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A REGRESSION MODEL TO PREDICT HOSPITAL MAINTENANCE EXPENDITURE

DIVISION OF HEALTH SERVICES RESEARCH
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SUMMARY

In the past decade the running costs of public hospitals in New South Wales increased fivefold with several yearly increments over 20 percent. The State has attempted to correct this situation but the "across the board" methods adopted discriminate against hospitals which are relatively more efficient or are already under pressure and as such are genuinely in need. It would be advantageous to identify hospitals whose expenditure deviates significantly from some average or expected level for hospitals of comparable size and function. Then these outliers could be scrutinised during the budget setting process with the aim of reducing inequalities and ensuring a more even distribution of resources. This means discriminating in favour of hospitals which would suffer unfairly from unselective restrictions on funds.

The objective of this study was to explore the use of the statistical technique of regression analysis as a tool for predicting hospital maintenance expenditure and explaining the contribution to maintenance expenditure made by various factors. The objective was pursued in two stages:

1. Developing an equation to predict hospital maintenance expenditure.

2. Identifying hospitals whose predicted maintenance expenditure deviated substantially from their actual maintenance expenditure.

This paper describes the equation which was developed and the results derived from it using data from the financial year 1976/77 for 216 of the schedule 2 and 3 hospitals in the state.

Stage One

The computerised regression analysis derived an equation relating maintenance expenditure to a number of selected factors. These were the average length of stay, three casemix factors, outpatient occasions of service, nurse education, size, and the teaching function of the six major teaching hospitals. The equation accounted for 84 percent of the variation in maintenance expenditure per separation among the 216 hospitals surveyed and the coefficients in the equation were interpreted to indicate the effect which each factor had upon expenditure. This interpretation could only be tentative because several of the factors in the equation were highly correlated with each other and this made the true value of the coefficients difficult to determine although the predictive power of the equation was unimpaired.

Stage Two

At this stage the equation produced in Stage One was used with expected length of stay (length of stay adjusted for the age and sex of patients) inserted in place of the actual length of stay for each hospital. The objective at this stage was to pick out hospitals deviating substantially from their predicted performance, with a penalty imposed for lengths of stay exceeding the expected values in the Relative Stay Index.

Over half the hospitals did not deviate appreciably from the predicted value, a quarter deviated significantly with actual exceeding predicted cost per separation and 15 percent deviated significantly with actual expenditure falling short of that predicted. Most of the group of hospitals which exceeded their predicted expenditure were small, and half had actual lengths of stay greatly exceeding that expected. Most of the hospitals with very long lengths of stay were performing at least in part a nursing home function and so should not be penalised if this role is acceptable through lack of alternative nursing home facilities in the area.

Many of the hospitals whose actual expenditure seriously exceeded the predicted value had occupancy rates below 60 percent. The staff establishment of these hospitals could be reviewed to ensure that it is appropriate for the actual workload at the hospital.

Conclusions

This approach provided some insight into factors affecting hospital maintenance expenditure, but in view of the factors which were not considered such as quality of care and the inadequacies of some of the data it appears that the same insight could be gained by other methods such as the Relative Stay Index and simple scrutiny of occupancy rates in relation to staff establishment. The analysis could be improved in many ways but it does not seem worthwhile to pursue this method of approach until better data are available on a regular basis.

It appears that a quite different method may yield more useful results. This is the output-oriented management system which involves departmental costing allied to the measurement of departmental outputs. An advantage of this approach in comparison with the regression equation is that it identifies particular areas or departments in the hospitals where economies may be effected.

INTRODUCTION

Four factors underlie the approach adopted in this paper:

1. The rapidly increasing maintenance expenditure incurred by hospitals in New South Wales. Maintenance expenditure here, and throughout this paper, refers to operating expenditure, or the routine costs incurred in running hospitals.

2. The current method for budgetting, based largely on the expenditure of the previous year.

3. The widespread practice of overspending without any limit being imposed on the size of the deficit.

4. The approach to cost containment which involves "accross the board" restrictions on the percentage increase in expenditure allowed beyond that in the previous year.

The trend in maintenance expenditure for N.S.W. public hospitals is similar to the pattern seen for hospital and health expenditure in other Australian states and overseas. However, the rate of increase in N.S.W. compares unfavourably with other countries such as Canada and the United States.* The principal components of the increase are inflation, increased volume of services, increases in wages greater than the trend in average weekly earnings, increased staff ratios and other non-salary increases (such as those arising from advanced technology). In the past decade there has been an increase of more than 500 percent in this State's maintenance expenditure and individual yearly increases well over 20 percent have been common. Gross percentage increases for the last seven years over the previous year's expenditure are as follows:

1970 - 1971	20%
1971 - 1972	20%
1972 - 1973	11%
1973 - 1974	25%
1974 - 1975	49%
1975 - 1976	23%
1976 - 1977	28%

The average increase over this period was 24% per annum and at this rate annual expenditure doubles every three years.

The Health Commission of New South Wales in the last 10 years has had two major programmes directed at restraining the extent of increase of the State's hospital budget. One was in 1972-73 and the other was in 1977-78. The methods adopted in both years were similar, and in 1972-73 the percentage increase was restrained to 11%. The guidelines for budget allocation in 1977-78 were based on two main factors:

1. For each hospital the percentage increase in budget allocation above the sum provided in 1976-77 was significantly lower than in previous years.

2. Additional staff positions have not been approved except in special circumstances and new services are being opened within a severely reduced programme.

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* J.M. Martins, "An output oriented management system for hospitals". Address to the School of Health Administration's Summer School on 'Cost Containment and Quality Control', Sydney, February 19-24, 1978.

It is argued that setting a hospital's budget by means of a fixed percentage increase over its previous year's budget allocation and imposing cost containment policies by reducing each hospital's percentage increase discriminates most against those hospitals operating in the most efficient manner or at maximum capacity while those hospitals with greater slack (e.g. low occupancy rate, overly high length of stay) suffer least.

The alternative to "across the board" cuts in budgets or containments of expenditure levels is to identify those institutions which appear to have particularly high expenditure in relation to their size and range of services. The expenditure patterns of these hospitals can be placed under greater than normal scrutiny during the budget setting processes. Through this mechanism expenditure cuts can be made on a more selective basis and thus budgets can be set with the assistance of inter-hospital comparisons.

This approach rewards efficient institutions in the budget setting process and penalises inefficient institutions. Budget restraint mechanisms are, by the same token, discriminatory.

In order to provide incentives in the budget process it is then important to identify hospitals whose expenditure deviates significantly from some average or expected level, taking account of special factors which may operate at individual hospitals (teaching functions or provision of special services for example). Various bases for comparison exist, among them:

1. comparison of cost per bed day or stay;

2. comparison of length of inpatients' stays standardised by age, sex and diagnostic category (the Relative Stay Index);

3. identification and comparison of component costs in relation to standard units of output (e.g. cost per meal, cost per kilo of dry linen, cost per weighted pathology procedure).

Option one is far too crude to enable meaningful inter-hospital comparisons. It is uncertain whether the Relative Stay Index adequately sorts efficient from inefficient hospitals. It certainly differentiates hospitals in terms of length of patient stays for various diagnostic categories but it is possible that in some cases inefficiencies of hospitals do not influence patients' length of stay.

The third mechanism, comparison of component costs, is probably the most desirable and is proceeding at several hospitals, notably Hornsby, St. Vincent's (Darlinghurst), Liverpool, Blacktown and Bankstown hospitals.

THE DATA BASE

Data for the financial year 1976-77 were collected from Schedule 2 and 3 hospitals in New South Wales. These institutions are state-funded (in contrast to private hospitals) and are managed in most cases by Boards of Directors (unlike the Schedule 5 hospitals, mainly psychiatric institutions, which are managed by the Health Commission).

Not all Schedule 2 and 3 hospitals were included in the analysis. Those designated as long-stay or convalescent homes were not included in the model, and other hospitals with an average length of stay above 30 days were also excluded. Essential data were lacking from some hospitals and these of course could not be included. 216 hospitals were entered in the model and Table 1 shows the numbers of hospitals excluded for various reasons.

Table 1: Hospitals in the Model, and those Excluded with the Reasons for Exclusion

Hospitals included		216
Hospitals excluded:		
Long-stay and convalescent homes	25	
Missing data	13	
Average length of stay exceeded 30 days	12	
No inpatient services	3	
Total excluded		53
Grand Total		269

Most of the data were readily available in the Finance Section of the Health Commission and some items were checked by a questionnaire sent to Regional Offices. Table 2 shows the sources of data and Table 3 shows the means and ranges of selected characterisitics of the hospitals in the model.

Table 2: Sources of Data Items

Data Item	Source
Maintenance Expenditure (Total operating payments less meals, accommodation, services to other hospitals and special interest grants.)	Finance Branch computer records as of 30.6.77.
Beds	Hospitals and Health Services Year-book of Australia, 1976-77, checked by a questionnaire sent to Regional Offices.
Daily Average of Occupied Beds	Finance Branch computer records as of 30.6.77.
Separations	Finance Branch computer records as of 30.6.77.
Outpatient Services	Finance Branch computer records as of 30.6.77.
Nurse Educators	Finance Branch forward estimates of hospital expenditure. Checked by a questionnaire sent to Regional Offices.
Average Length of Stay	Derived from Daily Average of Occupied Beds and Separations.
Occupancy	Derived from Daily Average of Occupied Beds and Number of Beds.
Expected Length of Stay	Relative Stay Index, Hospital Computer Services, for the year ending 31.12.76.
Casemix	Relative Stay Index, Hospital Computer Services, for the year ending 31.12.76.

Table 3: Means and Ranges of Selected Characteristics for the 216 Hospitals in the Model (1976-77 Financial Year)

Variable	Mean	Range
Maintenance Expenditure	$3,416,000	$84,000 - $57,909,000
Maintenance Expenditure per Separation	$800	$320 - $1,830
Maintenance Expenditure per Bed Day	$114	$47 - $188
Beds	114	7 - 1,221
Daily Average of Occupied Beds	82	4 - 933
Separations	3,707	74 - 43,394
Outpatient Services	32,825	0 - 715,790
Nurse Educators	2.1	0 - 35
Average Length of Stay	9.8 days	2.6 - 30 days
Occupancy*	65.5%	26.7% - 95.3%

* This is the average occupancy for the 216 hospitals and it is smaller than the statewide occupancy given by the mean of beds and the mean of

FACTORS INCLUDED IN THE MODEL

The factors selected for inclusion as predictor variables in the model are various outputs or characterisitics of hospitals which are expected to influence the maintenance expenditure per separation. Expenditure per separation is the dependent variable and a wide range of data was collected to represent various explanatory factors. Not all the factors originally selected remain in the final model because in some instances it appeared that the factor did not significantly influence the dependent variable and in other cases the data were not good enough to reveal whether the factor had an effect or not. As is the case with any statistical technique, the outcome depends upon the quality of the data available and at present there are deficiencies in both the type and accuracy of available statistics.

The factors used in the final model are listed below. Some can be simply represented but others require indirect indicators or proxy representation.

Maintenance expenditure per separation is the total maintenance expenditure for the 1976-77 financial year divided by the number of separations (deaths and discharges) from the hospital during that period. The total maintenance expenditure (M.E.) is that expenditure incurred in the routine running of the hospital, apart from capital expenditure. It includes salaries (near 80% of total M.E.), medical supplies, fuel and food.

Average Length of Stay (A.L.S.) is the average number of bed days consumed by patients separating from the hospital during the financial year. It is calculated from the daily average of occupied beds x 365 divided by the number of separations for the year.

Outpatient Throughput is represented by the total number of outpatient occasions of service reported for each hospital.

Nursing Education is represented by a proxy variable, the number of staff designated as nurse educators in each hospital.

Size is included to investigate whether there is any systematic relationship between size and expenditure per separation, apart from the effect of other factors correlated with size such as teaching activities. The factor representing size is the number of separations rather than the number of beds which over-estimates the utilised capacity or effective size of hospitals with low occupancy.

Teaching/Non-Teaching. A dummy variable was inserted to measure the effect of the teaching function in the six major teaching hospitals.

Casemix was included because it was anticipated that maintenance expenditure per separation will vary according to the complexity of the caseload. After testing various indicators of the casemix the following approach was used. The 47 diagnostic categories used in the Relative Stay Index were sorted into three groups:

(i) cases whose expenditure was unlikely to vary significantly from one day's stay to the next (e.g. infectious and parasitic, upper gastrointestinal, senility);

(ii) cases characterised by relatively short lengths of stay and an operation (e.g. tonsils and adenoids, normal delivery); and

(iii) cases with a relatively high cost per day and also a long length of stay (e.g. acute myocardial infarction).

The casemix factors are the <u>expected patient days</u> in each of the three groups. For a given hospital these factors would ideally be derived from the proportions of cases in each of the 47 diagnostic categories, and the expected length of stay for each category for that hospital. However, the manpower required to perform these calculations for 216 hospitals and 47 categories (followed by the aggregation into the three groups) was not available and to automate the data processing notional (estimated) average length of stay were used for each diagnostic category.

The notional lengths of stay were derived from the lengths of stay at selected hospitals and they are an approximation to the state average length of stay for each diagnostic category. Table 4 shows the composition of the three casemix factors and the notional lengths of stay used.

For each hospital the proportion of cases in each of the 47 categories were multiplied by the notional (estimated) State average length of stay for that category. The product of the calculation (proportion of cases x notional average length of stay) is a figure for the expected number of patient days which should be consumed in that diagnostic category by that hospital. These figures for expected days were added up within each of the three groups of diagnostic categories, giving the three casemix factors in the form of expected days.

Factors initially tested and excluded from the model

Several factors were included at first but did not make a statistically adequate contribution to the prediction of maintenance expenditure per separation and so were eliminated from the model. It was assumed in some cases that the factors are important but the proxy measures were inadequate to properly measure their effects. The eliminated variables were geographical location, provision of undergraduate medical education, and the provision of special (non-routine) services. Another factor, selected to represent the provision of postgraduate medical education (measured by the number of registrars, resident medical officers and interns at work in the hospital) was dropped because it was not clear that the variable as measured is a genuine output factor.

Factors not considered

Some important factors were not taken into account because appropriate data were unavailable. In the absence of reliable indicators of quality of care we were forced to assume that all hospitals in our sample provided care of equal quality. Obviously those hospitals with a teaching function and numerous special services provide more sophisticated levels of care but the question of quality at a given level of sophistication cannot be resolved at this stage. Eventually some index such as Roemer's index of hospital performance* may be refined to enable this factor to be taken into account.

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* M.I. Roemer, A.T. Moustafa and C.E. Hopkins, "A proposed hospital quality index: Hospital death rates adjusted for case severity".

CASEMIX FACTOR 1

R.S.I. CATEGORY NUMBER	R.S.I. LABEL	NOTIONAL LENGTH OF STAY IN DAYS
1	Investigation, procedures, healthy persons	5
2	Infectious and parasitic	7
3	Enteritis, diarrhoeal disease	5
7	Blood	8
8	Psychiatric	11
9	Other CNS and nerves	10
11	Other heart, hypertension	12
13	Symptomatic heart disease	14
14	Cerebrovascular disease	20
15	Circulation	12
16	Upper respiratory	6
17	Pneumonia	11
18	Bronchitis, emphysema, asthma	10
20	Other respiratory	6
22	Upper Gastrointestinal	9
25	Other Gastrointestinal	11
27	Other urinary	6
35	Skin disease	6
36	Orthopaedic	10
38	Perinatal	9
40	Symptoms, ill-defined diseases	5
41	Senility without psychosis	40
45	Internal Injury	8
47	Poisoning	8

CASEMIX FACTOR 2

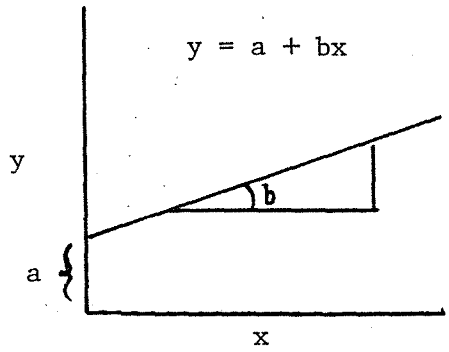
5	Benign neoplasms	5
10	Eye and ear	5
19	Tonsils and adenoids	3
21	Dental	2
23	Appendicitis	7
24	Hernia	9
28	Male genital	9
29	Other female genital	5
30	Disorders of menstruation	3
31	Complications of pregnancy and puerperum	8
32	Abortion	2
33	Normal delivery	7
34	Delivery with complications	9
42	Other fractures (excluding femur neck)	12
44	Dislocations	7
46	External Injury	5

CASEMIX FACTOR 3

4	Malignant neoplasms.	13
6	Endocrine and metabolic	13
12	Acute myocardial infarction	15
26	Nephritis and nephrosis	5
37	Congenital malformation	7
39	Immaturity	19
43	Fracture of neck of femur	32

A BRIEF EXPLANATION OF REGRESSION ANALYSIS

Regression is a statistical method to derive an equation which provides an estimate of one variable (the dependent variable) given the value of one or more explanatory (independent) variables. The simplest example is the relationship between a dependent variable (y) and one explanatory variable (x), given by the equation y = a + bx.



The point on the y axis where the line intercepts is given by the value 'a' and the slope of the line is 'b' the coefficient assigned to the independent variable. Given the values of 'a' the constant term in the equation and 'b' the slope of the line (the coefficient or the weight to be assigned to the explanatory variable) we can calculate the value of y for any given value of x.

Several explanatory variables may be involved and in this situation the relationship between the dependent variable and the explanatory variables is not easily depicted in graphical form. However, the objective is the same as was the case in the simple example, namely to produce an equation which best fits the set of data points provided.

The resulting equation has the form:

$$y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 \text{ etc.}$$

Again 'a' is the constant and 'b_1', 'b_2', 'b_3' etc. are the coefficients or weights assigned to the explanatory variables. The best fit is obtained by the method of least squares which is a standard technique for fitting a line to a set of data points.

The goodness of fit or the predictive accuracy of the equation for the given data is measured by the <u>multiple correlation coefficient</u> (R). The square of this value (R^2) indicates the proportion of the variability in the dependent variable that is accounted for by the equation. For example if R has the value 0.7 then R^2 is 0.49, indicating that the explanatory variables account for 49% of the variation in the dependent variable observed in the sample group.

The explanatory power of the coefficients in the equation

The equation is designed to predict the value of the dependent variable taking account of all the factors in the model, and the values of the coefficients are set to serve most effectively that predictive purpose. In theory, the value of the coefficient indicates how much the dependent variable will be changed by a unit change in that predictor variable (other factors remaining constant) but there are some dangers in attempting this explanatory interpretation of coefficients.

If two factors in the model are correlated with each other then their coefficients may be unreliable indicators of their individual contributions to the value of the dependent variable. The equation will take account of their combined effects but it may not partition their effects in an ideal manner between the two factors particularly if an important factor has been left out of the equation. In this case other variables correlated with the missing factor will be given extra weight, so exaggerating their true contribution.

Another point to bear in mind is the statistical reliability of the coefficients. The computer programme (REG) indicates the standard error of the estimate for each coefficient and the ratio of the coefficient to the standard error is called the "t-value". If the t-value exceeds 2 it is accepted that the variable makes some contribution to the prediction (the coefficient is accepted as being non-zero at a 95% confidence level). However, if the t-value only slightly exceeds 2, then the coefficient has a considerable range from near zero to near twice its face value. In other words the actual value of the coefficient is assumed to fall within plus or minus two standard deviations of its face value and again the 95% confidence level applies to this assumption. Given the range where 't' is only a little more than 2, the coefficient has limited explanatory value. If the t-value is less than 2 the coefficient can only be taken at face value at the interpreter's risk.

When the equation of best fit has been produced it is important to examine the discrepancies between the observed and predicted values for individual cases. The predicted value represents an average for individuals with that particular set of characteristics but a certain amount of deviation is likely to occur. Some deviation falls within the range that is acceptable (at various levels of confidence) given the inevitable margin of error in the model. Deviations beyond an acceptable confidence level may occur because one or more important general factors are missing from the equation, or because special factors are acting upon some individuals in the population.

RESULTS

I *The Model*

The data processing was carried out in two stages.

1. Development of the model or equation to describe the relationship between maintenance expenditure per separation and various characteristics of each hospital, including the observed average length of stay (ALS).

2. Use of the equation with expected length of stay (length of stay corrected for the age and sex of the patients) inserted in place of actual ALS, to calculate an expected cost per separation.

The input factors are those outlined earlier and the equation produced is as follows:

Maintenance expenditure (M.E.) per separation (in thousands of

dollars) = 2.413 + .034 (C.F.1.) + .087 (C.F.2.) + .063 (C.F.3.) +

.038 (A.L.S.) + .012 (O.P./SEPS.) + 258 (N.E./SEPS.) -

.386 (NON-T/T) - .428 (SIZE) + .025 (SIZE SQUARED).

The predictor variables in the equation are:

C.F.1. Casemix Factor 1, the expected bed days in group 1 of diagnostic categories divided by total separations (in all groups).

C.F.2. Casemix Factor 2, the expected bed days in group 2 of diagnostic categories divided by total separations.

C.F.3. Casemix Factor 3, the expected bed days in group 3 of diagnostic categories divided by total separations.

A.L.S. Average Length of Stay (daily average of occupied beds x 365 divided by total separations).

O.P./SEPS. Outpatient occasions of service divided by total separations.

N.E./SEPS. Number of nurse educators divided by total separations.

T/NON-T. The teaching/non-teaching dummy variable coded '1' for teaching hospitals and '2' for non-teaching hospitals.

SIZE The natural logarithm of separations.

SIZE SQUARED The square of the natural logarithm of separations.

Table 5 lists the factors in the equation with their coefficients, standard errors, t-values, and a range of values for the coefficients (plus or minus twice their standard errors). All the t-values exceeded 2, indicating that all the coefficients were significantly greater than zero (all made a worthwhile contribution).

The dependent variable, M.E. per separation, was expressed in thousands of dollars so to interpret the impact of the factors in the equation all the coefficients have to be multiplied by one thousand. As was pointed out in the previous section, there are some dangers in attempting to interpret the coefficients for the factors as precise indicators of the average cost of a

Table 5

COEFFICIENTS IN THE EQUATION WITH THEIR STANDARD ERRORS AND RANGES (AT THE 95% CONFIDENCE LEVEL)

FACTOR	VALUE OF COEFFICIENT	STANDARD ERROR	t VALUE (COEFFICIENT / STANDARD ERROR)	RANGE (COEFFICIENT $\mp$ 2x STANDARD ERROR)
R^2	.84			
Standard deviation	.120			
Constant	2.413	.291	8.3	1.831 to 2.994
Casemix 1	.034	.013	2.5	.007 to .069
Casemix 2	.087	.018	4.6	.051 to .123
Casemix 3	.063	.011	5.8	.041 to .085
Length of Stay	.038	.003	14.5	.033 to .043
Outpatient Services	.012	.002	7.4	.009 to .016
Nurse Education	258	032	8.0	193 to 323
Teaching/Nonteaching	-.386	.063	6.1	-.259 to -.513
Size	-.428	.082	5.2	-.264 to - .592
Size Squared	.025	.006	4.5	.014 to .036

unit of that factor. Another point requires explanation: some factors entered the equation divided by separations and others did not. This makes a difference in the interpretation of the coefficients.

Factors entering the model divided by separations are best interpreted in terms of their contribution to the total M.E. of the hospital, rather than the M.E. per separation. This is the case because multiplying the whole equation for M.E. per separation through by "total separations" would give Total M.E. (in thousands of dollars) = 2.413 x separations + .034 x the expected bed days in casemix group 1 + .087 x the expected bed days in casemix group 2 =+.063 x the expected bed days in casemix group 3 + .038 x daily average of occupied beds x 365 + .012 x the number of outpatient occasions of service + 258 x the number of nurse educators - .386 x non-teaching/teaching dummy variable x total separations - .428 x natural logarithm of separations x total separations + .025 x the square of the natural logarithm of separations x total separations.

Thus the coefficients for the various types of bed days, outpatient services and nurse educators represent the extra M.E. (in thousands of dollars) per unit of that factor. This interpretation was checked by a regression run using total M.E. and the same set of factors (with appropriate adjustments) as the explanatory variables. The values for the casemix factors, length of stay, outpatients and nurse educators agreed precisely with those in Table 6 but some deviation occurred for the teaching and size factors due to the high correlation between these three factors and daily average in the recast equation.

Thus it appeared that the quantum of nurse education represented by one nurse educator adds a sum of $258,000 to total M.E. (or a sum between $193,000 and $323,000 as indicated in Table 5). Likewise an outpatient occasion of service appeared to cost on average between $9 and $16 (Table 5).

The various categories of bed days posed peculiar problems of interpretation. As explained in Appendix A, the coefficient of A.L.S. was the average cost of the extra bed days when the number of actual bed days consumed (A.L.S. x 365) exceeded the expected bed days (the sum of the expected days in the three casemix groups). These bed days may be regarded as superfluous because they occurred in stays exceeding the notional average stay and their cost should approach the basic or hotel cost. To avoid the judgemental tone implied in the term "superfluous days" the coefficient for A.L.S. is designated as the "basic cost" of a day. The coefficients assigned to the three casemix factors were the average values for the extra expenditure incurred, beyond the basic cost, for a bed day in each casemix category.

Thus the estimated expenditure incurred by an extra day in each group may be obtained from the coefficient for that factor plus the coefficient for A.L.S. (the basic cost) as shown in Table 6.

Factors entering the model without being divided by separations (size and the teaching/non-teaching factor) were interpreted to show their effect on the cost per separation. Their contribution to total M.E. for a particular hospital would be given by the coefficient multiplied by the number of separations from that hospital.

The teaching/non-teaching factor was a dummy variable. The use of dummy variables enables the inclusion of factors which cannot be given a quantitative value. The dummy values for teaching/non-teaching were 1 and 2, so for teaching hospitals the contribution of the dummy was (1 x -$386 = -$386) per separation. For non-teaching hospitals the contribution of the dummy value was (2 x -$386 = -$772). Thus the average added cost per separation in a teaching hospital was $386 over and above the contribution of other factors in the model. The effect of this dummy variable is best explained by adjusting the constant in the equation. For

for a teaching hospital the constant is adjusted by minus .386 so the overall effect is to predict that the cost per separation in a teaching hospital was $386 over and above the contributions made by the other factors in the equation.

Table 6: Intepretation of the Length of Stay and Casemix Coefficients

	Coefficient (from Table 5)	Dollar value (from Table 5)
Length of stay factor (a basic bed day)	.038	$33 to $43
Casemix Factor 1 (the extra cost of a bed day in Casemix category 1)	.034	$7 to $69
Total cost of a bed day in Casemix category 1)		$40 to $112
Casemix Factor 2 (the extra cost of a bed day in Casemix category 2)	.087	$51 to $123
Total cost of a bed day in Casemix category 2		$84 to $166
Casemix Factor 3 (the extra cost of a bed day in Casemix category 3)	.063	$41 to $85
Total cost of a bed day in Casemix category 3		$74 to $128

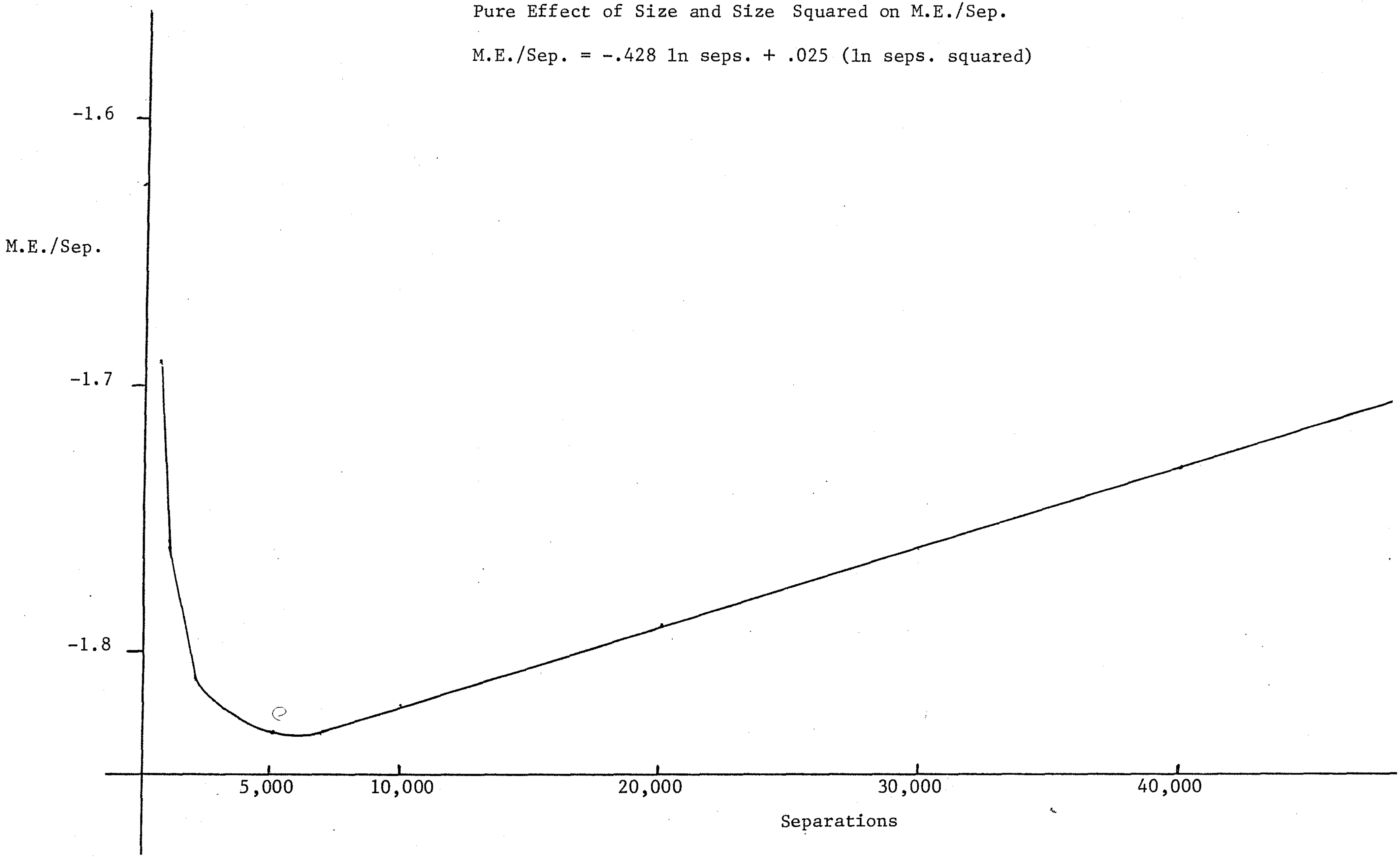
The effect of size is shown in Figure 1. The graph shows the pure effect of size on the M.E. per separation, that is, the effect of size as shown by the size and size squared coefficients after the other factors had all been taken into account. The important feature is the form of the graph in relation to the size factor, measured on the bottom axis (to obtain a predicted M.E. per separation for a particular hospital all the factors in the equation must be taken into account). The effect of size is probably best explained by adjusting the constant as was suggested above for the teaching factor. Therefore the constant would be adjusted by the quantity shown on the vertical axis for each size of hospital on the horizontal axis. As the values are all negative the end result is to reduce the magnitude of the constant by some figure ranging from 1.7 to 1.85 depending on the size of the hospital.

Between 500 separations and 5,000 separations the M.E. per separation may be expected to fall by $140. Size has no effect between 5,000 separations and 7,000 separations and then the graph rises steadily by about $30 for each increase of 10,000 separations. It appears that the optimum hospital size corresponded to 5,000 to 7,000 separations (approximately 140 to 190 beds, allowing an average stay of 8 days, and 80% occupancy). Such a conclusion may be an over-interpretation of the data, given the factors that were not taken into account in the equation such as the provision of special services and the method of remuneration of visiting medical officers.

FIGURE 1

Pure Effect of Size and Size Squared on M.E./Sep.

M.E./Sep. = -.428 ln seps. + .025 (ln seps. squared)



RESULTS

II *The Use of the Model*

The first stage of work produced an equation predicting M.E. per separation using actual A.L.S. and other factors. As the equation stood, predicted M.E. per separation depended very much upon the average length of stay. A hospital with a large A.L.S. had a larger predicted M.E. per separation than a hospital with a smaller A.L.S., other factors being equal. Length of stay is a factor that is amenable to manipulation by hospital administration and if the budget allocation for maintenance funds were based on the equation there would be considerable incentive to increase A.L.S. and so increase the predicted M.E. per separation. This would mean rewarding hospitals for a practice that is usually regarded as undesirable.

The objective in stage two was to remove the inflationary effect of a long average length of stay. This was done by replacing A.L.S. with expected length of stay from the Relative Stay Index. The expected length of stay for a hospital is based on statewide figures and adjusts for the age, sex and diagnostic mix of patients in that hospital.

The stage two calculation must be carefully distinguished from the stage one computation which generated the equation, and a set of predicted M.E. per separation. In stage two the coefficients assigned to the various factors in stage one were used to produce another set of predicted M.E. per separation. The relationship between the two stages is outlined in Table 7.

Table 7: Relationship between stage one and stage two of the computer analysis

STAGE 1	
Inputs:	The values of the dependent variable and the explanatory variables for each hospital.
Processing:	The method of least squares regression.
Products:	1. The equation, with coefficients assigned to each factor.
	2. A set of predicted values of the dependent variable, calculated using the equation.
STAGE 2	
Inputs:	1. The values of the explanatory variables for each hospital, with expected length of stay in place of actual length of stay.
	2. The coefficient or weight assigned to each factor by the equation produced in stage one.
Processing:	Calculation of the dependent variable (M.E. per separation) for each hospital using inputs 1 and 2.
Products:	A second set of predicted values for M.E. per separation with a penalty imposed where the actual length of stay exceeded the expected length of stay.

For each hospital the stage two calculation differed from the stage one prediction by {(expected L.S. minus A.L.S.) x $38} where $38 was derived from the coefficient for length of stay. Thus the calculated M.E. per separation was reduced by $38 for each extra day according to R.S.I. figures.

Table 8 shows the distribution of hospitals according to their deviation from the predicted M.E. per separation at stage two. The table shows that 58% of the total group fell within one standard deviation ($120) of the predicted value. At the "more than predicted" end of the range 27% of hospitals deviated by at least $120 and 12% deviated by at least two standard deviations ($240).

Table 8: The Distribution of Residual Values in the Stage Two Prediction

Size of Residual	Number of Hospitals		
At least $360 more than expected	17)		
$300 to $359	4)	27	(12%)
$240 to $299	6)		
$180 to $239	15)	32	(15%)
$120 to $179	17)		
$60 to $119	29)		
$0 to $59	28)	125	(58%)
$0 to $59 less than expected	42)		
$60 to $119	26)		
$120 to $179	21)	26	(12%)
$180 to $239	5)		
$240 to $299	3)	6	(3%)
At least $300 less than expected	3)		
TOTAL	216		(100%)

Tables 9 to 12 list hospitals whose stage two predictions deviated by at least one standard deviation from their actual M.E. per separation. A deviation at this level is significant at the 85% confidence level and deviation beyond two standard deviations is significant at the 95% confidence level. These tables are in two sections, with a summary containing the more important figures in part (a) and extra information in the main part of the table. Part (a) lists the residual values at stage one and stage two, and the adjustments made for the difference between the actual and expected lengths of stay. The second part lists, in addition to the items in part (a), the actual M.E. per separation, the predicted M.E. per separation at stage one and stage two, the actual average length of stay (A.L.S.), the expected length of stay from the Relative Stay Index, the size of the hospital (the number of beds), the average occupancy for the year, and two factors which could contribute to increased M.E. per separation but were not included in the final equation. The figure for special services was the number of facilities from a list of 14 high cost units (burns unit, orthopaedic unit, rehabilitation unit, for example) and the figure for R.M.O.'s etc. was the number of resident medical officers, registrars and interns working in the hospital.

In the tables the "residual" value is the difference between the actual and thepredicted M.E. per separation. Wherever A.L.S. was not identical to the expected length of stay, the residual in stage one differed from the residual in stage two. The column headed "A.L.S. minus expected L.S.

Table 9: Hospitals with their actual M.E. per separation at least $240 more than the stage two prediction.

Name	Actual ME/SEP	Stage One Prediction/ Residual	Stage Two Prediction/ Residual	A.L.S.	Expected L.S. (R.S.I.)	ALS-Expected L.S. x 38	Beds	Occ. %	Special Services	R.M.O.'s Etc.
Lockhart & District	1,260	1,080/180	840/420	16.1	9.7	240*	21	48	-	-
Adelong	1,440	1,490/-50	850/590	26.2	9.5	640*	17	69	-	-
Gundagai Dist.	940	720/220	640/300	10.3	8.3	80	42	41	-	-
McCaughey Mem.	1,230	1,040/190	680/550	16.4	6.9	360*	24	56	-	-
Wilson Mem.	1,110	980/140	710/400	15.4	8.2	270*	36	55	-	-
R. Newcastle (Rankin Pk.)	1,600	1,190/420†	990/610	18.6	13.2	210	110	56	-	-
Marrickville Dist.	1,540	1,160/380†	1,140/400	10.1	9.5	20	105	61	1	9
Rachel Forster	1,000	670/330†	750/250	6.3	8.4	-80	128	76	2	13
Royal South Sydney	1,390	1,050/340†	1,040/350	10.6	10.3	10	107	84	5	11
Coonabarabran (Binn)	1,660	1,620/40	980/680	25.1	8.3	640*	10	51	-	-
Dunedoo War Mem.	1,610	1,340/270†	880/730	20.2	8.0	460*	15	55	-	-
Coonabarabran (Bar. Sub)	1,270	1,580/-310	930/340	25.8	8.7	650*	15	67	-	-
Collarenebri	920	660/260†	580/340	9.3	7.3	80	33	47	-	-
Broken Hill	1,530	1,480/50	1,290/240	13.7	8.6	190	329	57	4	14
Boggabri	1,320	1,050/260†	820/500	15.3	9.2	230	30	42	-	-
Vegetable Creek	1,470	1,490/-30	780/690	28.9	10.2	710*	27	70	-	-
Manilla	1,100	850/250†	680/420	11.4	6.9	170	35	44	-	-
Bingara	1,440	1,440/0	790/650	27.1	10.0	650*	37	61	-	-
Walcha	1,020	1,020/0	760/260	15.5	8.7	260*	50	53	-	-
Braidwood	1,710	1,780/-70	1,130/580	26.9	9.8	650*	22	63	-	-
Boorowa	1,430	1,430/0	930/500	24.6	11.4	500*	27	60	-	-
Bangalow	1,310	1,360/-50	830/480	24.2	10.3	530*	19	82	-	-
St. Vincents (Lismore)	830	750/70	560/270	13.6	8.6	190	166	85	1	-
Yeoval	970	950/20	720/250	13.8	7.8	230	12	62	-	-
Ungarie	1,190	1,000/200	750/440	14.7	8.1	250	20	54	-	-
Parkes Peak Hill Sub.	1,480	1,230/250†	770/710	20.6	8.6	460*	28	46	-	-
St. Vincents (Bathurst)	1,050	880/170	750/300	12.7	9.2	130	66	68	-	-

† The stage one prediction is at least $240 less than the actual ME/Sep.
* This factor (the penalty for having A.L.S. greater than expected) is sufficient to account for at least $240 of the deviation from the predicted ME/Sep.

with their actual M.E. per separation at least $240 more than the stage two prediction.

Table 9(a) Summary of Table 9 Hospitals

Name	Stage One Residual	Stage Two Residual	Length of Stay Correction (A.L.S. - Expected L.S. x 38)
Lockhart & District	180	420	240*
Adelong	-50	590	640*
Gundagai District	220	300	80
McCaughey Mem.	190	550	360*
Wilson Mem.	140	400	270*
R. Newcastle (Rankin Pk.)	420†	610	210
Marrickville Dist.	380†	400	20
Rachel Forster	330†	250	-80
Royal South Sydney	340†	350	10
Coonabarabran (Binn)	40	680	640*
Dunedoo War Mem.	270†	730	460*
Coonabarabran (Bar. Sub)	-310	340	650*
Collarenebri	260†	340	80
Broken Hill	50	240	190
Boggabri	260†	500	230
Vegetable Creek	-30	690	710*
Manilla	250†	420	170
Bingara	0	650	650*
Walcha	0	260	260*
Braidwood	-70	580	650*
Boorowa	0	500	500*
Bangalow	-50	480	530*
St. Vincents (Lismore)	70	270	190
Yeoval	20	250	230
Ungarie	200	440	250
Parkes-Peakhill Subs.	250†	710	460*
St. Vincents (Bathurst)	170	300	130

† Stage one residual at least $240.
* This correction accounts for at least $240 of the stage two residual.

Table 10 (a) : Summary of the main features of Table 10 : Hospitals with their actual ME/Sep. between $120 and $240 greater than the stage two prediction.

Name	Stage One Residual	Stage Two Residual	Length of Stay Correction (A.L.S. - Expected L.S. x 38)
Hillston	150†	240	80
Mercy (Cootamundra)	10	140	130*
Berrigan War Memorial	30	180	140*
Henty	50	220	160*
Balranald	170†	220	50
Corowa	40	180	140*
Deniliquin	120	190	70
Merriwa	0	160	160*
Wallsend	120†	120	10
Royal North Shore	170†	210	40
Balmain	170†	190	20
Women's (Crown St.)	180†	160	-20
Royal Alexandra	120†	190	70
St. Joseph's (Auburn)	230†	240	10
Gulgong	0	200	200*
Cobar	60	130	80
Nyngan	-90	180	270*
Warren	40	180	130*
Bourke	20	130	110
Wilcannia	110	150	30
Gunnedah	80	140	60
Delegate	80	200	120*
Bombala	50	210	160*
St. John of God (Goulburn)	10	140	130*
Mercy (Young)	90	150	60
Campbell (Coraki)	80	230	160*
Bellinger River	10	150	140*
Tullamore	250†	270	30
Carcoar	190†	220	20
Oberon	0	170	160*
Blayney	120†	170	40

† Stage one residual at least $120.

* This correction accounts for at least $120 of the stage two residual.

Table 10: Hospitals with their actual ME/Sep. between $120 and $240 greater than the stage two prediction.

Name	Actual ME/SEP	Stage One Prediction/ Residual	Stage Two Prediction/ Residual	A.L.S.	Expected L.S. (R.S.I.)	ALS-Expected L.S. x 38	Beds	Occ.	Special Services	R.M.O.'s etc.
Hillston	810	650/150†	570/240	9.6	7.5	80	34	40	-	-
Mercy(Cootamundra)	820	810/10	680/140	11.4	8.0	130*	63	68	1	-
Berrigan War Memorial	880	840/30	700/180	11.1	7.4	140*	13	62	-	-
Henty	1,060	1,000/50	840/220	13.9	9.8	160*	18	50	-	-
Balranald	1,020	850/170†	800/220	10.9	9.5	50	21	50	-	-
Corowa	740	700/40	560/180	11.4	7.7	140*	89	64	-	-
Deniliquin	950	830/120†	760/190	9.3	7.4	70	95	61	1	-
Merriwa	780	780/0	620/160	11.4	7.3	160*	37	48	-	-
Wallsend	1,050	940/120†	930/120	8.4	8.1	10	134	72	4	6
Royal North Shore	1,830	1,660/170†	1,620/210	10.3	9.2	40	834	75	12	159
Balmain	1,220	1,050/170†	1,030/190	10.1	9.5	20	236	64	1	15
Women's (Crown St.)	970	790/180†	810/160	6.0	6.5	-20	272	58	2	17
Royal Alexandra	1,400	1,280/120†	1,210/190	7.5	5.8	70	580	51	9	73
St. Joseph's (Auburn)	830	600/230†	590/240	7.7	7.5	10	105	81	1	6
Gulgong	630	630/0	430/200	11.9	6.7	200*	45	65	-	-
Cobar	730	680/60	600/130	9.4	7.4	80	45	55	-	-
Nyngan	830	920/-90	650/180	15.7	8.5	270*	42	70	-	-
Warren	750	700/40	570/180	10.6	7.2	130*	38	65	-	-
Bourke	620	600/20	490/130	9.5	6.5	110	82	64	-	-
Wilcannia	800	680/110	650/150	7.2	6.3	30	32	41	-	-
Gunnedah	720	640/80	580/140	9.0	7.4	60	80	74	-	-
Delegate	930	850/80	730/200	10.3	7.2	120*	7	79	-	-
Bombala	930	880/50	720/210	13.1	8.9	160*	37	52	-	-
St. John of God (Goulburn)	680	670/10	540/140	11.0	7.5	130*	70	61	1	-
Mercy (Young)	730	640/90	580/150	9.8	8.3	60	72	71	-	-
Campbell (Coraki)	850	780/80	620/230	12.9	8.7	160*	47	54	-	-
Bellinger River	670	660/10	520/150	10.8	7.0	140*	64	73	-	-
Tullamore	1,140	900/250†	870/270	7.4	8.1	30	7	53	-	-
Carcoar	840	640/190†	620/220	8.5	8.0	20	23	38	-	-
Oberon	840	830/0	670/170	11.8	7.7	160*	33	52	-	-
Blayney	860	730/120†	690/170	9.1	8.1	40	38	55	-	-

† The stage one prediction is at least $120 less than the actual ME/Sep.
* This factor alone is sufficient to account for $120 of the deviation from the prediction.

Table 11 (a) : Summary of the main features of Table 11 : Hospitals whose ME/Sep. is $120 to $239 less than the stage two prediction.

Name	Stage One Residual	Stage Two Residual	Length of Stay Correction (A.L.S. - Expected L.S. x 38)
Cootamundra	-150†	-130	20
Wagga Wagga Base	-160†	-130	30
Holbrook District	-150†	-110	40
Barham & Koondrook	-120†	-120	0
Gloucester Sold. Mem.	-280†	-180	110
Gosford-Woy Woy Sub.	30	-130	-160*
Gosford	-90	-220	-130*
Hornsby	-100	-140	-40
Sydney	-60	-120	-60
St. Vincents Darlinghurst	-90	-110	-20
Prince of Wales Special Unit	60	120	-170*
Calvary (Kogarah)	-250	-230	10
Auburn Dist.	-110	-110	0
Blacktown	-160†	-220	-50
Dubbo Base	-100	-100	0
Pambula	-20	-120	-100
Batemans Bay	20	-140	-160*
Murrumburrah-Harden	-50	-110	-60
Young District	-220†	-140	80
Bowral & District	-120†	-120	-20
Byron District	-40	-120	-80
Dorrigo	-110	-110	0
Wauchope	-130†	-200	-80
Ballina	-90	-140	-60
Tweed Heads	-90	-220	-130*
Hastings (Pt. Macquarie)	-110	-190	-80
Lismore Base	-80	-110	-30

† Stage one residual at least - $120.

* This correction accounts for at least $120 of the stage two residual.

Table 11: Hospitals whose ME/SEP is $120 to $239 less than the stage two prediction.

ıe	Actual ME/SEP	Stage One Prediction/ Residual	Stage Two Prediction/ Residual	A.L.S.	Expected L.S. (R.S.I.)	ALS-Expected L.S. x 38	Beds	Occ. %	Special Services	R.M.O.'s etc.
otamundra	810	960/-150†	940/-130	8.5	8.0	20	65	56	1	-
gga Wagga Base	870	1,030/-160†	1,000/-130	9.4	8.5	30	222	77	6	12
lbrook District	470	620/-150†	580/-110	8.2	7.2	40	20	65	-	-
rham & Koondrook	530	650/-120†	650/-120	7.8	7.8	0	24	65	-	-
oucestor Sold. Mem.	540	830/-280†	720/-180	11.1	8.1	110	51	91	-	-
sford-Woy Woy Sub.	920	890/30	1,050/-130	10.7	14.8	-160*	63	69	-	-
sford	660	750/-90	880/-220	3.9	7.3	-130*	198	79	5	26
rnsby	840	940/-100	980/-140	7.5	8.5	-40	416	82	6	35
dney	1,180	1,240/-60	1,300/-120	6.3	7.9	-60	462	78	9	79
. Vincents Darlinghurst	1,320	1,410/-90	1,430/-110	8.7	9.1	-20	570	89	11	88
ince of Wales Special Unit	920	870/60	1,040/-120	6.2	10.6	-170*	26	73	-	-
lvary (Kogarah)	1,460	1,700/-250	1,690(-230)	10.6	10.3	10	101	84	5	11
burn Dist.	770	880/-110	880/-110	7.6	7.7	0	307	80	4	24
acktown	740	910/-160†	960/-220	6.0	7.3	-50	350	66	4	33
bbo Base	670	770/-100	770/-100	7.3	7.4	0	183	77	6	5
mbula	500	520/-20	620/-120	5.9	8.7	-100	31	41	-	-
temans Bay	430	410/20	570/-140	4.0	8.2	-160*	21	75	-	-
rrumburrah-Harden	510	560/-50	620/-110	6.9	8.5	-60	36	51	-	-
ung District	860	1,080/-220†	1,000/-140	9.6	7.4	80	68	64	2	-
wral & District	720	840/-120†	860/-120	7.4	8.0	-20	120	54	2	1
ron District	380	420/-40	500/-120	4.7	6.8	-80	31	61	-	-
rrigo	430	540/-110	540/-110	7.3	7.4	0	25	91	-	-
uchope	480	600/-130†	680/-200	5.7	7.8	-80	32	69	-	-
llina	540	620/-90	680/-140	7.6	9.1	-60	53	79	-	-
eed Heads	470	560/-90	690/-220	4.6	8.1	-130*	57	89	-	-
stings (Pt. Macquarie)	470	580/-110	660/-190	6.0	8.1	-80	104	79	1	-
smore Base	670	750/-80	780/-110	7.5	8.2	-30	250	78	2	5

This factor above is sufficient to account for $120 of the deviation from the prediction.

The stage one prediction is at least $120 more than the actual ME/Sep.

Table 12 (a) : Summary of the main features of Table 12 : Hospitals whose ME/Sep. is at least $240 less than the stage two prediction.

Name	Stage Stage One Residual	Stage Two Residual	Length of Stay Correction (A.L.S. - Expected L.S. x 38)
Maitland Clevedon Sub.	-350†	-230	110
Royal Newcastle	-320†	-310	20
Gosford - The Entrance	-70	-280	-210
Gosford - Wyoming	-220	-370	-150
Karitane - Woollahra	-200	-450	-250*
Trangie	-90	-250	-160

† Stage one residual at least - $240.

* This correction accounts for at least $240 of the stage two residual.

Table 12: Hospitals whose ME/SEP is at least $240 less than the stage two prediction

Name	Actual ME/SEP	Stage One Prediction/ Residual	Stage Two Prediction/ Residual	A.L.S.	Expected L.S. (R.S.I.)	ALS-Expected L.S. x 38	Beds	Occ. %	Special Services	R.M.O.'s etc.
Maitland Clevdon Sub.	670	1,010/-350†	900/-230	12.5	9.6	110	8	54	-	-
Royal Newcastle	1,340	1,670/-320†	1,650/-310	9.4	9.0	20	616	83	7	71
Gosford-The Entrance	480	550/-70	760/-280	5.5	11.0	-210	37	59	-	-
Gosford-Wyoming	390	610/-220	760/-370	5.8	9.8	-150	54	74	-	-
Karitane-Woollahra	330	530/-200	780/-450	2.6	9.2	-250*	31	45	-	-
Trangie	390	480/-90	640/-250	4.5	8.7	-160	15	40	-	-

† The stage one prediction is at least $240 more than the actual ME/Sep.

* This factor alone accounts for over $240 of the deviation from the predicted ME/Sep.

Table 9 lists hospitals with M.E. per separation at least $240 (two standard errors) more than predicted in stage two. Twenty-seven hospitals fell into this category. They tended to be small, (6 have less than 20 beds and 18 have less than 40), with low occupancy (6 less than 50% and 15 less than 60%). Only 6 had any special services, resident medical officers or interns.

At the start it is advisable to bear in mind that if the actual length of stay was six and a half days or more in excess of that expected, then this by itself generated a residual of $240, apart from the influence of any other factors. Fourteen of the 27 hospitals had their A.L.S. exceeding their expected L.S. by 6.5 days or more. Some of the A.L.S.'s approach 30 days beyond which hospitals were excluded on the grounds that they were *de facto* long stay institutions. This was an arbitrary cut-off point and it appeared that some hospitals with A.L.S. less than 30 days had some proportion of their capacity used in effect as nursing home accommodation.

The 32 hospitals in Table 10 with predicted M.E. per separation between $120 and $239 less than actual, ranged from a teaching hospital of 834 beds to two hospitals with 7 beds. Most of the hospitals in this group did not have resident medical officers, interns or special services. Fourteen of them had an A.L.S. more than 3.2 days in excess of expected L.S. which was sufficient to account for a discrepancy of $120 between actual and predicted M.E. per separation.

Towards the other (desirable) end of the distribution, Table 11 lists 26 hospitals whose actual M.E. per separation was between $120 and $239 less than the stage two prediction. As was the case in Table 10 a wide range of hospitals appeared in this list although neither of the extremes of size were represented (below 20 beds or above 600). Fifteen of the 26 hospitals had above 70% occupancy, compared with 3 out of 27 in Table 9, and 9 out of 32 in Table 10.

Table 12 lists 6 hospitals whose actual M.E. per separation is at least $240 less than the stage two predictions.

DISCUSSION

The Model

The equation explained 84% of the variation in M.E. per separation for the 216 hospitals in the model. It may be argued that a single factor such as length of stay had such a high correlation with M.E. per separation that the other factors were superfluous but in fact the t-values in Table 5 suggest that all the factors in the final equation made a valuable contribution. A correlation matrix for all factors in the equation is included as Appendix B.

Another possible criticism is the large size of the constant term in comparison with the coefficients of the explanatory factors in the equation. However, as was pointed out in the explanation of the teaching dummy variable and the size factors, the constant must in effect be adjusted by -.386 for teaching hospitals, by -.772 for non-teaching hospitals and by a further quantity between -1.7 and -1.85 depending on the size (see Figure 1).

The casemix and length of stay factors posed problems of interpretation even when the equation was re-written to predict total M.E. with the casemix coefficients expressed as costs per bed day. The mathematics are explained in Appendix A but in simple terms the length of stay (actual bed days consumed) term represents the average cost of bed days used in excess of the total expected (the sum of the expected days in each of the three casemix categories). The cost of these extra days presumably approached the basic hotel cost or the minimum cost of a bed day.

The other casemix coefficients represented the extra M.E. incurred, on average, by a day in each category of cases, over and above the basic cost. Thus the total cost per bed day in each category was the sum of the coefficient for that category plus the "basic day" coefficient (see Table 6).

It appears that the M.E. for a "basic day" was $38; for an average day in Category 1 was $72; for an average day in Category 2 was $125; and for an average day in Category 3 was $101. To explain the relative magnitudes of these figures, first consider the general relationship between cost per day and length of stay in hospital (Figure 2a). According to this simplified scheme the cost per day is initially high due to the expense of admission procedures and the tests, operations and procedures which tend to occur during the early part of the stay. The cost per day then falls away as the intensity of care declines until the daily cost approaches the basic or hotel cost. The diagnosic categories in the three casemix groups may be expected to manifest variations of the general scheme. Cases in Category 1 should have a relatively stable and not particularly high cost per day as in Figure 2b although lengths of stay are highly variable (Table 4). Cases in Category 2 have short stays with an operation or procedure giving a high initial cost per day and a relatively high average cost per day over the short stay (Figure 2c). Cases in Category 3 have an early peak similar to Category 2 but the stay is prolonged and the intensity of care remains moderately high so the cost per day does not decline at the same rate as Category 2 (Figure 2d). Consequently the average cost per day for Category 3 is intermediate between the other two categories.

The proxy variable for nurse education was the number of nurse educators on the hospital establishment, and the M.E. per nurse educator was in the vicinity of $250,000. This appears to be somewhat high and it may be compared with the results of a study by the Nurses Education Board which concluded that the cost of nurse education in a sample of five hospitals ranged from $3,000 to $4,000 per year per student in 1976.* Given the

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* S. Quine, <u>The Cost of Hospital Based Nurse Training</u>,

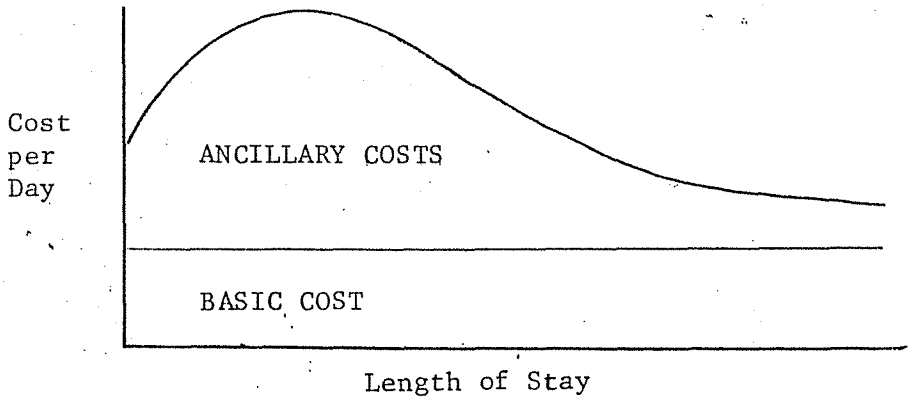


FIGURE 2b : Casemix category 1

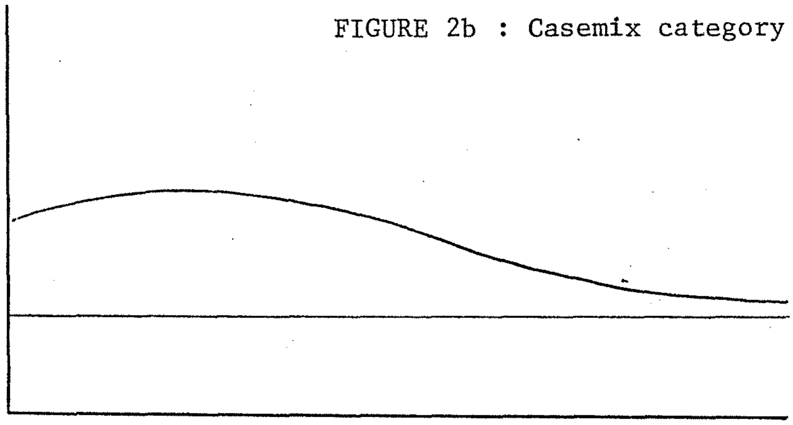


FIGURE 2c : Casemix category 2

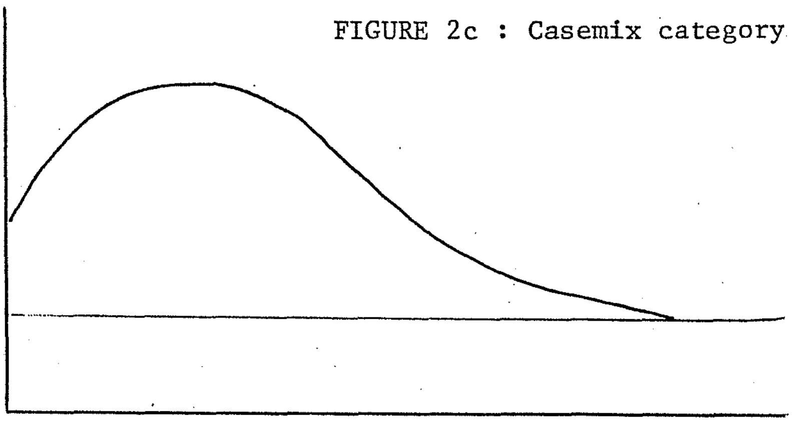
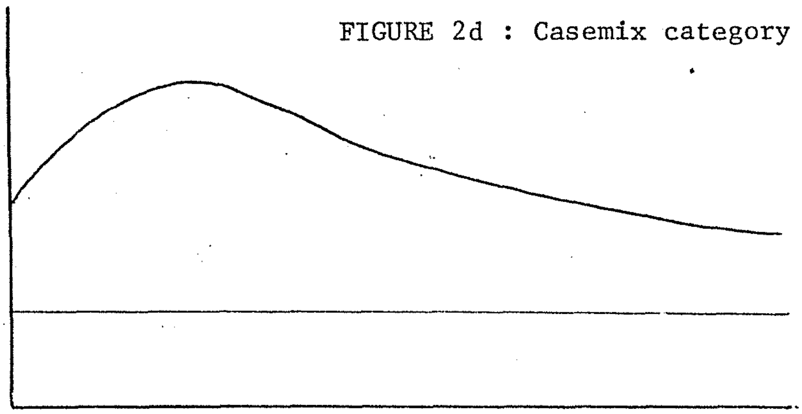


FIGURE 2d : Casemix category 3



ratio of nurse educators to students of 1 : 25 then the annual cost per nurse educator was in the range of $75,000 to $100,000. Allowing a higher ratio of educators to students gives a higher figure.

The figure of $12 per outpatient occasion of service is reasonable in view of Abelson's estimates ranging from $5 to $12 per outpatient service at six hospitals in 1973-74.*

The extra M.E. allowed for teaching hospitals, $386 per separation, appears to be very high particularly in view of the fact that the average length of stay in teaching hospitals is relatively low (less than 10 days in all cases), and allowance is made within the equation for cases in Category 3 with longer than average lengths of stay and high dependency.

The effect of size expressed in Figure 1 suggests an optimum size in the range of 150 to 200 beds. This is a smaller figure than that suggested in other studies** and it may reflect the failure of the model to take account of quality of care and provision of special services. The shape of the curve in Figure 1 may also reflect the failure of small hospitals to operate at the optimal point of their short-run cost curve through low occupancy so that their M.E. per separation was forced upwards.

Stage Two Predictions

At the stage two prediction 27 hospitals revealed actual M.E. per separation at least $240 (two standard errors) greater than the predicted value, and 32 hospitals deviated between $120 and $239 (at least one standard error) beyond the predicted value. In fairness to those hospitals one must look for factors which may justify increased M.E. per separation in some places caused by factors left out of the equation. One such factor is a large A.L.S. (exceeding expected L.S.) with a legitimate reason. The hospital may have some long-stay cases using the hospital because no nursing home facilities exist nearby, for instance.

This explanation is not satisfactory if the stage one prediction (allowing the whole A.L.S.) deviates substantially from the actual, as is the case for 10 hospitals in Table 9 and 11 hospitals in Table 10. However, the other hospitals in those tables may attribute all, or a substantial part of their deviation to the length of stay factor and they may claim that the expected L.S. derived from the R.S.I. tables does not do justice to their function.

In some hospitals low occupancy may contribute to the high actual M.E. per separation although low occupancy alone should not matter if the staff establishment was adjusted accordingly. Small hospitals with low average occupancy may need to cope with wide fluctuations in the rate of admissions, but some review may be required to determine the optimum staff establishment.

Tables 11 and 12 list hospitals which had their actual M.E. per separation at least $120 less than that predicted at stage two. In some instances this discrepancy was associated with a very low A.L.S. and the factors causing the small average length of stay in these places should be identified if possible. Transfers from one hospital to another may be recorded as two short stays, thus lowering the A.L.S. at both hospitals. One hospital in Table 12 was coded as a teaching hospital and so received an "allowance" of $386 per separation for that factor but in fact it was probably not serving a full teaching function during 1976-77.

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* P. Abelson, "Use of cost allocation statements in Hospitals". Hospital and Health Care, June 1976.

** J.L. Migue and G. Belanger, The Price of Health. Macmillan, Toronto, 1974.

It may be protested on behalf of hospitals at the "wrong" end of the scale of stage two predictions that factors such as quality of care should be taken into account for fair comparisons. In this event it would be reasonable to suggest that the disadvantaged hospitals could propose objective measures of quality of care to demonstrate their own superiority in this respect. These measures could also be used as inputs for a refined version of the regression model.

For many hospitals the decisive factor at stage two was the normative length of stay taken from the Relative Stay Index. It may be argued that normative values should be calculated for other factors in the model, if the method of inserting normative figures is valid at all. In fact this could mean examining the quantity of nurse education being provided, and the casemix. In each case the hospital role would need to be defined, in the first instance in relation to the regional requirements for nurse education and in the second instance in relation to the issues addressed in the discussion paper "Towards the Delineation of Hospital Roles".* If these issues are followed through then further development of the casemix factors would be required.

Conclusions: The Usefulness of the Method

The regression equation was used to identify several hospitals whose expenditure was considerably out of line with that predicted and it is easy to envisage how the method could be used with more recent data to locate hospitals whose budgets could be reviewed. However, before this approach is pursued two questions must be considered. The first concerns the validity or reliability of the results. Were enough factors taken into account in the equation and were the measures of those factors adequate? The second question is: could the same hospitals have been isolated by simpler means? In other words, did the machinery of regression analysis add anything to an understanding which could not have been obtained by some other method of review of hospital performance?

In answer to the first question, there are various ways in which the equation could be improved but in the short term the limitations in the quantity and quality of data would probably not allow great gains in predictive or explanatory power. Consequently, further refinement of the equation is not warranted at this stage.

This brings us to the second question, whether the equation in its imperfect form provided worthwhile information about hospital performance which could not be obtained by simpler means. The answer to this question lies in the characteristics of the hospitals which deviated substantially from their predicted expenditure. Most of these had actual lengths of stay which were very different from their expected lengths of stay in the Relative Stay Index and consequently these hospitals could have been picked out using the Relative Stay Index alone. In so far as hospitals were penalised for long stays exceeding the expected figure, the method of approach determined the results to an undesirable extent.

Apart from the length of stay factor the most common characteristic of the outlying hospitals was low occupancy and it seems likely that several hospitals were over-staffed in relation to their workload. These hospitals could probably be located by scrutinising the occupancy rates recorded in the financial returns followed by review of the staff establishment in hospitals with low occupancy.

A problem arises when neither the length of stay nor the occupancy rate accounted for the performance of outlying hospitals. Where in the structure of the hospital were the sources or causes of the deviant

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* D. Williams, & C. Weaver, Bureau of Personal Health Services, 1977.

performance? In what departments could economies be effected? This question brings us to consider a very different method of approach to hospital budgeting and financial management, namely the output-oriented management system with departmental costing. This approach has the advantage of going to the heart of theproblem by locating specific areas for attention. It was explained briefly by Martins* and is being used in some Sydney hospitals, at the present time.

* J.M. Martins, "An output oriented management system for hospitals". Address to the School of Health Administration's Summer School on 'Cost Containment and Quality Control', Sydney, February 19-24, 1978.

APPENDIX A

The casemix and length of stay coefficients.

Four variables in the model reflect casemix. CASEMIX FACTOR 1, is the ratio of expected bed days in diagnostic categories of type 1, see Table 4, (E.B.D.1) to the number of separations from the hospital. CASEMIX FACTOR 2 is the ratio of epxected bed days in diagnostic categories of type 2, (E.B.D.2) to the number of separations. CASEMIX FACTOR 3 is similarly defined using the diagnostic categories of type 3 to calculate E.B.D.3. A.L.S. is the ratio of the total number of bed days actually used to the number of separations.

E.B.D.1, 2 and 3 are based on notional (estimated State average) lengths of stay as explained in the section on factors in the model. These notional lengths of stay are listed in Table 4.

If in place of the notional length of stay we used actual lengths of stay for each diagnostic category in each hospital then the casemix factors would add up to the A.L.S. for each hospital. In this situation A.L.S. provides no additional information beyond that contained in the three casemix factors. As it is, A.L.S. does contain extra information, namely the discrepancy between the sum of the expected bed days (E.B.D.1 + E.B.D.2 + E.B.D.3) and the actual bed days used in all categories.

DISCREPANCY = A.L.S. - (E.B.D.1 + E.B.D.2 + E.B.D.3).

This DISCREPANCY FACTOR might even be included in the model, with the predictors E.B.D.1, E.B.D.2 and E.B.D.3 giving an equation of the form;

predicted M.E./Sep. = $\beta_0 + (\hat{\beta}_1 + \hat{\beta}_4)$ EBD1 + $(\hat{\beta}_2 + \hat{\beta}_4)$ EBD2 + $(\hat{\beta}_3 + \hat{\beta}_4)$ EBD3 + $\hat{\beta}_4$ DISCREPANCY + all the other factors. Substituting ALS and the bed day factors in this equation gives:

predicted M.E./Sep. = $\hat{\beta}_0 + \hat{\beta}_1$ EBD1 + $\hat{\beta}_2$ EBD2 + $\hat{\beta}_3$ EBD3 + $\hat{\beta}_4$ ALS + all the other factors. If we were to predict the M.E./Sep. for the same hospital in the absence of a discrepancy between actual and expected bed days the DISCREPANCY term would be left out ($\hat{\beta}_4$ would be zero). However, in the actual equation produced at stage one of the data processing $\hat{\beta}_4$, the coefficient for ALS does have a positive value indicating that the discrepancy factor has a cost (or at least a contribution to M.E.).

This coefficient is interpreted as it occurs in the rewritten form of the equation above (where it is attached to the DISCREPANCY term), to indicate the average M.E. per day of the excess of actual bed days consumed over the total expected bed days. Actual bed days are calculated from A.L.S. x 365 and the total of expected bed days are (EBD1 + EBD2 + EBD3). In other words the coefficient for ALS indicates the cost of an extra bed day incurred where hospital stays exceed the notional average. Similarly the rewritten form of the equation shows that the appropriate coefficient for a bed day in casemix category 1 is equal to the sum of the coefficient attached to C.F.1 in the actual equation ($\hat{\beta}_1$), plus the ALS (or discrepancy) coefficient ($\hat{\beta}_4$). Hence the costs derived in Table 6 for the various categories of bed days.