TALKING POINT

Forecasting hospital bed needs

T K SWEENEY, J S A ASHLEY

The 1962 Hospital Plan for England and Wales¹ suggested for planning purposes a maximum of 3.3 acute beds per 1000 total population. This figure was a compromise between several estimates of requirements made around that time by studies in different parts of England.²⁻⁵ These studies took account of current discharges and deaths, length of stay, and changes in the waiting list to arrive at what was then called the critical number⁶ of beds to meet demand. By adjusting the critical number for a selected percentage occupancy and relating it to the catchment population, a ratio of beds to population was obtained for the hospital under consideration. This method, however, assumes constant discharge rates, length of stay, and population structure. Furthermore, the well-established relation between length of stay and available beds⁷ tends to perpetuate widely different ratios in different places.

At any particular time the number of hospital beds occupied is the result of a complex interaction of bed supply and pressures such as morbidity, social circumstances, the referral practice of general practitioners, and consultants' decisions on the admission and discharge of patients. The dynamic outcome of these interactions may be studied by preparing trends of annual discharges and deaths,⁸ equated with admissions, average duration of stay, and turnover interval—the period of time a bed remains empty between successive patients.

Projection of trends may be the basis of estimates of future use and requirements which may be modified into more credible forecasts by additional information on the effects of likely changes in medical practice and disease epidemiology. Such extrapolations by age and specialty using national data from the Hospital Inpatient Enquiry (HIPE) have recently been made for London.⁹ A similar method for local application using a combination of data from Hospital Activity Analysis and the Annual Hospital Return (Form SH3) has been proposed.¹⁰ The method in this study is founded on the belief that hospital services should be planned to relate directly to the pattern of morbidity in the population served and is, therefore, based on projections of disease trends modified in the light of clinical and epidemiological information.

Method

National discharge rates and mean durations of stay for disease conditions as classified in the ICD¹¹ "A" list at different age groups for each sex for non-psychiatric patients were taken from the 1968-73* annual published HIPE tables (table I shows the data for appendicitis as an example). Though maternity was excluded from the study and the age groups between 15 and 44 were amalgamated, it was still impracticable to produce the 3000 extrapolations required to cover each disease in each of the six age groups 0 to 4, 5 to 14, 15 to 44, 45 to 64,

65 to 74, and over 75 for both sexes. Fortunately, patients suffering from most of the age- and sex-specific diagnostic categories use a small proportion of hospital beds. Projections were, therefore, limited to categories which occupied 0.1% or more of the total average beds used daily by both sexes of all ages. In 1972, taken as the base year, the average number of beds used daily was 172 000 so specific projections were made only for the 313 categories using 172 beds or more. Thus in the example given (table I) projections were made for the 5 to 14 and 15 to 44 age groups. For each of these categories five mathematical curves, chosen to give a wide range of possible underlying trends, were fitted to the series of discharge rates and durations of stay by using least squares regression techniques after transformation to straight-line equivalents as necessary. The most suitable curve was used to make extrapolations to 1986.

TABLE I—An example of the data available from the Hospital Inpatient Inquiry*

Age group	Discharge rate per 10 000 related population	Mean duration of stay (days)	Average beds used daily
0-4	2.2	9.1	10
5-14	32.9	7.4	256
15-19	57.5	6.8	179
20-24	36.5	7.0	123
25-34	18.6	7.3	117
35-44	11.0	7.8	66
45-64	8.2	11.6	156
65-74	6.1	13.4	54
75 +	5.8	16.1	40
All ages	18.0	8.1	1001

* Appendicitis in women in England and Wales in 1972 was used as the example.

The historical trends for each category were compared by age group and sex and with the corresponding data from series of mortality statistics¹² whenever these were an acceptable substitute for morbidity. The direction of the trends in the mortality series, tested for statistical significance, was compared with the direction of the curves used to prepare extrapolations. A commentary was written and questions framed about discharge rates and durations of stay in terms which drew attention to compatibility or any clear inconsistency between the discharge rates and mortality data—for example, the projection of historical trends of discharge rates for strokes shows a rise in most age groups contrary to the current falling mortality rates.

A similar procedure was followed using statistics from notifications in the case of tuberculosis. When mortality was not an acceptable proxy for morbidity and when it was thought helpful to do so, attention was drawn to the relation between the trend in hospital discharge rates and the relative levels of general practitioners' consultation rates in 1958 and 1970-1, taken from the two national studies of morbidity in general practice.^{13 14}

The projections and questionnaires were sent for comment to selected individual clinicians and national professional organisations whose members had specific interest in the particular disease. The same procedure was followed with epidemiologists, chosen on similar grounds. They could also be expected in making their comments to draw on other available evidence of the incidence of these diseases for which it is not possible validly to compare hospital discharge rates with mortality statistics or general practitioners' consultation rates.

In nearly all instances the comments that were received were interpreted in line with the following predetermined ground rules:

(1) When those consulted agreed with the projected values, that was accepted as the forecast.

(2) Alternative figures supplied were accepted as the forecast if they fell within the 95% confidence limits.

(3) When advised that discharge rates would rise higher than projected the upper confidence limit was chosen likewise; the lower

*For diseases exactly comparable in the 7th and 8th revisions of the ICD the period 1964 to 1973 was used.

Department of Health and Social Security, Hannibal House, Elephant and Castle, London SE1 6TE

T K SWEENEY, MB, MFCM, senior principal medical officer

Office of Population Censuses and Surveys, St Catherine's House, 10 Kingsway, London WC2B 6JP

J S A ASHLEY, MB, FFCM, medical statistician

confidence limit was selected when advised that a rise should be less. A similar approach was adopted about projected falls and durations of stay.

(4) In the few instances when advice was conflicting or at variance with recorded facts all available data were examined and what seemed to be the most reasonable figure was selected as the forecast. If no advice was available statistical projections were accepted unless there were clear reasons why these should be adjusted. Figure 1 illustrates the general procedure.

Diagnosis A List

A 121b

Sex Age Group

DISCHARGE RATES PER 10,000 POPULATION

Estimates										Projections		
1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1976	1982	1986
10.4	9.0	10.0	11.3	13.3	12.1	13.9	18.1	18.2	20.7	22.9	30.5	35.5

95% Confidence Limits

	Upper	Lower
1976	28.4	17.7
1982	39.1	22.9
1986	46.1	26.2

QUESTION

There is a projected rise in the number of discharges for this condition. Are clinical advances likely to cause a steeper rise in the number of admissions?

REPLY

Projected admission rises would occur with existing treatment and higher patient expectations. New treatments will further increase admission requirements.

DECISION

The upper confidence limit was adopted as the forecast.

FIG 1—An example of the information sent to clinicians and epidemiologists, their response, and the decision taken.

In each age and sex group categories not separately analysed were aggregated to form a group (the remainder) that was also projected. The forecast values for remainders were selected to preserve historical relationships with the sum of the separately analysed categories.

For each category the forecast values were incorporated in the following formula:

$$\frac{\text{Discharge rate} \times \text{mean duration of stay} \times \text{population}}{\text{Number of days in the year}}$$

to obtain the expected number of used beds. For each age group the total number of used beds was obtained by summation. Bed requirements may be derived by including an appropriate figure for turnover interval in the calculations.

Results

Tables II and III illustrate the results obtained by employing this technique for the 15 to 44 age group. Beds used by the age group as a whole are expected to fall by 1986 to 9.9 per 10 000 related population in men and to 11.6 in women; this is due largely to forecast falls in length of stay for both sexes and an 8% fall in discharge rate for women (table II).

Despite substantial projected population increases (14% in men and 13% in women) the age group will occupy 3500 fewer beds than in 1972 (table III) if the forecasts are correct. This net effect results from an increase in the use of beds by patients with some diagnoses and a fall by others. Women with gynaecological disorders and abortions are expected to need substantially fewer beds due mainly to the increasing popularity of day treatment. The reduction in bed use by men is widely distributed between diagnoses, including peptic ulcer, non-bony injury, and

TABLE II—Trends in non-psychiatric bed use 1968-78 at ages 15 to 44 in England and Wales with statistical projections and forecast values for 1986

Year	Discharge rate per 10 000 related population		Mean duration of stay (days)		Average beds used daily per 10 000 related population	
	Men	Women*	Men	Women*	Men	Women*
1968	49.4	76.3	12.0	8.6	16.2	17.9
1969	51.4	79.3	10.3	8.1	14.5	17.6
1970	50.2	81.8	9.7	7.8	13.3	17.5
1971	52.4	85.5	10.5	7.3	15.1	17.1
1972	52.1	85.2	8.8	6.7	12.5	15.6
1973	51.1	84.5	8.3	6.7	11.6	15.5
1974	51.9	85.4	8.0	6.2	11.4	14.5
1975	48.9	67.1	8.5	7.1	11.4	13.0
1976	53.3	73.8	7.8	6.6	11.4	13.3
1977	51.9	85.5	7.7	5.8	11.0	13.6
1978	51.9	70.9	7.2	6.1	10.2	11.9
1986	56.8	118.9	5.9	3.9	9.2	12.7
Forecast:	53.3	78.4	6.8	5.4	9.9	11.6

* Excluding maternity.

TABLE III—Average beds used daily in 1972 and forecast for 1986 at ages 15 to 44 in England and Wales

Diagnostic group	Men		Women	
	1972	1986	1972	1986
Peptic ulcer	415	316	*	*
Appendicitis	459	431	485	442
Hernia	370	346	*	*
Cholelithiasis and cholecystitis	*	*	357	495
Benign neoplasm of uterus	n.a.	n.a.	332	238
Gynaecological disorders (excluding neoplasms)	n.a.	n.a.	1926	1746
Abortions (therapeutic and spontaneous)	n.a.	n.a.	1211	526
Displacement of intervertebral disc	273	297	177	213
"Other" musculoskeletal disorders (excluding arthritis)	432	771	510	860
Abdominal pain	*	*	370	687
Principal fractures (excluding neck of femur)	1205	1478	*	*
Adverse effects of medicinal agents (poisoning)	*	*	267	609
"Other" injuries†	1303	1200	*	*
Total of the above	4457	4839	5635	5816
Others forecast explicitly not illustrated above	3531	2495	4164	3096
"Remainder" (see text)	4066	3587	4994	3440
Total	12054	10921	14793	12352

n.a. = not available.

* Less than 172 beds in 1972 (see text) and not forecast separately, but included in the "remainder."

† Including internal derangement of joints, intracranial injury, dislocations, sprains, and other injuries and reactions.

myocardial infarction. A rise in the incidence of fractures in men is forecast, as is a small increase for cholelithiasis and cholecystitis in women.

Table IV lists the seven conditions forecast to occupy a large proportion of the hospital beds used by all age groups in 1986. The basis for some of these forecasts illustrates how clinical and epidemiological input modified the statistical projections. When commenting on the inconsistency between the rising discharge rates and falling mortality rates for strokes, one clinical view was that more effective and prolonged treatment of hypertension would reduce its incidence if doctors were prepared to prescribe

TABLE IV—Principal categories using non-psychiatric beds in England and Wales*

Diagnostic group	All ages, both sexes			
	Percentage of total beds used			Forecast
	1972	1977	1978	
Cerebrovascular disease ("strokes")	10.3	10.3	11.5	11.2
"Other" forms of heart disease†	4.4	3.9	4.0	4.8
Osteoarthritis	2.0	2.3	2.3	4.4
Mental illness	1.4	2.5	2.5	3.4
Diseases of arteries, arterioles, and capillaries	3.2	2.6	2.2	3.4
Acute myocardial infarction	2.8	2.4	2.3	2.7
Fracture of neck of femur	1.4	2.5	2.8	2.6
Total	25.5	26.5	27.6	32.5

* Excluding maternity.

† Principally heart failure.

prophylactic hypotensive treatment and asymptomatic patients were willing to be treated. For the present, however, it was accepted that some increase in effective treatment might cause the incidence to level off and result in discharge rates and bed use at about the present level. Similarly, epidemiological considerations based on mortality¹⁵ influenced the forecast for acute myocardial infarction. In contrast, a considerable increase, well above the statistical projection, is forecast in beds for patients with osteoarthritis. This allows for increasing public demand for hip replacement and the extension of treatment to other joints.

Discussion

Arguments most often deployed against the approach in this study are that it perpetuates the influence of bed supply on bed use, is insensitive to local circumstances, and is inappropriate for estimating needs of the elderly.

INFLUENCE OF BED SUPPLY

Pressure on resources stimulates changes in practice and there is interaction between supply and demand in any study taking account of past and current use of hospital beds. Other factors, however, influence discharge rates and duration of stay, and when extrapolated trends are adjusted to take account of views of clinicians and epidemiologists the dependence between supply and demand is reduced. So far as is known no other published method does this.

INSENSITIVITY TO LOCAL CIRCUMSTANCES

Adequacy of housing and the general practitioner, district nursing, and other community services affect discharge rates and lengths of stay and have thus influenced the national data from which extrapolations were made. But these extrapolations cannot be sensitive to marked local deficiencies, which, if necessary, must be quantified locally when estimating local requirements. Nevertheless, it should be an important general principle that expensive services should not be planned for one section of the Health Service because of actual or expected deficiency in another. Shortages of community services—for example, general practitioners or home helps—may be sufficient to delay a reduction in bed numbers but should not be used to justify the permanent provision of excess hospital accommodation.

NEEDS OF THE ELDERLY

Advances in prevention and improvement in treatment and clinical management relate to diseases rather than to the entire population of an age group. It is valuable, therefore, to use the same diagnostic approach in estimating the bed needs of the elderly and it is fairly generally agreed that data for 65- to 74-year-old individuals can be processed in the same way as for younger patients, but other considerations have much force for those over 75. In that age group the principal diagnosis at discharge is often not the sole reason for admission or for a prolonged stay in hospital. In patients with multiple pathology epidemiological and clinical views on the credibility of extrapolations based on a single main diagnosis will often have limited relevance. Furthermore, social circumstances and the adequacy of resources, in particular of community services and psychiatric hospital accommodation, often have considerable influence. Additional refinement is probably necessary if the approach described in this paper is used for estimating bed requirements for those over 75. One possibility would be to prepare trends and projections only for shorter-stay patients

and to estimate in another way the bed needs of the longer stay who should be in hospital rather than in other accommodation.

RESULTS

Data for five subsequent years are now available but comment on the eventual accuracy of the forecast must still be speculative. Unforeseen factors like industrial unrest caused unusually wide variations in discharge rates and length of stay in some recent years. So far the predictions for women patients seem to be a great improvement on the unadjusted statistical projections and those for men seem acceptable. In the long term, however, it may be shown that the scope for fall in the length of stay has been underestimated as it was clear that clinicians took an understandably conservative view of the possibility of continued reductions. With hindsight the framing of the questions or the interpretation of comments might have allowed for this.

Patients with one of only seven conditions are forecast to occupy one-third of all beds in 1986. As shown in table IV significant changes in bed use for any of these conditions would substantially affect requirements. An approach that considers diagnosis would help in the surveillance of these large resource users and the early recognition of changes that would alter requirements.

Applications of the study

The areas and districts of England and Wales differ in demographic structure, morbidity, and social circumstances. Services provided also vary in emphasis and operational detail. If local services are planned in relation to diseases there is scope for taking these differences into account. It would be feasible for those who use this method to decide the extent to which national estimates of discharge rates and duration of stay reflect local morbidity and clinical management. In most instances acceptance of national values would probably be appropriate, but for some diseases in some age groups there would be sufficient grounds to make changes—for example, death rates and discharge rates for bronchitis and emphysema have been higher in Newcastle upon Tyne and lower in East Anglia than nationally (fig 2). In both regions it would be reasonable to weight national discharge rates by the relationship between the local and national death rates when calculating requirements. Comparative statistics of infectious diseases, like tuberculosis, could similarly

FIG 2—Relationship between death rates and discharge rates for bronchitis and emphysema for men aged 65 to 74 in two regions and in England and Wales. (Source HIPE.) * Northern RHA and † East Anglian RHA in 1974.

BMA Council 1981-2

Elected representatives

ENGLAND BY REGION

Northern: Dr G Cormack, general practitioner, Morpeth.
 Yorkshire: Dr J M Dunlop, district community physician, Kirkella, North Humberside.
 Trent: Dr M Hamid Husain, general practitioner, Rotherham.
 East Anglia: Dr A J Rowe, general practitioner, Bury St Edmunds.
 North-west Thames: Dr P F Kielty, general practitioner, Harpenden.
 North-east Thames: Dr Arnold Elliott, general practitioner, Ilford, Essex.
 South-east Thames: Dr W J Appleyard, consultant paediatrician, Canterbury.
 South-west Thames: Dr J A Hicklin, consultant in rheumatology and rehabilitation, Crawley, Sussex.
 Wessex: Mr A P J Ross, general surgeon, Winchester.
 Oxford: Dr Joan M St V Dawkins, specialist in community medicine, Northampton.
 South Western: Dr S Jane Richards, general practitioner, Exeter.
 West Midlands: Dr Mary White, general surgery, Bromsgrove.
 Mersey: Dr M Goodman, general practitioner, Liverpool.
 North Western: Dr S Jenkins, general practitioner, Manchester.

WALES

Dr G M Mitchell, senior lecturer, department of materia medica and pharmacology, Welsh National School of Medicine, Cardiff.

SCOTLAND

Dr J A Ford, consultant paediatrician, Glasgow.

NORTHERN IRELAND

Dr J Wilson, general practitioner, Co Antrim.

ELECTED BY THE REPRESENTATIVE BODY

Sir James Cameron, Wallington, Berkshire.
 Dr A A Clark, Dalmaur, Dunbartonshire.
 Dr Judith Hooper, GP trainee, Birmingham.
 Dr C J Wells, Sheffield.

REPRESENTATIVES OF COMMITTEES ELECTED BY RB MEMBERS IN THE RELEVANT BRANCH OF PRACTICE

GMSC: Dr J S Noble, Dr W G A Riddle, Dr D L Williams, and Dr M A Wilson.
 CCHMS: Mr M J Gilkes and Mr R K Greenwood.
 HJSC: Mr A M Mander, Dr M R Rees, and Dr S Six.
 CCCM: Dr A W Tranter.

The Association's chief officers and the chairmen of standing committees are ex-officio members of the Council. The chairmen and nominees of other committees are subject to reappointment.

Forecasting hospital bed needs—continued from p 333

be used to allow for high or low notification rates. National discharge rates could also be modified when a service is provided in a particular way. When a high proportion of patients requiring surgery for conditions like benign neoplasms, hernia, and female genital disorders are treated as day patients the relevant discharge rates could be lowered. Likewise an increasing number of medical patients with gastrointestinal disorders or diabetes, who would until recently have been admitted, are now investigated and treated as outpatients.

The length of stay may also be altered to correspond to clinically acceptable local practice. Values for turnover intervals, which often reflect administrative efficiency rather than clinical practice, should be supplied by those who understand the local scene.

The data might be used in the following ways.

- (1) Obtain the expected size and demographic structure of the catchment population.
- (2) Determine appropriate local figures for discharge rates, mean duration of stay, and turnover interval.
- (3) Calculate the beds required from the above data.

The co-ordinating responsibility for this work would be a suitable task for specialists in community medicine working in collaboration with statisticians and clinical colleagues.

We should like to thank Roger Edmunds, Wendy McLean, and Mary Gaffney for invaluable statistical advice and help. Without the generous co-operation of numerous epidemiologists, clinicians, and professional organisations a study of this nature could not have been carried out.

The views expressed in this article are those of the authors and should not be attributed to the Department of Health and Social Security or the Office of Population Censuses and Surveys.

References

- ¹ National Health Service. *A hospital plan for England and Wales*. Cmnd 1604. London: HMSO, 1962.
- ² Nuffield Provincial Hospitals Trust. *Studies in the function and design of hospitals*. London: Oxford University Press, 1955.
- ³ Barr A. The population served by a hospital group. *Lancet* 1957;iii:1105-8.
- ⁴ Forsyth G, Logan RFL. *The demand for medical care*. London: Oxford University Press, 1960.
- ⁵ Airth AD, Newell DJ. *The demand for hospital beds*. Newcastle upon Tyne: University of Durham, 1962.
- ⁶ Bailey NTJ. Calculating the scale of inpatient accommodation. In: *Towards a measure of medical care*. London: Oxford University Press for Nuffield Provincial Hospitals Trust, 1962:55-65.
- ⁷ Feldstein MS. *Economic analysis for health service efficiency*. Amsterdam: North-Holland, 1967.
- ⁸ Adelstein AM, Ashley JSA. Recent trends in mortality and morbidity in England and Wales. In: Hiorns RW, ed. *Demographic patterns in developed societies*. Symposia Society Study Human Biology, vol 19. London: Taylor and Francis, 1980:145-71.
- ⁹ London Health Planning Consortium. *Acute hospital services in London*. London: HMSO, 1979.
- ¹⁰ Butts MS, Ashford JR. A framework for planning hospital services. In: McLachlan G, ed. *Framework and design for planning*. Problems and Progress in Medical Care. Tenth series. Oxford: Oxford University Press for Nuffield Provincial Hospitals Trust, 1977:3-38.
- ¹¹ World Health Organisation. *International classification of diseases, injuries and causes of death. Eighth revision*. Geneva: WHO, 1967.
- ¹² Office of Population Censuses and Surveys. *Mortality surveillance, England and Wales 1968-75*. London: Office of Population Censuses and Surveys, 1977.
- ¹³ General Register Office. *Morbidity statistics from general practice*. Studies on medical and population subjects. No 14. London: HMSO, 1958.
- ¹⁴ Royal College of General Practitioners, Office of Population Censuses and Surveys, Department of Health and Social Security. *Morbidity statistics from general practice, 1970-1*. Studies on medical and population subjects. No 26. London: HMSO, 1974.
- ¹⁵ Florey CduV, Melia RJW, Darby SL. Changing mortality from ischaemic heart disease in Great Britain, 1968-1976. *Br Med J* 1978;ii:635-7.