

# Special Report

## Relative intensity measures: Pricing of inpatient nursing services under diagnosis-related group prospective hospital payment

by Russell P. Caterinicchio

*A sample survey (N=2660) was conducted at eight acute care hospitals in New Jersey during an 11-month period between 1979 and 1981 in order to develop a client-focused, case-mix sensitive measure of resource use for the allocation of inpatient general nursing costs. Using general linear modeling techniques, the direct and indirect effects of age, length of stay, multiple diagnoses, multiple procedures, the ratio of special care unit days to length of stay, and the effects of the presence of surgery, admission status, discharge status, and membership in Major Diagnostic Categories on indexed total units of nursing service were explored. The results of the analysis suggested that length of stay is the most significant predictor of indexed nursing units of service regardless of age and the complexity of the medical problem when case-mix is controlled through the assignment of cases to 13 nursing services isore-source clusters. The methodology yields an empirically derived patient-specific, case-mix adjusted length of stay statistic which can be used to apportion nursing costs by the case. The approach permits the estimation of nursing units of service which reflect the relative amount of nursing inputs and corresponding costs of direct patient care consumed by any given inpatient in any given hospital.*

### Introduction

The importance of the nurse in the delivery of inpatient care cannot be overemphasized. With the growing need for greater coordination of patient care and services, nursing has become more progressive, involving responsibilities for restoration, maintenance and prevention. Nursing care now involves not only administration of the medical regimen, physical functioning, teaching, and socio-emotional support, but such innovative activities as nursing quality assurance, and nursing diagnosis.

Changes in hospital nursing have not been paralleled by innovations in financial management or reimbursement systems. Expenses for nursing services are

recovered under room and board revenue. The labor-intensive costs associated with direct patient care through the nursing department are typically apportioned on a per diem basis, the patient day serving as the allocation statistic. Such an approach presumes that nursing activity is a function of the patient day, in spite of contentions in the literature of hospital economics that the patient day is at best a vague aggregate output measure. Moreover, given that nursing costs may account for up to 35 percent of all costs for direct patient care and up to 50 percent of a typical hospital's nonphysician personnel budget, the potentials for mismanagement and inefficiencies associated with the accounting of nursing services under "hotel-type" cost centers and per diem pricing become increasingly real and manifold for hospital administration. For example, recent research indicates that direct cross-subsidization of ancillary services by the nursing department is the most common pricing inefficiency, resulting in up to 47 percent of nurses' patient care availability time spent performing nonnursing duties.

Researchers have used many methods to measure nursing activity, attempting to more adequately account for nursing service costs. Management and industrial engineering approaches quantify the intensity of nursing through the study of performance time and task frequency in the delivery of direct and indirect care. The usual output measure of these approaches is the number of nursing-care hours per patient, per day. In addition to these traditional time-and-motion techniques, patient classification systems identify the intensity of nursing service corresponding to requirements displayed by clients placed into various dependence, need or acuity typologies. The most important developmental work in this research tradition of staffing and cost analysis was conducted by the John Hopkins Operations Group during the early 1960's.

While these methods have been very useful in helping administration to quantify nursing performance, forecast nurse staffing requirements, and introduce a margin of control of nursing service costs under per diem reimbursement, they all share an important weakness in internal validity: they are built upon the premise that nursing intensity and resource consumption are merely a function of volume changes, i.e., patient census. The methods do not recognize the effects of case-mix and client-specific attributes on nursing resource use. Neither the patient day nor patient census is sufficiently sensitive as a measure of output to explain variations or changes in nursing intensity associated with the servicing of clients'

derived demands. Hence, the costing of nursing service inputs by the per diem is not functionally linked to real changes in clients' demands given their differences in severity and complexity of illness.

## Problem statement

This investigation, including all initial developmental analysis, proceeded under contract entitled, *A Prospective Reimbursement System Based on Patient Case-Mix for New Jersey Hospitals 1976-1983*. This contract required the New Jersey State Department of Health to develop and implement the use of diagnosis related groups (DRG's) as an alternative output measure to the patient day.

As applied research, this study: Develops a measure of resource use which reflects the variable intensity of nursing consumption as a function of patient-specific attributes; and furnishes a pragmatic approach which permits a more reasonable and equitable allocation of general nursing costs on a per-case basis for DRG reimbursement.

This allocation statistic must identify the relative amount of nursing services and corresponding costs of direct patient care consumed by any given inpatient in any given hospital for a given base year.

Moreover, in the interest of basic research of hospital economics, this analysis attempts to construct a patient-focused cost function whereby the costing of nursing services is based upon the relationship between the intensity of general nursing intervention and inpatient illness attributes. With nursing costs reflecting the value of nursing inputs associated with the provision of services and the case serving as a proxy for output, this study: Identifies which client attributes explain the variable intensity of nursing inputs; and develops an alternative to the patient day in costing nursing services given the relative consumption of nursing intensity by each client.

This analysis develops a pricing mechanism which is sensitive to the variations in the intensity of general nursing labor associated with the treatment of cases displaying various illnesses and nursing problems.

## Theory

### Threats to the validity of the patient day

The employment of the patient day as the measure of resource use is the most popular approach in costing nursing services. It is an easily obtained utilization statistic that can be handled readily through generally accepted accounting principles. However, there are a number of serious threats to the validity of the patient day when it is used as a component in a cost function.

The task of specifying cost functions for inter-hospital production and operations remains a formidable challenge despite much theoretical and empirical work. Not only are problems encountered in identifying the kinds of inputs associated with the delivery of services and goods in multiple product institutions, but also general disagreement exists as to what constitutes measurable output and how relationships can be

established between inputs and outputs among various departments for costing and management purposes. Moreover, even if a consensus over operational definitions of inputs and outputs is achieved, the ability to actually implement and evaluate across hospitals is severely limited by the lack of uniform cost and revenue reporting systems.

These problems become paramount when an effort is made to specify a cost function for nursing services because costs are often not reported on a *functional* basis (e.g., total nursing costs typically include central supply and nonpatient care administrative costs), and virtually all nursing departments do not operate as revenue-producing centers. Accordingly, even if a case-mix patient classification system such as DRGs is available so that cases can be placed into meaningful output groups, charges are simply not available as proxy measures of input intensity for the nursing department; and an allocation statistic such as the ratio of costs to charges (RCC's) cannot be derived to apportion costs on a case-specific basis.

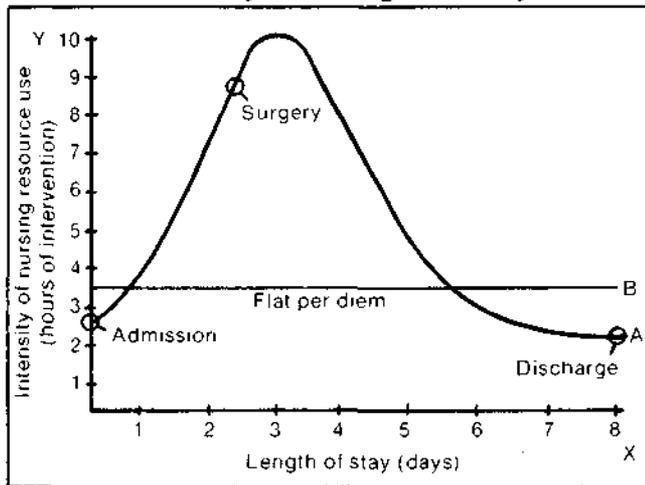
Over periods of real time, the patient day is too crude a measure to account for changes in intensity due to the effects of various illness states and procedures. Berki argues that the patient day is insensitive to such effects as variations in admissions, stay and diagnoses. The patient day as an output measure ignores changes in the use of capital and intensity of labor associated with the treatment of patients having various illnesses and problems. For example, when the patient day is used to price nursing services, this flat per diem does not respond to real variations in daily resource use. Given that patients can be classified into groups displaying similar derived demands for nursing services (based upon commonalities in diagnoses, procedures and nursing problems), intensity in the consumption of services will fluctuate during the length of stay. Intensity would be expected to accelerate before a major event such as surgery because nursing services would be focused on assessment, planning and pre-operative preparation. Intensity would probably peak shortly after the completion of surgery while nursing consumption would reflect intensive post-operative monitoring, care and teaching. As remission and wellness are achieved during the latter period of stay, nursing intensity would be expected to decay gradually to some minimal intervention in anticipation of the discharge. Such a scenario of variable nursing resource use over length of stay may be represented in terms of a log-normal distribution with the intensity of consumption as the ordinate and period of stay as the abscissa (Figure 1).

In the context of the theory and practice of professional nursing, the use of the patient day in pricing what nurses do appears patently inappropriate. The patient day is inappropriate as either an output measure or an input measure because nurses do not service patient days; nor can nurses' services be described in terms of a static, 24-hour period. Instead, nurses service clients whose demands vary every day throughout the period of hospitalization. In short, the professional labor of nursing departments consists of

services and judgments that are delivered in response to the constantly changing demands of clients given their respective medical and nursing problems. Hence, patients consume units of nursing service that vary in relation to their changing illness states. The patient day represents an accounting convenience that does not lend itself to the client-centered and service-focused professional labor of the nursing department.

**Figure 1**

**Plausible relationships between nursing intensity and length of stay**



**The proposed cost function**

The specification of a cost function for nursing services should be client-focused, and should accommodate the relationship between labor and the case whose consumption of labor varies conspicuously during the length of stay. With such a relationship established, the pricing of service inputs and the allocation of costs to each case (together with the weighted averaging of these case-specific costs within a defensible diagnostic output group) should yield a more equitable and reasonable approximation of actual nursing resource use.

Accordingly, the proposed cost function recognizes the case whose derived demands may be represented as an array of illness attributes and medical and nursing problems. In this respect, the case represents the "raw material" to which all direct patient care services are rendered. Professional nursing labor represents the inputs or units of service in response to these varying illness attributes and problems. These units of service encompass the universe of general nursing interventions performed by various skill levels. Interventions will include actions that involve both nursing and nonnursing skill and knowledge. Providing that all costs are functionally reported to reflect patient care, the costs represent the value attributed to nursing labor. Given that the case may be diagnostically assigned to a class whose members display similar patterns of medical or nursing resource use (e.g., intensity of interventions or length of stay), the case serves as the proxy for output.

The proposed cost function, therefore, establishes relationships between the case and units of service, and units of service and the value (costs) of the inputs. Case-specific units of service for any given hospital's inpatient population may be estimated by empirical techniques which identify the contribution of case-mix related attributes to variations in nursing resource use. The costing of inputs may then be achieved by treating the total nursing labor costs as the numerator and the total units of service as the denominator. Hence, the quotient furnishes the price per unit of service. Case-specific costs may be obtained by multiplying the price per unit of service by the total units of service derived for each case. The weighted mean cost per output group (the class containing diagnostically similar cases) may be obtained by summing the case-specific costs and dividing this sum by the total volume of cases contained in the output group.

**Method**

Detailed information about the Case-Mix Nursing Performance Study, the sample, methods and data collection instruments is available from the author.

In brief, this study utilized three self-administered schedules which were completed by various professional and technical personnel during the performance of their client-related duties.

The "Client Permanent Record" was designed as an adjunct to the hospital discharge abstract, and was completed by unit clerical and medical records personnel for each study client. The form provided a record of each client's movement through hospital services for the entire period of stay, and collected such information as: medical record number; calendar dates and shifts of admission, transfer and discharge on a unit-specific basis; admission and discharge classification, age, sex, primary payor, ethnic group, marital status, dates of surgery, principal and secondary diagnoses, and principal and secondary procedures.

Nursing activity data were collected by means of the "Client 8-Hour Nursing Activity Record." The purpose of this instrument was to furnish a bedside record of the reported *actual* number of minutes spent with each study client in the performance of nursing activities and other client-specific activities by each skill level on each shift for the entire length of stay. This schedule was completed by all levels of nursing personnel (i.e., Registered Nurses, Licensed Practical Nurses and attendants). "Nursing activity" included all interventions encompassing assessment and planning, teaching, emotional support, medications and treatments, and physical needs functioning. "Other activity" included non-nursing interventions involving patient transport, housekeeping, dietary, and miscellaneous bedside activities not requiring nursing skill and knowledge.

As a complement to the collection of reported bedside activity data, the "24-Hour Unit Activity Record" was completed by all levels of nursing personnel at each nursing station at the end of each tour of duty. This schedule permitted the collection of

estimated time in minutes spent in the performance of other (non-nursing) activities for groups of patients. These activities included messenger service, dietary, pharmacy, housekeeping, central supply, laundry and linen, and miscellaneous interventions not requiring nursing skill and knowledge. This activity data was prorated to each study client controlling for hospital, nursing unit type, skill level and shift.

## Procedure

The Case-Mix Nursing Performance Study was designed as a sample survey which permitted the collection of reported nursing intervention in actual minutes spent by each level of nursing personnel during the conduct of nursing and non-nursing activities on each shift for each client during the entire length of stay. The quality of on site data collection was controlled by the conduct of pre-test orientation sessions for participating personnel, and the execution of practice runs for selected patients over a three-day period. Specially trained extra-mural nursing monitors made rounds throughout the study sites to address problems encountered during the practice runs. These monitors were also present at selected shifts during actual data collection to exercise oversight and assure reporting compliance. Nursing units were selected at each study site on the basis of their respective size and case severity. All patients admitted or transferred to these selected nursing units were included in the study and were surveyed right up to discharge. The maximum sampling period for any given study patient was 32 days regardless of discharge. In this manner, nursing intensity data were collected for a total of 3,336 patients from eight hospitals over a period of 11 months.

In an effort to assure that the study data base possessed reasonable integrity, post-test site visits were made at the sample hospitals in order to review with nursing administration and participating nursing personnel the results of the interpolation program and unit-specific per diem nursing intensity analysis. This on site clinical review of the data permitted direct industry and professional nursing response concerning the acceptability of the data. As a result of the site visits and an independent audit of the data base, 87 cases were purged from the sample. The final useable sample consisted of 2,660 cases.

## Indices and operational definitions

A grand sum of total minutes of nursing and non-nursing interventions across all skill levels, across all nursing unit types was computed for each client. In addition, nonnursing time collected for groups of patients was prorated to each client. Hence, this grand sum of general nursing activity represented the amount of nursing units of service consumed by each client during the period of stay.

Principal Components Factor Analysis was conducted to examine how total activities behaved statistically between skill levels across the eight hospitals. The results strongly suggested that signifi-

cant differences existed between hospitals regarding the manner in which Registered Nurses, Licensed Practical Nurses and attendants were utilized in the provision of patient care and services. Hence, these findings provided empirical evidence in support of adjusting interventions to reflect real salary differentials between skill levels among the hospitals. In an effort to address the effects of salary differentials, a "Registered Nurse Equivalent Units of Service Index" (RNEUSI) was calculated. This was accomplished by indexing the average labor cost per hour for each skill level to the average labor cost per hour of Registered Nurses, where the index of the cost per hour of Registered Nurses is equal to unity. Accordingly, before the raw activity minutes were summed for all skill levels, the minutes were adjusted by the respective skill level indices. The following formula was used to furnish indexed total units of service for each client:

$$\text{RNEUSI} = \text{RNUR} + \text{RNON} + ((\text{LNUR} + \text{LNON}) \cdot 0.786) + ((\text{ANUR} + \text{ANON}) \cdot 0.722) \quad (1)$$

where

RNEUSI	is the Registered Nurse Equivalent Units of Service Index (grand total minutes of activity indexed to reflect skill level salary differentials);
RNUR	is total Registered Nurse nursing minutes;
RNON	is total Registered Nurse nonnursing minutes;
LNUR	is total Licensed Practical Nurse nursing minutes;
LNON	is total Licensed Practical Nurse non-nursing minutes;
0.786	is the Licensed Practical Nurse skill level index (ratio of average labor cost per hour of Licensed Practical Nurses to average labor cost per hour of Registered Nurses);
ANUR	is total attendant nursing minutes;
ANON	is total attendant nonnursing minutes;
0.722	is the attendant skill level index (ratio of average labor cost per hour of attendants to average labor cost per hour of Registered Nurses).

In addition to operationally defining nursing units of service (i.e., inputs) in this manner, three other indices were constructed from raw clinical information captured from the Client Permanent Record. A Multiple Diagnoses Index (MDI) and a Multiple Procedures Index (MPI) were computed by summing the number of diagnoses and procedures (reported as ICD-9-CM codes), respectively. These indices represented case severity in terms of multiplicity of medical problems and intensity of therapeutic and/or special diagnostic interventions. Finally, the period of stay was weighted by the number of days spent in special care units such as intensive care units and coronary care units. This index was obtained by dividing the number of special care unit days by the total length of stay. This quotient was labelled SCUDRAT (the ratio of special care units days to length of stay). Other client-specific

continuous variables included length of stay (LOS) and age.

### The patient-specific nursing resource use model

With these indices computed for each client, the initial quantitative step in constructing a patient-focused cost function for nursing services involved the specification of plausible relationships between nursing resource use (intensity of units of service) and case-mix attributes. Accordingly, the general model specifies indexed total units of service (RNEUSI) as the dependent variable and age (AGE), Multiple Diagnoses Index (MDI), Multiple Procedures Index (MPI), length of stay (LOS) and the ratio of special care unit days to length of stay (SCUDRAT) as independent variables.

While this multivariate model lent itself to general linear modeling techniques, the most significant challenge to specification and estimation involved the construction of classes of patients within which similar derived demands for nursing resource use could be identified. Lave and Lave have already demonstrated that such "isoresource categories" can be developed reasonably well by means of classification schemes that utilize raw diagnostic and procedural coding data (i.e., International Classification of Diseases). The data base of the Case-Mix Nursing Performance Study not only contained all raw ICD-9-CM diagnostic and procedural codes for each patient, it also contained admission and discharge status and the latest Major Diagnostic Categories (MDC's) into which patients were assigned given their principal diagnosis. Thus, a number of categorical variables were available to serve as potential partitioning elements in the construction of isoresource categories for nursing services.

### Exploratory analysis and testing

The preliminary exploratory analysis of the nursing resource use model involved correlation analysis of the variables across the sample without any case-mix controls. Correlation analysis was also conducted with the data *a priori* partitioned at the MDC level. The bulk of the statistical analysis in constructing and testing the model involved general linear modeling (unbalanced analysis of variance), using ordinary step-wise least squares regression analysis with the maximum  $R^2$  approach. Trend analysis and comprehensive tests of the disturbance terms were also done.

This approach essentially involved the partitioning of patients into the MDC's and observing the total effects of admission class (emergency vs. elective), discharge status (live vs. mortality) and the presence or absence of surgery. At this level of analysis, length of stay was regressed on indexed total units of service (RNEUSI). (Length of stay to the first order was used as the initial predictor variable because correlation analysis indicated that it explained up to 94 percent of the variance.) The intercepts and slopes of these curves were then studied to determine similarities; and

where similarities could be demonstrated, the MDCs were collapsed into clusters. In addition to reviewing commonalities in the statistical behavior of the curves, clusters were formed by observing similarities in per diem indexed intensity for each MDC as predicted by length of stay. Finally, the MDC's were broken down into subclasses of principal diagnoses based upon the intensity of threat to life. In this way, clusters representing special problems to nursing practice could be specified, and ranked from low to medium to high threat to life.

These analyses permitted the clustering of patients into the "best" classes that displayed similar patterns of nursing resource use given patients' case-mix attributes and nursing problems. The clusters not only had to behave well statistically in terms of estimating common patterns of nursing resource consumption, but had to be logical in terms of the nursing problems involved. In this way, the overall approach allowed the creation of isoresource categories "fine-tuned" to nursing.

### Results

Table 1 shows the descriptive statistics for the sample of hospitals compared to statewide parameters.

Table 2 illustrates mean per diem hours of intervention by activity category by nursing unit type across the sample of patients without case-mix controls.

Table 3 shows the matrix of zero-order correlation coefficients computed from among the six continuous variables across the sample without controlling for case-mix. (Because of the Law of Large Numbers, only alpha values equal to or less than 0.0001 were accepted as significant.)

An inspection of the Pearson correlation coefficients in Table 3 shows that length of stay was the most significant variable associated with indexed total units of service ( $r=0.7744$ ,  $p>0.0001$ ) followed by Multiple Diagnoses Index ( $r=0.3228$ ,  $p>0.001$ ), Multiple Procedures Index ( $r=0.2584$ ,  $p>0.0001$ ) and age ( $r=0.2326$ ,  $p>0.0001$ ). However, when case-mix was controlled by partitioning patients into MDC's, age lost its systematic association with indexed total units of service.

Table 4 illustrates the results of the MDC-specific correlation analysis as exemplified by MDC 5: Diseases and Disorders of the Circulatory System.

The analyses of commonalities in nursing resource use yielded nine initial nursing services isoresource clusters; the presence of surgery and partitioning by admission class improved the homogeneity of four of the initial clusters, resulting in 13 terminal nursing services isoresource clusters.

**Table 1**  
**Base-year cross-check of sample descriptive statistics and statewide parameters: 1979**

Item	Sample hospitals (N = 8)		All hospitals (N = 103)	
	Absolute frequency	Relative frequency (%)	Absolute frequency	Relative frequency (%)
Total discharges	2,660	100.00	1,141,968	100.00
Admission class				
Emergency/urgent	1,435	53.95	457,174	41.27
Elective	1,225	46.05	650,628	58.73
Sex				
Male	1,153	43.35	474,098	41.52
Female	1,507	56.65	667,788	58.48
Race				
White	1,796	67.52	886,514	78.18
Black	444	16.69	174,984	15.43
Asian/Pacific	14	0.53	6,477	0.57
American Indian/Alaskan				
Native	0	0	317	0.03
Hispanic	102	3.83	64,273	5.17
Other	304	11.43	1,428	0.13
Discharge status				
Live	2,590	97.37	1,092,814	97.21
Expired	70	2.63	31,378	2.79
Payment status				
Unknown/Other	399	15.00	21,112	1.85
Self	145	5.45	62,867	5.51
Blue Cross	1,010	37.97	427,516	37.44
Medicare	821	30.86	277,265	24.28
Medicaid	210	7.89	126,663	11.09
Other Government	13	0.49	12,884	1.13
Workman's Compensation	62	2.33	17,084	1.50
No charge	0	0	7,499	0.66

**Table 2**  
**Mean per diem hours of intervention by activity category and nursing unit type across the sample**

Nursing unit type	N-size*	X per diem hours			Ratio of per diem nonnursing to total per diem intervention
		Total per diem intervention	Per diem nonnursing	Per diem nursing	
Medical-surgical	2,310	3.91	1.49	2.42	0.3811
Obstetrics-gynecology	272	2.58	1.21	1.37	0.4689
Psychiatry	44	6.09	1.59	4.50	0.2611
Intensive care unit	53	9.98	2.89	7.09	0.2896
Coronary care unit	45	9.04	2.64	6.40	0.2920

\*This N-size exceeds the sample of 2660 cases since patients are counted on multiple nursing unit types as a result of transfers between units.

**Table 3**  
**Matrix of intercorrelations among the variables (Pearson correlation coefficients)**  
**N = 2660**

	LOS	AGE	MDI	MPI	SCUDRAT	RNEUSI
LOS	1.0000	<sup>1</sup> 0.3046	<sup>1</sup> 0.2997	<sup>1</sup> 0.2616	-0.0036	<sup>1</sup> 0.7744
AGE		1.0000	<sup>1</sup> 0.3291	0.0160	0.0283	<sup>1</sup> 0.2326
MDI			1.0000	<sup>1</sup> 0.1984	0.0515	<sup>1</sup> 0.3228
MPI				1.0000	-0.0906	<sup>1</sup> 0.2584
SCUDRAT					1.0000	0.0598
RNEUSI						1.0000

<sup>1</sup>Significant at the 0.0001 level where: LOS = length of stay; AGE = age; MDI = Multiple Diagnoses Index; MPI = Multiple Procedures Index; SCUDRAT = ratio of special care unit days to length of stay; RNEUSI = Registered Nurse Equivalent Units of Service Index.

**Table 4**  
**Matrix of intercorrelations among the variables (Pearson correlation coefficients)**  
**major diagnostic category 5:**  
**Diseases and disorders of the circulatory system**  
**N = 346**

	LOS	AGE	MDI	MPI	SCUDRAT	RNEUSI
LOS	1.0000	<sup>1</sup> 0.2324	<sup>1</sup> 0.3015	<sup>1</sup> 0.2522	-0.0111	<sup>1</sup> 0.7453
AGE		1.0000	<sup>1</sup> 0.3263	-0.0395	0.0063	0.1937
MDI			1.0000	0.0760	0.0169	<sup>1</sup> 0.3265
MPI				1.0000	-0.1691	<sup>1</sup> 0.2831
SCUDRAT					1.0000	0.0725
RNEUSI						1.0000

<sup>1</sup>Significant at the 0.0001 level where: LOS = length of stay; AGE = age; MDI = Multiple Diagnoses Index; MPI = Multiple Procedures Index; SCUDRAT = ratio of special care unit days to length of stay; RNEUSI = Registered Nurse Equivalent Units of Service Index.

### Multiple regression analysis and prediction equations<sup>1</sup>

Length of stay (LOS) tends to be systematically estimated as the most powerful predictor of indexed total units of service (RNEUSI). Except for the first-order prediction equation estimated for nursing services isoresource cluster 1 with surgery, the relationship between LOS and RNEUSI is predominantly curvilinear and positive: the greater the length of stay, the greater the consumption of general nursing units of service. This relationship is significant in intensity ( $p > 0.0001$ ) across all 13 terminal nursing services isoresource clusters.

Concerning the effects of age, Multiple Diagnoses Index (MDI), Multiple Procedures Index (MPI) and the ratio of special care unit days to length of stay (SCUDRAT), these variables tend to be "partialled" out when the direct and indirect effects of length of stay are controlled. The results of estimation analysis consistently indicated that these variables seldom contributed more than two percent to the total adjusted  $R^2$  values when the total effects of length of stay were controlled. Moreover, the standard errors of these estimates exceeded the 25 percent ceiling allowed in interpreting the integrity of the partial regression coefficients.

A general interpretation of these findings is that length of stay appears to be the most important predictor of nursing resource use regardless of age and the complexity of the medical problem when case-mix is controlled by means of the 13 nursing services isoresource clusters. The analysis furnishes empirical support for the use of length of stay as a predictor of nursing resource use, provided that length of stay is estimated on a patient-specific basis and adjusted for case-mix effects associated with principal diagnosis, admission status or the presence or absence of surgery.

<sup>1</sup>The prediction equations of the 13 terminal nursing services isoresource clusters together with tests of significance and analysis of the disturbance terms are available from the author, Dr. Russell P. Caterinicchio, Client-Centered Systems, Inc. 1931 Hamilton Avenue, Trenton, New Jersey 08619.

### Allocating nursing costs on a per-case basis

Since the statistical model used in this research permits the estimation of nursing inputs for each and every client in any given hospital's population, each case's consumption of nursing resources relative to the total consumption of nursing service inputs across all cases may be reasonably identified within acceptable limits of confidence. Accordingly, the following illustrations are provided to demonstrate the costing of nursing units of service and the derivation of a cost per case.

Given that hospital<sub>j</sub>'s total general nursing costs are functionally reported for any base year, the following equation represents the cost function between costs (the value of inputs) and patient-specific nursing inputs, and is used to price the nursing inputs (cost per unit of nursing service):

$$X_j = \sum C_j / \sum_{i=1}^N RNEUSI_i \quad (2)$$

where:

$$X_j = \text{cost per nursing unit of service for hospital}_j$$

$$\sum_{i=1}^N C_j = \text{total nursing costs for hospital}_j$$

$$\sum_{i=1}^N RNEUSI_i = \text{total nursing units of service of patients 1 to N in hospital}_j$$

If hospital<sub>j</sub>'s total nursing direct patient care costs were \$7,060,000.00 and a total of 42,142,177 nursing units of service were estimated from hospital<sub>j</sub>'s population of 16,877 cases, then the cost per unit of service is \$0.168:

$$\$7,060,000.00 / 42,142,177 = \$0.168$$

This cost per unit of service is the allocation statistic that is used to apportion nursing costs to each case subsumed under a given output group defined for any given hospital or group of hospitals. The allocation of nursing costs is based upon the functional relationship between estimated nursing resource use and patient-specific illness attributes. An output group consists of a class of diagnostically or therapeutically similar cases such as Diagnosis Related Groups (DRG's). The cost of nursing services for any given patient within a

given DRG for hospital<sub>j</sub> is derived by means of the following equation:

$$C_{igj} = Y_{igj} \cdot X_j \quad (3)$$

where:

- $C_{igj}$  = nursing cost for patient<sub>i</sub> in DRG<sub>g</sub> for hospital<sub>j</sub>;
- $Y_{igj}$  = estimated total nursing units of service (RNEUSI) for patient<sub>i</sub> in DRG<sub>g</sub> for hospital<sub>j</sub>;
- $X_j$  = cost per nursing unit of service in hospital<sub>j</sub>.

For example, if Client A belonged to DRG<sub>g</sub> and his estimated total nursing units of service were 3306.281, then the cost of nursing services for Client A is \$555.46:

$$\begin{aligned} C_{\text{Client A}} &= 3306.281 \cdot \$0.168 \\ C_{\text{Client A}} &= \$555.46 \end{aligned}$$

The arithmetic mean cost per case for any given DRG for any hospital is derived by the following formula:

$$\bar{X}_{gj} = \frac{\sum_{i=1}^N C_{gij}}{N_{gj}} \quad (4)$$

where:

- $\bar{X}_{gj}$  = mean nursing cost per case for DRG<sub>g</sub> in hospital<sub>j</sub>;
- $\sum_{i=1}^N C_{gij}$  = total nursing costs for patients 1 to N in DRG<sub>g</sub> for hospital<sub>j</sub>;
- $N_{gj}$  = number of cases in DRG<sub>g</sub> in hospital<sub>j</sub>.

Accordingly, if five cases were assigned to DRG<sub>g</sub> and their respective nursing costs were \$555.46, \$618.25, \$595.95, \$560.75, and \$538.29, then the mean cost per case for DRG<sub>g</sub> in hospital<sub>j</sub> is equal to \$573.74:

$$\frac{\$555.46 + \$618.25 + \$595.95 + \$560.75 + \$538.29}{5} = \$573.74$$

The arithmetic mean cost per case for any given DRG across any number of hospitals is derived by means of the following equation:

$$\bar{X}_{gn} = \frac{\sum_{i=1}^N N_{ig} \bar{X}_{ig}}{N_{gn}} \quad (5)$$

where:

- $\bar{X}_{gn}$  = weighted arithmetic mean cost per case for DRG<sub>g</sub> for n hospitals (inter-hospital mean nursing cost per case);
- $N_{ig}$  = number of cases in DRG<sub>g</sub> for hospitals 1 to N;
- $\bar{X}_{ig}$  = mean cost per case in DRG<sub>g</sub> for hospitals 1 to N;
- $N_{gn}$  = total number of cases in DRG<sub>g</sub> for n hospitals.

As an example, if there were a sample of five hospitals and the number of cases and the mean cost per case were known for DRG<sub>g</sub>, then the inter-hospital mean cost per case is calculated as follows:

$$\frac{(\$573.74 \cdot 5) + (\$567.25 \cdot 9) + (\$601.19 \cdot 7) + (\$588.93 \cdot 10) + (\$570.50 \cdot 19)}{50} = \$578.22$$

Table 5 provides examples of patient day versus client-focused costing of nursing resource use for 11 selected DRG's.

A careful review of Table 5 shows that the client-focused costing methodology generally tends to apportion greater amounts to nursing costs of those DRG's that would be expected to contain cases whose clinical and illness attributes affect greater nursing resource use. For example, DRG 121, "acute myocardial infarction, discharged alive, with cardiovascular complications, medical regimen," tends to be a very high nursing intensive DRG since nursing interventions would involve such activities as intensive assessment and monitoring, constant implementation of the medical regimen and patient education prior to discharge. An inspection of the mean costs and the percentage of mean total DRG costs under the respective allocation methodologies shows that the client-focused costing allows a greater apportionment of nursing costs to the case and to the DRG. The mean nursing cost per case is \$1,303.41 and the percentage of costs that nursing contributes to the DRG cost is 57.60 for the patient day approach as opposed to the mean nursing cost per case of \$1,468.13 and a percentage of 60.48 mean total DRG costs under client-focused costing. The opposite effect is observed for DRG 134, "hypertension, medical regimen." This DRG tends to be less nursing-intensive, relative to DRG 121 since the majority of interventions tend to involve administration of medication and physical functioning activities. The mean nursing cost per case is \$350.16 and the percentage of nursing costs contributed to the total DRG cost is 46.60 for the patient day allocation in contrast to the mean nursing cost per case of \$307.62 and a percentage of 43.40 mean total DRG costs under client-focused costing. These examples illustrate the flow of ancillary and nursing resources and the corresponding redistribution of costs given case-mix differences among patients and DRG's.

## Conclusions and discussion

### Summary of the findings

A sample survey was conducted at eight acute care hospitals in New Jersey over an 11-month period between 1979 and 1981 in order to develop a client-focused, case-mix sensitive measure of resource use for the allocation of inpatient general nursing costs.

Using general linear modeling techniques, the direct and indirect effects of age, length of stay, multiple diagnoses, multiple procedures, the ratio of special care unit days to total length of stay, and the effects of the presence of surgery, admission status, discharge status and membership in Major Diagnostic Categories on indexed total units of nursing service were explored. The results of the analysis suggested that length of stay is the most significant predictor of indexed nursing units of service regardless of age and the complexity of the medical problem when case-mix is controlled through the assignment of cases to 13 nursing services isoresource clusters. The relationship

**Table 5**  
**Examples of patient day versus client-focused costing**  
**of nursing resource use for 11 selected diagnosis-related groups (DRG's)**

DRG's and description	N-Size	$\bar{X}$ LOS	Patient day costing			Client-focused costing		
			$\bar{X}$ Nursing cost per diem	$\bar{X}$ Nursing cost per case	Percentage of $\bar{X}$ total DRG cost	$\bar{X}$ Nursing cost per diem	$\bar{X}$ Nursing cost per case	Percentage of $\bar{X}$ total DRG cost
002 Craniotomy, age $\geq$ 18, with principal diagnosis of trauma	21	19.67	\$63.16	\$1,242.24	44.08	\$70.50	\$1,386.48	46.80
025 Seizure and headache, age $\geq$ 18, or age 0-70, without substantial complication or comorbidity, medical regimen	266	5.14	44.37	228.04	43.47	35.77	183.81	38.27
033 Concussion, age 0-17, medical regimen	272	2.37	45.86	108.76	44.20	66.33	157.29	53.40
039 Lens, O.R. procedure	1,107	3.25	43.10	140.27	26.06	34.68	112.87	22.09
044 Acute major infection of the eye, medical regimen	9	4.44	43.15	191.77	47.17	49.03	217.90	50.36
057 Other tonsil or adenoid, O.R. procedure, age $\geq$ 18	15	2.40	42.03	100.88	25.28	43.01	103.23	25.71
062 Myringotomy, O.R. procedure, age 0-17	18	1.00	42.55	42.55	18.99	63.61	63.61	25.95
077 Minor chest or other O.R. procedures, age 0-70, without substantial complication or comorbidity	58	7.47	44.40	331.48	34.47	40.18	299.99	32.26
087 Pulmonary edema and respiratory failure, medical regimen	215	10.22	65.08	664.98	46.42	66.33	677.79	46.90
121 Acute myocardial infarction, discharge alive, with cardiovascular complications, medical regimen	285	16.70	78.04	1,303.41	57.60	87.90	1,468.13	60.48
134 Hypertension, medical regimen	650	7.65	45.80	350.16	46.60	40.23	307.62	43.40

between length of stay and indexed total units of nursing services was found to be highly statistically significant, positive and predominantly curvilinear: the greater the length of stay, the greater the consumption of general nursing units of service.

While this finding may appear intuitive and apparently tautological, the methodology actually yields an empirically derived patient-specific, case-mix adjusted length of stay statistic which can be used to apportion nursing costs. The approach permits the estimation of nursing units of service which reflect the relative amount of nursing inputs and corresponding costs of direct patient care consumed by any given inpatient in any given hospital.

### **Theoretical and practical implications**

This study is the first of its kind to utilize an empirical approach to construct and test a client-focused cost function for the pricing of nursing inputs under cost per case reimbursement. The ability to relate nursing costs to a unit of service reflecting patient-specific nursing resource use, and in turn, to allocate these costs in conjunction with other direct patient care costs and services to derive institutional or inter-institutional costs per case, is paramount to traditional per diem costing, and conventional fiscal management in hospitals. The methodology is sufficiently sensitive to variations in case severity to the extent that the costing of nursing services to any given output group (such as DRG's) more accurately approximates actual resource use during the period of stay.

The implications for hospital management are significant, since the methodology is totally computer

automated and lends itself to management information systems. For example, with the identification of the flow of nursing resources between and among diagnostic and therapeutic output groups such as DRG's, nursing administration possesses an enhanced capacity to coordinate the professional nursing labor pool in the direction of the institution's actual case load and case severity. Moreover, the ability to document the demand for nursing resources on a per-case basis goes hand in hand with the ability to exercise more effective control over the relationship between the nursing department and ancillary services. Such a management capability for nursing administration becomes particularly important in the light of the amount of direct cross-subsidization that nursing seems to provide in support of ancillary services. The amount of nonnursing reported in this data base as part and parcel of routine and intensive interventions has staggering implications for the efficient deployment of nursing personnel in the hospital setting. For one, the incentives introduced by cost-per-case reimbursement are directed towards efficient management of all components of patient care, thereby encouraging the integration of all departments for better administration and management of services and costs.

Nursing-intensive cases can be identified by means of this client-focused allocation methodology, and responsible nursing administration may now take advantage of this knowledge to manage professional nursing resources more efficiently: to direct nursing skill and knowledge to those cases displaying the most conspicuous consumption by virtue of their illness and case-mix attributes.