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A SURVEY OF IN-PATIENTS OF A LONDON TEACHING HOSPITAL: GENERAL RESULTS

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In recent years efforts have been directed towards the application in the health services of the mathematical and statistical techniques collectively embodied in operational research and universally recognized to be of value in industry and other organizational contexts. As a highly complex unit, the hospital is an obvious choice for the use of such techniques. However, this very complexity tends to defeat attempts at rationalization since its functions are so closely inter-related.

In order to make progress in this field, it is therefore advisable to demarcate a particular problem area and to study it as far as possible in isolation. One such area is that of the utilization of beds. In an ideal world, a hospital's beds would be occupied by patients whose requirements in terms of nursing, medical, and ancillary services are exactly matched to the available facilities. In practice, very little account can be taken of these qualitative aspects of the problem and it is no easy matter to match the mere number of patients to the number of beds available.

In March 1965 a one-year in-patient study was begun at St. Thomas's Hospital, London, with a view to throwing light on this more limited problem. More specifically, the ultimate objective was to determine ways in which admissions can be organized so as to reduce the number of empty beds and of bed-shortages. Although the emphasis was on admissions, information was collected on all patients who had anything to do with the principal in-patient departments of the hospital during the year, including, for instance, those placed on the waiting list and subsequently removed.

A great deal of useful information has been gathered from this survey and it is probable that much of it is unique in character. Moreover, many of the problems encountered and results found are very relevant to the implementation of Hospital Activity Analysis (Benjamin, 1965) which is being intoduced into an increasing number of hospitals. A report has been submitted to the Governors of the Hospital but it seemed worth-while to make the more interesting aspects of the study available to a wider readership. This article is the first of a series devoted to this end; it contains a brief description of the study and presents a few results relating to in-patient spells. It is hoped that subsequent articles will deal with waiting list information, occupancy, and the analysis of lengths of stay.

Description of the Study

The study ran from 8 March 1965 to 6 March 1966 and covered all the major in-patient departments except obstetrics and gynaecology. The admissions problem for maternity is rather special, while gynaecology overlaps with it at St. Thomas's. Private patients and staff were also excluded.

Some routine data, such as the bed occupancy returns, were preserved, but the main item of information was a summary form raised in respect of each actual or prospective admission. (Bennett (1966) found in a previous sample survey that about 16% of a year's admissions to St. Thomas's are re-admissions within the year.) The information recorded on this form (subsequently punched onto an 80-column card) included the sex, age, and address of the patient. A section for waiting list cases recorded a provisional diagnosis and details of letters and telegrams offering admission. In-patient data recorded included the admission ward, consultant, source of admission, details of ward transfers, time of operation, dates of admission and discharge, and some sociological information. Altogether up to nine dates were provided for; to deal with the resulting complications and to obtain the maximum information the Atlas MVC tabulating system was used for the analysis (Colin, 1964). Many methodological problems—not least those of definition—were encountered and these are more fully discussed in the report. To facilitate the testing of hypotheses about observed phenomena, the data were split by sex and analysed in two parts.

Admissions

Table I shows the total numbers of admissions

TABLE I

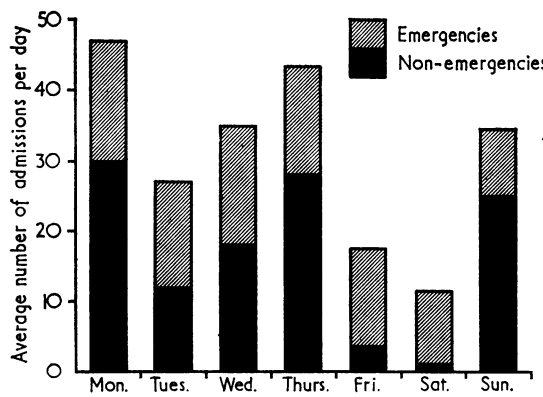
NUMBERS OF PATIENTS ADMITTED TO ST. THOMAS'S HOSPITAL DURING THE STUDY YEAR

Source of Admission	M	F	Total	%
Booked cases*	315	301	616	5·5
Unbooked waiting list*	2,893	2,508	5,401	48·1
All waiting list	3,208	2,809	6,017	54
Emergency bed service†	221	229	450	4·0
General practitioners†	110	99	209	1·9
O/P departments	374	273	647	5·8
Casualty	1,856	1,213	3,069	27·3
Other emergencies	240	202	442	3·9
All emergencies	2,801	2,016	4,817	43
Transfers	168	142	310	2·8
Unknown	48	33	81	0·7
All admissions	6,225	5,000	11,225	100

*Approximate figures
†Estimated from E.B.S. returns

from different sources. It will be seen that rather less than half are emergencies, the proportion being slightly higher for males (45%) than for females (40%). The sexes were in the ratio $1\frac{1}{4}$:1 but it must be remembered that the females excluded maternity and gynaecology cases. A comparison of the 'case-mix' at the hospital with national patterns suggests that St. Thomas's is fairly typical of the hospital service as a whole in those specialties for which it caters, although the E.N.T. Department is, perhaps, unusually large, with over 1,000 admissions a year.

The Figure depicts the average numbers of admissions which were emergency and non-emergency on different weekdays. As would be expected, there are enormous differences in the non-emergency numbers, reflecting the effect of differing daily routines. Not so obvious, but nevertheless discernible, are the differences in emergency admission



FIGURE—Average numbers of admissions per day.

rates: the mean rate for both Saturdays and Sundays falls to about two-thirds of that for weekdays. The latter also exhibit significant differences among themselves, Monday and Wednesday having slightly higher rates than Tuesday, Thursday, and Friday. This finding contrasts with those of other investigators (*e.g.*, Newell, 1954) and results from the quantity of data analysed. However, there is no inherent reason why any two days should have identical emergency rates, and the grouping is largely a matter of convenience in that it reduces the amount of information to be assimilated.

The figures may, of course, be split by specialty. Although the resulting information is not of very general interest, such figures are of use in assessing the efficiency of admitting arrangements. For instance, it was found that the general medical firms admitted 75% of their waiting list patients on Mondays or Thursdays, which obviously puts extra pressure on their beds on those days. The surgical firms, however, even though they are more tied to particular days by theatre allocations, achieved both separately and together a much more even spread of waiting list admissions through the week.

A question of great statistical interest is whether emergency admissions are purely random occurrences. If they are (and provided the rate of admission fluctuates only in a regular fashion), then the numbers of emergencies observed should follow the well-known Poisson distribution (see Newell, 1954). It is a feature of this distribution that its mean equals its variance (*i.e.*, the square of the standard deviation), so that any significant departure from this equality could indicate a degree of non-randomness. More specifically, an increase of variance might indicate a non-uniformity of admission rate week by week; while a decrease could indicate that some measure of control is exercised, *i.e.*, that at the end of a busy day some 'emergencies' are less likely to be admitted.

A dispersion test (Kendall and Stuart, 1967, p. 579) reveals that only on Thursday is the variance suspiciously small. Although the evidence is not very conclusive it is worth remarking that Thursday night has the highest occupancy at St. Thomas's so that there could be some case rejection for this reason.

Goodness-of-fit tests were executed to see if the shapes of the distributions were reasonably Poisson-like. One test out of the six was significant at the 5% level, but this was due to a surfeit of days with eight admissions. No other simple theoretical distributions would explain this phenomenon better and the result may safely be ascribed to chance.

Thus, provided the weekdays are grouped together

as described, the Poisson distribution appears to provide an adequate description of the pattern of arrival of non-waiting-list patients.

Ward Transfers and Operations

Table II shows that a total of 806 ward transfers were recorded in the study year. This seems surprisingly low, especially when it is observed that there are two surgical emergency wards, from which 62% of the first transfers take place. Even of the surgical emergencies, the great majority are not transferred at all. It will be seen that waiting list cases are transferred twice almost as often as once, which is due to the patients reverting to their original ward after a change of treatment regime or a visit to the intensive care unit. It was also found that 'expedited' patients, *i.e.*, emergencies off the waiting list, have more transfers per case than other emergencies, which supports the conjecture that these admissions are frequently for different conditions and consequently under different firms and on different wards from the waiting list recommendation.

TABLE II
WARD TRANSFER FREQUENCIES: DISCHARGED PATIENTS

No. of Transfers	Emergency		Non-emergency		Total	
	No.	%	No.	%	No.	%
0	4,545	88·8	5,921	98·0	10,466	93·7
1	535	10·4	65	1·1	600	5·4
2	36	0·7	55	0·9	91	0·8
3	4	0·1	2	0·0	6	0·1
6	1	0·0	0	0·0	1	0·0
No. of cases	5,121	100	6,043	100	11,164	100
Total transfers	625		181		806	
Transfers/case	0·122		0·030		0·072	

Table III shows the times from admission to the first operation split by specialty. It will be seen that about 7·8% were performed on patients admitted to a medical firm and that the time to operation of these cases is considerably higher than for admissions to surgical firms. This suggests that these are patients who are referred to a surgical firm, possibly after a lengthy review. Table III also demonstrates the important effect of age on the time to first operation, the obvious implication being that much more care is exercised before operations on older patients.

An analysis of the weekdays on which firms operate is of more local than general interest. Under 5% of first operations were carried out on Saturdays or Sundays and, with the possible exception of one surgical firm, these are probably confined to emergency cases. Friday was the busiest day over-all with 21% of the cases, although it was the slackest among the general surgical firms. The figure for Monday was only around 16% and this seems to represent an unevenness of the theatre load which it should be possible to even out.

Discharges

Destination on discharge is one of the less reliable pieces of information recorded. Apart from the general difficulty that a destination (being in the future) is always less certain than a source of admission (being in the past), there is a tendency to under-record patients going to a convalescent home. This is because they sometimes go home first for a short while. Yet this is quite an important matter from the sociological point of view.

To check on this point the medical social workers kindly provided a list of a quarter's discharges known to be destined for a convalescent home. An analysis of this information indicated that the ascertainment in the survey was some 82%. Using this percentage to adjust the estimates, it was found that over 85% of patients went home to stay. The

TABLE III
DISTRIBUTIONS OF TIME TO FIRST OPERATION BY SPECIALTY AND AGE

	General Surgery	Medical Firms	Other	Years of Age					All
				<5	5–14	15–44	45–64	65+	
	%	%	%	%	%	%	%	%	%
Days 0	16·1	4·3	10·8	18·8	16·0	16·1	8·1	8·7	12·6
,, 1	31·4	10·5	66·7	61·9	69·0	45·0	40·6	39·3	46·5
,, 2	17·3	5·2	7·3	7·3	5·8	13·3	13·1	11·7	11·8
,, 3	10·6	5·2	3·0	2·9	2·7	6·4	9·1	6·8	6·7
,, 4	7·0	6·2	2·5	0·7	1·9	4·0	6·6	6·9	4·8
,, 5–7	7·7	14·0	3·5	2·4	1·6	5·3	7·4	10·8	6·2
1–2 weeks	7·2	30·8	3·6	3·2	1·6	6·2	9·6	10·2	7·2
Over 2 weeks	2·7	23·9	2·6	2·7	1·2	3·7	5·6	5·5	4·2
Mean ± standard error	3·0 ±0·09	10·9 ±0·51	2·2 ±0·09	2·2 ±0·29	1·6 ±0·16	2·9 ±0·12	3·9 ±0·13	4·2 ±0·22	3·3 ±0·07
Median	1·1	8·0	0·6	0·7	0·5	0·8	1·1	1·2	0·8
No. of cases	2,753	465	2,870	409	667	2,078	1,922	922	5,998

average age of the 3·1% who went to a convalescent home was about 55 years as opposed to about 41 years for discharges as a whole. The death rate (about 4·7% over-all) showed a significant increase from 4·3% to 5·8% in the winter quarter (Nov.–Jan.).

Discussion and Conclusions

Although of some intrinsic interest, the figures given above for frequencies of admissions, discharges etc. need to be related to other concepts such as waiting list length, length of stay, and occupancy before any very important conclusions can be drawn. These topics and their interpretation will feature in subsequent papers. By anticipating these discussions, however, certain points may be profitably elaborated.

It is a feature of complex organizations that variability plays an important role, and hospitals provide no exception to this general rule. Apart from the largely financial problems of providing sufficient resources to satisfy the mean demand made upon them, the administrator's main headaches can be ascribed to such variability. Thus, in the use of beds, for example, it is a common experience that different wards may be over-full and partly empty on the same day. The particular problem of variation of bed occupancy level is due to two broad classes of factor—random and organizational.

By organizational variation is meant the variability that is introduced by the non-uniformity of hospital routine throughout the week. Thus, even if operating loads were constant from week to week, there could still be enormous variation from day to day due merely to the irreconcilable preferences of individual surgeons. Admitting days also tend to be only once or twice a week for one firm, and if these are not properly matched with those of other firms more variability will result.

To some extent these problems are inevitable and result from a preference for 'batch processing' as well as from a social pattern of activity which does not allow the possibility of week-end working. In as much as pre-operative preparation is required, repercussions from the week-end are felt on Mondays and even later. It should be the objective of management, however, to even things out as far as possible within these constraints. One of the by-products of extensive information—especially if weekdays are easily available in the tabulations—should be the highlighting of 'hot-spots' and possible remedies by re-organization.

Random variation is introduced into the hospital largely as a result of emergency admissions on the one hand and of unpredictable discharges on the other. Moreover, the unpredictability is worse in the case of emergencies, since no prior knowledge of likely length of stay is available and the course of treatment is less certain. It follows that the proportion of emergencies admitted is of key importance. It is no surprise to find that the proportion of emergencies observed for medical cases (73%) exceeds that for surgical cases (42%): indeed, the percentage of immediate medical admissions obtaining at St. Thomas's is less than has been found elsewhere, for example the 86% for the Oxford Region in 1965 (Barr, 1968). The fact that about a quarter of St. Thomas's medical admissions cannot be regarded as emergencies implies that statistical models ignoring this proportion are unlikely to be of great usefulness without modification.

As regards the shape of the emergency admission distribution, the fact that this is adequately fitted by the Poisson distribution is of great theoretical importance (see Pike, Proctor, and Wyllie, 1963, for instance). The practical implication of a departure from the Poisson distribution was discussed above and it is agreeable to find only scanty evidence of case rejection even on the busiest day.

The analysis of the effect of random variability over a period of time is of considerable mathematical complexity. It would not be appropriate to discuss the associated problems in this paper; the purpose of the above discussion is to outline the philosophy in the light of which the survey was carried out and the results are presented.

Summary

A one-year survey at St. Thomas's Hospital is described and its objectives are outlined. After discussion of the methodological problems involved, the more general results relating to individual patient spells are presented. The information covers admissions, ward transfers, operations, and discharges. Problems of organizing hospital admissions are considered to arise very largely from variation and are briefly discussed from this standpoint. Results relating to patients on the waiting list and detailed analyses of bed occupancy and length of stay will appear in subsequent articles.

I wish to acknowledge my indebtedness to the large number of people who were involved in the organization and analysis of the survey described, but especially to G. J. Draper and J. M. Bevan, who initiated and designed it. I am also grateful to the Governors of St. Thomas's Hospital, London, for permission to publish the results, and to the Nuffield Foundation, the United Oxford Hospitals and the Oxford Regional Hospital Board for financial support.

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