SOME ADMINISTRATIVE ASPECTS OF BED UTILISATION

IN GENERAL HOSPITALS

by David Morris

A Thesis submitted for the Degree of M.D.

University of Edinburgh

April 1968
<table>
<thead>
<tr>
<th>Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>2</td>
</tr>
<tr>
<td>Hospital Development and Bed Utilisation</td>
<td>8</td>
</tr>
<tr>
<td>The Historical Background</td>
<td>8</td>
</tr>
<tr>
<td>The Level of Provision</td>
<td>14</td>
</tr>
<tr>
<td>The Critical Number</td>
<td>17</td>
</tr>
<tr>
<td>Supply and Demand</td>
<td>24</td>
</tr>
<tr>
<td>Need and Demand</td>
<td>28</td>
</tr>
<tr>
<td>Future Planning</td>
<td>31</td>
</tr>
<tr>
<td>Statistics of Bed Utilisation</td>
<td>39</td>
</tr>
<tr>
<td>Sources of Data</td>
<td>39</td>
</tr>
<tr>
<td>Administrative Statistics</td>
<td>43</td>
</tr>
<tr>
<td>Basic Utilisation Data</td>
<td>44</td>
</tr>
<tr>
<td>Derived Indices</td>
<td>49</td>
</tr>
<tr>
<td>Interrelationships</td>
<td>50</td>
</tr>
<tr>
<td>Relevance of Indices</td>
<td>57</td>
</tr>
<tr>
<td>Use of Statistics</td>
<td>61</td>
</tr>
<tr>
<td>Increasing Bed Utilisation</td>
<td>63</td>
</tr>
<tr>
<td>Admissions from the Waiting List</td>
<td>65</td>
</tr>
<tr>
<td>The Value of Supporting Beds</td>
<td>76</td>
</tr>
<tr>
<td>Provision of Operating Theatres</td>
<td>83</td>
</tr>
<tr>
<td>Control of Emergency Admissions</td>
<td>90</td>
</tr>
<tr>
<td>(a) Validation Studies</td>
<td>92</td>
</tr>
<tr>
<td>(b) Effects of Admission Schedules</td>
<td>97</td>
</tr>
<tr>
<td>(c) Estimation of Parameters</td>
<td>102</td>
</tr>
<tr>
<td>(d) Rationalisation of Emergency Admissions</td>
<td>107</td>
</tr>
<tr>
<td>Conclusion</td>
<td>113</td>
</tr>
<tr>
<td>Appendix</td>
<td>119</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>121</td>
</tr>
<tr>
<td>References</td>
<td>122</td>
</tr>
</tbody>
</table>
The aspects of hospital service administration from which the utilisation of beds is considered are the planning and development of the hospital service, the statistical assessment of bed utilisation, and some of the operational factors which might be expected to affect levels of bed utilisation.

In relation to planning, methods of assessing bed requirements are reviewed, and detailed consideration is given to statistical techniques which have been evolved for this purpose. The relevance of data concerning bed utilisation to hospital development is discussed.

Sources of statistical material concerning hospitals in England and Wales are considered, and the shortcomings of currently available data relating to bed utilisation are discussed. Mathematical relationships between the various indices of bed utilisation are presented; and the relevance of these indices in administrative practice is discussed.

The problems of ensuring the admission of patients from the waiting lists are dealt with in relation to a study of such admissions, and the need for revision of admission procedures is argued. Consideration is given to the hypothetical effects upon bed utilisation of the use of pre-convalescent and other supporting beds, and shortages of operating theatre facilities.

A study of the effects upon bed utilisation of arrangements for the admission of emergency cases is described; this study is based upon the use of computer simulation techniques. As an alternative to simulation, mathematical formulae are developed, whereby various parameters of emergency bed occupancy may be estimated. The possibility of rationalisation of emergency admissions in urban areas is discussed.
The current active investigation of the hospital service and its workings reflects a response to many stimuli, each manifested in a different area of social activity. In Britain, the onus of planning and developing the service represents much of the work of government departments and Regional Hospital Boards; the replacement of obsolete accommodation with facilities suitable for the practice of contemporary medicine has led to the growth of a new specialism within the field of architecture; interest in the overall medical care of the community, and consideration of the role which could or should be played by the hospital service has activated academic departments, particularly in social and community medicine; problems associated with optimisation of the use of financial resources have interested economists; and subjective experience of the present shortcomings of the service, with long waiting lists, inadequate out-patient services, and in-patient services characterised by extreme variability in standards of care, accommodation, and staff attitudes, have aroused public interest.

In consequence, there is a large and growing volume of literature, dealing with the attitudes, opinions, and research findings of doctors, nurses, statisticians, architects, sociologists, psychologists and economists in relation to the hospital service and its functions. Of the many professional groups whose activities might impinge upon the hospital service, the only one which appears to have been reluctant overtly to discourse upon the service and its problems has been the group most intimately concerned - the hospital administrators themselves. The paucity of research into circumscribed administrative problems is the more apparent because many of these problems, albeit narrow in ambit and localised in influence, may be more readily
amenable to immediate solution than the wider issues of organisation and function with which the health services are now confronted.

The application of operational research techniques to the study of the hospital service has already produced much valuable information, even within the comparatively short time during which such studies have been carried out. These investigations are an important complement to the broader studies, whose primary concern is to consider the hospital service as one of a variety of alternative methods of providing facilities for health care. It is of the utmost importance that the hospital be properly integrated with the rest of the facilities for health care; it is of no less vital importance that the hospital service function efficiently within itself.

Consideration of the factors which contribute to the functional efficiency of the hospital service can only start within the hospital.

It is axiomatic that hospital operational research differs from industrial operational research in the necessity to deal with patients rather than inert, inanimate products. However, a consuming concern with the patient and his welfare may occasionally cloud the issue. Some research projects have approached the problems of the hospital service from consideration of the patients and how they use the service, rather than from consideration of the service and how it might be improved for the benefit of the patients. Because of the ascendancy of the interest in demographic data, the methods of collecting hospital statistical material, which are now under development in Britain, are misnamed. Although valuable in other contexts, data relating to the age, sex, marital status, occupation, residence and diagnostic grouping of patients, as recorded for Hospital Activity Analysis, have little bearing upon "hospital activity"; while other parameters, such as bed turnover rates and detailed analyses of the
utilisation of operating theatres, radiodiagnostic facilities and laboratory services, are recorded inaccurately, if at all.

It is not intended in any way to asperse the investigations of the hospital service which have been carried out by workers from outside the hospital field, nor to minimise the value of detailed information concerning the users of the service. But much of the value and relevance of this material is lost in the attempt to effect its metathesis to service administration. Only very recently have projects been undertaken which were primarily concerned not with the patient or the community, but with the hospital and the efficiency of its administration and utilisation. The use of computer simulation techniques, started at Oxford, and now in use at Lancaster, Bradford and Sheffield, may herald the general application of research methods, proven in science and industry, to the solution of administrative problems in hospitals.

Increasing the functional efficiency of the hospital service, while directly justifiable in economic terms, also has wider implications in the field of hospital service development. It is improbable that resources of personnel or materiel will ever be sufficient amply to provide for all of the demands for hospital care; so that prodigality in provision based upon considerations of inefficient utilisation, or wastage resulting from administrative inadequacy, must entail unnecessary exiguities in some sectors of the hospital service.

It is prudent, however, to ensure that the search to improve the efficiency of hospital utilisation is illuminated by a realistic appraisal of the issues involved. Broad assertions concerning certain measures of bed utilisation, and the hostile rejoinders evoked by them in the correspondence columns of medical and administrative journals,
suggest a yet unfulfilled need for accurate and appropriate statistical assessments of the efficiency of bed utilisation; the additional value of such statistics in routine administrative practice is obvious. Potential improvements in efficiency and economy deriving from reductions in the duration of patient stay are regularly proclaimed; the underlying intention is unexceptionable, but the unqualified choice of duration of stay as the index of utilisation of in-patient facilities invites criticism, particularly when it is possible that other means afford a more immediate prospect of achieving efficiency and economy. The primary object is to increase in-patient turnover, but shortening the duration of stay is only one method whereby this end may be achieved. Even where it is practicable, the efficacy of shorter hospital stay is not disjunct, but depends upon a sequence of further administrative activity whose ramifications may involve several aspects of the utilisation of personnel and materiel.

Patterns of hospital utilisation are subject to continuous modification, and one of the most important of the recent developments has been the increasing use of out-patient facilities for the investigation and treatment of patients who might have been dealt with, in earlier years, as in-patients. Given suitable facilities and administration, there is considerable scope for further development in this field, so that in-patient care as it now exists will come to assume a less significant role in the overall pattern of hospital care. Paradoxically, the effect of such developments may well be to increase the importance of proper consideration of the use of in-patient facilities. During the past twenty years, it has been possible substantially to increase the numbers of patients treated in hospital, without any comparable increase in available resources. That this
increased turnover is a direct result of the need to provide for continuing and increasing demand for hospital care is unquestionable; but if the currently encountered pressure on in-patient facilities is progressively transferred to out-patient departments, a conscious effort will be required to maintain such efficiency in bed utilisation as presently exists.

Accepting that developments of this nature will affect the interrelationships between hospital in-patient care and other forms of medical care, there remains the administrative problem of ensuring that the available in-patient facilities are used to the best effect. Many facets of clinical administration pose questions, on the answers to which the efficacy of administration depends. What factors deter waiting list patients from accepting beds when they are offered, and how can the influence of these factors be mitigated?; does the use of pre-convalescent beds enable better use to be made of acute general beds, other than to the extent attributable to increased bed availability?; how far is bed utilisation in surgical departments affected by the availability of operating theatre facilities?; is it possible to overcome the problems of bed utilisation arising from the need to provide accommodation for emergency admissions? These, and many similar questions must be answered fully if the efficiency of hospital administration is to be improved. A greater volume of operational research might profitably be directed to the consideration of such specifically administrative topics.

It is the purpose of this thesis to consider hospital bed utilisation from the viewpoint of service administration. The inadequacies of the bed as the unit of provision of in-patient facilities have been amply discussed by Newell (1964 (a)). Too narrow a view may obscure deficiencies in the provision and utilisation of such other facilities as laboratories and radiodiagnostic
services, and ignore the entire problem of staffing establishment. Yet, "it may be emotionally more satisfying to use human units, doctors, nurses and ancillary staff, but their availability is not as closely linked to patient care as is the bed. One doctor can serve many or few patients, the bed can serve just one...If its limitations as a unit are always borne in mind, it can be very useful". The aspects of bed utilisation which will be discussed are its relevance to hospital planning and development; the problems currently associated with its accurate statistical assessment, and the application of these statistics to administrative practice; and some of the measures which might be expected to improve the efficiency of bed utilisation.
HOSPITAL DEVELOPMENT AND BED UTILISATION

As the provision of hospital accommodation in Britain has proceeded from the era of random benefaction, through varying measures of statutory provision and voluntary co-ordination, to public ownership and governmental control, the necessities of first integrating the service and then planning its rational development have become apparent. At various stages, the question whether the existing services were adequate has elicited emphatic negative replies; this is perhaps the greatest difficulty encountered in hospital development. "Even the end to be attained is shrouded in doubt, let alone the means...if the aim is to provide an adequate service, what is the criterion of adequacy?" (Forsyth and Logan, 1960).

Inherent in the intention to provide a service characterised by appropriate quantity and equable distribution is the necessity to examine past and present patterns of hospital utilisation, in order to assess the future patterns which must be sought after. In the following paragraphs, some aspects of the provision of hospital services will be considered, with particular reference to the significance of bed utilisation in the planning process.

The Historical Background.

Since the advent of the National Health Service, it has been possible to undertake the large-scale planning of British hospitals in a co-ordinated manner, as a result of state ownership with ultimate governmental control. In the United States, appreciation of the need for integrated areal planning gave rise to the programmes sponsored by the larger charitable foundations, and eventually to the
Hospital Survey and Construction Act (the Hill-Burton Act), which, in 1946, authorised federal financial support for state agencies undertaking surveys of existing facilities and planning the long-term development of the hospital services. In both countries, however, the hospital facilities in existence at the time of the enactment of this legislation had developed without any system of rational planning. While the earliest hospitals had clearly fulfilled some measure of community need, many of the hospitals established during the nineteenth century were provided without any consideration of such factors as functional and geographic situation in relation to similar services already in existence, or to the medical care requirements of the community as a whole.

The development of the hospital service in Britain, from the medieval monastic hospice to the modern district general hospital, has been a process of gradual evolution, tramelled in its early stages by the effects of the English Reformation, and accelerated in its later stages by the awakening of social conscience and the application of scientific disciplines within medical practice. The establishment of shelters for the ailing and indigent was prompted by Christian charity, but insofar as the more prosperous members of the community preferred to be nursed through illness in the comfort of their own homes, hospitals were regarded, even as recently as a hundred years ago, as the last refuge for those unable to provide for themselves medically or socially. This attitude was reflected in the standards of accommodation and care provided, and in the often repressive regulations imposed as a condition of residence.

Although broader humanitarian principles, activated by the plight of the increasing urban populations of the Industrial Revolution, led to considerable expansion of the voluntary hospital
movement, there was no question of planning in the provision of hospital services. Abel-Smith (1964) has suggested that, even in the massive expansion of the hospital service which took place in the first half of the nineteenth century, no thought was given to any type of co-ordinated development, and the needs or interests of the patient were often the last consideration in the decision to establish hospitals. The inadequacies of the service were emphasised by the revision of the Poor Law in 1834. The attempt to discourage able-bodied pauperism effectively increased the populations of both the workhouse infirmaries and the voluntary hospitals, exacerbating the unsatisfactory conditions which prevailed in establishments of both types.

The ensuing hospital reform movement resulted in very considerable improvements in the hospital facilities provided, primary consideration being given to the proper training of nursing staff, and the application of the principles of hygiene to hospital construction. This movement was only one aspect of the contemporaneous social reform occurring in Britain and abroad; and while hospital reform may have received added impetus from events occurring in Britain, its general influence throughout Western society is evident from the work of Dix in the United States and of Fliedner in Germany, similar to that of Nightingale in Britain. Not only did this movement enable hospitals to fulfil Miss Nightingale’s criterion, that they "should do the sick no harm", but "the introduction of hygiene and efficiency made possible the development of hospitals which were of positive benefit to their patients" (Abel-Smith, 1964).

There was a parallel growth in the benefits deriving from medical science. The advent of anaesthesia widened the scope of surgery, and the introduction of antiseptic and aseptic techniques added to the necessary element of safety; towards the end of the century
diagnostic procedures were enhanced by the growth of radiology.

These factors transformed the hospital from the haven of the destitute sick to an institution whose services were actively sought. "Suddenly the facilities provided charitably for the poor became superior to anything which could be arranged for rich people in their own homes" (Duncum, 1964). Inevitably, the demand for hospital care increased, with a resultant explosive increase in the provision of beds. Between 1861 and 1911, the numbers of hospital beds in England and Wales were multiplied threefold (Pinker, 1966). The increasing demand also drew attention both to the overall level of provision of hospital services and to their relative siting and distribution. The earliest attempts to co-ordinate the provision of hospital facilities were made by the House of Lords Select Committee on Metropolitan Hospitals, established in 1890, and by King Edward's Hospital Fund for London, whose activities originally commenced in 1897. These efforts were confined to London, however, and were attended by only limited success. Throughout the rest of the country, the provision of hospital facilities was effected in the piecemeal establishment of voluntary hospitals, with the Poor Law Infirmaries acting as a supplement in the more enlightened areas.

The Report of the Royal Commission on the Poor Laws in 1909 "had recommended that a co-ordinated hospital service was essential" (Abel-Smith, 1964), but even the First World War and its effects upon the demand for hospital accommodation evoked no attempt to achieve such co-ordination. Not until the Dawson Report (Ministry of Health, 1920) appeared was serious consideration given to the problem. This Report expressed the view that "the organisation of medicine has become insufficient, and... fails to bring the advantages of medical knowledge adequately within reach of the people...The
general availability of medical services can only be effected by new and extended organisation, distributed according to the needs of the community. It was recommended that the hospital service be re-organised as a system of primary and secondary health centres, providing general and specialist facilities respectively. A combination of direct opposition, political turmoil, and unwillingness to undertake the necessary public expenditure prevented any part of the report being implemented.

In 1921, the Report of the Voluntary Hospitals Committee (the Cave Committee) observed that "the present lack of organisation and co-operation among the voluntary hospitals not only detracts from their efficiency, but is the cause of much avoidable expenditure. These institutions, which should be parts of a connected system, are for the most part units working in isolation or in competition with one another". This Committee recommended the establishment of the Voluntary Hospitals Commission (the Onslow Commission), which reported in 1923, endorsing the need for co-ordinated provision of hospital services, and recommending state financial aid for the provision of additional accommodation. Although the Commission had some effect in stimulating closer co-operation between voluntary hospitals in such provincial centres as Liverpool, Manchester, Birmingham and Sheffield, the response was generally poor, there was no direct government support, and the Commission was disbanded in 1928.

The problem was aggravated by the wider establishment of municipal general hospitals, following the Local Government Act of 1929. By this time, there was developing an awareness of the advantages to be derived from regional organisation, and in 1935 the British Hospitals Association established a new Voluntary Hospitals Commission (the
Sankey Commission) whose report was published two years later. This report advocated the establishment of a formal regional administration for hospitals, to include organisation of waiting lists, improvements in the utilisation of available beds, and the supervision of such services as blood transfusion, ambulances and supplies. Also envisaged was a rationalisation of hospital provision in terms of size and siting (Ross, 1952; Abel-Smith, 1964). Although this report received the qualified approval of the medical profession, it was coolly received by the government.

The out-break of the Second World War had a profound effect upon the British hospital service. "In a sense the hospitals were temporarily nationalised. New buildings were erected and old ones renovated. Special treatment centres were established...X-ray, surgical and other medical facilities were improved...at least 50,000 beds were added to the hospital service...and in general a measure of co-ordination among the hospitals was achieved. The emergency scheme...demonstrated what central government could accomplish through planning and financial assistance" (Lindsey, 1962). While the opportunities afforded by the governmental control necessary for the implementation of the Emergency Medical Service were not, perhaps, fully appreciated, it became clear that a return to the financial and administrative situation prevailing before the war was impossible. Towards the end of the war, exchanges between the government, the medical profession, the voluntary hospitals, and the local health authorities culminated in the White Paper (Ministry of Health, 1944) advocating regionalisation of future development of the hospital service, without interference in internal administration.

Following the appointment of Aneurin Bevan as Minister of Health after the 1945 General Election, there evolved the policy of complete
governmental control and co-ordination manifested in the National Health Service Act. In presenting the Bill for its second reading, Bevan stressed the previous lack of integration in the hospital service, pointing out that "our hospital organisation has grown up with no plan, with no system; it is unevenly distributed over the country...In the older industrial districts of Great Britain hospital facilities are inadequate".

In retrospect, many of the detailed provisions of the National Health Service Act, particularly those concerned with administrative organisation, have been seen to require modification. So far as the hospital service is concerned, however, its enactment enabled the development of an integrated system of hospital planning and provision, the need for which had been apparent for more than half a century.

The Level of Provision.

At least twenty years before the co-ordination of hospital development became a practical possibility, interested had begun to grow regarding the level of provision of hospital accommodation required in the community. Palmer (1956) reviewed much of the early literature on this subject, and revealed a striking consistency in the numbers of general beds which the various authors considered to be appropriate. Although the estimates for acute general beds varied between 2.5 and 9.0 per thousand of population, the vast majority of writers favoured a level of provision lying between 4.5 and 5.0 per thousand population.

During the Second World War, surveys of English hospitals were carried out jointly by the Nuffield Provincial Hospitals Trust and the Ministry of Health, in order to "gather information about the hospital facilities normally available" and "to assess the adequacy.
of the facilities" (Ministry of Health, 1945). Here again, there was a considerable measure of consistency in the levels of provision thought to be necessary by the experts conducting the surveys. In the Sheffield and East Midlands Area, and in the Yorkshire Area, it was suggested that 4.0 acute beds per thousand of population were required, while the survey of the South-Western Area recommended 4.6. For London and the Surrounding Area, three estimates ranging from 4.5 to 6.4 were given.

Another report based upon expert opinion was the memorandum on "The Development of Consultant Services" (Ministry of Health, 1950), which, in addition to prescribing patterns of consultant staffing, also indicated levels of provision of hospital accommodation which might be achieved. The estimates lay between 6.3 and 7.2 general beds per thousand population, but these figures included no provision for the chronic sick, tuberculosis, infectious diseases, or any of the specialties such as cardiology and plastic surgery which are arranged on a regional basis. While all of these reports were necessarily dependent upon expert opinion, the wide variations in some of the recommended levels of provision prompted a search for methods of assessment which were more "scientific".

The earliest statistical technique to be applied in hospital planning was that developed in the United States by the Commission on Health Care (1947). Using national vital statistics, the Commission demonstrated a high correlation between the numbers of deaths occurring in hospital and the use made of hospital beds. From this was developed the "bed-death ratio", which indicated that "for each hospital death 0.7 bed is used for one year". On the premise that "for the nation as a whole an average level of hospitalisation whereby 50% of all deaths would occur in general hospitals would appear to be
well within reason", the application of the bed-death ratio to 50% of the national mortality rate provided the number of general hospital beds required. This number represented beds at full occupancy, necessitating an incremental adjustment so as to allow for practicable levels of occupancy. The method was adopted for hospital planning in New York, although the ratio applicable to the mortality rate was modified to 0.41, obviating the need for any of the adjustments described (Klarman, 1966).

While this method may have seemed plausible, it was dependent upon several assumptions, most of which relate to utilisation. The relationship between levels of hospital utilisation and mortality is hardly surprising; although the closeness of the association may have been enhanced in the Commission's Report by the use of data averaged for each of the 48 states. While the bed-death ratio assumes a mean of 0.7, the report indicates that variations occur. "Teaching hospitals usually have high ratios...because they often keep patients longer than other general hospitals. Some governmental general hospitals have low ratios because they hospitalise many accident cases and many people who die only a short time after reaching the hospital". Further, the hospitals "serving white people have high ratios and those serving Negro people have low ratios". Thus, the use of a ratio of 0.7 implies uncritical acceptance of the prevailing average pattern of utilisation and its perpetuation in future hospital services.

Again, the adoption of the figure of 50% for the proportion of deaths occurring in hospital is "a matter of judgment". The Commission recounts that, in the decade preceding the preparation of its report, the proportion of deaths occurring in United States hospitals increased from 30% to 50%. In view of the reported relationship between hospital utilisation and mortality, it would not be surprising if the
bulk of this increase in "hospitalised mortality" between 1930 and 1946 were attributable to concomitant increases in the availability and utilisation of hospital services. Since "the percentage is higher in some small areas and in some cities", the adoption of 50% as "a reasonable goal for the nation...not so high but that it is within reasonable limits of attainment", pays little heed either to observed secular trends or to possible further increases in utilisation.

Deciding upon levels of bed occupancy rate in calculations of this nature is a procedure fraught with difficulty; this aspect of the problem will be dealt with when bed utilisation statistics are discussed. It is, however, worth noting that the application of this technique in calculating the number of general hospital beds required in the United States at the end of the war produced the familiar figure of 5.0 beds per thousand of population.

The other main method used to calculate general hospital bed requirements in the United States is that advocated by the American Hospital Association and Public Health Service (1961), which is, in essence, identical with the Critical Number Method developed in Britain a few years earlier.

The Critical Number.

The earliest attempts in Britain statistically to estimate levels of hospital in-patient accommodation sufficient to meet measured demands for hospital care came with a series of studies sponsored by the Nuffield Provincial Hospitals Trust. The first of these, jointly sponsored by the University of Bristol, was carried out in the areas around Northampton and Norwich (N.P.H.T., 1955), as part of a broader study in various aspects of hospital development.
For the purposes of this study, a new statistical technique was developed, which has been described subsequently by Bailey (1956; 1962). Based upon assessments of the case loads of the individual units in the hospitals involved, the method was designed to permit the calculation of the "critical number" of beds required to meet effective demand as evinced by the case load.

In the earliest of the studies which used this method, one of the primary problems consisted of the identification of the catchment populations relevant to the specialties under consideration. Since then, the development and comprehensive application of the Hospital In-Patient Enquiry has simplified the identification of such populations. At the time of these studies, however, this problem necessitated special investigations of the type described by Norris (1952) and Bailey (1962), and for this reason the studies were carried out in areas where geographical factors tended to produce fairly discrete catchment populations.

The critical numbers of beds are derived as follows:

(i) The numbers of patients requiring hospital care in the various specialties during a given period are assessed by counting the numbers of patients actually admitted during this period, and adjusting the totals by the amount of increase or decrease in the waiting lists between the beginning and end of the period.

(ii) The numbers of bed-days these patients would require is calculated by multiplying together the numbers of patients and appropriate mean durations of stay. Bailey (1962) has stressed the importance of the mean duration of stay, and believes that it is amenable to administrative control. In practice, however, it would be extremely difficult for clinicians to adjust discharge procedures so as to arrive precisely at a predetermined mean duration of stay.
In the Nuffield studies, the mean durations of stay used were those observed in current practice.

(iii) If the numbers of bed-days so derived are divided by the number of days in the period under consideration, the critical numbers of beds required to meet demand are obtained, assuming that all of these beds are fully occupied.

(iv) Because 100% bed occupancy is impossible to achieve over any prolonged period, the critical number is increased to allow for a more realistic bed occupancy rate. In all of the studies using this technique, a bed occupancy rate of 85% was used.

(v) Since, according to Queueing Theory (Bailey, 1962), the equalisation of supply and demand produces a queue, or in this instance a waiting list, of infinite length, the critical number is further increased by a small margin. In these studies, the margin used was twice the amount of the standard error applicable to the critical number.

(vi) The final stage comprises the expression of the critical numbers of beds derived for each specialty as a rate per thousand of the relevant catchment population.

Following the studies at Northampton and Norwich, in 1951 and 1952, other workers applied the same techniques elsewhere in England. Studies were carried out at Reading in 1956 (Barr, 1957), at Barrow-in-Furness in 1957 (Forsyth and Logan, 1960), and in the Tees-side conurbation in 1958 (Airth and Newell, 1962). A similar study at Luton was abandoned before completion.

Airth and Newell (1962) have suggested that the use of the critical number method in measuring demand is dependent upon the assumptions that the waiting lists are sufficiently accurate for numerical changes therein to reflect changes in the demand for in-
patient care, and that the patients who are admitted require in-patient care and remain in hospital for as long as is necessitated by medical considerations. One must also consider the tacit assumption that those who demand in-patient care are able to obtain it promptly.

That waiting lists generally contain a few inaccuracies, no matter how scrupulously they are kept, is widely recognised. In the survey of "The Hospital Services of the Sheffield and East Midlands Area" (Ministry of Health, 1945), it was acknowledged that "figures for waiting lists are notoriously inaccurate. Hospitals vary greatly in the frequency of revision of waiting lists...waiting lists may be completely inadequate as a reflection of an area's need...". The Institute of Hospital Administrators (1963) carried out a study of "Hospital Waiting Lists", which revealed wide variations in the arrangements for the maintenance and review of waiting lists in hospitals throughout Great Britain. This report raised the question whether "the number and variety of personnel responsible for keeping the lists are conducive to accuracy and reasonable uniformity...". A study of the waiting lists of the Cardiff teaching hospitals (Grundy et al., 1956) led to the conclusion that "their significance as a basis for estimating future bed requirements in the hospitals concerned is open to question".

It would seem that the most effective method of increasing the accuracy of waiting lists is to reduce the amount of time that patients have to wait before admission. Apart from the very obvious implications inherent in such a development, so far as the provision and utilisation of in-patients facilities is concerned, one can not disregard the occasional anecdotal account of intentional protraction of waiting time.

Manipulation of waiting lists is not unknown, and "consultants can inflate their lists in order to obtain increased clinical facilities..."
and accommodation or increased medical and nursing establishments" (I.H.A., 1963). Even disregarding the possibility of intentional misrepresentations, the present size of waiting lists and the rates of bed turnover in such specialties as general surgery, E.N.T. surgery, and gynaecology preclude any possibility that all centres will be able to reduce the size of waiting lists and the interval before admission to satisfactory levels in the near future. It seems, therefore, that some resulting degree of inaccuracy in waiting lists must be accepted.

Assumptions concerning ease of admission to hospital must also place in question the validity of the critical number method as a means of assessing effective demand. Patients who are in urgent need of in-patient care are sometimes compelled to wait, and occasionally do not obtain it at all. The work of Gibson et al. (1958) and Warren et al. (1967) has shown that such delays exhibit a selective effect, determined by the age and diagnosis of the patients concerned. While most emergencies of an obviously surgical nature are admitted quickly, diagnoses such as congestive cardiac failure, cerebro-vascular catastrophe and bronchitis are less "acceptable", as are elderly medical patients generally. This problem is particularly acute during the winter months, when demands for the immediate admission of patients in medical specialties are subject to sudden and marked increases (King Edward’s Hospital Fund, Annual Report, 1957). The advent of the Medical Referee in association with the Emergency Bed Bureaux can only be regarded as a desperate attempt to overcome the administrative inefficiency of admission procedures for emergency cases in British hospitals. The question of rationalisation of these admission procedures will be discussed further later in this work.

Unnecessary admissions and protraction of hospital stay are, perhaps, more a function of need than demand. However, although the
purpose of the critical number was to assess demand, these problems received detailed consideration in the Barrow study. As a result of discussions with hospital staff during periodic ward rounds, Forsyth and Logan (1960) reached the conclusion that 25% of male patients and 42% of female patients in general medical wards were "not, on clinical grounds alone, in need of in-patient care". In general surgery, the proportion of such cases was substantially lower, at 9% for both sexes.

There is no ready definition of necessity in relation to hospital care, and the extent to which the hospital service can or should accept responsibility for patients whose needs are not of a predominantly medical nature is a matter of individual philosophy. The work of Goodall (1951) demonstrated how widely value judgments can affect the apparent need for in-patient care; and Acheson and Feldstein (1964), investigating the variations in duration of hospital stay of patients treated by different obstetricians, "uncovered an important degree of variation in the use of a resource in limited supply for which no obvious reason can be found". The criteria of necessity adopted in the Barrow study were based upon somewhat idealistic assessments of the parts which might be played by general practitioners, local authority services, and hospital out-patient departments. "In fact, of course, none of these conditions applied" (Forsyth and Logan, 1960). One must question whether it is prudent to base recommendations for future hospital development upon views which are not only optimistic in nature, but may also be debatable in content.

The figure of 25% of unnecessary admissions was similar to that reported in a study by Graham and Gross (1959), which involved general medical patients at Birmingham. This study consisted of a retrospective consideration of hospital case-notes by a general practitioner, whose assessments were, once again, coloured by an optimistic view of the
possible scope of domiciliary medical services. In a subsequent study at Birmingham (Mackintosh et al., 1961), subjective assessments were made by members of the hospital staff before the patients left hospital, and the conclusion was reached that only 3.8% of medical patients "did not, on medical grounds, require admission". Some measure of comparison between these two Birmingham studies was effected by asking one of the earlier investigators to apply his original criteria to the material of the later study. Despite the 3.8% estimate of "unnecessary" admissions of the hospital staff, he concluded that there was "no diagnostic or therapeutic requirement at hospital level" in respect of 22.2% of the patients. Reconsideration of the case material by the hospital staff produced a compromise estimate of 13.3%, but the main conclusions of the study were that "the scope for reduction in frequency of admissions by improved domiciliary services and housing conditions is smaller than this figure (13.3%) would suggest"; and that "it is mainly in chronic and mental hospitals that improvements in domiciliary medical and social care can be expected to make their impact on the pattern of admission".

Because of the differing nature of the studies, and the different environments in which they were carried out, it is not possible directly to compare the results of these British studies with those carried out in the United States by Fitzpatrick et al. (1962) and Riedel and Fitzpatrick (1963). The American studies were similarly concerned with the use made of hospital services, and, in particular, with "the appropriateness of admission, length of stay, and procedures administered". In an effort to achieve complete objectivity, however, the criteria of necessity and appropriateness "were developed independently of case material, averages, and the personal concomitants of case review; they were developed by a consensus of knowledgeable specialists; they
were developed in advance of their application; and the principles of their formation were determined by the needs of the research itself for objectivity" (Riedel and Fitzpatrick, 1963). Inasmuch as they avoid any type of value judgment, the methods used in these studies might also form the basis of a continuing administrative review, in terms of patient care evaluation.

While there have been wide variations in the numbers of unnecessary admissions identified in these studies, there can be little doubt that a small proportion of the patients treated in general hospitals could manage without the benefits of in-patient care. Their significance in the context of hospital development, however, is perhaps best viewed with the fatalistic sentiments of Vines (1952), that "until domiciliary treatment is reinstated in its proper place in the scheme of the medical care of the population, it does not seem likely that any reliable relationship between the size of a hospital and that of the community it serves, can be worked out".

Thus, even if the general validity of attempting to assess demand is accepted, the assumptions underlying the use of the critical number method are not wholly tenable.

Supply and Demand.

One of the striking features of the critical number method was the close approximation of the required numbers of beds predicted by its use to the numbers of beds already available in each of the areas studied. This factor was predominant in giving rise to the reservations, concerning the value of the method, subsequently professed by those who used it. Airth and Newell (1962) discussed this finding, and presented data showing a close association between beds available in certain specialties in the hospital regions of England and Wales, and the
numbers required as calculated by the critical number method. They felt that the method was "less satisfactory, on a practical plane, than had been hoped". In discussing the problem of estimating bed requirements, Abel-Smith (1962) was moved to irony. "Despite all the talk about haphazard hospital development, it appeared that supply was nearly equal to demand. How wise our forefathers had been! Or how bad our interpretation of the statistics! What we had discovered was Say's Law. Within limits, supply creates its own demand".

This view reflected attitudes concerning the consequences of shortages of hospital accommodation, where it was assumed that general practitioners would reduce the numbers of referrals for admission, and hospital staff would reduce the duration of hospital stay. This assumption was supported by the results of contemporaneous work in the United States by Roemer (1961), who was able to observe the effects of the converse situation, of increased in-patient facilities in a community where previous levels of provision had been considered adequate. The increase in bed availability was accompanied by a parallel increase in bed utilisation, resulting from changes in the admission rate and inflation of the mean duration of stay for patients in almost all diagnostic categories. As a result of this and other, similar studies, Roemer (1964) expressed the opinion that "an equilibrium prevails...between the demand for, and the supply of, hospital beds in an area". Some qualification of this concept has been necessary in the light of the subsequent work by Feldstein (1964 (a)), demonstrating that shortage of beds is more likely to be accompanied by a fall in admission rates than by a reduction in the mean duration of hospital stay; and studies in Finland (Vaananen et al., 1967) present evidence that there may be
situations where the entire concept is inapplicable. These studies have identified a "saturation level" in respect of the hospital services utilised for the care of emergency cases, obstetric confinements, paediatric conditions, and terminal care; as might reasonably be expected, "hospital utilisation for these urgent and acute conditions does not rise with an increase in the supply of beds". Further, the accepted relationship between duration of stay and the availability of hospital facilities is upset by the observation that, where the level of hospital provision is very low, the duration of stay increases with decreasing bed availability. "Because of the small hospital capacity, only the most severe and difficult cases can be admitted, and the stays of these patients are long. On the other hand, when the relative amount of hospital capacity increases, even patients whose stay will be short are admitted".

In any case, the relationship between supply and demand is not the basis of the inadequacy of the critical number method. The real foundation of its shortcomings was touched upon in the reports of the Barrow and Tees-side studies, and subsequently by Newell (1964 (a)). As has been said, all of the Nuffield studies used an arbitrary bed occupancy rate of 85% in calculating the beds required; it is the use of this figure which obscures the deficiency in the method. Table I shows the beds available during 1965 for medical and surgical specialties in hospitals administered by the Regional Hospital Boards of England and Wales, together with the critical numbers required at 85% bed occupancy, and also at the prevailing rates of bed occupancy; the increment of twice the standard error has been omitted. It will be seen that the critical numbers required at 85% bed occupancy are closely correlated with the numbers available; the correlation coefficients are 0.987 in medical specialties, and 0.963 in surgical
Table I - Beds available in Medical and Surgical Specialties in Regional Board Hospitals; and Critical Numbers of beds required; England and Wales, 1965. (Derived from data in the Summarised S.H.3 Returns for 1964 and 1965, and the Annual Report of the Registrar General for 1965.)

<table>
<thead>
<tr>
<th>Region</th>
<th>Beds Available (per thousand population)</th>
<th>Critical Numbers of Beds Required (per thousand population)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At 85% Occupancy</td>
</tr>
<tr>
<td><strong>Medical Specialties</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newcastle</td>
<td>1.34</td>
<td>1.18</td>
</tr>
<tr>
<td>Leeds</td>
<td>1.48</td>
<td>1.30</td>
</tr>
<tr>
<td>Sheffield</td>
<td>0.90</td>
<td>0.79</td>
</tr>
<tr>
<td>East Anglia</td>
<td>0.82</td>
<td>0.73</td>
</tr>
<tr>
<td>N.W. Metropolitan</td>
<td>1.19</td>
<td>1.15</td>
</tr>
<tr>
<td>N.E. Metropolitan</td>
<td>1.59</td>
<td>1.51</td>
</tr>
<tr>
<td>S.E. Metropolitan</td>
<td>1.29</td>
<td>1.17</td>
</tr>
<tr>
<td>S.W. Metropolitan</td>
<td>1.10</td>
<td>1.01</td>
</tr>
<tr>
<td>Wessex</td>
<td>1.02</td>
<td>0.96</td>
</tr>
<tr>
<td>Oxford</td>
<td>0.81</td>
<td>0.72</td>
</tr>
<tr>
<td>South-Western</td>
<td>1.05</td>
<td>0.92</td>
</tr>
<tr>
<td>Wales</td>
<td>1.47</td>
<td>1.21</td>
</tr>
<tr>
<td>Birmingham</td>
<td>1.08</td>
<td>1.01</td>
</tr>
<tr>
<td>Manchester</td>
<td>1.23</td>
<td>1.11</td>
</tr>
<tr>
<td>Liverpool</td>
<td>2.06</td>
<td>1.86</td>
</tr>
<tr>
<td>England and Wales</td>
<td>1.23</td>
<td>1.11</td>
</tr>
<tr>
<td><strong>Surgical Specialties</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newcastle</td>
<td>1.58</td>
<td>1.40</td>
</tr>
<tr>
<td>Leeds</td>
<td>1.36</td>
<td>1.31</td>
</tr>
<tr>
<td>Sheffield</td>
<td>1.06</td>
<td>1.00</td>
</tr>
<tr>
<td>East Anglia</td>
<td>1.00</td>
<td>0.94</td>
</tr>
<tr>
<td>N.W. Metropolitan</td>
<td>1.07</td>
<td>1.10</td>
</tr>
<tr>
<td>N.E. Metropolitan</td>
<td>1.43</td>
<td>1.43</td>
</tr>
<tr>
<td>S.E. Metropolitan</td>
<td>1.47</td>
<td>1.46</td>
</tr>
<tr>
<td>S.W. Metropolitan</td>
<td>1.04</td>
<td>1.12</td>
</tr>
<tr>
<td>Wessex</td>
<td>1.26</td>
<td>1.29</td>
</tr>
<tr>
<td>Oxford</td>
<td>1.04</td>
<td>1.03</td>
</tr>
<tr>
<td>South-Western</td>
<td>1.20</td>
<td>1.21</td>
</tr>
<tr>
<td>Wales</td>
<td>1.24</td>
<td>1.45</td>
</tr>
<tr>
<td>Birmingham</td>
<td>1.21</td>
<td>1.20</td>
</tr>
<tr>
<td>Manchester</td>
<td>1.37</td>
<td>1.31</td>
</tr>
<tr>
<td>Liverpool</td>
<td>1.66</td>
<td>1.59</td>
</tr>
<tr>
<td>England and Wales</td>
<td>1.28</td>
<td>1.25</td>
</tr>
</tbody>
</table>
specialties. However, the association between the critical numbers at prevailing occupancy and beds available is even closer; the correlation coefficient is unity for medical specialties, and 0.998 for surgical specialties. The minuscule deviation from unity in the latter group is attributable to the adjustments arising from changes in the characteristically large waiting lists. Yet, despite the magnitude of the waiting lists in most surgical specialties, there is no region where the change in the size of the waiting lists during the year is sufficient to produce a difference between available beds and "required" beds greater than 3%.

Use of the critical number does not, in fact, provide any measure of demand, but allows calculation of the numbers of beds which would be required to deal with the same numbers of patients, with the same mean duration of stay, if the bed occupancy rate were to be changed from the prevailing rate to 85% or some other arbitrary figure. Where prevailing bed occupancy rates exceed this arbitrary figure, there is an apparent requirement for more beds than are currently available; and where the prevailing rates are below this figure, the apparent need is for fewer beds than are available. Seeking to achieve predetermined levels of bed occupancy is, as will be shown, neither desirable nor practicable. In consequence, it is doubtful whether the critical number method is of any more value in hospital planning than the earlier, conjectural estimates of bed requirements which Abel-Smith(196^ has described as "magic numbers".

In general, it would appear that, regardless of whether estimates of bed requirements are based upon expert opinion or currently available statistical techniques, the recommended level of provision does not differ substantially from the prevailing level. Feldstein (1963(a)) has summarised the conviction that medical practice adjusts and
acustoms itself to existing conditions in suggesting that "we can almost always find a use for more facilities and staff, and we can always get along with less"; and Forsyth and Logan (1960) pointed out that "the number of beds used is the number available". Because of the governing effect of supply upon demand, it may be inappropriate to use past or present levels of utilisation as a yardstick for future hospital development.

Need and Demand.

The critical number method, and some other statistical techniques developed for hospital planning (Querido, 1963; Klarman, 1964) base estimates of bed requirements upon the demand for hospital care. It is necessary to differentiate between demand and need. Brotherston (1962) points out "the danger that those who copy these techniques, as opposed to those who initiate them, may confuse 'effective demand' and 'need' and may come to believe that they are measuring need". Failure to draw this distinction, or loose substitution of one term for the other, is common in studies dealing with this aspect of medical care provision. Querido (1963), whose study in Amsterdam involved a technique similar to the critical number method, made no attempt to distinguish between need and demand, expressing the view that "need and capacity can be considered to be in equilibrium when...capacity is able to meet maximal demand". Similarly, Powell (1964) uses the terms indiscriminately. The confusion which can arise in this situation is shown in Klarman's (1964) discussion of hospital planning, where he states that the hospitals of New York City "have a liberal tradition of caring for indigent and medically indigent persons. Accordingly, it seemed plausible to assume that nobody who seeks hospital care in New York City goes without it. If this is so, the total volume of..."
general hospital care 'needed' in New York City is known; it is equal to the total amount used.

As in all other fields of medical care provision, the question whether hospital planning should attempt to cater for need, or demand, or either, appears to involve problems in social and economic philosophy, so that possible answers vary with the viewpoint adopted. Boulding (1966) differentiates need from demand with the view that the patient's "demand for medical care is what he wants; his need for medical care is what the doctor thinks he ought to have". This view, that the concept of need is determined by expert opinion, is supported by Feldstein (1966), who defines need as "the amount of care believed necessary by medical authorities".

Palmer (1956) suggests that "the medico-social ideal would be to have enough beds to accommodate every person needing care", and summarises the "ideal medical care situation" as that in which the attitudes of the population towards medical care are optimised, together with the quality, accessibility, and levels of utilisation of medical care facilities. "With these ideal conditions of medical care prevailing, the number of hospital beds needed in an area would be dependent entirely upon the prevalence of illness requiring hospitalisation".

She goes on to point out, however, that "an ideal medical care situation would be difficult to achieve, since there are too many determinants which can be controlled only partially, if at all".

That the satisfaction of all medical care needs is an unattainable goal is predominantly so because of the continuous expansion of the area of need. Brotherston (1962) has described this problem of "dealing with a dynamic, a shifting situation. The area of need moves with medical knowledge and social ideology". Although Davies (1962) believes that "one of the main problems with which the health service is now faced is
how to ascertain the needs of the community", it is doubtful whether any sort of measurement of need is possible with the accelerating growth of the body of medical science. "Every time a discovery is made... the horizon of need for medical care is suddenly enlarged" (Powell, 1965).

Apart from the problems inherent in its assessment, "the concept of need is often looked upon rather unfavourably by economists" (Boulding, 1966); and "among economists it is almost an article of faith that we cannot afford to do all the things that people need... No society has enough resources to meet all needs" (Klarman, 1964).

Although Powell (1966) does not differentiate clearly between need and demand, he gives an unequivocal statement of the position of some economists in this matter. "The vulgar assumption is that there is a definable amount of medical care needed, and that if this need was met, no more would be demanded. This is absurd".

The use of demand as a baseline for hospital planning presents similar problems. Paul Feldstein (1966) believes that "to plan for future use of a community's health facilities and personnel, the demand rather than the need for such resources must be projected". It is questionable whether this attitude is acceptable without the qualification that the community should be sufficiently sophisticated for demand to equal or exceed actual need, and sufficiently affluent to afford such a level of provision. After a detailed statistical consideration of various parameters indicating demand for hospital care, Martin Feldstein (1963(b)) reached the conclusion that "observed demand cannot serve as an adequate basis for planning the future provision of hospital beds", primarily because of the association between supply and demand.

In consequence, there develops the situation where a service must be provided, entailing some sort of planning, but realistic assessments
of need and demand are neither readily amenable to measurement nor practicable in application. The problem of deciding upon levels of provision remains.

**Future Planning.**

Many recent and current developments in the field of medical care will have a profound effect upon hospital utilisation in the future; but, so far as hospital planning is concerned, it is extremely difficult precisely to determine the extent of these effects. The shortening periods of hospital stay in almost all specialties and diagnostic groups suggest a diminishing need for hospital in-patient facilities, as do the trends toward out-patient and domiciliary care.

In some instances, these developments have taken place in response to existing shortages of hospital facilities. Perhaps because of this element of "cruel necessity", such procedures as the planned early discharge of obstetric patients, which resulted initially from the need to increase bed turnover, have faced the mixed reception from the medical profession described by Craig and Muirhead (1967). That there remains some opposition from the nursing profession is apparent in that "a hospital practising systematic early discharge is not considered satisfactory by the Central Midwives' Board for training pupil midwives" (Barr and Oddie, 1966). However, the manifest success of such schemes where there is an effective liaison between the three branches of the Health Service has overcome much opposition. The earlier view of this type of scheme, that, "though it might be suitable in emergency conditions, it had little part in long-term planning...may well need revision" (Brit. med. J., 1967).

In antithesis, the movement towards an active search for presymptomatic morbidity might necessitate an increase in in-patient accommodation.
The majority of those whose illnesses constitute the submerged portion of the "iceberg" of community morbidity (Last, 1963) could be dealt with in general practice or as hospital out-patients. Yet there would be some, particularly those who require surgical intervention, whose treatment would increase the in-patient load.

The long functional life of new hospitals requires that, in the planning stages, some consideration be taken concerning future patterns of hospital utilisation. It is, however, necessary to guard against too great a degree of speculation regarding the trends which may affect utilisation. In the past, the tendency has been to overestimate the effects of such trends. Titmuss (1950) has described the hardships suffered by the civilian population during the Second World War as a result of the pessimistic view taken in predicting the numbers of hospital beds which would be required for war casualties. Since the war, the continuing control and effective treatment of communicable diseases, particularly tuberculosis, have led to substantial reductions in in-patient facilities of this type; so that many former sanatoria are now occupied by geriatric patients, and isolation hospitals are being redeveloped for general use. Abel-Smith (1962) believes that "if the construction programme envisaged when the National Health Service was being planned had been carried out, Britain certainly would have built far too many hospital beds".

That a similar situation may develop in the case of more recent therapeutic advances, has been suggested by Beauman (1967). Throughout the country, intensive care units are being established for the treatment of such conditions as coronary thrombosis; but, "even with an accurate estimate of incidence, the variations in possible treatment policy are very considerable and cause wide variations in possible bed need". So far as chronic renal dialysis is concerned, "it is possible that in a
very few years renal transplant surgery may have rendered the method obsolete and a whole new set of bed requirements will need study".

This dilemma, of trying to provide for a future whose requirements are rendered uncertain by the transience of medical consuetude, is reflected in the more controversial aspects of the Hospital Plan (Ministry of Health, 1962). The proposed level of provision of maternity beds indicates acceptance of the findings of the Committee on Maternity Service (Ministry of Health, 1959), which relate the beds required to the birth rate, a defined proportion of hospital confinements, and a "normal" duration of hospital stay. However, both of the latter views have been subject to criticism; and Rhodes (1964) believes that "the Cranbrook Committee has been, perhaps unwittingly, responsible for ossifying the idea that there is something inherently valuable in puerperal care lasting ten days". The experimental fore-shortening of hospital stay for selected obstetric patients has already affected the utilisation of in-patient facilities sufficiently to reveal the necessity for a revision of future planning procedures in this specialty (Moßman, 1967). Perhaps the most controversial aspect of the Hospital Plan lay in the apparently unreserved acceptance of the suggestion by Tooth and Brooke (1961) that beds for mental illness might reasonably be reduced from 3.3, per thousand of population in 1960 to 1.8 per thousand in 1975. Their report was subject to vigorous criticism at the time of its publication "as being unrealistic and statistically unsound"; and although more recent work "shows that the predictions were substantially correct, and that the rundown forecast was, in fact, being maintained..." (Lancet, 1967), the implementation of recommendations entailing this degree of reduction in bed provision can affect bed utilisation so as "to turn the forecast into a self-fulfilling prophecy" (Rehin and Martin, 1963).
Although it is difficult to determine the allowances appropriate to current trends, part of the problem can be circumvented by avoiding the situation of being unable to adapt such hospital premises as are provided to the needs of future hospital practice. Many of the currently felt shortages in hospital accommodation derive not so much from the complete absence of facilities as from the functional obsolescence of hospitals whose basic structural fabric may yet be sound, and the uneconomic cost of converting this accommodation to meet the needs of contemporary hospital practice. The development of hospitals which are adaptable to changing patterns of utilisation is well established in this country, and some of the newer hospitals, designed with this end in view, have been reviewed by Llewelyn Davies and Weeks (1965). In this context, Llewelyn Davies (1960) has indicated the impracticability of planning hospitals with a short functional life, as an attempt to overcome the problem of obsolescence. "If they are strong enough to stand up with certainty for one year they will be strong enough to last for fifty years...We must therefore try to design hospitals which, although structurally long-lived, are flexible enough to remain efficient under changing use".

The probability that changing utilisation may necessitate physical modification of hospital accommodation is of less importance in the planning of wards than in the provision of such other facilities as radiodiagnostic departments, operating theatres and out-patient departments (Llewelyn Davies, 1960). However, it is in the design of ward accommodation that the reciprocal character of the relationship between planning and utilisation is most obvious. While ward design must incorporate adaptability to changing utilisation, the nature of the design may, in itself, determine the efficacy of utilisation. Miss Nightingale's thirty-bed ward, as it is now seen in many of our older
hospitals, not only minimises the privacy available to patients and results in the uneconomic use of space (N.P.H.T., 1955), but also entails a rigidity of bed allocation, if not by specialty, certainly by sex. The division of wards into separate rooms so as to allow "selective patient grouping" has many advantages. Studies in ward design of the type undertaken by the Nuffield Trust (N.P.H.T., 1955) and the Scottish Home and Health Department (1963; 1966) indicate that a far greater degree of latitude in bed allocation may be achieved, with consequent improvement in the efficacy of utilisation.

Apart from the obsolescent nature of many of the hospitals inherited by the Regional Hospital Boards at the inception of the National Health Service, another problem to be overcome has been the wide variation in levels of provision of in-patient accommodation, not only between different localities, but also between the different administrative regions. Norris (1952) wrote of the necessity "to remedy gross deficiencies in the hospital service; and a reasonable target for the immediate future is the provision of sufficient beds, so that the bed/population ratio of every locality is at least equal to the present average for the country as a whole".

This problem of deciding upon levels of provision is reflected in the declared position of the Ministry of Health. According to the terms of the National Health Service Act, it is incumbent upon the Minister to provide hospital accommodation "to such an extent as he considers necessary to meet all reasonable requirements...". The implementation of this rather general statement of objectives is complicated by the fact that funds available for hospital building "may be somewhat more or less, dependent upon the state of the economy, the capacity of the building industry, and other claims upon the national resources" (Ministry of Health, Hospital Plan, 1962). Nevertheless, certain broad
principles were described in the Hospital Plan, and remained virtually unchanged in the subsequent Hospital Building Programme (Ministry of Health, 1966). Reference was made to the findings of the Nuffield studies; "their results have to be used with caution, but they tend to confirm the view that an adequate service could be provided with fewer beds than at present". Despite this, the recommended levels of provision are more in keeping with the opinions expressed by Norris (1968) than with the suggestions embodied in the Nuffield reports. The intended provision of acute general beds at the empirical rate of 3.4 per thousand of population, as estimated for 1975, represents an overall decrease, but will be accompanied by the elimination of the gross differences prevailing between hospital regions in regard to the bed/population ratio.

The use of the bed/population ratio in hospital planning has been the subject of recurring criticism (Palmer, 1956), founded on the premise that the ratio makes no allowance for local variations in hospital bed requirements. Among the factors which have been cited as affecting the requirements of particular areas are the age structure of the population; the incidence and prevalence of diseases warranting hospital care; specific environmental, industrial and recreational hazards peculiar to the area; the level of provision of alternative and supporting services, such as hospital out-patient departments and local authority services; and the educational and economic characteristics of the local population. With a generally homogeneous population and a centrally co-ordinated service, many of these factors lose their significance. The more obvious of them, such as the structure of the population and the use of supporting services, have been provided for in the Ministry's plans. Most of the others must, in the light of present knowledge, be regarded as imponderables; their general effects
are recognised, but the possibility that the extent of their local influence may be sufficient to merit special consideration remains to be demonstrated. Use of the bed/population ratio can not allow for all contingencies, but, for the purpose of initiating hospital plans, there is nothing, at present, demonstrably better, particularly if an equable distribution of scarce resources is to be achieved.

There can be no pretence that the level of provision of in-patient accommodation envisaged in the Hospital Plan will be sufficient to meet all the future needs of the community. It must follow that a hospital service whose adequacy may be marginal should be subject to continuous, detailed, statistical scrutiny, both to ensure that available services are utilised with optimal efficiency, and to reveal those sectors of hospital care which require further development on a national scale. Heasman (1967) points out that "we must, to the best of our ability, be objectively critical of our current practices...If we can economise without detriment to the service we have more resources for other things". It is in this context that the relevance of bed utilisation to hospital development is predominant.

It is thus necessary to collect and prepare statistics of hospital utilisation which provide not only an overall picture of utilisation, but also details of local variations in utilisation, thereby providing a basis for comparisons which indicate those areas where administrative efficiency may be improved. However, "we have only partially succeeded so far in moulding our routine hospital statistics into the shape of an external audit permitting effective comparison between different hospitals and regions, and fruitful discussion of differences. There is not yet sufficient uniformity of processing and presenting data to permit this to be fully effective" (Brotherston, 1963). Hospital statistics, as they are currently prepared throughout the United Kingdom, provide only
approximate national and regional averages of bed utilisation; accurate assessments of bed utilisation are impossible, precluding valid comparisons which might form the basis of administrative action.
STATISTICS OF BED UTILISATION.

The detailed study of those aspects of health care with which the hospital service is primarily concerned requires the provision of much statistical material, whose form and content must be tailored according to proposed use. The early years of the National Health Service were characterised by a statistical aridity; perhaps because of this, the subsequent growth of statistical activity in the hospital sphere has not been a balanced process. Much academic research and governmental planning are dependent upon data of a demographic nature, and it was to meet this need that the major developments in the collection of hospital statistical material took place.

However, in attempting to provide such data, there was not, perhaps, sufficient consideration of the type of information required for the administration of the service; in particular, not enough emphasis was given to the importance of detailed routine assessments of bed utilisation, and the collection of accurate statistical data which will permit such assessments. The efficacy of hospital administration and the success of hospital development require adequate measurement of bed utilisation, so that statistics portraying this aspect of hospital activity merit close consideration.

It is the purpose of the succeeding paragraphs to consider such data as are currently available, and their shortcomings so far as service administration is concerned; and to discuss the indices which may be derived to assess bed utilisation, the interrelationships between these indices, and their relevance in administrative practice.

Sources of Data

The inception of the National Health Service brought the opportunity
to standardise the statistical data collected from hospitals throughout England and Wales. The consideration of periodical statistical reports has, for many years, formed part of the routine of administrative bodies within the framework of the hospital service, and the unification of the service promised to allow comparative reviews of local and regional hospital activity which had been impossible hitherto. But the necessity to provide data which would satisfy the requirements of academic institutions and the Ministry of Health, without acknowledging the divergence of interest between these bodies and the hospitals themselves, has had a detrimental effect upon the collection of national statistics suitable for comparative purposes in local hospital administration.

The detailed diagnostic, geographic, and social information with which many academic studies are concerned has undoubted relevance in such national and regional issues as hospital planning and development; but it has little relevance in local hospital administration, which must concern itself with assessments of the way in which the resources of particular hospitals are being used.

Routine statistical reports for purposes of hospital administration are prepared from material collected by Medical Records Offices, much of which is required for completion of the Annual S.H.3 Returns to the Ministry of Health. These returns constitute the Ministry's main source of data on hospital activity, and are submitted by each hospital group, the data being presented separately for each department in each hospital. The value of the summarised statistics may be considered to be in direct proportion to the degree of their accuracy; and although the S.H.3 statistics have been collected in their present form since 1953, they are still far from satisfactory. Anomalies in the methods recommended by the Ministry for the computation of some of the data have been allowed to persist; the examples of "day cases" and "available
beds" will be discussed shortly. However, none of these anomalies is irremediable, and the imposition of a rational conformity in the data collection would provide statistical material of enormous value in hospital administration and elsewhere. Forsyth and Logan (1962) have discussed the shortcomings of the S.H.3 statistics, but the hospital statistics which they regard as being of prime importance are clearly the "epidemiological" and population data sought after in the methodology of the Hospital In-Patient Enquiry and Hospital Activity Analysis; their suggestions make no allowance for the need in hospital administration for statistics reflecting the service and its efficacy rather than the consumers and their experience.

Since 1957, the Hospital In-Patient Enquiry has embraced all hospitals in England and Wales, providing a wide range of information concerning a 10% sample of patients discharged. The data thus obtained may rightly be regarded as "a mine of information to the research worker" (Brotherston, 1963). Several important studies have been based predominantly upon H.I.P.E. data, and the Operational Research Unit of the Oxford Regional Hospital Board has prepared a number of detailed reports from its H.I.P.E. returns. However, one of the difficulties encountered in hospital service operational research is a reluctance to act upon concrete and consequential research findings for the improvement of administration. Few studies based solely upon the H.I.P.E. can produce the type of results whose implications are so obvious as to have an immediate and unchallengeable relevance in the formulation of administrative policies. Because of this, and the fact that the H.I.P.E. data themselves have little relevance in routine hospital administration, the reports must be considered as having a primarily academic value.

A partial compromise between the interests of research and the
requirements of the service might be effected in the more recent
development of Hospital Activity Analysis (Benjamin, 1965). Based
upon data almost identical to that collected for the H.I.P.E., it
has the additional merit of covering all patients. It is also
susceptible to much more rapid processing, one of its primary purposes
being the provision of a "rapid feed-back" of information to clinical
and administrative personnel. Where such a wealth of information is
readily available, care must be taken in the selection of the material
which is to be presented; practice has shown that there is a very real
danger of obscuring important data in reports whose bulk deters proper
consideration.

The hope has been expressed that H.A.A. might provide all of the
statistical material required for administrative purposes (Yellowlees,
1965). The information collected in centres now using H.A.A. allows
the derivation of data such as the duration of hospital stay of patients,
and daily numbers of occupied beds; and its application to out-patients
could provide current information relating to the structure of waiting
lists. However, inasmuch as the data collected pertain entirely to the
patient and his movements, they can provide no information concerning
the daily availability of hospital beds and other facilities, so that
H.A.A. could not be used in its present form to prepare all administrative
statistics. As the use of H.A.A. becomes more general, it will
supersede H.I.P.E. as the primary source of hospital statistical data
for academic institutions and government departments. But unless its
methodology undergoes radical modification, so as to include the
automatic data processing of material which is currently derived from
daily ward returns, its use in hospital administration will have to be
supplemented by the continuing and extended collection of statistics
from other sources.
Administrative Statistics

In 1965, the report was published of a Joint Working Party of the Ministry of Health and the Association of Medical Records Officers, which was set up to consider bed utilisation statistics in hospital administration. The report suggested that "in order to administer the hospital service well "those concerned with hospital administration must be presented with meaningful statistics of hospital activity". This might seem axiomatic, but it is apparent from the Working Party's report that wide differences exist in the statistical material which various administrative bodies consider.

The Working Party's intention was to suggest a standardised presentation of statistical material, thereby ensuring that all bodies involved in hospital administration would be presented with those parameters and indices considered to be "essential" by the Working Party. Even though this purpose will be realised (Ministry of Health, Circular H.M. (65) 99), there remains "a great deal of loose thinking" about bed utilisation statistics (Benjamin and Perkins, 1961), and it is insufficient merely to present the appropriate data to administrative bodies, many of the members of which may regard statistics with incomprehension or even suspicion (Chambers, 1953). The most important aspects of this issue are that the data presented should have a direct and obvious relation to administrative practice; that those who consider such material should be conversant with its sources and significance; and that the data should be regarded objectively and used as an aid in administrative practice.

For the purposes of local administration, hospital in-patient statistics may be divided into two broad categories; those which demonstrate the demand for in-patient care, and those which indicate how available facilities are being used to meet this demand. The first of these groups must obviously include details of the size and growth
pattern of waiting lists, and the sources from which patients are admitted. It is to this group of statistics that H.A.A. could make its main contribution. The second group often seems more recondite, but is certainly the more important in terms of hospital administration. Because these data include such parameters as the actual use being made of beds, they consequently reveal those aspects of hospital utilisation where modifications of prevailing administrative policy may effect a more efficient use of resources. While the size of the waiting lists and the numbers of emergency admissions should weigh heavily in modifications of bed utilisation policy, detailed knowledge of these factors is rendered immaterial in the absence of valid indices of current bed utilisation. It is impossible to enjoin, effect and demonstrate any improvement upon the current use of beds, unless the current use is precisely measured and recorded.

Basic Utilisation Data.

The measured numbers from which the indices of bed utilisation may be derived are:

(i) the average daily number of beds available, during the time under consideration;
(ii) the average daily number of beds occupied, during the time under consideration;
(iii) the numbers of patients discharged from, or dying in, the hospital units concerned, during the time under consideration.

In some instances, figures are collected relating to the numbers of patients admitted to hospital; over a sufficiently prolonged period, however, numbers of patients admitted will approximate to number discharged and dying. For the remainder of this section, "the time under consideration" will be taken as one calendar year; where
monthly or quarterly statistics are prepared, appropriate adjustments are necessary in the derivation of some of the indices. Since one of the primary purposes of bed utilisation statistics should be to allow comparisons between similar units and departments, the basic data must be prepared for each unit in each hospital separately.

Hospital Activity Analysis as it now exists may be used to derive data relating to occupied beds and discharges and deaths. However, data relating to available beds can only be obtained from specially maintained records pertaining to each ward and specialty. The convenient premise that available beds may be equated to the theoretical bed allocation is untenable, as will be shown.

Reference has already been made to the shortcomings of existing statistical material, arising as a result of the Ministry of Health's instructions to Hospital Management Committees in the "Notes on Form S.H.3."

Since the most important aspect of these deficiencies is upon published data, which ought to be suitable for purposes of comparison, it may be germane to consider two of these anomalies in detail. The present method of computing the numbers of discharges gives rise to underestimates of the true picture because of the failure to take cognisance of "day cases". Minor surgical operations and surgical investigations are frequently carried out upon patients who arrive at the ward in the morning, undergo a general anaesthetic, and, after a few hours in bed to recover, return home in the evening. Of recent years, this practice has been extended, so that its scope now include such procedures as the repair of hernias. The development of "day case" surgery has been of very considerable value, allowing the investigation and treatment of large numbers of patients from the waiting lists, while minimising the utilisation of hospital resources. In some centres, the numbers of patients dealt with in this way may
amount to more than a third of all general surgical investigations and operations (Whiteman, personal communication), but the extent of this type of work is not demonstrated at all in current statistics.

Unfortunately, these patients are not included in the daily ward census, which is usually carried out at midnight. Indeed, the Ministry's instructions require that such patients "will be excluded from the discharges shown in Part 2 of S.H.3." Nor is it permitted to record their admission in the provided category of "Day Patients", since this term is "not intended to apply to patients who have minor surgery, and remain in hospital for some hours to recover, but do not stay overnight. Such patients should normally be regarded as out-patients for the purposes of form S.H.3." In rebuttal of this instruction, it might be pointed out that any patient who requires a bed to recover after an operation also requires a high degree of in-patient care and supervision, from both nursing and medical staff.

Accepting that there is a tenuous similarity between day case surgery and minor casualty surgery, it might be possible to accept the statistical inaccuracy, were it not compounded in the preparation of hospital cost accounts. While, in many centres, day cases are dealt with solely in the ward and the main operating theatre, their statistical inclusion among the out-patients renders such items as "cost per in-patient per day" and "cost per out-patient attendance" misleading. These units of cost can only represent realistic averages if the denominators used in their derivation are accurate. To give the out-patient department a gratuitous increment in its denominator, at the expense of the department which has actually carried out the work and to which are ascribed any incurred costs such as laundry and catering, makes hospital unit costing unrealistic.

The need for accuracy in computing statistics of bed availability
was lucidly presented in the Report of a study group sponsored by the Hospital Administrative Staff College of King Edward's Hospital Fund for London (1954). However, the cogency of these arguments apparently escaped notice in the subsequent compilation of the Ministry's instructions to Hospital Management Committees on this subject.

The Ministry's instructions relating to available beds require that the data recorded for each specialty "should be the average daily number of staffed beds which were available irrespective of whether they were used by that or any other department". This instruction also militates against the derivation of valid statistics, and is difficult to support in terms of logic. One might consider the hypothetical situation where a hospital had an orthopaedic surgery unit and a thoracic surgery unit, each with a theoretical complement of 30 beds; and where, as a result of differing demands for in-patient care in these two specialties, the orthopaedic surgeon was able periodically to "borrow" 10 beds from the thoracic surgeon. According to the Ministry's instructions, the thoracic surgeon would still have 30 "available beds", despite the fact that up to 10 of them might be occupied by orthopaedic patients; and statistics of bed utilisation by the orthopaedic surgeon, who would still have, in theory, only 30 "available beds", might well include such data as a bed occupancy rate exceeding 100%, a negative turnover interval, and a grossly inflated bed turnover rate; so that valid comparisons between this and other similar units would be effectively precluded.

Clearly, no bed may be considered to be "available" for one department if it is already occupied by a patient from another department; and no patient can occupy a bed which is not first "available" to him. Where "bed-borrowing" occurs, the data relating to bed availability must be emended accordingly. Where the practice
continues over a long period, as in the hypothetical situation described, there is an obvious necessity for review of the theoretical bed allocations. Such reviews should, in any case, be undertaken regularly in all hospitals, in conjunction with consideration of the effective use evinced by the bed utilisation indices for each specialty.

In 1961, the Sheffield Regional Branch of the Association of Medical Records Officers established a Working Party "to consider and report upon methods of collection and interpretation of hospital service statistics" (A.M.R.O., 1961). The report of this Working Party received the support of the senior officers of Sheffield Regional Hospital Board, and a copy was forwarded to the Ministry of Health. With regard to the question of available beds, the Working Party considered that, "if a true and accurate picture of the daily number of beds available to each specialty was not shown on each occasion bed occupancy statistics were being computed, then the statistical data produced would be both misleading and worthless. In view of these factors, the Working Party could not accept that the regulations laid down in the notes to Form S.H.5 provided an adequate basis upon which to calculate available beds".

Accordingly, some, but by no means all, Medical Records Officers prefer to ignore the Ministry's instructions, and present their annual returns with realistic assessments of bed availability. The Ministry must be aware of the anomaly, and of the consequent heterogeneity of the statistics it receives and publishes. But no modification has been made in the instructions, perhaps because of undue optimism concerning the potential of Hospital Activity Analysis, and perhaps for the reason given by the Joint Working Party in recommending that data relating to available beds be omitted from some Hospital Group statistics, namely, that "many hospitals are unable to record true
availability”. That this reasoning is open to question is manifest in the fact that some hospitals experiencing extensive "bed-borrowing" are able, with a little additional effort, to produce such data accurately and without difficulty.

It might be felt that the Ministry's present indulgence obviates unnecessary labour in Medical Records Offices. In antithesis, it could be argued that one of the primary purposes of the S.H.I.3 returns is frustrated by the production of misleading national and regional statistics.

**Derived Indices**

The four indices of bed utilisation most commonly derived from the basic data above are:

(i) the mean duration of stay;
(ii) the turnover interval;
(iii) the bed occupancy rate;
(iv) the bed turnover rate.

The mean duration of stay may be derived by dividing the total number of occupied bed-days by the number of discharges and deaths during the year

\[ s = \frac{365 \text{ Bo}}{D} \quad ....... (1) \]

where \( s \) is the mean duration of stay, \( \text{Bo} \) is the average daily number of occupied beds, and \( D \) is the number of discharges and deaths. This method is applicable in deriving the mean duration of stay of patients in most departments of general hospitals, where the turnover is usually high. In the case of long-stay units, however, it is necessary to resort to a direct consideration of the duration of stay of each patient.

The turnover interval is the mean number of days during which each bed stands empty between the discharge of one patient and the admission
of the next. Where data relating to vacant beds are available, it may be derived by dividing the total number of vacant bed-days by the number of discharges and deaths

\[ t = \frac{365 \times B_v}{D} \]

where \( t \) is the turnover interval, and \( B_v \) is the average daily number of vacant beds. More commonly, it is derived from the data relating to available and occupied beds

\[ t = \frac{365 \times (B_a - B_o)}{D} \] \hspace{1cm} (2)

where \( B_a \) is the average daily number of available beds.

The bed occupancy rate indicates the proportion of available beds which are occupied, on average, by expressing occupied and available beds as a ratio

\[ O = \frac{B_o}{B_a} \] \hspace{1cm} (3)

where \( O \) is the bed occupancy rate. Frequently, it is expressed in the form of a percentage.

The bed turnover rate indicates the use made of available beds, by expressing the mean number of patients passing through each bed during the year

\[ T = \frac{D}{B_a} \] \hspace{1cm} (4)

where \( T \) is the bed turnover rate.

It will be seen that the only data required for the derivation of these indices relate to available beds, occupied beds, and discharges and deaths.

**Interrelationships**

For as long as statistics have been prepared in the attempt to
assess bed utilisation efficiency, the bed occupancy rate has been cherished as an easily derived index of administrative performance. Its recent use in attempts to determine statistically the in-patient facilities required in certain parts of the country has already been described; and it has received periodic mention in the Annual Reports of the Ministry of Health.

However, this index has also been subject to strong criticism, chiefly on the basis that, of itself, the bed occupancy rate is not a valid index of bed utilisation. Benjamin and Perkins (1961) point out that "the occupancy rate conceals a good deal more than it reveals, and that considered by itself a movement upward or downward in the occupancy rate can not be properly interpreted". In considering the application of the bed occupancy rate to hospital planning, Schainblatt (1962) demonstrates that "this index, when used by itself, obscures important relationships between major determinants of bed need". An editorial in the Journal of the Institute of Hospital Administrators (Hospital, London, 1962) warns against the equation of bed occupancy rates with efficiency in utilisation; this would appear to be a common mistake on the part of administrative bodies, and one which could give rise to both unwarranted concern and unfounded complacency.

Despite these criticisms, the bed occupancy rate is still used, and its wider use has been recommended by the Joint Working Party on bed utilisation statistics. It would also seem that it is in current use in hospital planning in areas of the United States such as New York City (Klarman, 1964) and the State of California (Schainblatt, 1962).

In order to understand the shortcomings of this index, it is necessary to consider its relationship to the mean duration of stay and the turnover interval. This, and some of the other relationships
discussed below, may be developed a priori, but the algebraic methods used here are rather more succinct. Use will be made of the symbols and equations presented earlier:

Bo  Average daily number of occupied beds
Ba  Average daily number of available beds
D   Number of patients discharged or dying during the year
s   Mean duration of stay
 t   Turnover interval
 O   Bed occupancy rate
 T   Annual bed turnover rate

\[ s = \frac{365 \cdot Bo}{D} \] ..........(1)

\[ t = \frac{365 \cdot (Ba - Bo)}{D} \] ..........(2)

\[ O = \frac{Bo}{Ba} \] ..........(3)

\[ T = \frac{D}{Ba} \] ..........(4)

The relationship between the bed occupancy rate, the mean duration of stay and the turnover interval may be derived as follows

Therefore

\[ Bo = \frac{D \cdot s}{365} \] ..........(5)

And

\[ t = \frac{365 \cdot (Ba - Bo)}{D} \] ..........(2)

Therefore

\[ Ba = \frac{D \cdot t + 365 \cdot Bo}{365} \]

\[ = \frac{D \cdot t + D \cdot s}{365} \] (From (5))

\[ = \frac{D \cdot (s + t)}{365} \] ..........(6)

Hence, substituting equations (5) and (6) for Bo and Ba in (3),

\[ O = \frac{s}{s + t} \] ..........(7)
This equation was used to construct Figure 1, which shows the curvilinear relationship, asymptotic to maximal bed occupancy, between the bed occupancy rate and the mean duration of stay, at various values of turnover interval. It will be seen that a given bed occupancy rate may arise with any value of mean duration of stay, depending upon the turnover interval. Thus, a bed occupancy rate of 80% may be achieved with a mean duration of stay of 4.0 days, and a turnover interval of 1.0 day; or with a mean duration of stay of 20.0 days and a turnover interval of 5.0 days. In addition, it will be apparent that, with a decreasing mean duration of stay, a development currently taking place in almost all specialties, it is only possible to maintain a given bed occupancy rate by producing a concomitant decrease in the turnover interval.

Were the situation to arise, where "acceptable standards" of bed occupancy rate were adopted for administrative purposes, different hospital departments would find themselves trying to achieve an unattainable goal, or idling along with unnecessarily empty beds, depending upon the mean duration of stay characteristic of their patients. If, for instance, a standard of 90% were adopted by a Hospital Management Committee, the E.N.T. unit, where patients might have a mean duration of stay of about 4.0 days, would have to keep its turnover interval below 0.4 days, an impossible task; whereas the geriatric unit, with a mean duration of stay exceeding three months, could afford to let its turnover interval rise above 10.0 days. If the approach is less authoritarian, acknowledging that different departments have differing mean durations of stay, and expecting each department to exhibit a different level of bed occupancy rate, consideration of this index becomes otiose. If it is accepted that the E.N.T. unit will have a low bed occupancy rate, while the
RELATIONSHIP BETWEEN BED OCCUPANCY RATE AND MEAN DURATION OF STAY

AT VARIOUS VALUES OF TURNOVER INTERVAL

MEAN DURATION OF STAY (DAYS)

TURN OVER INTERVAL (DAYS)
geriatric unit is expected to maintain a high rate, the standard then being applied is that of the turnover interval; in such circumstances, it would be more rational to ignore the bed occupancy rate, and concentrate upon the turnover interval.

Another undesirable feature of preoccupation with the bed occupancy rate is that medical and nursing staffs can increase the rate at the expense of bed utilisation efficiency. The editorial previously cited (Hospital, London, 1962) illustrates this point with the excellent example of an E.N.T. unit of 20 beds, admitting two groups of 20 children for tonsillectomy each week; the groups are admitted on Sundays and Wednesdays, each child remaining in hospital for a period of 48 hours. This is a common procedure, enabling a high turnover rate, and facilitating the treatment of large numbers of children. However, the bed occupancy rate of such a unit is only 57%. If pressed to achieve a higher bed occupancy, the medical and nursing staff could increase the figure to 86%, merely by keeping each child in hospital for three days instead of two. While nobody would benefit from this manoeuvre, it would be necessary to retain some of the ward staff to look after the children, thus depriving other, perhaps more needy, departments of their services. Striving to increase the bed occupancy rate, without sufficient consideration of the other factors involved, may lead to this type of inefficiency; it is economically preferable to have beds empty, than to have them filled uselessly.

If the bed occupancy rate is to be considered at all, it must be considered in relation to the mean duration of stay prevailing in each hospital department; it has already been shown that this is a pointless procedure. Alternatively, Klarman (1964) has suggested that the bed turnover rate is a more useful index of bed utilisation, incorporating both the bed occupancy rate and the mean duration of stay.
Bed turnover rate = \( \frac{365 \times \text{Bed occupancy rate}}{\text{Mean duration of stay}} \)

While this equation is mathematically correct, it is unnecessary first to derive the bed occupancy rate and the mean duration of stay before calculating the bed turnover rate. Klarmann's equation may be reduced as follows:

Klarmann suggests

\[ T = \frac{365 \cdot 0}{s} \]

Substituting equation (3), above, for \( 0 \),

\[ T = \frac{365}{s} \times \frac{Bo}{Ba} \]

Substituting equation (1), above, for \( s \),

\[ T = \frac{D}{Ba} \]

\[ \ldots \ldots \ldots (4)! \]

Before leaving the question of the bed occupancy rate, it may be worthwhile to examine another aspect of its relationship to the bed turnover rate. This may be derived as follows:

\[ t = \frac{365}{D} (Ba - Bo) \]
\[ \ldots \ldots \ldots (2) \]

Therefore,

\[ D = \frac{365}{t} (Ba - Bo) \]
\[ \ldots \ldots \ldots (8) \]

Substituting equation (8) for \( D \) in (4), above,

\[ T = \frac{365}{t} \frac{Ba}{t} (Ba - Bo) \]
\[ = \frac{365}{t} (1 - \frac{Bo}{Ba}) \]

But \( \frac{Bo}{Ba} = 0 \)
\[ \ldots \ldots \ldots (3) \]

Therefore

\[ T = \frac{365}{t} (1 - 0) \]
\[ \ldots \ldots \ldots (9) \]

Figure 2 was prepared using this equation, and shows the direct inverse relationship between the bed occupancy rate and the bed turnover rate, at various values of turnover interval. As may be seen from Table II, the turnover interval is, perhaps, less amenable
RELATIONSHIP BETWEEN BED OCCUPANCY RATE AND BED TURNOVER RATE, AT VARIOUS VALUES OF TURNOVER INTERVAL.
to change than either the mean duration of stay or the bed turnover rate; so that attempts to increase bed utilisation by increasing the bed occupancy rate, without a deliberate effort to reduce the turnover interval, would produce effects diametrically opposed to those desired. It would seem, then, that the impression that the bed occupancy rate constitutes a valid index of bed utilisation is erroneous.

In many specialties, there is an increasing demand for hospital in-patient care, evinced by the fact that waiting lists continue to exist despite progressive increases in the numbers of patients treated (Ministry of Health, Annual Reports). The absence of other data necessitates recourse to the Ministry's published statistics, regardless of earlier criticism, in order to demonstrate the progressive increase in the bed turnover rate in recent years. This is partly shown in Table II, which gives the indices of bed utilisation for the three major hospital specialties in England and Wales from 1955 to 1965. Since the expressed demand shows no sign of diminishing, and it is not intended to effect any overall increase in the numbers of general hospital beds available, it is necessary that the bed turnover rate should continue to increase if the supply of in-patient care is to be any more closely approximated to the apparent demand.

That there is ample scope for further increases in the bed turnover rate may be inferred from the difference between the mean duration of hospital stay prevailing in this country and that encountered in other Western countries (Avery-Jones, 1964). There is some evidence that the decline in mean duration of stay of hospital patients in the United States has halted and is now beginning to reverse (Hospitals, 1966); but the present trend in British hospitals can continue for some years before the present American levels are reached.
**Table II** - Bed utilisation statistics in General Medicine, General Surgery and Gynaecology; England and Wales, 1955 to 1965.

Derived from data published in Annual Reports of the Ministry of Health.

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Utilisation *</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>s</td>
<td>22.2</td>
</tr>
<tr>
<td>Medicine</td>
<td>t</td>
<td>2.3</td>
</tr>
<tr>
<td>Surgery</td>
<td>T</td>
<td>14.9</td>
</tr>
<tr>
<td>Gynaecology</td>
<td>s</td>
<td>13.7</td>
</tr>
<tr>
<td>Surgery</td>
<td>t</td>
<td>1.5</td>
</tr>
<tr>
<td>T</td>
<td>24.2</td>
<td>24.2</td>
</tr>
<tr>
<td>Gynaecology</td>
<td>s</td>
<td>11.2</td>
</tr>
<tr>
<td>Surgery</td>
<td>t</td>
<td>1.4</td>
</tr>
<tr>
<td>T</td>
<td>29.0</td>
<td>30.1</td>
</tr>
</tbody>
</table>

* Symbols as in text
The mean duration of stay is not, however, the only factor to be taken into consideration in the increasing bed turnover rate, as may be seen from the relationship between the bed turnover rate, the mean duration of stay and the turnover interval. This relationship may be derived as follows

\[ T = \frac{365}{t} (1 - \theta) \]  

Substituting equation (7), above, for \( \theta \) in (9),

\[ T = \frac{365}{t} \left( 1 - \frac{s}{s + t} \right) \]

\[ = \frac{365}{s + t} \]  

(10)

From this equation, Figure 3 was prepared, showing the curvilinear relationship between the bed turnover rate and the mean duration of stay, at various values of turnover interval. As has been suggested, the improvements in the mean duration of stay and the bed turnover rate have not been accompanied by any substantial improvement in the turnover interval. It is apparent from Figure 3 that any success in attempting to reduce the turnover interval would have a marked effect upon the bed turnover rate, particularly in those specialties where a short duration of stay is customary. This point was well recognised by the Ministry of Health many years ago (Ministry of Health, Annual Report, 1952), and it is disappointing that so little change has been effected in the intervening years.

Relevance of Indices.

If Hospital Management Committees and other bodies responsible for the formulation of administrative policy in the hospital service are to be given an accurate picture of current bed utilisation, the indices which must be derived and presented are the mean duration of
Relationship between bed turnover rate and mean duration of stay, at various values of turnover interval.
stay, the bed turnover rate and the turnover interval.

While many factors influence the length of time that a patient remains in hospital, the interval between admission and discharge is ultimately determined by the senior medical staff. For this reason, attempts to increase bed utilisation by shortening the mean duration of stay will probably encounter greater obstacles than similar attempts based upon modification of the other two indices. Since medical staff must bear the responsibility for the welfare of patients, it is not unreasonable that some may regard with disfavour any intervention by administrators in this aspect of hospital care. Where it can be shown that time is being wasted, as in poor organisation of in-patient investigations, unnecessary delays between admission and the institution of treatment, or protraction of hospital stay for non-medical reasons, there may be strong arguments in favour of administrative intervention. In most instances, however, administrative bodies will be concerned with the mean duration of stay only insofar as it may have a bearing upon the other indices of utilisation.

The bed turnover rate is probably the most important of the indices, being the "productivity index" for hospital in-patient care. There is a limit to the extent to which industrial methods and outlook may reasonably be applied to administration of the hospital service, and the adoption of productivity norms would be undesirable. However, where a hospital department is found consistently to compare unfavourably with other, similar departments in terms of bed turnover, a closer examination of the internal administrative procedures is indicated. It may be discovered that there is good reason for the apparent deficiency, as, for instance, in a longer mean duration of stay because the department specialises in certain types of patient, or in a shortage of theatre facilities in surgical specialties. But if this
facet of hospital administration is to consist of active effectuation rather than passive observation, any department which regularly exhibits low bed turnover rates should be investigated with a view to administrative improvement.

The same may be said of the turnover interval, which gives a direct measure of the wastage occurring in the utilisation of hospital beds. This index reflects two aspects of hospital activity, the demand for in-patient care and the efficiency of ward administration. Hospital departments can only exhibit long turnover intervals where the demand for in-patient care is low, or the internal administration is poor, or both of these factors prevail. In the British hospital service, where most specialties carry a waiting list, the possibility of long turnover intervals arising from low levels of demand may be discounted. If it can be shown that this factor does produce long turnover intervals in individual departments, there is a clear case for closure or, preferably, reallocation of some of the beds involved.

In general, however, the length of the turnover interval in British hospitals must be taken as an indication of the standard of internal administration. Examination of the S.H.3 Returns from individual hospitals reveals that turnover intervals exceeding 5.0 days are common, and it is possible to find departments where this index exceeds 15.0 days. It is difficult to reconcile this waste of resources with recurrent anecdotal accounts of shortages of hospital beds.

Benjamin and Perkins (1961) have drawn attention to the dangers inherent in overzealous attempts to reduce the turnover interval. It is necessary to make allowances for the capabilities of ward staff to undertake increased workloads. Medical staff point out that beds will inevitably stand empty when patients are summoned from the waiting
list and fail to arrive, or if it is necessary to reserve beds for emergency admissions (Johnson, 1964; Qvist, 1964). However, both of the latter contributions to the turnover interval may be reduced, as will be shown in a succeeding section.

The turnover interval is, perhaps, the only index of bed utilisation concerning which administrative bodies may adopt a uniform standard, applicable to all hospitals and departments. Given any degree of unmet demand for hospital care, there is no reason why a geriatric unit should have a longer turnover interval than a paediatric unit, a cardiology unit, or a general surgery unit. Where reduction of long turnover intervals is prevented by shortages of personnel or material, administrative bodies will be faced with the alternatives of reallocating resources or allowing deficient utilisation to continue. The number of occasions on which long turnover intervals may be attributed entirely to the administrative defects resulting from shortage of resources is problematic. Where it is necessary for such deficient utilisation to continue, it is preferable that it should result from positive decision rather than unconscious omission. If it were considered that the increased workload entailed in reducing the turnover interval would impose an intolerable burden upon available staff, there would be, again, an indication for closure or reallocation of beds, in order to match the optimal utilisation of resources to the work potential of available staff.

In attempting to reduce prevailing turnover intervals, it should be ensured that the desired result, of increased bed turnover rate, is achieved. Care must be taken lest reduction of the turnover interval be effected simply by increasing the mean duration of stay.
Use of Statistics

The use of bed utilisation statistics, at both regional and hospital group levels, is one aspect of hospital administration which might profitably undergo extensive development in this country. Much of the hesitancy in this field in the past can be attributed to uncertainty regarding the significance of bed utilisation statistics, and their value in administrative practice. Reference has already been made to the varied pattern of use of statistics encountered by the Joint Working Party when its deliberations commenced in 1962. Nor was the uncertainty confined to Hospital Management Committees; in 1954, it was considered that "much of the Ministry's present actual use of statistics can still only be regarded as experimental" (Donelan, 1954).

Yet, despite the subsequent appearance of expository publications (King Edward's Fund, 1954; Brit. med. J., 1965; Benjamin and Perkins, 1961; Hospital (Lond.), 1962), there is, thus far, little evidence that statistics of bed utilisation are widely used in reaching administrative decisions. The premise that such statistics are scrutinised objectively with constructive intent is patently untenable in the face of persistently poor utilisation indices in individual departments, hospitals and regions. Indeed, it would seem that few members of either medical or lay committees are yet sufficiently familiar with the meaning or potential of the data to use them effectively.

One of the primary obstacles to the more general use of these statistics lies in the question of the point of initiation of the necessary developmental activity. It does not seem feasible to leave this matter in the hands of individual Hospital Management Committees, since, even in those instances where the Medical Records Officers are sufficiently well informed to offer guidance, the success of their efforts is entirely dependent upon the interest and co-operation of
senior colleagues, both medical and lay. The further development of operational research units and management services units within the Regional Hospital Boards may stimulate awareness of the necessity for greater activity in this area, but a co-ordinating influence will be required to ensure that progress is consistent throughout the country. It might be expected that this influence would emanate from the Ministry of Health, since it is at this level that the responsibility for the proper administration of the hospital service ultimately lies. There are, therefore, strong arguments in favour of the Ministry reviewing its position in relation to statistics of bed utilisation, with particular reference to the well-documented basis of the parameters and indices involved, and providing constructive and positive guidance for the future development of this aspect of hospital administration.
INCREASING BED UTILISATION

In seeking to improve the efficiency of utilisation of hospital beds, it must be borne in mind that the underlying objective is to increase the potential benefit accruing to the community as a whole. This objective would be defeated if a substantial increase in bed turnover rates, permitting higher admission rates, were effected at the cost of a net reduction in the value to the individual patient of the period of hospitalisation. In an apparently neglected circular concerning "The More Effective Use of Hospital Beds" (Ministry of Health, 1954), it was pointed out that, "while the function of a hospital is to restore patients to health as far as possible and as speedily as possible, it is not appropriate to seek to pass them through the hospital as through a factory on the conveyor-belt principle. On the judgment of the responsible clinician of what is appropriate for the particular patient must rest the final decision". This does not imply that attempts to increase the efficiency of bed utilisation should be regarded as potentially detrimental to standards of patient care. As will be shown, there are some increases in utilisation, resulting from the modification of administrative practices, which could be of direct benefit to patients.

The nature and relative value of the possible measures which would increase the efficiency of bed utilisation may be summarised in "quot homines, tot sententiae". Among many suggestions which have been made are the increased availability of hospital diagnostic and ancillary services to general practitioners; the re-organisation of bed provision and allocation; increased provision of supporting facilities such as operating theatres; better communications throughout hospitals; proper planning of diagnostic and therapeutic
procedures; revised arrangements for admission and discharge; and, perhaps the most frequently encountered suggestion, reduction of the duration of hospital stay.

In some centres, the duration of stay has been reduced in an effort to meet otherwise unmanageable demands upon in-patient resources; in other centres, early discharge has been carried out on an experimental basis. And while there has been, thus far, very little in the nature of the "controlled trial" assessment of early discharge advocated by Heasman (1964), many centres now practice planned early discharge, and favour shorter hospital stay for selected patients. In order to effect a wider reduction in the duration of hospital stay, it is necessary to convince the medical staff concerned of the need to adopt critical, enquiring attitudes towards procedures hallowed by long usage. If and when the development of these attitudes becomes more general, it may be possible to give fuller consideration to some of the other methods of increasing bed utilisation. Although some of these methods have been investigated, there are, unfortunately, few instances where the benefits to be derived are so clear-cut as to have made any significant impact upon administrative practice. Much research remains to be carried out in this field.

Of the aspects of administrative practice which might affect the efficiency of bed utilisation, those which will be considered are the problems associated with waiting list patients who fail to attend for admission when notified that a bed is available for them; the use of pre-convalescent and other supporting beds; the levels of provision of operating theatre facilities; and arrangements for the admission of emergency cases.
Admissions from the Waiting List.

A numerically small, but clinically well-recognised source of wastage in bed utilisation arises from the failure of waiting list patients to attend for admission when offered a bed. The relative severity of the problem varies between clinical specialties, according to the proportions of total admissions accounted for by waiting list patients. In general medicine, such wastage is small, waiting list admissions accounting for only some 10% of total admissions (Ministry of Health and General Register Office, 1963); in general surgery, gynaecology, and E.N.T. surgery, however, the corresponding proportions are of the order of 45%, 62%, and 84%, respectively, so that the problem is potentially more serious.

In a study involving two London hospitals, Qvist (1964) investigated the reasons given by patients who failed to attend. Of 7,119 patients sent for, 1,630 (22.9%) failed to attend; and of these, 63% gave reasons which Qvist considered to be "irresponsible". While Qvist's criteria of "irresponsibility" are not wholly unexceptionable, the failure of more than 20% of the waiting list patients in these two hospitals to accept the accommodation offered appears effectively to have lowered the levels of bed utilisation.

In a more limited study at Mansfield, Ward-McQuaid (1964) reported a non-arrival rate among general surgical patients of 25%. However, in a subsequent study of male patients undergoing repair of inguinal hernia in the Mansfield hospitals (Morris, et al., 1968), the non-arrival rate encountered was less than 11%. This apparently striking difference in behaviour between two groups drawn from the same population prompted further study of waiting list patients in this area.

Data were collected in respect of waiting list patients offered
beds for elective surgical investigation or treatment at King's Mill Hospital, between 1st March and 31st August, 1967. The data collected were those recorded on the forms used by the Records Office to notify patients that a bed is available. Included were details of the age and sex of patients; the clinical specialty and consultant; in some instances, the nature of the intended operative procedure; the proposed date of admission; and the date of completion of the form. In addition, data were collected concerning those instances where patients were notified by telephone or telegram, together with the date of any communication received from patients indicating that they would not be attending for admission as requested.

During the six-month period under consideration, 2,104 forms were prepared, asking patients to attend for admission in the specialties of general surgery, gynaecology, E.N.T. surgery, and ophthalmology. This total does not include 25 patients whose notifications were cancelled before the intended day of admission; but it does include 50 instances where patients attended for admission as requested, and were sent home because they were unfit for operation, or because no bed was available for them. The 2,104 forms concerned 1,904 patients, of whom 160 were sent for twice, and 20 were sent for three times during the six-month period. Because others of the 1,904 may have been sent for once or more previous to the commencement of the study, no attempt was made to differentiate between patients according to the number of times they were offered beds. In the presentation of the results, the numbers of "patients sent for" will be considered as 2,104. Of this total, 373 did not attend for admission, an overall non-arrival rate of 17.7%.

Table III shows the distribution by age and sex of the patients concerned. A slightly higher proportion of women were among the non-arrivals, but the overall difference in behaviour between the sexes
Table III - Distributions by age and sex of patients included in study.

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Patients sent for (number)</th>
<th>Patients attending for admission (number)</th>
<th>Patients not attending for admission (number)</th>
<th>(percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 15</td>
<td>183</td>
<td>158</td>
<td>25</td>
<td>13.7</td>
</tr>
<tr>
<td>15 to 24</td>
<td>59</td>
<td>50</td>
<td>9</td>
<td>15.3</td>
</tr>
<tr>
<td>25 to 34</td>
<td>75</td>
<td>57</td>
<td>18</td>
<td>24.0</td>
</tr>
<tr>
<td>35 to 44</td>
<td>74</td>
<td>60</td>
<td>14</td>
<td>18.9</td>
</tr>
<tr>
<td>45 to 54</td>
<td>113</td>
<td>93</td>
<td>20</td>
<td>17.7</td>
</tr>
<tr>
<td>55 to 64</td>
<td>107</td>
<td>90</td>
<td>17</td>
<td>15.9</td>
</tr>
<tr>
<td>65 to 74</td>
<td>65</td>
<td>54</td>
<td>11</td>
<td>16.9</td>
</tr>
<tr>
<td>75 and over</td>
<td>33</td>
<td>28</td>
<td>5</td>
<td>15.2</td>
</tr>
<tr>
<td>Not known</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>20.0</td>
</tr>
<tr>
<td>All ages</td>
<td>714</td>
<td>594</td>
<td>120</td>
<td>16.8</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 15</td>
<td>171</td>
<td>146</td>
<td>25</td>
<td>14.6</td>
</tr>
<tr>
<td>15 to 24</td>
<td>135</td>
<td>105</td>
<td>30</td>
<td>22.2</td>
</tr>
<tr>
<td>25 to 34</td>
<td>249</td>
<td>187</td>
<td>62</td>
<td>24.9</td>
</tr>
<tr>
<td>35 to 44</td>
<td>273</td>
<td>230</td>
<td>43</td>
<td>15.8</td>
</tr>
<tr>
<td>45 to 54</td>
<td>228</td>
<td>187</td>
<td>41</td>
<td>18.0</td>
</tr>
<tr>
<td>55 to 64</td>
<td>154</td>
<td>131</td>
<td>23</td>
<td>14.9</td>
</tr>
<tr>
<td>65 to 74</td>
<td>120</td>
<td>104</td>
<td>16</td>
<td>13.3</td>
</tr>
<tr>
<td>75 and over</td>
<td>47</td>
<td>38</td>
<td>9</td>
<td>19.1</td>
</tr>
<tr>
<td>Not known</td>
<td>13</td>
<td>9</td>
<td>4</td>
<td>30.8</td>
</tr>
<tr>
<td>All ages</td>
<td>1,390</td>
<td>1,157</td>
<td>253</td>
<td>18.2</td>
</tr>
<tr>
<td><strong>Both Sexes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 15</td>
<td>354</td>
<td>304</td>
<td>50</td>
<td>14.1</td>
</tr>
<tr>
<td>15 to 24</td>
<td>194</td>
<td>155</td>
<td>39</td>
<td>20.1</td>
</tr>
<tr>
<td>25 to 34</td>
<td>324</td>
<td>244</td>
<td>80</td>
<td>24.7</td>
</tr>
<tr>
<td>35 to 44</td>
<td>347</td>
<td>230</td>
<td>57</td>
<td>16.4</td>
</tr>
<tr>
<td>45 to 54</td>
<td>341</td>
<td>280</td>
<td>61</td>
<td>17.9</td>
</tr>
<tr>
<td>55 to 64</td>
<td>261</td>
<td>221</td>
<td>40</td>
<td>15.3</td>
</tr>
<tr>
<td>65 to 74</td>
<td>185</td>
<td>158</td>
<td>27</td>
<td>14.6</td>
</tr>
<tr>
<td>75 and over</td>
<td>80</td>
<td>66</td>
<td>14</td>
<td>17.5</td>
</tr>
<tr>
<td>Not known</td>
<td>18</td>
<td>13</td>
<td>5</td>
<td>27.8</td>
</tr>
<tr>
<td>All ages</td>
<td>2,104</td>
<td>1,731</td>
<td>373</td>
<td>17.7</td>
</tr>
</tbody>
</table>
was not statistically significant ($\chi^2 = 0.629; \ p > 0.25$). In both sexes, the non-arrival rate was high among young adults, sufficient to produce a significant irregularity in the distribution ($\chi^2 = 17.420; \ p < 0.025$). The failure of young adults to attend for admission as requested may be attributable, in part, to the potentially less serious nature of the illnesses they suffer; and factors which would prevail among young women are menstrual activity and the pressure of domestic commitments.

The secular pattern of non-arrivals is shown in Table IV; there is a small increase in the rate for the month of August, and a fall in the rate applicable to the few cases considered during September, but no significant secular trend is apparent. It might be expected that compliance with a notification to attend for admission would be influenced if the proposed admission coincided with family holidays. Table V shows the non-arrivals associated with the specific holiday periods which occurred during the study; while the numbers of patients asked to attend during the Easter and Spring holiday weekends are small, the overall increase in non-arrivals at holiday periods is of high statistical significance.

The study of waiting lists by the Institute of Hospital Administrators (1963) considered some of the methods used to notify patients that beds were available for them. Among the instances quoted were the teaching hospital which "calls in 80% of its patients by telegram and 10% by telephone"; and a general hospital, of whose patients "75% are called by messenger...". Although the report gives no details of the response to these techniques, it might be thought that the "urgency" commonly associated with telegrams would produce lower non-arrival rates. In the present study, however, there was no apparent difference between the effects of notification by letter or
Table IV - Response of patients according to the month in which they were asked to attend for admission.

<table>
<thead>
<tr>
<th>Month of proposed admission</th>
<th>Patients sent for admission (number)</th>
<th>Patients attending for admission (number)</th>
<th>Patients not attending for admission (number)</th>
<th>(percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>303</td>
<td>251</td>
<td>52</td>
<td>17.2</td>
</tr>
<tr>
<td>April</td>
<td>350</td>
<td>291</td>
<td>59</td>
<td>16.9</td>
</tr>
<tr>
<td>May</td>
<td>375</td>
<td>314</td>
<td>61</td>
<td>16.3</td>
</tr>
<tr>
<td>June</td>
<td>376</td>
<td>309</td>
<td>67</td>
<td>17.8</td>
</tr>
<tr>
<td>July</td>
<td>372</td>
<td>308</td>
<td>64</td>
<td>17.2</td>
</tr>
<tr>
<td>August</td>
<td>283</td>
<td>218</td>
<td>65</td>
<td>23.0</td>
</tr>
<tr>
<td>September</td>
<td>45</td>
<td>40</td>
<td>5</td>
<td>11.1</td>
</tr>
<tr>
<td>Entire period</td>
<td>2,104</td>
<td>1,731</td>
<td>373</td>
<td>17.7</td>
</tr>
</tbody>
</table>

\[
\chi^2 = 7.556 \quad p > 0.25
\]
Table V - Response of patients at selected holiday periods.

<table>
<thead>
<tr>
<th>Proposed timing of admission</th>
<th>Patients sent for (number)</th>
<th>Patients attending for admission (number)</th>
<th>Patients no attending for admission (number)</th>
<th>Percentage (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Easter weekend</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(24th to 27th March)</td>
<td>23</td>
<td>18</td>
<td>5</td>
<td>21.7</td>
</tr>
<tr>
<td><strong>Spring holiday</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(27th to 29th May)</td>
<td>29</td>
<td>18</td>
<td>11</td>
<td>37.9</td>
</tr>
<tr>
<td><strong>Factory holidays</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(30th July to 12th August)</td>
<td>134</td>
<td>96</td>
<td>38</td>
<td>28.4</td>
</tr>
<tr>
<td><strong>All holidays periods</strong></td>
<td>186</td>
<td>132</td>
<td>54</td>
<td>29.0</td>
</tr>
<tr>
<td><strong>Remainder of study period</strong></td>
<td>1,918</td>
<td>1,599</td>
<td>319</td>
<td>16.6</td>
</tr>
</tbody>
</table>

\[X^2 = 17.876\] \[p < 0.001\]
the other methods, as may be seen from Table VI. Even when the comparison is confined to patients given only one or two days notice, notification by letter does not appear to be any less effective than notification by telegram or telephone.

While there is no significant difference between the non-arrival rates encountered in the various clinical specialties (Table VII), there are wide variations in the rates associated with the operative procedures envisaged for the patients. It is emphasised that the operations listed in Table VIII are not necessarily those which were ultimately performed; the list merely indicates the intended operative procedures, so far as these could be ascertained from the data available. It will be seen that major abdominal operations and those associated with potentially serious underlying pathology, such as breast operations and cervical biopsy, have low non-arrival rates; while such procedures as the repair of inguinal hernia or uterine prolapse, and ligation of varicose veins, are attended by high non-arrival rates. It is possible that this variation reflects the attitudes of patients concerning the seriousness of their illnesses, or the degree of physical discomfort entailed. Another factor which must be considered is the length of time that patients spent on the waiting list before being offered beds. The Institute of Hospital Administrators (1963) expressed the view that "the likelihood of a patient failing to take advantage of the offer of a bed increases the longer the waiting period is before the first offer..."; and Grundy et al. (1956) produced statistical evidence to show that the non-arrival rate increases with the length of time spent on the waiting list.

Unfortunately, data were not readily available concerning the length of time spent on the waiting lists by the individual patients.
Table VI - Response of patients to different methods of requesting attendance for admission.

<table>
<thead>
<tr>
<th>Method of notification</th>
<th>Notice given (days)</th>
<th>Patients sent for (number)</th>
<th>Patients attending for admission (number)</th>
<th>Patients not attending for admission (number)</th>
<th>(percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter</td>
<td>≤ 2</td>
<td>679</td>
<td>535</td>
<td>144</td>
<td>21.2</td>
</tr>
<tr>
<td></td>
<td>&gt; 2</td>
<td>1,315</td>
<td>1,101</td>
<td>214</td>
<td>16.3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1,994</td>
<td>1,636</td>
<td>358</td>
<td>18.0</td>
</tr>
<tr>
<td>Telegram</td>
<td>≤ 2</td>
<td>96</td>
<td>83</td>
<td>13</td>
<td>13.5</td>
</tr>
<tr>
<td>Telephone</td>
<td>&gt; 2</td>
<td>14</td>
<td>12</td>
<td>2</td>
<td>14.3</td>
</tr>
<tr>
<td>Verbal</td>
<td>Total</td>
<td>110</td>
<td>95</td>
<td>15</td>
<td>13.6</td>
</tr>
<tr>
<td>All patients</td>
<td>2,104</td>
<td>1,731</td>
<td>373</td>
<td></td>
<td>17.7</td>
</tr>
</tbody>
</table>

Notice less than, or equal to two days:

\[ \chi^2 \frac{2}{1} = 3.060 \quad p > 0.05 \]

Totals:

\[ \chi^2 \frac{2}{1} = 1.332 \quad p > 0.10 \]
Table VII - Response of patients according to clinical specialty.

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Patients sent for</th>
<th>Patients attending for admission</th>
<th>Patients not attending for admission</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(number)</td>
<td>(number)</td>
<td>(number)</td>
</tr>
<tr>
<td>General Surgery</td>
<td>636</td>
<td>541</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gynaecology</td>
<td>726</td>
<td>580</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E.N.T. Surgery</td>
<td>441</td>
<td>360</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>301</td>
<td>250</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All specialties</td>
<td>2,104</td>
<td>1,731</td>
<td>373</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\chi^2 = 6.479 \quad \quad p > 0.05$
Table VIII - Response of patients according to site or nature of intended operative procedure

<table>
<thead>
<tr>
<th>Site or nature of operation</th>
<th>Patients sent for (number)</th>
<th>Patients not arriving (number)</th>
<th>Patients not arriving (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Surgery:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach and duodenum</td>
<td>46</td>
<td>1</td>
<td>2.2</td>
</tr>
<tr>
<td>Biliary tract</td>
<td>40</td>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>&quot;Laparotomy&quot;</td>
<td>19</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Circumcision, orchidopexy, excision of hydrocele</td>
<td>38</td>
<td>3</td>
<td>7.8</td>
</tr>
<tr>
<td>Breast</td>
<td>34</td>
<td>8</td>
<td>9.5</td>
</tr>
<tr>
<td>Inguinal hernia</td>
<td>87</td>
<td>23</td>
<td>26.4</td>
</tr>
<tr>
<td>Haemorrhoidectomy</td>
<td>43</td>
<td>10</td>
<td>23.3</td>
</tr>
<tr>
<td>Varicose veins</td>
<td>75</td>
<td>21</td>
<td>28.0</td>
</tr>
<tr>
<td><strong>Gynaecology:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Laparotomy&quot;</td>
<td>29</td>
<td>3</td>
<td>10.3</td>
</tr>
<tr>
<td>Hysterectomy, myomectomy</td>
<td>49</td>
<td>5</td>
<td>10.2</td>
</tr>
<tr>
<td>Cervical biopsy</td>
<td>25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>&quot;Gynae minors&quot; (D. &amp; C.,cautery)</td>
<td>360</td>
<td>71</td>
<td>19.7</td>
</tr>
<tr>
<td>Repair of prolapse</td>
<td>175</td>
<td>43</td>
<td>24.6</td>
</tr>
<tr>
<td><strong>E.N.T. and Ophthalmology:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tonsillectomy, adenoidectomy</td>
<td>206</td>
<td>34</td>
<td>16.5</td>
</tr>
<tr>
<td>Operations on ear drum</td>
<td>78</td>
<td>14</td>
<td>18.0</td>
</tr>
<tr>
<td>Resection of nasal septum</td>
<td>37</td>
<td>10</td>
<td>27.0</td>
</tr>
<tr>
<td>Nasal polypectomy</td>
<td>42</td>
<td>13</td>
<td>31.0</td>
</tr>
<tr>
<td>Removal of cataract</td>
<td>138</td>
<td>24</td>
<td>17.4</td>
</tr>
<tr>
<td>Correction of strabismus</td>
<td>109</td>
<td>17</td>
<td>15.6</td>
</tr>
<tr>
<td>All other operations</td>
<td>349</td>
<td>65</td>
<td>18.6</td>
</tr>
<tr>
<td>Operation not specified</td>
<td>75</td>
<td>5</td>
<td>6.7</td>
</tr>
<tr>
<td><strong>All patients</strong></td>
<td>2,104</td>
<td>373</td>
<td>17.7</td>
</tr>
</tbody>
</table>
in this study. Some impression can, however, be obtained from Hospital Activity Analysis, which came into general operation at King's Mill Hospital during the course of the study. It is emphasised that the data used do not relate specifically to the patients in the study; and that, while the operations listed in Table VIII are "intended", those in Table IX are retrospective descriptions of procedures carried out. Table IX shows the waiting times of patients undergoing various operations during the first six months after the general introduction of H.A.A. to this hospital. It will be seen that the operations in Table VIII which carry a high non-arrival rate are the same as those in Table IX where the waiting time is generally long. There is thus the possibility that much of the variation in non-arrival rates associated with different operations is not characteristic of the operations themselves; but, in keeping with the findings of Grundy et al. (1956), reflects the delay before operation.

Table X shows the non-arrival pattern associated with various amounts of notice given to patients concerning their admission. In calculating the notice given, it has been assumed that letters of notification were received by the first postal delivery on the day after they were posted; the "amount of notice given" is the number of days between this assumed receipt of notification and the requested time of admission. There is a general decrease in the non-arrival rate as the amount of notice given increases, until the last group, that of patients given more than seven days notice, when the non-arrival rate suddenly increases. Lest the high rate in this last group be construed as an argument in favour of shortening the notice given to patients, it should be pointed out that this group contained disproportionately large numbers of patients who, for reasons already demonstrated, might be expected to exhibit high non-
Table IX - Percentage distribution of patients undergoing selected operations, by amount of time spent on waiting list prior to admission.

(Derived from Hospital Activity Analysis data relating to patients admitted to King's Mill Hospital between 1st July and 31st December, 1967)

<table>
<thead>
<tr>
<th>Nature of operation (G.R.O. Class. Nos.)</th>
<th>Patients admitted (100%)</th>
<th>Time spent on waiting list (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Less than 30</td>
</tr>
<tr>
<td>Stomach and duodenum (420-427, 430, 431, 433)</td>
<td>36</td>
<td>58.3</td>
</tr>
<tr>
<td>Biliary tract (514-529)</td>
<td>36</td>
<td>44.4</td>
</tr>
<tr>
<td>Laparotomy (400)</td>
<td>18</td>
<td>72.2</td>
</tr>
<tr>
<td>Male genitalia (680-682, 685, 686, 690, 696)</td>
<td>23</td>
<td>52.2</td>
</tr>
<tr>
<td>Breast (380-383, 386)</td>
<td>65</td>
<td>87.7</td>
</tr>
<tr>
<td>Inguinal hernia (402)</td>
<td>79</td>
<td>34.2</td>
</tr>
<tr>
<td>Haemorrhoidectomy (483)</td>
<td>34</td>
<td>14.7</td>
</tr>
<tr>
<td>Varicose veins (913, 916)</td>
<td>36</td>
<td>19.4</td>
</tr>
<tr>
<td>Hysterectomy, myomectomy (721-724, 727)</td>
<td>74</td>
<td>33.8</td>
</tr>
<tr>
<td>Gynaec minors (731-733)</td>
<td>210</td>
<td>30.0</td>
</tr>
<tr>
<td>Biopsy of cervix (734)</td>
<td>9</td>
<td>77.8</td>
</tr>
<tr>
<td>Repair of prolapse (743, 744)</td>
<td>79</td>
<td>2.5</td>
</tr>
<tr>
<td>Tonsillectomy/adenoidectomy (261-263)</td>
<td>171</td>
<td>8.8</td>
</tr>
<tr>
<td>Operations of eardrum (203)</td>
<td>43</td>
<td>9.3</td>
</tr>
<tr>
<td>Removal of cataract (170, 173)</td>
<td>103</td>
<td>26.2</td>
</tr>
<tr>
<td>Correction of strabismus (109-115)</td>
<td>138</td>
<td>14.5</td>
</tr>
<tr>
<td>All other operations</td>
<td>411</td>
<td>36.5</td>
</tr>
<tr>
<td>No operations</td>
<td>69</td>
<td>49.3</td>
</tr>
</tbody>
</table>

All patients 1,634 30.9 19.8 17.3 26.1 6.0
Table X - Response of patients according to amount of notice of admission given to them.

<table>
<thead>
<tr>
<th>Amount of notice given (days)</th>
<th>Patients sent for admission (number)</th>
<th>Patients attending for admission (number)</th>
<th>Patients not attending for admission (number)</th>
<th>(percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 1</td>
<td>362</td>
<td>277</td>
<td>85</td>
<td>23.5</td>
</tr>
<tr>
<td>2</td>
<td>413</td>
<td>341</td>
<td>72</td>
<td>17.4</td>
</tr>
<tr>
<td>3</td>
<td>478</td>
<td>392</td>
<td>86</td>
<td>18.0</td>
</tr>
<tr>
<td>4</td>
<td>324</td>
<td>277</td>
<td>47</td>
<td>14.5</td>
</tr>
<tr>
<td>5</td>
<td>275</td>
<td>234</td>
<td>41</td>
<td>14.9</td>
</tr>
<tr>
<td>6</td>
<td>132</td>
<td>113</td>
<td>19</td>
<td>14.4</td>
</tr>
<tr>
<td>7</td>
<td>38</td>
<td>33</td>
<td>5</td>
<td>13.2</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>82</td>
<td>64</td>
<td>18</td>
<td>21.9</td>
</tr>
<tr>
<td>All patients</td>
<td>2,104</td>
<td>1,731</td>
<td>373</td>
<td>17.7</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 14.625 \quad p < 0.05 \]
arrival rates. Thus, 42.7% of this group were women aged between 15 and 34, as compared to 17.3% of patients given seven days notice or less; 17.1% of this group were asked to attend for admission at holiday periods, as against 8.5% in the remainder of the study group; and 74.4% were recorded as undergoing operations whose associated non-arrival rates (Table VIII) exceeded the overall mean of 17.7%, compared to 41.3% of the remaining patients. The differences between these proportions are statistically significant at 0.1%, 1.0%, and 0.1%, respectively. So that it is hardly surprising to find a high rate of non-arrival among patients given more than seven days notice.

The downward trend in non-arrival rate with increasing notice, when this group is excluded, was examined by the regression technique described by Maxwell (1961); a highly significant linear association was found between declining non-arrival rates and increasing amounts of notice given (p < 0.005).

Another area in which substantial variations in the non-arrival rates were encountered related to the consultants responsible for the care of the patients; these variations are shown in Table XI. Since the clinical specialty does not appear to have any bearing upon the non-arrival rate, the differences between consultants, which must be considered in attempting to account for their non-arrival patterns, are the amount of notice of admission which they give to patients, and the structure of their patient populations. The marginally significant differences in the non-arrival rates for individual consultants may be examined further, using the technique of "partitioning" (Maxwell, 1961), as shown in Table XII. On the basis of non-arrivals, it can be shown that consultants A to E form a homogeneous group ($\chi^2 = 1.971; p > 0.50$); and consultants F to I form another homogeneous group ($\chi^2 = 5.118; p > 0.10$); but the difference between these two groups is of high
Table XI - Response of patients according to identity of consultant responsible for their care.

<table>
<thead>
<tr>
<th>Consultant</th>
<th>Patients sent for (number)</th>
<th>Patients attending for admission (number)</th>
<th>Patients not attending for admission (number)</th>
<th>(percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>297</td>
<td>251</td>
<td>46</td>
<td>15.5</td>
</tr>
<tr>
<td>B</td>
<td>122</td>
<td>102</td>
<td>20</td>
<td>16.4</td>
</tr>
<tr>
<td>C</td>
<td>229</td>
<td>197</td>
<td>32</td>
<td>14.0</td>
</tr>
<tr>
<td>D</td>
<td>263</td>
<td>218</td>
<td>45</td>
<td>17.1</td>
</tr>
<tr>
<td>E</td>
<td>144</td>
<td>126</td>
<td>18</td>
<td>12.5</td>
</tr>
<tr>
<td>F</td>
<td>179</td>
<td>148</td>
<td>31</td>
<td>17.3</td>
</tr>
<tr>
<td>G</td>
<td>237</td>
<td>197</td>
<td>40</td>
<td>16.9</td>
</tr>
<tr>
<td>H</td>
<td>204</td>
<td>163</td>
<td>41</td>
<td>20.1</td>
</tr>
<tr>
<td>I</td>
<td>429</td>
<td>329</td>
<td>100</td>
<td>23.3</td>
</tr>
<tr>
<td>All consultants</td>
<td>2,104</td>
<td>1,731</td>
<td>373</td>
<td>17.7</td>
</tr>
</tbody>
</table>

$\chi^2 = 16.247$  \hspace{1cm} $p < 0.05$
<table>
<thead>
<tr>
<th>Consultant</th>
<th>Patients sent for</th>
<th>Patients attending for admission</th>
<th>Patients not attending for admission</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>297</td>
<td>251</td>
<td>46</td>
</tr>
<tr>
<td>B</td>
<td>122</td>
<td>102</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>229</td>
<td>197</td>
<td>32</td>
</tr>
<tr>
<td>D</td>
<td>263</td>
<td>218</td>
<td>45</td>
</tr>
<tr>
<td>E</td>
<td>144</td>
<td>126</td>
<td>18</td>
</tr>
<tr>
<td>Totals</td>
<td>1,055</td>
<td>894</td>
<td>161</td>
</tr>
<tr>
<td>F</td>
<td>179</td>
<td>148</td>
<td>31</td>
</tr>
<tr>
<td>G</td>
<td>237</td>
<td>197</td>
<td>40</td>
</tr>
<tr>
<td>H</td>
<td>204</td>
<td>163</td>
<td>41</td>
</tr>
<tr>
<td>I</td>
<td>429</td>
<td>329</td>
<td>100</td>
</tr>
<tr>
<td>Totals</td>
<td>1,049</td>
<td>837</td>
<td>212</td>
</tr>
<tr>
<td>All Consultants</td>
<td>2,104</td>
<td>1,731</td>
<td>373</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 8.833 \quad p < 0.005 \]
statistical significance ($\chi^2 = 8.833; p < 0.005$). So that the consultants may be divided into two discrete groups, one group having generally low non-arrival rates and the other having generally high non-arrival rates.

The line of division between these two groups is not entirely arbitrary, as may be seen from Table XIII. The mean amount of notice given by consultants A to E is greater than three days; that given by consultants F to I is less than three days. It is emphasised that only minimal delays occur in notifying patients that beds are available for them, after the consultants have advised the Medical Records Office of the patients who are to be admitted. Most letters of notification are sent out on the same day that the Records Office is given the names of the patients, and all are sent out within 24 hours. Where a large volume of work requires "priorities" for notification, the selection is in favour of the patients who are to receive shortest notice. The data presented in Table XIII may thus be taken as a fair representation of the behaviour of the individual consultants.

In order to eliminate the possibility of patients' ages affecting the non-arrival rates for the consultants, the data were standardised by the age and sex distribution of the patients, and also by the patterns of amount of notice given by the consultants. The "expected" numbers of non-arrivals thus derived were expressed as percentages of the observed non-arrivals, to give the "standardised non-arrival ratios" shown in Table XIV; also given are the "crude non-arrival ratios" derived from the overall pattern of non-arrivals. The differences between the ratios for the two groups of consultants were tested, using the technique described by the Registrar-General (General Register Office, 1967) for the comparison of standardised mortality ratios. There is a difference of high statistical significance between the
Table XIII - Percentage distribution of patients according to the amount of notice of admission given to them by each consultant.

<table>
<thead>
<tr>
<th>Consultant</th>
<th>Patients sent for (10%)</th>
<th>Amount of notice given (days)</th>
<th>Mean notice given (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 1 2 3 4 5 6 7 &gt; 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>297 0.7 2.7 2.0 11.4 42.8 11.4 7.1 21.9</td>
<td>5.67</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>122 9.8 7.4 18.9 45.1 1.6 6.6 - 10.7</td>
<td>4.09</td>
<td></td>
</tr>
<tr>
<td>C'</td>
<td>229 20.5 3.9 7.0 26.6 17.5 20.1 3.9 0.4</td>
<td>3.96</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>263 11.4 19.0 16.0 14.8 24.7 11.8 1.5 0.8</td>
<td>3.68</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>144 11.1 27.1 18.7 26.4 14.6 0.7 0.7 0.7</td>
<td>3.15</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>179 11.2 16.2 41.3 29.0 1.7 0.6 - -</td>
<td>2.96</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>237 17.3 12.2 48.5 13.1 7.2 1.7 - -</td>
<td>2.86</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>204 3.4 36.3 59.8 0.5 - - -</td>
<td>2.57</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>429 43.6 38.7 12.4 3.0 - 1.6 0.7 -</td>
<td>1.85</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>2,104 17.2 19.6 22.7 15.4 13.1 6.3 1.8 3.9</td>
<td>3.34</td>
<td></td>
</tr>
</tbody>
</table>
Table XIV - Crude and standardised non-arrival ratios for consultants, grouped according to mean notice of admission given to patients.

<table>
<thead>
<tr>
<th>Consultants</th>
<th>Mean notice given</th>
<th>Crude</th>
<th>Standardised by age and sex of patients</th>
<th>Standardised by notice given to patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, C, D and E</td>
<td>More than three days</td>
<td>86.1</td>
<td>84.1</td>
<td>91.2</td>
</tr>
<tr>
<td>F, G, H and I</td>
<td>Less than three days</td>
<td>114.0</td>
<td>116.8</td>
<td>107.9</td>
</tr>
</tbody>
</table>

Significance of differences between ratios

- \( p < 0.01 \)
- \( p < 0.01 \)
- \( p > 0.10 \)
crude non-arrival ratios for consultants giving mean notice of more than, or less than, three days. Standardisation by age and sex of the patients has the effect of slightly enhancing this difference, so that this factor can play little part in accounting for the differing non-arrival patterns. When the data are standardised by the amount of notice given, however, the difference between the non-arrival ratios is not statistically significant; thus, the amount of notice given to patients by consultants is of considerable importance in relation to the pattern of non-arrivals.

Of the other factors which may affect the non-arrival rates, and account for the residual difference in the non-arrival ratios, one which must again be considered is the length of time spent by patients on the waiting list. The Hospital Activity Analysis data used to prepare Table IX were also used to construct Table XV, which shows the distribution of waiting times before admission for patients under the care of consultants in the two groups. Once again, the patients covered by Table XV do not correspond to those in the study, but the data suggest that the consultants whose standardised non-arrival ratios are low are better able to reduce the delay between patients being put on the waiting list and being offered a bed.

The amount of notice given to patients is also of importance in relation to the replacement of patients who indicate that they will be unable to attend for admission. Of the 373 patients who did not attend for admission in the present study, 195 (52%) so informed the Records Office before the day arranged for their admission. Table XVI shows that there was a highly significant correlation between the amount of notice given to patients, and the amount received from them. It must be accepted that some patients will disregard letters offering in-patient accommodation; but the
Table XV - Percentage distribution of patients treated by consultants in two groups, by amount of time spent on waiting list prior to admission

(Derived from Hospital Activity Analysis data relating to patients admitted to King's Mill Hospital between 1st July and 31st December, 1967)

<table>
<thead>
<tr>
<th>Consultants</th>
<th>Patients admitted (100%)</th>
<th>Less than 30</th>
<th>30 to 89</th>
<th>90 to 179</th>
<th>180 to 269</th>
<th>270 to 359</th>
<th>360 or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, C, D and E</td>
<td>363</td>
<td>42.6</td>
<td>25.6</td>
<td>13.8</td>
<td>6.3</td>
<td>7.4</td>
<td>4.3</td>
</tr>
<tr>
<td>F, G, H and I</td>
<td>771</td>
<td>17.8</td>
<td>13.2</td>
<td>21.3</td>
<td>22.6</td>
<td>17.2</td>
<td>7.9</td>
</tr>
<tr>
<td>All consultants</td>
<td>1,634</td>
<td>30.9</td>
<td>19.8</td>
<td>17.3</td>
<td>14.0</td>
<td>12.1</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Table XVI - Association between amount of notice of admission given to patients, and amount of notice received from patients indicating intended non-arrival

<table>
<thead>
<tr>
<th>Notice given to patients (days)</th>
<th>Notice of intended non-arrival received from patients (days)</th>
<th>Patients no attending for admission (numbers)</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>&lt; 1</td>
<td>49</td>
<td>36</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>9</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>39</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>178</td>
<td>70</td>
<td>59</td>
</tr>
</tbody>
</table>

\[ r = 0.430 \quad p < 0.001 \]
greater the amount of notice given to patients, the better the prospect of replacing those who indicate that they are unable to attend for admission, and thus of attenuating possible reductions in bed utilisation.

The findings of this and other studies suggest that the following factors contribute to the non-arrival of waiting list patients when they are offered beds:

(i) the age of the patients;
(ii) the length of time that patients are on the waiting list before a bed becomes available for them;
(iii) the timing of requested admissions, particularly in relation to holiday periods;
(iv) the amount of notice of admission given to patients.

Within the system of admission of waiting list patients which appears to be prevalent in British hospitals, the first two of these factors are not amenable to control by hospital authorities; and the effects of the third could only be mitigated by avoiding elective admissions at holiday periods, and accepting an even greater wastage in the utilisation of in-patient resources. It may be possible, however, to circumvent the influence of all three factors by modification of the admission procedures.

The fourth factor, the amount of notice given to patients, is directly controllable by the hospital authorities. "The efficient use of beds in acute hospitals inevitably entails that some patients must be called into hospital at short notice" (I.H.A., 1963); but the numbers of such patients may be minimised by increasing the amount of notice routinely given. Accepting that, when patients indicate their inability to accept offers of in-patient accommodation, their replacements are given shorter notice, the replacements can be
given notice of three or four days if the routine admissions are given five or six days. The patterns of amount of notice given in the present study indicate that some of the consultants concerned endeavoured routinely to give patients four days notice or more; but, clearly, others considered two or three days to be quite sufficient. The amount of notice given did not appear to bear any relationship to the demands of practice in the various clinical specialties, so that it would be possible for some of the consultants to modify their current procedures.

The overall pattern of notice given in the present study was not unusually short. The Institute of Hospital Administrators (1963) reported that, in their sample of 92 hospitals, there "appeared to be twelve hospitals where some or all patients may receive no more than 24 hours notice of admission", and a further six where the "normal" amount of notice was two or three days. Qvist (1964) suggested that "short notice" does not seem to be the main reason for non-filling of beds; but the largest group of referrals in his study, patients who failed to arrive because of "domestic and business reasons", bears closer scrutiny. One might consider the hypothetical case of a young woman with three children, given 24 hours notice of admission after being on the waiting list for a year; she may not give "too short notice" as the reason for declining the offer of a bed, but the stated reason, the necessity to make arrangements for the care of the children, relates directly to the time available to make such arrangements.

Perhaps the most important single factor to be considered in relation to admission from the waiting list is effective communication between hospital and patients. Certainly, it is in this factor that the prevention of wastage in bed utilisation associated with non-
arrivals lies. Of the hospitals surveyed by the Institute of Hospital Administrators (1963), only one-third carried out regular review of waiting lists, to ensure their accuracy. Further, "only fourteen hospitals indicated that they operate any system of giving patients preliminary notice that they are likely to be called in, and only in the case of five of these hospitals is the system of general application". It would appear that many hospitals in this country make no effort to communicate with patients between the time they are put on the waiting list and the time they are offered in-patient accommodation.

Of the several recommendations contained in the Institute's report, perhaps the most important was that "patients who have been on the waiting list for some time...should be given some preliminary notice of their impending admission". Patients admitted from the waiting list may be divided, broadly, into two categories; those requiring "urgent" admission, and those whose admissions are dependent solely upon the chronological order of their being put on the waiting list and the availability of beds. If the system of "urgent" or "priority" admissions has any practical meaning, it should be possible to give patients in this category an indication of the probable timing of their admission when their names are added to the waiting list. Those patients who have to spend more than three months on the list should be advised three or four weeks in advance that a bed will shortly be available for them, and asked to indicate at that time whether they would be able to attend for admission; patients who declined, or failed to reply within a pre-arranged time period, could then be replaced without difficulty.

Neither this technique, nor any other, can guarantee that all waiting list patients will attend for admission when sent for; the
intercurrence of colds and accidents would prevent arrival of a few who had previously indicated their intention to accept the offered bed. But it is probable that some preliminary notification would reduce non-arrival rates. In the present study, 72 male patients with inguinal hernia were given between one and seven days notice (mean, 4.18 days), without any preliminary communication; the non-arrival rate was 27.8%. In the previous study of hernia patients in the same population (Morris et al., 1968) preliminary communication was an incidental part of the methodology, all patients being circularised some three weeks prior to admission, and all being given six or seven days notice of admission; the non-arrival rate was 10.6%. The earlier study involved male patients who were slightly younger; but on the basis of available data, the hernia patients in the two groups would appear to have been similar in other respects. While other, unrecognised, factors may have contributed to the lower non-arrival rate in the earlier study, it is probable that the statistically significant difference ($p < 0.001$) between the behaviour of patients in the two studies is in some measure attributable to preliminary communication and longer notice of admission.

The Value of Supporting Beds.

The use of beds additional to those in acute units has been advocated by several authors, as a means of enhancing the utilisation of the beds in the acute units. The nomenclature describing these additional beds varies widely, the terms most commonly encountered being "recovery", "continuation", "pre-discharge", and "pre-convalescent". In the United States, the practice of distinguishing between the acute and recovery phase of illness has been formalised, and developed into the concept of "progressive patient care".
In Britain, supporting beds are generally used for the care of patients after the acute phase of illness; but Pike et al (1963) recommend the use of supporting beds for some emergency admissions, in order to relieve the general units of the necessity to accommodate large numbers of short-stay emergencies. And although the pre-discharge unit described by Newell et al. (1966) is intended for the care of patients between acute illness and discharge, the reason for its establishment was the "problem of ensuring that a bed was available for a patient requiring immediate admission to hospital".

The use of supporting beds has been represented as having a twofold value; firstly, that they increase the efficiency of utilisation of available beds, and, secondly, that they offer economies in terms of costs. As yet, apparently no detailed study of their value has been undertaken to verify these hypotheses; and available data are, at best, inconclusive.

In describing the experimental pre-discharge ward at Dryburn Hospital, whose establishment was sponsored by the Nuffield Provincial Hospital Trust, Newell et al. (1966) indicated that the unit received the subjective approval of medical and nursing staffs, and patients; however, the data on bed utilisation are less reassuring. During the first two years of the unit's life, the only major specialties exhibiting improved indices of utilisation were gynaecology, where an additional consultant was appointed, and paediatrics, which did not make use of the facilities of the unit. Using the data on bed availability and occupancy presented in the study report, it is possible to demonstrate that in the grouped specialties of general medicine with dermatology, and general surgery with E.N.T. surgery, the annual bed turnover rates fell from 20.3 and 25.0 patients per available bed, respectively, to 19.4 and 23.0 patients per available bed, respectively, between the year immediately preceding the unit's
establishment and the second year of its use. The turnover intervals in these specialties rose from 2.2 and 3.8 days to 2.8 and 4.2 days, respectively, during the same period. By contrast, the paediatric bed turnover rate increased from 20.3 to 32.4 patients per available bed, and the turnover interval fell from 5.3 to 3.1 days.

The report points out that, in addition to overall increases in numbers of patients admitted, one of the effects of the unit was a change in the admission patterns within the specialties, enabling the reduction of waiting lists in surgical specialties and a higher proportion of emergency admissions in medical specialties. It is improbable, however, that benefits of this type are attributable so much to the special nature of the unit as simply to the increase in beds available in each specialty following the unit's establishment.

The basic principle underlying the Dryburn experimental unit was that pre-convalescent patients could be moved into the unit from the general wards so as to make way for emergency admissions; by this means, the necessity to keep beds empty for emergencies could be avoided. An alternative method of achieving the same end is the establishment of the type of casualty ward described by Pike et al. (1963), which provides accommodation for those emergency admissions whose hospital stay is predictably short. In the ten-bed unit described, the maximum length of stay envisaged was three days. The use of such a unit reduces the fluctuations in emergency bed occupancy which occur in the general wards, thereby, in theory, increasing the efficiency of bed utilisation.

However, the pattern of bed utilisation in the casualty ward is far from efficient. Pike et al. indicate that, if the casualty ward contains "enough beds to allow for a fluctuating demand 90% of the time, the average proportion of beds occupied will be only 35%". On
the basis of their observed mean duration of stay of 1.74 days, this implies a turnover interval of 3.23 days. Extremes of bed occupancy fluctuation in a small unit of this nature might be justifiable, if its use eliminated altogether the fluctuations encountered in the general wards. No data are presented concerning the patterns of bed utilisation in the general wards, but the situation may be inferred from the continuing necessity for the general wards to provide for those emergency cases who bypass the casualty department; for casualties whose duration of stay is predictably longer than three days; and for these patients who, after initial admission to the casualty ward, are found to require in-patient care for more than three days.

The suggestion by Pike et al. that "the usual standards of bed occupancy cannot be applied to this type of ward..." prompts enquiry; which standards of bed utilisation should be applied? It may be that "short-stay emergencies do not require highly specialised treatment and it is wasteful of facilities in major units to reserve beds for them there"; but unless it is clearly demonstrated that the use of this type of small supporting unit results in an overall saving of facilities by more efficient bed utilisation, the object of the exercise is defeated. For elective admissions, small units working for a few days each week and staffed by part-time nurses are usually characterised by efficient indices of utilisation, and afford opportunities to make optimal use of available facilities and personnel. Where emergency cases are concerned, and bed utilisation can not be planned ahead, the levels of utilisation are reduced in small units (Oxford R.H.B., 1966), the effects of bed occupancy fluctuations being proportionately greater.

The widely held belief that the use of pre-convalescent beds
offers advantages in terms of cost over acute general beds still awaits verification. The facts of the issue are not demonstrable from currently available data on hospital costs; Feldstein (1965) has suggested that such data are inadequate even for direct comparison between "acute" hospitals, because of the variations in "case-mix" which may occur. Certainly, the comparison of unlike units drawn by Scoular (1966) is manifestly improper. In comparing the average costs per patient per week in an acute general hospital and those in a "continuation treatment unit", he concludes that, in the provision of the latter type of unit, "more economic use can be made of the expensive facilities of the acute general hospital", because of the lower cost of treatment in the supporting unit. A slightly different picture may emerge from consideration of a hypothetical instance.

A patient is admitted to an acute surgical ward for elective gastrectomy. Assuming that there are no post-operative complications, his duration of hospital stay may be of the order of three weeks. The patient would probably have his operation one or two days after admission, requiring the undivided attention of the theatre nursing staff, the surgical team, and the anaesthetist at that time. The work of Barr (1964) on nursing dependency suggests that this type of patient would require a high intensity of nursing care during the immediate post-operative period; the same may be assumed concerning the medical supervision required. If the costs incurred during each day of this patient's hospital stay were plotted graphically, the distribution would be markedly skew, the peak coinciding with the day of operation; and almost all of the costs deriving from medical and nursing care, drugs and dressings would be expended during the first week or ten days of his hospital stay. So that, during the third week of his
stay, the only costs incurred would be those associated with minimal levels of medical and nursing supervision, and the indirect "fixed" hospital costs. At this stage, the total daily cost of his hospital care would be well below the average daily cost applicable over the entire hospital stay; it might well be of the same order as the cost of keeping the patient in a pre-convalescent unit.

The belief that it costs less to provide hospital care in a pre-convalescent bed than in a general bed is only tenable if it is accepted that, for each patient, the distribution of costs over time is rectangular. If, as seems more probable, the actual distribution is skewed unimodal, or polymodal, the greater part of total costs, those attributable to active investigation and treatment, will have been expended by the time the patient is suitable for transfer to pre-convalescent care. Thus, consideration of the cost per patient per day as currently presented in published tables of hospital costs, does not permit a realistic assessment of the economies possibly deriving from the use of supporting beds or early discharge schemes.

Deeble (1964) has suggested that such procedures may well result in an overall average increase in hospital treatment costs; and Gottrell (1966) has stated that "a more efficient use of beds, though a good thing for the consumer, will not reduce per-day costs for hospital authorities. Rather the reverse, for a new 'active' patient will consume more X-ray and laboratory services and, possibly, expensive medicines than a relatively 'inert' convalescent one".

In the present administrative framework of the hospital service, the use of supporting beds offers four main advantages. Firstly, there is the comfort of the patient; in general, pre-convalescent units offer a greater degree of peace and quiet, away from the tension and high activity of the acute unit. This is, however, a comparison attributable
to traditional ward design. Some of the newer ward designs, which permit selective patient grouping, render the activity and disturbance of the acute ward far less obtrusive to patients in the recovery stage after acute illness.

Secondly, there is the advantage associated with the use of nursing staff. During convalescence, the degree of medical and nursing supervision required by most patients is rather less than that provided in acute general wards, so that pre-convalescent units can be staffed largely by part-time and auxiliary nurses. Once again, this is more a reflection upon present methods of deployment of nursing personnel than an argument in favour of the pre-convalescent unit. Studies in nursing care of the type which have been carried out in the Oxford Region (Oxford R.H.B., 1962; Barr, 1964) promise an abundance of valuable information; if this can be used as the basis of more effective deployment techniques, it may be possible to match the nursing care provided to the requirements of each in-patient, regardless of the type of unit in which he is treated.

Thirdly, the use of supporting beds is often characterised by a more flexible bed allocation than that encountered in many acute general units. Newell et al. (1966) remarked upon this feature in the Dryburn unit, and felt that "this element of flexibility fully justifies the building of such a ward in new hospitals and old". The proprietary attitudes which have evolved with the British hospital service tend to reduce the efficiency of bed utilisation. It is to be hoped that "retrograde spread" from pre-convalescent units is not the only method of achieving a greater liberality of outlook concerning this aspect of bed utilisation.

Finally, adaptation as supporting units is, in many instances, the only method whereby the accommodation in small, obsolescent
hospitals can be conveniently used for the major specialties. While some of these hospitals will remain, together with the purpose-built pre-convalescent hospitals, the future concentration of the hospital service into fewer but larger district hospitals may render the use of many current supporting units less convenient.

Thus, while there are advantages associated with the use of pre-convalescent and other supporting beds, these generally reflect the present shortcomings of the hospital service and its administration. In terms of bed utilisation and cost economy, it is questionable whether they offer any advantage over acute general beds, other than to the extent of the increased bed availability which their use entails.

Provision of Operating Theatres.

The possibility that more efficient utilisation of beds in surgical specialties is prevented because of shortage of operating theatre facilities has been mentioned by several authors, although little attempt has been made to measure the extent of the problem. Airth and Newell (1962) mentioned deficiencies in theatre facilities as one possible factor accounting for "the existence of a large and increasing waiting list and at the same time an apparent surplus of beds" in general surgery in the Tees-side area. In replying to the suggestion that waiting lists could be abolished by a general reduction in the duration of patient stay, Turner (1967) stated that "the main cause of surgical waiting lists is lack of suitable operating-theatre space, operating-theatre personnel, and, in some cases, lack of sufficient nurses...if there is sufficient time to operate on only a given number of cases it could hardly help the waiting list to admit a greater number...by earlier discharge".

In his Amsterdam study, Querido (1963) considered 389 admissions
which accounted altogether for 7,773 occupied bed-days. Of these bed-days, 1,339 were "ineffective" in terms of the investigations and treatment carried out, 114 being attributable to "bottlenecks" associated with the use of operating theatres. While data were not presented which would indicate the proportion of wasted bed-days in surgical specialties arising from shortage of theatre accommodation, it seems probable that reductions in the level of bed utilisation arise from such shortages.

There is a dearth of factual information concerning the amount of operating theatre accommodation required in relation to surgical ward accommodation, most of the available assessments being based upon opinion. The "Studies in the Functions and Design of Hospitals" (N.P.H.T., 1955) briefly reviewed the levels of provision of theatre facilities in this country and the United States. The accepted level in American general hospitals is one theatre for every 20 surgical beds. In 1931, the level of provision in British hospitals varied between one theatre for 30 and one for 120 surgical beds; since the war, the recommendation of one theatre for every 50 surgical beds has been made.

Publications of the Ministry of Health, intended to provide guidance for those planning new hospitals, are bleak in their avoidance of the issue. The bulletin on "Operating Theatre Suites" (Ministry of Health, 1957) mentioned the difficulties in determining levels of provision, and frankly declined to make any recommendation. The more recent building note on the "Operating Department" (Ministry of Health, 1967) did not even allude to the problem.

Even amongst the surgeons themselves, there is a reluctance to express positive opinions. In an inaccurate reference to earlier work, the report of the Royal College of Surgeons (1964) on "The
Design of Operating Theatre Suites" mentions a level of provision of one theatre for every 30 beds; but formal commitment to any level of provision is avoided. The report prefers to relate theatre facilities to the consultant "firm", an entity which is indeterminate in size and, probably, outmoded in concept.

The only recent statement which can be regarded as categorical is that contained in the Report of a Working Party in Newcastle (Newcastle R.H.B., 1964), which considered that "to allow adequate time for cleaning and maintenance, no operating suite should be used for more than nine half-day sessions a week...we think it reasonable to provide in a district general hospital at least one operating suite for every forty general surgical and other surgical in-patient beds".

The amount of operating theatre time required is clearly a function of both the volume and type of work performed. Thus, an D.N.T. unit would require facilities to operate upon a large number of patients, the bed turnover rate of such units being generally high; but the length of operating time required for individual patients would be, on average, short, a substantial proportion of the procedures being brief operations such as tonsillectomy by guillotine. On the other hand, a thoracic surgery unit, with a relatively low bed turnover rate, would require facilities for fewer operations; but the time spent on individual operations would be considerably longer.

In the face of widely variable factors such as this, any "rule of thumb" applied to the provision of theatre facilities would almost certainly fail to approximate to the requirements of the unit concerned. It is not, however, necessary to perpetuate the choice between too generous a level of provision with prodigal capital expenditure, or too low a level with suppression of levels of surgical bed utilisation. While the problem is currently confounded
by the complete absence of any relevant statistical data indicating
the use made of operating theatre facilities in various surgical
specialties, it is possible to identify the relationship between the
availability of theatre facilities and certain parameters of bed
utilisation; were data concerning theatre utilisation to become
available, this relationship might form the basis of a more rational
approach to the provision of theatre facilities.

In this context, the term "theatre facilities" is intended to
include operating theatres and the other accommodation and equipment
normally associated with them, such as anaesthetic rooms, recovery
areas, and space for changing and storage; together with appropriate
staff in terms of nurses, anaesthetists and orderlies. It is
appreciated that, in many instances, shortage of staff represents a
greater embarrassment than shortage of equipment. In relation to
provision and function, theatre facilities must be regarded as an
inseparable combination of personnel and material.

If, for a given surgical specialty in a given area,
Ba  is the average daily number of beds available;
G   is the total number of operations performed during a year;
D   is the number of discharges and deaths during the year;
h   is the ratio of operations to total discharges during the year;
Q   is the number of hours of theatre time available during the year;
r   is the average number of operations per theatre-hour;
S   is the mean duration of stay;
T   is the annual bed turnover rate;
t   is the turnover interval;

Then     \[ G = r Q \]
And       \[ C = h D \]
Therefore  \[ r Q = h D \]
And \[ Q = \frac{hD}{r} \]

Now \[ D = T \cdot \text{Ba} \] (From (9); p. 50)

Therefore \[ Q = \frac{hT \cdot \text{Ba}}{r} \]

Therefore \[ \frac{Q}{\text{Ba}} = \frac{hT}{r} \]  

\[ \ldots..(11) \]

And \[ T = \frac{365}{s + t} \]  

((10); p. 57)

Therefore \[ \frac{Q}{\text{Ba}} = \frac{365h}{r(s + t)} \]  

\[ \ldots..(12) \]

From equation (12), it will be seen that, if the amount of theatre time in relation to available beds is fixed, then the aggregate of the mean duration of stay and turnover interval must also be fixed, assuming that the mean hourly operation rate and ratio of operations to discharges are characteristic of a given surgical specialty. Thus, if theatre facilities are used to full capacity, reductions in the mean duration of stay can only result in extension of the turnover interval, and will not affect the bed turnover rate. Conversely, if the availability of theatre facilities is sufficient to allow the mean duration of stay and the turnover interval to be reduced to the minimum level determined by clinical or other administrative factors, further increases in theatre time carry no benefit.

The other parameters involved in these equations, the mean hourly rate of operation and the ratio of operations to discharges, will be subject to some variation both between and within surgical specialties. It is improbable that they are amenable to control as a matter of administrative policy, so that their use in potential applications of these equations would be dependent upon observed patterns of current practice. The mean hourly rate of operation within a specialty will
vary from time to time with the types of operation observed, and the experience and individual techniques of the surgeons. But comparison of the mean rates encountered in a given unit over two consecutive periods of six months would, perhaps, demonstrate less difference than, for example, comparison between the rates found in an E.N.T. unit and a neurosurgery unit over the same period. Discussion of this point is necessarily conjectural, no statistical data being available for illustrative purposes. Suitable data might be collected in a series of ad hoc studies covering several specialties in several hospitals, but problems arise in the necessity to relate availability of theatre time to availability of beds; because of the recommended methods of computing "available beds", it is difficult to find hospitals where data on bed availability can be accepted as being strictly accurate.

The ratio of operations to discharges is another parameter not readily ascertainable from current statistics. Some indication can, however, be obtained from the Report of the Hospital In-Patient Enquiry for 1961 (Ministry of Health and General Register Office, 1964), by relating numbers of specific operations to discharges in certain specialties. In the report, the operations are classified by anatomical region, and not by specialty; and, since general surgeons perform some gynaecological and orthopaedic operations, and operations in such regions as the "buccal cavity and oesophagus" may be carried out by surgeons in four or five specialties, the estimates of the ratio are, at best, approximate.

In Table XVII, the parameters which can be estimated have been applied to equation (11), in order to provide some assessment of the levels of provision of theatre facilities required at various hypothetical values of mean hourly operation rate. Intentionally, the parameters
used have been exaggerated in order to present the most favourable theatre:bed ratios. The values of bed turnover rate presented for each specialty represent an increase of approximately 20% over prevailing levels (Ministry of Health, Annual Report, 1966). Two values of the ratio of operations to discharges have been given for each specialty; so far as can be ascertained from the H.I.P.E. data, the actual value appears to lie between the two, closer to the lower value.

For the purposes of assessing the functional availability of an operating theatre, the recommendation of the Newcastle Working Party (Newcastle R.H.B., 1964) has been generously interpreted; it has been assumed that an operating theatre would be available for not more than 25 hours each week, or 1,250 hours per year, including the time required for emergency operations. Because data relating to mean hourly operation rates are not available, the theatre:bed ratios have been calculated for a range of rates in each specialty.

Even with a generous margin of error in the selection of parameters, the levels of theatre provision required in each specialty approximate to the suggested level of one theatre for every 40 beds only at the lower operation rates in each range. One theatre for 40 beds is probably appropriate in the specialties characterised by low rates of bed turnover, but may be overgenerous for general surgery and E.N.T. surgery. Provision of one theatre for every 30 beds would almost certainly be excessive in any specialty.

The further development of Hospital Activity Analysis will enable accurate assessment of the ratio of operations to discharges. It might be unduly optimistic to anticipate early modifications in collection of hospital statistics which would permit assessment of true bed availability and mean hourly operation rates; but such data could be collected in suitable large ad hoc studies. Use of these
<table>
<thead>
<tr>
<th>Specialty</th>
<th>Annual Bed Turnover Rate</th>
<th>Operations Discharges</th>
<th>Ratio,</th>
<th>Ratio, Theatres : Available Beds when mean hourly operation rate is</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>General surgery</td>
<td>35</td>
<td>0.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gynaecology</td>
<td>40</td>
<td>0.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>E.N.T. surgery</td>
<td>54</td>
<td>0.8</td>
<td>1:36</td>
<td>1:53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0</td>
<td>1:28</td>
<td>1:43</td>
</tr>
<tr>
<td>Orthopaedic surgery</td>
<td>22</td>
<td>0.8</td>
<td>1:22</td>
<td>1:43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0</td>
<td>1:17</td>
<td>1:35</td>
</tr>
<tr>
<td>Thoracic surgery</td>
<td>18</td>
<td>0.8</td>
<td>1:16</td>
<td>1:31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0</td>
<td>1:13</td>
<td>1:25</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>25</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
formulae in the development of theatre facilities would then require the selection of appropriate bed turnover rates. In this respect, there is an apparent recurrence of the problem associated with the use of statistical techniques in predicting bed requirements - the necessity to adopt arbitrary standards of bed utilisation. In this instance, however, there is not the element of doubt or debate that exists in relation to future patterns of bed occupancy rate or use of domiciliary services; secular trends indicate that increased rates of bed turnover may, with certainty, be projected for the future. And, in contradistinction to prediction of bed requirements, where forward projections tend to reduce levels of provision with the possibility of restrictive effects upon future hospital utilisation, projected increases in bed turnover rates would improve the theatre:bed ratio for all specialties. Because this formula would be used to determine small integer numbers of theatres, variations attributable to errors in the applied utilisation index are proportionately much smaller than those which occur in the assessment of bed requirements. Thus, the problem is not to reduce the future provision of facilities to levels which, although apparently appropriate, may effectively dictate future patterns of utilisation; but to increase the provision of facilities marginally beyond the level at which they interfere with efficient bed utilisation.

Control of Emergency Admissions.

In many "acute" hospital units, particularly those relating to the larger specialties, the effective utilisation of beds involves the necessity to strike a balance between the numbers of beds which are used by patients admitted from the waiting list, and the beds which must be kept available for emergency admissions. The admission of
excessive numbers of waiting list patients in preference to emergencies can contribute to the type of administrative difficulty described by Gibson et al. (1958) and Warren et al. (1967), while the reservation of too many beds for emergencies may entail under-utilisation if the anticipated emergencies fail to arrive.

Efforts have been made to solve this administrative problem, using the observation that day-to-day demand for emergency accommodation follows the Poisson distribution. Newell (1954) presented a series of tables, indicating the numbers of beds required to provide for probable emergency demand at various levels of measurable mean daily demand, and showing also the possible effects upon levels of utilisation. Balintfy (1960) evolved a stochastic process, based upon theoretical assumptions, to predict numbers of admissions and discharges; but the precision of the model may have been reduced by the breadth of the assumptions, and its practical application is currently restricted by the necessity for open access to computer facilities. The demonstration by Pike et al. (1963) that the numbers of emergency beds occupied from day to day also follow the Poisson distribution may have predictive capabilities where emergencies are admitted daily, but its wider application is probably not practicable, as will be shown. Young (1965) suggested a method of providing for emergencies by the short-term control of waiting list admission; this requires the admission of waiting list patients at very short notice, a procedure not attended by universal success.

In all of these studies, it was assumed that emergencies would be admitted every day to the units under consideration. This assumption may be tenable only in isolated hospital units, serving discrete catchment populations, and obliged to provide accommodation for all of the emergencies arising in those populations. In areas of
high population density, it is customary to find several hospital units of the same type working in relatively close geographical proximity. To conserve resources of personnel and equipment, and for reasons of administrative convenience, the admission of emergencies is often undertaken in rotation by different units within a hospital, or by different hospitals within a city; so that an individual unit may admit emergencies on every second day, or every third day, or two days of each week, and so on, depending upon the number and size of the units involved.

In any unit, the numbers of beds occupied by emergency cases will vary from day to day, according to the numbers and duration of stay of the patients admitted. The rotational admission schedules will also affect the fluctuations in emergency bed occupancy, these fluctuations being, for example, less where two emergencies, on average, are admitted every day, than where six emergencies, on average, are admitted every third day. The effects of different admission schedules upon the day-to-day variations in emergency bed occupancy have been studied by the technique of computer simulation. Details of the technique are presented elsewhere (Handyside and Morris, 1968), but it may be briefly described as a Monte Carlo method, using random numbers to sample from a Poisson distribution for arrival of emergencies, and an observed or empirical distribution of duration of stay. It is intended to describe the studies which were carried out to compare the results of the simulation with observed data, and to show the effects upon emergency bed occupancy which may result from the use of different admission schedules.

(a) Validation Studies.

In order to assess the validity of the technique, simulated
sequences were compared with observed sequences, based on investigations carried out in five General Surgery units in the Sheffield Hospital Region. At the start of the study, a census was carried out in each of the units, to discover the numbers of patients who had been admitted as emergency cases. Thereafter, data were collected daily from each unit for a period of 70 days, between January 9th and March 19th, 1967, so as to ascertain the numbers of new emergencies admitted each day and the numbers of discharged patients who had originally been admitted as emergencies. In this way, a record was obtained of the numbers of beds in each unit occupied by emergency cases at midnight of each day during the study period.

In addition, data were collected concerning the duration of hospital stay of emergency cases discharged during the period of the study. The distributions of duration of stay for each of the five units are shown in Figures 4 to 6. It will be seen that there are marked differences in the patterns of duration of stay encountered. The longer average stay for patients in Unit 5 is to some extent accounted for in that this was the only unit which did not have access to pre-convalescent beds outside the parent hospital. During the period of the study, the average daily numbers of pre-convalescent beds used were 4.6 by Unit 1, 4.5 by Unit 2, and 12.9 by Units 3 and 4 together. In the absence of data indicating the precise extent to which these pre-convalescent beds were used by emergency cases, it is impossible to offer any comment regarding the significance of the differing patterns of duration of stay; it does not seem likely, however, that the differences are entirely accounted for in the availability of pre-convalescent beds.

The five units varied in other respects also. Units 1 and 2 each comprised approximately 35 beds, and were administered clinically
PERCENTAGE DISTRIBUTION OF DURATION OF STAY OF SURGICAL EMERGENCIES

UNIT 1

n = 112
mean = 8.52 days

UNIT 2

n = 167
mean = 6.65 days
PERCENTAGE DISTRIBUTION OF DURATION OF STAY OF SURGICAL EMERGENCIES

UNIT 3

- \( n = 97 \)
- \( \text{mean} = 9.99 \text{ days} \)

UNIT 4

- \( n = 207 \)
- \( \text{mean} = 10.09 \text{ days} \)
PERCENTAGE DISTRIBUTION OF DURATION OF STAY OF
SURGICAL EMERGENCIES

UNIT 5

n = 186
mean = 13.92
by different consultants. Complementary to each other in one of the Sheffield teaching hospitals, their admission schedules were so arranged that, at any time, one of these was theoretically open to emergencies. The schedules provided for the admission of emergencies on each day during alternate weeks, these admission weeks commencing on Thursdays. During the period of the study, Units 1 and 2 admitted 111 and 161 emergencies, respectively.

Units 3 and 4 were also complementary to each other, in the two general hospitals serving the Mansfield area. Unit 3 comprised approximately 45 beds, and Unit 4 approximately 50 beds, both units being staffed by the same team of surgeons. While emergencies were admitted to both units, a larger number of waiting list patients was admitted to Unit 3; and a greater proportion of the emergencies arising in the catchment population was dealt with in Unit 4, which was responsible for all the urological emergencies and all of the head injuries cared for by the general surgeons. Unit 3 admitted emergencies each Monday, Wednesday and Friday, and every alternate weekend; and Unit 4 admitted emergencies every day. The two units admitted 24 and 188 emergencies, respectively, during the study period.

Unit 5 comprised approximately 55 beds, all under the charge of one consultant in one of the non-teaching hospitals in Sheffield. Its admission schedule provided for the admission of emergencies on each Monday, Wednesday and Thursday, and alternate weekends. During the study, 188 emergencies were admitted.

Following the investigation of these units, the observed mean daily emergency admission rate, the distribution of duration of stay of discharged emergency patients, and the admission schedule appropriate to each unit were used as input data for the simulation programme. At this stage, it was discovered that Units 1, 2, 3 and 5 did not adhere
rigidly to their admission schedules, so that it was necessary slightly
to modify the computer programme to allow for the proportions of
emergencies not admitted in accordance with the schedules; this was
done by sampling from a secondary distribution of arrivals, under
the assumption that these patients would have the same distribution
of duration of stay as that observed in the unit under consideration.
The proportions of patients admitted outwith the stated schedules
were 11.7% for Unit 1, 11.8% for Unit 2, 7.5% for Unit 3, and 18.1%
for Unit 5. The simulation programme made no allowance for reduced
demands for emergency admissions at weekends, of the type encountered
by Newell (1954), because the data collected from the five units
failed to show any consistent pattern of variation in day-to-day
demand.

The observed sequences for each unit, together with the corresponding
simulated sequences, are presented graphically in Figures 7 to 11. The
simulated sequences used were selected from the output data, starting
after the period of stabilisation of bed occupancy levels necessary
to the technique, which assumes an empty unit at the commencement of
simulation (Handyside and Morris, 1968). Comparisons between the
observed and simulated sequences for each unit have been based upon
the general conformation of the pictorial representations, and also
upon the derivation of three parameters: -

(i) the mean bed occupancy;
(ii) the mean daily fluctuation;
(iii) the mean maximal bed occupancy.

The first of these parameters is self-explanatory, being the mean of
the numbers of beds occupied on each day. The mean daily fluctuation
is the mean of the moduli of changes in bed occupancy from day to day.
The mean maximal bed occupancy in the mean of the peak levels of
SIMULATION OF EMERGENCY BED OCCUPANCY

simulated and observed sequences for UNIT 1
SIMULATION OF EMERGENCY BED OCCUPANCY

simulated and observed sequences for UNIT 2
SIMULATION OF EMERGENCY BED OCCUPANCY

simulated and observed sequences for UNIT 3

OBSERVED SEQUENCE

SIMULATED SEQUENCE
SIMULATION OF EMERGENCY BED OCCUPANCY

simulated and observed sequences for UNIT 4

OBSERVED SEQUENCE

SIMULATED SEQUENCE
SIMULATION OF EMERGENCY BED OCCUPANCY

simulated and observed sequences for UNIT 5
occupancy occurring at the end of each group of consecutive days of admission. These parameters will be discussed further at a later stage; the reasons for using them are that they can be derived theoretically for any admission schedule where emergencies are not admitted every day, and they afford some measure of the extent of the fluctuations occurring in emergency bed occupancy. The data involved in this comparison between observed and simulated sequences are summarised in Table XVIII.

The parameters derived from the simulated sequences approximate to the observed data for all units except Unit 5. Initially, it was thought that the dissimilarity in this instance was attributable to the comparatively high proportion of emergency admissions accepted outwith the stated schedule. It seems more probable, however, that the differences are due to the collection of inadequate data relating to the duration of stay. Re-examination of the data revealed that, during the period of the study, twelve emergency patients were encountered in Unit 5 whose hospital stay exceeded six weeks. Nine of these were in hospital at the start of the study, seven of them being discharged during the study. A further one "long-stay" patient was admitted and discharged during the course of the study, so that the data relating to duration of stay included eight patients whose hospital stay exceeded 42 days. However, two patients who were in hospital when the study started were still in hospital when it finished, together with a further two "long-stay" patients admitted while the study was in progress. Thus, consideration of the duration of stay of patients discharged during the study included data relating to eight "long-stay" patients, who, between them, occupied 331 bed-days during the study; but excluded a further four who occupied 251 bed-days. The study period was clearly too short in relation to
Table XVIII - Summary of data comparing observed and simulated sequences of emergency bed occupancy

<table>
<thead>
<tr>
<th>Unit</th>
<th>Mean bed occupancy</th>
<th>Mean daily fluctuation</th>
<th>Mean maximal bed occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Observed 12.0</td>
<td>1.7</td>
<td>16.0</td>
</tr>
<tr>
<td></td>
<td>Simulated 11.3</td>
<td>1.6</td>
<td>15.5</td>
</tr>
<tr>
<td>2</td>
<td>Observed 15.8</td>
<td>1.9</td>
<td>19.4</td>
</tr>
<tr>
<td></td>
<td>Simulated 14.4</td>
<td>2.0</td>
<td>19.7</td>
</tr>
<tr>
<td>3</td>
<td>Observed 12.7</td>
<td>1.3</td>
<td>13.4</td>
</tr>
<tr>
<td></td>
<td>Simulated 13.2</td>
<td>1.4</td>
<td>13.9</td>
</tr>
<tr>
<td>4</td>
<td>Observed 24.9</td>
<td>2.1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Simulated 26.2</td>
<td>1.7</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Observed 41.3</td>
<td>2.4</td>
<td>42.4</td>
</tr>
<tr>
<td></td>
<td>Simulated 35.4</td>
<td>2.1</td>
<td>36.4</td>
</tr>
</tbody>
</table>
the distribution of duration of stay for the collected data accurately
to represent the situation prevailing in Unit 5; and the simulated
sequence has been, in consequence, unrealistically deflated.

While this methodological error in data collection is acknowledged,
it was felt that, for the other four units, the simulation process
produced sequences whose comparability to the observed data was
sufficiently acceptable to permit wider application of the technique.

(b) Effects of Admission Schedules.

To facilitate the use of this technique in assessing the effects
upon emergency bed occupancy of different admission schedules, standard
data were prepared relating to duration of stay and admission rate.
The distribution of duration of stay (Figure 12) was based, to some
extent, upon the patterns in the five observed units, but the upper
limit was set arbitrarily at 60 days. The admission rate used was
such that a unit of 50 beds would admit 1,000 emergency cases in a
year. These standard data might be applicable to general surgery
units in Britain, but reflect a rate of turnover rather higher than
that generally encountered at present. However, high turnover data
serve to emphasise the fluctuations which occur in emergency bed
occupancy; and, since two of the observed units (2 and 4) approximated
to this rate of turnover, the data are not altogether unrealistic.

Comparison between the various admission schedules is based upon
the parameters already discussed, and also upon a consideration of the
relative difficulty which might be encountered in making the best use
of the beds which are not occupied by emergency cases. It will be
assumed that it is undesirable for any of the hypothetical 50-bed
units to exceed its bed complement, either by the temporary establish-
ment of additional beds, or by "overflow" into other units.
HYPOTHETICAL DISTRIBUTION OF DURATION OF STAY
USED IN SIMULATION OF EMERGENCY BED OCCUPANCY

N = 1,000
mean = 9.295 days
The simulated sequence for a unit admitting emergencies every
day is shown in Figure 13. This sequence is applicable whether the
unit be isolated with its own catchment population, or working in
conjunction with other units to serve larger population groups;
provided the admission rate, distribution of duration of stay, and
admission schedule remain unchanged, the bed occupancy sequence is,
in general, independent of the number of units involved. It will
be seen that two types of fluctuation are exhibited by the sequence;
first, the small fluctuations occurring over periods of a few days,
and secondly the wider fluctuations spread over periods of weeks.
The first of these is a characteristic of the admission schedule.
The second is perhaps analogous to the periodicity discovered by
Newell (1964 (b) and personal communication) in his investigation
of obstetric bed occupancy. In the present study, it is associated
with the sequence of random numbers generated for the simulation
process, since all of the simulated sequences were based upon the
same series of random numbers, and all demonstrate a similar long-
term periodicity.

The fluctuations in bed occupancy associated with daily emergency
admissions range, in Figure 13, from 14 to 39 occupied beds. At any
time, this unit might expect to have at least 10 beds available for
use by patients admitted from the waiting list. Although the range
of fluctuation is wide, the increases which occur in emergency bed
occupancy are of gradual development, the steepest increment being
of 15 beds and occurring over a period of a week, from day 47 to day
54. It is necessary to plan the admission of waiting list patients
and their bed occupancy at least three or four days ahead. Despite
the unpredictable nature of the fluctuations in emergency bed
occupancy, this schedule affords the easiest opportunity to minimise
SIMULATION OF EMERGENCY BED OCCUPANCY

Admission Schedule -
Every day
the gap between emergency and waiting list bed occupancies, so as to reduce the numbers of empty beds on each day.

Figures 14 (a) and (b) are two of the sequences resulting from schedules which might be adopted where two units of similar size are working in conjunction. In Figure 14 (a), emergencies are admitted on every alternate day; in Figure 14 (b), the schedule is formalised so that the two units admit emergencies on the same days every week (in this instance, Monday, Wednesday and Friday), and cover Sundays alternately. The two sequences are very similar, the main difference being the exaggerated peaks of bed occupancy in Figure 14 (b) following the Sunday admissions; these peaks are most obvious at days 57, 71 and 113. The overall range of fluctuation is similar to that in Figure 13, but the day-to-day fluctuations are markedly increased. Thus, although 10 or 12 beds would be available for use by non-immediate patients at any time, it would be less easy to reduce the numbers of beds remaining empty, because of the danger of overcrowding when a sudden increase in emergency bed occupancy occurs.

The other two admission schedules which might be adopted where two units of equal size work in conjunction are shown in Figures 15 (a) and (b). The mean daily fluctuations are of the same order as those in Figures 14 (a) and (b), but there is a cumulative effect upon bed occupancy levels resulting from the admission of emergencies over periods of three or four consecutive days in Figure 15 (a) and seven consecutive days in Figure 15 (b). The numbers of beds available for use by non-immediate patients remains at 10 or 12 at any time in Figure 15 (a), but is reduced to less than 10 in Figure 15 (b). The problem of using the residual beds becomes progressively more difficult. In Figure 15 (b), it would be possible to predict that the schedule would produce a "trough" in emergency bed occupancy at day 27; but,
SIMULATION OF EMERGENCY BED OCCUPANCY

Admission Schedule:
- Alternate days

Admission Schedule:
- Each Monday, Wednesday and Friday, and alternate Sundays
SIMULATION OF EMERGENCY BED OCCUPANCY

Admission Schedule:
Each Monday, Tuesday and Wednesday,
and alternate Sundays

Admission Schedule:
Each day, on alternate weeks
even if it were possible to forecast the availability of between 35 and 40 beds for non-immediate patients at that time, the necessity to ensure the discharge of more than half of them within a week would present substantial administrative problems. Members of medical staff with experience of this admission schedule report that, far from attempting to keep beds filled, the ward staff frantically try to empty the ward during the week when emergencies are not being admitted, in order to prepare for the onslaught of the following week.

The admission schedules applicable to combinations of three units are illustrated in Figures 16 and 17. Figure 16 (a) shows the effects of the schedule where each of the three units admits emergencies every third day in strict rotation, and Figure 16 (b) represents the formalised situation where each unit has its own two regular week-days and covers every third Sunday. The situation is similar to that in Figure 14, except that the average number of patients admitted on any day is proportionately increased, producing a concomitant increase in the mean daily fluctuation. There are still about 10 beds constantly available for non-immediate patients, but the increased mean daily fluctuation reduces the ease with which the remaining beds may be effectively used.

Figure 17 (a) illustrates the schedule where emergencies are admitted on two consecutive week-days (in this instance, Monday and Tuesday) and every third Sunday; and Figure 17 (b) indicates what can happen when emergencies are admitted throughout every third week. In this sequence, it is not possible to admit all of the emergency patients who might be expected to arrive, without the emergency bed occupancy exceeding the theoretical bed complement on some occasions. Lest it be thought that such a schedule is purely hypothetical, it should be explained that precisely this schedule was in operation.
SIMULATION OF EMERGENCY BED OCCUPANCY

Admission Schedule:
- Every third day

```
<table>
<thead>
<tr>
<th>Day Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 28 42 56 70 84 98 112 126 140</td>
</tr>
<tr>
<td>0   10 20 30 40 50 0   10 20 30</td>
</tr>
<tr>
<td>Beds Occupied</td>
</tr>
</tbody>
</table>
```

Admission Schedule:
- Each Monday and Thursday, and every third Sunday

```
<table>
<thead>
<tr>
<th>Day Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 28 42 56 70 84 98 112 126 140</td>
</tr>
<tr>
<td>0   10 20 30 40 50 0   10 20 30</td>
</tr>
<tr>
<td>Beds Occupied</td>
</tr>
</tbody>
</table>
```
SIMULATION OF EMERGENCY BED OCCUPANCY.

Admission Schedule:
Each Monday and Tuesday, and every third Sunday

Admission Schedule:
Each day, during every third week
until recently in the three general medical units at Sheffield Royal Hospital; the reasons for its abandonment are obvious.

In large urban areas, it is not uncommon to find hospitals containing five or more units of the same type, with rotational schedules for the admission of emergencies which involve all of the units. Figure 18 (a) shows the simulated sequence for one of five units, and Figure 18 (b) illustrates the sequence for one of six units. In both instances, the admission of a large number of emergencies on one day of each week produces a characteristically "spiky" pattern of emergency bed occupancy, complicated by additional admissions every fifth or sixth week-end. The schedule indicated in Figure 18 (b) has been in use at Edinburgh Royal Infirmary for many years. It is not unusual for an individual general surgical unit to admit twelve emergencies on one day, and occasions arise when more than 15 are admitted.

It is clear that admission schedules of the type illustrated in Figures 15 (b), 17 (b) and 18 have a detrimental effect upon the efficiency of bed utilisation. However, the simulated sequences could never demonstrate the often intolerable burden which these schedules impose upon the medical and nursing staff concerned. Such admission schedules must be considered neither to optimise bed utilisation nor to afford any measure of administrative convenience.

In defence of these schedules, it might be pointed out that the range of the fluctuations occurring in the simulated sequences is much greater than that encountered in practice, because of the nature of the input data for the simulation programme. However, if actual turnover rates are lower by a sufficient amount to "damp" the fluctuations in these schedules, they could be expected to have a proportionate damping effect on fluctuations in more tractable
SIMULATION OF EMERGENCY BED OCCUPANCY

Admission Schedule:
- Each Monday, and every fifth Saturday and Sunday

Admission Schedule:
- Each Monday, and every sixth Sunday
The primary object of the simulation exercise is not to assess the precise effects of each admission schedule, but to demonstrate the comparative effects of different schedules using standard data.

Another problem associated with any schedule characterised by sudden marked increases in emergency bed occupancy is the necessity to deal with resulting overcrowding. In some units, this problem is fairly met, and dealt with by the establishment of extra beds, often in the centre of the ward. Where the authorities are less scrupulous, however, the unit may be temporarily closed to emergencies, regardless of the admission schedule, so that other neighbouring units or hospitals are compelled to accept more than a reasonable share of emergency work. This particular problem can only be overcome by increasing the authority of the Medical Referee of the Emergency Bed Bureau, or, preferably, by rationalisation of emergency admissions in centres of high population density.

(c) Estimation of Parameters.

The use of computer simulation provides a detailed picture of the effects upon emergency bed occupancy of individual admission schedules. However, it is possible to "shortcut" this procedure by using mathematical formulae to estimate the mean bed occupancy, the mean daily fluctuation, and the mean maximal bed occupancy. Where detailed study of emergency bed occupancy is not necessary, or recourse to computer simulation is not feasible, the formulae may be used to express the general consequences of any admission schedule, and may thus be useful for rapid comparison between schedules. The data required for these formulae are derived from the admission rate, the distribution of duration of stay, and the characteristics of the
admission schedule.

The basic data required are:

(i) the mean daily admission rate for emergencies (denoted "A"); in this study, each of the simulated 50-bed units was assumed to admit 1,000 emergencies each year, so that the mean daily admission rate was 2.740, and its standard error was 0.077;

(ii) the mean duration of stay (denoted "s"); as shown in Figure 12, the mean used here was 9.295 days, with a standard error, assuming 1,000 observations, of 0.296;

(iii) the admission cycle (denoted "K"), defined as the minimum number of days required to complete the admission schedule;

(iv) the admission interval (denoted "x"), defined as the mean number of days between the commencement of those days when emergencies are admitted; for ease of calculation, it may be regarded as the reciprocal of the proportion of days in each cycle when emergencies are admitted;

(v) the number of discrete periods of admission (denoted "n") during the cycle; where the schedule is such that emergencies are admitted on two or more consecutive days, each such aggregate of days may be regarded as a discrete period of admission.

Figure 19 demonstrates the means whereby the values of K, x and n may be derived for individual admission schedules. In the first example, the schedule calls for admissions on every Monday, Wednesday and Friday, and alternate week-ends, so that the cycle repeats itself every two weeks; K is thus 14. During each cycle of 14 days, emergencies are admitted on eight days, so that the mean time interval between the start of each day of admission is greater than one day but less than two days; the actual value is 14/8, or 1.75. At one stage during every cycle, this schedule requires that emergencies be admitted for
DERIVATION OF DATA REQUIRED FOR ESTIMATION OF BED OCCUPANCY PARAMETERS

Admission Schedule:
- Each Monday, Wednesday and Friday, and every alternate Saturday and Sunday

Admission Periods:

1. Each Monday and Tuesday, and every third Sunday
   - Admission Days: IIIII III III I
   - Duration: (21 days)
   - \( x = \frac{21}{7} = 3 \)
   - \( n = 3 \)

2. Each Wednesday, and every fifth Saturday and Sunday
   - Admission Days: I I I I I I I I I I I I I I I I I I
   - Duration: (35 days)
   - \( x = \frac{35}{7} = 5 \)
   - \( n = 6 \)

\( \frac{14}{8} = 1.75 \)

Beds Occupied

Day Intervals
four consecutive days (Friday, Saturday, Sunday and Monday); counting this aggregate of four, and the remaining single days in the cycle, the number of discrete periods of admission (n) during the cycle is thus 5.

In the second example, emergencies are admitted on two week-days and every third Sunday. The cycle thus repeats itself every three weeks, so that K is 21. Emergencies are admitted on 7 of each 21 days, so that x is 21/7, or 3. The days of admission in each cycle are aggregated into two groups of two days and one group of three days, so that n is 3.

In the third example, the cycle recurs every five weeks, K being thus 35. The admission interval is 35/7, or 5. In addition to one discrete period of admission every Wednesday, every fifth week-end also constitutes a discrete period of admission, so that n is 6.

The mean bed occupancy (Bo) is obtained by multiplying together the mean admission rate and the mean duration of stay (Bailey, 1962). In any unit where emergencies are admitted daily, the numbers of beds occupied from day to day will follow the Poisson distribution (Pike et al., 1963). Where any other admission schedule is in operation, this can not be so, since the extent of the fluctuations in bed occupancy induced by the admission schedule do not affect the mean bed occupancy. Thus, while the mean and the variance of bed occupancy may have the same value when emergencies are admitted daily, the variance is demonstrably greater, despite the constant mean, in other admission schedules.

In general, the admission of emergencies increases the number of beds occupied, and, conversely, discharges decrease bed occupancy. In a stable situation, the mean daily admission and discharge rates will approximate to each other over a prolonged period. The extent of the
increase in bed occupancy on each day when emergencies are admitted will be the algebraic sum of admissions and discharges on that day. The mean number of admissions on each such day will be the product of the admission rate and the admission interval, \( Ax \), and the mean number of discharges will be \( A \). The mean increase in bed occupancy associated with each admission day may thus be expressed as \( A(x - 1) \), the algebraic sum of admissions and discharges. In a period of stabilised bed occupancy, the sum of the increases in bed occupancy will equal the sum of the decreases, so that the sum of the moduli of fluctuations associated with each admission day will be \( 2A(x - 1) \). The mean daily fluctuation is, therefore, this value divided by the admission interval:

\[
\text{i.e., Mean Daily Fluctuation} = \frac{2A(x - 1)}{x}
\]

It will be seen that this is a function asymptotic to unity, so that the mean daily fluctuation can not be derived by this means for any admission schedule where \( x = 1 \), that is, where emergencies are admitted every day.

Over a fixed time period, the number of increases in bed occupancy associated with admission days is inversely proportional to the admission interval. Where this time period is the length of the admission cycle, \( K \) days, the number of increases will be \( \frac{K}{x} \); and, since it has been shown that the mean amount of increase arising from each admission day is \( A(x - 1) \), the sum of the increases during the admission cycle will be

\[
\frac{K A(x - 1)}{x}
\]

In those admission schedule where two or more admission days occur consecutively, the sum of bed occupancy increases during the cycle is shared among the number of discrete admission periods, \( n \). The mean of the maximal bed occupancy levels associated with these periods is thus
\[
\frac{K A(x - 1)}{x n}
\]

Increases and decreases in bed occupancy are distributed about the mean bed occupancy level so that, in a stabilised situation, half of the sum of the differences between maxima and minima lies above, and half below the mean. The mean maximal level thus exceeds the overall mean by

\[
\frac{K A(x - 1)}{2xn}.
\]

If \(Bo\) represents the mean bed occupancy level,

\[
\text{Mean Maximal Bed Occupancy} = Bo + \frac{K A(x - 1)}{2xn}
\]

This formula also embraces the asymptotic moiety \(x - x\), precluding its application to those schedules where emergencies are admitted daily.

These formulae have been used to estimate the parameters of mean bed occupancy, mean daily fluctuation, and mean maximal bed occupancy in relation to the schedules portrayed in Figures 13 to 18. The results are given in Table XIX, together with the values derived directly from the simulated sequences. The only significant difference between the "simulated" and "estimated" parameters is in the mean daily fluctuation relating to the schedule illustrated in Figure 14 (b).

The probable upper limits of the numbers of admissions which could occur during the longest admission periods characteristic of each admission schedule are shown in Table XX. This Table was prepared by Mr. A. J. Handyside, using the method described by him in the Appendix to this thesis.

Although the technique of computer simulation affords a method of examining in detail the effects of different admission schedules upon emergency bed occupancy, the probable effects of the schedules may be roughly gauged using mathematical formulae. If the simulation
Table XIX - Parameters comparing effects upon emergency bed occupancy of certain admission schedules; derived from simulated sequences and by mathematical estimation.

<table>
<thead>
<tr>
<th>Admission schedule (Figure)</th>
<th>Mean bed occupancy</th>
<th>Mean daily fluctuation</th>
<th>Mean maximal bed occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Simulated 25.4±4.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14 (a) Simulated 24.6</td>
<td></td>
<td>2.8 ± 0.2</td>
<td>25.9 ± 4.6</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>2.7 ± 0.2</td>
<td>26.8 ± 4.6</td>
</tr>
<tr>
<td>14 (b) Simulated 24.6</td>
<td></td>
<td>3.2 ± 0.2</td>
<td>26.2 ± 4.6</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>2.7 ± 0.2</td>
<td>27.1 ± 4.6</td>
</tr>
<tr>
<td>15 (a) Simulated 24.6</td>
<td></td>
<td>2.7 ± 0.2</td>
<td>28.6 ± 4.6</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>2.7 ± 0.2</td>
<td>30.3 ± 4.6</td>
</tr>
<tr>
<td>15 (b) Simulated 24.6</td>
<td></td>
<td>2.8 ± 0.2</td>
<td>34.2 ± 4.7</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>2.7 ± 0.2</td>
<td>35.1 ± 4.7</td>
</tr>
<tr>
<td>16 (a) Simulated 25.8</td>
<td></td>
<td>4.1 ± 0.4</td>
<td>29.1 ± 4.6</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>3.7 ± 0.4</td>
<td>28.2 ± 4.6</td>
</tr>
<tr>
<td>16 (b) Simulated 25.7</td>
<td></td>
<td>3.9 ± 0.4</td>
<td>29.1 ± 4.6</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>3.7 ± 0.4</td>
<td>28.7 ± 4.6</td>
</tr>
<tr>
<td>17 (a) Simulated 25.8</td>
<td></td>
<td>3.6 ± 0.4</td>
<td>32.4 ± 4.6</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>3.7 ± 0.4</td>
<td>31.9 ± 4.6</td>
</tr>
<tr>
<td>17 (b) Simulated 25.2</td>
<td></td>
<td>3.3 ± 0.4</td>
<td>45.3 ± 4.9</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>3.7 ± 0.4</td>
<td>44.7 ± 4.9</td>
</tr>
<tr>
<td>18 (a) Simulated 25.0</td>
<td></td>
<td>4.5 ± 0.4</td>
<td>33.4 ± 4.6</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>4.6 ± 0.4</td>
<td>33.4 ± 4.6</td>
</tr>
<tr>
<td>18 (b) Simulated 25.0</td>
<td></td>
<td>4.5 ± 0.4</td>
<td>34.2 ± 4.6</td>
</tr>
<tr>
<td></td>
<td>Estimated 25.5±4.6</td>
<td>4.6 ± 0.4</td>
<td>33.5 ± 4.6</td>
</tr>
</tbody>
</table>

* With 99% confidence limits, based upon standard errors of mean duration of stay and mean daily admission rate.
Table XX - Upper limits of numbers of admissions likely to occur during longest admission periods characteristic of each admission schedule*.

<table>
<thead>
<tr>
<th>Admission schedule (Figure)</th>
<th>Longest admission period (days)</th>
<th>Highest number of admissions Once every 100 cycles</th>
<th>Once every year</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>1</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>14 (a)</td>
<td>1</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>14 (b)</td>
<td>2</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>15 (a)</td>
<td>4</td>
<td>34</td>
<td>31</td>
</tr>
<tr>
<td>15 (b)</td>
<td>7</td>
<td>54</td>
<td>50</td>
</tr>
<tr>
<td>16 (a)</td>
<td>1</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>16 (b)</td>
<td>2</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td>17 (a)</td>
<td>3</td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td>17 (b)</td>
<td>7</td>
<td>77</td>
<td>70</td>
</tr>
<tr>
<td>18 (a)</td>
<td>3</td>
<td>57</td>
<td>50</td>
</tr>
<tr>
<td>18 (b)</td>
<td>2</td>
<td>47</td>
<td>40</td>
</tr>
</tbody>
</table>

* For individual 50-bed units, each admitting 1,000 emergency cases per year.
technique may be regarded as offering a fair representation of the effects of the schedules, the formulae described would appear to provide a comparably accurate estimate of the parameters.

(d) Rationalisation of Emergency Admissions.

It is probable that much of the difficulty currently encountered in finding in-patient accommodation for emergency cases could be obviated by co-ordination of hospital facilities and rationalisation of emergency admissions in appropriate geographical areas. Any scheme for rationalisation of emergency admissions would necessarily involve consideration of:

(i) the probable demand for emergency beds, and the resources available to meet this demand;
(ii) the way in which available resources may best be used;
(iii) methods of integrating and supervising services for the admission of emergencies.

In isolated areas, the identification of the population in which emergencies will arise, and the decision regarding which hospital will admit them, are often less difficult than in large urban areas. Where a district general hospital serves a self-contained catchment population, there can be no alternative but that it must provide for all emergencies, other than the small proportion requiring immediate treatment in units catering for "regional specialties", such as neurosurgery or plastic surgery. In instances such as this, the more important consideration is how to determine the best method of using available resources to meet demand.

In larger urban areas, the catchment population usually extends far beyond the urban boundaries, so that it is necessary to consider data from such sources as Hospital Activity Analysis to identify the
population covered. In addition to providing details of all immediate admissions, whether from general practitioners or Casualty or other hospital departments, the data considered should include information relating to requests for immediate admission which could not be fulfilled by any of the hospitals involved.

The estimation of probable demand from data relating to previous hospital utilisation is justifiable in this instance. Despite an enormous increase in the total number of in-patients treated in Britain each year, emergency admissions in all specialties are reported to have increased by only 4% between 1948 and 1966 (Lees, 1967). Of far greater importance than this slight secular trend is the seasonal variation in demand for emergency accommodation in certain specialties. Although not completely predictable in terms of degree or timing, this type of variation can be anticipated, and, given adequate administrative control, can be dealt with as it arises; the system of "coloured alerts" currently used by the London Emergency Bed Bureau is substantially effective, even with voluntary implementation.

It has been seen that the demand for in-patient care may be influenced by the availability of existing facilities. There is the possibility that an improvement in the system of admitting emergencies might increase demand by producing alterations in the criteria of definition of emergencies. Such increases would be desirable insofar as they revealed cases of real need currently obscured by the difficulties associated with emergency admission procedures. Were the situation to arise where larger numbers of patients were referred as emergencies when not strictly in need of immediate admission, it would be necessary for hospital medical staff to refer cases back to general practitioners without admission, as is at present sometimes necessary. The work of Vaananen et al. (1967) suggests that there is a limit to the possible
number of emergency cases arising in any population, regardless of the
case of access to in-patient accommodation.

The identification of in-patient resources is simple in terms of
bed availability; as has been seen, however, the utilisation of
general beds can be affected by the availability of pre-convalescent
beds, so that numbers of available beds must be adjusted to include
the pre-convalescent beds accessible to each specialist unit. The
identification of functional units within each specialty may be less
easy. Because of the proprietary attitudes which have evolved with
the hospital service, large hospitals containing five or six "firms"
in such specialties as general medical and general surgery are
occasionally criticised for functioning as "several cottage hospitals
under one roof". The Commission on Health Care (1947) demonstrated
the relative inefficiency of small clinical units; and the advantages
of combining many small units into a few larger ones have been amplified
in one of the publications of the Operational Research Unit of Oxford
Regional Hospital Board (1966). While it is possible to ignore the
continuing independence of small units in devising a rational scheme
for the admission of emergencies, the problems of bed utilisation
encountered in small units might well be exacerbated by the implementation
of such a scheme.

The way in which available resources are used to meet the demand
for emergency accommodation will be determined by local circumstances.
Considerations regarding the economic use of personnel and equipment
would probably preclude the situation where all units admit emergencies
every day; but the adoption of rotational admission schedules must be
undertaken with circumspection. It is clear from the simulation
studies described earlier that, as a general principle, no schedule
should be adopted which entails individual units being either open or
closed to emergencies for more than two consecutive days, especially where emergency demand and turnover are high. In a large hospital containing four or more units of the same type, arrangements should be made for more than one unit to accept emergencies at any time. Before admission schedules are adopted, their probable effects upon emergency bed occupancy may be assessed by using the formulae described earlier. For this purpose, the distribution of duration of stay would be that prevailing in the unit under consideration; but the proper admission rate would be that derived from the emergency turnover rate applicable to the area under consideration, and the size of the particular unit in relation to the overall provision of facilities in the individual specialty for the area.

The proportions of total emergencies admitted to individual units should be dependent solely upon the size of the units in terms of available beds. By definition, the need to provide for emergency cases is the most pressing aspect of the work of any acute unit, and the fulfilment of this commitment should not be influenced by the relative demand for elective investigation or treatment. Disregarding the merits of centrally co-ordinated waiting lists, any proportionate reduction in the number of emergency admissions to an individual unit, in order to increase waiting list turnover, should be carried out only with the knowledge and consent of the other units whose share of emergency work would be accordingly increased. The long-standing prerogative of "teaching hospitals" to select their admissions is now foundering, undermined by the necessity to extend both undergraduate and post-graduate education into "non-teaching hospitals"; and realisation of the intention in the "Hospital Building Programme" (Ministry of Health, 1966) that "the teaching hospitals will play an increasing part as district general hospitals serving the communities
around them..." should render illusory any functional differentiation between teaching and non-teaching hospitals, so far as service commitment is concerned.

The administration and supervision of emergency admissions might be undertaken in either of two ways. Where services are provided by two or three large hospitals, there may be arguments in favour of "area zoning", of the type currently used in some centres in order to deal with road accidents and other casualties. The alternative, perhaps preferable, is that all requests for emergency admission should be dealt with by the Emergency Bed Bureau, which should also be kept informed of direct admissions from such sources as casualty departments. The Bed Bureau would then be in a position to co-ordinate the available facilities, so as to minimise the delay in effecting the admission of emergency cases while ensuring an even distribution of the associated work-load. This procedure need not preclude the general practitioner's expression of preference for admission to a particular unit; but, as at present, compliance with a stated preference would depend upon bed availability.

The Bed Bureaux have been in existence for a sufficient period for their value to be unassailable. Consideration should now be given to the question whether it is necessary for their efficacy to depend upon purely voluntary co-operation. If the work entailed in dealing with emergency admissions is to be equably distributed, there must be a co-ordinating authority able to ensure comparable levels of emergency turnover in all of the units concerned.

The rationalisation of emergency admissions would have obvious advantages for the patient and his general practitioner. So far as the hospital staff are concerned, an overall increase in workload need not be anticipated, but the more equable distribution of work
would clearly be felt in different ways. Full integration of resources in large urban areas, and the adoption of appropriate rotational admission schedules could combine administrative convenience with more efficient utilisation of available beds.
CONCLUSION

Data relating to patterns of bed utilisation have a particular part to play in the development of the hospital service, but not at the stage of initial planning. The use of the statistical techniques which have been evolved to predict bed requirements entails the application, at some stage, of one or more of the indices of bed utilisation. Whatever the indices used, the selection of appropriate quantitative levels is the point at which all of the available techniques fail. Even where it is possible to achieve a measure of accuracy in predicting the future incidence of specific conditions requiring hospitalisation, as in obstetrics and, perhaps, emergency admissions, future durations of stay are quite unpredictable. In practice, either the current indices of utilisation are applied, or an attempt is made to predict future patterns of utilisation. In the first instance, as with the critical number method, the apparent requirements of the future are almost identical to the available resources of the present. In the second instance, the level of provision may be manifestly excessive, as with application of the Cranbrook recommendations based upon a ten-day puerperium; or the level represents such a substantial reduction in the availability of resources as directly to affect patterns of utilisation, as may happen with psychiatric in-patient facilities. When the predicted patterns of utilisation are based entirely upon subjective personal opinions regarding what might be the future relationship of the hospital service to other methods of health care, the last vestige of the "scientific" approach is removed, and the assessment of bed requirements returns to the era of guesswork.

The proper application of bed utilisation data to hospital development is retrospective rather than prospective. The future
structure of the British hospital service has been largely determined and described; with a few exceptions, such as geriatrics, the regional and local levels of provision of in-patient facilities have been prescribed empirically on the basis of the accommodation currently available throughout the country. However, the plans laid down are not so immutable as to preclude modification of recommended levels of provision within and between specialties; and the accommodation provided in new hospitals will be much more adaptable to changing utilisation than are older designs. Thus, as the demands for specific types of in-patient care vary with time, the in-patient facilities provided can undergo re-arrangement. In order to assess those areas of hospital care where further provision or re-allocation of facilities are indicated, it will be necessary to develop and apply measurements of the quantity and quality of hospital utilisation; of the quantitative measurements, the most important are accurate statistics of bed utilisation.

The other area of need for accurate statistics of bed utilisation is in the routine administrative assessment of the efficiency with which hospital resources are being utilised. Although a great deal of effort is currently expended in the collection and preparation of statistical data in hospitals throughout the country, the return, in terms of accurate statistics appropriate to the requirements of local hospital administration, is disappointingly small. There is not yet sufficient compass nor universal precision in S.H.3; and Hospital Activity Analysis, where it is used, is not entirely appropriate.

Presentation to consultant medical staff of data indicating the time spent by their patients on the waiting lists, the numbers of patients of various diagnostic groups treated, and the distribution of duration of patient stay, may act as a spur to more effective use of
resources, particularly where comparisons indicate that more effective use is attainable. But, even where consultants are willing to make the effort, these statistics alone are not enough. Reductions in the duration of stay are pointless if they do not increase the bed turnover rate, because of commensurate increases in the turnover interval; in addition to showing how beds have been profitably used, it is necessary to show if they have been wasted. Hospital Activity Analysis, in its present form, may indicate the need for improvements in bed utilisation, and may even suggest the means of effecting improvements. But no improvement can be demonstrated, let alone measured, unless the turnover interval and the bed turnover rate are considered. Measurement of these indices, with sufficient precision to permit valid comparisons at different times and between different departments, is not possible in the absence of data relating to bed availability characterised by greater accuracy than that achieved in many hospitals at present.

The bed is the fundamental unit of facilities for in-patient care. Admittedly, the efficacy of its utilisation is dependent upon adequate provision of supporting diagnostic and therapeutic services; that "adequate" levels of provision of these services have not yet been identified in relation to provision of beds arises primarily from insufficient consideration of, and concomitant deficient knowledge of, the use made of these services. The want of this knowledge can not be accepted as an argument against proper consideration of bed utilisation in administrative practice. Rather, the efficient utilisation of beds, although an end in itself, may be regarded as a means of highlighting areas of deficient knowledge concerning the functioning of the hospital service. If it were routine procedure to attempt to account for poor utilisation, the need for investigation of the factors which influence bed utilisation would be far more apparent.
The unsatisfactory nature of administrative hospital statistics as a whole is reflected in the several unanswerable questions concerning hospital utilisation, some of which have been touched upon in this work. How often do shortages of operating theatre time, laboratory services, radiodiagnostic facilities, and other ancillary equipment and staff produce delays in the diagnosis, treatment, and discharge of in-patients? What theatre time is available in British hospitals, and how much more is needed? To what extent does the performance on out-patients of surgical investigations and operations requiring general anaesthesia produce economies by avoiding the use of in-patient facilities? How many biochemical, haematological, bacteriological and radiological investigations of various types are carried out, and how many of them are ordered "routinely" by junior medical staff without any consideration of necessity or cost? How often could the timing of requests for such investigations be arranged to make optimal use of ancillary facilities, so as to avoid delays arising at periods of high demand? Does the use of admission units, pre-discharge wards, or other supporting beds offer any sort of economy to the hospital service?

All of these questions are germane, not only to routine hospital administration, but also to the rational development of the service. None of them can be answered on the basis of hospital statistics currently available; and very few will be answerable after the general introduction of Hospital Activity Analysis. Information about patients is vital to the development of criteria for patient care evaluation. Efficient hospital administration requires, in addition, much more basic information not only on the use of beds, but also on the use of operating theatres, laboratories, and the other resources without which a modern hospital can not function; and more refined methods of costing, to indicate the areas where genuine economies may be effected.
Certain aspects of hospital service function which affect the utilisation of beds may require sophisticated techniques of investigation. Examples are the operation of maternity units (Oxford R.H.B., 1964) and the effects of arrangements for the admission of emergencies, to which computer simulation has been applied; and the relationship between supply and demand in the provision of in-patient accommodation, to which special statistical techniques have been applied (Feldstein, 1964 (a) and (b)).

In other cases, such techniques are unnecessary, and a critical approach would obviate the need for detailed investigation. For instance, Querido (1963) has demonstrated the amount of unnecessary delay which may arise in the investigation and treatment of in-patients. The adequate planning of in-patient investigations is not dependent upon the knowledge and application of Critical Network Analysis; in many instances, brief deliberation before the patient is admitted may suggest sources of delay which could be avoided. Having decided that it is absolutely necessary to admit a patient for investigation, attention should be given to the question whether there are, among the procedures which will certainly be carried out, such investigations as radiological studies which have to be arranged some days in advance, or biochemical studies which can only be carried out at specific times. Tentative arrangements made prior to the patient's admission could reduce the duration of hospital stay. Similarly, where consultants do not visit wards every day, the commencement of definitive investigation and treatment might be expedited by the preparation for junior medical staff of a list of the required investigations, before the patient's admission.

This element of forward planning in bed utilisation is an inevitable part of efficient clinical management. Many of the administrative decisions relating to bed utilisation rest with hospital medical staff, and it is in their hands that the improvement of bed utilisation efficiency predominantly lies; yet no part of the present general or
specialist training of the medical profession prepares doctors to undertake administrative action of this nature. There is, perhaps, a need for some members of hospital medical staff to re-appraise the nature and methods of implementation of the primary aims of the hospital service. Such features as the apparent reluctance to give waiting list patients adequate notice of admission, and the relative difficulty encountered in securing the emergency admission of elderly medical patients, are not consistent with a recognised primary object efficiently to operate a public service.

Heasman (1966) has indicated the appositeness to clinical administration of the industrial managerial functions of defining objectives, devising policies to effect their implementation, and assessing the extent and efficiency of their attainment. This view is also expressed in the pamphlet on "Management Functions of Hospital Doctors" (Ministry of Health, 1966), which stresses the importance of the development, from the early stages of medical training, of those critical attitudes which would foster the more efficient use of hospital resources. In stating the managerial responsibilities of the consultant, the pamphlet suggests that he must make "continual efforts to ensure that in providing the best treatment and care for the patients the most efficient use is made of the limited resources of the hospital...".

Improvements in the utilisation of all hospital facilities are dependent upon the administrative ability of medical staff; but there is no other segment of the hospital's resources where patterns of utilisation are so dictated by the attitudes of the medical staff as is the case with the bed. It is thus necessary to provide members of medical staff with appropriate statistical material, to educate them in its proper consideration and application, and to encourage enquiring attitudes concerning the operation of the hospital service, in order to increase the efficiency of bed utilisation.
APPENDIX

Upper Limits of Numbers of Admissions during Admission Periods.

Assuming that the day-to-day incidence of emergencies requiring hospitalisation follows the Poisson distribution, the probability of a number of emergency admissions occurring on a given day may be calculated from the Poisson function

\[ p(x) = \frac{e^{-m} m^x}{x!} \quad (x = 0, 1, 2 \ldots ) \]

where \( x \) is the number of admissions, \( m \) is the mean daily admission rate, and \( e \) is the exponential constant (2.718 \ldots).

Where emergencies are admitted every day, the admission rate is the estimated mean daily admission rate; thus, in the admission schedule illustrated in Figure 13, the admission rate is

\[ m = \frac{1,000}{365} = 2.74 \]

Where emergencies are admitted in accordance with any other admission schedule, the admission rate to be considered is the "effective" admission rate, used in the simulation process (Handyside and Morris, 1968). In this case, the total number of admissions over a time period is divided by the number of days on which emergencies were admitted.

The effective admission rates for the schedules considered in the thesis are

- Figures 14 and 15 \( m = 1,000 \times \frac{2}{365} = 5.48 \)
- Figures 16 and 17 \( m = 1,000 \times \frac{3}{365} = 8.22 \)
- Figure 18 (a) \( m = 1,000 \times \frac{5}{365} = 13.70 \)
- Figure 18 (b) \( m = 1,000 \times \frac{6}{365} = 16.44 \)
Given a number of independent Poisson distributions, \( n \), with means \( m_1, m_2, \ldots, m_n \) respectively, the joint distribution of these variables will be Poisson, with mean

\[ M = m_1 + m_2 + \ldots + m_n \]

(Cramer, 1955). Thus, in those admission schedules where two or more admission days occur consecutively to form an admission period, the admission rate for the period may be regarded as the product of the effective admission rate and the number of days in the period.

It is desired to assess the number of admissions, \( \theta \), which will be equalled or exceeded with a particular probability during the longest admission period characteristic of each admission schedule. The area of the upper tail of the Poisson distribution, corresponding to this probability, is therefore calculated. The probability of equaling or exceeding \( \theta \) once in every hundred admission cycles is 0.01. Thus,

\[ 1 - \sum_{x=0}^{\theta} \frac{e^{-M} M^x}{x!} = 0.01 \]

where \( M \) is the product of the effective admission rate and the number of days in the admission period. Hence, values of \( \theta \) are readily obtained from published tables, using

\[ \sum_{x=0}^{\theta} \frac{e^{-M} M^x}{x!} = 0.99 \]

The probability of equalling or exceeding \( \theta \) once every year is \( \frac{K}{365} \), where \( K \) is the length, in days, of the admission cycle. Thus, similarly, values of \( \theta \) may be obtained, using

\[ \sum_{x=0}^{\theta} \frac{e^{-M} M^x}{x!} = 1 - \frac{K}{365} \]

Alan J. Handyside.
ACKNOWLEDGEMENTS

I should like to acknowledge the valuable advice, and unstinting assistance in the collection of statistical material, which I received from the following Medical Statistics and Records personnel:

Mr. K. Trout, Sheffield Regional Hospital Board;

Mr. A. Whitman, Mr. G. A. Hall, and Mrs. J. Hall, Mansfield and District Hospital Group;

Mr. F. Eastwood and Mrs. J. Horsfield, Sheffield Northern General Hospital;

Miss G. M. Whyte and Mrs. M. Wildgoose, Sheffield Royal Hospital.

I am grateful to Miss J. Pickering and Mrs. J. W. H. Silvester for their assistance in the preparation of illustrations, and to Mr. J. D. L. Morris for photographic reproductions.

The research involving computer simulation would not have been possible without the help and co-operation of Mr. A. J. Handyside, to whom I am further beholden for advice and guidance in all matters statistical and mathematical.

Finally, for his kindness and forbearance, and for a light rein, I am indebted to my former departmental head, Professor J. Knowelden.

Sheffield,  

David Morris  

March 1968.
REFERENCES

Annotations and Leading Articles

(1954) "Measuring Hospital Efficiency"
Brit. med. J., 1, 570.

(1962) "The Use of Misuse of Bed Occupancy Statistics"
Hospital (Lond.), 53, 196.

(1966) "Hospital Statistics"
Hospitals, 40, August 1, 423.

(1967) "Early Discharge of Maternity Patients"

(1967) "Psychiatric Beds"
Lancet, 2, 30.

ABEL-SMITH, B.

(1962) "Hospital Planning in Great Britain"
Hospitals, 36, May 1, 39.

(1964) "The Hospitals, 1300 - 1940"
London, Heinemann Educational Books Ltd.; passim.

ACHESON, E. D. and FEIDSTEIN, M. S.

(1964) "Duration of Stay in Hospital for Normal Maternity Care"

AIRTH, A. D. and NEWELL, D. J.

(1962) "The Demand for Hospital Beds"
Newcastle-upon-Tyne, University of Durham; passim.

AMERICAN HOSPITAL ASSOCIATION and UNITED STATES PUBLIC HEALTH SERVICE

(1961) "Area-wide Planning for Hospitals and Related Health Facilities"

ASSOCIATION OF MEDICAL RECORDS OFFICERS, SHEFFIELD REGIONAL BRANCH

(1961) "Hospital Statistics"
Report of a Working Party; Sheffield, A.M.R.O.

avery-jones, F.

(1964) "Length of Stay of Hospital"
Lancet, 1, 521.
BAILEY, N. T. J.

(1956) "Statistics in Hospital Planning and Design"
Appl. Statist., 5, 146.

(1962) "Calculating the Scale of In-Patient Accommodation"
In "Towards a Measure of Medical Care"; London,
Nuffield Provincial Hospitals Trust; p. 55.

BALINTFY, J. L.

(1960) "A Stochastic Model for the Analysis and Prediction
of Admissions and Discharges in Hospitals"
Proceedings of the Sixth International Meeting of the
Institute of Management Sciences; New York, Pergamon;
p. 288.

BARR, A.

(1957) "The Population Served by a Hospital Group"
Lancet, 2, 1105.

(1964) "Measuring Nursing Care"
In "Problems and Progress in Medical Care"; First Series;
London, Nuffield Provincial Hospitals Trust; p. 77.

BARR, A. and ODDIE, J.

(1966) "Hospital Beds for Maternity Patients"
Med. Care, 4, 130.

BENJAMIN, B.

(1965) "Hospital Activity Analysis"
Hospital (Lond.), 61, 221.

BENJAMIN, B. and PERKINS, T. A.

(1961) "The Measurement of Bed Use and Demand"
Hospital (Lond.), 57, 31.

BEVAN, A.

(1946) National Health Service Bill, Second Reading,
Hansard, House of Commons, 422, col. 44.

BOULDING, K. E.

(1966) "The Concept of Need for Health Services"

BROTHERSTON, J. H. F.

(1962) "Medical Care Investigation in the Health Service"
In "Towards a Measure of Medical Care"; London,
Nuffield Provincial Hospitals Trust; p. 18.

(1963) "The Use of the Hospital"
Med. Care, 1, 142 and 225.
CHAMBERS, F.

(1953) "The Use of Administrative Statistics by the Management Committee"

COMMISSION ON HEALTH CARE

(1947) "Hospital Care in the United States"
New York, The Commonwealth Fund; ch. XX and XXI.

COTTRELL, J. D.

(1966) "The Consumption of Medical Care and the Evaluation of Efficiency"
Med. Care, 4, 214.

CRAIG, G. A. and MUIRHEAD, J. M. B.

(1967) "Obstetric Aspects of the Early Discharge of Maternity Patients"
Brit. med. J., 2, 520.

CRAMER, H.

(1955) "The Elements of Probability Theory"
New York, John Wiley and Sons; p. 104.

CROMBIE, D. C. and CROSS, K. W.

(1959) "Serious Illness in Hospital and at Home"

DAVIES, J. O. F.

(1962) "Problems for Operational Research in the National Health Service"
In "Towards a Measure of Medical Care"; London, Nuffield Provincial Hospitals Trust; p. 1.

DREDLE, J. S.

(1965) "An Economic Analysis of Hospital Costs"
Med. Care, 2, 130.

DONELAN, C. J.

(1954) "The Use of Hospital Statistics in the Ministry of Health"
Med. Rec., 3, 204.

DUNCAN, B.

(1964) "The Development of Hospital Design and Planning"
FELDSTEIN, M. S.

(1963 (a)) "Operational Research and Efficiency in the Health Service" Lancet, 1, 491.

(1964 (b)) "Hospital Planning and the Demand for Care" Bull. Oxf. Univ. Inst. Statist., 26, 361.


FELDSTEIN, P. J.


FITZPATRICK, T. B., RIEDEL, D. C. and PAYNE, B. C.

(1962) "Character and Effectiveness of Hospital Use" In "Hospital and Medical Economics"; Edited by W. J. McNerney; Chicago, Hospital Research and Educational Trust.

FORSYTH, G. and LOGAN, R. F. L.

(1960) "The Demand for Medical Care" London, Nuffield Provincial Hospitals Trust; passim.

(1962) "Studies in Medical Care" In "Towards a Measure of Medical Care"; London, Nuffield Provincial Hospitals Trust; p. 66.

GENERAL REGISTER OFFICE

(1956) "Code of Surgical Operations" London, H.M.S.O.


GIBSON, J. R., HUGHES, T. L. and BROUGHTON, A. V. L.

(1958) "Ease of Admission to Hospital of Medical and Surgical Emergencies" Med. Offr., 22, 117.

GOODALL, J. W. D.

(1951) "Early Ambulation; A Survey of Hospital Practice" Lancet, 1, 43.
GRUNDY, F., HITCHENS, R. A. N., and LEWIS-FANING, E.

(1956) "A Study of Hospital Waiting Lists in Cardiff"
Cardiff, Board of Governors of United Cardiff Hospitals.

HANDYSIDE, A. J. and MORRIS, D.

(1968) "Simulation of Emergency Bed Occupancy"
Hlth. Serv. Res. (in Press)

HEASMAN, M. A.

(1964) "How Long in Hospital"
Lancet, 2, 559.

(1966) "Bed Usage"
In "Centrepiece; Collected Conference Reports 1966";
Edinburgh, Scottish Hospital Centre, 1967; p. 13.

(1967) "The Use of Statistics in Estimating Hospital Bed Needs"
Script of Lecture delivered at The Hospital Centre,
King Edward's Hospital Fund for London, on 18th October.

INSTITUTE OF HOSPITAL ADMINISTRATORS

(1963) "Hospital Waiting Lists"
Report of the Study and Research Committee; London, I.H.A.

JOHNSON, H. D.

(1964) "999 Emergencies"
Lancet, 1, 495.

KING EDWARD'S HOSPITAL FUND FOR LONDON

(1954) "Hospital Bed Occupancy"
Report of the First Study Group set up by the Administrative Staff College; London, K.E.H.F.

(1957) "Sixty-First Annual Report, 1957"

KLARMAN, H. E.

(1966) "Some Technical Problems in Areawide Planning for Hospital Care"

LAST, J. M.

(1965) "The Iceberg; Completing the Clinical Picture in General Practice"
Lancet, 2, 26.

LEES, W.

(1967) "The Role of Out-patient Surgery"
Script accompanying Lecture delivered at Nottingham General Hospital, on 13th December.

- 126 -
LINDSEY, A.
(1962) "Socialised Medicine in England and Wales"
Chapel Hill, University of North Carolina Press; p. 19.

LLEWELYN DAVIES, R.
(1960) "Architectural Problems of New Hospitals"
Brit. med. J., 2, 768.

LLEWELYN DAVIES, R. and WEEKS, J.
(1965) "General Hospitals"
Archit. Rev., 137, 413.

McEWAN, R. D.
(1967) "The Case for a New Maternity Bed Ratio"
Lancet, 1, 489.

MACKINTOSH, J., McKEOWN, T. and GARRATT, F. N.
(1961) "An Examination of the Need for Hospital Admission"
Lancet, 1, 815.

MAXWELL, A. E.
(1961) "Analysing Qualitative Data"
London, Methuen and Co.; ch. III and IV.

MINISTRY OF HEALTH - Annual Reports

(1952) Cmd. 9009; London, H.M.S.O., 1953; Part II, Ch. XIII
(1955) Cmd. 9857; London, H.M.S.O., 1956; Part I, Appx. II.
(1956) Cmd. 293; London, H.M.S.O., 1957; Part I, Appx. II.
(1957) Cmd. 495; London, H.M.S.O., 1958; Part I, Appx. II.
(1958) Cmd. 806; London, H.M.S.O., 1959; Part I, Appx. II.
(1959) Cmd. 1086; London, H.M.S.O., 1960; Part I, Appx. II.
(1963) Cmd. 2389; London, H.M.S.O., 1964; Appx. III.
(1964) Cmd. 2688; London, H.M.S.O., 1965; Appx. III.
(1965) Cmd. 3039; London, H.M.S.O., 1966; Appx. V.
"Interim Report on the Future on Medical and Allied Services"
(The Dawson Report); Consultative Council on Medical and Allied Services; Cmd. 695; London, H.M.S.O.

"Final Report"
(The Cave Committee); Voluntary Hospitals Committee; Cmd. 1335; London, H.M.S.O.

"The Hospital Services of the Sheffield and East Midlands Area", by L. G. Parsons, S. C. Fryers and G. E. Godber; London, H.M.S.O.

"The Hospital Services of the Yorkshire Area", by H. Bason, R. V. Clark and W. H. Harper; London, H.M.S.O.

"The Hospital Services of the South-Western Area", by W. J. Gill, A. Griffiths and G. C. Kelly; London, H.M.S.O.

"The Development of Consultant Services" London, H.M.S.O.

"The More Effective Use of Hospital Beds" Hospital Circular H.M. (54) 89; London, Ministry of Health.

"Operating Theatre Suites" Hospital Building Bulletin No. 4; London, H.M.S.O.

"Report of the Committee on Maternity Services" (The Cranbrook Committee); London, H.M.S.O.

"A Hospital Plan for England and Wales" Cmd. 1604; London, H.M.S.O.


"The Hospital Building Programme" Cmd. 3000; London, H.M.S.O.

"Management Functions of Hospital Doctors" Paper prepared by a Sub-committee of the Advisory Committee for Management Efficiency in the National Health Service; London, Ministry of Health.


"Operating Department" Hospital Building Note No. 26; London, H.M.S.O.
MINISTRY OF HEALTH and DEPARTMENT OF HEALTH FOR SCOTLAND

(1944) "A National Health Service"
    Cmd. 6502; London, H.M.S.O.

MINISTRY OF HEALTH and GENERAL REGISTER OFFICE

(1963) "Report on Hospital In-Patient Enquiry for 1959"
    London, H.M.S.O.; Part II, Table 12.

(1964) "Report on Hospital In-Patient Enquiry for 1961"
    London, H.M.S.O.; Part II, Tables 2 and 8.

MORRIS, D., WARD, A. W. M., and HANDYSIDE, A. J.

(1968) "Early Discharge after Hernia Repair"
    Lancet (In Press)

NEWCASTLE REGIONAL HOSPITAL BOARD

(1964) "General Principles Regarding Requirements in Operating
    Suites"
    Newcastle, Newcastle, R.H.B.; p. 8.

NEWELL, D. J.

(1954) "Provision of Emergency Beds in Hospitals"

(1964 (a)) "Problems in Estimating the Demand for Hospital Beds"

(1964 (b)) "Statistical Aspects of the Demand for Maternity Beds"

NEWELL, D. J., ZINOVIEFF, A., and HUNT, L. W.

(1966) "The Evaluation of an Experimental Pre-Discharge Ward"
    In "Problems and Progress in Medical Care"; Second
    Series; London, Nuffield Provincial Hospitals Trust;
    p. 209.

NORRIS, V.

(1952) "Role of Statistics in Regional Hospital Planning"
    Brit. med. J., 1, 129.

NUFFIELD PROVINCIAL HOSPITALS TRUST and UNIVERSITY OF BRISTOL

(1955) "Studies in the Functions and Design of Hospitals"
    London, Nuffield Provincial Hospitals Trust; passim.

OXFORD REGIONAL HOSPITAL BOARD

(1962) "Nursing Care in a Modern Hospital"
    Oxford, Oxford R.H.B.

(1964) "Computer Simulation of a Maternity Hospital"
    Oxford, Oxford R.H.B.
OXFORD REGIONAL HOSPITAL BOARD (continued)

(1966)  "More Use from Available Beds"
Oxford, Oxford R.H.B.

PALMER, J.

(1956)  "Measuring Bed Needs for General Hospitals"
Washington D.C., United States Public Health Service,
Department of Health, Education and Welfare.

PIKE, M. C., PROCTOR, D. M. and WYLLIE, J. M.

(1963)  "Analysis of Admissions to a Casualty Ward"

PINKER, R.

(1966)  "English Hospital Statistics, 1861 - 1938"

POWELL, J. E.

(1966)  "A New Look at Medicine and Politics"

QUERIDO, A.

(1963)  "The Efficiency of Medical Care"
Leiden, Stenfert Kroese; ch. 3.

QUIST, G.

(1964)  "Hospital Bed Occupancy"
Lancet, 2, 1122.

RESHIN, G. F. and MARTIN, F. M.

(1963)  "Psychiatric Services in 1975"
London, Political and Economic Planning; p. 50.

RHODES, P.

(1964)  "The Normal Puerperium is Ten Days"
Lancet, 2, 746.

RIEDEL, D. C. and FITZPATRICK, T. B.

(1964)  "Patterns of Patient Care"
Ann Arbor, University of Michigan, Bureau of Hospital
Administration; p. 19.

ROEMER, M. I.

(1961)  "Bed Supply and Hospital Utilisation; A Natural Experiment"
Hospitals, 32, November 1, 36.
ROEMER, M. I. (continued)

(1964) "Controlling Hospital Use through Limiting Bed Supply"
Proceedings of the Fifth Annual Symposium on Hospital Affairs; Chicago, Graduate School of Business,
University of Chicago; p. 69.

ROSS, J. S.

(1952) "The National Health Service in Great Britain"
London, Oxford University Press; ch. 7.

ROYAL COLLEGE OF SURGEONS OF ENGLAND

(1964) "The Design of Operating Theatre Suites"

SCHAINBLATT, A. H.

(1963) "On the Measurement of Hospital Bed Need"
Berkeley, State of California Department of Public Health,
Hospital Utilisation Research Project.

SCOTTISH HOME AND HEALTH DEPARTMENT

(1963) "Ward Design"
Hospital Planning Notes No. 1; Edinburgh, H.M.S.O.

(1966) "The Falkirk Ward; An Experiment in Design"
Edinburgh, H.M.S.O.

SCOULAR, G. H.

(1965) "Bed Usage"
In "Centrepiece; Collected Conference Reports 1966";

TITMUSS, R. M.

(1950) "History of the Second World War; Problems of Social Policy"

TOOTH, G. C. and BROCKE, E.

(1961) "Trends in the Mental Hospital Population and their Effect on Future Planning"
Lancet, 1, 710.

TURNER, D. B. P.

(1967) "Surgical Waiting Lists"
Brit. med. J., 1, 642.

VAANANE, I. S., HARO, A. S., VAUHCONEN, O. and MATILA, A.

(1967) "The Level of Hospital Utilisation and the Selection of Patients in the Finnish Regional Hospital System"
Med. Care, 5, 279.
VINIES, H. W. C.

(1952) "Background to Hospital Planning"
London, Faber and Faber Ltd.; p. 34.

WARD-McQUAILD, J. N.

(1964) "Hospital Bed Occupancy"
Lancet, 2, 1241.

WARREN, M.D., COOPER, J. and WARREN, J. L.

(1967) "Problems of Emergency Admissions to London Hospitals"

YELLOWIIES, H.

(1965) "Automatic Data Processing"
Hospital (Lond.), 61, 364.

YOUNG, J. P.

(1965) "Stabilisation of Inpatient Bed Occupancy through Control of Admissions"
Hospitals, 39, October 1, 41.