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CT Scanning in a District General Hospital

A Primer for Planning & Management

by PAUL KIND AND SUSAN SIMS

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INTRODUCTION

This document is intended as a user-guide for individuals and groups concerned with planning for, and management of a CT scanner in a District General Hospital. It is based on the experience in 25 CT scanner units (see table 1), as elicited from detailed discussions with a wide range of staff, including Radiologists, Radiographers and Health Service Managers, supplemented by questionnaire data.

The guide is designed to meet the requirements of a wide range of potential users. The first 4 sections deal with a series of key tasks - assessing the local case for CT, identifying costs and resource implications, reviewing management and operational aspects of CT, and predicting problems. Although the specific information needs of different hospitals will depend on local circumstances, it is possible to anticipate general management information requirements, and so the fifth section therefore covers the design of systems to assist in the monitoring and evaluating a CT scanner unit.

This guide does not deal with technical questions, or try to evaluate the performance of specific CT installations in any comprehensive way. We have limited ourselves to a number of comments, based on observation of CT scanning in practice, with the purpose of stimulating thought in a field in which there are no simple answers. The analysis of specific data has been kept to a minimum and has, wherever practical, been presented in tables or appendices which can be referred to for supplementary information as the need arises. "Action checklists" are provided at the end of each section and can be photocopied for use as working documents.

Much of the content of this document has been circulated to staff in those CT units and Health Authorities which have assisted with the work of the Project, and their helpful comments on earlier drafts is greatefully acknowledged. Overall direction of this work, which was funded by the DHSS, has been the responsibility of Peter Verow and David Wilkinson (Consultant Radiologists at York District Hospital), Alan Williams (Professor of Economics at York University, and Ken Wright (Senior Research Fellow at the Centre for Health Economics). Where residual deficiencies remain these must, of course, be attributed to us.

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A. ASSESSING THE CASE FOR CT

The following section covers a number of themes which should be considered in the course of establishing a case for a local CT scanner. For the purposes of this document they are presented independently although in practice they interact to a greater or lesser extent. Access to existing CT scanner facilities, for example, will influence the volume and case mix of patient referrals. Clinical demand too, will be affected by the experience of using such facilities. Indeed the very process of investigating the case for CT may itself have an impact on the wider formation of policy and the development of radiological services within a Health Authority.

The installation of a CT scanner will have consequences for the hospital in which it is located, for other hospitals in the vicinity and for specialist centres in the Region. Its impact will be evident within the X-Ray Department itself.

The need for a local CT scanner may be articulated in terms of a number of factors, each of which needs careful consideration. Foremost amongst them are likely to be the demands of Radiologists, the demands from Clinicians, and the location of existing scanners. It is therefore each of these that we first consider in more detail.

1. Radiological demand factors

1.1 Consultant Radiologist opinion

Perhaps the most important question to be settled, at least initially, is the attitude of the local Radiologists. It should not be assumed that the prospect of a local CT scanner will be universally welcomed. There may be serious doubts about the need for such a facility, given the size of the hospital, its proximity to other specialist centres, and the age and professional interests of the Radiologists currently in post. There may be concern too, about the desirability of diverting time and effort into acquiring a CT scanner. This may be a particular problem if the improvement of other aspects of the radiology services are considered to be a higher priority in the competition for scarce resources.

It has been found to be advantageous to ensure that a Consultant Radiologist is involved from the outset in all activities associated with the planning and resourcing of a CT scanner, especially where the original impetus for the acquisition of the scanner comes from outside the X-Ray Department, for example from Consultants in other specialties or from public appeals.

1.2 CT and District radiology services

A development plan for local radiology services should already be inexistence. The acquisition of a CT scanner may or may not be a part of that plan, in which some form of ranking of priorities will be implicit, if not explicit. It will be important to assess the impact of installing of

CT scanner upon the overall plan, not least on other developments which may have consequently to be postponed, or even deferred indefinitely. This may prove particularly awkward if the scanner is being purchased out of the proceeds of a public appeal since it may nevertheless require the diversion of some NHS resources for its operation and maintenance. The effects of by-passing the development plan should be carefully evaluated.

1.3 CT and Regional policy

Where a CT scanner is installed in a District Hospital it is not only the local population which is affected. The entire patient referral network for CT in that area will be fundamentally changed and this may have important consequences for other hospitals which already have their own scanner, and for hospital where CT is planned as a future development. The provision of CT facilities in a hospital will virtually extinguish the flow of patients referred to other non-specialist centres. Hospitals which had provided a supra-District service may now find themselves with spare scanning capacity which will persist for some. The increasing demands for CT in District Hospitals makes it imperative that individual local initiatives are co-ordinated. This can be more easily achieved if a well constructed Regional policy is in place. It is clear that some Authorities are only now attending to this task.

Although the acquisition of a CT scanner may make no immediate demands on Regional resources this position will not hold indefinitely. The serviceable life of a scanner is likely to be of the order of 8-10 years (although it may become technically obsolescent before this). The replacement of the scanner may then well become a matter of concern for the

Regional Health Authority. It will be difficult to change service provision once patterns of clinical practice have adapted to its existence.

1.4 Replacing existing investigations

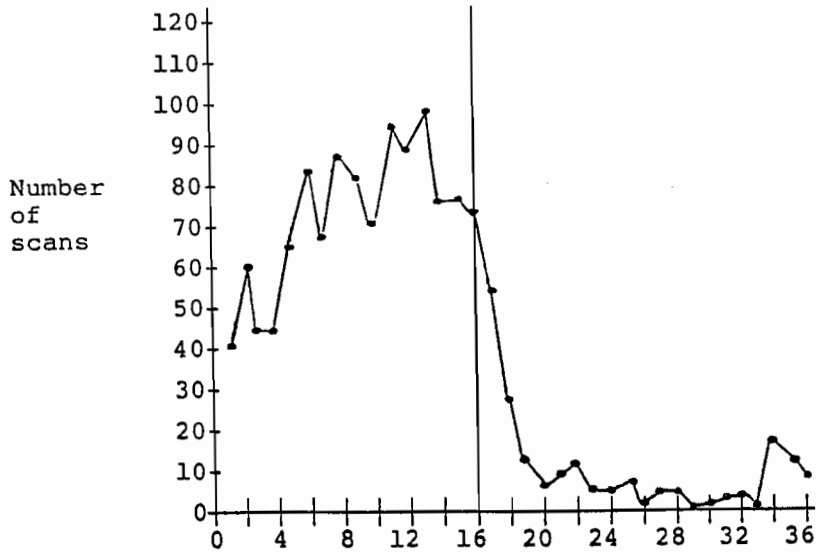
Although CT has successfully displaced a range of less efficient procedures it is difficult to anticipate the precise way in which Radiologists will actually use CT. When a patient is referred to the X-Ray Department for examination the Radiologist can, and some would argue should, recommend an alternative if in his opinion the diagnostic information being sought could be gained using a different procedure. Such a practice will depend on the relationship between Consultant colleagues and it is not easy to predict how the arrival of CT will affect this. The appointment of new Consultants may also result in changes in referral practice. In one large District Hospital the local availability of CT resulted in an immediate 50% fall in the number of carotid angiograms but this trend has now been reversed. No effect had been noted on the rate of renal angiography. Chest tomograms have been almost totally replaced by CT.

In a second hospital an exercise by Consultant Orthopaedic Surgeons and Radiologists in which the diagnostic usefulness of CT was jointly evaluated has led to the gradual phasing out of radiculography in favour of CT scanning. Radiculograms are now seldom requested as first-line investigations of patients with low back pain. This type of joint evaluation can be extended once initial experience of CT has been gained. Where Radiologists have more specialised interested there may be greater scope for changing local custom and practice.

CT scanning in many non-teaching hospitals is predominantly used for investigations of traumatic head injuries and intracranial disease. On average 50% of CT referrals in the surveyed hospitals were for brain scans. Patients with intracranial disease are usually no longer sent for isotope brain scans (IBS) and this can lead to a dramatic reduction of such investigations. The pattern of patient referrals for IBS over the past 6 years in the Department of Radiology at York is shown in Figure 1. A similar experience was noted in another hospital which had seen a 10-fold reduction in the number of isotope brain scans following the installation of their CT scanner.

The Nuclear Medicine capacity which is released as a result of this change in referral practice can be taken up by encouraging the examination of other types of patient, say the elderly confused, for whom IBS may provide an adequate level of diagnostic information.

Figure 1 : Isotope brain scans



ACTION CHECKLIST : ASSESSING THE CASE FOR CT

a. Do Radiologists want a CT scanner?

b. What place does CT have in any development plan for local radiology services?

c. Does the planned scanner acquisition conform to any Regional CT policy?

d. How would a local CT facility affect existing units in other hospitals?

e. Will CT replace existing forms of examination?

f. What impact will CT have on the demand for other related services in the hospital, e.g. Nuclear Medicine?

2. Clinical Demand

2.1 Existing demand

Where there is no local scanner, patients are usually referred outside the District for their CT examination. Information on such cases of the type of scan requested and the referring Consultant, is unlikely to be routinely collected. The practice in some hospitals is to channel such referrals through the local X-Ray Department, or through a designated Consultant Radiologist, but even so the details of each referral may not always be recorded. Where this sort of arrangement is not the usual practice, a temporary collaborative arrangement between Radiologists and their Consultant colleagues might ensure that these data were collected so as to build up a picture of existing demand patterns.

Detailed examination of the records held by neighbouring CT scanner units may reveal the local patients, their referring Consultant/specialty, basic clinical details and the type of scan which was carried out but it has proved difficult in practice to trace patients who have been admitted to some other hospital with CT, under the care of a Consultant in that hospital. Identifying existing referrals to neighbouring CT scanners may be difficult to achieve if (i) responsibility for patient care is transferred to Consultants outside the District or (ii) information systems do not routinely capture the relevant data items.

As a last resort local clinicians could be surveyed directly - each one making their own estimates of existing CT referrals.

2.2 Future demand

Predicting future levels of demand is always difficult, but could be achieved by asking Consultants to estimate their likely referral rates, given their knowledge of casemix and preferred diagnostic pathways. The results of such a survey conducted immediately prior to the installation of the York scanner are compared in Table 2 with the current levels of patient referral.

The General Physicians had estimated their probable usage of in-house CT scanner at a relatively modest level below 10% of the total estimated throughput. In the event, actual referrals from this source were nearly 5 times higher than anticipated. Estimates for many specialties proved to be fairly accurate, although the case mix at any one time may be changing as local interests develop. Gynaecological referrals, for example, are increasing at the present time as pelvimetry becomes more frequently requested.

The number of acute, in-patient referrals can be expected to rise as Consultants become less constrained in the type of case for which CT can be requested. Just under half the CT scans in the surveyed hospitals were perfomed on in-patients. Patients presently referred elsewhere can now be scanned locally. The overall growth in numbers of patients can vary enormously but may be quite significant in the first 1-2 years following the CT scanner's arrival (Table 3).

The availability of a CT scanner in the local District Hospital can act as a stimulus to clinicians, both inside and outside the NHS, to refer

their patients for examination. The level of demand from such sources is difficult to estimate and will fluctuate as the personal referral network changes, perhaps as a result of new scanner facilities becoming elsewhere. Three years after the York scanner came into service some 10% of patients were referred from outside the District, including an estimated 3% who were private referrals.

2.3 Operational case mix

The potential contribution of CT to patient management and treatment should be regularly assessed with judicious reference to the current literature. New uses for CT will often emerge from the experience of specialist units where large series of patients have been examined. Radiologists who are asked to replicate such an investigation may need to have had a requisite degree of previous expertise. Contact with colleagues in the same specialty in other hospitals should be encouraged so as to gain first-hand experience of practical uses of CT scanning.

The pattern of demand for CT scans, as indicated by the case mix of units which were surveyed, is given in Tables 4 and 5. The majority of CT units record a predominance of brain scans, closely linked to neurology and neurosurgery where these specialties are present. Two CT scanners in hospitals with specialist radiotherapy units recorded a majority of body scans. Where these specialties are absent then physicians provide the majority of referrals.

A more detailed breakdown of scan types for York District Hospital is given in Figure 2. In none of the surveyed hospitals did orthopaedic

referrals reach the level of 25% of all scans which is found at York; surgical referrals accounted for at least 12% of CT scans in most hospitals.

Figure 2 : Types of CT Scan Carried out at York District Hospital

	Percentage
Abdomen	10
Brain	47
Lumbar spine	23
Kidneys	2
Liver	3
Pancreas	3
Pelvis	2
Sinuses	2
Thorax	2
Others	6

ACTION CHECKLIST : CLINICAL DEMAND FACTORS

a. What type of patients are currently referred for CT?

b. What type of cases might, but cannot currently, be referred for CT?

c. What changes in diagnostic procedures might result from the provision of a local CT scanner?

d. What demand might there be from clinicians outside the hospital for access to the scanner?

3. Existing Scanner Location

Access to CT scanners in neighbouring hospitals may be influenced by factors which effectively limit the Consultants' capacity to refer their patients. The single most telling factor may be the physical distance between the referral source and the scanner. It may not practical to consider transporting some types of case, for example the acutely ill patient, who could be exposed to an unacceptable degree of risk or discomfort. The potential value of a scanner is compromised under such circumstances.

The problem of patient transport should not be underestimated. In-patients invariably require nurse escorts who may have to be detached from their normal duties for the entire day. In 1984, patients referred to the York scanner from outside its own immediate catchment area, were required, on average, to make a round trip of 84 miles (see Figure 3). Where lengthy ambulance journeys are involved the crew may have to travel outside their normal operating area and must then wait for the patient before making the return journey. Since road conditions are not always predictable the punctuality of patients arriving at distant CT units cannot be assured. This can lead to problems for the CT Radiographers who have to cope with the disruption of their scheduled lists. A patient's late arrival cannot always be compensated for by bringing forward other patients' examinations. If the transported patients require preparation for their CT scan then it would be advisable to ensure that a morning appointment is arranged since some time may be needed to allow contrast to be properly administered and to take effect.

ACTION CHECKLIST : LOCATION

a. What is the current distribution and accessibility of the nearest existing CT scanners?

b. What are the logistics of transporting patients between local hospitals and the nearest CT scanners?

c. Who provides the transport, and what level of medical/nursing support is required for patients during transport?

d. Are there implications for patient selection when referring to nearby CT units?

4. Benefits for the Patient

There are a number of patient benefits which are sometimes claimed for CT. These will not apply in all circumstances and the scale of any benefit has to be weighed carefully, both in health terms and in terms of resources.

a. Improved access - a local facility will avoid the need for transport to hospitals outside the area with consequent reduction in inconvenience for the patients and their families.

b. More patients can be examined on an out-patient basis.

c. Patients avoid invasive procedures some of which are associated with a degree of risk (although the use of contrast media for scanning means that CT procedures themselves are not always non-invasive).

d. More patients can be examined - selection criteria may be relaxed; acute patients who perhaps could not have tolerated a lengthy ambulance journey can now be examined locally; less urgent cases can be examined at an earlier stage in their illness.

e. Improved levels of confidence - patients who are examined via CT may feel more certain about any diagnostic result - even a negative CT scan may be reassuring for the patient.

f. Diagnosis is made more quickly and patient uncertainty is consequently reduced. This can be important where patients see the CT examination as the start of the treatment process.

The rate of change in clinical practice following the introduction of CT may be slow and consequent patient benefits may be only gradually realised. The individual Consultant's learning curve may dictate the pace at which CT replaces existing procedures and this may mean patients continue to be examined using techniques which would otherwise be more speedily replaced. In one instance the use of an existing, conventional procedure has had to be continued so as to provide practical experience for training purposes.

ACTION CHECKLIST : PATIENT BENEFITS

a. What patient benefits are relevant in local circumstances?

b. Can these be expressed in terms of NHS resources?

c. What is the scale of any resource implications?

d. Can non-resource benefits be quantified in any way?

B. IDENTIFYING COSTS AND RESOURCES

1. Setting-up Costs

The capital costs of providing accommodation for the scanner, acquiring and installing the equipment may not easily be established. In the case of one CT unit, neither the Fund nor the local Health Authority could supply information on these costs. Gaining access to data on capital costs may be difficult for Authorities where CT has already been running for a number of years. The personnel concerned with the planning and acquisition of the scanner have often changed their responsibilities within the Authority and are no longer in a position to locate the relevant files. The purchase price of the CT scanner itself is not always separately itemised.

1.1 Accommodation

It may be possible to provides the physical space required to accommodate a CT unit within existing buildings. This could involve the adaptation of rooms and will almost certainly necessitate the strengthening of the floor on which the scanner gantry has to stand. Sufficient space will be required to house the scanner itself as well as its associated high voltage equipment, computer control gear and viewing console. CT scanners have been housed in accommodation of varying sizes ranging from 60 to 300 square metres, depending upon staffing levels, availability of space, proximity to main X-Ray Department, age of hospital and type of scanner. In some hospitals the CT service engineer is also provided with a small storeroom.

The proximity of the CT unit to the main X-Ray Department is an important consideration. If there is to be common staffing of CT then the unit should be as close to the main Department as possible, and preferably housed within it. Siting the CT unit in this way should also ensure that existing darkroom and film processing facilities can also be shared. Half the surveyed CT units were accommodated in the main Department (see Table 6).

Where the accommodation for a CT scanner has been purpose-built the opportunity has sometimes been taken to provide a comprehensive imaging suite in which Nuclear Medicine and Ultrasound are also housed. Where resources permit, such a unit may have its own patient reception and waiting areas, staff room and toilets, in addition to the space required for the various imaging systems.

There will be resource costs in providing accommodation by either route and these will include the costs of design, construction, laying in services and fitting-out.

1.2 Equipment

The specification of a suitable CT scanner configuration is a technical matter for which expert advice is available. Where Radiologists have no prior background in CT it will be particularly important to ensure the widest possible contact with existing users, preferably those with a comparable case mix and in hospitals with a similar complement of specialties.

The location of the CT scanner within the hospital may mean that a separate film processing unit has to be provided. A remote viewing console should be considered an essential feature of the proposed development. Radiotherapy treatment planning may require separate specialist equipment.

A not uncommon phenomenon, especially where a scanner is bought using Appeal funds, is the offer of a fixed period of pre-paid maintenance in with the purchase price. Given the levels of reliability in some systems it will be advisable to evaluate the risks and advantages of such a scheme carefully.

1.3 Staff recruitment and training

CT will be a new imaging technique for many Radiologists and a decision may be needed about the requisite level of expertise in staff. Any new staff appointments should be made as soon as possible so that they are able to contribute fully to the process of installing and commissioning the machine. The costs of these staff changes may arise before the scanner is actually acquired.

Key personnel may need to be detached from their usual duties for significant periods of time, for example during pre-purchase visits to existing CT sites or to the manufacturer's plant.

1.4 Total setting-up costs

Table 9 summarises the capital costs of CT scanner units in 8 of the surveyed hospitals. The costs for accommodation range from £40,000-

£205,000, the average being £98,000. Equipment costs (including the scanner and any relevant peripheral units such as magnetic tape drives, or other mass-storage devices, remote viewing consoles and air-conditioning units) were between £67,m000 and £81,000.

The total capital costs on average were £0.5 million. Where funds are raised through public subscription Regional or Local Authorities often made a donation of the order £100,000. Control of any residual balances following the close of the Scanner Appeal can be a matter of dispute between the Health Authority and the Scanner Trustees.

ACTION CHECKLIST : SETTING-UP COSTS

a. How is the necessary physical accommodation to be made available?

b. Are there any important operating consequences following from its proposed location?

c. What are the basic equipment costs?

d. Is additional equipment required and if so, what are its costs?

e. Are there competent staff who can selected the CT equipment?

f. What are the costs of recruiting experienced radiographic staff and of training existing staff?

2. Costs of Operating the Scanner

Where a scanner has been purchased by public subscription then the Fund's trustees may agree to meet all or part of the revenue consequences, either indefinitely or for a limited transitional period. The Fund might, for example, only cover the costs of non-staff items, such as the X-Ray tube replacement or maintenance contract. In a number of instances the Fund assumed responsibility for the costs of employing a Consultant Radiologist. Where there are residual balances in a scanner Appeal Fund then these can be usefully retained to cover future low-level upgrades of the scanner system. As a general guide to the costs of operating a CT scanner unit, the costs for the scanner at York District Hospital are set out in Appendix 1.

2.1 Staffing the scanner

Staff costs are likely to be the single largest element of the costs of running a CT service. These costs will not only include those of radiographic, medical and nursing staff directly concerned with the CT scanner, but also those of staff who are only intermittently involved, such as nurse escorts for in-patients coming down from the wards, anaesthetists who may sometimes be required to sedate a patient, porters and ambulance staff who are involved in the movement of the patient. Some staff such as secretaries, porters and nurses may share their activities between CT and the main X-Ray Department

Where the CT scanner shares existing staff with the main X-Ray Department then some form of apportionment of costs will be necessary. The

costs of porters, X-Ray nurses and support staff could be taken from the ratio of patient examinations in the CT unit to the total for the Department as a whole. Where Radiologists or Radiographers are concerned then Radiographic work units may be a better basis for such apportionment.

There was considerable variation in the levels of staffing in the CT units which were surveyed. A Senior Radiographer was invariably in post with responsibility for the day to day running of the scanner and an additional complement of 2 radiographic staff was found in 11 of the units. It was considered impractical to operate a scanner with less than 2 members of staff in attendance. In some units the number of staff directly involved with the patient at the time of a scan was as high as 5. Staffing levels in the surveyed hospitals are given in Table 7.

The level of Radiologists' staffing costs will depend on their approach to the management of the CT scan. Radiologists who engage in multi-tasking should only incur a fraction of their salary costs. The actual proportion of their time, and hence costs, can be determined by observing their activities on a normal working day. A small group of Consultants who were asked to specify the percentage of their time devoted to CT scanning, including the preparation of reports, estimated that this was between 30% and 50% on each session. Where Radiologists operate a dedicated management policy with respect to CT scanning it will of course be necessary to include the full costs of these staff. It was often pointed out that Radiographers performed some of the administrative tasks which could be better delegated to clerical and secretarial staff, although formal whole-time appointment of such support staff was not commonplace.

The costs of operating on out-of-hours service should be the subject of specific study. There will be cost implications as far as Radiographers are concerned and some consideration should be given to the number of competent staff able to support such a service. Staff may need transport in order to attend (following a call out) and Radiologists will be entitled to claim travel costs.

It is rarely the case that other support staff are wholly concerned with the provision of the CT scanner. Porters, X-Ray nurses, medical records and other clerical staff are typically assigned to the main X-Ray Department, rather than to a CT unit. This practice may differ where the scanner is part of a neurosurgical or radiotherapy facility. Budget holders may well be located in other Departments. In costing the CT scanner service it will be necessary to estimate for these staff, the balance between their general duties and activities specific to the CT unit.

Staffing accounted for 44% of the total revenue costs of CT scanning in the surveyed hospitals. Radiologists' salaries generated half of this figure. Proportions were highest in hospitals which has only recently acquired their CT scanners. The average staff costs in the surveyed hospitals was £53,800.

2.2 Consumables

The costs of consumables used directly as a result of providing the CT scanner facility included the costs of replacement of X-Ray tubes, film and processing chemicals, and contrast media. The failure rate of X-ray tubes

is a function of frequency and intensity of use and appears to be between 1 per 12-18 months.

A major element in the cost of consumable items is likely to be the replacement of the scanner's X-Ray tube. There can be problems in estimating the cost of this item when the X-Ray tube is imported and its dollar price is subject to variations in exchange rate. The cost of the most recent replacemen at York was nearly £20,000. The number of exposures for which the X-Ray tube is guaranteed varies from machine to machine and there can be changes to the technical specification which extend the effective life of the tube. In the budget for the York scanner it is assumed that the tube will need to be replaced once very 2 years on average.

The electrical power consumed by the scanner, by its associated hardware and by the air-conditioning of the environment, is a matter for specialist measurement. In the case of the York scanner an annual rate of some 125,000 units was estimated, based on theoretical consumption levels.

The quantity of film used will depend upon the volume and mix of patients referred to the CT unit. Where the numbers and types of scan, and the film format, are all known, then the total volume of film required can be estimated. Manufacturers operate their own specific discount scheme for NHS Authorities and the actual cost of film can be easily obtained. It may not be possible to accurately estimate the cost of processing this film if darkroom equipment is shared and chemicals are replenished by the main Department.

The costs of contrast media depend on the requirements of the Radiologists and ther can be huge variation in practice. Little use is made of contrast preparations in some CT units. On average 48% of brain scans required i.v. contrast; 37% of patients were given i.v. contrast prior to an abdominal scan (see Table 8). Where protocols do specify contrast media these are sometimes quite complicated, involving 2 or 3 modes of administration (oral/rectal/i.v.). Other consumable items, such as drugs, needles and syringes should also be included. The average cost of consumables in the survey was £30,220 (24% of the total revenue costs).

2.3 Maintenance costs

There are, broadly speaking, two approaches to the problem of maintaining the CT scanner and its hardware. The manufacturers may have their own trained personnel who will provide engineering support under a preventive maintenance agreement. Alternatively, the hospital may use its own technicians to provide first-line cover and only use the manufacturer's engineers for major problems. Some manufacturers are prepared to offer an in-house service for an extra 10%-15% of the standard contract, or to reduce their maintenance premium if first-line support is provided by the customer. Different experiences have been reported in the quality of manufacturers' field service. Response time to call-out varies according to the proximity of the engineering service centre, and this may be subject to change by the manufacturer. Slow response to reported scanner malfunctions can result in the loss of CT sessions and delays in investigations which are costly to patients and the health service. CT units recorded the loss of 1 session per month on average through unplanned downtime.

It will be necessary to negotiate separate agreements with the suppliers of any ancillary equipment that is not part of the original configuration. The use of non-standard equipment or additional hardware which is not approved by the scanner's manufacturer can adversely affect the terms of any maintenance agreement. Additional non-contract maintenance items, such as air-conditioning failure, may also occur from time to time.

The average cost of maintenance was £33,500, 28% of the total revenue costs. Other indirect costs associated with heating, domestic cleaning, maintenance and rates account for a further average £4,700.

2.4 Total revenue costs

The average figure for revenue costs for all 11 hospitals is £122,260 which is the same order of magnitude as the cost of the York scanner. Revenue costs for the surveyed CT scanners are given in Table 10. The average revenue cost per patient scanned is £92.42, slightly lower than the costs charged to private patients who are scanned in NHS hospitals.

ACTION CHECKLIST : OPERATING COSTS

a. What proportion of Radiologists' time is concerned with CT scanning and associated activities?

b. What is whole-time equivalent establishment of Radiographers?

c. How should the costs of nursing, portering and other shared support staff be allocated?

d. What are the unit costs of consumables, including electricity?

e. What are the costs of maintenance, including non-contract items?

C. MANAGEMENT AND OPERATIONAL ISSUES

1. Availability

The availability of staffed CT sessions will depend upon many factors. In most CT units the service operates for 10 sessions per week, but in 2 cases where the costs are currently borne by a Trust Fund rather than the Health Authority, the number of sessions is only 5 or 6 per week. Running a 10-session week, where there are few referrals (as in the early stages of developing the service), may result in vast overcapacity, with only 1 or 2 patients being scanned per day. Once the service is fully established, however, it may be necessary to seek ways of extending the availability to meet increasing levels of demand. The length of the scanner day could be modified by staggering the start time of CT Radiographers and running the service beyond the usual 9.00 a.m. - 5.00 p.m. One hospital with neurosurgery offers 3 evening sessions per week which are separately funded by the scanner Appeal Fund. The number of weekly sessions could also be increased by running the scanner on Saturday mornings. Within the normal operating schedule it should be possible to increase availability by scanning patients over the lunchtime, if suitable arrangements are made for radiographic cover.

The question of an out-of-hours service may have to be tackled independently. Financial constraint in some hospitals with CT ruled out the feasibility of offering such a service, even where it was considered desirable by the local Radiologists. In one hospital the out-of-hours service is operated voluntary by Radiographers and some concern has been expressed that such an arrangement places unfair pressure on staff. If an out-of-hours service is to be run, it is argued that it should be on a

properly funded basis. Not all Radiologists with whom this was discussed considered that it was necessary to offer a specialised out-of-hours CT service, especially if all Radiographers in the main X-Ray Department had been trained to a minimum level which would allow them to perform a CT brain scan in an emergency. In 12 hospitals where an out-of-hours service is supported, there was a widely varying uptake ranging from 4 to 70 scans over a 3 month period, the average being 2 per week.

ACTION CHECKLIST : AVAILABILITY

a. What level of availability is planned for the CT service?

b. How many sessions per week are planned?

c. What is the planned length of the scanner day?

d. Should patients be booked for examinations over the lunchtime, and if so, then what type of patient?

e. is there a need for an out-of-hours service?

2. Access

It may be useful to have an explicit policy on the degree of access to be offered to local clinicians, certainly in the early stages of a developing service. Close collaboration with Consultant colleagues and joint review of difficult cases may be of mutual benefit. The majority of CT units in fact have such a policy and only accept referrals from Consultants, but this policy is often eroded in practice and CT requests which originate with SHOs are usually accepted. In only 2 of the surveyed hospitals were GP referrals accepted.

CT request forms were vetted by Radiologists in most hospitals, the objective being to weed out inappropriate requests or those in which clinical data is significantly incomplete. The rigour with which this quality control task is performed varies enormously. In one hospital a Consultant Radiologist declined to accept requests which did not carry the patients' date of birth. Radiologists do not routinely review patients' notes as part of this vetting process, although some did express the view that this was important in planning the CT scan.

The criteria for accepting a CT request should be agreed in advance with the various referral sources. It will be difficult to modify a system which has broken down or is not being properly operated by Radiologists. One Radiologist has instituted a formal report-back system in which Consultants are obliged to provide information about the value of the CT scan report. Failure to conform to this system may result in delays in processing future requests.

ACTION CHECKLIST : ACCESS

a. What is the appropriate level of access?

b. Should all referrals originate with a Consultant?

c. Should CT requests be vetted by a Consultant Radiologist, if so, then how carefully?

d. How selective should Radiologists be when accepting CT scan requests?

e. What criteria should be used for accepting/rejecting a CT request, and how are these criteria to be established?

3. Management

When arranging visits to hospitals with CT and otherwise collecting survey material for the Project, it was necessary to identify an individual with management responsibility for CT scanning. It was not always clear that such an individual was designated. In some instances a Superintendant Radiographers had overall control of the CT unit - in others a Consultant Radiologist was in charge. The nominated Consultant very often turned out to be the individual with historic links to the initial acquisition of the scanner. Sometimes the Consultant in charge was from a different specialty, such as Radiotherapy. The lines of management responsibility are presumably clear within the hospitals concerned but no clear or uniform pattern is apparent to the outsider.

In the absence of a formal management structure it will be left to the Division, or to peer group influence, to decide upon the extent to which standard protocols should be adopted. Informal exchange between Radiologists of their experience in using the CT scanner is to be expected as a part of normal professional relationships. This can be especially useful where a Radiologist has a particular interest in specific types of referral. The development of such areas of interest can assist in the development of greater degrees of expertise, but may also result in the skewing of referral patterns where one Radiologist becomes the preferred choice of referring Consultant colleagues.

There can be substantial variation in the number and type of scans performed by different Radiologists within a single CT unit. Quality

control and a mechanism for reviewing case-mix and workload problems may also be assisted if some form of management structure is in place.

ACTION CHECKLIST : MANAGEMENT

a. How is the scanner managed on a day to day basis?

b. Should there be a single Consultant with overall responsibility - e.g. the Chair of Division?

c. How far should individual Radiologists be encouraged to adopt standard protocols for specific examinations rather than each Radiologist developing their own set?

d. Should certain Radiologists specialise in CT work?

e. How can quality control of both the images and the reporting of film be achieved - is there a case for peer review?

f. What is a reasonable level of workload for the individual Radiologist?

4. Training

There are differences of opinion, even amongst Radiologists, about the status of CT scanning. Some regard it as a separate, specialised imaging modality - other regard it as "just another X-Ray procedure". It is against this background that the question of training has to be considered. CT may be seen as a new form of imaging which requires new skills in the Radiologist, such as the recognition of normal and pathological conditions, artefacts and physiological processes, as well as an understanding of the relationship between CT and other radiological tests. Similarly, Radiographers may be expected to display new skills in handling complex equipment, developing protocols and in pattern recognition.

Formal pre-delivery training provided by the manufacturer seems to be aimed principally at Radiographers. Varying degrees of prior CT scanning experience amongst Radiographers were found during the Project survey. Some had no prior experience whatsoever, others had in the past been involved with head scanners. Informal visits by Radiologists to established CT units, as observers, seemed to be a useful means of acquiring some first-hand knowledge although this did not always prove to be of value once the new scanner service was actually operating. Installation engineers also played an important informal training role. Formal training by an on-site specialist was typically provided by manufacturers for a period of 2 weeks, after which telephone support could be obtained. There was general agreement that this type of training in the early stages of a developing service was probably adequate to meet the short term needs of Radiographers. Several Radiographers expressed the

view that further periods of training were desirable after some 'hands-on' experience had been gained.

Once a trained Senior CT Radiographer became available then they were usually given the task of supervising the in-house training of all other Radiographers likely to be involved with the CT unit. This in-house training typically lasted for 4 weeks, after which a Radiographer would be considered competent to work without supervision.

Although there was agreement about the need to train Radiographers, there was some divergence of opinion about the form and object of that training, and about the respective roles of the trained Radiographer and the Radiologist.

ACTION CHECKLIST : TRAINING

a. Are special skills required in order to gain the maximum diagnostic value from CT, and if so, then what are these skills?

b. Can these skills be acquired in the course of actually using CT, or should there be more formal training?

c. What type of pre-delivery training is available?

d. What are the opportunities for temporary secondment of staff to other hospitals with CT?

e. Should Radiographers and Radiologists be trained?

f. Is there a role for post-experience courses?

g. Is quality control an important issue, and if so, how could this be achieved, both for Radiologists and for Radiographers?

5. Archiving

CT, unlike conventional imaging systems, offers the Radiologist the opportunity of storing the source material on magnetic disc or tape. The recent advent of CT in District Hospitals has perhaps encouraged Radiologists to take an over-cautious view of the need to retain these image data on multiple recording media, hence archiving of CT scans is a commonplace feature of the Radiographers' daily tasks. The policy of holding on to these duplicate data has been extended in a number of hospitals so that a second set of CT films are routinely prepared. One set are filed in the usual X-Ray record system; the second set may be held in a separate CT archive, in case the first set are damaged or lost. Where magnetic media are used to hold archived scans there can be problems of storage. The volume of material which is accumulated can soon occupy a signficant physical space. If these tapes or discs are rotated through the archive then this form of back-up to the CT service will only ensure the retention of image data for a limited duration (3-6 months on average). One hospital retains only selected slices of abnormal scans, but holds these for a 5-year period. A second hospital retains its records only until the images have been finally reported.

It must be seriously questioned whether such an archiving system is providing a useful function, epecially when the process of recording the data is itself time-consuming, as is the case with magnetic tape (estimates for York are 5 minutes for a brain scan, 15 minutes for an abdomen). The number of occasions that archived scans are actually accessed must be virtually nil, given a CT unit in which normal precautions are exercised in the filing and distribution of films. No clear guidance on the archiving

of CT images has been located, but at least one Consultant Radiologist felt that serious medico-legal issues were involved and he would continue to hold duplicate films until formally instructed otherwise.

ACTION CHECKLIST : ARCHIVES

a. Is archiving required for all CT scans?

b. If scans are to be selectively archived then what criteria will be exercised to choose them?

c. Who is to be responsible for deciding to archive a particular scan?

d. What recording medium will be used in the archive?

e. If magnetic storage media are used then what are the physical housing constraints?

f. What will be the period of rotation of archived material?

D. PREDICTING PROBLEMS

1. Management of CT Sessions

The Royal College of Radiologists' updated report on the provision of CT services (1986) describes the responsibility of the diagnostic radiologist as being concerned with

> ... the total conduct of the examination, involving its planning including clinical planning, detailed supervision, interpretation and interrogation of the considerable quantity of derived data. The Radiologist must define the area of interest in the tomographic sections to be taken on individual patients. He must see the tomograms on the monitor as they are processed, determine the necessity for further sections with or without contrast medium enhancement, make the intravenous injection if necessary, supervise the recording of the pictures to ensure optimal information and also interpret the results. (p.2 of the Report)

Approaches to the management of CT scanning sessions differ from unit to unit and sometimes between Radiologists in a single unit. At one end of the range Radiologists remain present throughout the patient's examination, supervising the use of contrast, checking on progress and making any necessary changes, perhaps terminating the scan once sufficient diagnostic information has been generated. This form of so-called 'dedicated' management contrasts markedly with the approach adopted by other Radiologists in which standard protocols are enacted by Radiographers to whom the responsibility for supervising the scan is effectively delegated.

Occasionally the Radiologist will not only be located outside the CT unit, he may in fact be away from the hospital entirely. Films for patients may then be reported many hours after the patient has left the scanner unit. Somewhere between these two extremes is located a compromise solution, 'multi-tasking', in which the Radiologist is available nearby for practical assistance and supervision of the CT scan, but is actually engaged in other duties, for example reporting X-Ray films in his office. Radiographers have reported difficulties sometimes in locating Radiologists in order to know whether a patient can be taken off the scanner table, or in order to administer contrast if required. It has been argued that the use of standard protocols and delegation to Radiographers of the supervisory function prejudges the nature of the diagnostic information which may result from the CT scan. Some Consultants consider that the concept of a dedicated CT session is all well and good in theory, but that pressures from other duties precludes it in reality.

ACTION CHECKLIST : MANAGEMENT

a. What is the role of the Radiologist in the management of the CT scan?

b. Are there facilities for Radiologists who wish to operate dedicated CT sessions?

c. What arrangements are there for contacting Radiologists who operate a 'multi-tasking' system?

d. Should Radiologists see the CT image before the patient leaves the unit?

e. Can the management and supervision of the CT scan be safely delegated to a Radiographer?

2. Training Radiographers

The need for a pool of trained staff will depend upon the type of CT scanning service which is offered. If an out-of-hours scanning is envisaged then any Radiographer may be required to carry out a brain scan in an emergency. The length of time required to train all staff to a reasonable level of competence may easily be underestimated. One hospital had expected that all Radiographers would benefit equally from a training programme which would ensure that a pool of expertise was always available for assignment to the CT unit, and for cover during sickness and absence. Some two years after the scanner's installation it had still proved impossible to achieve this. Pressure of work, both in the main Department and in the CT unit itself, cut down the opportunity for such training.

Not all Radiographers have a natural aptitude for CT and some form of selection process might be thought necessary. It may be prudentinitially to consider selecting only Senior grades for CT training or to implement some form of pre-training assessment.

ACTION CHECKLIST : STAFF TRAINING

a. What is the minimum level of expertise compatible with the needs of a functional CT service?

b. Should Radiographers receive formal training?

c. What types of training schemes are compatible with these considerations?

3. Hardware

Malfunction or inadequate design of the air-conditioning system appears to be the most frequently encountered hardware problem. These problems did not always materialise until the systems were working under the more extreme circumstances. In one case the rupture of a water pipe resulted in damage to the scanner computer console; in a second case the air-conditioning system was inadequate to cope with the accumulated heat output from the CT scanner in a newly-built and self-contained imaging suite. At York a back-up air-condition system was installed so as to compensate for the poor performance of the system which had been originally installed. The moral seems to be that the design of such units should be very carefully specified and that they should be located so as to avoid the loss of scanner hardware or destruction of film or other sensitive material, should the systems fail.

The X-Ray tube will usually be guaranteed for a fixed number of exposures. The parameters of any such guarantees will be specified in the service contract or at the time of any tube replacement. The replacement rate may not be constant so that a variable interval between failures can be expected. A record of the number of exposures might be useful in monitoring the performance of the X-Ray and help to give notice of system impending tube failure. An assessment of the tube's condition can sometimes be made by the service engineer.

The initial specification of the CT scanner may have been made so as to match the scale of funds available for its purchase. One consequence of actually running a CT scanning service can be the realisation that the

performance of the system falls short of the practical requirement. A significant growth in the demand for CT scanning can be anticipated and this may bring operational problems in its wake. The disc storage capacity may limit the volume of image data which can be held. Larger capacity on-line disc storage or faster reconstruction times may be required and these can be expensive. There is a natural temptation to shop around for such additional hardware and to seek alternative suppliers. This may be counter-productive if separate maintenance arrangements have also to be negotiated. Where the scanner is made up from more than one suppliers' products then there is every likelihood of each supplier/manufacturer disclaiming responsibility in the event of a system failure. Arbitration in such circumstances can be a prolonged affair.

ACTION CHECKLIST : HARDWARE

a. Are the air-conditioning units adequately designed and properly sited?

b. What is the guaranteed operational life of the X-Ray tube?

c. Is the X-Ray tube's use being monitored?

d. Do hardware limitations restrict the volume or type of work undertaken in the CT unit?

e. What hardware modifications could be made to assist the day-to-day running of the unit?

4. Software

It is easy to treat the scanner as a 'black box' which produces images and to disregard the role of the computer, both as the processor of the image data and as potentially, the means of capturing relevant information about the patient. There may be automatic upgrading of the systems software, in which case technical improvements will become available at irregular intervals. Some sophisticated systems already have an abundance of post-processing routines, many, perhaps the majority, of which are seldom accessed. It may be possible to release much-needed on-line storage space if such software can be held off-line.

The details of any patient logging systems held on the scanner computer should be well documented. If the system is a standard product the manufacturer may be prepared to release details of the storage format of any disc files, thus rendering them accessible by other information systems. In some cases the source listing of the logging program might be made available for modification, so that it can be tailored to meet local information needs. The possibility of interfacing such systems with other operating the hospitals or Health Authority, should be investigated.

Scanner computer software tends to be system-specific. The extent of any software portability, or upwards compatibility should be explored well before decisions have to be taken about the replacement or upgrading of the existing scanner computer.

ACTION CHECKLIST : SOFTWARE

a. Are source listing available of any patient logging system?

b. Can the standard system be tailored to meet local information needs?

c. Is there software support for this type of activity?

d. How easy will it be to interface the CT computer to other local information processors?

e. What level of portability is there in the existing software?

E. MANAGMENT INFORMATION

There is little or no uniformity in the type of data collected on patients and their CT scans. The administrative structure of the X-Ray Department may dictate both the nature of the information and the manner in which it is collected and stored. Some information is collected with no clear indication of any eventual use. This makes for difficulty in monitoring and evaluating a single CT unit, and for making comparisons between units. Even the basic currencies of the 'patient examinations' and 'radiographic work units' are interpreted differently in different hospitals. In one hospital the percentage of X-Ray Department workload, as measured by radiographic work units, was 5 times higher than the percentage computed on the basis of patient examinations. The number of units given for 3 types of scna is listed in Table 11. There is clearly scope for much creative accounting of CT workload under such circumstances.

Routine collection of data should be geared to management activity - monitoring service provision and demands for development, evaluating current practice and identifying potential initiatives. A suggested standard checklist of data items is given in Figure 4, together with the frequency with which these items are routinely recorded in the CT units which were surveyed. Although the identify of the referring Consultant may be a matter of record, the specialty from which the patient originates is not always obvious. Cross-referral of say, Accident and Emergency and Orthopaedic patients, can produce discrepancies in the assessment of workload.

Example reports on CT usage are also given in Figures 5 and 6. These reports could be generated routinely once the need for regular feed-back

had been established. Such reports might indicate the balance of activity between referring specialties, the size of Radiologists' workload, and the pattern of inward referrals from neighbouring Authorities.

In addition to providing routine management information such systems should be capable of supporting clinical research needs. The patient logging system at York, designed as part of this Project, has enabled Consultants to obtain lists of patients who have been referred for specific CT investigations, as well as providing support for Radiographers who may be asked to provide details of any CT scans carried out on named patients.

Figure 4 : Checklist of Data Items for CT Scans
(Frequency of recording)

Patient name	25
Date of birth	24
Hospital number	9
CT scan number	24
Clinical details on referral	11
Urgency of request (scheduled, emergency, etc.)	5
Date of scan	25
Radiologist	22
Referring Consultant	25
Referring Specialty	2
Source hospital	23
Patient status (in-patient, private, etc.)	25
Ward (if in-patient)	24
Type of scan	25
Details of contrast	25
Number of slices	18
Radiological findings	14

ACTION CHECKLIST : MANAGEMENT INFORMATION

a. What information is required to effectively monitor and evaluate the work of the CT scanner unit?

b. How does the weighting of CT scans (in terms of work units) compared with other hospitals?

c. Is it possible to identify the referral specialty of all in-patients?

d. Are referring Consultants aware of their use of the scanning facility?

CONCLUSION

There seem to be as many different ways of setting up and operating CT scanner units as there are actual facilities. The reasons for this diversity are the varied settings in which the scanner is located, the different obligations undertaken in the initial phase, the varied interests and attitudes of the Radiologists and their clinical colleagues, and the different pressures generated by local management.

Newcomers should beware of uncritical emulation of a one "model", but concentrate instead on a careful analysis of their own likely requirements, and to seek to establish a modus operandi which is flexible enough to adapt to changing pressures, for the common experience seems to be that things can change rapidly, and not very predictably, especially over the first 2 or 3 years, as people come to learn at first hand what their own local service proves to be good and bad at. It is to guide that 'careful analysis' that this booklet has been prepared.

It might be seen as the ground-clearing general prologue which could set the terms of reference to a more detailed local option appraisal, to be conducted preferably by a small mixed team drawn (say) from radiology, a major clinical discipline, community medicine, management finance, possibly with the assistance of an economist with experience of option appraisal, so that all aspects of the proposal can be considered together in a systematic manner.

In preparing these comments we have been greatly assisted, and impressed by the willingness of those running existing CT suites in District Hospital to share their experiences. Most would do something or

other differently if they were starting out afresh. Thus the last piece of gratuitous advise we would give to any potential investor in CT is: go and talk to colleagues in hospital which already have CT, and go through with them any of our points which seem likely to be important to you.

Finally, if there are matters not adequately covered here which turn out to be important in your situation, let us know, for one day we may want to produce a revised and updated second edition as we discover even greater diversity than we have encoutered hitherto.

Table 1 : Non-Teaching District Hospitals with CT Scanners

Hospital	Scanner Type	No of beds	No of Radiologists	No of X-Ray Exams	Specialties R/T	Specialties Neuro Surgery
A	SIEMENS	570	6	88,600		
B	ELSCINT	230	3	50,000		
C	PHILIPS	450	4	55,200		
D	IGE	810	3	4,200	X	
E	TECHNICARE	930	5	66,800	X	
F	TOSHIBA	250	4	48,000		
G	SIEMENS	420	7	26,400		
H	SIEMENS	560	8	79,500		
I	ELSCINT	760	2	83,500		
J	ELSCINT	620	10	40,000		X
K	ELSCINT	600	4	57,200		
L	TECHNICARE	840	4	73,000		
M*	EMI	540	2	66,200		X
n	PHILIPS	845	5	75,100		
o	SIEMENS	550	6	30,500	X	
p	SIEMENS	560	8	75,500		
q	PICKER	780	6	100,000	X	
r	PICKER	240	5	37,600		
s	IGE	530	4	53,000		
t	IGE	510	4	41,000		
u	SIEMENS	180	4	22,200		
v	IGE	650	8	90,000	X	
w	TOSHIBA	820	5	68,000	X	
x	PHILIPS	430	7	81,000	X	
y*	PHILIPS	750		n/a		X

Note

The first 13 hospitals (A-M) were visited during the period October 1985-June 1986. The remaining 12 hospitals (n-y) were surveyed by questionnaire during May and June 1986.

* part of neuro unit

Table 2 : Estimated and Actual Case Mix at York District Hospital

Type of Referral	Pre-Scanner Estimated	First Year Case Mix	1984/85 Case Mix
Orthopaedic	25	20	27
Medical	12	30	29
Surgical	7	8	5
ENT	3	2	4
Opthalmic	*	3	*
Paediatric	5	7	8
Neurological	26	9	2
Psychiatric	8	4	10
Geriatric	1	3	4
Gynaecological	3	1	*
Urological	10	8	*
Other	0	5	11

* - indicates less than 1%

Table 3 : Rate of Growth in CT Scanner Workload in Selected District Hospitals

Hospital	No of Scans Year 1	No of Scans Last Year	No of Years	Growth	% Growth
A	1534	2575	3	1041	68
B	195	336	3	141	72
C	941	-	1		
D	1002	-	0		
E	1151	1844	3	693	60
F	770	-	0		
G	513	1370	4	1087	212
H	1883	-	0		
I	1370	-	0		
J	1478	3251	7	1773	120
K	750	-	0		
L	1196	2007	5	811	68
M	781	2918	6	2137	274

Table 4 : Case Mix in CT Units (Type of Scan)

Hospital	Case Mix in 1st Year			Case Mix Last Year		
	Head	Body	Spine	Head	Body	Spine
A	52	43	4	52	25	18
B	57	43	0	85	15	0
C	41	53	5	35	47	15
D	21	70	1	-	-	-
E	56	43	0	55	40	3
F	47	30	22	-	-	-
G	16	76	8	27	51	22
H	75	17	4	63	27	7
I	62	31	5	59	30	10
J	78	22	0	70	27	2
K	67	31	2	-	-	-
L	59	15	6	51	24	24
M	94	4	2	95	1	4

Table 5 : Case Mix in District Hospitals

Specialty	Surgery	Orthopaed.	Gen. Med.	Paediatric	E.N.T	Geriatric	Psyhiatry	Neurosur.	Neurology	R/T	Other
	(percentage referrals from each specialty)										
Hospital											
A	7	16	35	4	6	-	4	1	8	2	17
B	19	-	59	11	-	4	3	-	-	-	4
C	13	10	41	6	3	2	-	-	-	17	8
D	4	-	13	-	-	-	1	-	-	13	3
E	20	4	46	3	5	2	4	-	-	13	3
F	15	19	29	3	3	5	2	-	-	15	9
H	8	12	26	2	-	5	1	3	27	8	8
I	13	13	35	6	3	3	1	-	10	9	7
J	10	3	31	3	5	4	3	16	11	5	9
K	10	8	42	12	4	14	-	-	-	-	10
L	5	27	29	8	4	4	10	-	2	1	10
o	12	10	35	3	2	7	2	28	1		
p	23	9	46	3	3	3	>1	9	>1		3
q	9	7	15	2	6	5	2	31	1	15	7
t	19	10	36	4	6	10	1			14	
u	15	12	60	3	2	2	1	4			1
v	3	15	8	2	1	2	2	60	5		2
w	23	13	39	3	2	4	1			7	8
Mean percentage referral rate	13	12	35	5	4	5	2				

Table 6 : Physical Location of CT Scanner in Surveyed Hospitals

Hospital	Location of Scanner				
	Main Department	Imaging Suite	Purpose Built	Self Contained	Away from main Department
A	X				
B	X				
C		X		X	
D			X	X	
E				X	
F	X				
G		X			
H				X	
I				X	
J	X				
K		X	X	X	
L	X				
M				X	
n	X				
o				X	
p	X				
q	X				
r				X	
s	X				
t	X				
u	X				
v				X	
w	X				
y				X	

Table 7 : Staffing Levels in Non-Teaching District Hospitals with CT Scanners

Hospital	CT Sessions	No of Radiologists	No of Radio-graphers in CT		No of Nursing Staff	No of Other Staff
			SNR	BAS		
A	10	7	2		1	1.0
B	5	3	2		-	-
C	6	4		1	-	.5
D	10	4	2		-	2.0
E	10	5	3		-	1.0
F	10	4	3		-	-
G	10	8	3		-	1.0
H	10	X	3		1	.5
I	10	3	2		-	-
J	10	6	2	1	1	1.0
K	6	4	2		2	.1
L	10	6	2	1	-	-
M*	9	1				
n	10	5	1		-	-
o	10	4	2		-	1.5
p	10	5	3	1	-	-
q	10	4	2		-	.5
r	12	8	3		-	.5
s	10	4	2		-	-
t	10	3	1		-	-
u	9	7	3		-	-
v	10	4	2		-	-
w	10	5	2		1	.3
x	10	3	2		-	1.0
y*	7	1	7	2	1	5

* part of neuro unit

Table 8 : Percentage of Scans Requiring Intravenous Contrast

Hospital	Brain	Abdomen
A	48	28
B	55	43
C	40	20
D	70	19
E	47	36
F	64	38
G	61	50
H	36	37
I	21	22
J	20	20
K	26	45
L	50	40
M	42	n/a
n	65	17
o	90	50
p	50	80
q	40	10
r	60	2
s	50	40
t	50	80
u	15	10
v	95	40
w	33	50
x	20	50
y	60	50

Table 9 : Capital Costs of CT Scanning in Selected District Hospitals

HOSPITAL	ACCOMMODATION	EQUIPMENT	TOTAL
B	90,450	167,460	257,910
D	205,000	581,000	786,000
E	62,150	617,160	679,310
F	40,000	255,000	295,000
I	46,800	344,000	390,800
K	105,480	386,830	492,310
L	77,670	441,560	519,230
M	159,780	428,220	588,000
AVERAGE COSTS	£98,420	£402,650	£501,070

Table 10 : Revenue Costs for Selected CT Scanners

HOSPITAL	STAFF	CONSUMABLES	MAINTENANCE	OTHER	TOTAL
A	75,470 (44)	63,230 (37)	31,260 (18)	3,100 (1)	17,060
B	17,150 (32)	8,280 (16)	24,460 (46)	3,550 (6)	53,440
D	62,240 (43)	29,330 (20)	44,900 (31)	8,820 (6)	145,290
E	51,000 (40)	29,790 (23)	39,950 (32)	6,320 (5)	127,060
F	53,960 (60)	17,870 (20)	15,000 (17)	3,390 (3)	90,160
G	62,570 (43)	30,550 (21)	46,900 (32)	4,550 (4)	144,570
H	74,800 (48)	41,640 (27)	34,400 (22)	3,670 (3)	154,510
I	41,720 (40)	28,550 (27)	32,500 (31)	2,260 (2)	104,580
K	57,590 (55)	13,470 (13)	27,000 (26)	5,950 (6)	104,010
L	44,210 (36)	38,850 (31)	36,500 (29)	4,490 (4)	124,050
M	51,060 (41)	30,930 (25)	36,000 (29)	6,120 (5)	124,110
AVERAGE % OF TOTAL REVENUE COST	44%	24%	28%	4%	
AVERAGE COSTS	£53,800	£30,200	£33,500	£4,700	£122,200

Table 11 : Number of Radiographic Work Units for 3 Types of CT Scan

Hospital	Brain	Abdomen	Spine
A	73	68	70
C	40[1]	60[1]	60
D	90[2]	90	90
E	73	68	70
F	60[3]	60	60
G	90[2]	90	90
I	80	80	80
L	180	180[4]	90

1 + 20 units for contrast
2 + 90 units for contrast
3 + 60 units for contrast
4 + 90 units for i/v contrast

Figure 3 : Average Distance of Patients Referred from Outside York Health Authority

(42 mile catchment area)

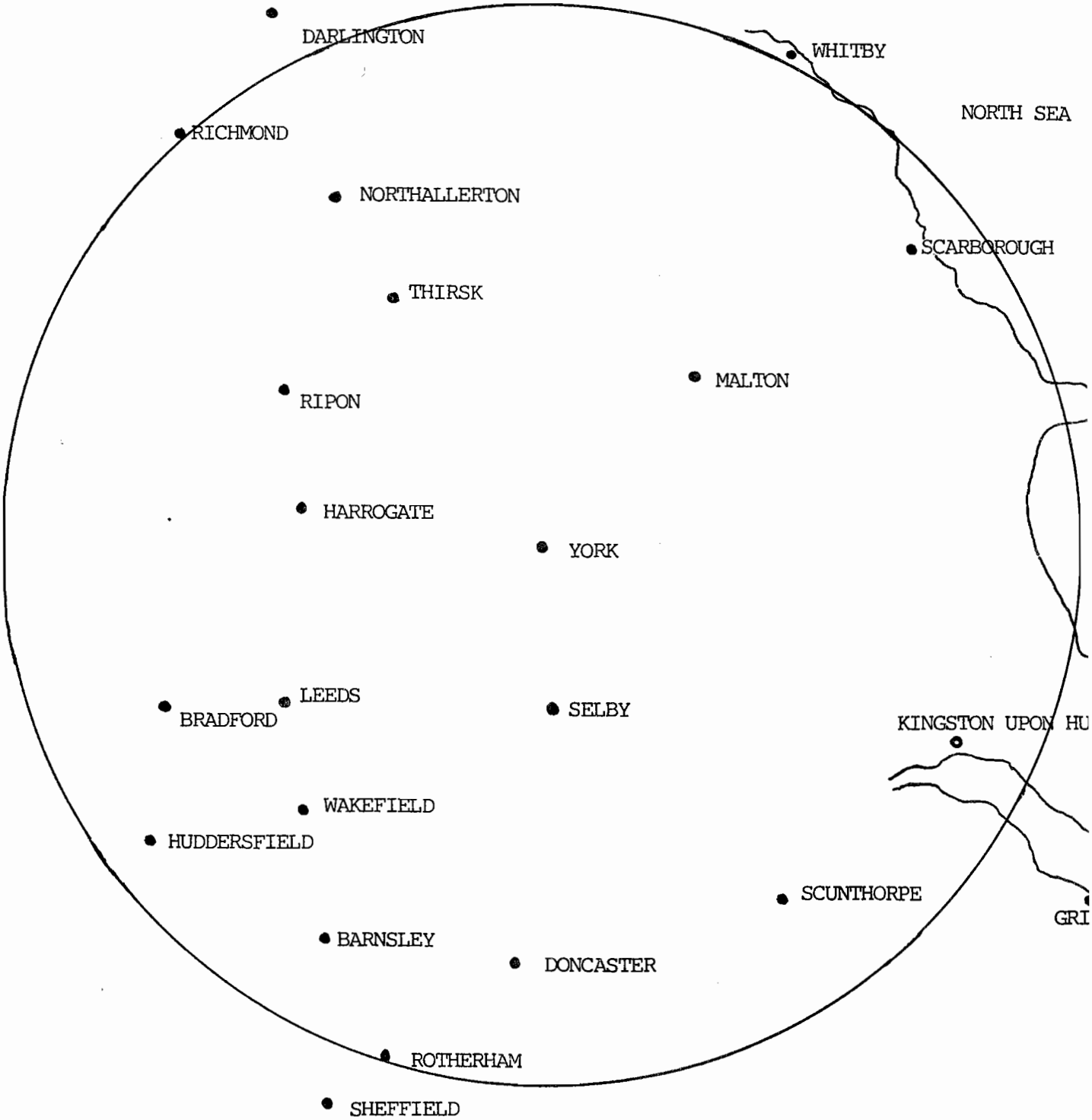
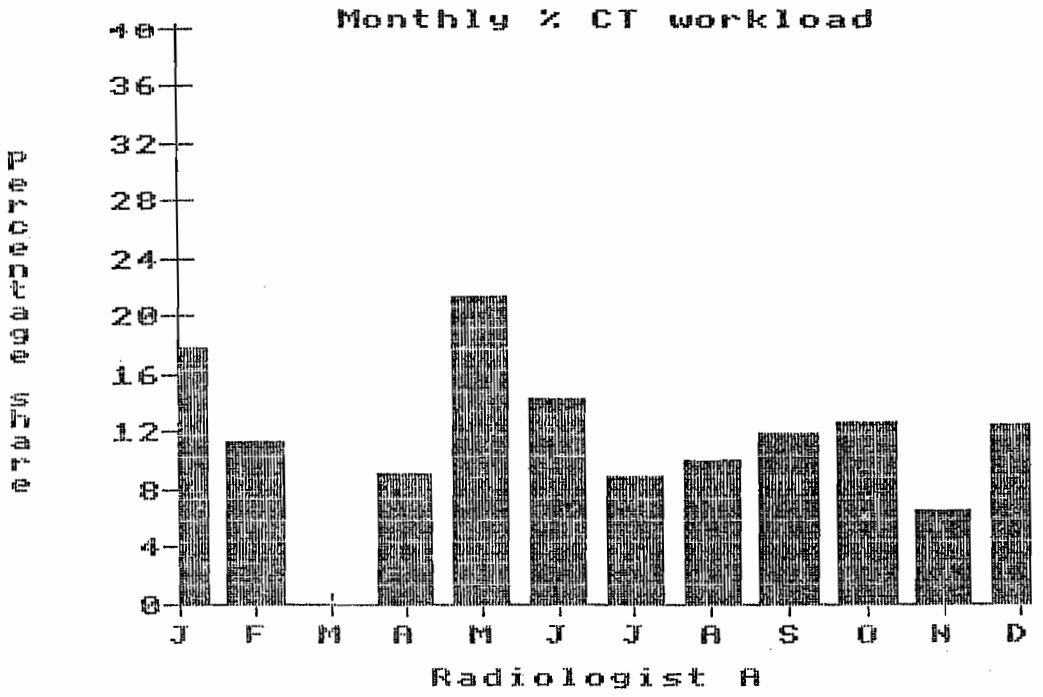
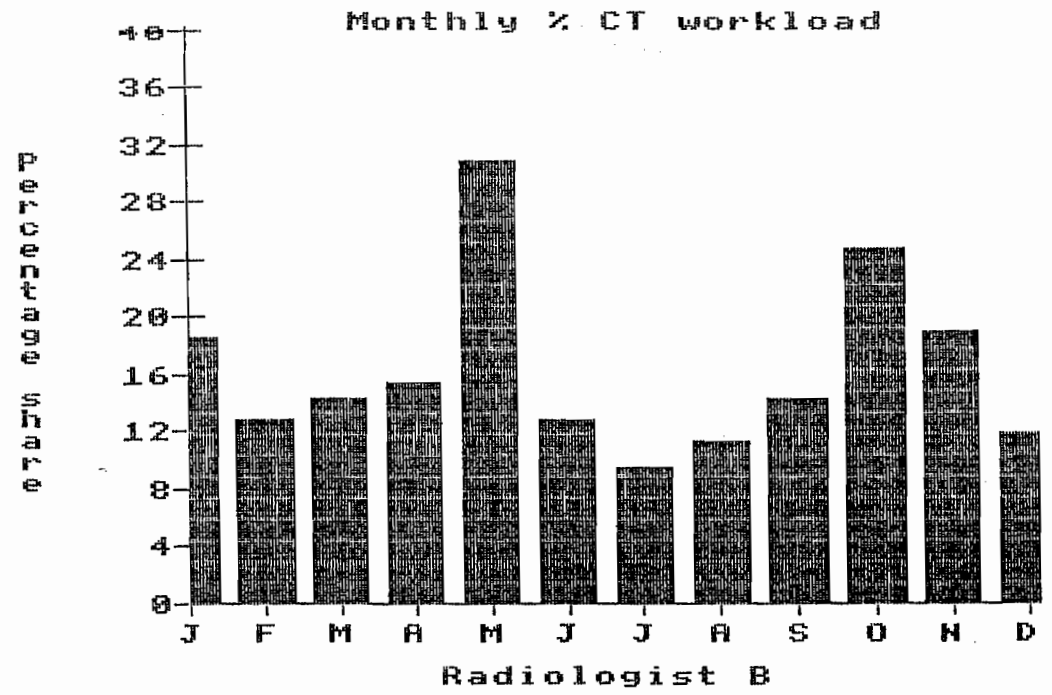


Figure 5 : CT Scanner Unit - Workload Report
July - December 1985

Radiologist	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	AVERAGE
A							
No patients	14.00	15.00	15.00	19.00	11.00	20.00	15.67
Sessions	3.00	3.00	3.00	4.00	2.00	3.00	3.00
List Size	4.67	5.00	5.00	4.75	5.50	6.67	5.26
% workload	8.92	10.07	11.90	12.67	6.55	12.50	10.43
B							
No patients	15.00	17.00	18.00	37.00	32.00	19.00	23.00
Sessions	4.00	4.00	5.00	9.00	6.00	4.00	5.33
List Size	3.75	4.25	3.60	4.11	5.33	4.75	4.30
% workload	9.55	11.41	14.29	24.67	19.05	11.87	15.14
C							
No patients	44.00	20.00	15.00	27.00	32.00	37.00	29.17
Sessions	10.00	4.00	4.00	7.00	6.00	9.00	6.67
List Size	4.40	5.00	3.75	3.86	5.33	4.11	4.41
% workload	28.03	13.42	11.90	18.00	19.05	23.12	18.92
D							
No patients	24.00	47.00	33.00	18.00	27.00	29.00	29.67
Sessions	6.00	10.00	8.00	4.00	6.00	7.00	6.83
List Size	4.00	4.70	4.12	4.50	4.50	4.14	4.33
% workload	15.29	31.54	26.19	12.00	16.07	18.12	19.87
E							
No patients	13.00	14.00	4.00	7.00	17.00	11.00	11.00
Sessions	4.00	4.00	1.00	3.00	3.00	3.00	3.00
List Size	3.25	3.50	4.00	2.33	5.67	3.67	3.74
% workload	8.28	9.40	3.17	4.67	10.12	6.87	7.09
F							
No patients	47.00	36.00	41.00	42.00	49.00	44.00	43.17
Sessions	9.00	7.00	9.50	9.50	9.50	9.50	9.00
List Size	5.22	5.14	4.32	4.42	5.16	4.63	4.82
% workload	29.94	24.16	32.54	28.00	29.17	27.50	28.55
TOTALS							
Patients	157.00	149.00	126.00	150.00	168.00	160.00	
Sessions	36.00	32.00	30.50	36.50	32.50	35.50	
List size	4.36	4.66	4.13	4.11	5.17	4.51	

Figure 6 : Radiologists' Share of Total CT Workload





APPENDIX 1 : COSTS OF CT SCANNING AT YORK DISTRICT HOSPITALS

CAPITAL

1. Accommodation

Costs of providing all the physical accommodation for the CT scanner including space for:

(a) The X-Ray gantry and table

(b) The high voltage supply

(c) Computer control

(d) Remote viewing facilities

(e) Film processing

(f) Archive store

(g) Staff room

In other hospitals these costs may arise from the construction of new, purpose built accommodation or the conversion of existing buildings and rooms to provide the necessary space for the scanner and its associated hardware.

Total costs of accommodation	£ 74,500

2. Equipment

Hardware costs including:

(a) Purchase of the CT Scanner

(b) Installation of air-conditioning units

(c) Provision of film processing equipment

(d) Furnishing and equipping the CT unit

Total costs of equipment	£507,300
TOTAL CAPITAL COSTS	£581,800
ANNUAL EQUIVALENT COSTS	£ 78,700

REVENUE

1. Staff

The costs of all radiographic, medical and nursing staff involved in the provision of the CT scanner facility, together with the costs of providing the necessary support services:

(a) Radiologists

(b) Radiographers

(c) Any additional payments for out-of-hours work

(d) Training

(e) Nurses and porters

(f) Clerical support

(g) Medical records

Some staff can be identified exclusively with the CT scanner, others may share their activities between CT and main X-Ray. Where staff are not full-time in CT it is necessary to estimate the proportion of their duties which should properly be included in the costs

Annual cost	£ 44,000

2. Consumables

The costs of all consumables used directly as a result of providing the CT scanner facility:

(a) Replacement X-Ray tubes

(b) Electrical power for scanner and air-conditioning

(c) Film and processing chemicals

(d) Contrast media

(e) Drugs, syringes and needles

(f) Recording media for achive

Annual cost	£ 39,200

3. Direct Costs

Other costs directly linked with the CT scanner facility:

(a) Maintenance, both contract and non-contract items

(b) Patient transport, within hospital and between units in the catchment area

(c) Transport for Radiologists and Radiographers outside normal working hours.

Annual cost	£ 38,800

4. Indirect Costs

Costs arising from the housing of the CT scanner and not directly attributable to its use:

(a) Engineering and maintenance

(b) Cleaning

(c) Heating

(d) Rates

(e) Incidental expenses - telephone, office equipment, uniforms, etc.

Annual costs	£ 2,100

TOTAL ANNUAL REVENUE COSTS	£123,300
TOTAL ANNUAL COSTS (INCLUDING CAPITAL)	£202,000
AVERAGE COST PER PATIENT (n=2000)	£ 101.00