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Integrated Models for Public Policy Analysis: An example of actually using simulation models in health care planning*

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1. Introduction

An analysis of the brief but well documented history of the use of computer based modelling techniques in urban and regional planning and analysis would suggest there is a lot of scope for future improvement in both the design of models and in the understanding of the nature of the planning process. Although certain methods have become commonplace in planning it is true to say that the optimism that was expressed towards the future of mathematical models in the planning process in the 1960's has largely been replaced by scepticism over the last decade (Batty, 1980). However, it may be that due to a number of developments the time is ripe for a further promotion of analytic methods in urban and regional planning. In this paper we describe the contribution of an integrated modelling approach to the analysis of health care provision in an English District Health Authority. The purpose is to demonstrate that if models can provide the right kind of information for the planning problem at hand then their use may actually be encouraged and support given for their development. Despite being a report on a particular application in a single authority it is hoped that some of the lessons learnt will be of wider applicability.

The paper is structured as follows. In the next section we briefly examine the role of models in planning and put forward an argument that suggests a new phase of model promotion and development is in order. Section 3 outlines a framework in which different types of models can be embedded, thus being an extension of ideas first discussed in a recent paper (Clarke and Williams, 1982). This is followed in Section 4 by an example of the use of this framework in relation to strategic planning of health care facilities. Section 5 describes the use of this set of models to examine the problem of geriatric service provision in a District Health Authority. A concluding section outlines some directions for future research.

2. The Role of Models in Planning

Much has been written on the use of model based analysis in planning but often comments that were relevant a decade ago no longer apply. This is because of the very obvious but important fact that planning problems, the planning process and the range of methods available all change and evolve and sometimes at a rather alarming speed. A good example of this and relevant in relation to the later sections of this paper is the nature of strategic planning in the National Health Service. Put bluntly, before 1974 strategic planning in the N.H.S. did not exist in any formal sense (Bevan, 1983) and hence there was simply no demand for methods that would address medium to long term problems in this field. However, since then the situation has changed dramatically with the introduction of a statutory planning process and a mushrooming in the effort devoted to computer modelling in the health care sector. Concurrently over the last decade we have witnessed a remarkable revolution in computer and information technology (I.T.) which continues at an ever increasing pace. The contribution of I.T. to the management and planning of both the public and private sectors is potentially immense and offers an excellent opportunity for the modeller on the one hand to harness the tremendous computer power available and on the other to have access to information systems the nature of which he has in the past complained never existed.

In a similar vein the range of modelling techniques available is now more diverse than ever, and the experience gained in model applications is considerable, although this has largely been gained outside planning practice. At the same time there has been a consolidation and extension in the understanding of existing techniques (eg. Lowry models, multivariate analysis, disaggregate choice models) and an incursion into a new range of methodologies (dynamical systems theory, bifurcation theory, q. analysis, micro-methods). In many cases these newer methods may be no more effective in meeting the needs of planners in the same way as their older counterparts. However, it may be that, for example, dynamic models rather than being able to "forecast" the future will be able to chart likely patterns of development in a qualitative sense and identify critical variables that control this development.

Finally, as many observers have highlighted, the nature of the problems faced in urban and regional systems have changed over the last

20 years. Although manifest in many different ways (eg. inner cities, urban riots, unemployment, lack of services, etc.) their root cause is undoubtedly an economic one. Through successive world recessions, monetary crises, spiralling inflation and government mis-management of the economy there has been general industrial decline and a massive increase in unemployment (at least sixfold from 1968 to 1983 depending on whose figures you believe). Many of the criticisms directed at urban models comment on the fact that despite their existence and use they have contributed virtually nothing towards the amelioration or eradication of these urban problems. This of course represents a total misunderstanding of the role of models in decision making and a lack of comprehension of how the political decision-making process works. Even if models come up with some solution or answer to a particular problem there is no guarantee whatsoever that the policy recommendations will be taken up by the appropriate level of government. If models are to be judged solely on their ability to solve problems they will almost always be seen as failures. It is in their role as aids to decision making and debate - the providers of information - that their strength lies. We now progress to outline a planning framework in which they can make a useful contribution.

3. Frameworks for the Use of Model Based Analysis in Planning

One of the many paradoxes that exist concerning model based analysis is the observation that despite the ever increasing range of models available and the continual refinement of existing models, in traditional planning related activity they appear to be used less frequently. Many arguments have been put forward as to why this situation has developed. Simply stated much can be explained by the fact that a considerable amount of the effort devoted to model refinement has not always been directed towards realistic planning problems. It is therefore natural to ask in the context of tackling problems of current relevance whether we can build on past progress or whether it is necessary to adopt a whole new conceptual framework for tackling these issues. The answer to this questions will probably be determined by the ingenuity that modellers apply in using the techniques that have been developed to tackle real world problems and their ability to persuade planners that they can in fact make a useful contribution. Planners, for their part must be more adept at problem specification and perhaps be less suspicious of the motives of the model based analyst.

What is safe to say is that most planning problems contain high levels of interdependency between various subsystems and often models will have to be developed that address this. This implies that any one particular method on its own may not be sufficient and a resort to an eclectic or integrated approach, however unfashionable, may be necessary. This is really a call for good systems analysis where the important elements of a system are identified and their relationships defined.

Many public sector systems can be considered to have the following major elements:

(I) Demand or need: which may be well defined or poorly defined. There may be latent and revealed demand (see Section 4) and it is usually heterogeneous in nature. Demand will most commonly exceed supply and there is often an intimate relationship between supply of a service and the demand expressed for it. The oft quoted example is that of medical services where Feldstein (1967) demonstrated the elastic nature of the revealed demand for certain types of treatment. For these reasons and others the modelling or determination of demand may prove difficult and in many studies very crude methods are applied.

(II) Supply: The supply of different types of public services may appear in some cases to be a relatively straightforward process: someone empties the dustbin, you receive treatment in a hospital bed, new roads are constructed and new houses are built, etc. Of course this is inevitably the end-product of a rather complicated organisational and planning procedure. For example a hospital bed is of no use without the support of medical, nursing, scientific, catering and administrative functions. These all combine, in a highly complex manner to provide the service a patient receives. Similar examples can be provided from other services. The point to be made is that if we wish to change the provision of a service these inter-relationships between the components of the supply system will have to be accounted for. An analogy can be drawn between these systems and an input-output representation, except that the coefficients of our 'supply matrix' will often be non-linear. Thus a marginal increase in output (eg. patients treated) may not be achieved simply through a marginal increase in each of the relevant inputs. A further, important task in representing the supply-side is determining the costs of the various inputs and the total cost of providing different kinds of services. Models of the supply side of certain public services have commonly ignored these issues but they need to be tackled if we are to move towards realistic and useful contributions to problem solving.

(III) The allocation processes: There are several different types of allocation processes in operation within a given public service. First of all there is the allocation at national level to a service from the total budget set for the public sector. There is often an allocation between regions as in the Rate Support Grant and the R.A.W.P. procedure in the N.H.S. There may be further spatial allocations and then within the budget of a given organizational body there is an allocation between the different services it provides and at what location they are provided. Although this process is supposed to be aimed at allocating resources to meet the needs of the population or of certain client groups it inevitably results in the funding of services - that is the supply side components discussed above. For this process to be successful it requires an intimate knowledge of the workings of the supply side.

Given certain levels of resource allocation which are then transformed into a service provision a different set of allocation processes are set in operation. These include the allocation of groups of individuals to certain services (eg. the elderly to different types of geriatric care), spatial allocation (eg. the referral of individuals to a particular hospital) and individual allocation (eg. the determination of whereabouts on the housing waiting list a particular household is placed).

Models that address these various allocation processes will of necessity be diverse: ranging from optimisation methods for resource allocation problems, spatial interaction models for spatial allocation problems and micro-methods for individual allocation.

(IV) Impact Analysis

No analysis of a planning problem is complete without an assessment of the likely outcomes of the proposed solution. This is normally achieved through a set of indicators that attempt to describe how the "costs" and "benefits" of the plan will be distributed between various parties involved. Traditional economic criteria however may not always be the most appropriate and an expansion of the indicators commonly used in appraisal is to be encouraged. Again using a health service example, simplistic indicators such as the numbers on the end of year waiting list tell us virtually nothing. As we have argued elsewhere the basis of a good indicator system is a good information system allied with the appropriate methodological tools (see Clarke and Wilson, 1983).

Of course a dynamic component underlies each of these sub-systems and methods for the analysis of change must also be developed. Methods for dynamical systems theory, such as bifurcation and micro-simulation will be useful as well as more conventional techniques such as demographic models.

Our argument therefore is that a considerable range of public service planning problems can be viewed in this framework and that models should be developed for each of the various components in turn. The ultimate task is then to integrate these models into an overall model package. This could probably be supplemented through the use of interactive computing and computerised graphics. The application described in the next section has gone some way towards achieving this, although we have not as yet fully developed the supply side model.

4. A Simulation Model of a District Health Authority: the acute care component.

4.1 Introduction

In recent years problems associated with health care service provision have attracted the attention of regional scientists and others. Much of the interest in regional science has focussed on the location of hospital services and the concomitant issues of access and efficienty in relation to the flows of patients (eg. Mayhew and Leonardi, 1983). A more traditional geographical interest has centred on studies of spatial epidemicology and in assessing the relationships between morbidity and various socio-economic factors. In other disciplines there is also an interest in planning related issues concerning the health care system. These include social policy, community medicine, operational research, health economics and accountancy. What does appear to be lacking in this multi-disciplinary field is a truely inter-disciplinary approach (as suggested in Clarke and Wilson, 1983, although see Dear, 1983, for a counter argument).

The problems faced by health authorities in this country are wide-ranging and relate to the changing demand for care, the different forms of providing care and perhaps most acutely to the financial stringencies imposed by central government. The situation has changed from one which existed since the inception of the N.H.S. whereby increased need has always been met by increased resources to one which no longer allows for this demand led resource allocation. (Despite government ministers claims that expenditure is increasing in real terms this does not match the natural growth in demand for care, mainly consisting of a growth in the elderly population.) This has implied that health care planners can no longer finance growth out of extra revenue but that choices must be made as towards priorities and that a critical reappraisal of existing practices must be undertaken. This is an area where model based analysis can help planners by providing information on what may happen under a number of various policy proposals. In this section we outline the model package we have constructed in an attempt to achieve this goal and in Section 5 we describe an application of the model to an actual planning problem facing a District Health Authority in England. The model described focusses on the in-patient care system and our aim has been to develop a tool of general applicability both in a spatial sense (it could be used in any district given the appropriate information) and in a disciplinary sense (the output from the model would be of use to different groups of people within the authority, eg. Treasurer's department, Unit Administrators, the District Management Team, planners, consultants and so on).

In this paper we can only briefly outline the approach and refer the interested reader to Clarke and Spowage (1982, 1983).

4.2 An Overview of the Simulation Model

The model we describe consists of four main components. First, there is a model of population dynamics in which we annually update the characteristics of the District population. Secondly, a morbidity model converts these characteristics into demand or need for hospital care. Thirdly, there is a model of the supply side which represents the type and amount of care that can be provided at various locations for different conditions and client groups. Finally there is an allocation model which allocates need to supply and generates a set of indicators both in terms of care provided and resources consumed. We describe each of these in turn and present examples of the potential range of outputs.

No attempt is made within the existing framework to embed any optimisation methods. We believe that it is possible to construct a fairly crude mathematical programming model for the allocation of resources between important groups of services (eg. between acute and community care, or between hospitals). We also believe that operations research methods are an important tool for a number of management issues. Both these approaches could be built in to our existing set of models (see Clarke and Prentice, 1982 and Wilson and Clarke, 1982, for details). However, we also are of the opinion that it is useful to construct models that allow planners to explore the consequences of their decisions in some detail. The approach outlined here allows for this possibility.

The population component of the model consists of two parts. First, we synthetically generate a sample of individuals and households together with their associated attributes that we consider to be of interest. Secondly, we successively update the attributes of this sample for each year of the simulation exercise, using micro-simulation methods. For a review and justification of the methodology see Clarke et al, 1981.

A micro-level representation of the population involves generating lists of individual and household attributes for a sample of the population. Two methods for deriving these lists can be considered. First, we could sample from the population in an Authority but this would usually prove expensive in time and resources. An alternative is to use statistical synthesising techniques to generate a joint probability distribution of household and individual attributes from which a population can be sampled using Monte-Carlo methods. The method involves generating this joint distribution in such a way as to be consistent with any available information on the conditional and marginal distributions of attributes. These may be obtained from sources such as the census, the Family Expenditure Survey, the General Household Survey and so on. For a full description of the theory of the method see Clarke and Williams (1983) or McFadden et al (1977)

This latter method is the one we have adopted in this particular study. In particular we have made extensive use of the 1981 census in addition to other sources, such as the F.E.S. and G.H.S.

Given an initial population, one of our modelling tasks is to update its characteristics each year, of a (say) ten year period. To achieve this we employ a micro-simulation model; we test whether each individual or household is eligible for certain demographic transitions and then determine whether they occur, again using Monte Carlo sampling. To run the model, we require information on the conditional probability or an event, birth or death whatever, taking place as a function of certain individual or household attributes such as age, sex, marital status, race and so on. Much of this is obtainable from published data though often not at the appropriate spatial scale.

Given that we can obtain these conditional probabilities in one form or another, we can process each individual and household on our list through a series of events. The following events are considered for each eligible household and individual: birth, death, marriage, divorce, net out-migration, leaving home, residential relocation, labour market transitions (retirement, redundancy, school leaving, job change, re-entering labour market). For a full discussion of the model used see Clarke and Spowage

(1982). We can now turn to a discussion of the health care demand sub-model.

Agreeing upon what is meant by 'the demand for health care' is extremely problematic, not to mention attempting to construct a model of it. A range of studies have attempted to identify the factors that influence the variations in demand for health care between different groups of individuals, between and within different regions of a country and so on. One particular point that causes much confusion is the distinction between latent and revealed demand, that is between those that experience some illness and those that actually are diagnosed and treated for an illness. The latter very much depends on access to medical facilities and the techniques that are available to treat certain conditions.

There is a diverse number of ways by which an individual may arrive at a hospital for treatment. Figure 1 outlines the main flows which we consider. We distinguish between these various flows for the following reasons. Firstly, there are clear differences between many of them. The referral system, by which an individual originally consults his GP and, depending on the outcome, is referred to one of several medical channels of treatment, is a very different process than say the accident and emergency system. When it comes to examining policy options and identifying controllable variables this distinction becomes important.

Secondly, data collected by hospitals (such as the Hospital Activity Analysis) provides information only on revealed demand. We are however interested more generally in the morbidity characteristics of the population at large and so consider the whole system. This then allows for policy options, such as alternative forms of treatment to be examined.

G.P. morbidity statistics and information concerning the referral system are derived from Morbidity Statistics in General Practice 1971-72, the last major survey of its kind. This provides us with the following information

(1) The number of episodes, consultations and persons for each of diagnostic groups by age and sex (shown in Table 1). Episodes are the medical events - from first consultation to 'discharge'. Consultations are the number of visits by a patient to a G.P. and persons are the number of individuals involved. This information allows us to introduce multiple events into our model - this acknowledges that a person may be

ill with the same condition more than once in a year.

(2) The outcomes of visits to G.P.'s given condition. The following rates are identified for each condition:

(a) Referral rate - percentage of all patients referred for a given condition

(b) In-patient rate

(c) Out-patient rate

(d) Investigation rate

(e) Local Authority informed rate

(f) Other

Thus we can sample for each individual the outcome of a visit to a G.P. The nature of the condition, and the outcome would then become extra individual attributes. In the present model we allow for up to three conditions being identified in any year.

As can be seen from Figure 1, however, not all patients arrive via the referral system: accident and emergencies typically form a significant proportion of in-patient flows. For these flows we must return to Health District data where information on accident and emergency admissions is available. The additional flows in Figure 1, such as transfers, we also obtain from local data.

The full morbidity model is shown in Figure 2 . Each individual in our sample population is tested in a probabilistic manner using Monte Carlo sampling for each of the transitions that they are eligible for. This allows us to build up stocks of individuals with appropriate morbidity attributes for each of the various pathways into hospital care. In addition to these individuals there is also an extra component of demand, consisting of beginning of year waiting lists, patients already occupying a bed at the beginning of the year (important in geriatric care) and inflows from outside the District. These are all modelled separately. Furthermore we also subtract from the total demand those patients living within the District who receive treatment in another authority.

Although patients have morbidity characteristics or conditions care is provided by medical and surgical specialties. We need to determine therefore on the basis of condition, age and sex which specialty an individual will receive treatment. Probabilities for this allocation have been derived from H.A.A. data. The specialty allocated is added as an extra attribute to each individual in the demand pool. We now proceed to discuss the representation of the supply side.

In constructing a model of the supply side of the hospital system we are faced with the complicated task of determining how the various inputs into a hospital, in terms of manpower, and resources of different types, are transformed into the provision of medical care of various forms. Many direct analogies can be seen with an input-output framework. The 'final demand' may be the provision of bed-days for a given specialty. In effect, we have to articulate a complex production function. This relationship between supply and inputs is clearly not linear: sometimes a marginal increase in supply can be provided with few resources implications (when there is some slack in the system) but on other occasions a small increase in supply may imply a substantial increase in inputs (for example if a new consultant had to be appointed). In addition in certain situations an increase in one input (say beds provided) will only allow more care to be provided if the appropriate range of other inputs is increased (eg. operating theatre time available). This is why we often find in summary statistics specialites with low bed occupancy rates yet long waiting lists.

The determination of the costs of providing the different resource inputs, that in total constitute the care package for each patient is an important task. Much research has recently been devoted to both accounting and statistical techniques for assessing the costs of in-patient care per day by specialty and hospital (eg. Ashford et.al, 1981, Coverdale et al, 1980, Magee and Osmolski, 1979). For our own purposes we have developed a method of estimating in-patient costs by specialty and hospital per day using balancing factor methods. These use all the available information from both Regional and District returns to provide estimates that are consistent with these known distributions. Full details of the method can be found in Forte and Wilson (1983).

In our current model we have not as yet built in a full representation of the supply side: we simply focus on bed days produced by specialty by hospital and we trace the underlying accounts linking these to resource inputs and costs. The next step in model development is to extend this approach into a more sophisticated representation. However, this is not a requirement for the example we describe in the next Section.

In allocating demand to supply at the area or district level extensive use has been made of Hospital Activity Analysis data. In particular, the mapping of patients' conditions (and specialty) into a particular facility will depend very much on local factors. The demand component of the allocation procedure consists of the following main groups:

(i) *Direct in-patients:* we assume that all this category have their demand satisfied.

(ii) *Accident and emergency patients:* once again we assume that this category are directly admitted.

(iii) *Out-patients who become in-patients:* The majority of this category are either placed on the waiting list or become 'booked and planned' patients.

(iv) *Waiting list:* this consists of two separate components: the beginning of year list and those who get added to it during the year. We assume that those who have been waiting the longest with a given condition and specialty get treated first.

(v) *In-flows from outside districts:* as the figures on these are an expression of revealed demand we assume that they all get treated.

(vi) *Internal transfers:* the probability of an in-patient being transferred once admitted is taken from H.A.A. data.

The allocation procedure is outlined in Figure 3 (and discussed in greater detail in Clarke and Spowage, 1983). Once a patient has been assigned a bed the probability of being admitted to a certain hospital is derived (from H.A.A. data) and the length of stay determined on the basis of condition, age and sex. That number of bed days is subtracted from the total available supply. If no supply is available the patient is admitted to an alternative location, if available, or if not, put on the waiting list. For each in-patient the cost of treatment is calculated from our specialty costing data. When all potential demand has been processed a variety of summary statistics are output. Because of the flexibility of the microsimulation approach these can be cross-classified in almost any form that is required. A number of examples are presented in Tables 2, 3, 4, 5 and 6.

Table 2 gives the number of in-patients by condition, age and sex for the first simulation period. Table 3 is the cross-classification of conditions by specialty again for the first year, and Table 4 gives the types of operation for each of 12 specialties in the district. Turning now to resource implications, Table 5 presents the cost by Hospital and Specialty in the first year and Table 6 the distribution of costs by age and sex for the same period. This information and much more would be available to the planner for each of the simulation periods.

To summarise we can state that the model descrived operates on a present practice basis - reflecting existing procedures. These can of course be modified to represent particular plans and policies (as we shall see in Section 5).

5. Application of the Health Service Model: the problem of geriatric care

5.1 Introduction

The example of the application of the model described in Section 4 concerns the problem of planning the provision of geriatric care (in-patients) in a district health authority. Because the planning process has not yet been completed the identity of the authority must remain anonymous, although in the next sub-section we describe its general features. The particular planning problem faced in this case is fairly well specified yet it serves to demonstrate the usefulness of models in providing certain types of information relevant to planners. We should also emphasise that the model was not constructed solely to address this problem, but to be a tool of general applicability in relation to health care planning. Hence this is just one of many strategic planning problems it could potentially contribute towards analysing.

5.2 Background

The health authority we are working with is located in the North of England and has a population just under the national average for all health authorities (183,000). At present there are a total of six hospitals: two main general hospitals, an orthopaedic hospital with accident and emergency facilities, two long-term stay geriatric hospitals and a long term stay orthopaedic/geriatric hospital. Their facilities are summarised in Table 7. However, there is under construction a new district general hospital which is due to be commissioned in 1988. This will take over the functions of the two existing general hospitals and the orthopaedic/accident and emergency hospital. The future of the remaining hospitals is still to be determined. Our major task in the project we are undertaking is to help determine exactly what planning strategy in terms of the location of facilities, the mix of specialites, the financial implications, etc. to adopt, and what affect this will have for the residents of the authority.

A more immediate problem however, is that of geriatric care provision. A legacy of pre-1974 organisation is that a large number of geriatric patients (about 12%) reside in an adjoining authority. Developments within that authority will mean that these cross-boundary flows will be reduced over the next few years, although because of the freedom of G.P.'s to refer patients to a consultant or hospital of their choice (and the corresponding freedom of the clinician to accept that patient) it is impossible to put an absolute figure on the net reduction. Despite this, a target figure of a 70% reduction has been set. Our first task therefore was to assess the potential affect of this change on the total number of geriatric patients over the next few years. This was to be undertaken with the backcloth of a changing population structure to be accounted for. It is a well known feature, nationally, that the elderly population as a proportion of the total population is increasing. However, how this is reflected at the District level will very much depend on the local situation. Clearly there will be some variation between authorities.

Our second task in this exercise was to take stock of existing facilities and to examine if a cost saving relocation of facilities prior to 1988 could be achieved. To be able to finance the new hospital development at planned levels it is thought that some £1.3 millions of savings in revenue will be required by 1988. Could some reorganisation of service provision, which would be necessary anyway by 1988, contribute towards this total? Our brief was therefore to examine a number of alternative possibilities and to determine if they were feasible. The information derived from this exercise could then be used by the management team in consultation with the authority to decide what to do, if anything.

5.3 Simulation Results

The first set of results pertain to the problem of assessing the demand for geriatric in-patient care in the District over the period 1981-87. We made the following assumptions.

(i) Birth, death and migration rates would remain at 1981 rates.

(ii) The age and sex specific morbidity rates would remain constant

(iii) The types of care provided would remain the same

(iv) Hospital and condition specific lengths of stay would be at 1981 levels

(v) Patients from outside the district have the same distribution of attributes as those in the district.

We ran the model under four different scenarios:

(i) Inflows would remain at 1981 levels
(ii) Inflows would cease altogether in 1983
(iii) Inflows would reduce at the rate of 20% per annum from 1983 onwards
(iv) Inflows would be reduced to 30% of 1981 levels in 1983 and in following years.

The model was run with a sample size of slightly over 40,000 individuals - giving a 1 in 4 sample. A summary of the results obtained are given in Tables 8 and 9. Table 8 shows the projected number of new geriatric in-patients for each of the seven years under the four scenarios. By new in-patients we mean those admitted within that year thus excluding patients already occupying a bed at the beginning of the year. During the simulation period the total population of the authority is projected to fall by 1.55% about 2,000 persons, but proportion of persons over the age of 65 increases by 2% - therefore resulting in a small but gradual increase in the total number of elderly persons.

Under the no-change scenario this increase in the elderly population is reflected by a slight increase in the number of in-patients (recall that we are basing our projections under the five assumptions listed above). Under scenario B, as we would anticipate there is a sudden decline in year 3 as in-flows cease, but a gradual increase from then on. Scenario C, which successively reduces in-flows reflects this in a continual reducation in in-patients. Scenario D, which is the expected scenario mirrors scenario B, but with in-flows still making a small contribution.

How this is reflected in the demand for bed-days is shown in Table 9. We list the total number of bed-days available in the district, the total bed-days utilised in 1982 and the bed-days "demanded" under the various scenarios. An interesting exercise is to compare the bed-day projections under scenarios A and D. This is shown at the foot of the table. We can note that there is about a 7-8% reduction and this is reflected in a 6-7,000 saving in bed-days. On the right-hand side of Table 9 we give the total bed-days available at each hospital. It is clear that the projected reduction in bed-days exceeded existing supply of geriatric services at hospital 3. Could there therefore be some rearrangement of facilities which would lead to savings in resources, without any detriment to the level of care provided. This forms the next piece of our analysis.

On the basis of the above analysis the planning team within the authority suggested that we examined the following proposal, under scenario D from above. Close all facilities at hospital 3 and transfer the 8 E.N.T. beds at hospital 4 into orthopaedic beds. These E.N.T. beds have extremely low occupancy rates (in 1982 the average daily bed occupation was 0.3) no operative procedures are undertaken and nearly all patients receive treatment outside the district. This shift means a reduction in geriatric beds of 10 and orthopaedic by 5. The potential saving in costs would be anywhere up to the region of £200,000 dependent on staff redeployment policy. Table 10 presents some results for this scenario. We compare hospital admissions by hospital and specialty for 1981 culled from H.A.A. and SH3 returns and the projected totals for 1983. A point that should be raised is that these totals include patients who are already occupying a bed at the beginning of the year - in geriatrics this is a significant number - about 6% of all geriatric in-patients have lengths of stay greater than one year. A further point is that at hospital 3 all geriatric patients in 1981 were admitted as orthopaedic patients but get transferred to the care of the geriatrician before discharge. These appear on the SH3 returns but not in the H.A.A. data that we used. The results show that in crude terms the closure of hospital 3 cold be possible if the geriatric inflows were reduced to 30% of their existing levels and that the configuration of orthopaedic beds was rearranged. The occupancy rates in year 3 for geriatrics and orthopaedics were about the same level, or slightly below the actual 1981 rates. This all, of course, assumes the continuation of existing practice. Furthermore the actual management of this type of change is the subject for further analysis. Beds of course can not just be increased or decreased at will but requires detailed planning. This then is the next stage of the analysis. We have shown that in broad terms the proposals should not reduce the overall level of care provision but we now need to undertake a feasibility study in terms of local arrangements and so on.

6. Conclusion

The above description is but a brief outline of the type of planning analysis the set of models we are constructing are intended to handle. More complex issues will be analysed in the future. A final important point to make is that the model has not produced a solution as such - that was suggested by the planners. Its major role has been simply the provider of information to those that are in a decision making position. Many other issues will be discussed and contributions made in relation to the planning problem at hand. We hope we have shown that models designed to address public policy issues can make a contribution to the general debate.

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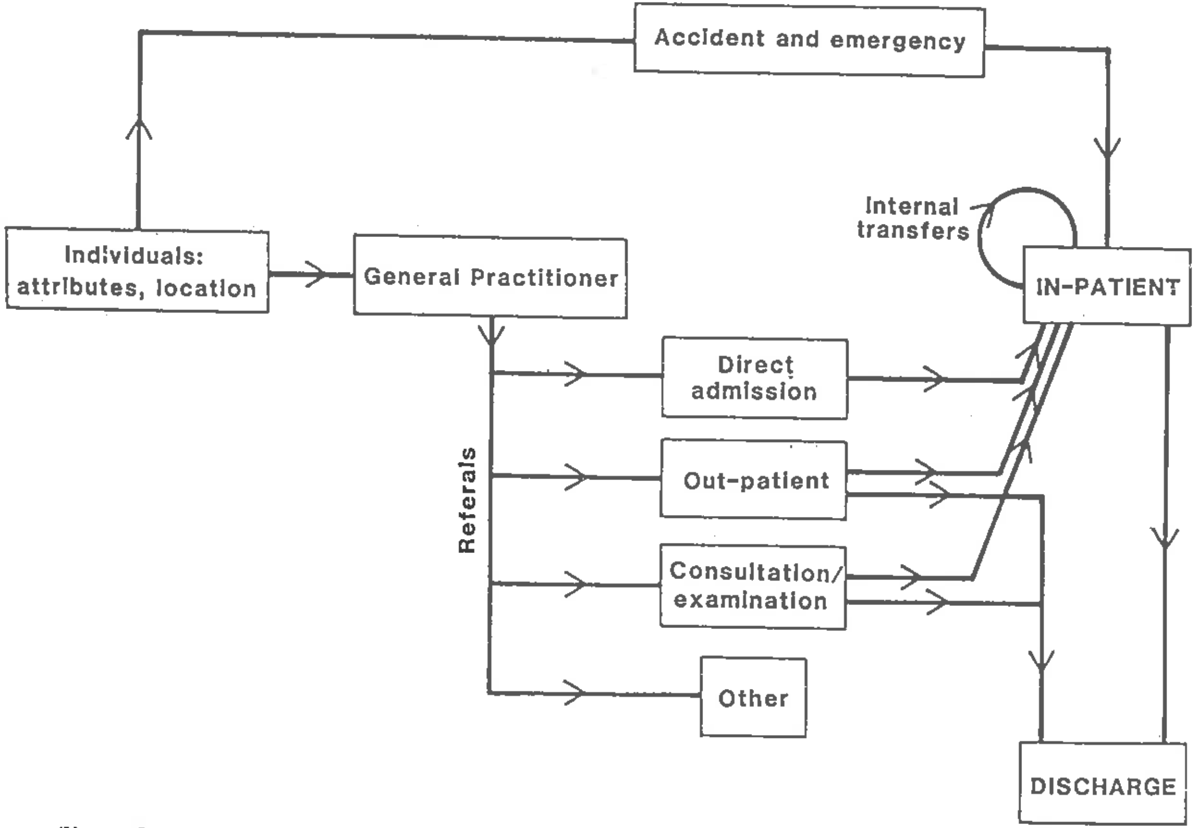

Figure 1 : Examples of flows in the patient-hospital interface.

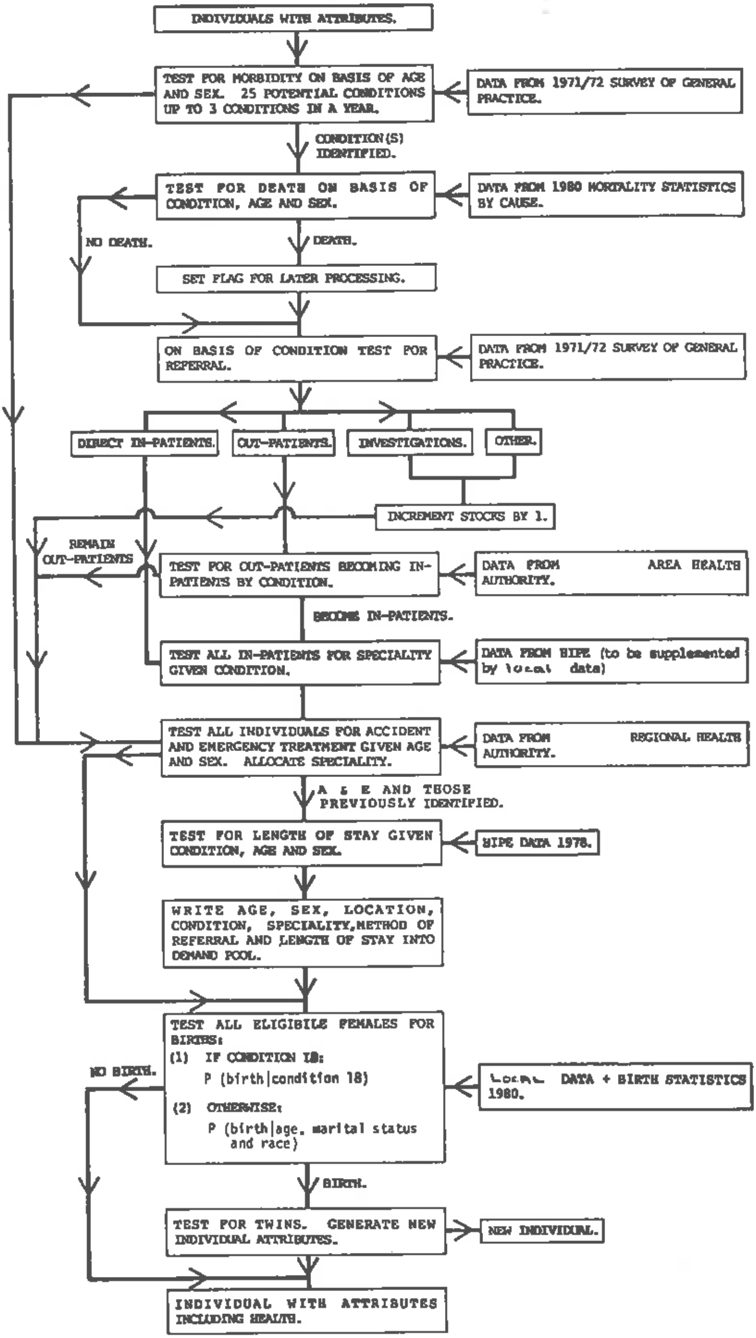

Figure 2 : Morbidity Model

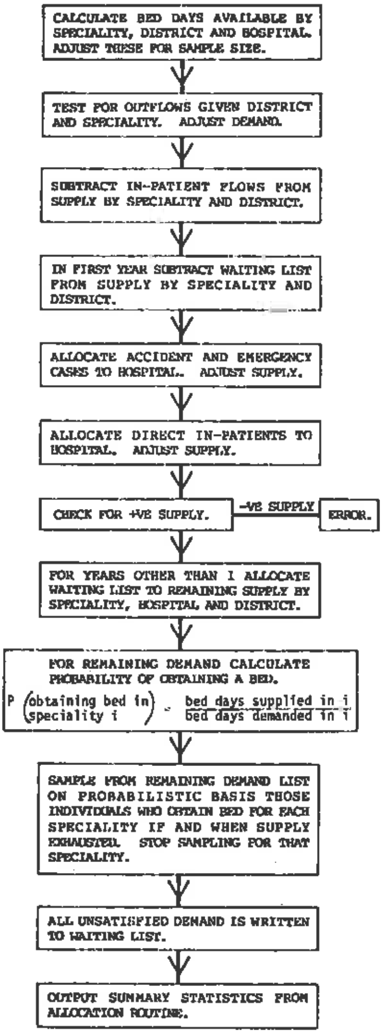

Figure 3 : ALLOCATION MODEL.

1. Infective and parasitic diseases
2. Neoplasms (malignant)
3. Neoplasms of lymphatic and maematopoietic tissues
4. Benign neoplasms
5. Endoctrine, nutritional and metabolic diseases
6. Diseases of blood and blood-forming organs
7. Mental disorders
8. Diseases of nervous system
9. Diseases of eye
10. Diseases of ear and mastoid processes
11. Rheumatic fever, hypertensive disease and heart disease
12. Diseases of peripheral circulatory system
13. Diseases of respiratory system
14. Diseases of digestive system
15. Diseases of urinary system
16. Male genital disorders
17. Diseases of breast and female genital system
18. Conditions of pregnancy, childbirth and puerperium
19. Diseases of skin and subcutaneous tissue
20. Diseases of musculoskeletal system and connective tissue
21. Congenital anomalies
22. Certain causes of perinatal morbidity
23. Symptoms and ill-defined conditions
24. Fractures, dislocations and sprains
25. Other injuries and reactions
26. Persons without current complaint or sickness

Table 1: Diagnostic Conditions (I.C.D. Classification)

INPATIENT DEMAND BY CONDITIONS

MALES

CONDITION	0-1	2-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75+	TOTALS
1	20	20	20	30	30	10	0	0	0	0	132
2	10	0	0	0	0	30	30	0	10	20	101
3	0	0	0	0	0	0	0	0	0	0	0
4	0	10	0	0	10	30	0	10	0	0	61
5	10	0	0	0	10	10	0	10	30	10	81
6	0	10	0	0	0	30	0	20	0	0	61
7	0	30	20	41	20	10	30	20	0	20	193
8	0	0	20	20	10	0	20	0	0	10	81
9	0	20	10	30	10	10	20	10	20	20	152
10	0	10	0	10	0	0	0	0	0	0	20
11	0	0	0	10	30	10	112	112	101	122	497
12	0	0	20	20	0	20	51	81	20	71	284
13	41	91	101	61	51	71	41	61	61	20	599
14	20	51	112	142	173	101	71	71	0	51	792
15	0	0	20	10	0	51	0	20	41	20	162
16	20	30	10	20	0	10	10	20	10	0	132
17	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0
19	0	10	0	20	41	41	10	10	0	10	142
20	0	0	0	61	41	81	61	112	20	41	416
21	10	0	20	10	10	0	0	10	0	0	61
22	254	0	0	0	0	0	0	0	0	0	254
23	30	20	112	51	71	61	91	51	20	30	538
24	0	20	20	20	0	10	0	0	20	0	91
25	10	10	51	142	152	91	10	91	10	0	568
26	10	0	0	10	0	20	10	0	0	0	51

TABLE 2(a).

FEMALES

CONDITION	0-1	2-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75+	TOTALS
1	20	51	30	10	10	20	20	20	10	10	203
2	0	0	0	10	51	41	41	41	20	41	244
3	0	0	0	0	0	0	0	0	0	10	10
4	0	10	0	10	20	61	20	10	10	10	152
5	10	0	0	10	30	0	10	30	0	10	101
6	0	10	0	30	30	0	71	41	41	51	274
7	10	10	10	20	71	0	41	0	30	30	223
8	10	20	0	10	0	10	20	10	10	10	101
9	10	20	0	0	10	20	10	0	0	20	91
10	0	10	10	0	0	0	0	0	0	0	20
11	0	0	0	10	0	0	30	61	91	244	436
12	10	0	10	20	71	61	10	30	71	152	436
13	20	41	51	30	20	51	20	101	51	91	477
14	41	20	30	61	152	112	101	41	30	61	649
15	10	20	0	0	10	20	30	20	10	20	142
16	0	0	0	0	0	0	0	0	0	0	0
17	0	0	20	274	213	173	142	142	10	10	984
18	0	0	0	101	81	41	0	0	0	0	223
19	10	0	10	41	10	20	10	10	41	20	173
20	0	0	0	51	61	91	112	71	71	81	538
21	10	0	0	10	0	0	0	0	0	0	20
22	304	0	0	0	0	0	0	0	0	0	304
23	20	30	51	71	112	101	71	30	10	81	589
24	0	0	0	0	0	0	0	10	30	61	122
25	0	30	81	152	51	61	61	20	10	91	558
26	0	10	0	51	30	41	10	0	0	0	142

TABLE 2(b).

CONDITION	SPECIALTY 1	2	3	4	5	6	7	8	9	10	11
1	101	132	0	0	61	0	0	10	10	20	0
2	51	10	0	20	213	0	0	0	51	0	0
3	0	0	0	0	0	0	10	0	0	0	0
4	0	0	0	0	152	0	20	0	41	0	0
5	61	20	0	30	30	0	10	0	20	0	10
6	122	20	0	41	91	0	0	0	61	0	0
7	233	61	0	81	10	0	10	0	0	0	20
8	71	51	0	20	0	0	41	0	0	0	0
9	0	0	0	0	0	0	0	244	0	0	0
10	10	30	0	0	0	0	0	0	0	0	0
11	426	0	0	233	0	0	0	0	0	0	274
12	183	20	0	213	254	20	0	10	10	0	10
13	507	355	0	122	10	71	0	0	0	0	10
14	81	30	0	20	1248	0	0	0	41	0	20
15	10	30	0	0	233	0	0	0	30	0	0
16	0	0	0	0	132	0	0	0	0	0	0
17	0	0	0	0	183	0	0	0	802	0	0
18	0	0	0	0	0	0	0	0	223	0	0
19	0	10	142	0	61	0	101	0	0	0	0
20	10	0	0	91	10	0	842	0	0	0	0
21	0	0	0	0	41	0	20	0	0	20	0
22	0	41	0	0	0	0	0	0	0	518	0
23	162	61	0	10	680	0	30	20	112	30	20
24	0	0	0	0	0	0	213	0	0	0	0
25	375	41	10	10	375	30	203	71	10	0	0
26	0	20	0	0	30	0	10	0	132	0	0
TOTALS	2405	934	152	893	3816	122	1512	355	1542	589	365

TABLE 3.

SPECIALTIES

1 GENERAL MEDICINE
2 PAEDIATRICS
3 DERMATOLOGY
4 GERIATRICS
5 GENERAL SURGERY
6 EAR NOSE & THROAT
7 ORTHOPAEDIC SURGEF
8 OPTHALMOLOGY
9 GYNAECOLOGY
10 SPECIAL CARE
11 CORONARY CARE

OPERATIONS BY SPECIALTY

OPERATION	1	2	3	4	5	6	7	8	9	10	11
1	0	0	0	0	0	0	41	0	0	0	0
2	0	0	0	0	20	0	0	0	0	0	0
3	0	0	0	0	0	0	0	254	0	0	0
4	0	0	0	0	0	122	0	0	0	0	0
5	0	0	0	0	10	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	112	0	0	0	0	0	0
8	20	0	0	0	1116	0	0	0	71	0	0
9	0	0	0	0	213	0	0	0	71	0	0
10	0	0	0	0	213	0	0	0	0	0	0
11	0	0	0	0	41	0	0	0	964	0	0
12	0	0	0	0	10	0	0	0	284	0	0
13	0	0	0	0	10	0	741	0	0	0	0
14	0	0	0	0	122	0	0	0	0	0	0
15	0	0	0	0	20	0	132	0	0	0	0
16	30	10	0	0	183	0	10	0	0	0	0
17	0	0	0	0	51	0	203	0	61	0	0
TOTALS	51	10	0	0	2121	122	1126	254	1451	0	0

TABLE 4.

SURGICAL OPERATIONS

1	NERVOUS SYSTEM
2	ENDOCRINE SYSTEM
3	EYE
4	EAR NOSE AND THROAT
5	UPPER ALIMENTARY TRACT
6	THORAX (WITH HEART & LUNGS)
7	BREAST
8	ABDOMEN
9	URINARY SYSTEM
10	MALE GENITAL ORGANS
11	FEMALE GENITAL ORGANS
12	OBSTETRICS
13	ORTHOPAEDIC
14	PERIPHERAL VESSELS
15	SKIN & SUBCUTANEOUS TISSUE
16	OTHER SURGICAL PROCEDURES
17	NON-OPERATIVE PROCEDURES

SPECIALTY	HOSPITAL 1	2	3	4	5	6
1	1111.1	1241.9	0.0	0.0	0.0	0.0
2	0.0	425.2	0.0	0.0	0.0	0.0
3	158.8	0.0	0.0	0.0	0.0	0.0
4	0.0	924.4	60.6	0.0	526.5	185.0
5	521.0	1071.5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	31.5	0.0	0.0
7	0.0	0.0	123.4	1652.1	0.0	0.0
8	102.7	0.0	0.0	0.0	0.0	0.0
9	185.9	430.2	0.0	0.0	0.0	0.0
10	0.0	290.2	0.0	0.0	0.0	0.0
11	0.0	242.5	0.0	0.0	0.0	0.0
TOTALS	2079.5	4625.9	183.9	1683.7	526.5	185.0

TABLE 5 : Cost by hospital and specialty (£000's) (excluding obstetrics)

COST BY AGEGROUP,SEX & SPECIALTY

MALES

SPECIALTY	0-1	2-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75+
1	0.0	0.0	1.3	266.1	100.0	110.4	63.7	179.9	430.7	175.1
2	63.9	108.6	59.9	10.1	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	3.9	8.4	41.3	16.1	24.5	0.0	9.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0	42.7	321.8
5	10.7	13.6	41.3	105.7	106.1	139.4	38.5	123.5	34.0	94.6
6	0.0	0.0	3.8	5.7	1.0	4.8	0.0	0.0	0.0	0.0
7	0.0	36.2	31.7	53.1	46.9	77.8	99.1	158.9	85.6	63.6
8	0.0	2.2	1.1	7.1	4.9	16.5	4.9	5.5	9.3	14.3
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	216.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	27.4	9.1	49.7	26.4	30.4	0.0
TOTALS	290.8	160.5	139.1	451.8	294.6	399.3	272.1	550.7	632.9	678.4

TOTAL COST FOR MALES 3870.1

FEMALES

SPECIALTY	0-1	2-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75+
1	0.0	0.0	0.0	42.9	49.4	93.3	125.6	207.8	92.1	414.6
2	41.6	75.1	66.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	5.2	0.0	7.1	0.0	0.0	13.6	0.0	0.0	4.5	25.2
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	194.2	148.8	956.9
5	4.3	13.5	25.9	121.9	153.2	119.0	107.0	107.4	81.6	151.3
6	0.0	0.0	1.0	0.0	3.8	7.6	0.0	3.8	0.0	0.0
7	0.0	8.0	0.7	43.7	49.5	69.7	86.3	128.3	217.2	519.3
8	1.6	2.2	0.0	0.0	0.5	4.4	3.8	0.0	0.0	24.2
9	0.0	0.0	3.0	222.2	130.8	119.3	52.3	57.8	13.5	17.2
10	74.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	7.1	5.1	11.2	47.7	10.1	18.3	0.0
TOTALS	126.8	98.7	103.7	437.8	392.4	438.1	422.8	709.5	576.1	2108.6

TOTAL COST FOR FEMALES 5414.4

TABLE 6 : Cost by age, sex and specialty (£000's) (excluding obstetrics)

SPECIALTY	HOSPITAL					
	1	2	3	4	5	6
GENERAL MEDICINE	61	49				
PAEDIATRICS		28				
DERMATOLOGY	11					
GERIATRICS		96	10		96	48
GENERAL SURGERY	40	49				
E.N.T.				8		
ORTHOPAEDICS			13	71		
OPHTHALMOLOGY	15					
GYNAECOLOGY	14	23				
S.C.B.U.		20				
CORONARY CARE		4				
OBSTETRICS		120				
TOTALS	141	389	23	79	96	48

TABLE 7: Beds by Specialty by Hospital in the Health Authority

SCENARIO	YEAR 1	2	3	4	5	6	7
NO CHANGE IN-FLOWS AT CURRENT RATE	918 (96)	926 (91)	934 (83)	922 (96)	933 (97)	937 (92)	943 (93)
ALL INFLOWS STOP IN YEAR 3	910 (111)	924 (93)	843 (0)	815 (0)	825 (0)	841 (0)	863 (0)
FROM YEAR 3 ONWARDS IN-FLOWS REDUCED BY 20% PER ANNUM	921 (99)	919 (101)	901 (81)	873 (62)	849 (44)	947 (19)	849 (0)
FROM YEAR 3 ONWARDS IN-FLOWS AT 30% OF 1981 LEVELS	916 (109)	912 (97)	863 (32)	853 (28)	867 (32)	856 (36)	879 (29)

TABLE 8: Total of New Geriatric In-patients and Inflows (in brackets) Under 4 Senarios

		YEAR 1	2	3	4	5	6	7
TOTAL BED * DAYS PROVIDED (1982 FIGURES)		91432	91432	91432	91432	91432	91432	91432
TOTAL BED DAYS * UTILISED (1982)		87198	87198	87198	87198	87198	87198	87198
DEMAND FOR BED DAYS UNDER ALTERNATIVE SCENARIOS	A	84561	86298	8623	84992	86094	87322	87869
	B	84243	86541	79041	76241	76437	77645	78989
	C	85163	85099	84167	81926	79625	78993	79220
	D	84910	85003	80986	78763	79801	78917	80029
D as a percentage of A		100.4 -349	98.5 1295	93.9 5249	92.6 6229	92.7 6293	90.5 8405	91.8 7169

NOMINAL BED DAYS AVAILABLE

HOSPITAL 2
33215

HOSPITAL 3
3103 (geriatric)
3431 (T & O)

HOSPITAL 5
33507

HOSPITAL 6
17082

TABLE 9: Supply and Demand for Bed Days Under Alternative Scenarios

*   excluding T & O at hospital 3.

	1981 HOSPITAL						1983 HOSPITAL					
	1	2	3	4	5	6	1	2	3	4	5	6
1	1363	1029					1322	1076				
2		1051						1101				
3	158	42					169					
4		715	36		154	76		676			149	78
5	1328	1876					1842	2129				
6				105								
7			129	1633						1786		
8	405						439					
9	502	1136					637	1008				
10		819						729				
11		398						343				

TABLE 10: Number of In-patients Treated by Specialty and Hospital 1981 and 1983