# Picking Your Brains: A DSS for Neurosurgery

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*This research involves the construction of a decision support system (DSS) to assist clinical managers in costing and contracting in the new internal market for neurosurgery in the UK National Health Service. The research requires the use of a novel method to collect detailed patient costing data. This data is used to build up profiles of 'similar' patients for contracting purposes using clustering techniques. The clusters are employed in a simple DSS to evaluate and simulate the effects of cost and activity changes under different contracting scenarios. The detailed data allows further uses in clinical audit, outcome studies and macro-level health policy analysis.*

## Introduction

This paper illustrates how a clinical unit, the Wessex Neurological Centre (WNC) within the National Health Service (NHS) can cost its activities and contract with its purchasers in the new internal market. The research demonstrates a decision support system (DSS) constructed from data supplied by an innovative data capture method. This method allows clinical managers access to detailed activity and cost data which has uses beyond the current study. The research further investigates the worth of patient clustering categories widely used elsewhere. The following sections discuss the nature of the problem facing managers in the NHS and their data needs. Consideration is given to current methods for grouping patients and to the use of DSS in the medical environment. The process by which data is captured and used is discussed, along with sample data from one medical specialty - neurosciences. Finally, the applicability of this system to other specialties and of the data to other uses is considered.

## Background - The Nature of the Problem

Health care costs are rising rapidly. According to the Economist (1994) "those who finance health care - i.e. governments and insurance companies - are responding by demanding more information about the cost, effectiveness and quality of the services they are buying". Against this background, in 1989, the UK government published a paper on the future of the NHS. One important thrust was to bring a new style of management to hospitals, enabling and encouraging the introduction of private-sector style attitudes and values. These would have a major impact on the way in which hospitals control and manage their resources. Greater financial accountability would be a first step to the creation of internal markets in which service agreements would be drawn up between District Health Authorities (DHAs) and fund-holding GPs (as purchasers of services) and hospitals (as providers). It became clear that the market philosophy would encourage the purchaser to buy services from whichever hospital was felt to give the "best value", and the providers similarly to sell their services to any DHA. To facilitate this, systems would need to be developed to ensure that costs and benefits are carefully and continuously monitored, and that the services offered are realistically, and perhaps competitively, priced.

## The Contracting Process

Various types of contract have been proposed (under a general atmosphere of 'managed competition'), although not all have yet been fully implemented. The aim is to overcome problems inherent in the previous financial allocation system, namely that fixed money allocations to health authorities inhibited short-term increases in patient throughput volume, and also that since capital was essentially treated as a free good it was not efficiently managed (Ellwood, 1992). Although competition in health care has benefits, it is not without costs. As Ellwood points out, perfect competition requires, inter alia, consumers having a choice of suppliers, known prices and qualities and access to information. Estimates of the transactions costs of trading between purchasers and providers range from 10 to 20% of total costs and result in the need for regulation and control. In the internal market, money and patients go together so that any treatment should have payment attached.

Currently three types of contract are possible - block, cost and volume, and cost per case (figure 1). It is up to the purchasers and providers of health care to negotiate contracts on an annual basis. Block contracts specify a range of treatments to be carried out, the remuneration for which is not based on throughput; essentially the fee is for access. Cost and volume contracts have elements of the block contract, but above a certain specified throughput, treatments are charged on a cost per case basis. This additional charge is supposed to reflect the marginal cost of treatment if the extra throughput of patients represents the use of unplanned spare capacity.

This type of contract does, of course, necessitate more detailed costing data than block contracts. The final type, cost per case is costed on actual activity levels and requires the most detailed costing. The implications of changes in activity levels, and hence risks, for both purchaser and provider are clearly different for each contract type, and the contracts differ greatly in the volume and accuracy of data required to service them. Currently most contracts are of the block type but gradually both purchasers and providers are moving to cost and volume and cost per case. For example, the WNC has experienced a 20% increase in workload since 1989; such an increase would be difficult to sustain if all contracts were of block type. The price charged for any activity is supposed to be at actual cost, where cost includes depreciation and interest.

The internal market has been artificially constrained during the early years as a transitional measure to allow purchasers and providers to prepare. In particular, all the services offered by a particular hospital specialty are usually offered at a common price, rather than there being any attempt to set a price for each type of service. Such specialty-level pricing is crude; although most clinicians recognise that different patients incur different costs, most probably do not feel equipped to quantify differential costs and, even if they did, purchasers might be reluctant to accept them. There is, therefore, a widely felt need for a more accurate reflection of the different costs associated with treating various types of medical condition within any particular specialty. However, any contract which is not of a block nature will need to specify clearly the product or service being traded. Ellwood concludes that the direct care costs associated with a particular specialty are "of dubious credibility", and that the Department of Health would be ill-advised to remove the safeguard of the transitional restrictions on the market place, such as block pricing. This research offers a method for accurate cost compilation which will overcome some of these difficulties. Further, the transparency of the method enhances the acceptability of the results by all contracting parties.

## Hospital Costing Data - deriving standard costs

Prior to the reforms, cost information was poor, indeed most data concerned highly aggregated activities and was not financial. The Economist suggests that "the writing and collection of patient records has changed little in response to the computer age, as doctors have been reluctant to abandon paper for electronics". What experience there is of cost collection suggested that most costs in the hospital sector are fixed or semi-fixed with, perhaps, three-quarters being staff costs (Ellwood, 1992). Coles (1989) suggests that up to 72% of hospital costs cannot be readily attributed to individual patients, though Coverdale et al, (1980) offer 60%. Under the new contracting system, hospitals will have to decide how to price the services provided by each specialty. The form of these new contracts is largely under the control of the purchaser and provider. Indeed, many purchasers are seeking a charge for each finished consultant episode (FCE), and so the relevant DHA needs to set a price for each `patient episode' treated.

An episode begins when a patient is admitted, and continues until they are discharged from the care of a particular consultant - hence a single admission may be made up of a number of FCEs. Since every patient episode is unique, costing and pricing could be achieved using a `job costing' approach, in which the hospital records the actual cost of providing the service received by each patient. However, this would require a large continuous data collection exercise, and a preferable alternative is the establishment of `standard costs'. Indeed, the former approach is contrary to the views of the NHS Management Executive (NHSME) and is resisted by most purchasers. In the standard costing case, each patient episode is assigned to a pre-defined group that typically requires a similar amount of resource to treat. It relies on the ability of the provider's management to define cohesive treatment groups and to estimate the resources likely to be used in providing a service for each. However, as in any standard costing approach, variances are likely due to changes in input prices, volumes, case-mix, efficiency and treatment patterns (Ellwood, 1992).

**Previous Costing Attempts**

In 1984 the WNC admitted 1185 patients with a mean stay of 12.5 days at a mean cost of about £2500 per operated patient and a cost per occupied bed day of about £146 (at 86% occupancy). It is interesting to contrast this with the 1992 Department of Health figures which suggest that the cost of the average patient week was £1,072 up from £991 in 1991. Not only are costs of care rising rapidly but specialisms such as neurosurgery are more expensive than general medicine.

The first problem involves disentangling the cost of operating the Unit from the costs of operating the remainder of the hospital. This is a daunting tasks since the activities of the Unit and the hospital are complex and inter-related. For example, the hospital is a teaching one, there are centrally funded pathology services, there are other regionally funded services and the site also contains residential accommodation for staff. Further, the accounting system did not distinguish between costs incurred by the unit and those incurred elsewhere; and the functional rather than cost centred organisational framework precluded pricing for a lot of services. Overhead apportionment was often arbitrary.

The essence of the costing problem is that, often particularly at micro-levels such as the patient, the resources used in the production of the service cannot be identified unambiguously. Usually resources are used by many patients and so the costs are joint. Overhead costs present additional problems. In some cases the supplying unit offers a price for the service (for instance all pathology tests of a certain type are priced similarly). Alternatively average costs may be used or actual costs based on the quantification of all resources used. Further difficulties in costing arise when there is not a single price for any resource. For example, nurses on different grades cost different amounts, just because an 'F' grade nurse carries out an activity for a particular patient does not mean that an 'A' grade could not or will not have done the task. Even in non-staff costs, differences may appear if the same goods are purchased in bulk or individually. This becomes more of an issue in the internal market if a unit standing between purchasers of services on one hand and being purchaser of services on the other has different types of contract with each. For example, the WNC may have a block contract with one DHA but have to pay for each individual pathology test. Such individual costs will not be represented fully in the contract price paid. Perhaps the most important distinction is between variable and fixed costs. Costs are fixed or variable in relation to a measure of output, so the distinction helps elucidate the cost implications of changing input levels. Costs are only non-variable within a particular time and over particular ranges of output. Many resource use costs have both a fixed and a variable element.

This work addresses the issues highlighted. The costing problems outlined exist and the introduction of the internal market has given fresh emphasis to the activity cost issue. On the benefits side, technology has improved and functional reorganisation of the hospital and budgetary devolution to the WNC has assisted in drawing boundaries around the unit. However, the nub of the problem, identifying, classifying and recording activities, durations, uses and costs remain. It is against this background that the current research attempts to shed light, having developed a new method for so doing.

### Diagnostic Related Groups

Many attempts have been made to derive patients groups and thus standard costs. The earliest proposals were clinically-based, trying to identify homogeneous groups of patients who had similar clinical properties, for example, the same illness or injuries. Whilst progress has been made in this type of clinical analysis, little attention has been paid to the management properties of patient groups. Thus, although patients might have similar clinical problems, there is no suggestion that the costs of treatment might be similar: no two broken legs or head injuries are identical. The lack of cost data persisted until the US Government investigated hospital reimbursement schemes based on patient types and standard costs. One way in which standard costs can be achieved which has aroused much interest in the US and has been evaluated in over 20 countries is the use of diagnostic related groups (DRGs); patients with similar medical conditions are grouped together, and costs associated with each group constructed.

According to Fetter (1991), one of the originators, DRGs were designed to allow hospital performance to be measured and evaluated. In essence, the developers searched for the "simplest regulatory mechanism that could substitute for the absence of an open market in healthcare". This market was conceived never to be fully open since health consumers have little information about the value and quality of treatment and, by and large, do not pay for most services. The mechanism for DRG use (Scarpaci, 1988) is to, first, assign the patient to one of 23 major diagnostic categories. Then the hospital payment rate per case is multiplied by the weighting of the assigned DRG. The weight represents the mean resources expended on a medical/surgical procedure relative to the mean national amount of resources consumed per case by an average hospital. The patient is then assigned to one of more than 468 DRGs (the number has slowly increased as some are sub-divided in the search for greater homogeneity). As Scarpaci states "the assignment of a patient to one of 468 DRGs does not represent a definite diagnosis, a total account of itemised charges nor a comprehensive evaluation of patient care. Rather DRGs are a tracking facility that enable hospitals to operate as multi-product firms whose outputs are medical and surgical procedures. Instead of using the traditional measures of hospital performance such as the proportion of medical staff specialists, bed size and occupancy rates, DRGs gauge performance based on treatment procedures and patient attributes".

In the neurological area there are only a small number of DRGs - 36 - divided between, surgical and medical principal diagnoses. For example, in the surgical group, patients would be assigned to a different DRG based on whether the principal diagnosis of their problem was intercranial, spinal, extracranial vascular, or peripheral and cranial nerve. If the condition is medical, examples are brain tumours, degenerative nervous system disorders, multiple sclerosis, and head injuries.

**Problems with DRGs**

Although DRGs are a step in the right direction, it is clear that there are a number of difficulties which might restrict their use for costing and contracting. For example, Greenhalgh and Todd (Bevan, 1989) question the use of DRGs, which rely "on the assumption that those in the same diagnostic group consume the same amount of health care resources [which] implies that patients are treated according to their diagnoses regardless of the individual clinical characteristics or treatments". Bevan suggests that homogeneity is only meaningful over a large number of patients not at an individual level. It may be that the vital decision in terms of resource use is the doctor's decision to admit the patient rather than factors such as length of stay. This concurs with Babson (1973) who found that over 90% of total direct patient costs are incurred in the first 30% of any stay, and Sanderson et al. who state that the last few days of any stay tend to be cheap. In summary, Fetter (1991) suggests that there are three main problems in predicting costs of services; not all diseases are equally well understood, treatments for the same disease differ, and the coding of illnesses is difficult.

It should be clear that for any `standard cost' approach to be useful, clinicians and managers need to have confidence in the groupings. This needs to be in terms of the extent to which the costs associated with each group are an accurate reflection of actual costs and therefore a sound basis for pricing. Williams et al. (1982) find that average costs do not reflect well the actual use of resources. Horn and Schumacher (1979) contend that average cost is not useful since for most DRGs the standard deviation of cost is greater than the mean. Manton and Vertrees (1984) point to the instability of average cost within DRGs, since more categories implies fewer patients in each and also because the high costs during the terminal stages of chronic illnesses of the elderly are not reflected in DRGs. The requirements for any groupings are that they should be comprehensive and mutually exclusive, clinically coherent and homogeneous in their use of resources. Rosko (1988) goes further suggesting that any good patient classification system needs to have certain characteristics, viz. be based on reliable data and on iso-resource use groups of patients, there needs to be a manageable number of categories, the system needs to be meaningful to doctors, and the information has to be accessible at reasonable cost.

In an attempt to overcome some difficulties, additional factors are reflected in some DRGs. There is considerable debate as to whether age or comorbidity is preferable. Comorbidity is present when the patient has more than one disease or injury though the secondary ones may be minor compared to that used for DRG classification. The developers of DRGs investigated comorbidity but found that "most of our hypotheses about what ought to make a difference could not be supported by the data...when all else failed we used age" (Fetter, 1991). Subsequent work, however, pointed to the dominance of comorbidity over age as a differentiating factor, and so comorbidity has now replaced age in 95 DRGs which had age categories. Yet, only half of the 18 neurosurgery DRGs used here are stratified by the presence of complications, although Munoz et al. (1988) assess complications and comorbidities as directly influencing both costs and length of stay, while age did not. Again, Desharnais et al. (1988) found that age alone, in the absence of comorbidities does not result in substantially higher costs or longer stays. They find that patients over 70 may have an average length of stay of about half a day longer that those under 70, whereas those with comorbidities have stays three days longer. Perhaps the most striking finding here is that even patients aged over 90 without comorbidities were discharged faster than younger patients with comorbidities. Age, according to Jencks and Dobson (1987), is a poor predictor of cost but a strong predictor of death.

**Alternatives to DRGs**

The doubts as to whether DRGs are the most effective indicator of costs have led to the development of healthcare resource groups (HRGs) in the UK. HRGs, modified DRGs, are seen to reflect more accurately UK clinical practice and cost profiles; similar modification of DRGs has been undertaken in the Netherlands (Verheyen and Nederstigt, 1992). In the UK, since cost data is limited, length of stay is widely used as a proxy for resource use. Even though most hospital costs are fixed, this, coupled with imperfect diagnostic coding, restricts the accuracy and development of HRGs. As discussed, the problems with DRGs and similar measures are that they do not take into account severity, nor length of stay. Indeed few DRGs are homogeneous across acute specialities. In fact, they may just reflect faulty clinical decisions or faulty execution (Rosko, 1988). Fetter (1991) gives examples of two DRGs for which resource utilisation may vary by a factor of seven between hospitals and a factor of ten between cases. Johansen (1986) finds that DRGs are inferior to other methods in explaining variability in length of stay. Sanderson (1989) argues that some DRGs are homogeneous with respect to length of stay whilst others are not. McNeil et al. (1988) find some DRGs can be improved in terms of homogeneity whilst others cannot, and it is not always clear how this may be done clinically. Similarly, Horn and Schumacher (1982) maintain DGRs are the least adequate method for patient grouping when compared using two statistical criteria for homogeneity.

McMahon and Newbold (1986) find physician practice to explain more intra-DRG variability than does severity. There are also other factors which may affect intensity of care such as emergency versus planned admission and clinical decisions such as the choice to treat for survival or for pain relief (Jencks and Dobson, 1987). They highlight two further issues. First, patients considered outliers in terms of DRG category are significantly more likely to have been outliers before in previous episodes, and, second, certain doctors always had a higher proportion of patients classified as outliers compared to their colleagues. Initial work by Greenhalgh and Todd (1985) points to "marked differences in the use of resources per day between patients with exactly the same diagnosis and between patients requiring the same treatment procedure". In similar vein, Horn et al. (1986) state "it is now well accepted that individual DRGs are not homogeneous with respect to resource use". Berki (1983) goes further " there is as yet no taxonomy based on clinical data that can demonstrably classify cases in terms of their severity and clinical case management complexity into a set of exhaustive and mutually exclusive homogeneous cells". Berki sees DRGs and disease staging as currently the best developed, though neither yields a set of iso-resource categories within acceptable effectiveness criteria. A further candidate criteria for differentiation is outcome. Little work has been performed relating outcomes to costs, however, Munoz et al. (1989) calculate that mean total costs for patients who die are over five times those for patients who survive. Similarly, the former have an average length of stay over four times greater than survivors.

It is clear that the WNC needs to have a basis for costing and contracting. Yet, following from the above, the question is, if DRGs or HRGs are not a sufficiently reliable ingredient in the pricing model, are there more representative groupings which can be used? There is a clear need to assess current classification possibilities and to evaluate their effectiveness for costing and contracting.

## Testing DRGs, HRGs and Standard Costs

The WNC faces the problems described above. As a budget-holder, the WNC recognises the need to manage its resources, and acknowledges that one way this might be achieved is to measure costs accurately. It is an acute unit, dealing with disorders of the spine (degeneration/disc disease, tumour) and brain (tumour, trauma, haemorrhage) many of which are emergencies and, therefore, currently provided as part of a block contract. The WNC is a self-contained unit offering a spectrum of treatment ranging from 'cold' investigation to neurological intensive care, and it has already suffered financial problems due to major shifts in case-mix within the block contracts (British Medical Journal, 1992). Block contracts have emphasised the need to understand the effects of case-mix changes and its resource consequences.

The WNC has three wards, including an intensive care unit. Managers are already aware of fixed costs, and see ways in which some variable costs, for example costs arising from drugs and tests, could be captured and analysed. However, one of the most significant costs is staff, which is semi-fixed, and it is difficult to relate costs precisely to particular types of patient episode or categories of activity. The project recognises the need for a more accurate pricing model based on a better understanding of variable and semi-fixed costs. Hence, the model forms part of a DSS which could be equally useful to other specialisms in preparing bids to purchasers. Further, it could also be used by purchasers to experiment with the effects of demand changes. As identified, the first task is to consider alternative ways in which patient episodes might be grouped, and to implement a method by which the costs of service provision, particularly staff time, could be more accurately measured.

## Grouping of Data

Greenhalgh and Todd (1985) identify lack of available data as inhibiting the effective financial management of clinical units. They maintain that accurate patient costing requires identification of the activity which consumes resources in terms of staff time and consumables. Ashford and Butts (1979) add, "all that is required to relate the financial inputs to the patient care outputs is to compile a detailed record of all types of services provided". However, they go on to state that this cannot be done directly. Yet, technology has advanced considerably since 1979. Manton and Vertrees (1984) suggest that in addition to DRGs, other data might be useful including discharge status, auxiliary diagnosis, age and sex, and treatment. A large quantity of this data about each patient is already collected in the WNC. This takes a variety of forms, and is collected for a variety of purposes; some is demographic, some historical, and only some is current.

The `output' of the WNC is defined in terms of FCEs; a patient enters the service, moves through it (consuming resources), and is discharged (perhaps to a different specialty or perhaps to the care of a GP). Each episode generates various activities, (nursing, intensive nursing, surgery, admission, discharge) and costs can be calculated for these and attached to that episode. If there is a satisfactory match between types of episode and DRGs or HRGs, such that managers can be confident that the latter form a reasonably accurate aggregation of episode types, it is necessary only to gather costs.

Within any particular specialism, such as neurosurgery, there might be quite a modest number of HRGs. If, however, there is not a satisfactory match between HRGs and costs associated with particular patient episodes, then a different grouping might yield a more accurate determinant of costs to be fed into a pricing model. This might involve modification of the HRGs or developing different groupings. Miles et al. (1976) were some of the first to attempt to group or cluster patients and claim that if customer classes can be measured by attributes, then one has the basis for control of the 'production' process. This control is of cost, via classification of patients according to their patterns of resource consumption, with the caveat that the classes must be medically meaningful. One aspect of the current research project is to undertake a comprehensive analysis of the determinants of variable cost for a range of patient episodes, to determine groupings that produce data which is more useful for contracting. Ultimately, however, the final determinant of the grouping method chosen must be its usefulness to clinicians and managers.

### Accurate Measurement of Activity Costs

The above requires an accurate method of capturing data. Mindful of Coles' (1989) statement that "patient-based costing would require a marked increase in information gathering and computerisation", and Doremus and Michenzi's (1983) findings of substantial errors in hospital discharge data, two factors were influential in determining an appropriate method. First, staff are already required to record a variety of data, and it is important that costing data is seen as complementary rather than duplicating existing collection. Where possible, any proposed system should either draw upon existing data sources, or provide an alternative, more acceptable, way of meeting requirements. Second, health professionals are already operating in a demanding environment and it is therefore important that any system to monitor and record activities should not place an additional burden upon them, and have a perceived operational benefit. An obtrusive data collection system may also be perceived negatively by patients.

The initial phase concentrated on establishing the chronological flow of patients through the WNC, identifying key activities. From this, the complete set of activities undertaken could be established as a precursor to measuring activity durations. Clearly, the first task in analysing activities is to record all activities undertaken. A number of possible methods exist for this, however here the interest is patient-centred, so the chronological flow of a patient is used as the recording process, and the work clarified, probably for the first time, the range and nature of the activities carried out, as a necessary precursor to data collection.

## Data Capture and Decision Support

In the light of the above constraints, a variety of data capture methods were investigated. Past hospital data collection methods have relied on cumbersome systems such as form filling or retrospective keyboarding by nurses and doctors. None has the desired characteristics and most have been rejected by those who operate them. There is, however, a method, common in retail business which has potential here. The project team decided to barcode all activities, and to use portable light pens to capture the data.

Each activity (for example, bed bath or giving drugs) is given a unique code printed on laminated pads, either carried or strategically placed, to be scanned during the performance of the activity. In addition, each patient has a unique code, generated on admission, which acts as a label to which activities are attached. Each activity performer (nurse, doctor, physiotherapist) is given their own, uniquely coded, light pen. The pens are compact, a little larger than a standard ink pen. Each pen is equipped to capture the start and finish times of each activity and at the end of each period is downloaded to a central PC. Note that is important to capture not only that an activity took place but the duration and also the type (or grade) of staff who undertook it since users may be of different types or grades, and therefore represent different costs.

In order to ensure completeness in the recording and to eliminate the possibility of unaccounted down-time, a hierarchy of bar codes is used. This starts at the level of the medical staff - doctor, nurse, physiotherapist etc., the second level is the patient upon whom the activity is performed, the third level concerns the actual activity, while the lowest level records the duration. Similar hierarchies are used for recording drug usage and operating theatre activities. The approach is patient-centred since the interest is to distinguish different activity levels for different patient classes. Figure 2 illustrates the range of activities covered by the exercise for both direct and indirect resources. Although there may be recursions, most patients will conform to the chronological flow outlined in figure 3. This is used to identify activities occurring at any stage of the patient's progress. Thus it begins with the clerical activity of admission and follows a patient through pre-operative nursing, medical and investigation activities to surgery and recovery. Due to the nature of the specialism, most patients require intensive post-operative care before they are moved to a lower level care ward and then discharged.

Although used in a variety of retail and manufacturing environments, bar-coding has not been widely used in health care. Despite the first mention in 1986 (Rappoport, 1986), it has not found general use and, where it is used, is confined to activities such as laboratory use. Timpka et al. (1992) find two major health-care uses - stock and item distribution and clinical laboratory applications. The authors see the benefits as increasing ease and speed of data input and increasing accuracy. Though the former is sometimes disputed, the latter is generally true. The main problems is a lack of standardisation and difficulty in integrating resultant data into other systems. Both these difficulties did not pose a problem here, although some software had to be specially written. Interestingly, Timpka et al. do not envisage any role for bar-coding in health-care planning and administration, though they state there is potential in clinical audit work. Figure 4 illustrates some of the bar-codes developed in the project and their associated hierarchy. In similar vein, figure 5 details the data collection activities undertaken in the operating theatre. This demonstrates the multiple participants and multiple simultaneous activities which may be taking place during a patient episode.

Each patient's episode of care is analysed in terms of the medical interventions, the activities these generate, and the associated costs. A picture emerges of cost drivers for particular patient groups, which can be fed into a pricing model to allow, for instance, sensitivity analysis on particular groups for contracting purposes. Even crude analysis of the data has enabled preliminary observations about standard timings for commonly-performed activities. The end result of the costing phase is the processing of the data to produce clusters of patients. The clusters are of `similar' patients, that is, patients who consume similar amounts of resources. Similarity may depend on illness, length of stay, age or other attribute. When manipulated into manageable groups, these form the basis of contracting and of the DSS. The DSS will allow managers to simulate the effects on activity and costs of various contract types and different bases for contracting. This should enable better planning and more efficient resource utilisation.

Figures 6. and 7. show details of data prior to expert filtering (to remove outliers) and clustering. Filtering is necessary to remove obviously implausible data. For every activity, nurses and doctors who regularly perform it were questioned as to the maximum and minimum possible value the variable might take. In some cases these were augmented by trial timings of activities. For instance, there is a minimum time possible for taking the patient from the ward to the operating theatre. This involves use of a lift which may not be readily available, and a distance to travel. Similarly, to get maximum potential values, an informal risk analysis was carried out. Staff were asked to imagine a worst case scenario, where everything possible might go wrong for the most difficult type of patient. Note that patient "difficulty" is not necessarily the same as severity. A severely ill patient may be in a coma and therefore passive, a less ill patient may resist. Similarly, mobile patients may be able to perform some tasks for themselves - this may not be the quickest way to carry out tasks but may be part of rehabilitation. This process of filtering provided an upper and lower bound for the data. After timings were obtained, data which lay outside the bounds were candidates for removal. However, data was fed back to the experts if a significant number of readings exceeded the bounds. This process is vital since the data is used to differentiate patients, and so data was not excluded unless there was complete agreement that it was erroneous.

Figure 6. demonstrates the range of activities performed on individual patients. The most intensive count of activities on a particular patient, 1828 activities, during his/her FCE is nearly twice that of the fifth patient and compares to a mean number of significant activities per day of around 30. The median patient in the data collection exercise had fewer than 200 activities performed. Clearly, vastly different resource usages are implied by this activity data, yet many of these patients would be classified in identical DRG categories. Any contracting process would need to differentiate such patients. Figure 7 details the mean and standard deviation durations of some activities. Again, the very large standard deviations imply that different patients consume non-similar resources. Figure 8 presents the data graphically, demonstrating the shape of the distributions. Initial analysis by the project team has focused upon "dependency scores" as a possible surrogate for resource use, although further work is required to establish more precisely the strength of this. The clustering process takes the bar-code data in order to produce groups of similar patients. The resultant clusters provide the input to a simple robust DSS used by staff as a basis for contracting.

In the costing and contracting problem here, the data derived from the bar-coding system provides the data-base of the DSS, the model-base is the set of tools used to investigate the behaviour of costs under various scenarios and contracting possibilities. Because the DSS needs to be readily available and usable by staff, a standard DSS generator, a spreadsheet, is used to display results and allow user interaction. The system developed has aspects of both institutional and ad hoc DSS. It is necessary to automate as much of the data analysis as possible to provide management with standard outputs on a regular basis. This facilitates control. However, for annual contracting negotiations, users will want to experiment and simulate alternatives. A standard DSS generator is used because it needs to be compatible with current systems and expertise. As shown, the problem solution is data intensive. That is, obtaining and processing the data for the DSS posed the bulk of the work. Once the costing data is available and clustering has taken place, the DSS is relatively straight forward.

**Conclusion and Future Potential**

Although the data produced by the system is primarily collected for contracting, it will have a multitude of uses elsewhere. For example, figures 9. and 10. show early results of analysis of nurse time by grade. It can be seen that the preparation of shift report is highly labour-intensive while full neurological observation is similarly time-consuming. This highlights potential areas for management or technological intervention. Given that the data is categorised by grade, management can assess whether the appropriate grade of nurse is undertaking each task. Conversely, when looking to support the Unit, consideration can be given to whether investment in appropriate technology can improve efficiency or effectiveness in those tasks which take up considerable nurse time.

In terms of using clustered data, Donaldson and Magnussen (1992) feel "it is doubtful whether the use of DRGs...can deliver more efficient clinical practice" In addition to testing DRGs and other measures this data (consider, for instance, changes in severity during a patient episode) may have a role in clinical audit, in looking at the outcome effects of different treatment profiles and in wider studies on issues such as the effects of ageing on the population. This involves the comparison of the use of resources by different age categories and projection of the results as the average population age increases. Not only is the population ageing but there is an increase in the very old. The proportion of retired people in the UK will increase from 18.4% to 19.8% by the next decade. Based on present consumption, health care costs are expected to rise by 40% by the year 2025. There are also impacts from improved health which compresses morbidity into a smaller time-frame, from advancement of medical technology resulting in greater opportunities for health improvement but also raised expectations. This is compounded by increased education of patients - better informed perhaps meaning more demanding (Lagergren, 1993). Although total heath care volumes and hence costs are rising rapidly, disaggregating the total shows that acute hospital care is outstripping other components - chronic, psychiatric and primary. Thus, data from this study might give an important insight into likely future health care costs especially in acute units. Lagergren suggests that the only solutions to restrict rising costs are to structurally redesign the health system (reduction in hospital beds, day-surgery, improved co-ordination between health authorities and social services), increasing efficiency by managed competition and patient choice, improved systems for management, cost control, monitoring and evaluation and lastly, more accurate assessment of needs, outcomes and quality of care. It can be seen that this project provides support for some of these. The Economist identifies the crux of the problem of clinical audit and outcomes, "if health-care systems are to be made more efficient there must be some way of measuring their input (sick patients) and output (cured ones)". In clinical audit, the system, because it is patient centred, gives an audit trail of what happened to any given patient and when. In the investigation of specific outcomes profiles of similar patients can be investigated to highlight if practice differed significantly between patients. This may provide a valuable learning tool for clinicians. In a study of outcomes of neurological care at the WNC Pickard et al (1988) suggest that neurosurgical procedures appear to offer relatively good value for money. However, they point to the real differences in the cost effectiveness of treatments offered by neurosurgeons, implying that certain procedures are more beneficial than others. They report that monitoring trends in cost effectiveness would be useful in determining whether services are evolving appropriately, but recognise that such monitoring requires greater accuracy and consistency in both the cost and the product of care estimates. This necessitates considerable work in allocating costs to individual patients - which the current system provides. Lastly, they highlight the need to see the cost effectiveness of a new treatment in the context of the overall cost effectiveness of managing a patient to final outcome rather than simply in terms of the immediate burden on the budget. Perhaps the acquisition of cost effectiveness data can be used to demonstrate to purchasers the need to consider total, long term costs when engaging in the contracting process.

A further use of the data is to develop cost drivers for the Unit. While patient throughput is undoubtedly a major consideration, there is evidence (Thorpe, 1988) that some costs are related more to staffed beds than output and it may be that the ratio of forecast to actual admissions is more important than actual admissions. Thorpe finds that cost differences are more related to teaching activities than to any other cause, while case-mix, wage-rates and service intensity are also significant. Complexity and length of stay directly influence costs while specialisation does not (Barer, 1982). As discussed the decision to admit is a key cost driver with hospitals showing considerable variation in the incidence of hospitalisation for similar diagnoses (Wennberg et al., 1984). Hence, the activities of individual physicians is of interest. Having activity data on individual patients should allow professional discretion to be highlighted.

Lastly, the WNC has to follow the directives of the NHSME who consider it to be performing well if it is meeting Patients' Charter standards, providing publicly stated evidence of outcomes and meeting financial returns of 6% p.a.. The NHSME recognise that current performance is variable and that information systems are poor. They see the internal market as a means to an end, driven by common sense not ideology and emphasising dialogue between purchasers and providers.

This work has highlighted the effects of the new NHS internal market on one specialism, neurosurgery. It has shown the need for accurate, timely and relevant data to guide the activities of those involved in the contracting process. It has demonstrated a robust, yet inconspicuous, method of data capture and the mechanism by which this might be implemented. It reports the results of the data collection exercise which clearly demonstrate the need to base contracting on resource usage. Finally, it indicates how this data is be used to provide support to clinical and management staff by the provision of a DSS. While previous work has pointed to a lack of alteration in clinician behaviour after the provision of cost data (Wickens et al., 1983), this work has been driven by clinicians who recognise that they must now take resources into account. The data collection system can also be used routinely for planning and control and could easily be adapted for other specialisms since the methodology is readily transferable.

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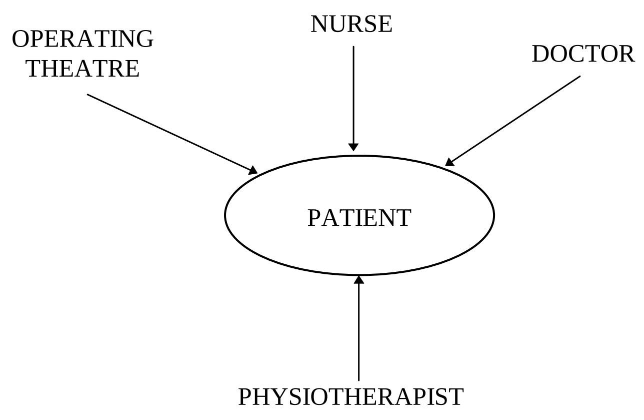
**<u>WESSEX NEUROLOGICAL CENTRE</u>**

**PATIENT CENTERED ACTIVITY STUDY**

<u>DIRECT RESOURCE INPUT</u>




<u>INDIRECT RESOURCE INPUT</u>

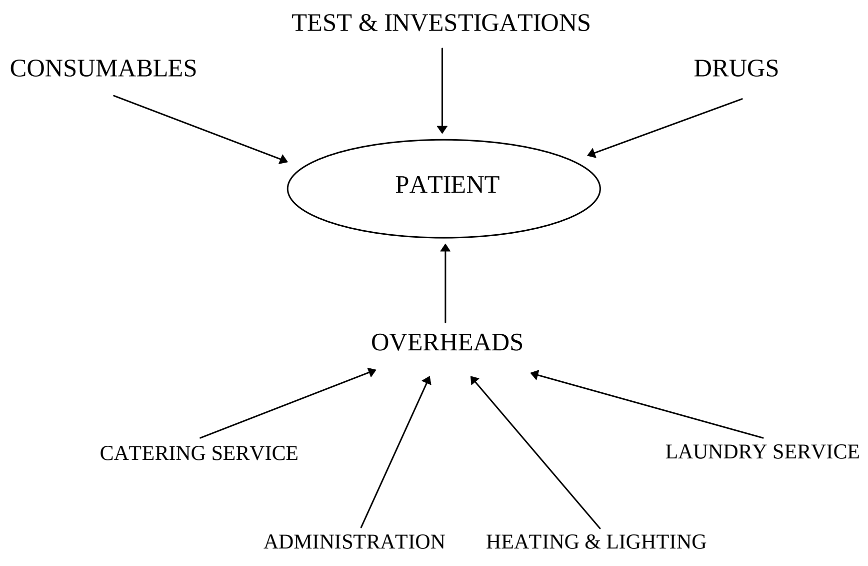



*Figure 1. Patient Centred Data Collection*

## CHRONOLOGICAL PATIENT FLOW

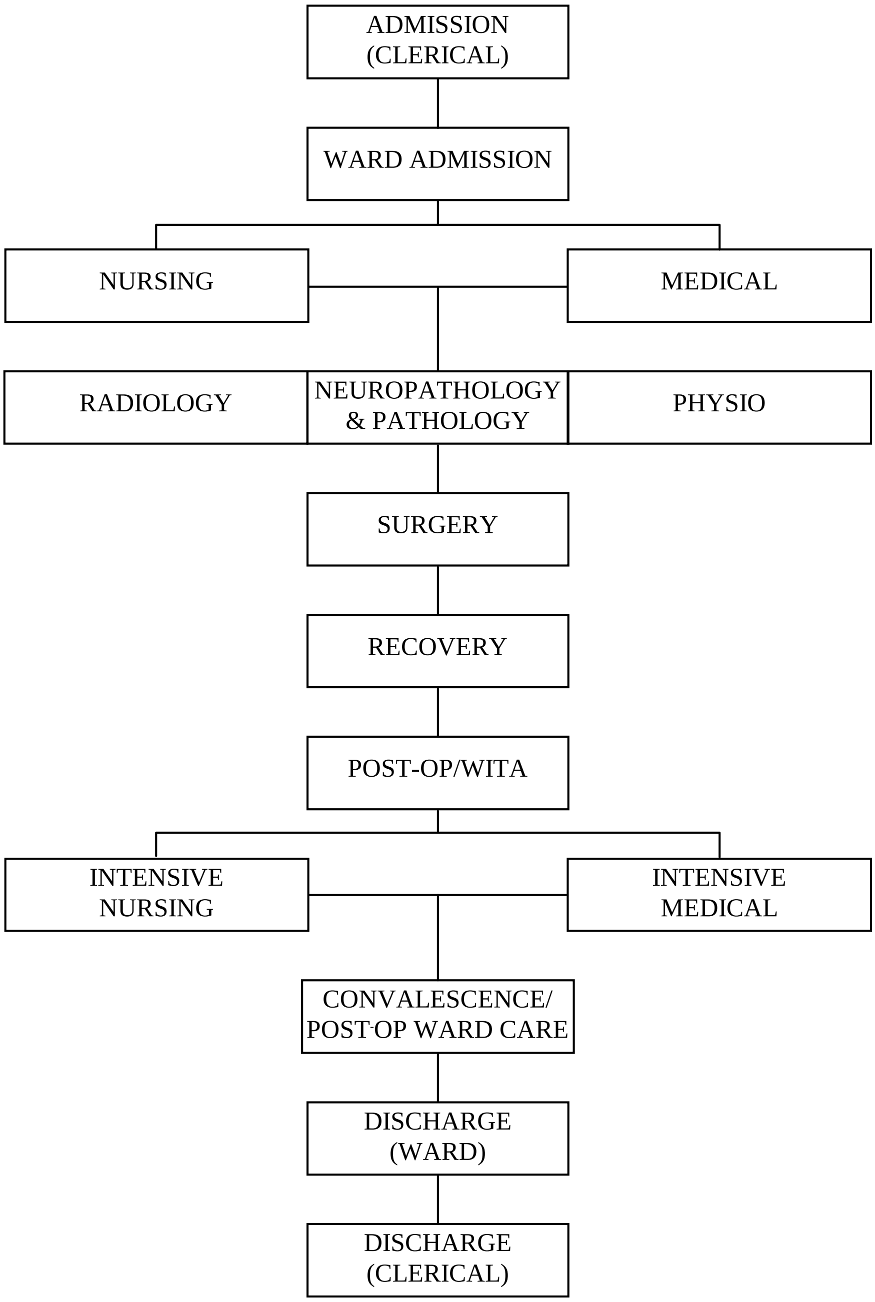



*Figure 2 Chronological Patient Flow*

*Figure 3 Bar Code Examples*

*Figure 4 Data Collection Example*

*Figure 5 Actiivity Count per Patient*

*Figure 6 Activity Duration - Means and Standard Deviations*

*Figure 7 Sample Activity Durations and Frequencies*