattern if physician differences explained more of the variance in cost than did differences in the severity measure. The percent of variance explained was

computed using the Automatic Interaction Detector (AID) procedure contained in the OSIRIS.IV Statistical package (OSIRIS, 1981). AID follows the basic principle of least squares in determining which single independent variable, at each step in the AID procedure, provides maximum improvement in the ability to predict values of the dependent variable. With total cost for each intermediate product serving as the dependent variable, and physician identification number and the patient's severity index (stage number) as the independent variables, AID identified one of the two independent variables as most important in explaining variation in intermediate product cost. If physician number was selected as the more important independent variable in explaining cost variation, then the resource cost center associated with that intermediate product was retained for further investigation. If, on the other hand, the stage variable was more important in explaining variation in total intermediate product cost, then the associated cost center was removed from further consideration. The objective of this step was to identify aggregate cost centers (intermediate products) in which the variation in cost was explained primarily by physician differences, rather than by patient medical condition differences.

The second intermediate product (aggregate cost center) selection process involved DRGs where physician identification was the important variable in explaining variation in costs within the DRG for all the aggregate cost

centers. This situation occurred when the variation in cost was not highly correlated with severity or, in some cases, when stage was not a good measure of severity. For such DRGs, the aggregate cost centers that contributed more than 5% to the total DRG treatment cost were kept for further investigation.

The selection process just discussed and the results achieved are presented in Figure 5.1 and summarized as follows:

a. If physician and severity variables were both important in explaining cost variance in the different aggregate cost centers (intermediate products), then the cost centers where physician was important across the two years were selected. The cost centers for DRG 82, Respiratory Neoplasms (Appendix 3.2), and DRG 355, Non-radical Hysterectomy (Appendix 3.6), were selected under this decision rule.

b. If only physician was important in explaining cost variance, then the selection decision was based on the cost center's contribution of more than 5% to total costs. The practice pattern variables for DRG 14, Cerebrovascular Disorders (Appendix 3.1), DRG 88, Chronic Obstructive Pulmonary Disease (Appendix 3.3), DRG 127, Heart Failure and Shock (Appendix 3.4), DRG 198, Total Cholecystectomy (Appendix 3.5), and DRG 209, Major Joint Procedures (Appendix 3.7), were selected under this rule.

c. If only severity of the patient's condition was

FIGURE 5.1
Selection of Intermediate Products

DRG	Description	Cost Centers
14	Specific Cerebro-vascular Disorders except TIA	LOS Lab Pharmacy EKG/EEG Physician Med ICU
82	Respiratory Neoplasms	Radiology Surgery Physical Therapy
88	Chronic Obstructive Pulmonary Disease	Bed Days Lab Pharmacy Respiratory Therapy
127	Heart Failure and Shock	Bed Days Lab Pharmacy Respiratory Therapy
198	Total Cholecystectomy	Bed Days Lab surgery
355	Non-radical Hysterectomy	Pharmacy Lab Surgery
209	Major Joint Procedures	Bed Days Pharmacy Lab Med Supplies
215	Back and Neck Procedures	Dropped from Analysis

important in explaining the cost variance, then the DRG was dropped from further analysis. DRG 215, Back and Neck Procedures (Appendix 3.8), was eliminated under this rule. The results of the selection processes are included at Appendix 3¹ for all DRGs.

Formation of Practice Patterns

Certain data adjustments were used to ensure that the clustering technique provided homogeneity of resource use within the groups which were formed. To reduce the skewness of cost distributions, logs of the intermediate product costs were computed. Further, since there was no a priori method of weighting the different resources, it was decided to standardize the log values $((\text{value} - \text{mean})/\text{standard deviation})$. This standardization caused each of the different cost centers to have an equal weight in the cluster analysis. Finally, the level of intermediate product use for each patient was severity adjusted in order to reduce the total cost variation observed in the practice pattern. Within each severity level for each resource, the mean cost of the total patient population was subtracted from the individual patient's actual cost. For each

¹In some DRGs, Adult Bed costs were used to measure intermediate products associated with room costs and in other cases lengths of stay were used. Due to the mechanics of the cost accounting system, bed costs would be a misleading variable to reflect differences in intermediate product use if there were significant ICU costs, since there would be no accumulation of routine costs. Therefore, in DRGs with significant ICU costs, LOS was substituted for bed costs.

patient, the residual represents a level of intermediate product use adjusted for the effect of severity. Therefore, the intermediate product use for patients with different levels of severity could be compared, since the influence on intermediate product use attributable to the different severity levels was removed. The final cluster groups were thus formed using variation in intermediate product cost patterns from an overall group norm, with the variation due to factors other than differential severity of the patient's medical need.

One of the difficulties associated with clustering lies in deciding how many groups to form. Unfortunately, this fundamental step requires subjective evaluation (Everitt, 1979). In the present analysis, the number of cluster groups was determined by a subjective visual inspection of the cluster structures as they were formed. A graph of the number of clusters against the measure of the distance between two clusters when they were joined at a given step was completed. Large 'jumps' in the distance coefficient suggested that at that step two relatively different clusters were joined. Therefore, large increases in the between group distance coefficient suggested the existence of heterogeneous clusters.

The results of clustering the 1983 and 1984 data sets for the seven DRGs are reported in Appendix 4 and 5. Appendix 4 provides the mean log values for each of the intermediate product groups used in the practice pattern

definitions. In addition, the mean of the sum of the intermediate products costs and the mean of the total costs for each cluster group are presented. In Appendix 5, the practice pattern differences are graphically displayed with the y-axis representing the standardized log deviations from the overall DRG mean. The patterns are graphically differentiated from each other by the use of different notations for each cluster group (i.e. dotted, dashed, solid, etc.). Therefore, the practice pattern differences within each DRG and between years within DRGs are displayed. Although a few of the graphical displays (e.g. DRG 82 - Appendix 5.2) require a careful examination in order to differentiate the patterns, the cluster analysis produced patterns which were different from each other and generally repeated across years.

A major thrust of the research reported here was to define practice patterns in a manner which reflected the interrelationships in the use of intermediate products. An interesting result was that two primary patterns of intermediate relationships emerged. For example, in some DRGs (e.g. DRG 88 - Appendix 5.3, DRG 198 - Appendix 5.5, and DRG 209 - Appendix 5.7), the patterns represent different levels of resource use but no interaction. In these DRGs, it appeared that the intermediate product use differences were highly correlated with LOS. In other DRGs (e.g. DRG 14 - Appendix 5.1, DRG 82 - Appendix 4.2, DRG 127 - Appendix 5.4, and DRG 355 - Appendix 5.6), there was

considerable crossing among the different patterns in their respective levels of different intermediate product use. These results suggest a more complex physician decision logic affecting the selection of the type and volume of intermediate products.

Financial Significance of Clusters

Analysis of Variance (ANOVA) is not a sufficient statistical technique to evaluate clustering results. This observation can be demonstrated by hypothetically applying cluster analysis to a distribution which is accepted as approximately normal. For example, the results of a cluster analysis on a distribution of I.Q. scores could return two clusters with respective means of 70 and 130. If an ANOVA was performed with cluster number as a categorical variable to explain variation in I.Q. scores, a significant F-statistic would be reported. A significant F-statistic would also be reported, if instead of a normal distribution, the distribution was bimodal with means of 70 and 130. Thus, discriminating differences in means for the cluster groups is a necessary, but not sufficient, step in evaluating the value of a cluster analysis.

In the research reported here, however, there was less concern with the capability of cluster analysis to identify different physical states of nature, as would be implied by a bimodal distribution, and more concern with differentiating the treatment process with respect to the

relative variability in the manner in which the volume and type of intermediate products were combined to produce a patient treatment. Therefore, the results of an ANOVA were very important in demonstrating the financial significance of the differences in the practice patterns. If the differences in practice patterns were not financially significant, then there would have been little reason to continue the analysis.

In order to determine the financial significance of the cluster groups in explaining variation in intermediate product use, single ANOVAs were performed with the cluster groups identified in Appendix 4 as the independent variable. The dependent variables in the separate ANOVAs were patient costs measured in three different ways. -Within each DRG, the dependent variables included 1) the relative level of intermediate product use measured in standardized log deviations from the overall group mean; 2) the sum of the intermediate products used to define the practice patterns measured in dollars; and 3) total cost of each patient's episode of care. The results of these analyses are presented in Appendix 6 and summarized in Figure 5.2.

Two major items are of interest when examining these results: 1) the magnitude of the explained variance; and 2) the consistency of the practice patterns across the two years. There was no "standard" level of explanatory power to use in determining the worthiness of further analysis. The criterion used here was that an Eta-square above .20 -

FIGURE 5.2
Fraction of Variance Explained by Clusters - 1983/1984

DRG	Sum of Intermediate Product Cost		Total Cost	
	83 Eta Sq	84 Eta Sq	83 Eta Sq	84 Eta Sq
14	.38	.28	.28	.22
82	.50	.42	.30	.20
88	.35	.63	.33	.62
127	.51	.55	.55	.57
198	.39	.14	.36	.15
355	.64	.53	.51	.43
209	.43	.45	.42	.46

- Note 1) Sum of Intermediate Product cost is the total cost of the intermediate products used in defining the practice patterns.
 2) Total cost is the total cost of all intermediate products consumed in the patient treatment.

.25 explained a substantial enough portion of the variation in intermediate product use to justify further analysis. The results were generally comparable across the two years which signifies that the cluster analysis performed equally as well on both data sets.

Validity of the Cluster Solution

One of the concerns with cluster analysis is to determine the validity of the cluster solution. While different patterns were identified in the separate data sets, it was important to determine if the cluster solution simply had isolated aberrations within the different data sets or whether consistent practice pattern differences really had been discovered. It was also desirable, at this point in the analysis, to combine the patterns formed separately for 1983 and 1984 into a single pattern in order to simplify further analyses of the pattern differences. The results of two validation techniques and the financial significance of the combined patterns are discussed in this section.

a. Replication

If a cluster solution is discovered repeatedly across different samples from the same general population, then it can be inferred that the solution is a result of general relationships in the data set (Aldenderfer, 1984). On the other hand, a cluster solution which is not stable across data sets is unlikely to be useful in communicating valid

differences in practice patterns. The replication technique is a check on the internal consistency of the solution.

To test the replication of the clusters identified in the two data sets, bivariate frequency tables were computed. These tables matched patients classified into clusters from the separate data sets with the patient classification resulting from a combined cluster solution. The combined cluster solution was developed by merging the patients from the separate data sets and applying the same cluster methodology used previously. In order to adjust for any inflation effect occurring between years (which might distort the comparison of cost variability in the cluster analysis) the severity adjustment was accomplished separately within each data set before merging the patients into the combined set. The mean values of the combined cluster solution are presented in Appendix 7 and the graphical representations of the practice patterns are presented in Appendix 8.

The bivariate frequency tables are presented in Appendix 9. For each DRG, the patients assigned to clusters from the separate data sets were compared to the cluster solution from the combined data set. In order to identify deviations in cluster matches between years, the patients classified in each separate data set were compared to their classification resulting from the combined set. Therefore, three frequency tables are provided for each DRG, reflecting a comparison for the total set as well as comparisons for

each of the separate data sets.

For each frequency table in Appendix 9, four summary statistics are reported. First, the accuracy of an exact match of cluster membership between the combined and separate solutions was computed. This figure, however, may underestimate the stability of the clusters since the different cluster solutions did not result in equal cluster populations. For example, in Appendix 9.1, of the 274 patients treated in DRG 14, 102 were classified in cluster 1 as a result of the separate cluster analyses, and only 82 were classified in cluster 1 from the combined analysis. The difference is due to the changes which occurred in the relative relationships of the distance measures when the two data sets were combined. Therefore, the best match that could be achieved, due to differences in population sizes, was 80% (82/102). The second summary statistic shown for each frequency table in Appendix 9 accounted for patient movement between adjacent clusters due to changing relative relationships of the distance measures. The accuracy of the adjacent match was computed by adding patients in one adjacent cluster to the cluster total. For example, in Appendix 9.1, the Adjacent Match was computed as follows:

$$(70 + 0) + (52 + 13) + (60 + 6) + (3 + 7) = 211/274 = 76\%$$

The third and fourth summary statistics are a standard Chi Square and a Kappa (κ) statistic. The Kappa statistic measures the agreement in patient classification among the different cluster solutions that would be the result of

other than chance alone (Fleiss, 1981). Kappa values greater than .75 represent excellent agreement between the cluster solutions, values below .40 represent poor agreement, and values between .40 and .75 represent good agreement. Of course, statistical inference is not valid in testing the significance of the Kappa statistic since the same data that was used to generate the hypothesis of cluster formation cannot be used to generate statistical confidence. Therefore, confidence limits for the Kappa statistic are not provided. The summary statistics from Appendix 9 are summarized in Figure 5.3.

The results of the bivariate frequency tables indicated that the patterns were stable over time. The accuracy of the exact match for all patients ranged from 66% to 93%. The Kappa values for the combined solution were all in the "good" to "excellent" range. The adjacent match ranged from 76% to 100% and the Chi Square statistics were all significant. Considering that the cluster analysis is classifying patients according to relative variability in the cost of intermediate product use measured in standardized log deviations resulting from a medical care process that was changing over time, the results appear quite strong. Additionally, the patterns were stable regardless of whether the patterns interacted or not. For example, DRG 209, Major Joint Procedures (Appendix 8.7), exhibited practice patterns which were monotonically separate, with no overlap or interaction. The capability of

FIGURE 5.3
Summary of Bivariate Tables

DRG	Measures	Combined	1983	1984
14	Exact %	.69	.66	.72
	Kappa	.57	.53	.61
	Adjacent %	.76	.71	.82
	Chi-sq	280	140	173
82	Exact %	.69	.68	.70
	Kappa	.59	.59	.60
	Adjacent %	.89	.95	.92
	Chi-sq	610	401	273
88	Exact %	.74	.66	.82
	Kappa	.61	.52	.74
	Adjacent %	.94	.94	.94
	Chi-sq	469	234	275
127	Exact %	.68	.49	.83
	Kappa	.58	.35	.77
	Adjacent %	.96	.94	.97
	Chi-sq	715	267	594
198	Exact %	.93	.98	.88
	Kappa	.83	.95	.72
	Adjacent %	1.0	1.0	1.0
	Chi-sq	186	115	77
355	Exact %	.66	.77	.54
	Kappa	.50	.66	.34
	Adjacent %	.90	.98	.95
	Chi-sq	598	429	247
209	Exact %	.75	.72	.77
	Kappa	.65	.60	.68
	Adjacent %	.90	.92	.95
	Chi-sq	596	254	349

- Note 1) Combined Column is the cluster solution based on both 1983 and 1984 data sets. The column 1983 and 1984 is the cluster solution for the individual data sets.
- 2) Exact % is the cluster agreement for patients clustered separately/combined.
- 3) Adjacent % follows same logic as Exact % except agreement included adjacent cluster.
- 4) Kappa < .40 signifies poor support for cluster agreement, Kappa > .75 is excellent support, between .40 and .75 is good.

these patterns to be stable over time is perhaps not as surprising as the patterns exhibited in DRG 82, Respiratory Neoplasms (Appendix 8.2). These practice patterns exhibited differences both in the level of intermediate product use and in the manner in which the patterns demonstrated an apparent substitution among intermediate products. The internal consistency of these patterns across years provided evidence that the cluster solution classified patients according to differences in the consumption patterns of intermediate products.

b. External Validity

The significance of association of variables not used in a cluster's formation with individual clusters is considered among the better ways to validate a clustering solution (Aldenderfer, 1984). If variables are selected that theoretically should be associated with the different cluster groups and a significant result is discovered, then the validity of the cluster solution is strengthened. External validation directly tests the generality of the cluster solution against characteristics that should theoretically differentiate intermediate product use. In other words, the theoretical constructs developed in Chapter 1 (i.e., patient, physician, and outcome characteristics) pertaining to pattern differences should be significant in differentiating the clusters identified through the cluster analysis. If various physician, patient, or outcome characteristics were not different

FIGURE 5.4
Summary of Cluster External Validation

Characteristic	Diagnoses Related Group						
	14	82	88	127	198	355	209
PATIENT							
Age	x		x		x		x
Zip					x		x
Stage		x	x				
Payor					x	x	x
Admin Type	x	x	x		x	x	x
Race		x			x	x	
Teaching patient						x	
Sex							x
Religion							
ICD-9-CM		x	x	x		x	x
PHYSICIAN							
Specialty	x	x	x	x			
Discharge Service	x						
Physician	x	x				x	x
OUTCOME							
Discharge Status	x	x	x	x	x		x

Note 1) Where x signifies the variable was significant, Chi-square $P \leq .05$. Therefore, these characteristics are not independent with respect to cluster membership.

across the practice patterns, then the value of the cluster solution would be reduced significantly. In order to determine the association of various characteristics with the cluster solution, a Chi-square test of independence was utilized. If a significant chi-square statistic was discovered, then it was concluded that the instances of the various characteristics were not distributed among the clusters, but were dependent, or strongly associated, with a specific cluster. The results of the external validation are provided in Appendix 10 and summarized in Figure 5.4. The variable was considered significant if the Chi-square P-value was $\leq .05$.

Although the same external characteristic was not consistently significant in identifying practice pattern differences across all DRGs, there were a few characteristics that were important in a majority of DRG cases. Patient variables Admission Type and ICD-9-CM Diagnosis Codes, physician variables Specialty and individual physician identifier, and the outcome variable Discharge Status were fairly consistent in their significant association with the different patterns. The validity of the cluster solution was strengthened by the significant association of characteristics that theoretically support pattern differences in intermediate product use with the clusters.

c. Financial Significance of the Combined Clusters

Although the validity of the combined cluster solution

FIGURE 5.5
Summary of Financial Significance of Combined Clusters

DRG	Practice Pattern Intermediate Products Eta-sq	Total Costs Eta-sq
14	.19	.21
82	.27	.20
88	.44	.42
127	.29	.34
198	.36	.33
355	.51	.42
209	.56	.53

Note 1) Sum of Intermediate Product cost is the total cost of the intermediate products used in defining the practice patterns.

2) Total cost is the total cost of all intermediate products consumed in the patient treatment.

was supported by both replication and external validation, further exploration of the pattern differences was justified based on the financial significance of the clusters. The financial significance of the combined cluster solutions in explaining variation in 1) the individual intermediate measured in standardized log deviations; 2) the sum of the intermediate products measure in dollars; and 3) the total costs of the DRG are presented in Appendix 11 and summarized in Figure 5.5.

The results in Figure 5.5 supported continuation of the analysis. Although only 19% of the intermediate product use was explained in DRG 14, the other DRGs had a respectable portion of variation in costs explained by the cluster solution. If the reasons for the pattern differences could be identified and if these reasons are amenable to change, then the potential to reduce costs has been provided.

Development of a Predictive Model

Once practice patterns were identified within DRGs, it was important to develop a predictive model of pattern membership. If a model was developed that significantly improved the ability to predict patient membership in a practice pattern, then an increased understanding of the effect of the independent variables selected in the model on intermediate product use was demonstrated. Gaining a conceptual understanding of how the independent variables affected pattern membership was also considered important.

If physician practice patterns were to be affected by information from the model, then the model would have to provide assistance reaching an understanding as to how different independent variables (patient, physician, outcome) affect practice pattern membership.

One of the difficulties encountered in the analysis was that both the dependent variable (cluster group) and the independent variables were nominally scaled. Consequently, multiple regression analysis together with multiple and partial correlation analysis were not applicable, since these techniques assume interval scale measurement for dependent variables. Multiple Discriminate Function Analysis was also considered. While this technique accepts categorical measures of the dependent variable, it still assumes that all independent variables are interval scaled, and hence it could not be used. In addition, Multiple Discriminate Function Analysis, in allowing for interrelationships among predictors, derives a new set of independent variables (discriminate functions). From the conceptual view of understanding the relationships of variable effects, the discriminate functions may be conceptually arbitrary and uninterpretable (Andrews, 1973).

Multivariate Nominal Scale Analysis (MNA) was developed at the University of Michigan's Institute for Social Research by Andrews and Messenger (Andrews, 1973). MNA was designed to handle problems where 1) the dependent variable is nominally scaled; 2) the independent variable is nominal,

ratio or interval scaled; and 3) any form or pattern of relationships may exist between any independent and dependent variable and between any pair of independent variables. MNA determined the additive effect of independent variables in computing a probability of cluster group membership (dependent variable). MNA was designed to 1) help gain a conceptual understanding of the independent variable's effect on the dependent variable; and 2) assist in the development of accurate predictions. In contrast to Discriminate Function Analysis, MNA was designed for its output to be easily interpretable. Statistically, the MNA program is based on repeated applications of least squares dummy variable regressions. A complete discussion of the MNA statistical properties is available in Andrews and Messenger (Chapter 2, 1973).

The first point of interest in applying MNA involved the identification of the overall percentage distribution of patients within the different clusters. For example, as shown in Appendix 12.1, 30% of the patients were classified into cluster 1, 23% into Cluster 2, 39% into Cluster 3, and 8% into Cluster 4. Therefore, if one wished to predict the practice pattern for any particular patient without any additional information, one would have chosen the modal group (Cluster 3) and have been correct 39% of the time. Appendix 12 provides four summary statistics which indicate the effectiveness of the MNA model to predict patient membership in a cluster. The results are summarized in

Figure 5.6.

First, a Multivariate Theta (θ) statistic, which generalizes a Bivariate Theta (θ_i) statistic, was used to assess cluster predictive capability. The Bivariate Theta is defined as the proportion of patients classified correctly when using a prediction-to-the-mode strategy in the frequency distribution of each category of the individual predictor variables (Andrews, 1973). The Multivariate Theta generalizes this concept over all independent variables. In Figure 5.6 (DRG 14), the Multivariate Theta of .60, for example, indicates that 60% of the patients could be classified correctly after taking into account each of the patient's scores on the different independent variables. The specifics of the MNA prediction of patients within each cluster is provided in Appendix 13.1 - 13.7.

A reporting of the MNA model's capability to predict patient membership compared to chance alone is displayed in two ways. First, a gain in predictive accuracy is computed by comparing the difference between the model's prediction (e.g., 60%) and the modal group (e.g., 39%) to the modal group (e.g., 39%). Second, the fraction of the unexplained variance that the model explains is computed by comparing the difference between the model (60%) and the modal group (39%) to the unexplained variance ($1 - .39$). As shown in Figure 5.6 (DRG 14), the MNA model provides a 55% gain in predictive accuracy over chance alone and explains 34% of

FIGURE 5.6
Summary of Effectiveness of MNA Model

DRG	R^2	Modal Fraction	θ	Gain Exp Var	Decrease Unexp Var
14	.25	.39	.60	55%	34%
82	.17	.30	.51	67%	30%
88	.13	.34	.51	50%	18%
127	.09	.35	.44	24%	14%
198	.27	.73	.81	10%	35%
355	.25	.47	.61	30%	26%
209	.16	.40	.55	39%	25%

- Note 1) R^2 = Generalized Multiple Correlation Ratio
- 2) Modal Fraction is the % of total patients in the modal cluster.
- 3) θ is the Multivariate Theta
- 4) Gain Exp Var is the gain in explained variance due to predictive model

$$[(\theta - \text{Modal Fraction}) / \text{Modal Fraction}]$$
- 5) Decrease Unexp Var is the portion of unexplained variance explained by model.

$$[(\theta - \text{Modal Fraction}) / (1 - \text{Modal Fraction})]$$

the variance left unexplained by chance alone.

Finally, a Generalized Squared Multiple Correlation (R^2) is also shown in Figure 5.6 (DRG 14). An R^2 of .25 which is equivalent to a multiple correlation of .50 was roughly interpretable as having explained 25% of the variance in the dependent variable.²

In addition to understanding the overall capability of the independent variables to predict intermediate product use, it also was important to understand the individual contribution of each of the independent variables. While the MNA model provided an increased ability to predict intermediate product use, it was important to determine the relative contribution of the independent variables (i.e., patient, physician, and outcome). If the practice patterns were valid and financially significant, but the important variables in predicting intermediate product use were patient and outcome related, then modification of physician practice patterns would be inappropriate. In fact, there may be little the institution could do to alter intermediate product use, in such an instance, short of encouraging a more advantageous patient mix. If, however, a physician related independent variable was important in the MNA model's predictive ability, then intermediate product use

² The concept of variance when applied to a nominally scaled dependent variable is a subtle one. The generalized R^2 is actually a variance-weighted average of the R^2 which result from the separate analyses of each category of the dependent variable when each category is treated as a dummy variable (Andrews, 1973).

could potentially be changed by influencing the physician's selection and or volume of intermediate products consumed in the management of the patient case.

An MNA statistic, Bivariate Theta (θ_i) (where (i) is the specific independent variable) measured the strength of the simple bivariate relationship of the individual independent variable toward practice pattern membership. This statistic provided the same function for a single independent variable as the Multivariate Theta provided for the total model. For example, in Appendix 14.1, the Bivariate Theta (θ_{MD}) for physician is 56.6, indicating that knowing only a patient's physician would permit correct prediction of pattern membership 90% of the time. The percent column in Appendix 14 relates the gain in predictive accuracy due to the bivariate relationship to the accuracy of the overall model. As shown in Appendix 14.1, for example, 90% of the gain in accuracy from the overall model could be captured by utilizing the simple bivariate relationship of physician.

Association With Individual Physicians

Examination of the detailed statistics for the physician variable provides an indication of the importance of this variable as a predictor of pattern membership, holding constant all other independent variables. The detailed statistics are provided in Appendix 15. Before explaining their use, however, an orientation to Appendix 15

is provided.

Explanation of Detailed Statistics

As an example, a portion of Appendix 15.1 is reproduced as Figure 5.7. The upper left-hand corner of Figure 5.7 shows the total number of patients (274) classified in DRG 14 for both 1983 and 1984. Reading across from this figure are the number and percent of total patients classified into each cluster. Reading down from the total patient figure are the individual physician code numbers, the number of patients treated by that physician, and the percent of the total patients treated by the physician. Reading across from the above statistics, and separated by double solid lines, are the three detailed statistics for each physician (e.g. %, adj%, and coefficient).

The row labeled "%" (percent) shows the percent distribution of that physician's patients in the different clusters. Comparison of an individual physician's percent with the total percent across all patients shows how this physician differs from the average of all physicians in practice pattern membership. For example, in Figure 5.7, physician 1 has 87.5% of his patients classified into Cluster 4 when the average across all physicians is 8%.

The row labeled "coeff" (coefficients) contains the core of the additive model upon which MNA is based. These coefficients show the effect of an individual physician on the likelihood of patient membership in each practice

FIGURE 5.7
Detailed Physician MNA Statistics

Description	Measure	C1 1	C1 2	C1 3	C1 4
Total = 274	N	82	64	106	22
	%	29.9	23.4	38.7	8.0
MD Code = 1	%	0.00	0.00	12.50	87.50
N = 16	Adj%	5.58	4.35	4.98	85.10
Total% = 5.84	Coeff	-24.35	-19.01	-33.71	77.07
MD Code = 2	%	33.33	26.67	40.00	0.00
N = 15	Adj%	32.33	27.59	38.78	1.29
Total% = 5.47	Coeff	2.41	4.24	0.09	-6.47
MD Code = 3	%	27.27	27.27	45.45	0.00
N = 11	Adj%	21.81	23.30	53.97	0.91
Total% = 4.01	Coeff	-8.11	-0.05	15.29	-7.12
MD Code = 4	%	16.67	59.52	21.43	2.38
N = 42	Adj%	19.57	61.99	16.27	2.17
Total% = 15.33	Coeff	-10.36	38.63	-22.42	-5.86
MD Code = 5	%	37.50	25.00	37.50	0.00
N = 16	Adj%	35.82	21.79	41.96	0.43
Total% = 5.84	Coeff	5.89	-1.56	3.27	-7.60

Note 1) The figures are for 1983 and 1984 combined.

pattern. Taken into account in these coefficients are 1) any relationships among various independent variables (i.e., physician and discharge status); and 2) any relationships among each independent variable and the dependent variable (i.e., cluster membership). Consequently, the coefficients indicate the gain or loss in likelihood of pattern membership after holding constant all other independent variables. Stated another way, the coefficients indicate the effect of the physician on practice pattern membership if the physician's patients were distributed as in the general patient population with respect to all other independent variables.

In Figure 5.7, for example, physician 1 had no patients in cluster 1 when the average physician would have had 29.9% in cluster 1. However, the coefficient shows that some of this effect was due to discharge status, and this effect is removed when discharge status is held constant. Rather than 29.9% less likely, physician 1 is slightly less likely (24%) to have patients classified into cluster 1. Therefore, it appears that some of the difference in the percent of patients classified into cluster 1 were due to the correlation of discharge status with physician identification. The adjusted percent figure, therefore, relates only the physician effect on pattern membership.

The row labeled "adj%" (adjusted percent) is the sum of the coefficient and overall percent for that category. For example, in physician one's case:

$$\text{Adj\%} = \text{coeff} + \text{overall \%}$$

$$5.58 = -24.35 + 29.9$$

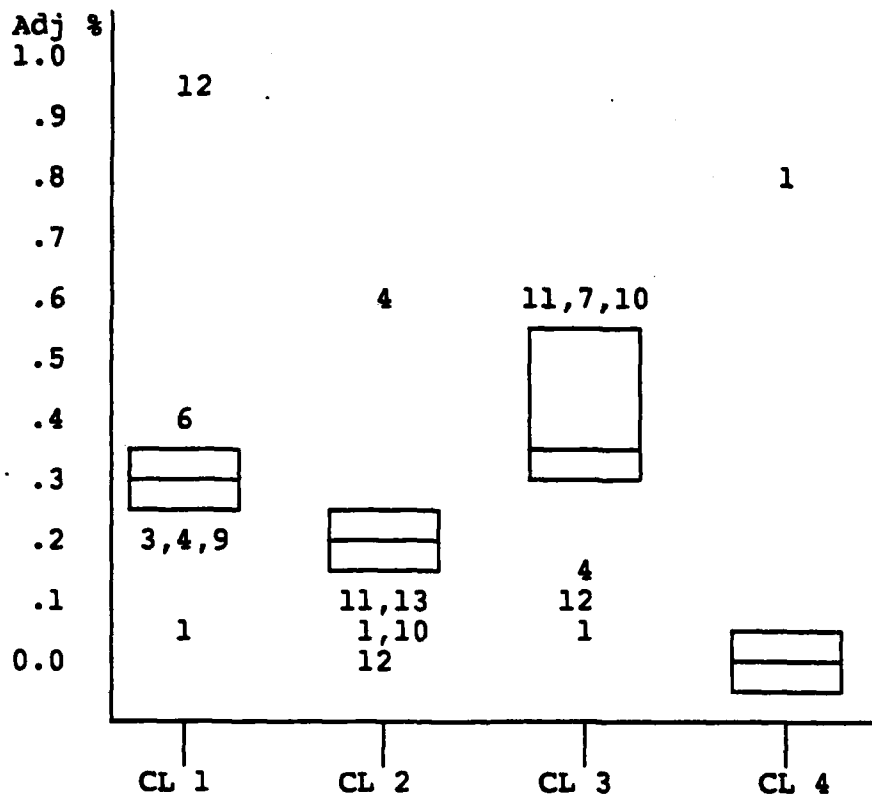
Therefore, while the adjusted percent (5.58) has changed slightly in comparison to the overall percent, the result shows that the difference in patient membership is still largely due to the treatment patterns of this physician.

Application of Detailed Statistics

Appendix 16 presents data on the effect of an individual physician on patient membership in a practice pattern. Association of individual physicians with different practice patterns was accomplished by visually comparing adjusted percentages among physicians utilizing a modified Box-and-Whisker diagram (Hortwig, 1981). Box-and-Whisker diagrams provide a focus on a part of the distribution of adjusted percentages among physicians which was of most interest --the extreme values or tails. There was less interest in investigating physicians who tended to practice near the group norm. In Figure 5.8, the Box-and-Whisker diagram from Appendix 16.1 has been reproduced in order to clarify its interpretation.

In Figure 5.8, each cluster is represented by a box formed by an upper and lower bound. Each box includes 50% of the physicians who treated patients in each cluster. The horizontal line within the box represents the mean percent across all physicians. For example, 50% of all physicians had an adjusted percent of their patients of between 25% and

FIGURE 5.8
Association of Single Physicians with Patterns



- Note 1) The adj% is the percentage of a physicians cases classified into the different clusters holding constant all other independent variables.
- 2) The numbers on the figure represent individual physician identification.

35% classified into Cluster 1. Physicians beyond these boundaries are marked individually according to their individual adjusted percent scores for each cluster. It is thus easy to pick out physician 12 as highly associated with cluster 1 and physician 1 as highly associated with cluster 4. There is, of course, symmetry in the diagram. If, for example, physician 12 is highly associated with respect to cluster 1, then he/she should have a low association with respect to the other clusters. In some cases, the lack of precision of the y-axis did not allow all physicians to be graphically represented (e.g., cluster 4). In this case, all physicians except physician 1 were grouped around the group mean. In reviewing Figure 5.8, it is quite easy to associate individual physicians with specific practice patterns. Since these results utilize the adjusted percent coefficient, they are independent of the effects of the other independent variables.

Summary

A summary of the research reported here is broken into three areas: 1) formation of practice patterns; 2) association of patterns with patient, physician, and outcome characteristics; and 3) association of individual physicians with specific practice patterns.

a. Formation of Practice Patterns

Practice patterns which reflect differences in the volume and type of intermediate products consumed in treating patients classified into various DRGs can be

identified (Appendix 7,8). Further, differences can be validated by 1) the internal consistency of the intermediate product relationships across time (Appendix 9); and 2) by association of the patterns with external variables (patient, physician, and outcome characteristics) not used in the pattern's formation (Appendix 10). The financial significance of the patterns in explaining variation in intermediate product cost can also be determined also (Appendix 11).

The capability to identify different patterns which relate to the manner in which intermediate products were combined to produce a patient treatment within a specific DRG has been demonstrated. Therefore, a crucial step in determining the feasibility of implementing a cost reduction strategy based on improving clinical productivity has been demonstrated.

b. Association of Patterns with Characteristics

The association of the different practice patterns with physician, patient, and outcome characteristics was demonstrated successfully. An MNA model of practice pattern membership was developed which, when compared to chance alone, increased significantly the ability to forecast patient membership in a pattern (Appendix 12, 13). The predictor variable that was most consistent in its contribution to the accuracy of the MNA model was individual physician identification (Appendix 14). This was an impressive finding which directly supports the hypothesis

that physician practice style differences are important in explaining differences in intermediate product use.

It was hypothesized in Chapter 4 (Selection of Diagnosis-Related Groups) that variation in physician practice style would be easier to identify in medical than surgical cases. Although this hypothesis was generally proven to be correct, physician was an important variable in predicting practice pattern membership in DRG 355, Non-radical Hysterectomy (Appendix 14.6). It is important to note that physician was not always the most important predictor variable (e.g. DRG 198, Total Cholecystectomy - Appendix 14.5; and DRG 209, Major Joint Procedures - Appendix 14.7). If physician had been identified consistently as the most important predictor variable, then it might be possible that the MNA model was somehow biased toward physician effect. The mixed results, however, provide increased confidence that the MNA model has identified in a valid fashion when physician was or was not important in differentiating intermediate product use. It is concluded that in certain DRGs, individual physician practice styles have a significant effect on the level and/or type of intermediate products consumed within a patient treatment.

c. Association of Single Physicians with Patterns

If physician practice styles are to be affected, then individual physicians must be associated with the different patterns. The capability of associating individual

physicians with different patterns was demonstrated (Appendix 15 and 16). It is clear from the results presented in Appendix 16 that different physicians utilize different volumes and types of intermediate products in treating similar patients, after adjustments are made for the effects of other variables in the model. Although professional judgements will be required to evaluate the appropriateness of the different patterns, it is concluded that individual physician practice styles significantly affect intermediate product use.

In Chapter 6, general implementation issues are discussed, including the magnitude of potential cost savings that might result if a cost reduction strategy was implemented based upon the current research. In addition, future improvements in the research approach are discussed.

CHAPTER 6

IMPLEMENTATION AND FUTURE WORK

The current research has identified physician-associated practice patterns that could lead to cost reductions within an acute care facility through modification of physician practice styles. This chapter discusses implementation issues related to the current research and future work to be considered in improving the research approach.

Implementation Issues

Implementation issues are categorized into three major areas of concern. First, the magnitude of the cost reduction potential is computed. Second, issues related to the capability of an institution to operationally install this research approach are discussed. Finally, the importance of the institutional environment, particularly the medical staff attitude toward cost reduction, is presented.

Magnitude of Potential Cost Reduction

It is difficult to determine precisely the magnitude of

cost reductions that might result from the application of the research reported here, since the clinical appropriateness of the different patterns has not yet been evaluated. A range of potential cost reduction, however, can be computed. An upper bound can be estimated, for example, by assuming that the lowest cost pattern is appropriate for all patients. This would assume that regardless of the different patient characteristics among the patterns (i.e. differences in discharge status, ICD-9-CM diagnosis and procedural codes, etc.) the utilization of intermediate products for all patients should mirror the lowest cost pattern. The cost reduction impact of the differences in the patterns is computed by subtracting the mean of the lower cost pattern from the other pattern means and multiplying the result by the number of patients in each pattern.

A lower bound can be estimated by multiplying the upper bound by the increase in predictive accuracy from the MNA model (Appendix 14) that is attributed directly to the physician identification. Such a calculation can be viewed as a lower bound because it includes only the physician effect that can be measured explicitly. Thus, this lower bound assumes that no portion of the unexplained component of pattern membership is due to physician. It also assumes that the higher cost patterns are appropriate, in that the patient characteristics that differentiate the patterns are considered to be valid reasons for intermediate product use

FIGURE 6.1
Range of Potential Cost Reductions

DRG	Number of Patients	UPPER BOUND Cost Reduction Due to Pattern Differences (in dollars)	UPPER BOUND COST/CASE	Physician Effect (Appendix 14)	LOWER BOUND Cost Reduction Attributed To Physician (in dollars)	LOWER BOUND COST/CASE
14	274	1,644,240	6001	.199	327,203	1194
82	364	866,488	2380	.088	76,250	209
88	338	1,130,697	3345	.072	81,410	241
127	394	1,150,412	2920	.041	47,466	120
198	263	93,940	357	0	0	0
355	566	305,955	541	.090	27,539	49
209	422	683,078	1619	.021	14,345	34
		5,874,850	2241		531,512	203

Note 1) All cost figures are for 1983 and 1984 Combined.

differences. While discharge status may be related to a higher cost pattern, it should be noted that increased use of intermediate products may not be clinically justified. Clinical investigation of pattern differences may reveal higher cost reduction potential than is implied by physician differences alone. Additionally, physician was not important in differentiating patterns in DRG 198, Total Cholecystectomy, which indicated general physician agreement on the practice pattern. Such high physician agreement, however, might provide a potential to shift the entire practice pattern. Thus, the methodology's capability to describe the practice pattern, even when there is no difference in clinical productivity, might provide incentives for physicians to agree on a lower cost pattern.

Upper and lower bounds calculated as just discussed are shown in Figure 6.1. The "true" cost reduction potential probably lies within the bounds. If an institution were to consider implementation of a cost reduction strategy based on the current research, it is clear that the estimate of cost savings should be greater than the costs of implementing the cost reduction strategy. Although the range of patient cases (DRGs) was limited in the current research, the results of this research application suggest that an institution can expect to discover a physician effect across its total cases.

Institution Specific Issues

When considering implementing a cost reduction strategy based on clinical productivity comparisons, a hospital should evaluate a number of institution specific characteristics. These characteristics include sophistication of its information systems, availability of statistical software, personnel training and skill level, and hospital size. Information system support must be fairly sophisticated to form practice patterns. At a minimum, an institution would require the capability to combine financial data from the patient's bill with clinical record abstract data that are at least as complete as the UHDDS. Although charges could be used as the distance measure in the cluster analysis, the accuracy of the cluster solution would be enhanced if costs, rather than charges, were available. Additionally, data related to the identification of the physician managing the case, the physician's specialty, and the physician's association with a hospital department must be available. Therefore, a database that associates an inpatient episode of care with patient, physician, and outcome characteristics (Appendix 2) and includes intermediate product cost data should be available. It would also be helpful if an on-line data manipulation capability were available for interactive access.

An institution would also require access to automated statistical packages that can support Cluster Analysis (Fox, 1976), Multivariate Nominal Analysis (Andrews, 1973), and Automatic Interaction Detector (AID) (Sonquist, 1973). Although other statistical techniques could be substituted for AID and MNA, the effect of such substitution on the validity of the results is, of course, unknown.

Skilled personnel to implement the strategy would also be required. Unfortunately, the formation of practice patterns and determination of pattern differences cannot be completely automated, primarily due to the subjective decisions required in the application of the cluster analysis. In addition, decisions must be made at each step in the application of the methodology as to whether further analysis is justified. Therefore, the application of the methodology requires an individual with a combination of statistical, information system, and conceptual skills. Depending on the experience and education of personnel within the institution, outside assistance might be required on a full or part-time basis.

Finally, institutional size would have to be considered, since there must be a sufficient sample size within each of the DRGs to be investigated. An adequate case load would be required to provide confidence in the statistical technique results and to provide sufficient physician case-loads to allow individual physician practice differences to be identified. In the current research, DRGs

with less than one hundred cases and/or physicians with fewer than five cases per year within the DRG were not considered. Thus, some hospitals might have difficulty generating sufficient case loads to conduct the analyses. This limitation can be solved, to some extent, by combining patients from several years. The inclusion of patient across several years, however, decreases internal validity of the results since the effect of "history" alone can cause differences among the practice patterns (Cook, 1979).

Medical Staff Environment

Reducing hospital costs by improving clinical productivities depends on the success in shifting physician practice styles to lower cost patterns. An institution's capability in affecting practice patterns depends jointly on 1) the ability to identify pattern differences; and 2) on the receptiveness of the medical staff in accepting change in individual practice styles. The focus of the current research has been on determining the feasibility of identifying practice pattern differences in order to develop a "tool" to direct cost reduction efforts. Regardless of how well this tool functions, the effectiveness of cost reduction efforts depends on how well the medical staff utilizes it. Observations of medical staff relationships within the study institution provides insight into potential effectiveness of the cost reduction strategy proposed in the current research effort.

A great deal of effort was expended sensitizing the medical staff to the importance of providing care that is not only high quality but is also delivered in a cost efficient manner. The demonstration institution is most fortunate to have a physician "statesman" who is influential in both the formal administrative and medical staff organizational structures and who is held in high clinical regard by the medical staff members. The leadership provided by this individual is considered the most crucial element in a cost reduction strategy aimed at changing physician practice patterns.

An example of the leadership exhibited within the medical staff in preparing physicians for the more constrained fiscal environment introduced by PPS is a change which occurred in the Medical Staff By-laws. With no dissenting votes, the medical staff altered its governance to reflect that staff privileges are at risk for physicians who provide care inefficiently. Clearly, the medical staff within the study institution has instilled, through strong leadership efforts, a positive attitude toward developing efficient patterns of care.

An example of the joint effect between medical staff attitude and the adequacy of the information system tool is highlighted by reviewing the results of a cost reduction meeting that was held with the Orthopaedic surgeons in early 1985. Conducted before the current research was completed, the meeting's topic was the gross variation in the cost

distribution of patients treated within DRG 209, Major Joint Procedures. While the surgeons recognized that variation in cost was an appropriate cost reduction concern, the effect of patient differences (in level of severity and type of surgical procedures performed) was definitely an issue. Although the surgeons were open to change, they insisted that variation in cost due to the patient differences had to be accounted for before physician practice pattern differences were addressed.

If the information system tool is inadequate in the eyes of the physician group, change will be difficult to achieve. Of course, if medical staff leadership is poor, then change will be extremely difficult to initiate. Consequently, both the tool and the medical staff must be capable of supporting practice pattern change. When considering implementation of a cost reduction strategy based on clinical productivity comparisons, the adequacy of the medical staff leadership must be evaluated, and if necessary, nurtured.

Future Work

A number of observations concerning the future development of the methodology reported in the current research can be made. The areas for future work encompass a wider application of the methodology, improvements in the methodology, and further investigation of the reimbursement implications of physician practice pattern effects on

clinical and facility productivities.

Wider Application

The current research application was limited to a narrow set of DRGs within a single institution. The ability to define and differentiate practice patterns should be tested with a broader scope of DRGs across multi-institutions.

A research paper in progress at the University of Michigan addresses an analytical approach to identifying which DRGs in an institution should be the focus of cost containment efforts (Martin, 1985). In investigating a much broader range of DRGs, this in-progress research addresses the identification of DRGs having the greatest physician-associated cost variation, and therefore, the greatest potential to reduce costs through the improvement of clinical productivities. It is anticipated that this research will identify a wider range of DRGs within the study institution for application of the current research methodology.

While the current research effort was limited to a single institution, the identification of practice patterns should be expanded to include multi-institutional settings. One would expect much wider variation in costs when multi-institutions are included in the analysis. It would be of academic, as well as of practical, interest to determine the ability to explain variation in intermediate product costs

across institutions. Although individual institutions probably would exhibit different practice patterns, due to differences in medical staffs, practice pattern differences might repeat consistently across institutions. If practice patterns did repeat across hospitals, then the results could be generalized, and there would not be a need to replicate the analysis within each institution. Therefore, the current research could serve as an empirical research tool in addition to its institution-specific application.

The inclusion of the institutional source of variation in intermediate product use would certainly complicate the analysis. The definition, reliability, and validity of the data (i.e., patient, physician, outcome, and cost characteristics) required for the analysis would have to be carefully evaluated. Additional data to identify institutional differences would have to be conceptually developed and recorded. The mechanics of incompatibility of information systems across hospitals would have to be addressed. The implications of multi-institutional variation are, however, important for policy analysis in evaluating the institutional equity of PPS and for overall cost reduction potential in determining the physician effect in contributing to clinical productivity differences across institutions.

Improvements in Methodology

The capability to identify potentially inappropriate

intermediate product use has been demonstrated in the research reported here. The demonstration of this capability was a necessary first step in developing a cost reduction strategy based on the explicit articulation of the sources of variation among clinical productivities. Before implementing a cost reduction strategy based on the research reported here, however, further refinement in the capability to differentiate clinical productivities should be considered.

The next logical step following identification of practice pattern differences would be to identify those specific intermediate products which account for the cost variation. The utilization of intermediate product volume, rather than aggregated cost, data would identify the individual intermediate product volume and mix differences among the practice patterns. Therefore, information could be provided to the medical staff that, in addition to associating individual physicians with different practice patterns, identified the specific intermediate products which accounted for the pattern differences.

It is interesting to note that the database required to compare individual clinical productivities exists at the study institution. Individual records for each intermediate product which generated a charge in a patient's bill have been combined into a "resource database". This database contains the patient number, admission date, identification number of the intermediate product, intermediate product

description, quantity consumed, and charge for the intermediate product.

The procedure of comparing practice patterns would be fairly straightforward and could be accomplished by subtracting the average quantity of intermediate products consumed in each pattern from the other patterns. Where the intermediate product use was similar among patterns, it would cancel out. Therefore, both the high and low levels of intermediate product use that reflect both volume and mix differences could be displayed for the different patterns.

To provide information to the medical staff in the most clinically meaningful manner, an additional capability needs to be added within the database. Intermediate products within each aggregate cost center should be "mapped" in a clinically meaningful way in order to facilitate the investigation of pattern differences. A hierarchical relationship should exist within the database that clinically groups the intermediate products. For example, antibiotics should be grouped separately from barbituates. If these relationships were developed, then it would be fairly easy to "traverse" the hierarchical relationship within the database to determine within which clinical groups large differences exist. The ability to focus on particular subsets of the resource database would facilitate the investigation of specific intermediate product differences among practice patterns.

Further development work on measuring outcomes of care

specificity is also required. The exploration of explicit criteria for assessing both the process and outcome of care is probably best presented by Donabedian (1982), who reviews the work of such pioneers as McNerney (1962), Payne (1967), Sullivan (1966), Williamson (1978), and Rubenstein (1977). The "school of thought" that deals with the use of explicit criteria to assess health outcomes has been developed through the work of Williamson (1977), Brook (1977), and Mushlin (1980) among others (Donabedian, 1982). Although the ultimate judgement of quality must rest on implicit review of the entire record of patient care, the use of explicit criteria is encouraged. It is clear that improvements in the specificity of assessing health outcomes are required when encouraging changes in the volume and/or types of intermediate products consumed in the process of care.

In hind-sight, an improved method of identifying intermediate products to be used to define practice patterns should be considered. Rather than selecting intermediate products based on relative variance in cost explained by either the physician or severity variables (Chapter 5, Determination of Intermediate Products), the intermediate product selection should have been based on their relative contribution to the total treatment cost. Utilizing the former selection rule (e.g., variance explained), DRG 215, Back and Neck Procedures, would not have been dropped from the analysis. The greater cost variance explained by the

severity variable could have masked significant physician practice style differences. Therefore, DRG 215 was probably dropped from the analysis prematurely and inappropriately.

Investigation of Reimbursement Effect of Clinical and Facility Productivity

As discussed in Chapter 3, research is required to determine the relationship between physician practice pattern effects on clinical productivity (intermediate product use) and facility productivity (admission/surgical rates). Physician effects on both types of productivity has important implications for the financial viability of an institution. Figure 6.2 shows the relationship between high and low clinical and facility productivities and the payment system. Hospitals which are over-bedded are either under-occupied or over-utilized (Griffith, 1976). The reverse is true for under-bedded hospitals.

If a physician is highly productive in relationship to clinical productivity (e.g. low intermediate product use) and highly productive in relationship to facility productivity (e.g. low surgical or admission rate), then the physician's effect is most financially advantageous for the institution when the institution is reimbursed under a capitation-based payment system. If a physician is highly productive relative to clinical productivity and lowly productive relative to facility productivity, then the hospital has a financial advantage in a case-based payment system. If the physician is lowly productive relative to

FIGURE 6.2
Reimbursement Implications of Patterns

		CP	
		High	Low
FP	High	HMO	Cost-Based (Under bedded)
	Low	Case-Based	Cost-Based (Over bedded)

intermediate products resulting from differences in physician practice styles is probably inappropriate, and thus, the volume and/or mix of intermediate products could be changed without negatively affecting the quality of care.

Before considering implementation of this cost reduction strategy, however, it had to be demonstrated that 1) practice patterns could be identified, 2) the different patterns could be associated with patient, physician, and outcome characteristics, and 3) individual physicians could be associated with the different patterns. The demonstration of the capability to accomplish these tasks was the major thrust of the research effort reported here.

The current research had demonstrated that physician-associated practice pattern differences do exist within the demonstration hospital. Therefore, it is concluded that a cost reduction strategy based on improving clinical productivities through modification of inappropriate physician practice styles is feasible. While the results of this research are institution specific, there is no reason to suspect that similar capabilities of identifying potentially inappropriate intermediate product use would not be discovered in other institutions.

clinical productivity, then the physician provides a positive financial effect under a cost-based system that is over or under bedded depending on whether the physician is lowly or highly productive relative to facility productivity.

A physician's propensity to be highly or lowly productive, in relationship to clinical and facility productivities, has important financial implications for an institution. An improved understanding of the relationship between the physicians effect on 1) the use of intermediate products; and 2) the initiation of an admission will become increasingly important as the reimbursement environment becomes more dynamic.

Conclusions

^{in this hospital}
The current research presented a hypothesis that, cost reduction is possible in a case-based prospective payment environment by improving clinical productivity through changing the volume and/or mix of input intermediate products. Potentially inappropriate intermediate product use can be identified through comparisons of different practice patterns that reflect how the intermediate products were combined to produce an inpatient episode of care. However, rather than investigating gross variation in intermediate product use, the variation must be differentiated into its two major components -- patient and physician. Variation in the volume and type of input

APPENDICES

APPENDIX 1
STAGING RESULTS

APPENDIX 1.1 DRG(14)

STAGING CRITERIA
Diagnostic Category - Alzheimer's Disease

Stg	Desc	83	84	Supporting Evidence
2.2	Breakdown of social adj, seizures, speech disorders Involuntary movements	0	2	EKG non-specific focal paroxysmal disch Impaired judgement and/or abstract reasoning

Diagnostic Category - Disease of Carotid Artery

Stg	Desc	83	84	Supporting Evidence
2.2	Aphasia, Focal seizures, intellect deficits	0	2	

Diagnostic Category - Aneurysm of Cerebral Vessels

Stg	Desc	83	84	Supporting Evidence
1.0	Aneurysm w/o complications	1	1	Aneurysm visualized by angiography
2.2	Pyramidal tract or cerebellar disfunc	5	2	Multiple cranial nerve disorders assoc w/ Pyramidal or cerebellar trait
3.1	Subarchnoid Hemorrhage	1	2	abnormalities on Physical findings blood,etc. in spinal fluid
4.0	Death	5	9	

Diagnostic Category - Disease of Vertebral Artery

Stg	Desc	83	84	Supporting Evidence
2.0	Cerebellar ataxia homolateral horner sign, facial sensory loss, cerebellar signs, etc	50	170	lesion supported by cerebral angiography
3.0	Coma	0	1	
4.0	Death	8	3	

Diagnostic Category - Infective Endocarditis

Stg	Desc	83	84	Supporting Evidence
3.2	Splenic or renal abscess or infective encephalitis	0	1	Physical findings lab data consistent with problem

Diagnostic Category - Acute Myocardial Infarction

Stg	Desc	83	84	Supporting Evidence
2.3	Cerebral Vascular accident	2	1	Physical findings abnormal lab findings
3.2	Cardiac Arrest	0	1	secondary to MI w/ successful resuscitation

Diagnostic Category - Atrial Fibrillation

Stg	Desc	83	84	Supporting Evidence
3.2	w/ cerebral embolus or CVA or stroke	1	0	Right or Left side

Diagnostic Category - Disease of Mitral Valve

Stg	Desc	83	84	Supporting Evidence
3.4	w/ embolic phenomena cerebral embolus	2	2	Clinical expression depends on location of embolus

Diagnostic Category - Essential Hypertension

Stg	Desc	83	84	Supporting Evidence
3,5	CVA	46	52	Positive neurologic findings

APPENDIX 1.2 DRG(82)

STAGING CRITERIA
Diagnostic Category - Cerebral Tumors

Stg	Desc	83	84	Supporting Evidence
4.0	Death	1	1	

Diagnostic Category - Cancer of Larynx

Stg	Desc	83	84	Supporting Evidence
1.0	Tumor confined to region of origin w/ normal mobility	1	0	
5.0	Death	0	1	

Diagnostic Category - Cancer of the Lung

Stg	Desc	83	84	Supporting Evidence
1.0	A Tumor ≤ 3 CM Surrounded by lung or visceral Pleural w/o evidence of invasion to a lobar bronchus at bronchoscopy	53	32	
2.0	Tumor > 3 CM invades visceral Pleura or assoc atelectasis or obstructive Pneumonitis	13	18	
3.1	Tumor w/ direct extension into an adjacent struct	10	10	

Stg	Desc	83	84	Supporting Evidence
3.2	Tumor involving regional Lymph nodes	0	1	
3.3	Distal Metastasis present	59	44	
4.0	Death	47	38	

Diagnostic Category - Cancer of Colon and Rectum

Stg	Desc	83	84	Supporting Evidence
4.2	Distant metastasis	1	0	Pathologic confirmation

Diagnostic Category - Cancer of Breast

Stg	Desc	83	84	Supporting Evidence
4.0	Carcinoma w/ one or more of following: >2 signs from stg 3 extensive edema skin satellite skin nodules involve supraclavicular or lymph nodes int mammary metastases edema of arm distant metastases	8	15	Physical exam of mass and nodes, mammography and other tests Path confirmation
5.0	Death	4	1	

Diagnostic Category - Unknown

Stg	Desc	83	84	Supporting Evidence
0.0		1	3	
4.4		1	1	

APPENDIX 1.3 DRG(88)

STAGING CRITERIA
Diagnostic Category - Bronchitis

Stg	Desc	83	84	Supporting Evidence
2.2	Recurrent Pneumonia	2	2	Positive Chest x-ray
3.1	Dyspnea and Hypoxemia at rest	1	3	PO ₂ < 60 MMHG Cyanosis

Diagnostic Category - Chronic Obstructive Pulmonary Disease

Stg	Desc	83	84	Supporting Evidence
2.0	Chronic Bronchitis early emphysema	65	45	Chronic cough morning sputum recurrent resp infect vent funct tests
3.1	Emphysema	72	74	Dyspnea at rest incapacitation
3.2	Pulmonary Hypertension	0	1	Pul Pressure > 30/15 MMHG
3.3	Corpulmonale	31	15	Venous Pressure > 140MM H2O EKG criteria
4.0	Death	8	8	

Diagnostic Category - Asthma

Stg	Desc	83	84	Supporting Evidence
2.2	Atelectasis or Bronchial Inf	2	2	Physical Findings of atelectasis x-ray findings Bronchial Obstruct Purulent secretion Positive cultures

Diagnostic Category - Unknown

Stg	Desc	83	84	Supporting Evidence
0.0		8	3	

APPENDIX 1.4 DRG(127)

STAGING CRITERIA
Diagnostic Category - Toxic Erythema

Stg	Desc	83	84	Supporting Evidence
3.3	Extensive Erythema w/ cardiac Failure	1	0	Cardiomegaly, hepatosplenomegaly Dyspnea

Diagnostic Category - Decubitus Ulcer and Ulcer of Skin

Stg	Desc	83	84	Supporting Evidence
4.0	Death	1	0	

Diagnostic Category - Alcoholism

Stg	Desc	83	84	Supporting Evidence
3.4	Alcoholism w/ gastro-intestinal disease or neuro- logical disease	1	0	Peptic ulcer esophagitis malabsorbtion Hepatitis, cirrhosis fatty liver Pancreatitis

Diagnostic Category - Celiac Disease

Stg	Desc	83	84	Supporting Evidence
3.2	Congestive Heart Failure	0	1	deformity or

Diagnostic Category - Cardiomyopathies "Primary"

Stg	Desc	83	84	Supporting Evidence
3.1	Chronic Hypokinetic Heart Failure	7	15	

Diagnostic Category - Rheumatic Fever

Stg	Desc	83	84	Supporting Evidence
3.1	w/ Congestive Heart Failure	3	1	

Diagnostic Category - Acute Myocardial Infarction

Stg	Desc	83	84	Supporting Evidence
4.0	Death	0	1	

Diagnostic Category - Atherosclerosis of Coronary Arteries

Stg	Desc	83	84	Supporting Evidence
2.2	Minimal CHF	60	91	Elevated venous pressure elevated > 10 MMHG diastolic pressure gallop rhythm
2.3	Physical Evidence of Moderate CHF	0	2	As above
4.0	Death	16	12	

Diagnostic Category - Atrial Fibrillation

Stg	Desc	83	84	Supporting Evidence
3.1	w/ CHF	5	26	Pulmonary congestion hyprothorax on chest x-ray, dependent edema and tender hepatic enlargement
4.0	Death	0	1	

Diagnostic Category - Ectopic Cardiac Arrhythmia

Stg	Desc	83	84	Supporting Evidence
3.3	CHF	26	26	EKG demonstration

Diagnostic Category - Disease of Mitral Valve

Stg	Desc	83	84	Supporting Evidence
3.3	w/ Rt and left failure	16	10	Dependent Edema Hepatosplenomegaly ascites

Diagnostic Category - Diseases of Aortic Valve

Stg	Desc	83	84	Supporting Evidence
3.3	Left Ventricular Failure	5	6	Dyspnea, orthopnea PND, Pul edema chest x-ray show pul congestion/edema elevated LV end diastolic pressure

Diagnostic Category - Aortic Regurgitation

Stg	Desc	83	84	Supporting Evidence
3.2	Aortic Regurgitation w lf sided CHF	1	0	Pulmonary artery wedge press >15 chest x-ray Pul edema or congestion

Diagnostic Category - Chronic Pericarditis

Stg	Desc	83	84	Supporting Evidence
3.1	Chronic Pericarditis w/ CHF	1	0	Pulsus Paradoxus EKG - low volt electrical alternans

Diagnostic Category - Essential Hypertension

Stg	Desc	83	84	Supporting Evidence
3.1	Hypertensive HD manifested by CHF	23	22	LVH on EKG Gallop rhythm elevated >10MMHG end diastolic pressure
3.3	Azotemia	1	0	Bun >40 MGM% Creatinine >2MGM%
3.4	Hypertensive encephalopathy	0	1	
3.5	Cerebral-Vascular accident	0	1	Positive neurological findings

Diagnostic Category - Glomerulonephritis(Acute)

Stg	Desc	83	84	Supporting Evidence
3.2	ABN w. Hypertension and HF	4	2	

Diagnostic Category - Hypothyroidism

Stg	Desc	83	84	Supporting Evidence
3.1	Cardiovascular CHF or neurological manifestation	2	1	

Diagnostic Category - Thyrotoxicosis

Stg	Desc	83	84	Supporting Evidence
2.3	w/ CHF	0	1	

APPENDIX 1.5 DRG(198)

STAGING CRITERIA

Diagnostic Category - Extrahepatic Biliary Obstruction

Stg	Desc	83	84	Supporting Evidence
1.0	Extrahepatic biliary obstruction	1	1	Elevated serum enzymes alkaline phosphatase Hyperbilirubinemia ultrasound, CAT scan Operative and path findings, liver biopsy
2.1	Suppurative cholangitis	1	0	as above

Diagnostic Category - Disorders of Bilirubin Excretion

Stg	Desc	83	84	Supporting Evidence
1.2	Rotor syndrome or benign familial recurrent cholestasis or recurrent jaundice of pregnancy	1	1	moderate, recurrent clinical signs

Diagnostic Category - Cholecystitis

Stg	Desc	83	84	Supporting Evidence
1.0	Chronic cholecystitis	118	131	Abdominal x-ray cholecystography ultrasound, CAT scan operation, path findings
2.2	Acute cholecystitis	3	3	as above
3.4	Acute cholecystitis pancreatitis	1	0	above plus blood and urine analysis

Diagnostic Category - Pancreatitis

Stg	Desc	83	84	Supporting Evidence
2.1	Acute pancreatitis	0	1	inc serum amylase abdoinal tap, hypo/ hyperglycemia x-ray abdomen and chest gastrointestinal series ultrasound, Cat scan operative findings

APPENDIX 1.6 DRG(355)

STAGING CRITERIA
Diagnostic Category - Pelvic Inflammation

Stg	Desc	83	84	Supporting Evidence
1.1	W/O Comp	5	1	Elevated White blood count Elevated Sedimentation rate Tenderness in Adnexal Regions Tenderness on Movement Cervix
1.2	W Tubal Obstruc	3	2	No Patency Demonstrated
2.1	W Abscess	3	2	Palpable Mass in Adnexa Abscess seen

Diagnostic Category - Benign Tumor of Ovary

Stg	Desc	83	84	Supporting Evidence
1.1	Ltd Ovary	10	7	Physical Findings

Diagnostic Category - Uterine Fibroma

Stg	Desc	83	84	Supporting Evidence
1.0	W/O Comp	62	58	Irregular Enlargement of Uterus, no pain, no rapid growth of Fibroids
2.1	Min Bleeding	31	41	Abnormal Bleeding Pain and Pressure
2.2	Pressure on Adj Viscerea	18	21	Same
3.1	Obstruction to ureters or ademia	0	6	Same as 2.1 with bleeding caused ademia or pain

Diagnostic Category - Disease of Ovary

Stg	Desc	83	84	Supporting Evidence
1.0	Benign Tumor	4	4	Exam of Tumor
2.0	W Pain or Menstrual Dysfunct	7	7	Pain, Menstrual Irregularities

Diagnostic Category - Cancer of Corpus Uteri

Stg	Desc	83	84	Supporting Evidence
1.1	Cancer Confined to Corpus	13	16	Group by type of Adenocarcinoma
3.0	Outside Uterus, but not outside Pelvis	2	0	

Diagnostic Category - Cancer of Ovary

Stg	Desc	83	84	Supporting Evidence
1.1	Lim to 1 ovary	3	4	Diag of Ovarian Cancer visual and Biopsy

Diagnostic Category - Cancer of Cervix Uteri

Stg	Desc	83	84	Supporting Evidence
0.0	In Situ	15	9	Carcinoma of Cervix not invading base Membrane
1.1	Early Stromal Invasion	1	2	Histologic Diag

**Diagnostic Category - Dysfunctional Uterine Bleeding
Secondary to Abn Endocrine Func**

Stg	Desc	83	84	Supporting Evidence
1.0	Bleeding due to abn endocrine, W/o anemia W no Organic Path	33	28	Inc in Uterine Bleeding Organic cause ruled out Hemo>10mg Hemat>30%

Diagnostic Category - Uterovaginal Prolapse

Stg	Desc	83	84	Supporting Evidence
1.1	Vaginal Prolapse	12	5	
1.2	Min Prolapse of Uterus	27	22	Well Within Vagina
2.1	Enrerocele	0	1	Cervix Protrudes beyond T.E. Vag orifice
2.2	Severe or complete Uterine Prolapse	0	2	Same as 2.1
2.3	W Ulceration of Cervix	1	1	Same as 2.1 with Ulceration

Diagnostic Category - Endometriosis

Stg	Desc	83	84	Supporting Evidence
1.0	Interna	27	13	Lesions Visual, no biopsy necessary
2.0	Externa	12	19	Same as above except points total 6 to 15
3.0	Externa W intestinal or Uretreal Obstruct	2	2	Same as above except points total 16 to 30

Diagnostic Category - Infections of the Vulva

stg	Desc	83	84	Supporting Evidence
1.1	Vulvitis or Vaginitis	0	1	Asymptomatic, discovery on routine exam

Diagnostic Category - Uterine Infection

stg	Desc	83	84	Supporting Evidence
1.0	Endometritis	0	1	History-Abdom pain, fever, bleeding - Exam-Discharge, Uterus and adnema tender

Diagnostic Category - Anomalities of the Uterus

stg	Desc	83	84	Supporting Evidence
1.3	Bicornuate Uterus	0	1	One vagina, one cervix visual Two distinct Horns are noted

Diagnostic Category - Not Identified

stg	Desc	83	84	Supporting Evidence
0.0	Unknown	14	25	Unknown

APPENDIX 1.7 DRG(209)

STAGING CRITERIA

Diagnostic Category - Atherosclerosis of Coronary Arteries

Stg	Desc	83	84	Supporting Evidence
4.0	Death	1	0	

Diagnostic Category - Pyogenic Arthritis

Stg	Desc	83	84	Supporting Evidence
1.0	Acute Pyogenic Joint Infection	12	11	Physical Exam, Smear and Culture from joint Blood Culture, x-ray

Diagnostic Category - Osteomyelitis

Stg	Desc	83	84	Supporting Evidence
3.1	Osteomyelitis w/ sequestrum formation or draining sinus	1	0	Physical Exam, x-ray culture, biopsy

Diagnostic Category - Intracapsular Fracture of Hip

Stg	Desc	83	84	Supporting Evidence
1.0	Fracture of Femoral neck w/o deformity or displacement	19	15	Physical Exam x-ray, tomograms

Diagnostic Category - Fracture of Femer

Stg	Desc	83	84	Supporting Evidence
1.1	Linear Fracture w/o displacement	3	0	Physical Exam x-ray

Diagnositic Category - Spondylitis, Ankylosing

Stg	Desc	83	84	Supporting Evidence
1.0	Ankylosing spondylitis involving mainly sacroliac joint	1	0	Clinical findings/sympt radiological find HL-A-B27 antigen pres Rheumatoid Fact Neg

Diagnostic Category - Rheumatoid Arthritis

Stg	Desc	83	84	Supporting Evidence
1.0	R.A. meeting Diagnostic Criteria	22	25	Clinical Signs/sympt Postive RA Factor Subcultaneous nodules Biopsy, Soft Tissue swelling effusion osteoporosis on x-ray
3.1	RA w/ Comp loss of cartilage bone erosion or Apemia(HGB<11 GM%)	1	1	X-ray exam, Blood Culture
3.3	RA w/ Fibrosis or bony anlylosis More one joint	0	1	Clinical signs sympt, x-ray

Diagnostic Category - Osteoarthritis

Stg	Desc	83	84	Supporting Evidence
1.0	Osteoarthiritis	106	148	X-ray Abnormality no pain or stiffness or lim of motion
2.1	Osteoarthiritis w/ pain	1	1	Pain usually aching Poorly localized occurs w/ motion

Diagnostic Category - Bursitis

Stg	Desc	83	84	Supporting Evidence
1.0	Chronic Bursitis	0	1	Physicial Exam x-ray

Diagnostic Category - Unknown

Stg	Desc	83	84	Supporting Evidence
0.0		29	22	
1.0		0	1	
3.1		0	1	

APPENDIX 2
DESCRIPTION OF DATA ELEMENTS

APPENDIX 2
DESCRIPTION OF DATA ELEMENTS

Data Element	Description	Values
1	Patient Number	Patient Unique
2	Date of Admission	Patient Unique
3	Admission Type	Not Recorded Emergency Re-admission
4	Age of Patient	Years
5	Diagnosis at Discharge	ICD-9-CM
6	Discharge Status	Not Recorded Home Nursing Home Died
7	Distance	Travel Distance in Miles from Hospital To Patient's Residence
8	Diagnosis-Related Group	1 to 470
9	Diagnostic Category of Stage	101 to 1502 (Approx 420 different MDCs)
10	Third Party Payor	Private/Commerical Blue Cross Medicaid Medicare
11	Pre-admission Testing Status	Tested Not Tested
12	Primary Diagnosis Flag for Stage	On Not On
13	Race	Type
14	Religion	Type

Data Element	Description	Values
15	Sex	Male Female
16	Stage	1.0 to 4.0
17	Teaching Service Patient	Yes No
18	Patient's Zip Code	Primary Service Area Secondary Service Area Outside Primary/secondary
19	Year of Admission	1983 1984
20	Attending Physician Code	Three Digit No.
21	Physician Speciality	Speciality Type
22	Discharge Service	Medical Department
23	Total Full Cost	Dollar Cost of Stay
24	Room Full Cost	Dollar Cost
25	Pharmacy Full Cost	Dollar Cost
26	EKG Full Cost	Dollar Cost
27	EEG Full Cost	Dollar Cost
28	Lab Full Cost	Dollar Cost
29	LOS	Days
30	ICU Full Costs	Includes MICU, SICU, CCU
31	Surgery Full Costs	OR plus Anesthesia
32	Medical Supplies Cost	Dollar Cost
33	Physical Therapy Cost	Dollar Cost
34	Radiology Full Cost	Dollar Cost
35	Renal Dialysis Cost	Dollar Cost

Data Element	Description	Values
36	Respiratory Therapy Cost	Dollar Cost
37	Speech Therapy Cost	Dollar Cost

AD-A166 328

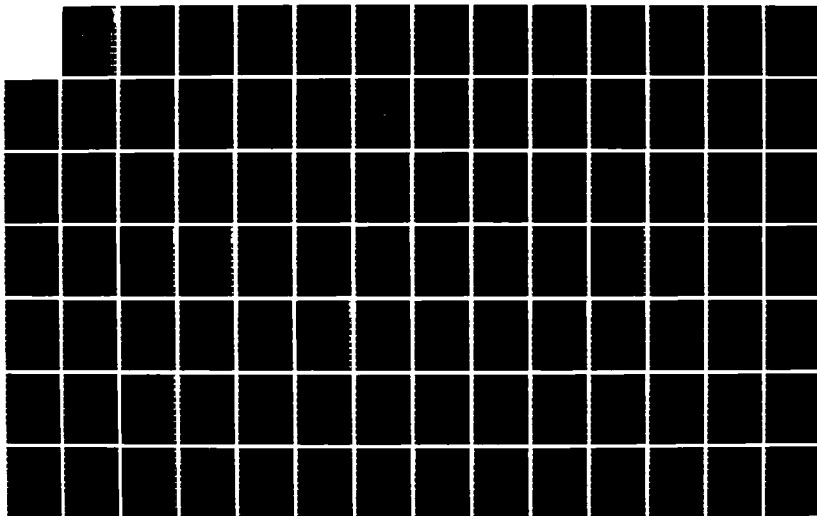
PHYSICIAN PRACTICE PATTERNS WITHIN AN ACUTE CARE
FACILITY(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB
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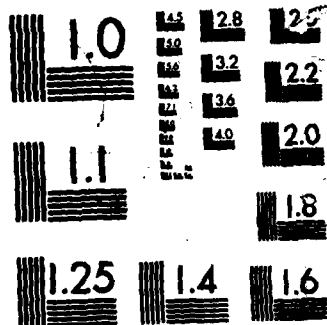
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MICROCOPY

CHART

APPENDIX 3
SELECTION OF RESOURCES

APPENDIX 3.1 DRG(14)

SELECTION OF RESOURCES

Resource	% Total Cost
Adult Bed/LOS*	.48
Surgery	.01
Laboratory*	.10
Pharmacy*	.06
Med Supplies	.05
Radiology	.06
EEG/EKG*	.03
Respiratory Therapy	.05
Emergency Room	.02
Physical Medicine*	.07
ICU*	.08

Note 1: The astrisked resources were selected to define the practice pattern. Radiology was not selected because it demonstrated minimal variance in cost distribution. The six resources selected totaled to 82% of total cost.

APPENDIX 3.2 DRG(82)
SELECTION OF RESOURCES

Resource	83 Split	84 Split
Pharmacy	Severity	Physician
Laboratory	Severity	Physician
EKG/EEG	Severity	Severity
Radiology*	Physician	Physician
Surgery*	Physician	Severity
Physical Therapy*	Physician	Physician
LOS	Severity	Physician
Respiratory Therapy	Severity	Physician
ICUs	Severity	Severity
Medical Supplies	Severity	Physician

Notel: The astrisked resources were selected to define a practice pattern. Although Surgery varied more by Severity in 84, it was almost an even split. Physician input suggested this resource might be important, therefore it was retained in the analysis.

APPENDIX 3.3 DRG(88)
SELECTION OF RESOURCES

Resource	% Total Cost
Adult Bed*	.48
ICU	.01
Laboratory*	.15
Pharmacy*	.09
Med Supplies	.02
Radiology	.02
EEG/EKG	.02
Respiratory Therapy*	.16
Renal	.04

Notel: The astrisked resources were selected to define the practice pattern. They account for 88% of total costs.

APPENDIX 3.4 DRG(127)

SELECTION OF RESOURCES

Resource	% Total Cost
Adult Bed*	.44
ICU	.07
Laboratory*	.18
Pharmacy*	.07
Med Supplies	.03
Radiology	.02
EEG/EKG*	.05
Respiratory Therapy*	.09
ER	.03

Notel: The astrisked resources were selected to define the practice pattern. The selected resources account for 83% of total costs.

APPENDIX 3.5 DRG(198)

SELECTION OF RESOURCES

Resource	% Total Cost
Adult Bed*	.48
Surgery	.32
Laboratory*	.06
Pharmacy*	.05
Med Supplies	.02
Radiology	.03
EEG/EKG	.01
Respiratory Therapy	.01
Emergency Room	.01

Notel: The astrisked resources were selected to define the practice pattern. Surgery was not selected because it demonstrated minimal variance in cost distribution.

APPENDIX 3.6 DRG(355)
SELECTION OF RESOURCES

Resource	83 Split	84 Split
Pharmacy*	Physician	Physician
Laboratory*	Physician	Physician
Radiology	Severity	Severity
Surgery*	Physician	Physician
LOS	Severity	Physician
ICUs	Severity	Severity
Medical Supplies	Severity	Physician

Notel: The astrisked resources were selected to define a practice pattern due to importance of physician in explaining variation in aggregate cost center costs.

APPENDIX 3.7 DRG(209)

SELECTION OF RESOURCES

Resource	% Total Cost
Adult Bed*	.44
ICU	.01
Surgery	.31
Laboratory*	.06
Pharmacy*	.06
Med Supplies*	.03
Radiology	.01
EEG/EKG	.01
Respiratory Therapy	.02
Physical Medicine	.05
Renal	.01

Notel: The astrisked resources were selected to define the practice pattern which represented 59% of total costs. Although less than 5% of total costs, Medical Supplies was included as a special interest item.

APPENDIX 4
MEAN VALUES FOR 1983/1984 .

APPENDIX 4.1 DRG(14)

MEAN VALUES OF RESOURCES FOR 1983/1984

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean
LOS	.52	.59	.54	.49	.17	-.04	-1.38	-.79
Pharmacy	.88	.85	.46	.53	.16	-.42	-1.49	-.60
Lab	1.11	1.00	.48	.41	-.05	-.25	-1.31	-.68
Physical Therapy	.34	.47	-.18	.36	.43	-.23	-.90	-.41
EEG	-.03	.27	1.24	-.54	-.72	1.20	-.05	-.61
ICU	2.52	2.51	-.31	-.32	-.35	-.33	-.29	-.43
Sum Row 1-6 in dollars	5875	7115	1829	2309	1799	1663	249	524
Total Cost in dollars	12942	15794	7838	8593	6873	7063	1541	2725

Note 1) The individual intermediate products (e.g, Lab,

etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

APPENDIX 4.2 DRG(82)
MEAN VALUES OF RESOURCES FOR 1983/1984

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5	
	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean
Radiology	.25	-.06	1.26	.58	-.25	.13	.30	-.30	-.97	-1.40
Surgery	6.16	4.40	-.19	-.15	-.12	-.19	-.16	-.13	-.17	-.40
Physical Therapy	.97	.28	-.43	.36	1.77	1.87	-.38	-.58	-.40	-.34
Sum Row 1-3 in dollars	1375	969	1194	722	687	935	430	279	77	57
Total Cost in dollars	11070	6566	9393	5561	6733	9932	3967	3691	3475	2705

Note 1) The individual intermediate products (e.g, Lab, etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

APPENDIX 4.3 DRG(88)

MEAN VALUES OF RESOURCES FOR 1983/1984

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean
Pharmacy	1.15	1.28	.34	.51	-.30	-.17	-1.04	-1.10
Lab	1.55	1.66	.36	.49	-.53	-.25	-.95	-1.16
Respiratory Therapy	.80	1.31	.46	.54	-.41	-.10	-.80	-1.34
LOS	1.00	1.58	.42	.59	-.26	-.29	-1.18	-1.12
Sum Row 1-4 in dollars	5391	5948	2298	2279	1614	1275	750	536
Total Cost in dollars	12576	14546	5523	5633	4327	3296	2175	1735

Note 1) The individual intermediate products (e.g, Lab, etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

APPENDIX 4.4 DRG(127)
MEAN VALUES OF RESOURCES FOR 1983/1984

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5	
	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean
LOS	1.82	1.21	.42	.12	-.12	-.71	-.26	-.04	-1.30	-.90
Pharmacy	1.82	1.31	.35	.20	-.06	-.63	-.67	-.42	-1.04	-1.02
Lab	1.60	1.37	.47	-.07	-.08	-.45	-.84	-.48	-.71	-1.21
EKG/EEG	.78	.30	.79	.44	-.60	-.32	-.61	-.06	-.20	-1.38
Respiratory Therapy	.95	.89	.51	.36	.41	-.02	-1.71	-1.99	-.33	-.59
Sum Row 1-5 in dollars	8564	4058	2408	1554	1410	959	757	900	698	1029
Total Cost in dollars	20177	11008	6332	4369	3858	2703	2846	3478	1934	2857

Note 1) The individual intermediate products (e.g, Lab, etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

APPENDIX 4.5 DRG(198)

MEAN VALUES OF RESOURCES FOR 1983/1984

Resources	Cluster 1		Cluster 2	
	1983 Mean	1984 Mean	1983 Mean	1984 Mean
Adult Days	.91	.86	-.36	-.28
Pharmacy	1.00	.93	-.41	-.30
Lab	.96	1.07	-.39	-.35
Sum Row 1-3 in dollars	2255	2124	1202	1367
Total Cost in dollars	3329	3332	2056	2277

Note 1) The individual intermediate products (e.g, Lab,

etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

APPENDIX 4.6 DRG(355)

MEAN VALUES OF RESOURCES FOR 1983/1984

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean
Pharmacy	1.47	1.22	.67	-.04	-.51	-1.8	-.48	-1.04
Lab	1.75	1.22	.19	-.46	-.24	-.03	-.88	-1.13
Surgery	.84	.73	.48	.84	-.04	-.33	-1.30	-.97
Sum Row 1-3 in dollars	1843	1634	1274	1304	1070	1120	866	928
Total Cost in dollars	3959	3733	2950	2875	2471	2674	2202	2213

Note 1) The individual intermediate products (e.g, Lab,

etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

APPENDIX 4.7 DRG(209)

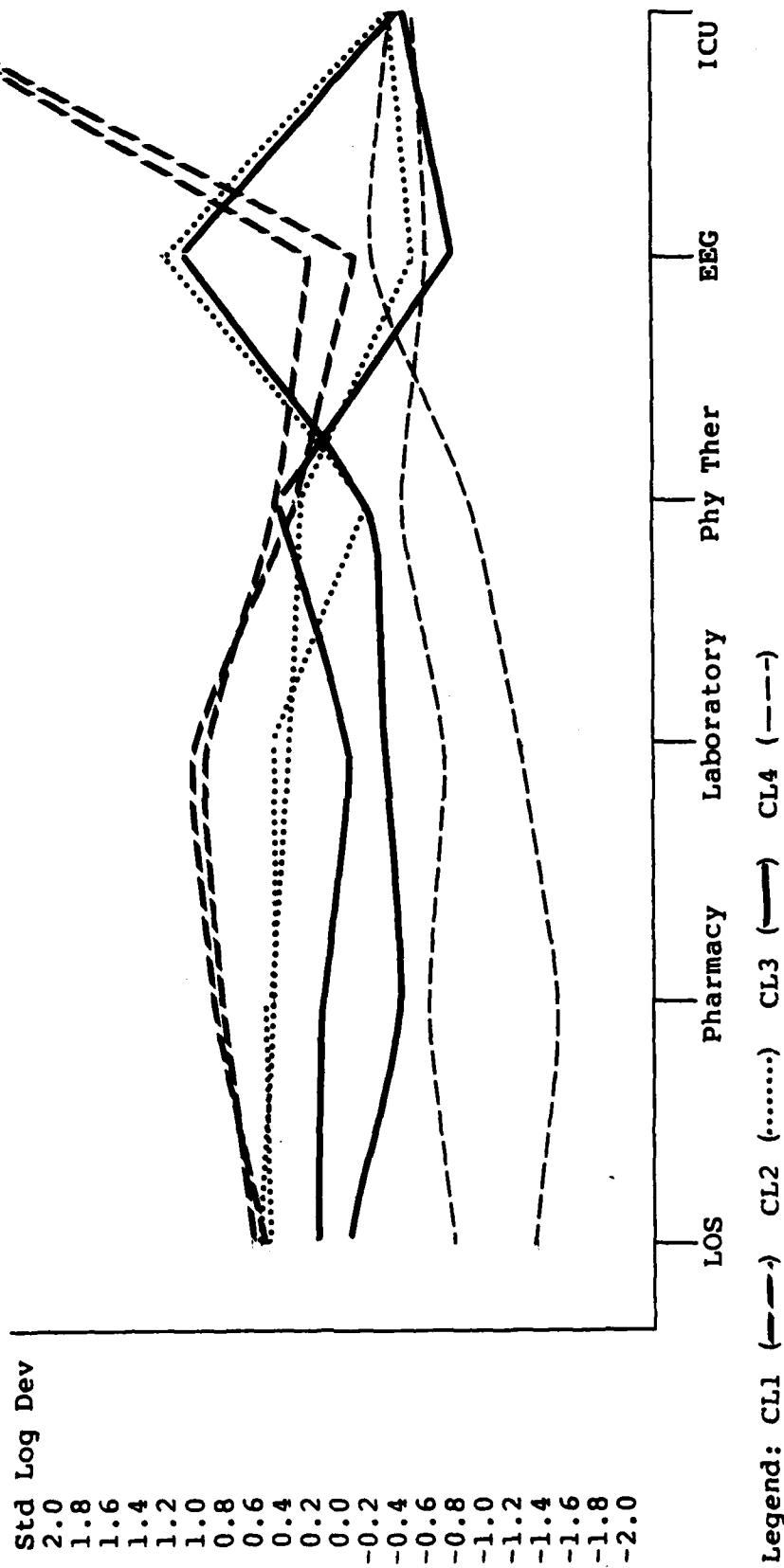
MEAN VALUES OF RESOURCES FOR 1983/1984

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean	1983 Mean	1984 Mean
Adult Days	1.57	1.34	.22	.20	-.30	-.12	-1.05	-1.01
Pharmacy	1.45	1.49	.49	.19	-.39	-.26	-1.05	-.85
Lab	.55	.75	.53	.74	-.24	-.46	-.74	-.61
Med Supplies	1.13	1.05	.53	.29	-.19	-.06	-1.42	-1.26
Sum Row 1-4 in dollars	8309	7661	4259	4409	3493	3680	2619	2627
Total Cost in dollars	11657	12081	7308	7842	6222	7063	5021	5865

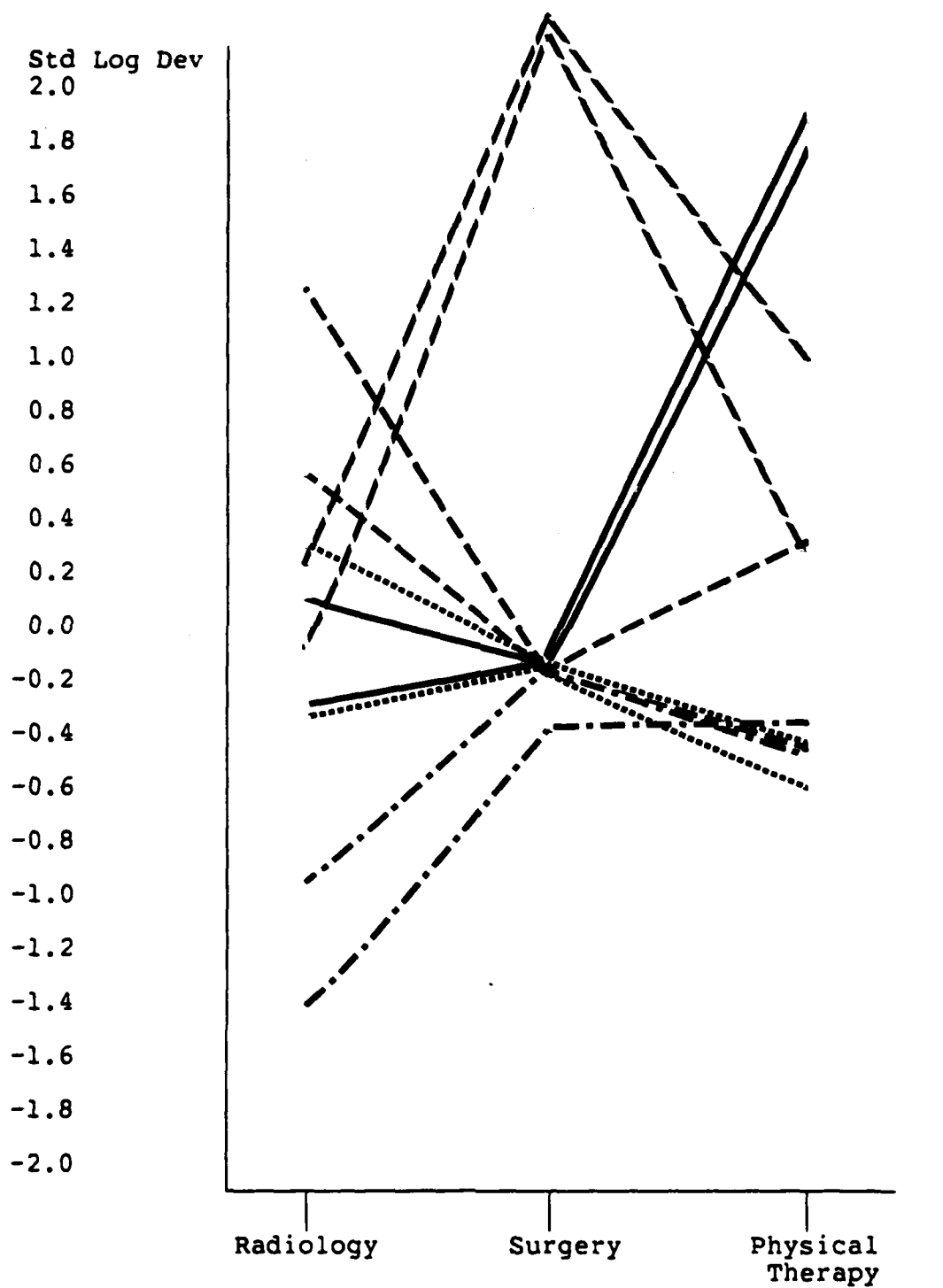
- Note 1) The individual intermediate products (e.g, Lab, etc.) are standardized logs.
- 2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

APPENDIX 5
GRAPH OF PRACTICE PATTERNS 1983/1984

APPENDIX 5.1 DRG(14)
GRAPH OF PRACTICE PATTERNS FOR 83 AND 84

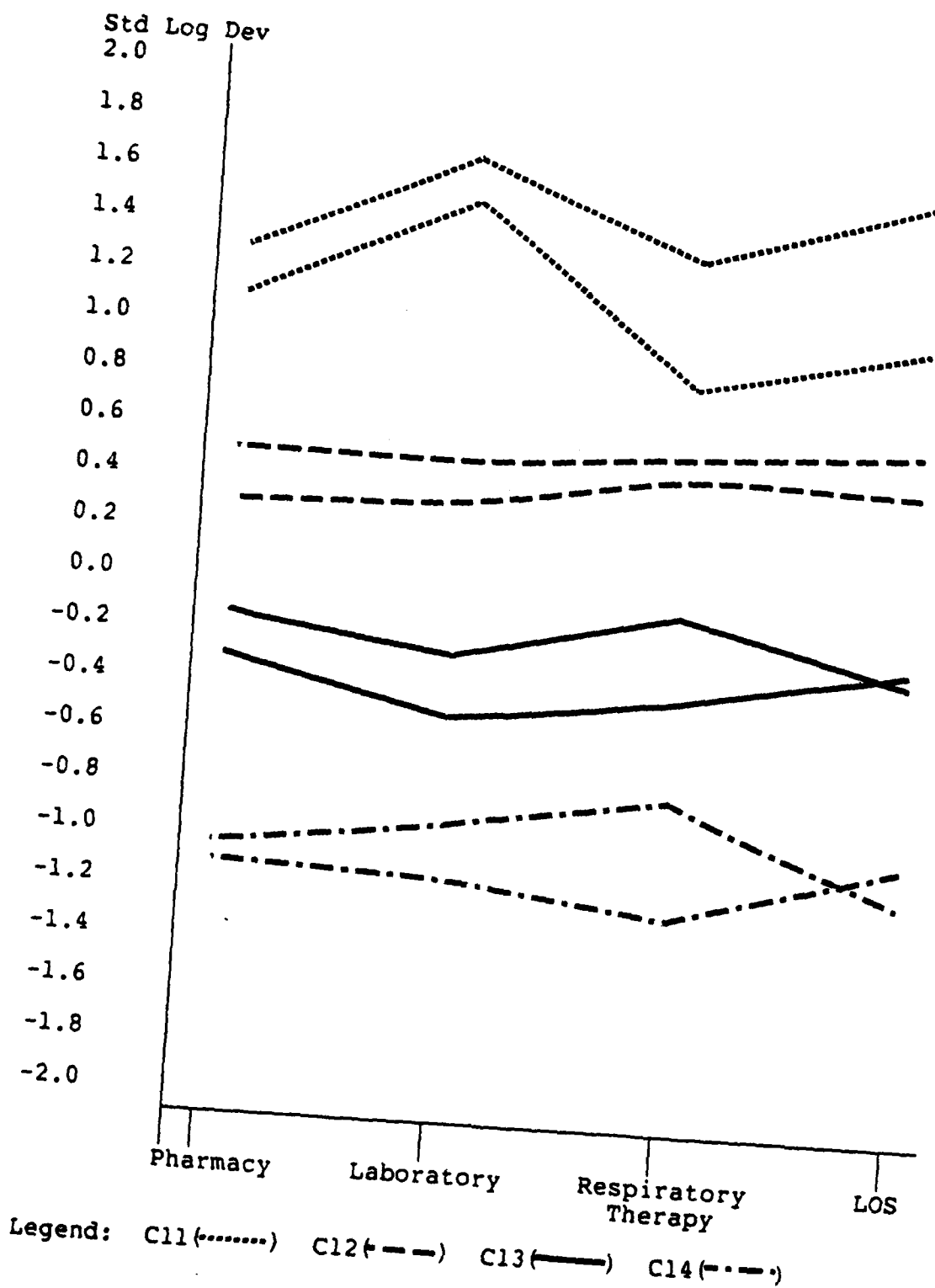


APPENDIX 5.2 DRG(82)
 GRAPH OF PRACTICE PATTERNS 83 AND 84

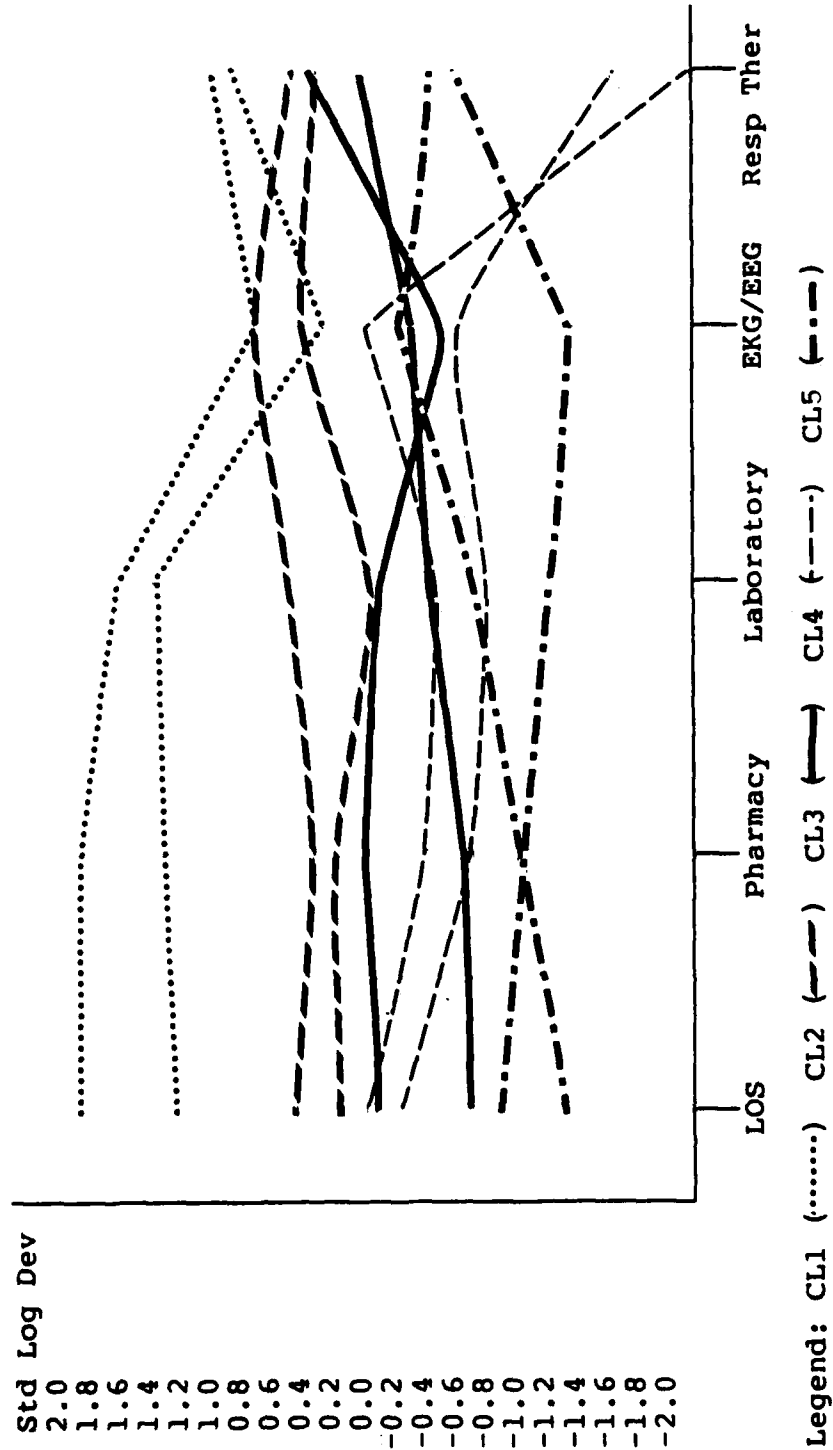


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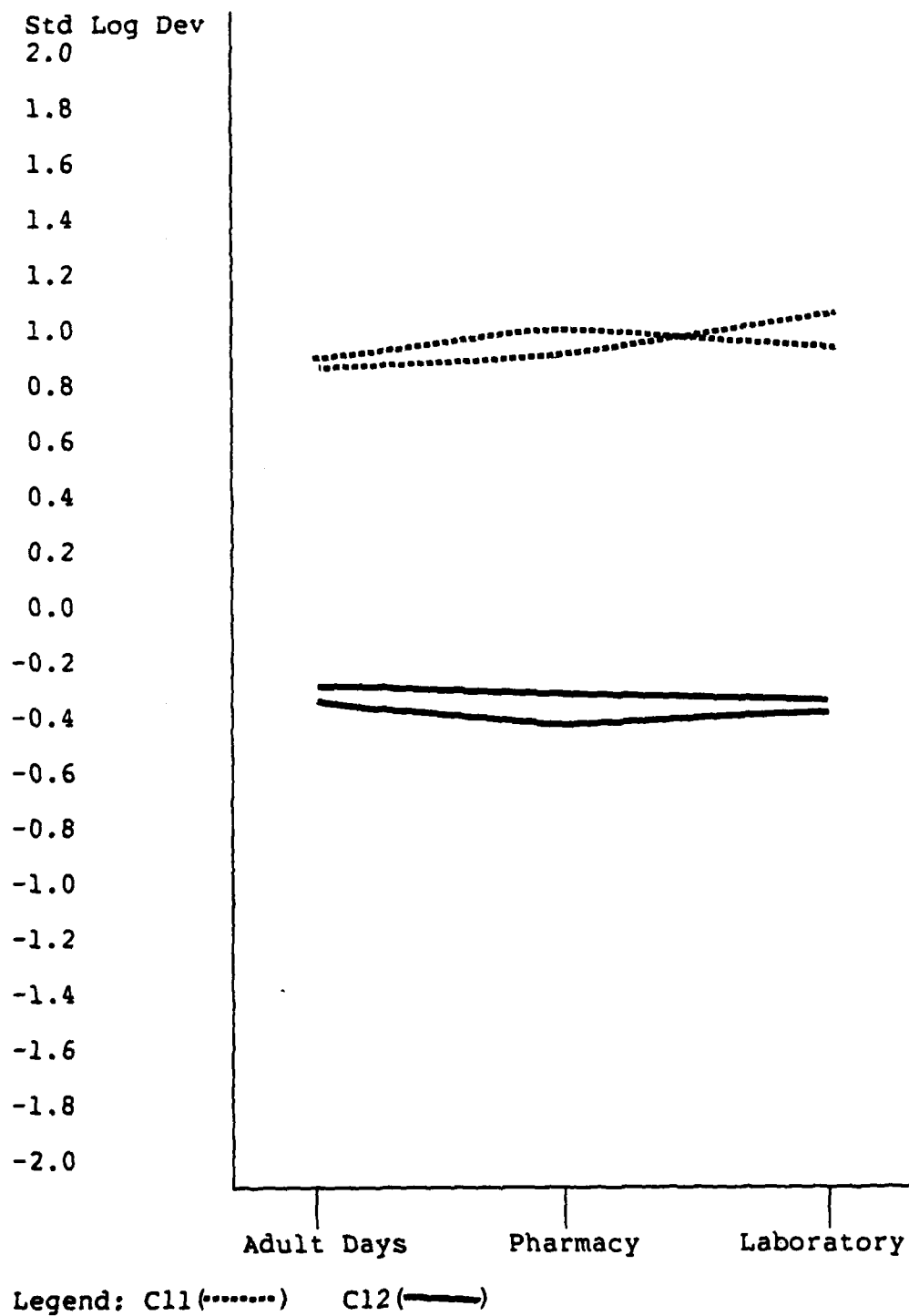
APPENDIX 5.3 DRG(88)
GRAPH OF PRACTICE PATTERNS 83 AND 84



APPENDIX 5.4 DRG(127)
GRAPH OF PRACTICE PATTERNS FOR 83 AND 84

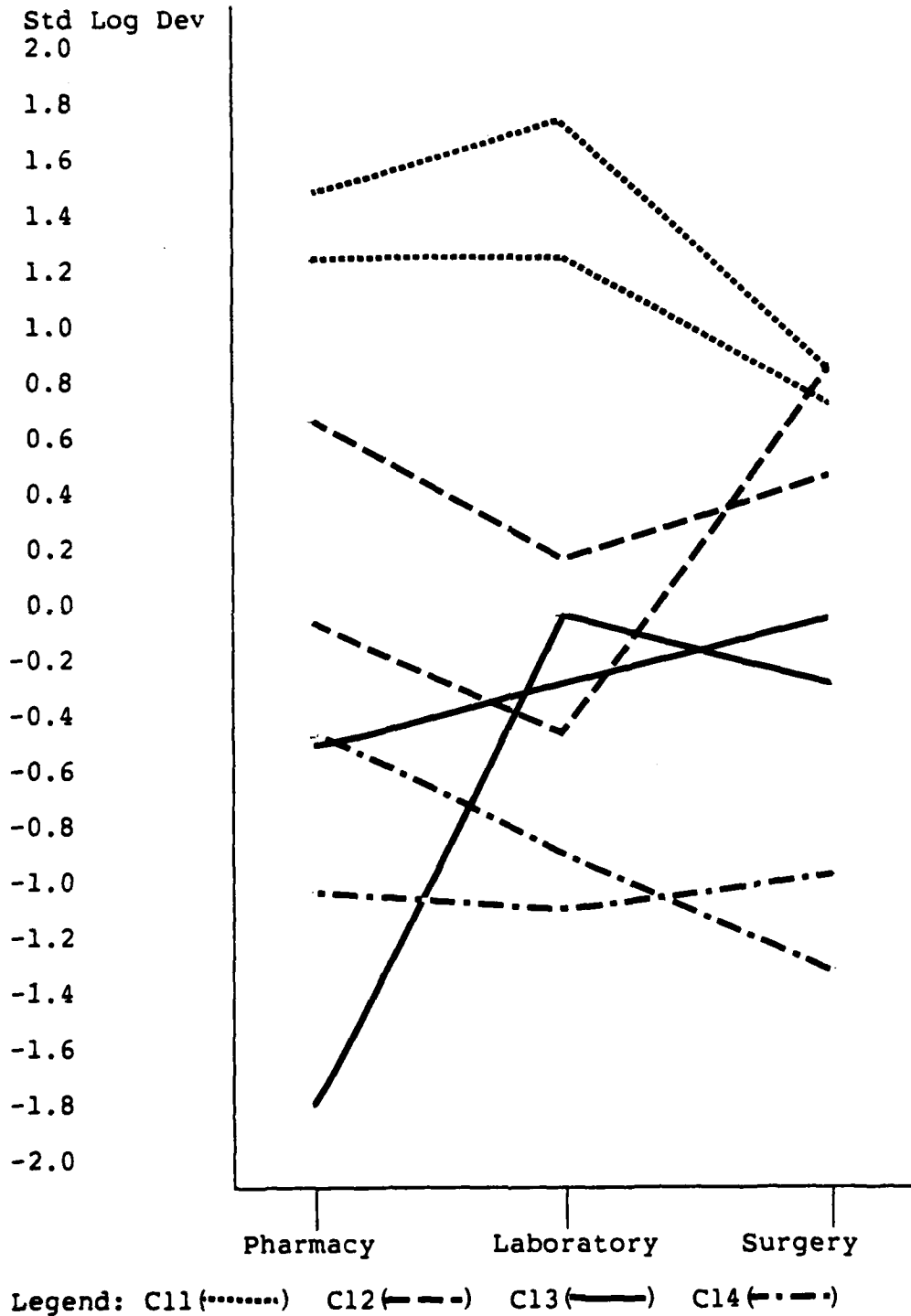


APPENDIX 5.5 DRG(198)
GRAPH OF PRACTICE PATTERNS 83 AND 84

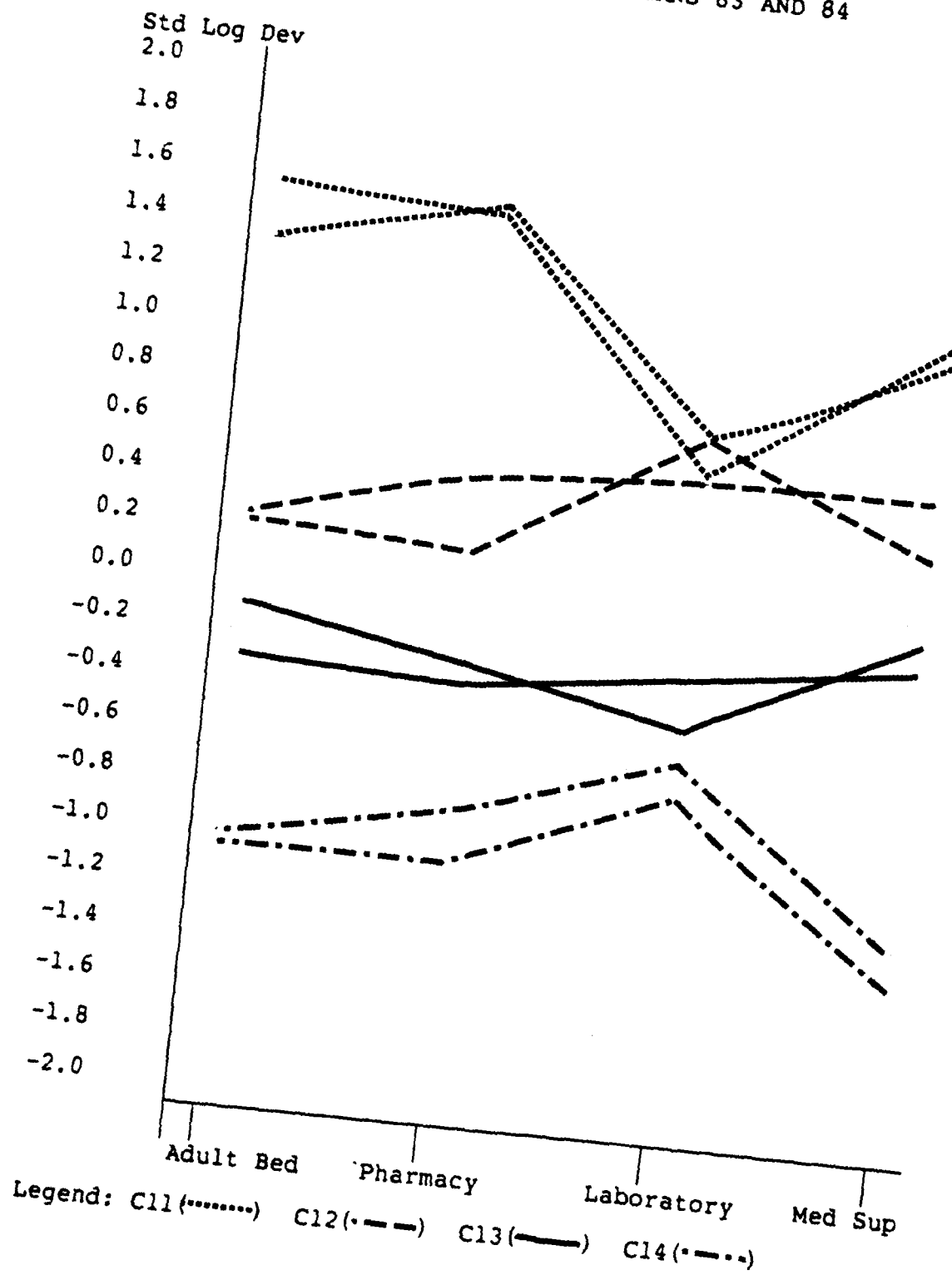


APPENDIX 5.6 DRG(355)

GRAPH OF PRACTICE PATTERNS 83 AND 84



APPENDIX 5.7 DRG(209)
 GRAPH OF PRACTICE PATTERNS 83 AND 84



APPENDIX 6
FINANCIAL SIGNIFICANCE OF CLUSTERS 1983/1984

APPENDIX 6.1 DRG(14)

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1983

Resource	Measurement	Eta-Sq	F-Stat	Significance
LOS	Std Dev	.50	39.6	.0000
Pharmacy	Std Dev	.60	59.6	.0000
Laboratory	Std Dev	.55	47.4	.0000
Physicial Therapy	Std Dev	.26	14.6	.0000
EEG	Std Dev	.63	69.5	.0000
ICU	Std Dev	.83	199.0	.0000
Sum of Rows 1-6	Dollars	.38	23.7	.0000
Total Cost	Dollars	.28	15.4	.0000

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1984

Resource	Measurement	Eta-Sq	F-Stat	Significance
LOS	Std Dev	.30	21.4	.0000
Pharmacy	Std Dev	.34	25.2	.0000
Laboratory	Std Dev	.33	24.4	.0000
Physicial Therapy	Std Dev	.13	7.6	.0000
EEG	Std Dev	.60	73.2	.0000
ICU	Std Dev	.91	493.0	.0000
Sum of Rows 1-6	Dollars	.28	18.8	.0000
Total Cost	Dollars	.22	13.7	.0000

APPENDIX 6.2 DRG(82)

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1983

Resource	Measurement	Eta-Sq	F-Stat	Significance
Physical Therapy	Std Dev	.67	100.3	.0000
Radiology	Std Dev	.42	34.8	.0000
Surgery	Std Dev	.98	2996.9	.0000
Sum of Rows 1-3	Dollars	.50	48.5	.0000
Total Cost	Dollars	.30	20.9	.0000

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1984

Resource	Measurement	Eta-Sq	F-Stat	Significance
Physical Therapy	Std Dev	.75	118.0	.0000
Radiology	Std Dev	.46	33.5	.0000
Surgery	Std Dev	.87	274.2	.0000
Sum of Rows 1-3	Dollars	.42	29.1	.0000
Total Cost	Dollars	.20	9.9	.0000

APPENDIX 6.3 DRG(88)

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1983

Resource	Measurement	Eta-Sq	F-Stat	Significance
Pharmacy	Std Dev	.44	47.3	.0000
Laboratory	Std Dev	.62	100.5	.0000
Respiratory Therapy	Std Dev	.33	30.2	.0000
LOS	Std Dev	.46	52.0	.0000
Sum of Rows 1-4	Dollars	.35	33.6	.0000
Total Cost	Dollars	.33	30.1	.0000

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1984

Resource	Measurement	Eta-Sq	F-Stat	Significance
Pharmacy	Std Dev	.53	54.9	.0000
Laboratory	Std Dev	.71	124.2	.0000
Respiratory Therapy	Std Dev	.65	92.6	.0000
LOS	Std Dev	.70	116.7	.0000
Sum of Rows 1-4	Dollars	.63	81.7	.0000
Total Cost	Dollars	.62	79.0	.0000

APPENDIX 6.4 DRG(127)

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1983

Resource	Measurement	Eta-Sq	F-Stat	Significance
LOS	Std Dev	.63	71.3	.0000
Pharmacy	Std Dev	.58	58.5	.0000
Laboratory	Std Dev	.51	42.8	.0000
EKG/EEG	Std Dev	.42	30.7	.0000
Respiratory Therapy	Std Dev	.73	115.1	.0000
Sum of Rows 1-5	Dollars	.51	43.4	.0000
Total Cost	Dollars	.55	51.3	.0000

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1984

Resource	Measurement	Eta-Sq	F-Stat	Significance
LOS	Std Dev	.50	55.0	.0000
Pharmacy	Std Dev	.57	72.7	.0000
Laboratory	Std Dev	.57	72.5	.0000
EKG/EEG	Std Dev	.26	19.5	.0000
Respiratory Therapy	Std Dev	.71	130.4	.0000
Sum of Rows 1-5	Dollars	.55	67.6	.0000
Total Cost	Dollars	.57	71.7	.0000

APPENDIX 6.5 DRG (198)

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1983

Resource	Measurement	Eta-Sq	F-Stat	Significance
Adult Bed	Std Dev	.34	63.7	.0000
Pharmacy	Std Dev	.41	85.2	.0000
Laboratory	Std Dev	.38	73.8	.0000
Sum of Rows 1-3	Dollars	.39	77.3	.0000
Total Cost	Dollars	.36	70.1	.0000

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1984

Resource	Measurement	Eta-Sq	F-Stat	Significance
Adult Bed	Std Dev	.24	43.8	.0000
Pharmacy	Std Dev	.28	53.8	.0000
Laboratory	Std Dev	.38	83.1	.0000
Sum of Rows 1-3	Dollars	.14	21.7	.0000
Total Cost	Dollars	.15	23.5	.0000

APPENDIX 6.6 DRG(355)

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1983

Resource	Measurement	Eta-Sq	F-Stat	Significance
Pharmacy	Std Dev	.53	106.0	.0000
Laboratory	Std Dev	.51	100.2	.0000
Surgery	Std Dev	.39	59.7	.0000
Sum of Rows 1-3	Dollars	.64	169.8	.0000
Total	Dollars	.51	98.7	.0000

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1984

Resource	Measurement	Eta-Sq	F-Stat	Significance
Pharmacy	Std Dev	.53	100.8	.0000
Laboratory	Std Dev	.58	127.3	.0000
Surgery	Std Dev	.45	75.7	.0000
Sum of Rows 1-3	Dollars	.53	102.3	.0000
Total	Dollars	.43	68.2	.0000

APPENDIX 6.7 DRG(209)

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1983

Resource	Measurement	Eta-Sq	F-Stat	Significance
Adult Bed	Std Dev	.54	75.7	.0000
Pharmacy	Std Dev	.60	97.0	.0000
Laboratory	Std Dev	.23	18.9	.0000
Med Supplies	Std Dev	.59	90.7	.0000
Sum of Rows 1-4	Dollars	.43	48.0	.0000
Total Cost	Dollars	.42	46.0	.0000

FINANCIAL SIGNIFICANCE OF CLUSTERS - 1984

Resource	Measurement	Eta-Sq	F-Stat	Significance
Adult Bed	Std Dev	.50	72.6	.0000
Pharmacy	Std Dev	.52	80.9	.0000
Laboratory	Std Dev	.39	46.7	.0000
Med Supplies	Std Dev	.52	79.0	.0000
Sum of Rows 1-4	Dollars	.45	61.4	.0000
Total Cost	Dollars	.46	62.4	.0000

APPENDIX 7
MEAN VALUES FOR COMBINED PATTERNS

APPENDIX 7.1 DRG(14)

MEAN VALUES OF RESOURCES FOR COMBINED

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
LOS	.61	.068	.70	.098	-.70	.280	-.75	.052
Pharmacy	.62	.048	.62	.067	-.94	.400	-.66	.058
Lab	.52	.065	.68	.076	-.67	.400	-.67	.054
Physical Therapy	.48	.099	-.01	.145	-.30	.219	-.30	.062
EEG	-.68	.010	1.40	.017	-.07	.012	-.22	.081
ICU	.26	.027	.15	.030	-2.49	.480	.22	.024
Sum Row 1-6 in dollars	3170	231	2962	240	2355	1084	981	50
Total Cost in dollars	9999	680	10167	840	8385	3505	2838	177

Note 1) The individual intermediate products (e.g, Lab,

etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

3) The data is for 1983 and 1984 combined.

APPENDIX 7.2 DRG(82)
MEAN VALUES OF RESOURCES FOR COMBINED

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Radiology	.57	.156	-.08	.197	.69	.294	.04	.020	-1.07	.058
Surgery	3.87	.215	-.36	.050	-.24	.022	-.11	.020	-.20	.025
Respiratory Therapy	-.09	.266	1.66	.144	-.42	.022	-.37	.030	-.41	.026
Sum Row 1-3 in dollars	3225	1033	772	80	737	36	368	17	81	6
Total Cost in dollars	10601	2104	7306	641	5612	355	3559	266	3119	248

Note 1) The individual intermediate products (e.g, Lab, etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

3) The data is for 1983 and 1984 combined.

APPENDIX 7.3 DRG(88)

MEAN VALUES OF RESOURCES FOR COMBINED

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Pharmacy	1.03	.058	.18	.031	-.69	.041	-1.71	.249
Lab	1.08	.075	-.33	.055	-.57	.049	-1.38	.189
Respiratory Therapy	.96	.044	-.08	.036	-.49	.044	-1.82	.325
LOS	1.16	.052	-.03	.032	-.72	.055	-1.39	.234
Sum Row 1-4 in dollars	4426	321	1691	56	932	32	551	152
Total Cost in dollars	10616	752	4208	123	2595	85	1995	594

Note 1) The individual intermediate products (e.g, Lab,

etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

3) The data is for 1983 and 1984 combined.

APPENDIX 7.4 DRG(127)
MEAN VALUES OF RESOURCES FOR COMBINED

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
LOS	1.20	.068	.14	.038	-.88	.052	-.01	.094	-.92	.271
Pharmacy	1.18	.067	.23	.038	-.79	.049	-.37	.098	-.91	.296
Lab	1.17	.054	-.08	.036	-.46	.043	-.42	.101	-1.18	.368
EKG/EEG	.53	.080	.14	.062	-.12	.076	-.06	.118	-1.49	.321
Respiratory Therapy	.85	.033	.40	.033	-.07	.045	-2.09	.052	-.42	.201
Sum Row 1-5 in dollars	4234	246	1627	43	871	26	862	65	2249	1062
Total Cost in dollars	11123	582	4523	112	2392	66	3399	240	5424	2246

Note 1) The individual intermediate products (e.g, Lab, etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

3) The data is for 1983 and 1984 combined.

APPENDIX 7.5 DRG(198)

MEAN VALUES OF RESOURCES FOR COMBINED

Resources	Cluster 1		Cluster 2	
	Mean	Std Dev	Mean	Std Dev
Adult Days	.87	.121	-.41	.044
Pharmacy	.94	.109	-.44	.044
Lab	.98	.112	-.46	.040
Sum Row 1-3 in dollars	2239	120	1198	23
Total Cost in dollars	3396	154	2054	35

- Note 1) The individual intermediate products (e.g, Lab, etc.) are standardized logs.
- 2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).
- 3) The data is for 1983 and 1984 combined.

APPENDIX 7.6 DRG(355)

MEAN VALUES OF RESOURCES FOR COMBINED

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Pharmacy	1.48	.238	.66	.039	-.29	.042	-.53	.054
Lab	1.06	.247	.66	.071	-.16	.041	-.63	.052
Surgery	.40	.238	.85	.063	.11	.034	-1.08	.040
Sum Row 1-3 in dollars	1741	88	1437	20	1148	8	920	7
Total Cost in dollars	3920	193	3225	54	2659	22	2247	28

Note 1) The individual intermediate products (e.g, Lab,

etc.) are standardized logs.

2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).

3) The data is for 1983 and 1984 combined.

APPENDIX 7.7 DRG(209)

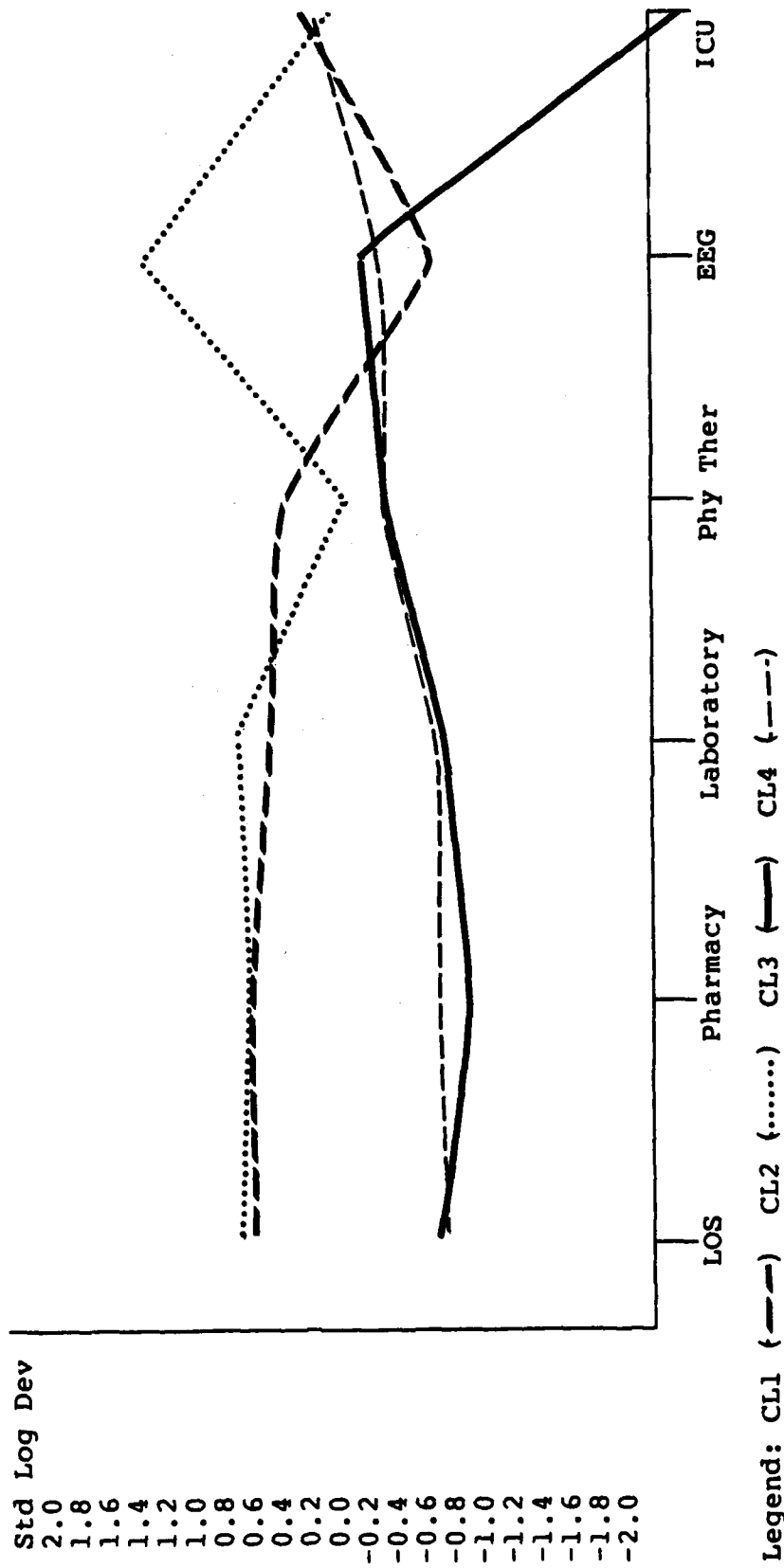
MEAN VALUES OF RESOURCES FOR COMBINED

Resources	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	Mean	Std dev	Mean	Std dev	Mean	Std dev	Mean	Std dev
Adult Days	1.89	.319	.44	.056	-.36	.028	-.72	.078
Pharmacy	2.17	.366	.50	.046	-.41	.029	-.83	.054
Lab	1.14	.193	.48	.066	-.23	.051	-.74	.089
Med Supplies	1.50	.253	.49	.063	-.049	.040	-1.25	.067
Sum Row 1-4 in dollars	9879	885	4778	78	3379	46	2881	78
Total Cost in dollars	14063	1025	8109	122	6420	73	5845	116

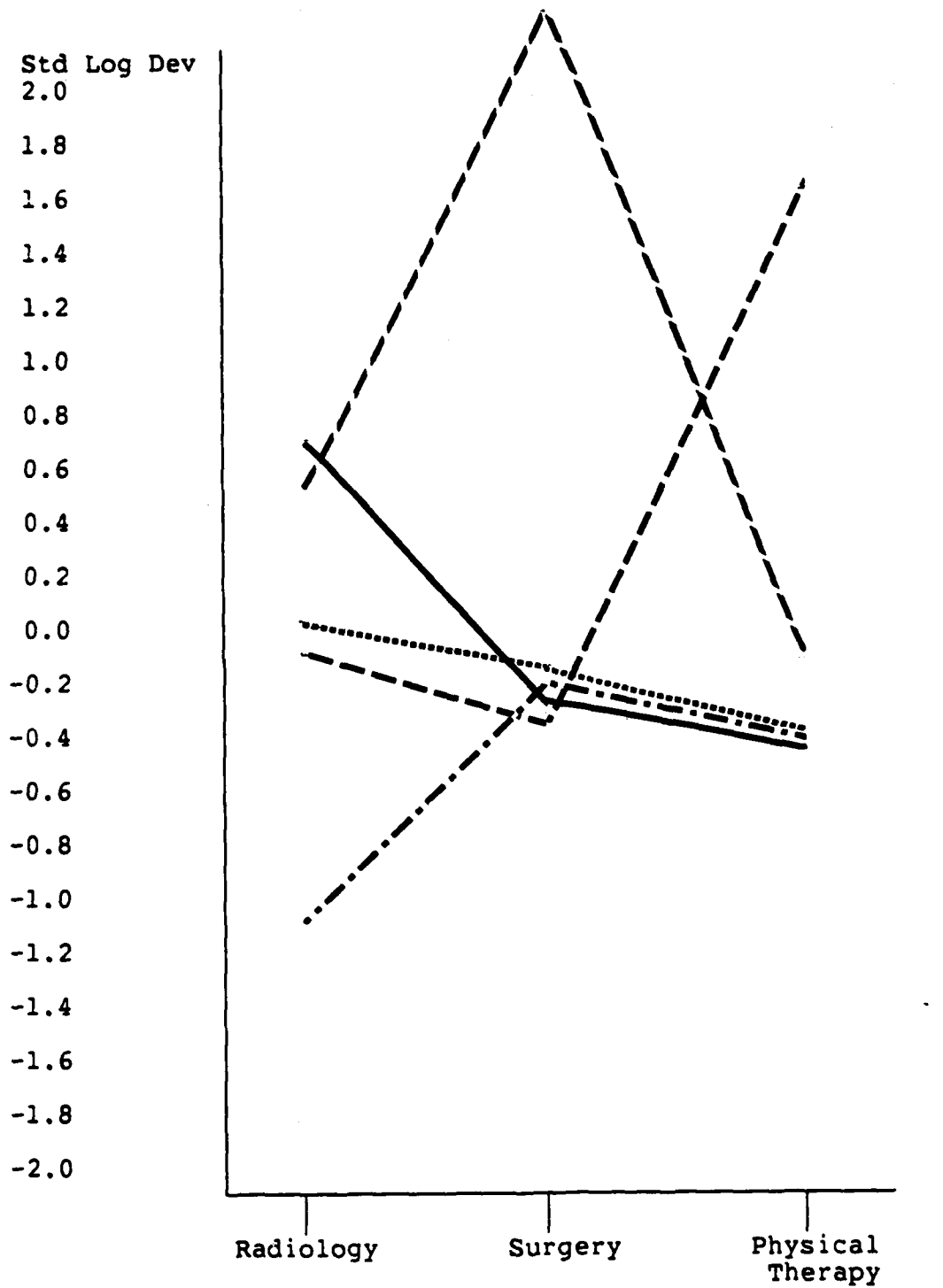
- Note 1) The individual intermediate products (e.g, Lab, etc.) are standardized logs.
- 2) The sum row is the total costs for the sum of the intermediate products (aggregate cost centers).
- 3) The data is for 1983 and 1984 combined.

APPENDIX 8
GRAPH OF COMBINED PRACTICE PATTERNS

APPENDIX 8.1 DRG(14)
GRAPH OF PRACTICE PATTERNS

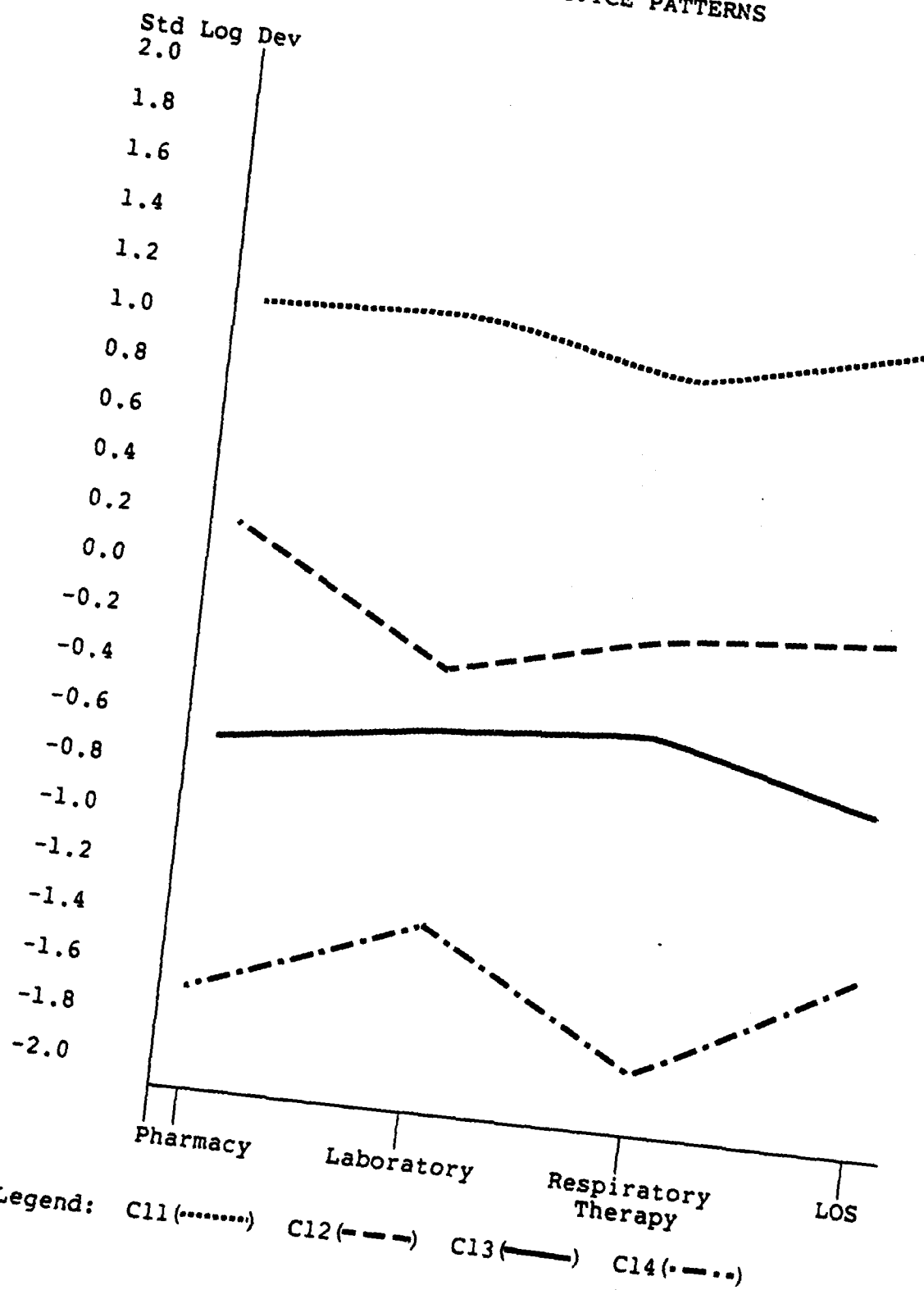


APPENDIX 8.2 DRG(82)
GRAPH OF PRACTICE PATTERNS

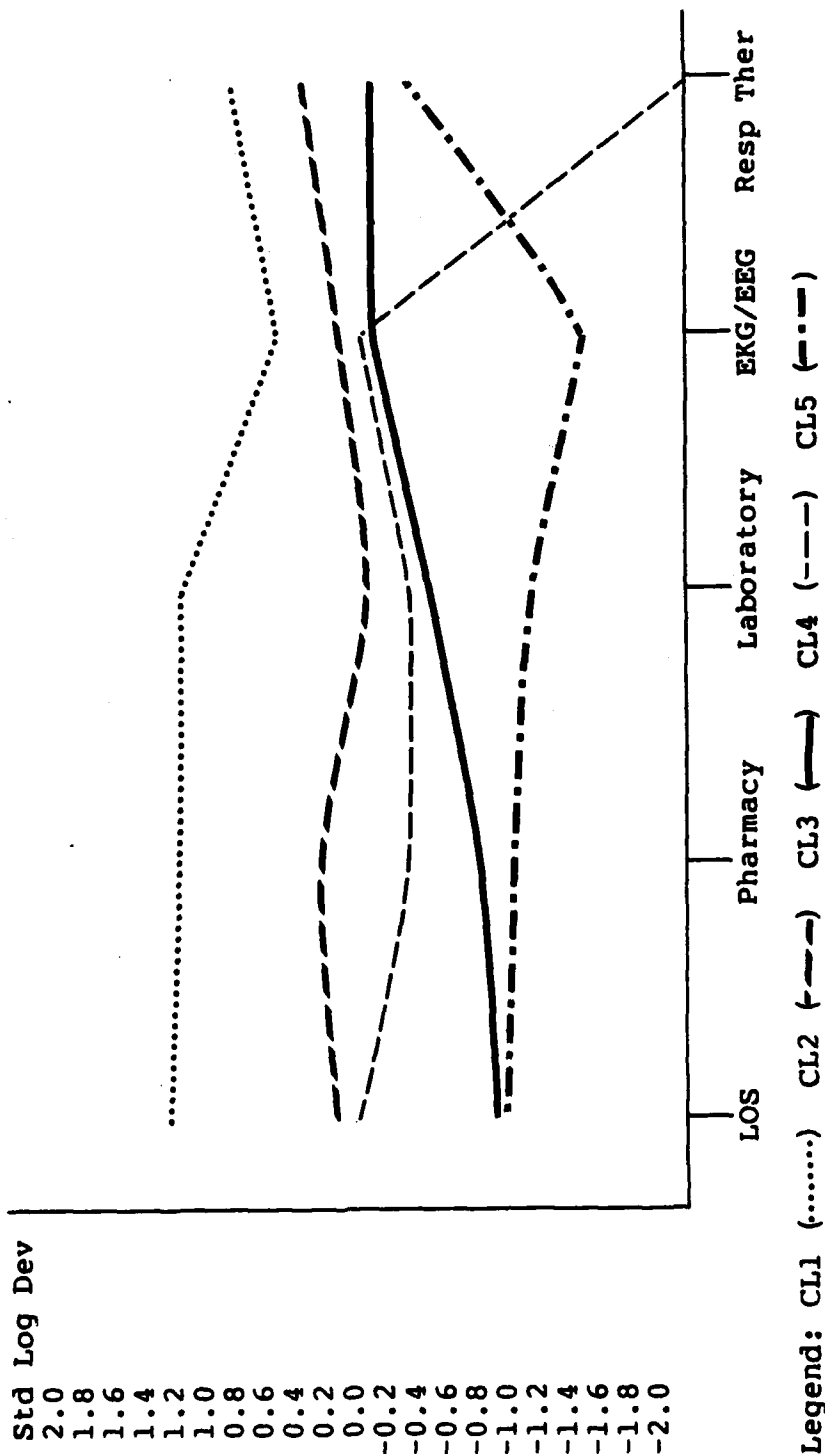


Legend: C11(---) C12(-.-) C13(—) C14(.....) C15(---)

APPENDIX 8.3 DRG(88)
GRAPH OF PRACTICE PATTERNS

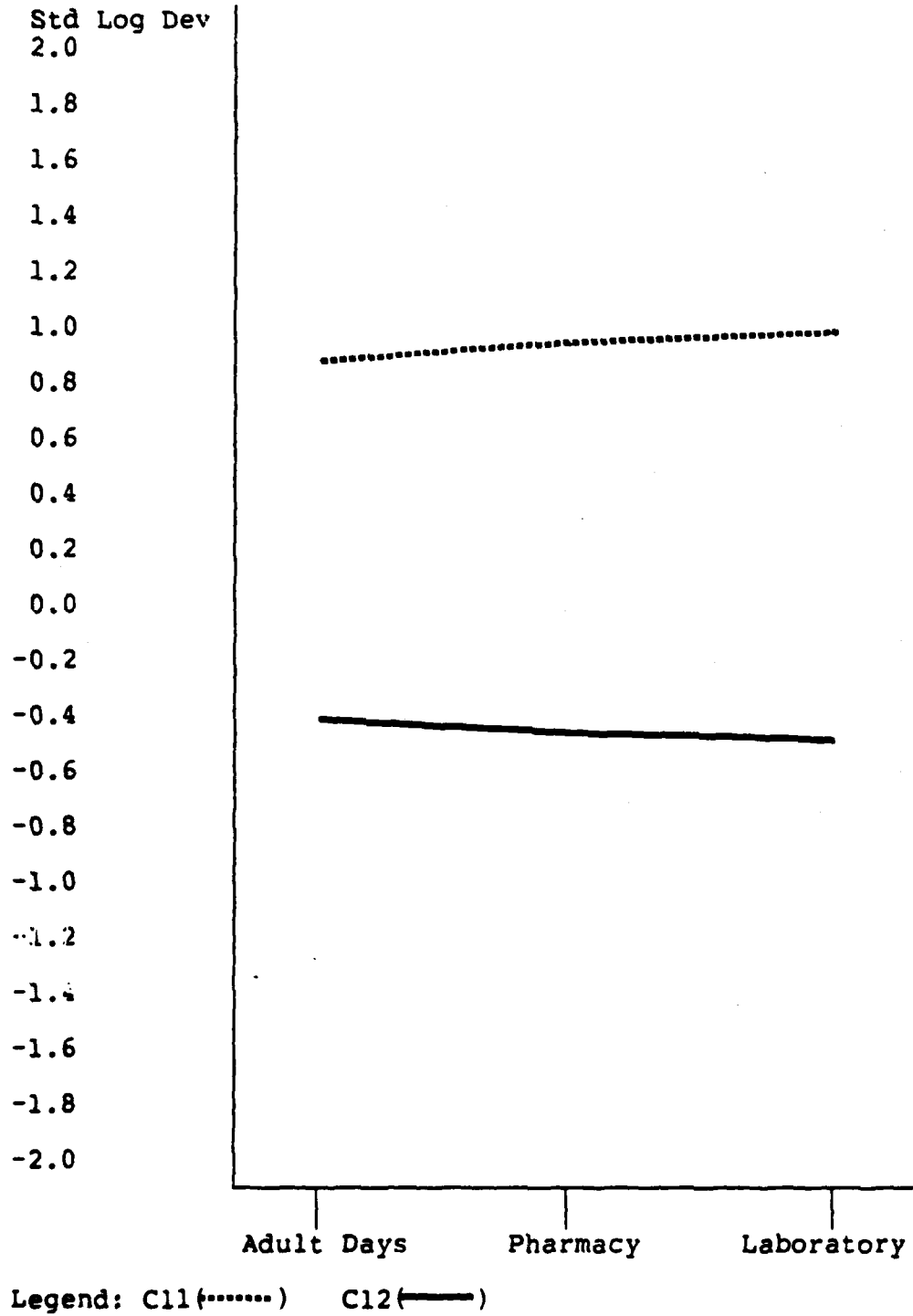


APPENDIX 8.4 DRG(127)
GRAPH OF PRACTICE PATTERNS



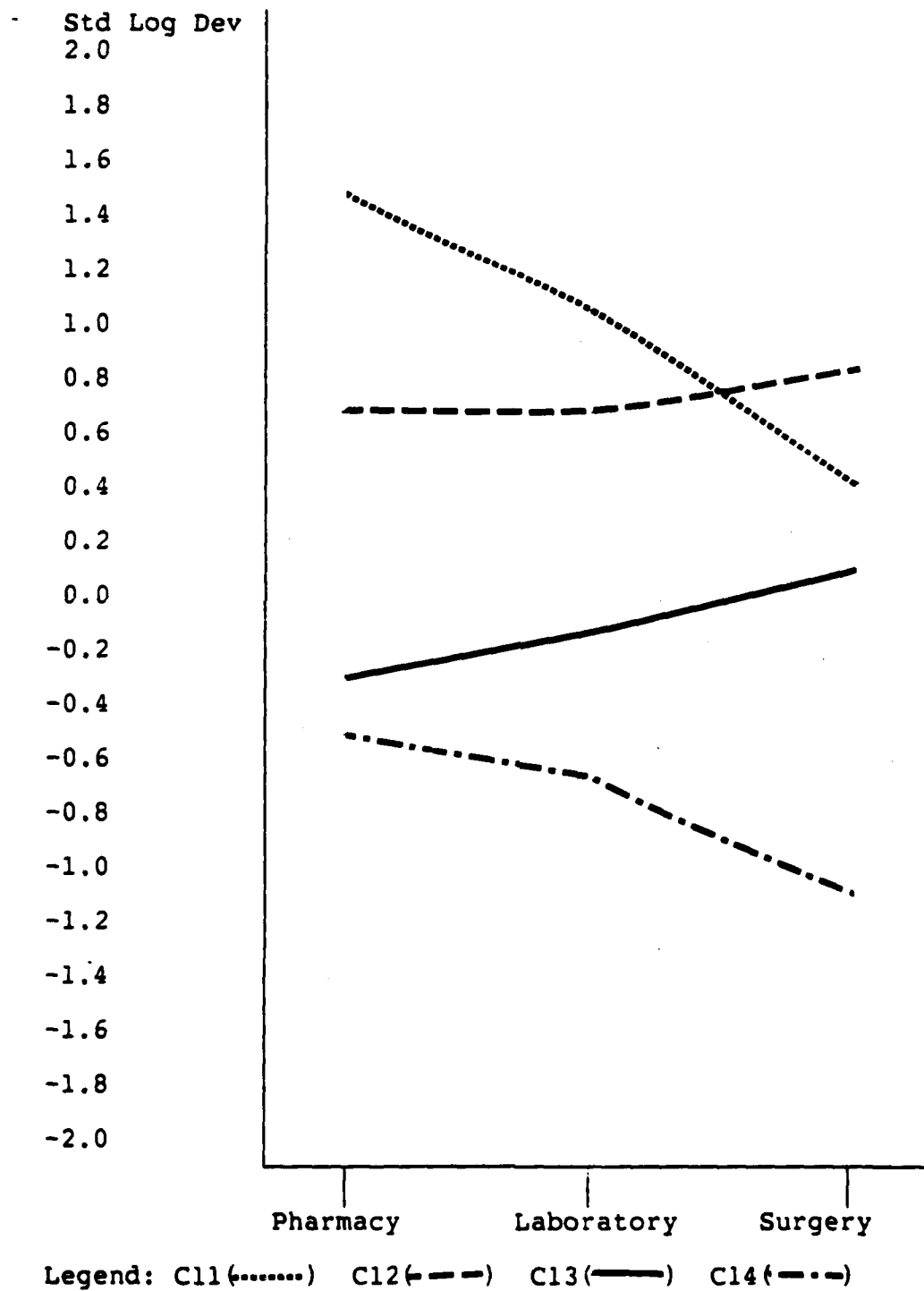
APPENDIX 8.5 DRG(198)

GRAPH OF PRACTICE PATTERNS

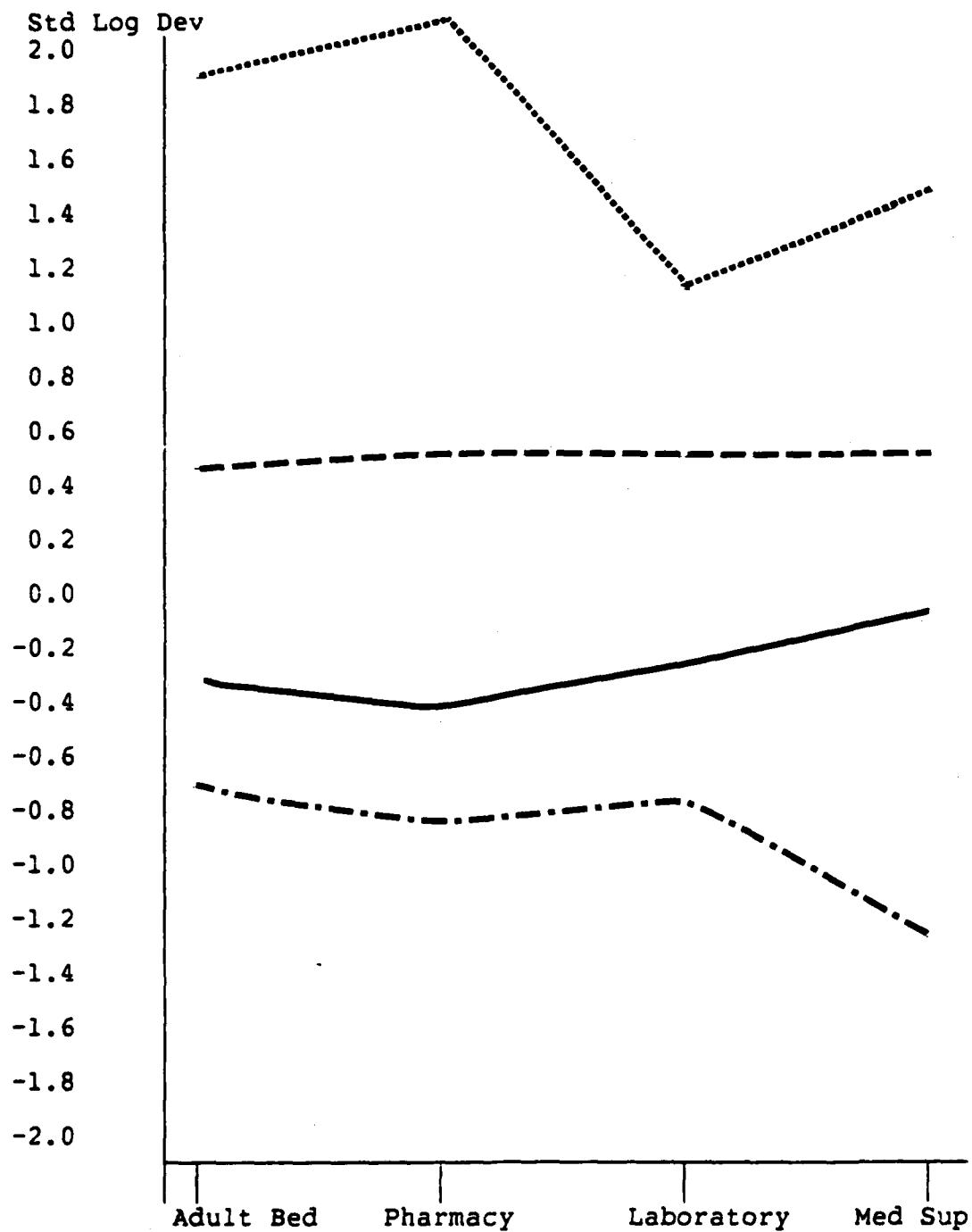


APPENDIX 8.6 DRG(355)

GRAPH OF PRACTICE PATTERNS



APPENDIX 8.7 DRG(209)
GRAPH OF PRACTICE PATTERNS



Legend: C11(.....) C12(- - -) C13(—) C14(- . - .)

APPENDIX 9
COMPARISON OF CLUSTERS

APPENDIX 9.1 TOWAY ANALYSIS DRG(14)

INDIVIDUAL CLUSTERS FOR 83 AND 83
COMPARED TO COMBINED CLUSTERS

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	274	82	64	106	22
Row%		29.9	23.4	38.7	8.0
Col%					
C1 1	102	70	0	30	2
Row%		68.6		29.4	2.0
Col%	37.2	85.4		28.3	9.1
C1 2	72	0	52	13	7
Row%			72.2	18.1	9.7
Col%	26.3		81.3	12.3	31.8
C1 3	67	1	0	60	6
Row%		1.5		89.6	9.0
Col%	24.5	1.2		56.6	27.3
C1 4	33	11	12	3	7
Row%		33.3	36.4	9.1	21.2
Col%	12.0	13.4	18.8	2.8	31.8

Chi-Square 280.91 Sig=0.

 κ .57

Accuracy of exact match = .69

Accuracy of adjacent match = .76

Appendix 9.1 (continued)

INDIVIDUAL CLUSTERS FOR 83 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Indivual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	122	32	36	45	9
Row%		26.2	29.5	36.9	7.4
Col%					
C1 1	52	27	0	24	1
Row%		51.9		46.2	1.9
Col%	42.6	84.4		53.3	11.1
C1 2	32	0	31	1	0
Row%			96.9	3.1	
Col%	26.2		86.1	2.2	
C1 3	24	0	0	19	5
Row%				79.2	20.8
Col%	19.7			42.2	55.6
C1 4	14	5	5	1	3
Row%		35.7	35.7	7.1	21.4
Col%	11.5	15.6	13.9	2.2	33.3

Chi-Square 140.26 Sig=0.

 κ .53

Accuracy of exact match = .66

Accuracy of adjacent match = .71

Appendix 9.1 (continued)

INDIVIDUAL CLUSTERS FOR 84 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	152	50	28	61	13
Row%		32.9	18.4	40.1	8.6
Col%					
Cl 1	50	43	0	6	1
Row%		86.0		12.0	2.0
Col%	32.9	86.0		9.8	7.7
Cl 2	40	0	21	12	7
Row%			52.5	30.0	17.5
Col%	26.3		75.0	19.7	53.8
Cl 3	43	1	0	41	1
Row%		2.3		95.3	2.3
Col%	28.3	2.0		67.2	7.7
Cl 4	19	6	7	2	4
Row%		31.6	36.8	10.5	21.1
Col%	12.5	12.0	25.0	3.3	30.8

Chi-Square 173.48 Sig=0.

 κ .61

Accuracy of exact match = .72

Accuracy of adjacent match = .82

APPENDIX 9.2 TOWAY ANALYSIS DRG(82)
INDIVIDUAL CLUSTERS FOR 83 AND 83 COMPARED TO COMBINED CLUSTERS
Combined Cluster

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Total Row% Col%	364	20 5.5	111 30.5	87 23.9	80 22.0	66 18.1
Cl 1 Row% Col%	12 3.3	2 16.7 10.0	3 25.0 2.7	2 16.7 2.3	1 8.3 1.3	4 33.3 6.1
Cl 2 Row% Col%	88 24.2	8 9.1 40.0	59 67.0 53.2	19 21.6 21.8	0	2 2.3 3.0
Cl 3 Row% Col%	133 36.5	5 3.8 25.0	49 36.8 44.1	66 49.6 75.9	13 9.8 16.3	0
Cl 4 Row% Col%	70 19.2	2 2.9 10.0	0	0	66 94.3 82.5	2 2.9 3.0
Cl 5 Row% Col%	61 16.8	3 4.9 15.0	0	0	0	58 95.1 87.9

Chi-Square 610.78 Sig=0. $\kappa = .59$
Accuracy of exact match = .69
Accuracy of adjacent match = .89

Appendix 9.2 (continued)

INDIVIDUAL CLUSTERS FOR 83 COMPARED TO COMBINED CLUSTERS
Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Total Row% Col%	199	10 5.0	61 30.7	47 23.6	46 23.1	35 17.6
C1 1 Row% Col%	5 2.5	1 20.0 10.0	1 20.0 1.6	1 20.0 2.1	1 20.0 2.2	1 20.0 2.9
C1 2 Row% Col%	18 9.0	5 27.8 50.0	11 61.1 18.0	0	0	2 11.1 5.7
C1 3 Row% Col%	97 48.7	2 2.1 20.0	49 50.5 80.3	46 47.4 97.7	0	0
C1 4 Row% Col%	46 23.1	1 2.2 10.0	0	0	45 97.8 97.8	0
C1 5 Row% Col%	33 16.6	1 3.0 10.0	0	0	0	32 97.0 91.4

Chi-Square 401.15 Sig=0. $\kappa = .59$
 Accuracy of exact match = .68
 Accuracy of adjacent match = .95

Appendix 9.2 (continued)

INDIVIDUAL CLUSTERS FOR 84 COMPARED TO COMBINED CLUSTERS
Combined Custers

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Total Row% Col%	165	10 6.1	50 30.3	40 24.2	34 20.6	31 18.8
Cl 1 Row% Col%	7 4.2	1 14.3 10.0	2 28.6 4.0	1 14.3 2.5	0	3 42.9 9.7
Cl 2 Row% Col%	70 42.4	3 4.3 30.0	48 68.6 96.0	19 27.1 47.5	0	0
Cl 3 Row% Col%	36 21.8	3 8.3 30.0	0	20 55.6 50.0	13 36.1 38.2	0
Cl 4 Row% Col%	24 14.5	1 4.2 10.0	0	0	21 87.5 61.8	2 8.3 6.5
Cl 5 Row% Col%	28 17.0	2 7.1 20.0	0	0	0	26 92.9 83.9

Chi-Square 273.03 Sig=0. $\kappa = .60$
 Accuracy of exact match = .70
 Accuracy of adjacent match = .92

APPENDIX 9.3 TOWAY ANALYSIS DRG(88)

INDIVIDUAL CLUSTERS FOR 83 AND 83
COMPARED TO COMBINED CLUSTERS

Combined Clusters

Indivual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	338	91	122	97	28
Row%		26.9	36.1	28.7	8.3
Col%					
C1 1	50	48	2	0	0
Row%		96.0	4.0		
Col%	14.8	52.7	1.6		
C1 2	145	42	93	10	0
Row%		29.0	64.1	6.9	
Col%	42.9	46.2	76.2	10.3	
C1 3	115	0	20	87	8
Row%			17.4	75.7	7.0
Col%	34.0		16.4	89.7	28.6
C1 4	28	1	7	0	20
Row%		3.6	25.0		71.4
Col%	8.3	1.1	5.7		71.4

Chi-Square 469.35 Sig=0.

 κ .61

Accuracy of exact match = .73

Accuracy of adjacent match = .94

Appendix 9.3 (continued)

INDIVIDUAL CLUSTERS FOR 83 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Indivual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	187	57	68	51	11
Row%		30.5	36.4	27.3	5.9
Col%					
C1 1	23	23	0	0	0
Row%		100.0			
Col%	12.3	40.4			
C1 2	74	33	41	0	0
Row%		44.6	55.4		
Col%	39.6	57.9	60.3		
C1 3	73	0	20	51	2
Row%			27.4	69.9	2.7
Col%	39.0		29.4	100.0	18.2
C1 4	17	1	7	0	9
Row%		5.9	41.2		52.9
Col%	9.1	1.8	10.3		81.8

Chi-Square 234.97 Sig=0.

 κ .52

Accuracy of exact match = .66

Accuracy of adjacent match = .94

Appendix 9.3 (continued)

INDIVIDUAL CLUSTERS FOR 84 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	151	34	54	46	17
Row%		22.5	35.8	30.5	11.3
Col%					
Cl 1	27	25	2	0	0
Row%		92.6	7.4		
Col%	17.9	73.5	3.7		
Cl 2	71	9	52	10	0
Row%		12.7	73.2	14.1	
Col%	47.0	26.5	96.3	21.7	
Cl 3	42	0	0	36	6
Row%				85.7	14.3
Col%	27.8			78.3	35.3
Cl 4	11	0	0	0	11
Row%					100.0
Col%	7.3				64.7

Chi-Square 275.02 Sig=0.

 κ .74

Accuracy of exact match = .82

Accuracy of adjacent match = .94

APPENDIX 9.4 TWOWAY ANALYSIS DRG(127)

INDIVIDUAL CLUSTERS FOR 83 AND 83 COMPARED TO COMBINED CLUSTERS
Combined Cluster

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Total Row% Col%	394	77 19.5	140 35.5	97 24.6	31 7.9	49 12.4
Cl 1 Row% Col%	58 14.7	49 84.5 63.6	6 10.3 4.3	0	3 5.2 9.7	0
Cl 2 Row% Col%	122 31.0	24 19.7 31.2	87 71.3 62.1	9 7.4 9.3	0	2 1.6 4.1
Cl 3 Row% Col%	112 28.4	2 1.8 2.6	45 40.2 32.1	65 58.0 67.0	0	0
Cl 4 Row% Col%	45 11.4	2 4.4 2.6	1 2.2 .7	21 46.7 21.6	21 46.7 67.7	0
Cl 5 Row% Col%	57 14.5	0	1 1.8 .7	2 3.5 2.1	7 12.3 22.6	47 82.5 95.9

Chi-Square 715.31 Sig=0. $\kappa = .58$
 Accuracy of exact match = .68
 Accuracy of adjacent match = .96

Appendix 9.4 (continued)

INDIVIDUAL CLUSTERS FOR 83 COMPARED TO COMBINED CLUSTERS
Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Total Row% Col%	172	37 21.5	56 32.6	39 22.7	15 8.7	25 14.5
Cl 1 Row% Col%	15 8.7	12 80.0 32.4	0	0	3 20.0 20.0	0
Cl 2 Row% Col%	52 30.2	23 44.2 62.2	25 48.1 44.6	3 5.8 7.7	0	1 1.9 4.0
Cl 3 Row% Col%	48 27.9	2 4.2 5.4	30 62.5 53.6	16 33.3 41.0	0	0
Cl 4 Row% Col%	27 15.7	0	1 3.7 1.8	19 70.4 48.7	7 25.9 46.7	0
Cl 5 Row% Col%	30 17.4	0	0	1 3.3 2.6	5 16.7 33.3	24 80.0 96.0

Chi-Square 267.80 Sig=0. $\kappa = .35$

Accuracy of exact match = .49

Accuracy of adjacent match = .94

Appendix 9.4 (continued)

INDIVIDUAL CLUSTERS FOR 84 COMPARED TO COMBINED CLUSTERS
Combined Custers

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Total	222	40	84	58	16	24
Row%		18.0	37.8	26.1	7.2	10.8
Col%						
Cl 1	43	37	6	0	0	0
Row%		86.0	14.0			
Col%	19.4	92.5	7.1			
Cl 2	70	1	62	6	0	1
Row%		1.4	88.6	8.6		1.4
Col%	31.5	2.5	73.8	10.3		4.2
Cl 3	64	0	15	49	0	0
Row%			23.4	76.6		
Col%	28.8		17.9	84.5		
Cl 4	18	2	0	2	14	0
Row%		11.1		11.1	77.8	
Col%	8.1	5.0		3.4	87.5	
Cl 5	27	0	1	1	2	23
Row%			3.7	3.7	7.4	85.2
Col%	12.2		1.2	1.7	12.5	95.8

Chi-Square 593.80 Sig=0. $\kappa = .77$
 Accuracy of exact match = .83
 Accuracy of adjacent match = .97

APPENDIX 9.5 TOWAY ANALYSIS DRG(198)

INDIVIDUAL CLUSTERS FOR 83 AND 83
COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2
Total	263	84	179
Row%		31.9	68.1
Col%			
C1 1	70	68	2
Row%		97.1	2.9
Col%	26.6	81.0	1.1
C1 2	193	16	177
Row%		8.3	91.7
Col%	73.4	19.0	98.9

Chi-Square 186.56 Sig=0.

κ .83

Accuracy of exact match = .93

Accuracy of adjacent match = 1.0

Appendix 9.5 (continued)

INDIVIDUAL CLUSTERS FOR 83 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2
Total	125	36	89
Row%		28.8	71.2
Col%			
Cl 1	36	35	1
Row%		97.2	2.8
Col%	28.8	97.2	1.1
Cl 2	89	1	88
Row%		1.1	98.9
Col%	71.2	2.8	98.9

Chi-Square 115.44 Sig=0.

 κ .95

Accuracy of exact match = .98

Accuracy of adjacent match = 1.0

Appendix 9.5 (continued)

INDIVIDUAL CLUSTERS FOR 84 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2
Total	138	48	90
Row%		34.8	65.2
Col%			
C1 1	34	33	1
Row%		97.1	2.9
Col%	24.6	68.8	1.1
C1 2	104	15	89
Row%		14.4	85.6
Col%	75.4	31.3	98.9

Chi-Square 77.13 Sig=0.

 κ .72

Accuracy of exact match = .88

Accuracy of adjacent match = 1.0

APPENDIX 9.6 TOWAY ANALYSIS DRG(355)

INDIVIDUAL CLUSTERS FOR 83 AND 83
COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	566	51	114	265	136
Row%		9.0	20.1	46.8	24.0
Col%					
Cl 1	94	42	47	5	0
Row%		44.7	50.0	5.3	
Col%	16.6	82.4	41.2	1.9	
Cl 2	117	0	64	52	1
Row%			54.7	44.4	.9
Col%	20.7		56.1	19.6	.7
Cl 3	266	0	3	197	66
Row%			1.1	74.1	24.8
Col%	47.0		2.6	74.3	48.5
Cl 4	89	9	0	11	69
Row%		10.1		12.4	77.5
Col%	15.7	17.6		4.2	50.7

Chi-Square 598.29 Sig=0.

 κ .50

Accuracy of exact match = .66

Accuracy of adjacent match = .90

Appendix 9.6 (continued)

INDIVIDUAL CLUSTERS FOR 83 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	289	27	60	135	67
Row%		9.3	20.8	46.7	23.2
Col%					
C1 1	34	23	11	0	0
Row%		67.6	32.4		
Col%	11.8	85.2	18.3		
C1 2	67	0	49	17	1
Row%			73.1	25.4	1.5
Col%	23.2		81.7	12.6	1.5
C1 3	146	0	0	115	31
Row%				78.8	21.2
Col%	50.5			85.2	46.3
C1 4	42	4	0	3	35
Row%		9.5		7.1	83.3
Col%	14.5	14.8		2.2	52.2

Chi-Square 429.24 Sig=0.

 κ .66

Accuracy of exact match = .77

Accuracy of adjacent match = .98

Appendix 9.6 (continued)

INDIVIDUAL CLUSTERS FOR 84 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	277	24	54	130	69
Row%		8.7	19.5	46.9	24.9
Col%					
Cl 1	60	19	36	5	0
Row%		31.7	60.0	8.3	
Col%	21.7	79.2	66.7	3.8	
Cl 2	50	0	15	35	0
Row%			30.0	70.0	
Col%	18.1		27.8	26.9	
Cl 3	120	0	3	82	35
Row%			2.5	68.3	29.2
Col%	43.3		5.6	63.1	50.7
Cl 4	47	5	0	8	34
Row%		10.6		17.0	72.3
Col%	17.0	20.8		6.2	49.3

Chi-Square 247.96 Sig=0.

 κ .34

Accuracy of exact match = .54

Accuracy of adjacent match = .95

APPENDIX 9.7 TOWAY ANALYSIS DRG(209)

INDIVIDUAL CLUSTERS FOR 83 AND 83
COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	422	62	111	173	76
Row%		14.7	26.3	41.0	18.0
Col%					
C1 1	35	34	1	0	0
Row%		97.1	2.9		
Col%	8.3	54.8	.9		
C1 2	132	22	81	28	1
Row%		16.7	61.4	21.4	.8
Col%	31.3	35.5	73.5	16.2	1.3
C1 3	168	1	27	132	8
Row%		.6	16.1	78.6	4.8
Col%	39.8	1.6	24.3	76.3	10.5
C1 4	87	5	2	13	67
Row%		5.7	2.3	14.9	77.0
Col%	20.6	8.1	1.8	7.5	88.2

Chi-Square 596.39 Sig=0.

 κ .65

Accuracy of exact match = .75

Accuracy of adjacent match = .90

Appendix 9.7 (continued)

INDIVIDUAL CLUSTERS FOR 83 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	196	28	52	86	30
Row%		14.3	26.5	43.9	15.3
Col%					
Cl 1	16	15	1	0	0
Row%		93.8	6.3		
Col%	8.2	53.6	1.9		
Cl 2	63	11	39	13	0
Row%		17.5	61.9	20.6	
Col%	32.1	39.3	75.0	15.1	
Cl 3	76	1	12	60	3
Row%		1.3	15.8	78.9	3.9
Col%	38.8	3.6	23.1	69.8	10.0
Cl 4	41	1	0	13	27
Row%		2.4		31.7	65.9
Col%	20.9	3.6		15.1	90.0

Chi-Square 254.93 Sig=0.

 κ .60

Accuracy of exact match = .72

Accuracy of adjacent match = .92

Appendix 9.7 (continued)

INDIVIDUAL CLUSTERS FOR 84 COMPARED TO COMBINED CLUSTERS

Combined Clusters

Individual Clusters	Cell Stat	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total	226	34	59	87	46
Row%		15.0	26.1	38.5	20.4
Col%					
C1 1	19	19	0	0	0
Row%		100.0			
Col%	8.4	55.9			
C1 2	69	11	42	15	1
Row%		15.9	60.9	21.7	1.4
Col%	30.5	32.4	71.2	17.2	2.2
C1 3	92	0	15	72	5
Row%			16.3	78.3	5.4
Col%	40.7		25.4	82.8	10.9
C1 4	46	4	2	0	40
Row%		8.7	4.3		87.0
Col%	20.4	11.8	3.4		87.0

Chi-Square 349.03 Sig=0.

 κ .68

Accuracy of exact match = .54

Accuracy of adjacent match = .95

APPENDIX 10
EXTERNAL VALIDATION OF CLUSTERS

APPENDIX 10.1 DRG(14)

EXTERNAL VALIDATION OF CLUSTERS

Category	Variable	Significance of Chi-Sq
Patient	Age*	.04
	Zip	.17
	Stage	.69
	Payor	.29
	Admission Type*	.01
	Religion	.06
	Race	.71
	Teaching Service Pat	.45
	Pre-Admission Testing	N/A
	Sex	.44
Physician	ICD9CM	.77
	Speciality*	.00
	Discharge Service*	.00
Outcome	Physician*	.00
	Discharge Status*	.03

Note 1) N/A signifies that only one value of variable is specified in the dataset, therefore the Chi-sq test could not be completed.

2) (*) signifies that the variable was used as evidence of external validation, $P \leq .05$.

APPENDIX 10.2 DRG(82)

EXTERNAL VALIDATION OF CLUSTERS

Category	Variable	Significance of Chi-Sq
Patient	Age	.66
	Zip	.06
	Stage*	.00
	Payor	.85
	Admission Type*	.01
	Race*	.03
	Teaching Service Pat	.68
	Pre-Admission Testing	N/A
	Sex	.68
	Religion	.64
	ICD9CM*	.01
Physician	Speciality*	.00
	Discharge Service	.67
	Physician*	.00
Outcome	Discharge Status*	.00

Note 1) N/A signifies that only one value of variable is specified in the dataset, therefore the Chi-sq test could not be completed.

2) (*) signifies that the variable was used as evidence of external validation, $P \leq .05$.

APPENDIX 10.3 DRG(88)

EXTERNAL VALIDATION OF CLUSTERS

Category	Variable	Significance of Chi-Sq
Patient	Age*	.00
	Zip	.65
	Stage*	.01
	Payor	.21
	Admission Type*	.00
	Religion	.87
	Race	.15
	Teaching Service Pat	.64
	Pre-Admission Testing	N/A
	Sex	.20
	ICD9CM*	.05
Physician	Speciality*	.02
	Discharge Service	N/A
	Physician	.24
Outcome	Discharge Status*	.03

Note 1) N/A signifies that only one value of variable is specified in the dataset, therefore the Chi-sq test could not be completed.

2) (*) signifies that the variable was used as evidence of external validation, $P \leq .05$.

APPENDIX 10.4 DRG(127)

EXTERNAL VALIDATION OF CLUSTERS

Category	Variable	Significance of Chi-Sq
Patient	Age	.12
	Zip	.12
	Stage	.21
	Payor	.61
	Admission Type	.38
	Religion	.30
	Race	.32
	Teaching Service Pat	.62
	Pre-Admission Testing	N/A
	Sex	.34
	ICD9CM*	.04
Physician	Speciality*	.01
	Discharge Service	N/A
	Physician	.10
Outcome	Discharge Status*	.00

Note 1) N/A signifies that only one value of variable is specified in the dataset, therefore the Chi-sq test could not be completed.

2) (*) signifies that the variable was used as evidence of external validation, $P \leq .05$.

APPENDIX 10.5 DRG(198)

EXTERNAL VALIDATION OF CLUSTERS

Category	Variable	Significance of Chi-Sq
Patient	Age*	.00
	Zip*	.02
	Stage	.17
	Payor*	.01
	Admission Type*	.00
	Religion	.78
	Race*	.03
	Teaching Service Pat	.58
	Pre-Admission Testing	.23
	Sex	.46
	ICD9CM	N/A
Physician	Speciality	N/A
	Discharge Service	.34
	Physician	.31
Outcome	Discharge Status*	.00

Note 1) N/A signifies that only one value of variable is specified in the dataset, therefore the Chi-sq test could not be completed.

2) (*) signifies that the variable was used as evidence of external validation, $P \leq .05$.

APPENDIX 10.6 DRG(355)

EXTERNAL VALIDATION OF CLUSTERS

Category	Variable	Significance of Chi-Sq
Patient	Age	.26
	Zip	.34
	Stage	.13
	Payor*	.02
	Admission Type*	.03
	Religion	.77
	Race*	.00
	Teaching Service Pat*	.02
	Pre-Admission Testing	N/A
	ICD9CM*	.01
	Sex	N/A
Physician	Speciality	.07
	Discharge Service	.56
	Physician*	.00
Outcome	Discharge Status	.33

Note 1) N/A signifies that only one value of variable is specified in the dataset, therefore the Chi-sq test could not be completed.

2) (*) signifies that the variable was used as evidence of external validation, $P \leq .05$.

APPENDIX 10.7 DRG(209)

EXTERNAL VALIDATION OF CLUSTERS

Category	Variable	Significance of Chi-Sq
Patient	Age*	.00
	Zip*	.01
	Stage	.80
	Payor*	.00
	Admission Type*	.03
	Religion	.08
	Race	.60
	Teaching Service Pat	.67
	Pre-Admission Testing	N/A
	Sex*	.00
	ICD9CM*	.00
Physician	Speciality	N/A
	Discharge Service	.53
	Physician*	.00
Outcome	Discharge Status*	.00

Note 1) N/A signifies that only one value of variable is specified in the dataset, therefore the Chi-sq test could not be completed.

2) (*) signifies that the variable was used as evidence of external validation, $P \leq .05$.

APPENDIX 11
FINANCIAL SIGNIFICANCE OF COMBINED CLUSTERS

APPENDIX 11.1 DRG(14) FINANCIAL
SIGNIFICANCE OF CLUSTERS COMBINED

Resource	Measurement	Eta-Sq	F-Stat	Significance
LOS	Std Dev	.49	87.5	.0000
Pharmacy	Std Dev	.45	73.7	.0000
Laboratory	Std Dev	.41	62.0	.0000
Physicial Therapy	Std Dev	.11	11.4	.0000
EEG	Std Dev	.72	226.4	.0000
ICU	Std Dev	.54	108.3	.0000
Sum of Rows 1-6	Dollars	.19	21.1	.0000
Total Cost	Dollars	.21	24.5	.0000

Note 1) Data for years 1983 and 1984 combined.

APPENDIX 11.2 DRG(82)

FINANCIAL SIGNIFICANCE OF CLUSTERS COMBINED

Resource	Measurement	Eta-Sq	F-Stat	Significance
Respiratory Therapy	Std Dev	.63	153.2	.0000
Physical Therapy	Std Dev	.42	64.7	.0000
Surgery	Std Dev	.88	687.7	.0000
Sum of Rows 1-3	Dollars	.27	33.8	.0000
Total Cost	Dollars	.20	22.4	.0000

Note 1) Data for years 1983 and 1984 combined.

APPENDIX 11.3 DRG(88)

FINANCIAL SIGNIFICANCE OF CLUSTERS COMBINED

Resource	Measurement	Eta-Sq	F-Stat	Significance
Pharmacy	Std Dev	.68	238.4	.0000
Laboratory	Std Dev	.57	149.6	.0000
Respiratory Therapy	Std Dev	.60	167.4	.0000
LOS	Std Dev	.68	236.1	.0000
Sum of Rows 1-4	Dollars	.44	86.3	.0000
Total Cost	Dollars	.42	80.0	.0000

Note 1) Data for years 1983 and 1984 combined.

APPENDIX 11.4 DRG(127)

FINANCIAL SIGNIFICANCE OF CLUSTERS COMBINED

Resource	Measurement	Eta-Sq	F-Stat	Significance
LOS	Std Dev	.63	71.3	.0000
Pharmacy	Std Dev	.53	115.5	.0000
Laboratory	Std Dev	.46	83.1	.0000
EKG/EEG	Std Dev	.24	31.7	.0000
Respiratory Therapy	Std Dev	.76	318.8	.0000
Sum of Rows 1-5	Dollars	.29	39.2	.0000
Total Cost	Dollars	.34	50.5	.0000

Note 1) Data for years 1983 and 1984 combined.

APPENDIX 11.5 DRG (198)

FINANCIAL SIGNIFICANCE OF CLUSTERS COMBINED

Resource	Measurement	Eta-Sq	F-Stat	Significance
Adult Bed	Std Dev	.36	146.8	.0000
Pharmacy	Std Dev	.42	191.6	.0000
Laboratory	Std Dev	.46	221.8	.0000
Sum of Rows 1-4	Dollars	.36	136.1	.0000
Total Cost	Dollars	.33	130.5	.0000

Note 1) Data for years 1983 and 1984 combined.

APPENDIX 11.6 DRG(355)

FINANCIAL SIGNIFICANCE OF CLUSTERS COMBINED

Resource	Measurement	Eta-Sq	F-Stat	Significance
Pharmacy	Std Dev	.40	122.8	.0000
Laboratory	Std Dev	.30	80.7	.0000
Surgery	Std Dev	.45	155.5	.0000
Sum of Rows 1-3	Dollars	.51	198.0	.0000
Total	Dollars	.42	134.4	.0000

Note 1) Data for years 1983 and 1984 combined.

APPENDIX 11.7 DRG(209)

FINANCIAL SIGNIFICANCE OF CLUSTERS COMBINED

Resource	Measurement	Eta-Sq	F-Stat	Significance
Adult Bed	Std Dev	.52	150.9	.0000
Pharmacy	Std Dev	.68	300.3	.0000
Laboratory	Std Dev	.32	64.3	.0000
Med Supplies	Std Dev	.59	197.4	.0000
Sum of Rows 1-4	Dollars	.56	174.9	.0000
Total Cost	Dollars	.53	157.3	.0000

Note 1) Data for years 1983 and 1984 combined.

APPENDIX 12
MNA OVERALL STATISTICS

APPENDIX 12.1 DRG(14)

OVERALL STATISTICS

Cluster Number	Percentage	Number of Cases
1	29.93	82
2	23.36	64
3	38.69	106
4	0.03	22

$R^2 = .25$ (Generalized Squared Multiple Correlation)

$\Theta = .60$ (Multivariate Theta)

Predictive Accuracy Gain = 55% $[(.60 - .38) / .38]$

Fraction Unexplained Variance = 34%
 $[(.60 - .39) / (1 - .39)]$

APPENDIX 12.2 DRG(82)

OVERALL STATISTICS

Cluster Number	Percentage	Number of Cases
1	5.49	20
2	30.49	111
3	23.90	87
4	21.94	80
5	18.13	66

$R^2 = .17$ (Generalized Squared Multiple Correlation)

$\Theta = .51$ (Multivariate Theta)

Predictive Accuracy Gain = 67% $[(.51 - .30)/.30]$

Fraction Unexplained Variance = 30%
 $[(.51 - .30)/(1 - .30)]$

APPENDIX 12.3 DRG(88)

OVERALL STATISTICS

Cluster Number	Percentage	Number of Cases
1	24.72	91
2	33.15	122
3	34.51	127
4	8.28	28

$R^2 = .13$ (Generalized Squared Multiple Correlation)

$\Theta = .514$ (Multivariate Theta)

Predictive Accuracy Gain = 50% $[(.514 - .345) / .345]$

Fraction Unexplained Variance = 18%
 $[(.51 - .34) / (1 - .34)]$

APPENDIX 12.4 DRG(127)

OVERALL STATISTICS

Cluster Number	Percentage	Number of Cases
1	19.54	77
2	35.53	140
3	24.62	97
4	7.87	31
5	12.44	49

$R^2 = .09$ (Generalized Squared Multiple Correlation)

$\Theta = .439$ (Multivariate Theta)

Predictive Accuracy Gain = 24% $[(.439 - .355) / .355]$

Fraction Unexplained Variance = 14%
 $[(.44 - .35) / (1 - .35)]$

APPENDIX 12.5 DRG(198)

OVERALL STATISTICS

Cluster Number	Percentage	Number of Cases
1	26.62	70
2	73.38	193

$R^2 = .27$ (Generalized Squared Multiple Correlation)

$\Theta = .81$ (Multivariate Theta)

Predictive Accuracy Gain = 10% $[(.81 - .73)/.73]$

Fraction Unexplained Variance = 35%
 $[(.81 - .73)/(1 - .73)]$

APPENDIX 12.6 DRG(355)

OVERALL STATISTICS

Cluster Number	Percentage	Number of Cases
1	9.01	51
2	20.14	114
3	46.82	265
4	24.03	136

$R^2 = .25$ (Generalized Squared Multiple Correlation)

$\Theta = .61$ (Multivariate Theta)

Predictive Accuracy Gain = 30% $[(.61 - .47) / .47]$

Fraction of Unexplained Variance = 26%
 $[(.61 - .47) / (1 - .47)]$

APPENDIX 12.7 DRG(209)

OVERALL STATISTICS

Cluster Number	Percentage	Number of Cases
1	8.29	35
2	31.28	132
3	39.81	168
4	20.62	87

$R^2 = .16$ (Generalized Squared Multiple Correlation)

$\theta = .55$ (Multivariate Theta)

Predictive Accuracy Gain = 39% $[(.55 - .40)/.40]$

Fraction of Unexplained Variance = 25%
 $[(.55 - .40)/(1 - .40)]$

CLASSIFICATION MATRIX

Predicted

APPENDIX 13
CLUSTER PREDICTIONS VS ACTUAL MEMBERSHIP

APPENDIX 13.1 DRG(14)

CLUSTER PREDICTIONS VS ACTUAL MEMBERSHIP

CORRECTLY CLASSIFIED

Predicted	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Weighted N	35	26	89	14
Percentage	.43	.41	.84	.64

Actual	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Totals
Cluster 1	35	8	39	0	82
Row%	42.7	9.8	47.6	0	100.0
Cluster 2	12	26	26	0	64
Row%	18.8	40.6	40.6	0	100.0
Cluster 3	6	9	89	2	106
Row%	5.7	8.5	84.0	1.9	100.0
Cluster 4	1	1	6	14	22
Row%	4.5	5.4	27.3	63.6	100.0
Totals	54	44	160	16	274
Row%	19.7	16.1	58.4	5.8	100.0

PHYSICIAN PRACTICE PATTERNS WITHIN AN ACUTE CARE
FACILITY(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB
OH T C MCKEE 1986 AFIT/CI/NR-86-22D

UNCLASSIFIED

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APPENDIX 13.2 DRG(82)

CLUSTER PREDICTIONS VS ACTUAL MEMBERSHIP

CORRECTLY CLASSIFIED

Predicted	C1 1	C1 2	C1 3	C1 4	C1 5
Weighted N	2	61	50	30	42
Percentage	.10	.55	.57	.38	.64

CLASSIFICATION MATRIX
Predicted

Actual	C1 1	C1 2	C1 3	C1 4	C1 5	Totals
Cluster 1	2	7	3	2	6	20
Row%	10.0	35.0	15.0	10.0	30.0	100.0
Cluster 2	0	61	20	19	11	111
Row%	0.0	55.0	18.0	17.1	9.9	100.0
Cluster 3	0	17	50	13	7	87
Row%	0.0	19.5	57.5	14.9	8.0	100.0
Cluster 4	0	22	14	30	14	80
Row%	0.0	27.5	17.5	37.5	17.5	100.0
Cluster 5	1	9	8	6	42	66
Row%	1.5	13.6	12.1	9.1	63.6	100.0
Totals	3	116	95	70	80	364
Row%	0.8	31.9	26.1	19.2	22.0	100.0

APPENDIX 13.3 DRG(88)

CLUSTER PREDICTIONS VS ACTUAL MEMBERSHIP

CORRECTLY CLASSIFIED

Predicted	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Weighted N	46	82	36	10
Percentage	.51	.67	.37	.36

CLASSIFICATION MATRIX

Predicted

Actual	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Totals
Cluster 1	46	33	10	2	91
Row%	50.5	36.3	11.0	2.2	100.0
Cluster 2	19	82	20	1	122
Row%	15.6	67.2	16.4	0.8	100.0
Cluster 3	19	42	36	0	97
Row%	19.6	43.3	37.1	0.0	100.0
Cluster 4	5	10	3	10	28
Row%	17.9	35.7	10.7	35.7	100.0
Totals	89	167	69	13	338
Row%	26.3	49.4	20.4	3.8	100.0

APPENDIX 13.4 DRG(127)

CLUSTER PREDICTIONS VS ACTUAL MEMBERSHIP

CORRECTLY CLASSIFIED

Predicted	Cl 1	Cl 2	Cl 3	Cl 4	Cl 5
Weighted N	26	102	37	8	0
Percentage	.34	.73	.38	.26	0

CLASSIFICATION MATRIX
Predicted

Actual	Cl 1	Cl 2	Cl 3	Cl 4	Cl 5	Totals
Cluster 1	26	40	11	0	0	77
Row%	33.8	51.9	14.3	0.0	0.0	100.0
Cluster 2	16	102	17	5	0	140
Row%	11.4	72.9	12.1	3.6	0.0	100.0
Cluster 3	7	50	37	3	0	97
Row%	7.2	51.5	38.1	3.1	0.0	100.0
Cluster 4	4	15	4	8	0	31
Row%	12.9	48.4	12.9	25.8	0.0	100.0
Cluster 5	4	29	13	3	0	49
Row%	8.2	59.2	26.5	6.1	0.0	100.0
Totals	57	236	82	19	0	394
Row%	14.5	59.9	20.8	4.8	0.0	100.0

APPENDIX 13.5 DRG(198)

CLUSTER PREDICTIONS VS ACTUAL MEMBERSHIP

CORRECTLY CLASSIFIED

Predicted	Cluster 1	Cluster 2
Weighted N	28	185
Percentage	.40	.96

CLASSIFICATION MATRIX

Predicted

Actual	Cluster 1	Cluster 2	Totals
Cluster 1	28	42	70
Row%	40.0	60.0	100.0
Cluster 2	8	185	193
Row%	4.1	95.9	100.0
Totals	36	227	263
Row%	13.7	86.3	100.0

APPENDIX 13.6 DRG(355)

CLUSTER PREDICTIONS VS ACTUAL MEMBERSHIP

CORRECTLY CLASSIFIED

Predicted	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Weighted N	10	67	204	64
Percentage	.20	.59	.77	.47

CLASSIFICATION MATRIX

Predicted

Actual	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Totals
Cluster 1	10	14	22	5	51
Row%	19.6	27.5	43.1	9.8	100.0
Cluster 2	1	67	39	7	114
Row%	0.9	58.8	34.2	6.1	100.0
Cluster 3	2	32	204	27	265
Row%	0.8	12.1	77.0	10.2	100.0
Cluster 4	0	10	62	64	136
Row%	0.0	7.4	45.6	47.1	100.0
Totals	13	123	327	103	566
Row%	2.3	21.7	57.8	18.2	100.0

APPENDIX 13.7 DRG(209)

CLUSTER PREDICTIONS VS ACTUAL MEMBERSHIP

CORRECTLY CLASSIFIED

Predicted	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Weighted N	0	80	125	28
Percentage	0.0	.60	.74	.32

CLASSIFICATION MATRIX

Predicted

Actual	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Totals
Cluster 1	0	22	12	1	35
Row%	0.0	62.9	34.3	2.9	100.0
Cluster 2	0	80	46	6	132
Row%	0.0	60.6	34.8	4.5	100.0
Cluster 3	0	31	125	12	168
Row%	0.0	18.5	74.4	7.1	100.0
Cluster 4	0	9	50	28	87
Row%	0.0	10.3	57.5	32.2	100.0
Totals	0	142	233	47	422
Row%	0.0	33.6	55.2	11.1	100.0

APPENDIX 14
PREDICTIVE EFFECT OF INDIVIDUAL VARIABLES

APPENDIX 14.1 DRG(14)

ADDITIVE EFFECT HOLDING VARIABLES CONSTANT

Variable	Modal %	Bi-Variate Theta	Difference	Percentage
Physician	38.7	56.6	19.9	90%
Discharge Status	38.7	47.1	8.4	38%
Age	38.7	39.0	.3	1%
Admission Type	38.7	39.0	.3	1%

- Note 1) Modal % is % of total patients classified into the modal cluster.
- 2) Bi-Variate Theta is the contribution to the model's predictive accuracy for each independent variable.
- 3) Difference is the difference between modal % and Bi-Variate Theta.
- 4) Percentage is the % of the model's total predictive power when using the single variable $[(\text{Bi-Variate Theta} - \text{Modal \%}) / (\Theta - \text{Modal \%})]$

APPENDIX 14.2 DRG(82)

ADDITIVE EFFECT HOLDING VARIABLES CONSTANT

Variable	Modal %	Bi-Variate Theta	Difference	Percentage
Physician	30.5	39.3	8.8	42%
ICD9CM	30.5	33.5	3.0	14%
Discharge Status	30.5	33.2	2.7	13%
Race	30.5	33.2	2.7	13%
Stage	30.5	35.7	5.2	25%

Note 1) Modal % is % of total patients classified into the modal cluster.

2) Bi-Variate Theta is the contribution to the model's predictive accuracy for each independent variable.

3) Difference is the difference between modal % and Bi-Variate Theta.

4) Percentage is the % of the model's total predictive power when using the single variable $[(\text{Bi-Variate Theta} - \text{Modal \%}) / (\Theta - \text{Modal \%})]$

APPENDIX 14.3 DRG(88)

ADDITIVE EFFECT HOLDING VARIABLES CONSTANT

Variable	Modal %	Bi-Variate Theta	Difference	Percentage
Physician	34.5	41.7	7.2	42%
ICD9CM	34.5	38.5	4.1	24%
Discharge Status	34.5	38.1	3.6	21%
Admission Type	34.5	38.0	3.5	18%
Age	34.5	36.7	2.2	13%
Speciality	34.5	34.5	0	0

- Note 1) Modal % is % of total patients classified into the modal cluster.
- 2) Bi-Variate Theta is the contribution to the model's predictive accuracy for each independent variable.
- 3) Difference is the difference between modal % and Bi-Variate Theta.
- 4) Percentage is the % of the model's total predictive power when using the single variable $[(\text{Bi-Variate Theta} - \text{Modal \%}) / (\Theta - \text{Modal \%})]$

APPENDIX 14.4 DRG(127)

ADDITIVE EFFECT HOLDING VARIABLES CONSTANT

Variable	Modal %	Bi-Variate Theta	Difference	Percentage
Physician	35.5	39.6	4.1	49%
Discharge Status	35.5	37.0	1.5	18%
IDC9CM	35.5	36.8	1.3	15%
Speciality	35.5	36.0	.5	6%

Note 1) Modal % is % of total patients classified into the modal cluster.

2) Bi-Variate Theta is the contribution to the model's predictive accuracy for each independent variable.

3) Difference is the difference between modal % and Bi-Variate Theta.

4) Percentage is the % of the model's total predictive power when using the single variable $[(\text{Bi-Variate Theta} - \text{Modal \%}) / (\Theta - \text{Modal \%})]$

APPENDIX 14.5 DRG(198)

ADDITIVE EFFECT HOLDING VARIABLES CONSTANT

Variable	Modal %	Bi-Variate Theta	Difference	Percentage
Discharge Status	73.4	74.2	.8	10%
Admission Type	73.4	74.3	.9	11%
Age	73.4	73.4	0	0
Payor	73.4	73.4	0	0
ICD9CM	73.4	73.4	0	0
Zip Code	73.4	73.4	0	0
Race	73.4	74.2	.8	10%
Physician	73.4	73.4	0	0

- Note 1) Modal % is % of total patients classified into the modal cluster.
- 2) Bi-Variate Theta is the contribution to the model's predictive accuracy for each independent variable.
- 3) Difference is the difference between modal % and Bi-Variate Theta.
- 4) Percentage is the % of the model's total predictive power when using the single variable $[(\text{Bi-Variate Theta} - \text{Modal \%}) / (\Theta - \text{Modal \%})]$

APPENDIX 14.6 DRG(355)

ADDITIVE EFFECT HOLDING VARIABLES CONSTANT

Variable	Modal %	Bi-Variate Theta	Difference	Percentage
Physician	46.8	55.8	9.0	64%
ICD9CM	46.8	50.5	3.7	27%
Admission Type	46.8	47.1	.4	3%
Race	46.8	47.1	.4	3%

Note 1) Modal % is % of total patients classified into the modal cluster.

2) Bi-Variate Theta is the contribution to the model's predictive accuracy for each independent variable.

3) Difference is the difference between modal % and Bi-Variate Theta.

4) Percentage is the % of the model's total predictive power when using the single variable $[(\text{Bi-Variate Theta} - \text{Modal \%}) / (\Theta - \text{Modal \%})]$

APPENDIX 14.7 DRG(209)

ADDITIVE EFFECT HOLDING VARIABLES CONSTANT

Variable	Modal %	Bi-Variate Theta	Difference	Percentage
Discharge Status	39.8	47.8	8.0	53%
ICD9CM	39.8	44.5	4.7	31%
Age	39.8	41.0	1.2	8%
Physician	39.8	42.1	2.1	14%
Zip Code	39.8	43.1	3.3	22%

Note 1) Modal % is % of total patients classified into the modal cluster.

2) Bi-Variate Theta is the contribution to the model's predictive accuracy for each independent variable.

3) Difference is the difference between modal % and Bi-Variate Theta.

4) Percentage is the % of the model's total predictive power when using the single variable $[(\text{Bi-Variate Theta} - \text{Modal \%}) / (\Theta - \text{Modal \%})]$

APPENDIX 15
PHYSICIAN PERCENTAGES AND COEFFICIENTS

APPENDIX 15.1 DRG(14)

PHYSICIAN PERCENTAGES AND COEFFICIENTS

Description	Measure	Cl 1	Cl 2	Cl 3	Cl 4
Total = 274	N	82	64	106	22
	%	29.9	23.4	38.7	8.0
MD Code = 1 N = 16 Total% = 5.84	%	0.00	0.00	12.50	87.50
	Adj%	5.58	4.35	4.98	85.10
	Coeff	-24.35	-19.01	-33.71	77.07
MD Code = 2 N = 15 Total% = 5.47	%	33.33	26.67	40.00	0.00
	Adj%	32.33	27.59	38.78	1.29
	Coeff	2.41	4.24	0.09	-6.47
MD Code = 3 N = 11 Total% = 4.01	%	27.27	27.27	45.45	0.00
	Adj%	21.81	23.30	53.97	0.91
	Coeff	-8.11	-0.05	15.29	-7.12
MD Code = 4 N = 42 Total% = 15.33	%	16.67	59.52	21.43	2.38
	Adj%	19.57	61.99	16.27	2.17
	Coeff	-10.36	38.63	-22.42	-5.86
MD Code = 5 N = 16 Total% = 5.84	%	37.50	25.00	37.50	0.00
	Adj%	35.82	21.79	41.96	0.43
	Coeff	5.89	-1.56	3.27	-7.60

Appendix 15.1
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4
MD Code = 6	%	44.44	27.78	27.78	0.00
N = 18	Adj%	38.75	26.09	33.02	2.14
Total% = 6.57	Coeff	8.83	2.73	-5.67	-5.89
MD Code = 7	%	28.57	14.29	57.14	0.00
N = 14	Adj%	25.10	15.47	57.86	1.58
Total% = 5.11	Coeff	-4.83	-7.89	19.17	-6.45
MD Code = 8	%	25.81	22.58	45.16	6.45
N = 31	Adj%	29.08	23.65	42.40	4.87
Total% = 11.31	Coeff	-0.84	0.29	3.71	-3.16
MD Code = 9	%	24.00	24.00	52.0	0.00
N = 25	Adj%	20.75	22.99	55.47	0.79
Total% = 9.12	Coeff	-9.18	-0.36	16.78	-7.24
MD Code = 10	%	33.33	6.67	60.00	0.00
N = 15	Adj%	32.74	6.17	60.21	0.87
Total% = 5.47	Coeff	2.82	-17.19	21.53	-7.16
MD Code = 11	%	26.67	13.33	53.33	6.67
N = 15	Adj%	27.16	9.95	56.82	6.07
Total% = 5.47	Coeff	-2.77	-13.41	18.13	-1.96

Appendix 15.1
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4
MD Code = 12	%	100.0	0.00	0.00	0.00
N = 18	Adj%	93.19	-3.29	9.43	0.67
Total% = 6.57	Coeff	63.27	-26.65	-29.25	-7.36
MD Code = 13	%	21.05	13.16	55.26	10.53
N = 38	Adj%	24.88	13.98	51.57	9.57
Total% = 13.86	Coeff	-5.02	-9.42	12.87	1.57

APPENDIX 15.2 DRG(82)

PHYSICIAN PERCENTAGES AND COEFFICIENTS

Description	Measure	C1 1	C1 2	C1 3	C1 4	C1 5
Total = 364	N	20	111	87	80	66
	%	5.49	30.49	23.90	21.98	18.13
MD Code = 1 N = 14 Total% = 3.85	%	0.00	28.57	35.71	7.14	28.57
	Adj%	6.14	29.20	31.83	2.04	30.79
	Coeff	0.64	-1.29	7.93	-19.93	12.66
MD Code = 2 N = 47 Total% = 12.91	%	0.00	17.02	12.77	14.89	55.32
	Adj%	-3.74	18.62	15.48	20.64	40.01
	Coeff	-9.24	-11.87	-8.43	-1.34	30.87
MD Code = 3 N = 28 Total% = 7.69	%	14.29	14.29	28.57	25.00	17.86
	Adj%	15.24	15.58	25.11	25.96	18.11
	Coeff	9.74	-14.91	1.21	3.98	-0.02
MD Code = 4 N = 29 Total% = 7.97	%	13.79	37.93	20.69	20.69	6.90
	Adj%	14.84	33.98	22.15	19.69	9.34
	Coeff	9.35	3.48	-1.75	02.28	-8.80
MD Code = 5 N = 23 Total% = 6.32	%	0.00	52.17	21.74	21.74	4.35
	Adj%	4.51	53.74	16.24	15.92	9.59
	Coeff	-0.99	23.25	-7.66	-6.06	-8.54

Appendix 15.2
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4	C1 5
MD Code = 6	%	0.00	33.33	50.00	4.17	12.50
N = 24	Adj%	1.74	38.45	41.05	3.62	15.14
Total% = 6.59	Coeff	-3.76	7.95	17.15	-18.36	-2.99
MD Code = 7	%	2.33	29.07	23.26	34.88	10.47
N = 86	Adj%	2.92	27.53	26.41	33.21	9.93
Total% = 23.63	Coeff	-2.57	-2.97	2.51	11.23	-8.20
MD Code = 8	%	5.66	30.19	16.98	26.42	20.75
N = 53	Adj%	2.65	29.44	19.09	29.67	19.14
Total% = 14.56	Coeff	-2.84	-1.05	-4.81	7.69	1.01
MD Code = 9	%	10.00	42.50	27.50	7.50	12.50
N = 40	Adj%	8.52	44.91	25.02	5.94	15.61
Total% = 10.99	Coeff	3.02	14.42	1.11	-16.04	-2.52
MD Code = 10	%	15.00	30.00	25.00	30.00	0.00
N = 20	Adj%	17.74	25.54	26.94	29.24	0.53
Total% = 5.49	Coeff	12.25	-4.95	3.04	7.27	-17.60

APPENDIX 15.3 DRG(88)

PHYSICIAN PERCENTAGES AND COEFFICIENTS

Description	Measure	C1 1	C1 2	C1 3	C1 4
Total = 338	N	91	122	97	28
	%	26.9	36.1	28.7	8.3
MD Code = 1 N = 11 Total% = 3.25	%	45.45	27.27	27.27	0.00
	Adj%	39.13	29.00	22.04	9.83
	Coeff	12.50	-7.10	-6.66	1.55
MD Code = 2 N = 31 Total% = 9.17	%	41.94	29.03	29.03	0.00
	Adj%	36.29	26.37	30.22	7.12
	Coeff	9.37	-9.73	1.52	-1.17
MD Code = 3 N = 17 Total% = 5.03	%	29.41	23.53	35.29	11.76
	Adj%	22.58	21.42	35.61	20.39
	Coeff	-4.34	-14.67	6.91	12.10
MD Code = 4 N = 24 Total% = 7.10	%	29.17	45.83	20.83	4.17
	Adj%	21.41	50.30	18.20	10.09
	Coeff	-5.52	14.21	-10.49	1.80
MD Code = 5 N = 44 Total% = 13.02	%	20.45	40.91	31.82	6.82
	Adj%	30.45	33.14	32.50	3.92
	Coeff	3.53	-2.96	3.80	-4.37

Appendix 15.3
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4
MD Code = 6	%	9.52	38.10	42.86	9.53
N = 21	Adj%	3.91	41.90	36.24	17.96
Total% = 6.21	Coeff	-23.01	5.80	7.54	9.67
MD Code = 7	%	31.91	38.30	23.40	6.38
N = 47	Adj%	38.55	36.66	26.84	-2.05
Total% = 13.91	Coeff	11.63	0.56	-1.86	-10.33
MD Code = 8	%	28.57	23.81	42.86	4.76
N = 21	Adj%	19.38	29.25	37.81	13.56
Total% = 6.21	Coeff	-7.54	-6.85	9.11	5.27
MD Code = 9	%	40.00	26.67	26.67	6.67
N = 15	Adj%	37.71	33.37	22.58	6.33
Total% = 4.44	Coeff	10.79	-2.72	-6.12	-1.95
MD Code = 10	%	12.50	25.00	50.00	12.50
N = 16	Adj%	22.07	23.77	57.42	-3.25
Total% = 4.73	Coeff	-4.86	-12.33	28.72	-11.54
MD Code = 11	%	22.22	40.74	11.11	25.93
N = 27	Adj%	33.45	37.08	14.28	15.19
Total% = 7.99	Coeff	6.53	0.98	-14.42	6.91

Appendix 15.3
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4
MD Code = 12	%	31.58	31.58	26.32	10.53
N = 19	Adj%	26.83	36.68	16.04	20.45
Total% = 5.62	Coeff	-0.09	0.59	-12.66	12.17
MD Code = 13	%	18.75	46.88	21.88	12.50
N = 32	Adj%	20.27	46.56	25.55	7.62
Total% = 9.47	Coeff	-6.65	10.47	-3.15	-0.67
MD Code = 14	%	23.08	46.15	30.77	0.00
N = 13	Adj%	1.97	57.56	35.92	4.55
Total% = 3.85	Coeff	-24.95	21.46	7.23	-3.74

APPENDIX 15.4 DRG(127)
PHYSICIAN PERCENTAGES AND COEFFICIENTS

Description	Measure	C1 1	C1 2	C1 3	C1 4	C1 5
Total = 394	N	77	140	97	31	49
	%	19.5	35.5	24.6	7.9	12.4
MD Code = 1 N = 21 Total% = 5.33	%	23.81	47.62	19.05	0.00	9.52
	Adj%	17.19	60.20	28.07	-16.58	17.09
	Coeff	-2.35	24.67	3.45	-24.45	4.65
MD Code = 2 N = 34 Total% = 8.63	%	17.65	38.24	23.53	2.94	17.65
	Adj%	17.59	1.38	-11.70	38.10	0.62
	Coeff	-1.96	-34.15	-36.32	30.23	-11.82
MD Code = 3 N = 11 Total% = 2.79	%	9.09	45.45	36.36	0.00	9.09
	Adj%	6.27	53.30	44.28	-16.31	18.44
	Coeff	-13.28	17.77	19.66	-24.18	6.00
MD Code = 4 N = 11 Total% = 2.79	%	18.18	63.64	0.09	0.09	0.00
	Adj%	12.95	78.03	15.20	-8.60	8.39
	Coeff	-6.59	42.50	-9.42	-16.47	-4.04
MD Code = 5 N = 31 Total% = 7.87	%	22.58	48.39	12.90	9.68	6.45
	Adj%	22.02	56.96	19.09	-6.93	14.84
	Coeff	2.48	21.43	-5.53	-14.80	2.40

Appendix 15.4
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4	C1 5
MD Code = 6	%	17.24	27.59	31.03	3.45	20.69
N = 29	Adj%	16.55	-1.38	-4.77	37.64	-2.04
Total% = 7.36	Coeff	-2.99	-36.92	-29.39	29.77	-14.49
MD Code = 7	%	7.14	35.71	28.57	7.14	21.43
N = 14	Adj%	7.30	5.67	-6.44	41.81	-2.36
Total% = 3.55	Coeff	-12.87	-29.87	-31.06	33.95	-14.79
MD Code = 8	%	5.56	50.00	22.22	5.56	16.67
N = 18	Adj%	0.03	58.35	34.93	-9.36	22.02
Total% = 4.57	Coeff	-19.51	22.81	10.31	-17.23	9.59
MD Code = 9	%	8.33	41.67	33.33	0.00	16.67
N = 12	Adj%	6.63	56.95	38.91	-16.82	20.31
Total% = 3.05	Coeff	-12.91	21.42	14.30	-24.69	7.87
MD Code = 10	%	17.50	25.00	37.50	7.50	12.50
N = 40	Adj%	15.17	32.81	46.65	-8.88	20.23
Total% = 10.15	Coeff	-4.37	-2.72	22.03	-16.75	7.79
MD Code = 11	%	12.00	24.00	20.00	28.00	16.00
N = 25	Adj%	8.95	34.87	27.57	10.52	24.06
Total% = 6.35	Coeff	-10.59	-0.66	2.95	2.66	11.62

Appendix 15.4
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4	C1 5
MD Code = 12	%	21.43	14.29	50.00	7.14	7.14
N = 14	Adj%	21.21	23.78	55.89	-9.74	14.84
Total% = 3.55	Coeff	1.66	-11.75	31.27	-17.61	2.41
MD Code = 13	%	17.39	34.78	21.74	4.35	21.74
N = 23	Adj%	13.61	3.95	-10.25	38.80	-0.13
Total% = 5.84	Coeff	-5.93	-31.58	-34.87	30.93	-12.57
MD Code = 14	%	30.00	30.00	20.00	15.00	5.00
N = 20	Adj%	31.29	45.92	25.60	-8.97	12.14
Total% = 5.08	Coeff	11.74	10.39	0.98	-16.83	-0.30
MD Code = 15	%	25.00	8.33	25.00	25.00	16.67
N = 12	Adj%	23.18	14.75	35.72	9.82	22.50
Total% = 3.05	Coeff	3.64	-20.79	11.11	1.95	10.07
MD Code = 16	%	18.75	43.75	18.75	12.50	6.25
N = 32	Adj%	15.03	54.29	27.91	-3.93	12.68
Total% = 8.12	Coeff	-4.51	18.76	3.29	-11.80	0.24
MD Code = 17	%	28.57	34.29	28.57	2.86	5.71
N = 35	Adj%	23.92	45.96	37.89	-12.74	11.08
Total% = 8.88	Coeff	4.37	10.43	13.27	-20.74	-1.36

Appendix 15.4
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4	C1 5
MD Code = 18	%	50.00	33.33	0.00	0.00	16.67
N = 12	Adj%	126.83	54.68	94.47	109.06	24.62
Total% = 3.05	Coeff	107.29	19.14	69.85	101.19	12.19

APPENDIX 15.5 DRG(198)

PHYSICIAN PERCENTAGES AND COEFFICIENTS

Description	Measure	C1 1	C1 2
Total = 263	N	70	193
	%	26.6	73.4
MD Code = 1 N = 13 Total% = 4.94	%	30.77	69.23
	Adj%	26.09	73.91
	Coeff	-0.53	0.53
MD Code = 2 N = 22 Total% = 8/37	%	18.18	81.82
	Adj%	13.74	86.26
	Coeff	-12.88	12.88
MD Code = 3 N = 32 Total% = 12.17	%	43.75	56.25
	Adj%	45.62	54.38
	Coeff	19.00	19.00
MD Code = 4 N = 39 Total% = 14.83	%	25.64	74.36
	Adj%	30.33	69.67
	Coeff	3.72	-3.72
MD Code = 5 N = 23 Total% = 8.75	%	34.78	65.22
	Adj%	28.81	71.19
	Coeff	2.20	-2.20

Appendix 15.5
(continued)

Description	Measure	Cl 1	Cl 2
MD Code = 6	%	16.67	83.33
N = 24	Adj%	11.39	88.61
Total% = 9.13	Coeff	-15.22	15.22
MD Code = 7	%	30.77	69.23
N = 26	Adj%	31.80	68.20
Total% = 9.89	Coeff	5.19	-5.19
MD Code = 8	%	31.25	68.75
N = 16	Adj%	38.20	61.80
Total% = 6.08	Coeff	11.58	-11.58
MD Code = 9	%	18.18	81.82
N = 22	Adj%	25.34	74.66
Total% = 8.37	Coeff	-1.28	1.28
MD Code = 10	%	19.35	80.65
N = 31	Adj%	15.26	84.74
Total% = 11.79	Coeff	-11.36	11.36
MD Code = 11	%	20.00	80.00
N = 15	Adj%	20.76	79.24
Total% = 5.70	Coeff	-5.86	5.86

APPENDIX 15.6 DRG(355)

PHYSICIAN PERCENTAGES AND COEFFICIENTS

Description	Measure	C1 1	C1 2	C1 3	C1 4
Total = 566	N	51	114	265	136
	%	9.0	20.1	46.8	24.0
MD Code = 1 N = 40 Total% = 7.07	%	2.50	7.50	80.00	10.00
	Adj%	5.59	5.26	82.20	6.95
	Coeff	-3.42	-14.88	35.38	-17.07
MD Code = 2 N = 24 Total% = 4.24	%	4.17	8.33	50.00	37.50
	Adj%	0.85	6.40	53.12	39.63
	Coeff	-8.16	-13.74	6.30	15.60
MD Code = 3 N = 26 Total% = 4.59	%	11.54	46.15	34.62	7.69
	Adj%	10.46	47.75	34.83	6.96
	Coeff	1.45	27.61	-11.99	-17.07
MD Code = 4 N = 39 Total% = 6.89	%	17.95	30.77	38.46	12.82
	Adj%	18.32	34.54	30.92	16.22
	Coeff	9.31	14.40	-15.90	-7.81
MD Code = 5 N = 47 Total% = 8.30	%	8.51	14.89	42.55	34.04
	Adj%	8.50	13.10	45.41	33.00
	Coeff	-0.51	-7.05	-1.41	8.97

Appendix 15.6
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4
MD Code = 6	%	18.18	9.09	54.55	18.18
N = 11	Adj%	15.37	4.96	54.51	25.16
Total% = 1.94	Coeff	6.36	-15.18	7.69	1.14
MD Code = 7	%	9.23	4.62	21.54	64.62
N = 65	Adj%	8.49	5.97	19.85	65.69
Total% = 11.48	Coeff	-0.52	-14.17	-26.97	41.66
MD Code = 8	%	5.56	2.78	47.22	44.44
N = 36	Adj%	5.13	4.63	45.06	45.19
Total% = 6.36	Coeff	-3.88	-15.51	-1.76	21.16
MD Code = 9	%	21.43	7.14	57.14	14.29
N = 15	Adj%	24.30	10.46	49.90	15.35
Total% = 2.47	Coeff	15.28	-9.69	3.098	-8.68
MD Code = 10	%	1.96	11.76	66.67	19.61
N = 51	Adj%	1.55	9.86	69.30	19.29
Total% = 9.01	Coeff	-7.46	-10.28	22.48	-4.74
MD Code = 11	%	8.11	24.32	59.46	8.11
N = 37	Adj%	9.03	26.36	57.68	6.94
Total% = 6.54	Coeff	0.01	6.21	10.86	-17.09

Appendix 15.6
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4
MD Code = 12	%	12.50	9.38	53.13	25.00
N = 32	Adj%	15.62	7.93	50.78	25.67
Total% = 5.65	Coeff	6.61	-12.21	3.96	1.64
MD Code = 13	%	5.00	15.00	70.00	10.00
N = 20	Adj%	3.12	14.20	66.01	16.68
Total% = 3.53	Coeff	-5.89	-5.94	19.19	-7.35
MD Code = 14	%	10.71	57.14	26.79	5.36
N = 56	Adj%	9.46	59.25	31.70	-0.41
Total% = 9.89	Coeff	0.45	39.10	-15.12	-24.44
MD Code = 15	%	0.00	58.33	33.33	8.33
N = 12	Adj%	-4.08	50.66	37.08	16.34
Total% = 2.12	Coeff	-13.09	30.52	-9.74	-7.69
MD Code = 16	%	16.67	22.22	50.00	11.11
N = 18	Adj%	19.72	17.35	51.60	11.33
Total% = 3.18	Coeff	10.71	-2.79	4.78	-12.70
MD Code = 17	%	9.09	27.27	45.45	18.18
N = 11	Adj%	11.51	30.13	43.02	15.34
Total% = 1.94	Coeff	2.50	9.99	-3.80	-8.69

Appendix 15.6
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4
MD Code = 18	%	11.11	18.52	44.44	25.93
N = 27	Adj%	10.60	18.18	46.13	25.09
Total% = 4.77	Coeff	1.59	-1.96	-0.69	1.06

APPENDIX 15.7 DRG(209)

PHYSICIAN PERCENTAGES AND COEFFICIENTS

Description	Measure	C1 1	C1 2	C1 3	C1 4
Total = 422	N	35	132	168	87
	%	8.3	31.3	39.8	20.6
MD Code = 1	%	5.88	43.14	39.22	11.76
N = 51	Adj%	3.08	48.30	35.29	13.33
Total% = 12.09	Coeff	-5.21	17.02	-4.52	-7.29
MD Code = 2	%	11.54	23.08	42.31	23.08
N = 26	Adj%	13.10	17.06	42.71	27.13
Total% = 6.16	Coeff	4.80	-14.22	2.90	6.51
MD Code = 3	%	5.63	18.31	42.25	33.80
N = 142	Adj%	7.28	22.52	40.17	30.02
Total% = 33.65	Coeff	-1.01	-8.75	0.36	9.41
MD Code = 4	%	7.69	46.15	30.77	15.38
N = 13	Adj%	9.13	42.89	27.92	20.06
Total% = 3.08	Coeff	0.84	11.61	-11.89	-0.55
MD Code = 5	%	16.00	42.67	34.67	6.67
N = 75	Adj%	16.34	42.57	35.00	6.10
Total% = 17.77	Coeff	8.04	11.29	-4.81	-14.52

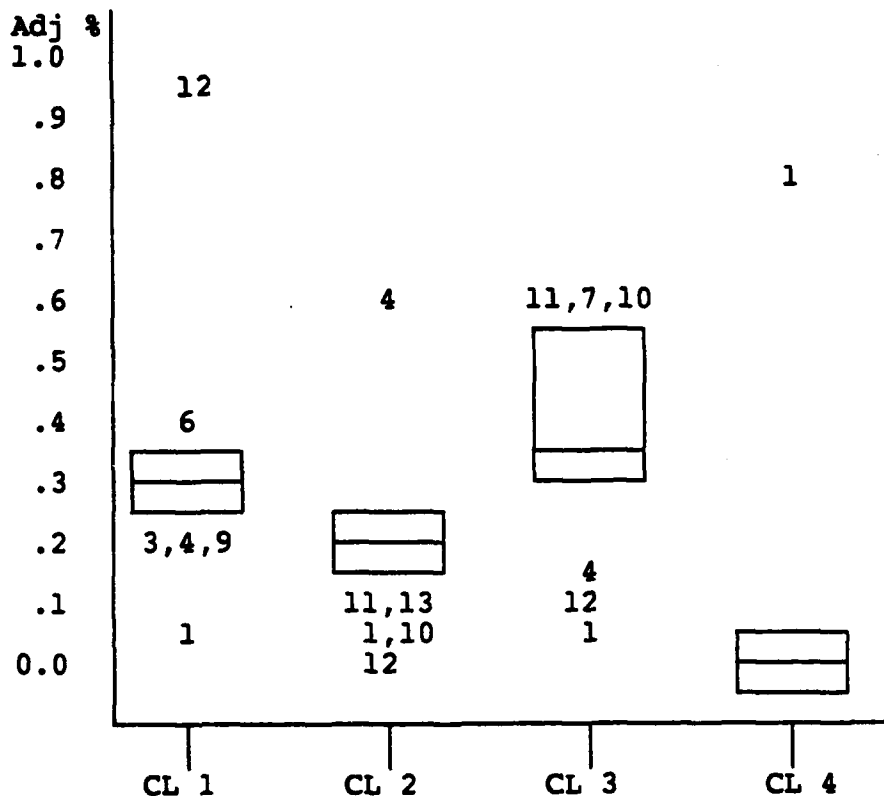
Appendix 15.7
(continued)

Description	Measure	C1 1	C1 2	C1 3	C1 4
MD Code = 6	%	7.69	40.38	40.38	11.54
N = 52	Adj%	5.54	32.43	46.93	15.10
Total% = 12.32	Coeff	-2.75	1.15	7.12	-5.51
MD Code = 7	%	11.11	38.89	44.44	5.56
N = 18	Adj%	7.06	32.57	47.46	12.92
Total% = 4.27	Coeff	-1.24	1.29	7.65	-7.70
MD Code = 8	%	4.44	26.67	40.00	28.89
N = 45	Adj%	4.65	23.82	42.29	29.23
Total% = 10.66	Coeff	-3.64	-7.46	2.48	8.62

APPENDIX 16
ASSOCIATION OF MD WITH PATTERNS

APPENDIX 16.1 DRG(14)

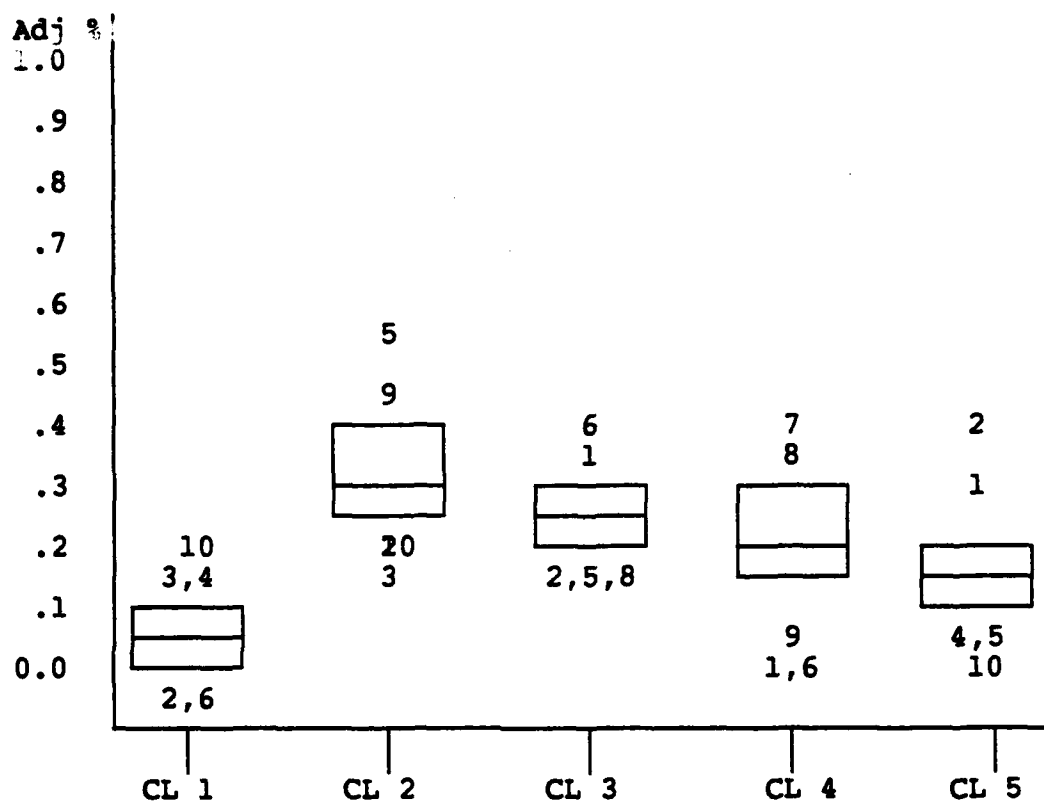
ASSOCIATION OF MD WITH PRACTICE PATTERNS



- Note 1) The adj% is the percentage of a physician's cases classified into the different clusters holding constant all other independent variables.
- 2) The numbers on the figure represent individual physician identification.

APPENDIX 16.2 DRG(82)

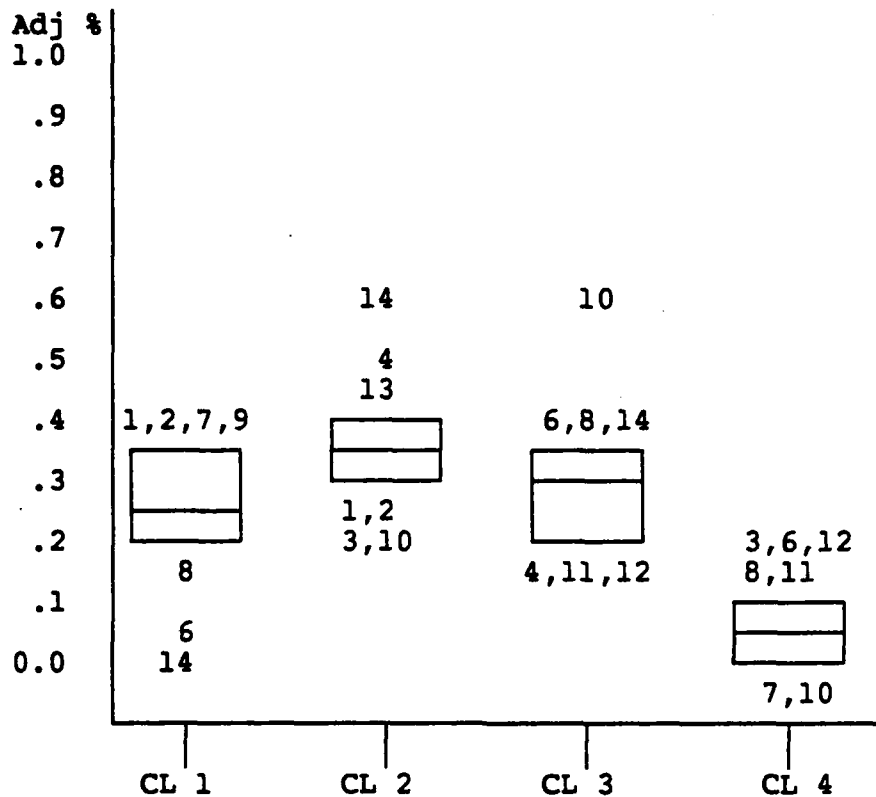
ASSOCIATION OF MD WITH PRACTICE PATTERNS



- Note 1) The adj% is the percentage of a physician's cases classified into the different clusters holding constant all other independent variables.
- 2) The numbers on the figure represent individual physician identification.

APPENDIX 16.3 DRG(88)

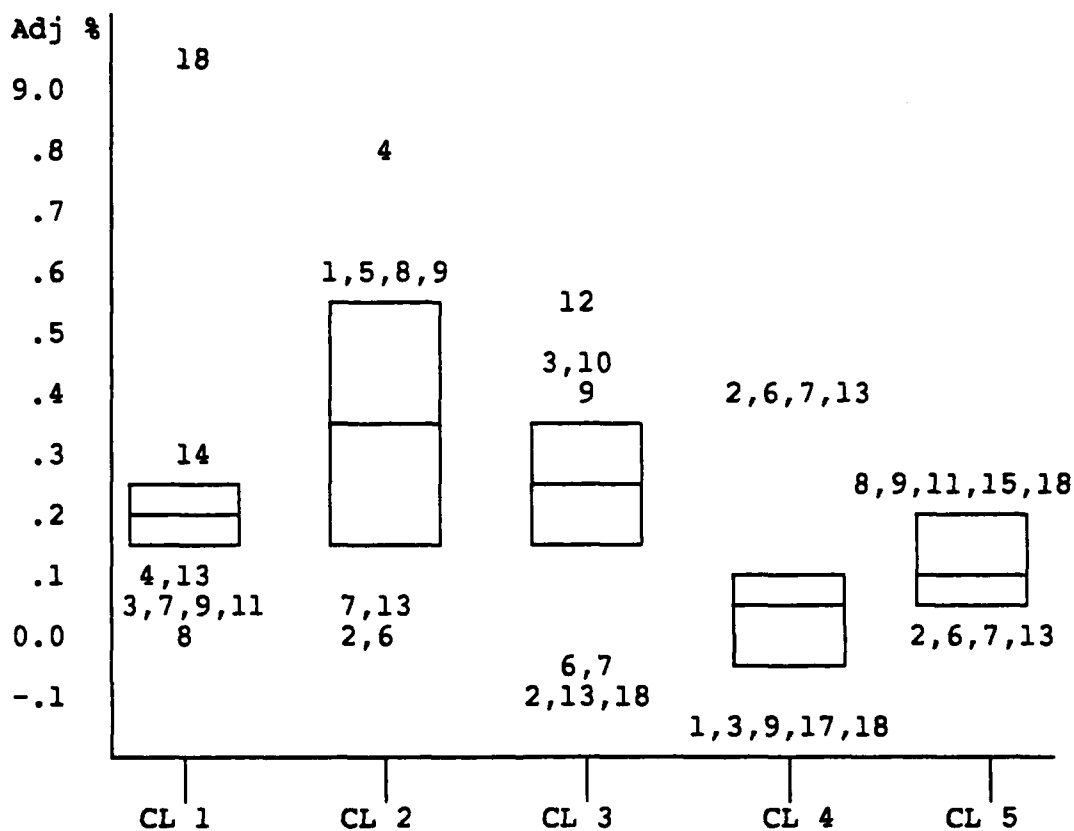
ASSOCIATION OF MD WITH PRACTICE PATTERNS



- Note 1) The adj% is the percentage of a physician's cases classified into the different clusters holding constant all other independent variables.
- 2) The numbers on the figure represent individual physician identification.

APPENDIX 16.4 DRG(127)

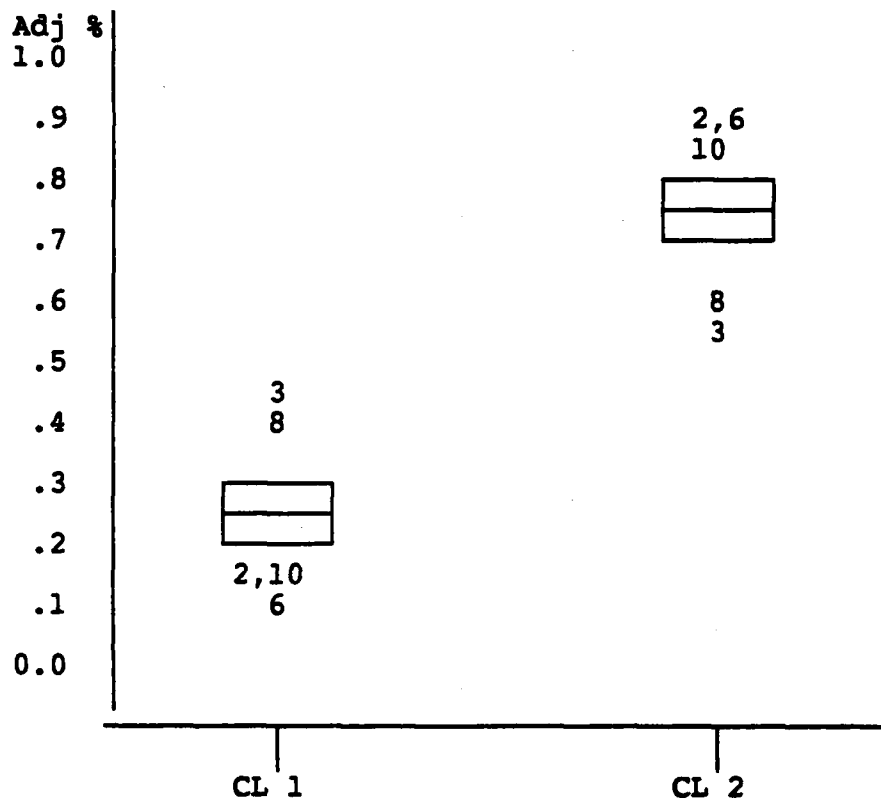
ASSOCIATION OF MD WITH PRACTICE PATTERNS



- Note 1) The adj% is the percentage of a physician's cases classified into the different clusters holding constant all other independent variables.
- 2) The numbers on the figure represent individual physician identification.

APPENDIX 16.5 DRG(198)

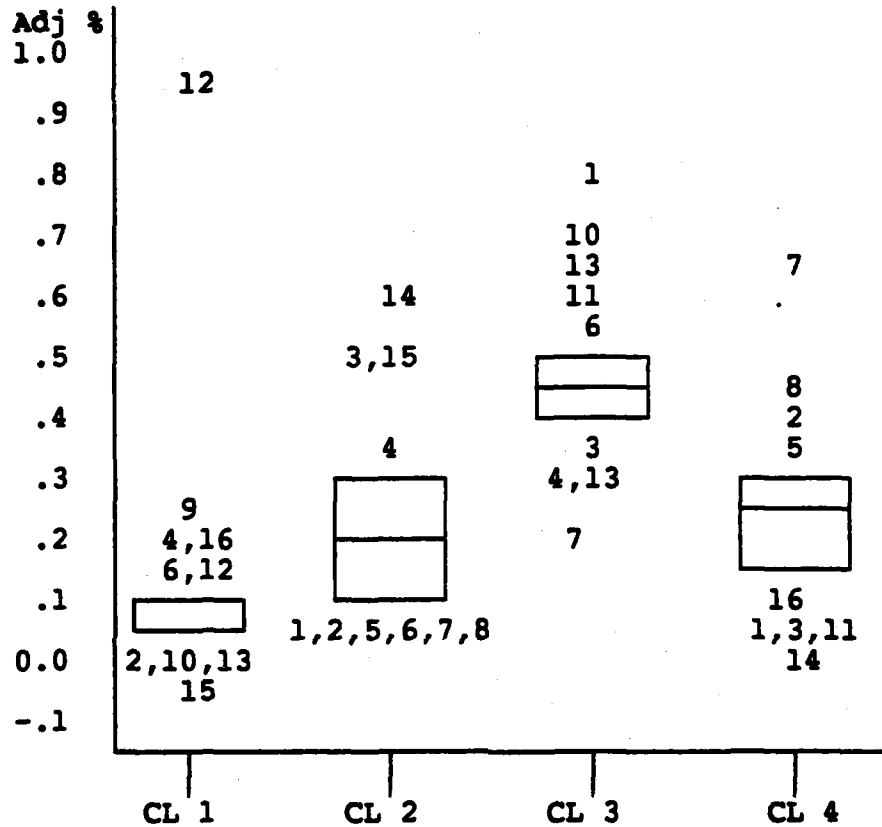
ASSOCIATION OF MD WITH PRACTICE PATTERNS



- Note 1) The adj% is the percentage of a physician's cases classified into the different clusters holding constant all other independent variables.
- 2) The numbers on the figure represent individual physician identification.

APPENDIX 16.6 DRG(355)

ASSOCIATION OF MD WITH PRACTICE PATTERNS

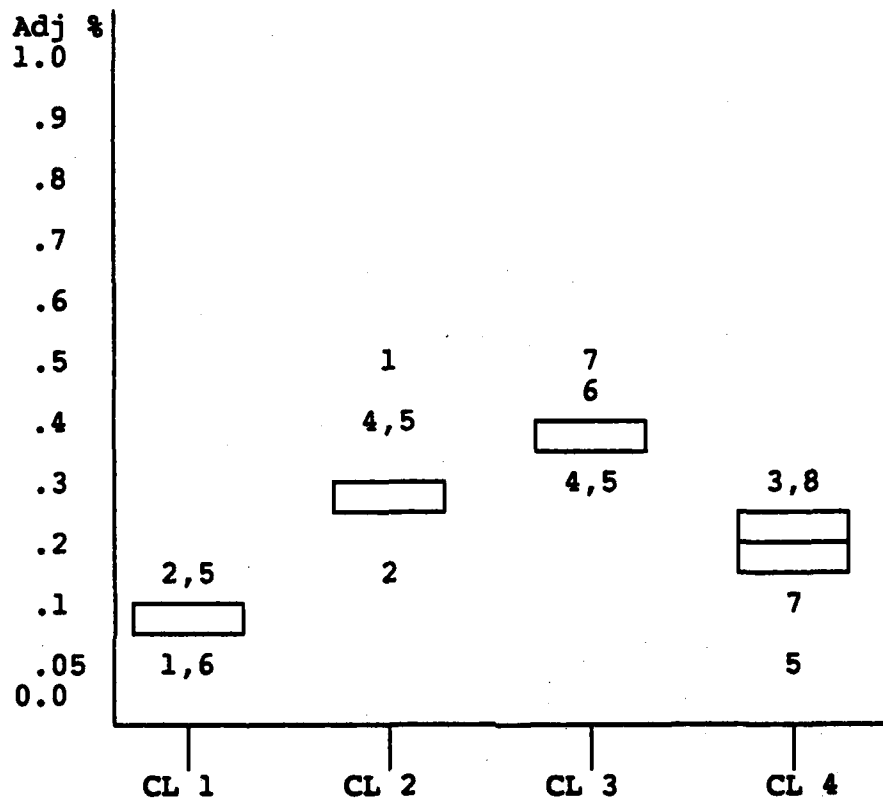


Note 1) The adj% is the percentage of a physician's cases classified into the different clusters holding constant all other independent variables.

2) The numbers on the figure represent individual physician identification.

APPENDIX 16.7 DRG(209)

ASSOCIATION OF MD WITH PRACTICE PATTERNS



- Note 1) The adj% is the percentage of a physician's cases classified into the different clusters holding constant all other independent variables.
- 2) The numbers on the figure represent individual physician identification.

BIBLIOGRAPHY

BIBLIOGRAPHY

- Aldenderfer, Mark and Blashfield, Roger K. Cluster Analysis Sage Publications 1984 pg 14
- Andrews, Frank M. and Messenger, Robert C. Multivariate Nominal Scale Analysis, Institute for Social Research, University of Michigan 1973
- Bentler, Peter M.; Lettieri, Dan J; Austin, Gregory A. Data Analysis Strategies and Designs for Substance Abuse Research, National Institute on Drug Abuse, 1976.
- Brewster, A., Jacobs, C.M., Bradbury, R.C.; "Classifying Severity of Illness by Using Clinical Findings" Health Care Financing Review 1984
- Brook, R.H. and Williams, K.N. "Quality Health Care for the Disadvantaged" Journal of Community Health 1975.
- Brook, Robert H., and Williams, Kathleen N. "Evaluation of the New Mexico Peer Review System, 1971 to 1973" Supplement to Medical Care Dec 76
- Brook, Robert H.; Davies-Avery, Allyson; Greenfield, Sheldon; Haris, Jeff L.; Leah, Tova; Solomon, Nancy E.; and Ware, John E. Jr. "Assessing the Quality of Medical Care Using Outcome Measures: An Overview of the Method" Supplement to Medical Care 15 Sept 77.
- Bunker, J.P., "Surgical Manpower: A Comparison of Operations and Surgeons in the United States and in England and Wales", New England Journal of Medicine, 282:135-144 1970
- Butler, P.W. and Bentley, J.D., The Disease Staging Case-Mix of a Sample of Teaching Hospitals: A Technical Report, Association of Medical Colleges 1982
- Childs, Alfred W., and Hunter, E. Diane. "Non-Medical Factors Influencing Use of Diagnostic X-ray by Physicians." Medical Care July-Aug 72 323-325.
- Commission on Professional and Hospital Activities(CPHA 1966) Length of Stay in Short Term Hospitals (1963 - 1964), New York:McGraw-Hill 1966
- Commission on Professional and Hospital Activities(CPHA

1978) The International Classification of Diseases, 9th Revision, Clinical Modification, Vol 1, Diseases Tablular List (Ann Arbor, Mich: CPHA 1978)

Conklin, J.E., Lieberman, J.V., Barnes, C.A., Louis, D.Z., "Disease Staging: Implications for Hospital Reimbursement and Management", Health Care Financing Review 1984

Connell, Frederick A.; Day, Robert W.; Logerfo, James P.; "Hospitalization of Medicaid Children: Analysis of Small Area Variation in Admission Rates", American Journal of Public Health, June 81 Vol 71. No 6. Pg. 606-613

Connell, Frederick A.; Blide, Leslie A.; Hanken, M.; "Clinical Correlates of Small Area Variations in Population-Based Admission Rates for Diabetes", Medical Care 84

Cook, Thomas D., and Campbell, Donald, T., Quasi-Experimentation: Design and Analysis Issues for Field Settings Houghton Mifflin Co. 1979 pp53.

Daniels, Marcia; Schroeder, Steven; "Variation Among Physicians in Use of Laboratory Tests - II. Relation to Clinical Productivity and Outcomes of Care", Medical Care 15:482-487 1977

Data Analysis Strategies and Designs For Substance Abuse Research (Bentler, 1976), Ed. Bentler, P.M.; Lettieri, D.J.; Austin, G.A. Dec 76 pg 145

Deacon, Ronald; Lubitz, James; Gornick, Marian; Newton, Marilyn; "An Analysis of Variations in Hospital Use by Medicare Patients in PSRO Areas, 1974-77, Health Care Financial Review, Summer 79 pg. 79-107

DeGeyndt, W., "Five Approaches For Assessing Quality of Care", Hospital Administration, 15 1970.

Discursive Dictionary of Health Care, prepared by staff for the use of Subcommittee on Health and Environment of the Committee on Interstate and foreign Commerce, U.S. House of Representatives Feb 1976.

Donabedian, Avedis, "Evaluating the Quality of Medical Care", Milbank Memorial Fund Quarterly, vol 44 1966.

Donabedian, Avedis, A Guide to Medical Care Administration, Vol II: Medical Care Appraisal - Quality and Utilization, New York: American Public Health Association, 1969.

- Donabedian, Avedis Explorations in Quality Assessment Vol I: The Definition of Quality and Approaches to its Assessment Health Administration Press, 1980
- Donabedian, Avedis; Wheeler, John R.C.; Wyszewianski, Leon; "Quality, Cost, and Health: An Integrative Model", Medical Care Oct 82, Vol 20 No. 10
- Donabedian, Avedis; Exploration in Quality Assessment and Monitoring - The Criteria and Standards of Quality, Vol II, Health Administration Press, Ann Arbor, Michigan 1982.
- Donabedian, Avedis, Explorations in Quality Assessment and Monitoring Vol III : The Methods and Findings of Quality Assessment and Monitoring Health Administration Press, 1985.
- Dror, Y., Public Policy Making Reexamined, San Francisco:Chandler Publishing Co., 1968.
- Eisenberg, John M., and Nicklin, David. "Use of Diagnostic Services by Physicians in Community Practice." Medical Care Mar 81 297-309
- Everitt, B. "Unresolved Problems in Cluster Analysis", Biometrics, 35:169-181 1979
- Fetter, R.B., Shin, Y., Freeman, J.L., Averill, R.F., Thompson, J.D., "Case-Mix Definition by Diagnosis-Related Groups", Medical Care 18 Feb 1980
- Fleiss, Joseph L., Statistical Methods for Rates and Proportions, New York:John Wiley and Sons 2nd Ed. 1981
- Freeborn, Donald K.; Baer, Daniel; Greenlick, Merwyn R.; Baily, Jeffery; "Determinants of Medical Care Utilization: Physicians' Use of Laboratory Services", American Journal of Public Health 62:846-853 1972
- Freko, D. "Admissions Fall but Margins are Up in 84", Hospitals, vol 59, No. 9 May 85.
- Friedman, B., LaTour, S., and Hughes, E.F.X. "A Medicare Voucher System: What Can It Offer?" Presented to the Conference on Future of Medicare, sponsored by the Committee on Ways and Means, the Congressional Budget Office, the Congressional Research Service, Nov 29-30, 1983.
- Fox, Daniel J. and Guire, Kenneth E. Documentation For Midas, Statistical Research Laboratory, The University of Michigan, 3rd Ed. 1976 pg 72.

- Garg, M.C.; Louis, D.Z.; Gliebe, W.A.; Spirka, C.S.; Skipper, J.K.; and Parekh, R.R., "Evaluating Inpatient Costs: The Staging Mechanism", Medical Care 16(3):191 1978
- Gittelsohn, Alan M., and Wennberg, John E., "On the Incidence of Tonsillectomy and Other Common Surgical Procedures." Chapter 7, pp 91-106. In John P. Bunker, Denjamin A. Barnes, and Frederick Mosteller, eds., Costs, Risks, and Benefits of Surgery New York: Oxford University Press, 1977. 401 pp
- Gonnella, J.S., Hornbrook, M.C. and Louis, D.Z. "Staging of Disease: A Case-mix Measurement" Journal of the American Medical Association 251(5):637 1983
- Griffith, John R.; Hancock, Walton M.; and Munson, Fred C.; Cost control in Hospitals, Health Administration Press: Ann Arbor, Mi., 1976
- Griffith, John R.; Restuccia, Joseph D.; Tedeschi, Philip J.; Wilson, Peter A.; Zuckerman, Howard S.; "Measuring Community Hospital Services in Michigan", Health Services Research, 16:2 Summer 81 pg 135-160
- Gustafson, D.H. and Holloway, D.C. "A Decision Theory Approach to Measuring Severity of Illness", Health Services Research 10 Spring 1975
- Hartwig, F. and Dearing, B., Exploratory Data Analysis, Sage Publications, No. 16
- Hlatky, Mark A.; Low, Kerry L.; Botvinick, Elias H.; Brundage, Bruce H.; "Diagnostic Test Use in Different Practice Settings: A Controlled Comparison" Archives of Internal Medicine 143:1886-1889 1983
- Horn, S.D., Schumacher, D.N., Bertram, D.A., Sharkey, P.D., "Measuring Severity of Illness: Homogeneous Case-Mix Groups" Center for Hospital Finance and Management, Division of Health Care Organization, Department of Health Services Administration, School of Hygiene and Public Health, Johns Hopkins University, 1981
- Horn, S.D., Sharkey, P.D., and Bertram, D. "Measuring Severity of Illness: Homogenous Case-Mix Groups" Medical Care 21:14-31 Jan 83.
- Horn, S.D., Horn, R.A., Sharkey, P.D., "The Severity of Illness Index as a Severity Adjustment to Diagnosis-Related Groups" Health Care Financing Review 1984
- Hornbrook, M.C. "Hospital Case Mix: Its Definition, Measurement, and Use: Part II. Review of Alternative

Measures," Medical Care Review, Vol 39 No. 2 Summer 82
pg. 97

Hurtado, A.V. and Greenlick, M.R. "A Disease Classification System for Analysis of Medical Care Utilization with a Note on Symptom Classification" Health Services Research Fall 1971

Lembecke, Paul A., "Measuring the Quality of Medical Care Through Vital Statistics Based on Hospital Service Areas: 1. Comparative Study of Appendectomy Rates", American Journal of Public Health, Vol 42 March 52, pg 276-288

Lewis, Charles E., "Variations in the Incidence of Surgery" New England Journal of Medicine, Oct 69 Vol 281 Pg. 880-884

Linn, Lawrence S., Yager, Joel, Leake, Barbara D., Gastaldo, Gregory, Palkowski, Chris, "Differences in the Number and Costs of Tests Ordered by Internists, Family Practitioners, and Psychiatrists", Inquiry 21 Fall 84 pp 266-275

Louis, D.Z., Banes, C., Jordan, N., Moynihan, C., Pepitone, T., Spiaka, C., Siedl, K., Westwedge, J., Disease Staging: A Clinically Based Approach to Measurement of Disease Severity - Vol 1 Executive Summary NCHSR 83-58, August 1983

Louis, D.Z., Banes, C., Jordan, N., Moynihan, C., Pepitone, T., Spiaka, C., Siedl, K., Westwedge, J., Disease Staging: A Clinically Based Approach to Measurement of Disease Severity - Vol 4 Staging Software User's Manual NCHSR 83-58, August 1983

Louis, D.Z., Banes, C., Jordan, N., Moynihan, C., Pepitone, T., Spiaka, C., Siedl, K., Westwedge, J., Disease Staging: A Clinically Based Approach to Measurement of Disease Severity - Vol 5 Reabstracting Study NCHSR 83-58, August 1983

Luft, H.S., "On the Use of Vouchers For Medicare" Milbank Memorial Fund Quarterly, 62:637-650 Spring 84.

Luft, H.S., "How Do Health Maintenance Organizations Achieve Their Savings"? New England Journal of Medicine, June 78, pg 1336-1343

Lyle, C.B.; Applegate, W.B., Citron, P.S. et al; "Practice Habits in a Group of Eight Internists", Ann Internal Medicine 84:594-601 1976

Manton, Kenneth G. and Vertrees, James C. "The Use of Grade

of Membership Analysis to Evaluate and Modify
Diagnosis-Related Groups," Medical Care, Dec 84 pg
1079

Martin, J.B., Wheeler, J.R.C., Durance, P.D., and Mckee,
T.C., "Cost Containment Priorization Under a Case-Based
Payment System", an unpublished pager (Ann Arbor 1985).

Martin, J.B., Durance, P.D., Mckee, T.C., Wheeler, J.R.C.,
Tedeschi, P.J., Bischak, D.P., Burket, W.R., "An
Institution Specific Methodology for Pursuing DRG-Based
Cost Control", an unpublished paper (Ann Arbor 1984)

Mckee, Timothy C. "Diagnosis Related Groups - A Basis for a
Hospital Management Information System" an unpublished
Masters Thesis, The University of Michigan, 1979. pg 37

McCracken, S.; Latessa, P.; Wennberg, J., "A Study of
Hospital Utilization in Iowa in 1980

McNerney, Walter J. and Study Staff, Hospital and Medical
Economics: A Study of Population, Services, Costs,
Methods of Payment, and Controls, Chicago: Hospital
Research Educational Trust, 1962, vol 1 and 2.

McPherson, Klim; Wennberg, John E.; Ole B.; Clifford,
Peter; "Small Area Variations in the Use of Common
Surgical Procedures: An International Comparison of New
England, England, and Norway" New England Journal of
Medicine Vol 307 Nov 82, pg. 1310-1314

Morehead, Mildred A.; Donaldson, Rose S.; et al. A Study of
the Quality of Hospital Care Secured by a Sample of
Teamster Family Members in New York City New York:
School of Public Health and Administrative Medicine,
Columbia University; 1964. 98 pp

Mullner, R. and Kobrinski, E.J. "The Professional Activity
Study of the Commission on Professional and Hospital
Activities", Health Services Research, Vol 18, No. 2
Summer 82 Part II.

Mushlin, Alvin I. and Appel, Francis A., "Testing an
Outcome-Based Quality Assurance Strategy in Primary
Care", Supplement to Medical Care 18 May 80.

OSIRIS IV User's Manual, Institute for Social Research The
University of Michigan, Ann Arbor, MI. 7th Ed. March
1981 pg 291

Payne, Beverly C., "Continual Evolution of a System of
Medical Care Appraisal", Journal of the American
Medical Association 201(1967)

- Peabody, F.W. "The Physician and the Laboratory", Boston Med Surgcal Journal, 1922 187:324-328
- Person, R.J.C., Smedby, B., Byfenstan, R., "Hospital Case Loads in Liverpool New England, and Uppsala: An Internation Comparison" Lancet 2:559 1968
- Ray, Wayne A.; Federspiel, Charles F.; and Schaffner, William. "Prescribing of Chloramphenicol in Ambulatory Practice: An Epidemiologic Study among Tennessee Medicaid Recipients." Annals of Internal Medicine 84 (March 1976):266-270.
- Riedal, D.C., Fitzpatrick, T.B.; Patterns of Patient Care Ann Arbor Michigan, The University of Michigan Bureau of Hospital Administration 1964
- Roos, Noralou P.; Roos, Leslie L.; Hentclelf, Paul D.; "Elective Surgical Rates - Do Higher Rates Mean Lower Standards"? New England Journal of Medicine, Vol 297, Aug 77, pg. 360-365
- Roos, Noralou P., "Hysterectomy: Variation in Rates Across Small Areas and Across Physician Practices", American Journal of Public Health, Vol 74, Ap 84, pg 327-335
- Rubenstein, Lisa; Mates, Susan; and Sidel, Victor W.; "Quality of Care Assessment by Process and Outcome Scoring: Use of Weighted Algorithmic Assessment Criterion for Evaluation of Emergency Room Care of Women with Symptoms of Urinary Tract Infection", Annals of Internal Medicine 86(May 77)
- Schroeder, Steven A.; Kenders, Kathryn; Cooper, James K.; Remme, Thomas E.; "Use of Laboratory Test and Pharmaceuticals - Variation Among Physicians and Effect of Cost Audit on Subsequent Use", Journal of American Medical Association 225:969-973 1973
- Schoreder, Steven, Schlifftman, B. A., Diemme, Thomas, "Variation Among Physicians in Use of Laboratory Tests: Relation to Quality of Care" Medical Care, vol 8 1974 pp 709-713
- Sheps, M.C., "Approaches to the Quality of Hospital Care", Public Health Reports, 9 1955.
- Simborg, Donald W., "DRG Creep - A New Hospital-Acquired Disease", New England Journal of Medicine, vol 304 no. 26, June 25, 1981.
- Sonquist, John A., Baker, Elizabeth L., Morgan, James N., Searching For Structure, Survey Research Center, The University of Michigan 1973

Southwick, Arthur F. and Siedel, George J. III., The Law of Hospital and Health Care Administration, Health Administration Press 1978.

Stockwell, Heather, and Vayda, Eugene, "Variations in Surgery in Ontario." Medical Care April 79, 390-396.

Sullivan, Daniel F., "Conceptual Problems in Developong an Index of Health", National Center for Health Statistics. P.H.S. Pub no. 1000, Ser no. 17 Wash DC: U.S. Government Printing Office, May 66.

Thompson, J.D., Fetter, R.B., and Mross, "Case-mix and Resource Use", Inquiry 12:300-312, 1975.

U.S. General Accounting Office, "Problems in Administering Medicare's Health Maintenance Organization Demonstration of Projects in Florida" Report to the Honorable Lawrence J. Smith, House of Representatives, Wash D.C. March 8, 1985.

Vayda, E., "A Comparison of Surgical Rates in Canada and in England and Wales", New England Journal of Medicine 289:1224-1229 1973

Wagner, D., Draper, E., "Acute Physiology and Chronic Health Evaluation (APACHE II) and Medicare Reimbursement" Health Care Financing Review 1984

Wennberg, John, Gittelsohn, Alan, "Small Area Variations in Heath Care Delivery", Science , 182:1102-08 Dec 73

Wennberg, J.E.; Gittelsohn, A.; "Health Care Delivery in Maine : Evaluating the Level of Hospital Performance", Journal of Maine Medical Association 66:11 pg 298-306 1975

Wennberg, John; Gittelsohn, Alan; "Variations in Medical Care Among Small Areas", Vol 246, Scientific American, 1982 246:120-134

Wennberg, John E., "Dealing with Medical Practice Variations: A Proposal for Action", Health Affairs Summer 1984 pp 16.

Wennberg, John E.; McPherson, Klim; Caper, Philip; "Will Payment Based on Diagnosis-Related Groups Control Hospital Costs"? New England Journal of Medicine, Aug 84 pg. 295-300

Williamson, John W. "Evaluating Quality of Patient Care: A Strategy Relating Outcome and Process Assessment", Journal of the American Medical Association 218(Oct 71).

Williamson, John W. Assessing and Improving Health Care Outcomes: The Health Accounting Approach to Quality Assurance Cambridge, Mass: Ballinger Publishing Co. 1978. of Hospital Use" Health Services Research 19:3 Aug 84, pg. 333-355

Wong, Edward T.; Lincoln, Thomas L.; "Ready, Fire, ... Aim - An Inquiry into Laboratory Test Ordering", Journal of American Medical Association vol 250 November 11, 1983

Wyszewianski, Leon, Wheeler, John R.C., Donabedian, Avedis, "Market-Oriented Cost-Containment Strategies and Quality of Care", Milbank Memorial Fund Quarterly Vol 60 No. 4 1982, pg 521-22.

Young, W.W., Swinkola, R.B. and Zorn, D.M. "The Measurement of Hospital Case-Mix" Medical Care 20 May 1982

Young, W.W., et al, "Hospital Case-mix: Development and Implementation" Health Care Research Department, Blue Cross of Western Pennsylvania, 1983

Young, W.W., "Incorporating Severity of Illness and Comorbidity in Case-Mix Measurement" Health Care Financing Review 1984

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