MEDICAL PRACTICE

Process and Outcome

Firm, patient, and process variables associated with length of stay in four diseases

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Summary and conclusions

Factors associated with length of stay in three London teaching hospitals during 1972 and 1975 were examined in patients treated for myocardial infarction, cerebrovascular disease, inguinal hernia without obstruction, and gall stones. Statistical analyses were carried out with multiple regressions on log lengths of stay.

Increased length of stay was associated with infection in all four groups and with the seriousness of operative procedures in all but patients with cerebrovascular disease. Although age was a significant variable in patients with hernias and gall stones, it had relatively little practical effect on length of stay. Other significant variables in at least one disease were obesity, number of abnormalities in blood chemistry, administration of parenteral fluids or oxygen, or use of monitoring devices, and whether chest radiography was carried out, blood electrolytes and urea were measured, or anticoagulants were used. Patients with cerebrovascular disease who were not discharged to their own homes stayed on average more than two and a half times longer than other patients.

Between a third and a half of the variance was explained by these variables and the variation among

firms. The method described is reproducible in other hospital settings, and the study shows that much new information could be available routinely without mounting expensive field trials.

Introduction

Few objective data are available on the factors associated with duration of stay in National Health Service hospitals. Heasman's work with the Scottish Consultants' Review of In-Patient Statistics (SCRIPS) showed a wide variation in stay for common-place diseases such as inguinal hernia without obstruction¹ and myocardial infarction.² He also identified large differences between teaching and non-teaching hospitals in the time that patients remain in the wards as well as between consultants treating patients with the same diseases and suggested that examination of the factors relating to patients and organisation might offer further explanation.² Donabedian's concept of structure (features of the institution in which the care is given) included organisational factors, but he also drew attention to process factors (what is done to the patient).³ We have conducted an exploratory study to identify some of the patient and process factors associated with hospital stay in two medical and two surgical diseases commonly seen in hospital and to show that this information may be obtained from routinely collected data. Diagnoses were coded according to the International Classification of Diseases based on the recommendations of the Eighth Revision Conference, 1965.

Length of stay was analysed for patients discharged from three London teaching hospitals in 1972 and 1975 with the principal diagnoses of myocardial infarction (ICD 410), cerebrovascular disease (ICD 431-438), inguinal hernia without obstruction (ICD 550), and gall stones (ICD 574). Patients with each disease in each year were treated as separate study populations.

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Method

Data were abstracted from case notes by specially trained clerks supervised by a physician. Hospital Activity Analysis (HAA) printouts and unprocessed HMP 1 forms were used to identify patients with the four diagnoses. To foster homogeneity we excluded patients who had died, those with malignancy, those aged under 15, and those cared for by specialist firms; patients whose stay exceeded 99 days (which occurred only among those with cerebrovascular disease) were also excluded. Only patients who were operated on for gall stones and unilateral hernias were included in the surgical groups.

In addition to information obtained by HAA and SCRIPS (age, sex, principal and secondary diagnoses, marital state, principal operation, admission and discharge dates, consultant in charge) we collected data on vital signs, laboratory and x-ray findings, secondary operations, and medications, as the Commission on Professional and Hospital Activities (CPHA) in the USA has done on several million patients. We, however, produced additional variables by combining items of basic data in the computer, though as in the cases of HAA, SCRIPS, and the CPHA the same information was collected for all patients. A panel of clinicians, whose patients were not included in the study, produced a list of test and examination procedures that they thought necessary for patients admitted to hospital with the four diagnoses. Each of the procedures was considered in the analysis.

An extensive list of variables was considered for each disease.* As the different practices of firms might have contributed to the variability in duration of stay, firms that had treated at least three patients with that disease in the year analysed were also included. Data for each diagnosis in each of the two years were analysed with an "optimal" regression model, which forced the computer to include variables representing firms† but left it free to select the additional variables significantly associated with log length of stay. As the criterion of significance we used $P \leq 0.1$, which we believe to be appropriate in research of this kind; only patient and process variables significant in both years are included here. The log length of stay was chosen in the dependent variable because its statistical distribution is far less skew than that of length of stay. A regression analysis of the length of stay itself would give undue weight to those patients with very long stays.

Independent variables that were dichotomous—for example, results of investigations—were awarded 0 if normal, "not done" (which for the purpose of the study we took to mean that the patient had not presented with symptoms suggestive of an abnormality), or "not used" and 1 otherwise. Age was treated as a continuous variable. On the chemistry variable a 1 was awarded for each blood chemistry value that exceeded the normal limits for the hospital in which it was measured. The tests considered were electrolytes and urea; total bilirubin; alkaline phosphatase; plasma proteins; aspartate and alanine aminotransferases, hydroxybutyrate and lactate dehydrogenases, or creatine phosphokinase; and creatinine for a maximum total of 6. A 0 was awarded if no abnormalities were found or tests were not done.

The patient was given 1 on the infection variable (infection was verified from case notes) if urine, sputum, blood, or other bacteriological investigation was done and antibiotics or other anti-infective agents were administered and the peak temperature exceeded 37.4°C or was missing from the notes; otherwise 0 was given. Some underenumeration occurred for this variable, primarily when bacteriological investigations were not done.

The operation-risk variable represented the sum for each patient of the weights assigned to each operation performed on him during the admission studied. This was calculated from the North-east Metropolitan Regional Hospital Board's 1969 classification and weighting of operations⁴—namely, major (20), intermediate (10), and minor (4)—which were designed to provide a measure of theatre work-load. These weightings generally apply equally well to distinctions of severity. We believed that they would be more precise than a variable which merely counted the number of operations. Operations performed outside the theatre were included if they came within the classification, though procedures such as intravenous or intramuscular injections, urinary catheterisation, and induction of anaesthesia were not. Data were collected on a maximum of four operations or procedures recorded.

Inherent limitations of a retrospective study based on medical

records are the possible omission of data from the case notes and clerical inaccuracy in abstracting information. A random weekly review of coding production, however, showed a clerical error rate of only 0.5%. Some underenumeration may have occurred through discharge summaries not being complete but there was no definite evidence of this.

Results

MYOCARDIAL INFARCTION

The average length of stay for patients with myocardial infarction (table I) declined from 1972 to 1975. When the logarithms are converted to days the mean length of stay in 1972 was 20.0 days and in 1975 14.9 days. Thirty-four per cent of the variance was explained by the variables in the first year, while 44% was explained by these in the second year. Although more of the explanation was accounted for by the patient and process variables, in 1975 the contribution made by firms in both years cannot be entirely discounted. Three of the 10 firms were responsible for significantly longer stays in 1972 than the average for that year, even when adjustments were made for the other significant variables, and the same firms kept their patients in hospital significantly longer in 1975.

The panel of clinicians regarded chest radiography as mandatory for myocardial infarction. Doing this investigation was associated with an increased stay of 17% in 1972 and 13% in 1975. While some increase in stay may be preferable to a shorter stay when chest radiography is not done, the additional three and a half days in 1972 and two days in 1975 may suggest a delay in scheduling. Patients given parenteral fluids or oxygen or connected to monitoring devices stayed longer than other patients. In both years about two-thirds of the patients with infarcts were in the coronary care unit, but care of this kind was not associated in our data with increased stay in either year.

The operation-risk variable was significant in both years. If, for example, a patient had only one minor operation (weighted 4) in 1972, the stay was on average increased by $4 \times 1\%$ (4%) in that year and by $4 \times 2\%$ (8%) in 1975. A moderately serious procedure (weighted 10) such as angiography increased stay by 10% in the first year and 20% in the second, whereas a major operation (weighted 20)—for example, insertion of a pacemaker—was associated with a 20% increase in 1972 and a 40% increase in 1975.

The use of anticoagulants increased stay in both years by about 20%. Interestingly in 1972, 30% of patients with myocardial infarction were given anticoagulants, whereas in 1975 only 15% were given them, perhaps as a result of the controversy about the use of these agents in this disease.⁵

Patients with infection stayed on average one-third longer than other patients in both years, adding five or six days to their stay. Findings in 1974,⁶ later confirmed,⁷ suggested that diabetic patients with myocardial infarction should be kept in hospital longer because they are particularly liable to late cardiac arrest. We did not find that diabetes was a significant factor in longer stays in 1975, even though 8% of the patients in that year were diabetic.

CEREBROVASCULAR DISEASE

Only one patient with cerebrovascular disease stayed longer than 99 days in 1975, though there had been 12 such cases in 1972. Despite these exclusions the range in stay was far greater for patients with this disease than other diseases, as is suggested by the much larger coefficients of variation (table II). The average lengths of stay corresponded to 15.1 days in 1972 and 18.5 days in 1975. Firms explained only 8% and 7% of the variation in both years, leaving infection and the discharge variable accounting for 27% and 25% of the variance respectively. The enormous increase in average length of stay in both years associated with patients not discharged to their own homes is not surprising. The finding, however, that these patients stayed on average more than two and a half times longer than other patients should stimulate discussion of alternatives to keeping these patients in expensive acute care facilities when the acute phase of the disease may have passed.

Although the regressions for all diseases showed infection to be significantly associated with longer stays, the proportional increase was much more dramatic for patients with cerebrovascular disease, who on average stayed in hospital 77% longer than other patients in 1975 and 129% longer in 1972. Here, as elsewhere, we were unable to

*Full details may be obtained from the authors.

†To include the effect of an individual firm in the regression equation we defined an indicator variable set to 1 for all patients treated by this firm and to 0 for all other patients. We then carried out the regression with the last firm functioning as a constant. Each regression, therefore, included one less firm than the total firms contributing data.

determine whether infection caused stays to be longer or resulted from longer stays.

INGUINAL HERNIA

Much more of the variance in stay for patients operated on for inguinal hernia without obstruction was explained in 1972 than in 1975 (table III). The difference between the two years (49% and 34%) was largely attributable to the differences in the amount of variation explained by firms. In the earlier year eight of the 18 surgical firms kept their patients significantly longer than their colleagues, even when adjustment was made for the significant patient and process variables. In 1975, however, only two firms were responsible for long stays, both of which had been among the eight in 1972. The shorter average length of stay in 1972 (6.7 days) and the differences accounted for by firms in that year suggest that some firms were experimenting with early discharge of patients with hernia. In 1972, 22% of the patients were in hospital for four days or less compared with 6% in 1975. The average stay in the later year was 7.7 days.

Age was significant in both hernia regressions, but its practical effect on length of stay was less than is generally assumed, confirming the results of Posner and Lin.⁸ For each 10 years of age, stay increased by 8% in 1972 and 5% in 1975. As older patients are less likely to be considered for early discharge,⁹ the 0.5% a year in 1975 (table III) is probably more representative of the effect of age when early discharge is not occurring. The average age in both samples was about the same (51 in 1972 and 53 in 1975); thus patients were in their 70s before stays were on average increased by even one day.

In 1972 obesity increased a patient's length of stay by 13%. Since obesity complicates hernia operations,¹⁰ few obese patients were discharged in the short-stay group, which may have inflated the proportional increase found for 1972. The statistic associated with obesity in 1975 (table III) fell somewhat short of our accepted significance level; nevertheless, we included this variable in the final

regressions because it made a similar showing in the analysis of gall stones, suggesting that obesity should not be totally ignored as an influence contributing to length of stay for surgical patients.

An increased stay of almost one day when blood electrolytes and urea were measured raised the question whether these tests could be made before an elective admission. Our panel of clinicians believed that the tests were desirable to avoid performing an elective operation on a patient with an electrolyte or urea abnormality. If they could not be done as an outpatient procedure, saving a day by not doing them in hospital would not be justified.

The use of parenteral fluids or feeding was associated with a 31% increase in hospital stay in 1972 and a 20% increase in 1975. Again the size of the increase in the earlier year may reflect the early discharge of low-risk patients. The presence of infection added 35% or more to the length of stay in both years.

If in addition to the hernia operation (weighted 10) a patient had one minor operation his stay increased by 6%. With another moderately serious operation his stay was on average 16% longer. Suprapubic or transurethral prostatectomies (weighted 20) were performed on a few patients (four in both years together) at the time of the hernia operation, which on average increased stay by 32%. A few other patients, however, accumulated high scores for this variable, which comprised different combinations of operations weighted 4 or 10.

GALL STONES

Length of stay for gall stones declined from 15.1 days in 1972 to 13.9 days in 1975. More variation was explained by firms in 1975 than in 1972. No firms were responsible for significantly longer stays than average in the earlier year, but in 1975 three firms significantly exceeded the average stay, even after adjustment was made for significant variables. Altogether more of the variance was explained for gall stones (49% and 59%) than in other diseases (table IV).

Once again, although age was a significant variable in both years,

TABLE I—Influence of variables on lengths of stay among patients with myocardial infarction

	Parenteral fluids, oxygen, or monitoring devices		Chest radiography done		Operation risk		Anti-coagulants used		Infection present		Variance explained by firms (%)	Total variance explained (%)	Coefficient of variation (%)	Mean log length of stay	1 SD
	% I	t ratio*	% I	t ratio*	% I	t ratio*	% I	t ratio*	% I	t ratio*					
1972 (n = 329)	11	1.8	17	2.0	1/unit	2.7	19	3.4	31	4.8	20	34	15	1.3012	0.1925
1975 (n = 275)	17	2.9	13	2.0	2/unit	5.7	20	2.8	36	4.9	17	44	16	1.1733	0.1858

% I = Approximate increase in stay expressed as a percentage.

*Significance of variables was assessed by means of the t ratio (ratio of computed value to estimated standard error), the larger the ratio the more unlikely it is that this is a purely chance effect.

TABLE II—Influence of variables on lengths of stay among patients with cerebrovascular disease

	Not discharged to own home		Infection present		Variance explained by firms (%)	Total variance explained (%)	Coefficient of variation (%)	Mean log length of stay	1 SD
	% I	t ratio*	% I	t ratio*					
1972 (n = 138)	175	4.4	129	4.0	8	35	34	1.1799	0.4048
1975 (n = 132)	152	4.7	77	3.1	7	32	27	1.2687	0.3393

% I = Appropriate increase in stay expressed as a percentage.

*For explanation see footnote to table I.

TABLE III—Influence of variables on lengths of stay among patients with inguinal hernia without obstruction

	Age		Patient obese		Blood urea and electrolytes measured preoperatively		Parenteral fluids/feeding given		Operation risk		Infection present		Variance explained by firms (%)	Total variance explained (%)	Coefficient of variation (%)	Mean log length of stay	1 SD
	% I	t ratio*	% I	t ratio*	% I	t ratio*	% I	t ratio*	% I	t ratio*	% I	t ratio*					
1972 (n = 364)	0.8/year	5.6	13	2.1	11	2.2	31	3.0	1.5/unit	2.5	37	3.9	31	49	24	0.8226	0.1977
1975 (n = 279)	0.5/year	2.9	8	1.4	12	2.4	20	1.7	1.5/unit	2.0	35	4.2	16	34	18	0.8871	0.1635

% I = Approximate increase in stay expressed as a percentage.

*See footnote to table I.

TABLE IV—Influence of variables on lengths of stay among patients with gall stones

	Age		Blood chemistry abnormalities		Patient obese		Operation risk		Infection present		Variance explained by firms (%)	Total variance explained (%)	Coefficient of variation (%)	Mean log length of stay	1 SD
	% I	t ratio*	% I	t ratio*	% I	t ratio*	% I	t ratio*	% I	t ratio*					
1972 (n = 170)	0.8/year	3.9	9.5/unit	3.7	9.5	1.6	0.8/unit	2.4	27	4.2	15	49	15	1.1783	0.1750
1975 (n = 162)	0.5/year	2.8	9.5/unit	4.3	7.0	1.3	1.0/unit	4.0	17	3.4	21	59	14	1.1422	0.1562

% I = Approximate increase in stay expressed as a percentage.

*See footnote to table I.

the discrimination of the age variable is debatable. For each decade over the average age of about 50 in both years, age was associated with 5% or 8% of lengthened stay. In contrast, one abnormality in blood chemistry (over half of the patients in each year had at least one) increased stay by more than did an additional 10 years of age.

Although the obesity variable did not quite meet our acceptable significance level, we included it in the final regressions for the reasons stated above. In general, it had a similar proportional effect on increasing stay as that found for hernias.

Gall stone operations carried a weight of 20; thus the interpretation of table IV is that an additional minor operation increased the average stay by about 4%. An intermediate operation such as prophylactic appendectomy added on average 8-10% to a hospital stay, whereas, for example, a secondary operation on the bile duct (with the exclusion of operative cholangiography) increased stay by about 20%. The presence of infection added 27% to the duration of stay in 1972 and 17% in 1975.

Discussion

An exploratory study of lengths of stay for specific diseases permits influential factors to surface that may not necessarily accord with a-priori notions of what *should* affect length of stay. Our findings show that length of stay, like all aspects of medical care, is complex, and that these complexities should be taken into consideration before establishing norms.

Simpson observed that "the range in length of stay for particular conditions results as much from the force of habit or perverse necessity as from considered judgment."¹¹ Our data could be interpreted as providing examples of all three. Firms that kept their patients in the ward longer than average in both years may have been dealing with cases that were different in ways not accounted for by our patient variables; or we may have been seeing evidence of the force of habit. We built patient risks into the model as measures of "perverse necessity." The association between longer stays for all patients with infection or for patients with hernia who were given parenteral fluids may be even better examples of this perversity, representing the constitutional susceptibilities that thwart recovery in some patients under the best of conditions. Both may in part be the results of clinical mismanagement, but it is unrealistic to suppose that all infection, for example, can be prevented in hospital. The possibility that infection may result from longer stays as well as cause them suggests that earlier discharge might be worth consideration on clinical as well as economic grounds.

To the extent that better clinical management increases length of stay (and poorer management decreases it) the judgment to keep a patient in longer should be regarded as sound. Few would argue that patients with infarcts should not have chest radiography or that patients entering hospital with abnormal heart or liver enzyme concentrations or patients given anticoagulants should not stay longer. When admission is elective, abnormalities could perhaps be identified and treated beforehand, but this assumes an ideal availability of laboratory facilities, which may be far from the case.

The significance of the operation-risk variable in increasing the length of stay is not surprising, but the weakness of the age variable is interesting since it is given considerable weight in establishing norms for specific diseases in the USA. While age undoubtedly has an overall effect on bed occupancy,¹² its

usefulness in the analysis of length of stay for particular diseases may be limited.

The explanation of a third to more than half of the variation in duration of stay, while perhaps disappointing in a controlled experiment, is encouraging in an exploratory study of a complex phenomenon which is further affected by changes in policy and fashions of practice from year to year. No claim can be made for the universality of findings obtained only from teaching hospitals, even in two years. We believe, however, that the method is reproducible in other hospital settings. The fact that this amount of information can be obtained from routinely collected data rather than expensive field trials seems to justify continuing this exploratory work elsewhere.

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Details of the list of variables considered for each disease may be obtained from Dr L Carol Fernow, King's Fund Record Project, Guy's Hospital, St Thomas Street, London SE1 9RT.

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WORDS New medical words are constantly being coined, and are usually constructed from Greek or Latin roots. The late Richard Asher was concerned with the proper construction of new terms, a process he facetiously called neologopoiesis. Some terms, seemingly from antiquity, are of comparatively recent coinage. *SCIENCE* (*scio*, *sciens*, knowing) in the modern sense dates from the eighteenth century, being previously known as natural philosophy. Scientist dates from 1840 and served to resolve the dilemma of what to call a female man of science. *ATOM* (*G a-tomos*, not cuttable), a particle so small as to be incapable of further division, was used by Democritus in a conjectural sense about a hypothetical particle. John Dalton, of colour blindness fame, revived the term in its modern sense in the late eighteenth century. *GAS* is of special phonetic interest. The term was coined by van Helmont in the early seventeenth century. He took the Greek *χᾶος*, pronounced *chah-os*, with *ch* as in Scottish *loch*, and meaning infinite space or chasm (whence also the English *chaos*). He made an approximate phonetic transcription into Dutch, in which language *g* is pronounced as Scottish *ch*. He accordingly spelt it *gas* (pronounced *chuss* in Dutch) in which form it has entered so many other languages in which the *g* is hard, as in *gap*. *χᾶος* is from the stem *χα-*, yawn and I should like to think is echoic. I can just imagine an ancient Greek yawning in deeply and letting the air out with a loud 'χα.'