MRI ASSESSMENT PROGRAM

SECOND INTERIM REPORT

A REPORT BY THE

MRI TECHNICAL COMMITTEE

OF THE

NATIONAL HEALTH TECHNOLOGY ADVISORY PANEL

MAY 1988

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Any comments or information relevant to the subject matter of this report would be welcome. Correspondence should be directed to :

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MRI ASSESSMENT PROGRAM - SECOND INTERIM REPORT

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AUSTRALIAN INSTITUTE OF HEALTH

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EXECUTIVE SUMMARY

- This report presents usage, cost and efficacy data from the MRI Assessment Program, as a continuation of an earlier analysis.

- Analysis has been performed on data from 8565 examinations relating to 7997 patients examined by the units at Royal North Shore (RNSH), Royal Melbourne (RMH), Royal Adelaide (RAH) and Princess Alexandra (PAH) Hospitals.

- Demand for services at RNSH and RMH is heavy, and waiting time for examination is in excess of six weeks at each of these units. Both RNSH and RMH are approaching maximum achievable patient throughput under their present operating conditions (2800 and 2400 patients per year respectively).

- MRI was used mainly for examination of the head and spine (59% and 25% of examinations respectively). Most head examinations but only 51% of spinal examinations were completed in less than 1 hour.

- At the time of examination, in the opinion of the radiologists, 88% of MRI examinations were considered indispensable or helpful and 12% of no assistance. In cases where CT was available, MRI was considered superior or greatly superior in 68%. CT was considered superior in 4.5%.

- An analysis of expenditure has been performed for the units at RNSH, RMH and RAH for the period July 1987 - March 1988. The data are preliminary, subject to audit and do not include a component for interest or leasing charges.

- Average costs per scan for this period were $621 (RNSH) $543 (RMH) and $754 (RAH). There was considerable month to month variation in cost per scan at all units due largely to unscheduled down time, which included a three month shut-down at RAH. If that period is ignored, average cost per scan at RAH was $616.

- Brief details are given of more detailed follow up studies conducted at RNSH, RMH, RAH and PAH.

- A consensus statement is included which summarises the view of the Technical Committee on the potential applications of MRI in Australia. The statement mainly reflects the experience gained by users of MRI in hospitals participating in the assessment program.

- The performance of MRI scanners in the program has been significantly enhanced through upgrades made available by manufacturers. The need to maintain a program for upgrading MRI scanners is seen as essential, given the continued rapid evolution of the technology.

INTRODUCTION

This second interim report from the MRI Technical Committee of the National Health Technology Advisory Panel (NHTAP) presents further usage and cost data from the MRI Assessment Program, continuing the analysis reported earlier (1).

The data in the present publication include minimum data set analysis from the units at Royal Melbourne, Royal North Shore, Royal Adelaide and Princess Alexandra Hospitals (RMH, RNSH, RAH and PAH), and some details of the follow up studies being conducted on selected patients and disease categories at those hospitals. Cost data analysis is included for RNSH, RMH and RAH. Future reports will include data from the unit at Sir Charles Gairdner Hospital (SCGH).

In addition, a consensus statement has been included which summarises the views of the Technical Committee on significant areas in the potential application of magnetic resonance imaging. The statement reflects the experience gained in the program by users of MRI in the participating Australian hospitals and also takes account of trends in overseas experience reported in the literature.

Taken together, the data in this report provide a further view of the use of MRI in Australia as the expertise at the participating hospitals develops.

As in the first interim report, the cost data reported here are subject to audit and should be regarded as an initial guide to levels of capital and operating expenditure.

The information in the report is intended for use by those with an interest in future MRI services in Australia, including health authorities, professional bodies and the NHTAP.

Features of the Program

As indicated in the first interim report(1) the program is supported by Commonwealth and State government grants. In addition, a Commonwealth Medicare Benefit is available for examinations of appropriate patients at each of the units.

The data reported here have been obtained from MRI units in busy service radiology departments in public hospitals rather than from centres of research. While this has in some respects made assessment more difficult, it has provided good first hand experience of how a new diagnostic technology operates in this situation. An aim of the program has been to assess the efficacy of MRI imaging in the context of its

use within teaching hospitals, with appropriate specialist referral. As with other assessments of diagnostic technologies, cooperation from clinicians in the participating hospitals and other centres has been essential in the development of more detailed studies.

Rising cryogen costs in Australia are continuing to cause concern to those units operating scanners which have superconductive magnets. The scanners being used in the program have relatively high consumption requirements for liquid helium, the cost of which is expected to reach about $30 per litre within the next year, giving projected annual expenditure of $130,000-160,000 at each unit. No immediate technical solution to this situation is in prospect.

It has been noticeable that the performance of the scanners in the program has been significantly enhanced through the upgrades made available by the manufacturers. These have contributed greatly to improvements in image quality and to some extent in patient throughput. There has been concern at the delay in obtaining certain upgrades, some of which have required additional developmental work by the manufacturers.

The need to maintain an appropriate program for upgrading MRI scanners is seen by the Technical Committee as essential. Given the continued rapid evolution of this technology, existing scanners will quite quickly become obsolescent unless provision is made to incorporate improvements offered by the manufacturers. Provision for such upgrades should be considered in budgeting arrangements for existing and future MRI scanners in Australia.

Demand for services from the units at RNSH and RMH is heavy, and waiting times for examinations is now in excess of six weeks at both centres.

MINIMUM DATA SET ANALYSIS

A Minimum Data Set (MDS) in a standard format has continued to be collected on each patient during examination at each MRI unit. A detailed analysis of data from the MDS is included in Appendix A.

Numbers of Examinations

Up to 30 March 1988 some 9650 MRI examinations had been conducted at RNSH, RMH, RAH, and PAH. The first three months of operation of each unit are treated as a pilot period. The data relating to 1085 examinations carried out during that phase will be dealt with separately.

Analysis has been performed on data from 8565 examinations relating to 7997 patients. The number of completed examinations was 8272. Some 293 scans were not completed due to patient discomfort or technical difficulties. Assessment of uncompleted scans is performed at each MRI unit as part of the quality control procedures. Some 485 patients (6.1%) required two or more scans for all required information to be obtained.

Throughput data to 30 March 1988 are given for RNSH, RMH and RAH in Figures 1-3. RNSH is operating on a two shift basis. Examination of the figures for the months December 1987 - March 1988 suggest that a maximum throughput of 2800 examinations per annum may be possible at that unit under those arrangements. RMH is operating an extended single shift and on that basis a maximum throughput of 2400 examinations per annum may be possible. The RAH figures are lower, reflecting use of a single shift operation, and the time taken to recover from the quench and subsequent shut down in July-September 1987 (Appendix B).

It should be noted that periods of unscheduled downtime occurred at each unit, and that these significantly affected patient throughput. Actual throughputs for calendar year 1987 were 2481 examinations at RNSH and 2264 examinations at RMH. Throughput figures will require further analysis over the next six months.

FIGURE 1

NUMBER OF SCANS – JULY 1986–MARCH 1988

ROYAL NORTH SHORE HOSPITAL

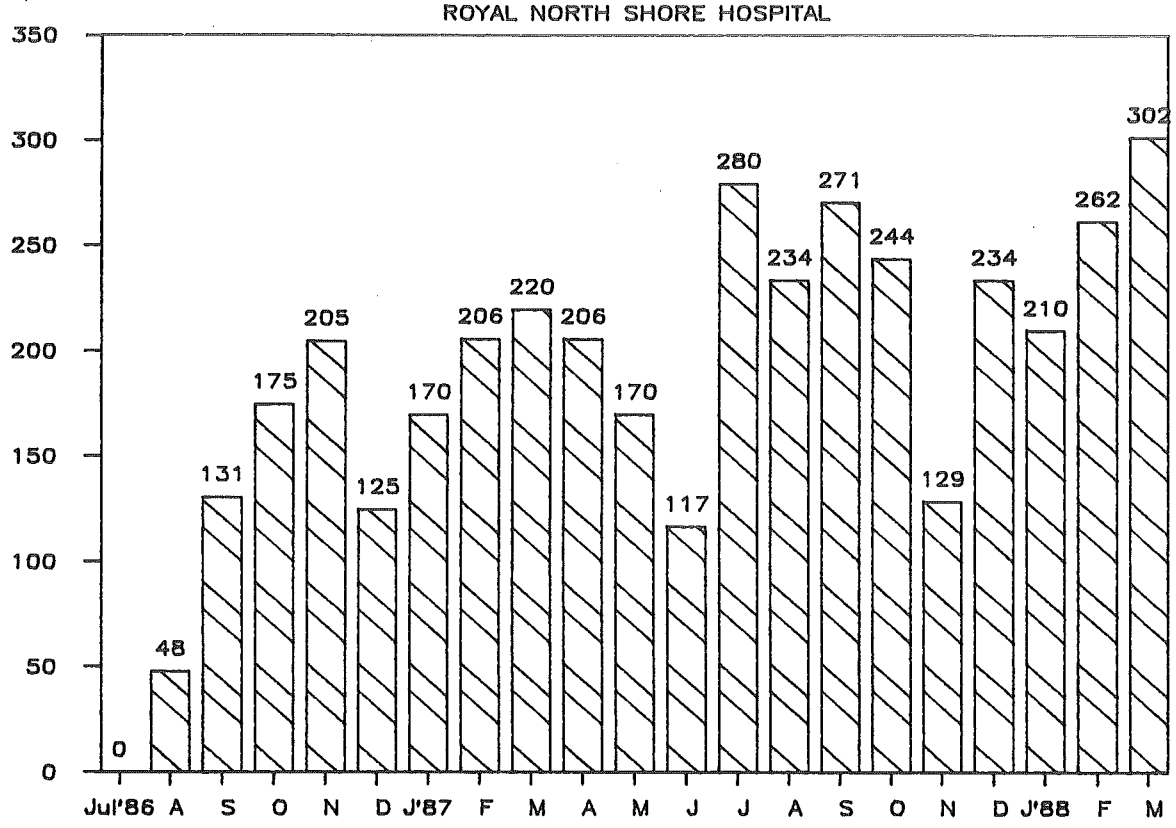


FIGURE 2

NUMBER OF SCANS – JULY 1986–MARCH 1988

ROYAL MELBOURNE HOSPITAL

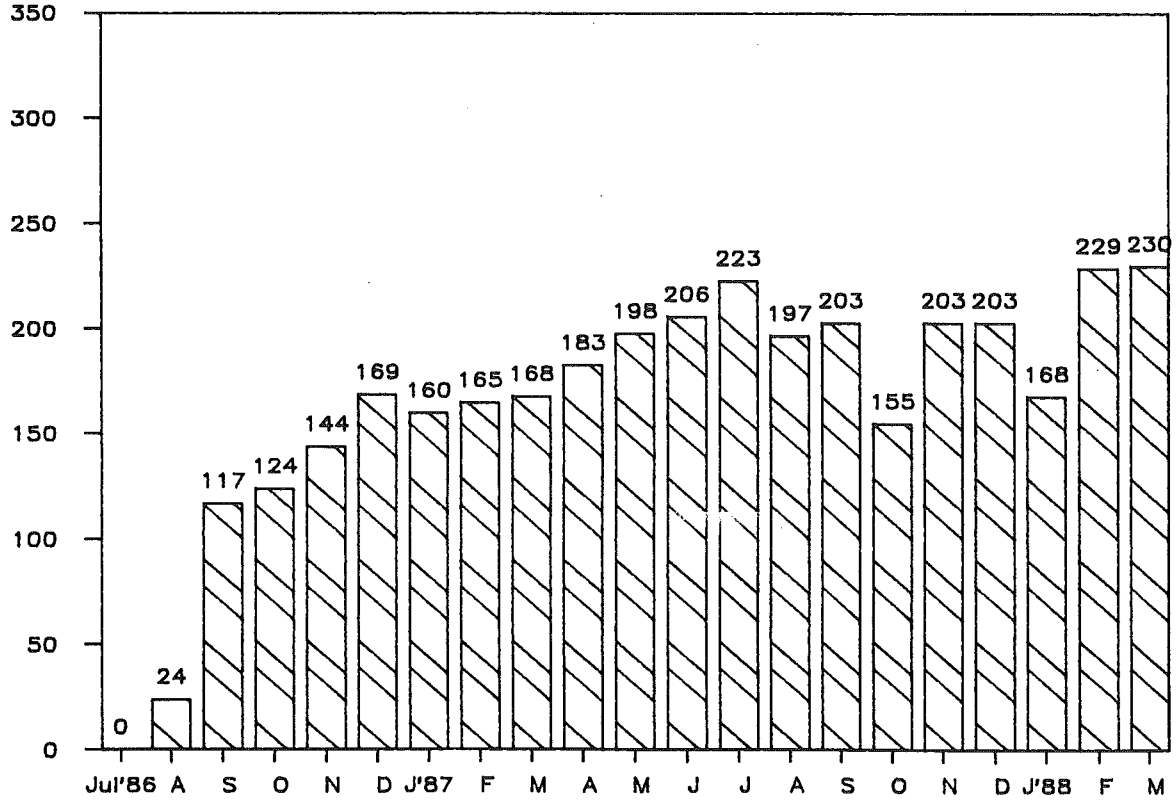
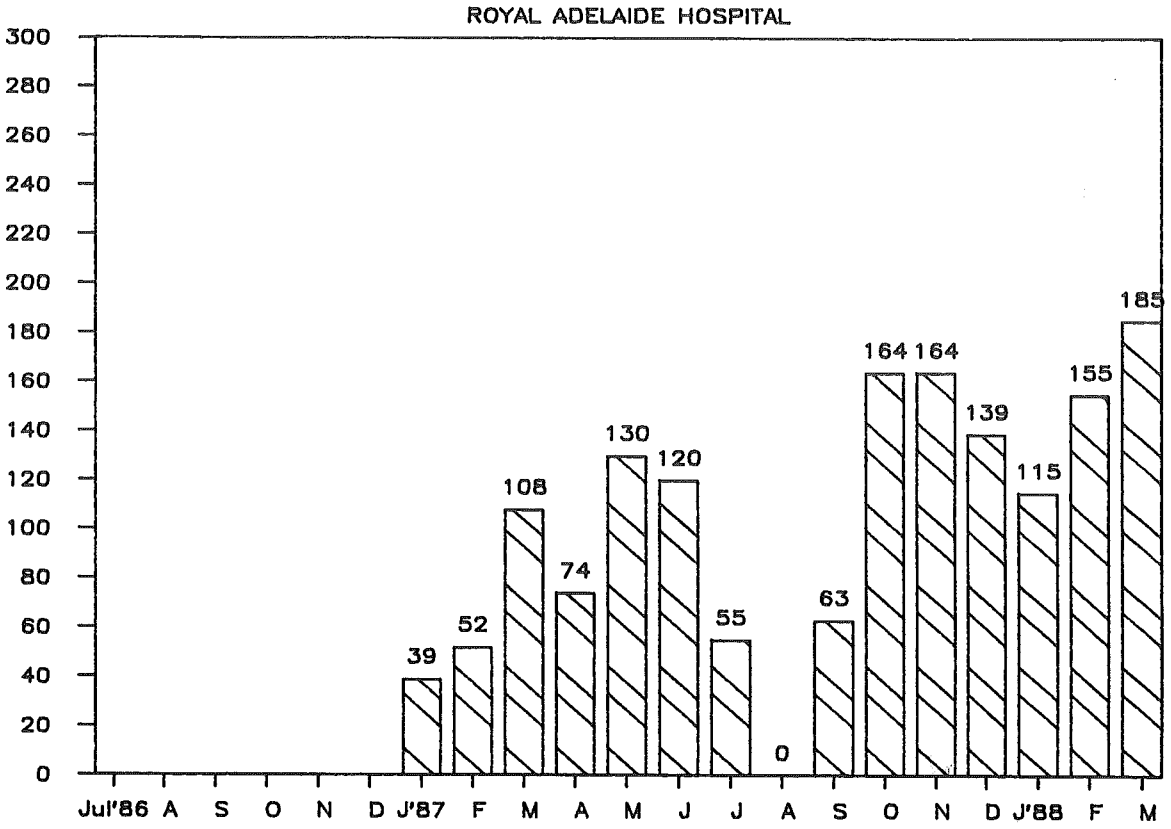


FIGURE 3

NUMBER OF SCANS – JULY 1986–MARCH 1988



Patient Residence

An analysis of patient addresses for the three hospital units by postcode gave the distribution shown in Table 1.

TABLE 1
DISTRIBUTION OF PATIENT RESIDENCE

Patient residence	Numbers	Per cent
RNSH		
Sydney Metropolitan Area	2382	66
NSW Rural	647	18
Wollongong Region	198	6
Newcastle Region	158	4
ACT Region	105	3
Other	99	3
RMH		
Melbourne Metropolitan	2360	74
Victoria Rural	482	15
Geelong Region	105	3
Tasmania	136	4
Other	121	4
RAH		
Adelaide Metropolitan	1088	80
SA Rural	211	16
Darwin	18	1
Other	47	3

Patient Status

Section 2 of Appendix A relates to the status of patients examined. As noted in the first interim report, the majority of patients (69%) are outpatients. This reflects the current use of MRI on patients who are mobile (79%), with 90% being recorded as either "fully active" or with "limited activity". Approximately one third of referrals were from other hospitals.

This distribution of patient status is associated with a considerable workload in scheduling and co-ordination of patients and in the subsequent follow-up with referring

specialists. There is also associated expenditure on ambulance transfers and medical supervision of ill patients from other hospitals.

Time of Examination

The majority (67%) of MRI examinations took less than 60 minutes (time in room); 82% of head examinations were completed in under 60 minutes, whereas only 51% of spine examinations were completed in that time.

Males and females continued to be equally represented, with the majority of patients (52%) in the age range 30-59. Fourteen percent of patients were under 19 years of age.

Patient History

As well as data on patient residence and status, information was collected on the presenting signs and symptoms, coded to the International Classification of Diseases Code (9th Revision). These data have been analysed for head examinations and are presented in Section 3 of Appendix A. The range of signs and symptoms reflect the difficulty of collecting consistent data in this area in a busy service environment.

MRI continues to be used mainly for examination of the head (59%) and spine (25%) and this experience is reflected in the consensus statement. The reason why the MRI tests were undertaken was mainly (59%) reported as 'Disease present, diagnosis uncertain, test for further information'. Since the period covered in the first interim report, the reason 'Plan Management' has risen from 16% to 21% and the 'Rule Out Disease' category has fallen from 26% to 20%.

Examination by Radiologists

Section 4 of Appendix A provides an analysis of MRI examinations performed and the subjective opinion of the radiologists on their usefulness at the time of examination.

As was the case with data covered in the first interim report, the opinion of the radiologists was that, at the time of examination approximately one-third of studies were 'normal'. These cases are being followed-up with referring clinicians to determine the final diagnosis. Such 'normal' findings have potential benefits to patients in cases where the presence of serious disease is suspected on the basis of earlier examinations. Other common categories of diagnosis listed in Section 3 of Appendix A are neoplastic disease, vascular disorder, degenerative disease and congenital/developmental disease.

In the subjective opinion of the examining radiologists some 88% of the MRI examinations were considered to be either indispensable or helpful, with 12% being considered of no assistance. These opinions reflect the views of senior radiologists experienced in the use of existing diagnostic modalities. Support for the opinions of the radiologists is emerging at follow-up with the referring clinicians.

MRI was compared with CT where the latter was available. MRI was considered to be superior in the majority of cases. The category 'CT not done' has increased to 34% overall. In many spinal cases the examination to be compared with MRI is myelography or discogram. In cases of suspected multiple sclerosis it is the opinion of three of the MRI units that if an imaging modality is required, MRI alone is sufficient. As mentioned in the first interim report, CT results are regarded as not available when the quality of the CT examination is doubtful.

In those cases where CT was available, MRI was considered to be superior or greatly superior in 68%. CT was considered superior to MRI in 4.5% of these cases.

COST DATA

Capital Costs

Equipment and site works in the MRI program have been funded through capital grants from Commonwealth and State governments. Details of expenditure are given in Table 2. As mentioned in the first interim report(1), interest and leasing charges associated with the capital grants have not been included.

TABLE 2
CAPITAL COSTS OF MRI EQUIPMENT AND SITING

	RNSH $m	RMH $m	PAH $m	RAH $m	SCGH $m
Equipment	2.7	2.9	2.7	2.1	4.0
Site	0.7	0.3	0.3	0.6	0.8
Total	3.4	3.2	3.0	2.7	4.8

The units were purchased at different times. The levels of expenditure on equipment partly reflect changes in the value of the Australian dollar relative to other currencies.

As regards the site expenditure, three units were installed in purpose-built sites (RNSH, RAH and SCGH) with special shielding provisions for medium to high field superconductive scanners. The units at RMH and PAH were installed in existing buildings.

For the purposes of the assessment program, capital costs have been handled in terms of straight line depreciation, of the equipment over five years, and of the site over ten years. In the case of RMH and PAH, where modifications have been made to existing buildings, a notional rental of $200 per square metre per annum is added to the site depreciation figure to provide comparability with the other three institutions.

Details of the monthly depreciation figures for the MRI units are given in Table 3.

TABLE 3
MONTHLY DEPRECIATION ON MRI UNITS

	RNSH $	RMH $	PAH $	RAH $	SCGH $
Equipment	44,735	47,537	45,279	34,877	66,667
*Other	-	168	189	930	-
Site	6,103	2,463	2,130	5,000	6,667
Notional Rental	-	1,667	1,833	-	-
Total	50,838	51,835	49,431	40,807	73,334

* "Other" relates to minor ancillary equipment purchased in association with the MRI unit

Operating Costs

Table 4 gives the overall operating costs for the units at RNSH, RMH and RAH for the period July 1987 - March 1988. The proportions of expenditure associated with major items is

FIGURE 4

EXPENDITURE – JULY 1987–MARCH 1988
ROYAL NORTH SHORE HOSPITAL

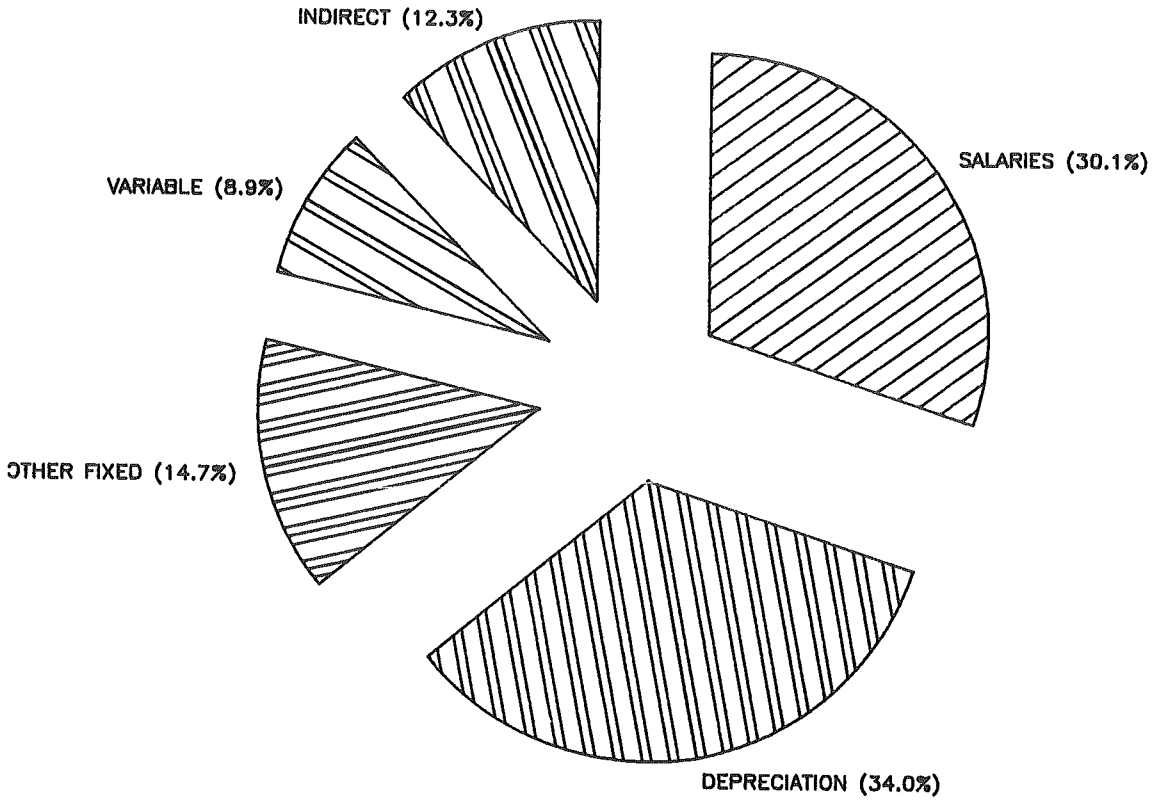


FIGURE 5

EXPENDITURE – JULY 1987–MARCH 1988
ROYAL MELBOURNE HOSPITAL

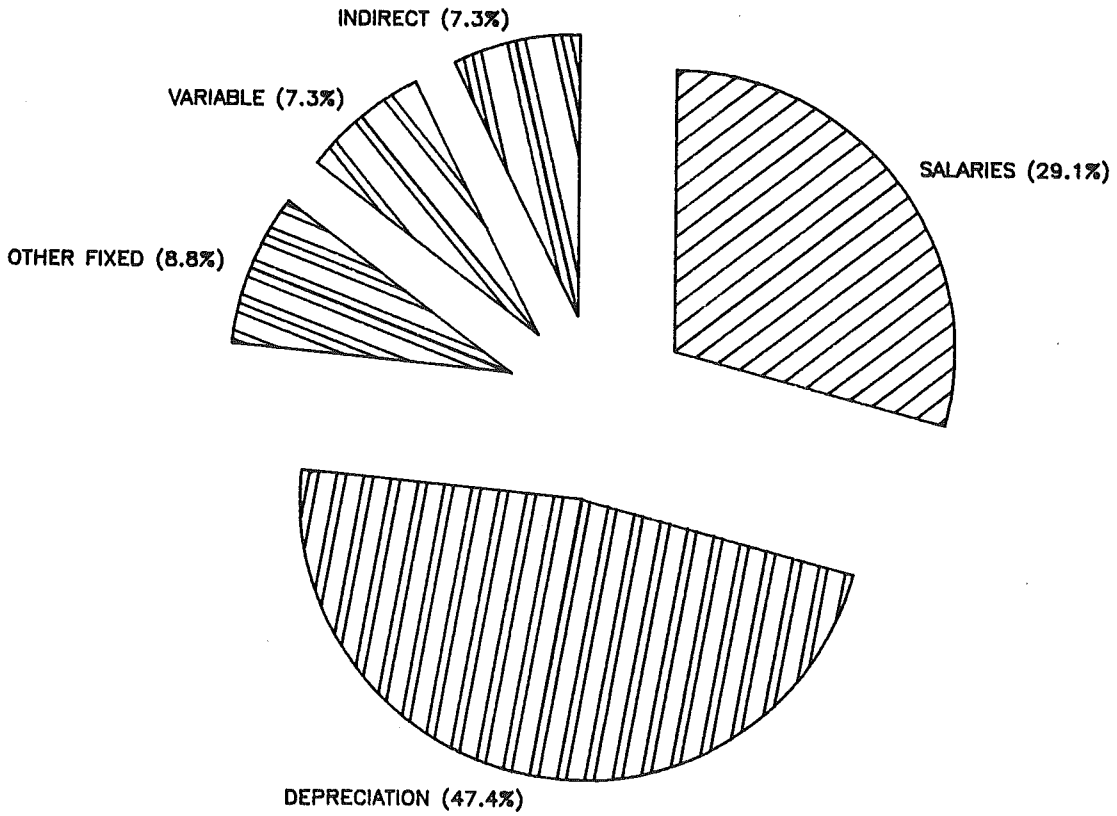
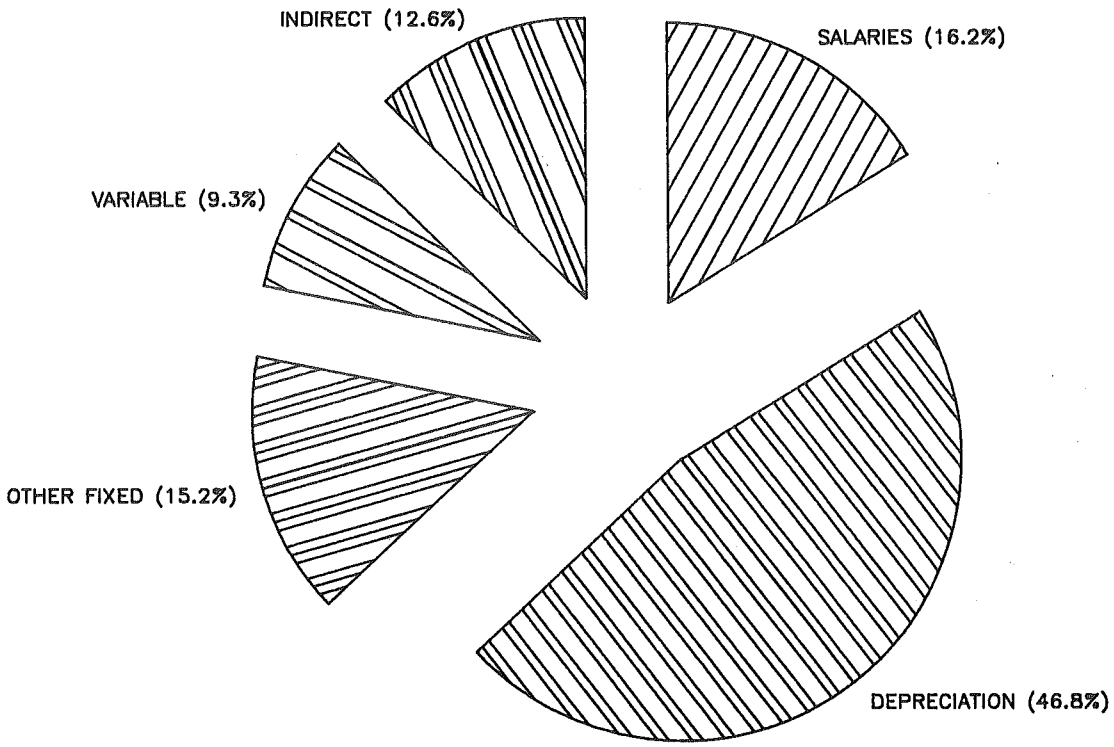


FIGURE 6

EXPENDITURE – JULY 1987–MARCH 1988
ROYAL ADELAIDE HOSPITAL



shown in Figures 4-6. The data for RAH reflect downtime of 57 days during this period associated with a magnet quench and subsequent corrective action.

TABLE 4
PRELIMINARY COST DATA FOR THREE MRI UNITS, JULY 1987-MARCH 1988

	RNSH $	RMH $	RAH(a) $
Depreciation on equipment and site	457,542	466,515	367,263
Salaries and Allowances	404,154	286,738	127,094
Maintenance	197,610	86,495	118,956
Variable costs	120,001	72,209	72,577
Indirect costs	164,899	71,937	98,553
	1,344,206	983,894	784,443

(a) Expenditure at RAH reduced due to shut down during July/August/September.

Salaries and allowances

Salaries varied widely between the units, these variations reflecting staffing policies, levels of remuneration under different awards for each State, and hours of operation. In the case of RNSH, a two shift operation is worked with a radiologist in attendance at each shift. RMH operates an extended single shift using one radiologist. RAH operates a single shift using part of the salary of a hospital radiologist and payments to visiting medical officers.

Maintenance

Maintenance costs varied with the type of equipment (superconductive units at RNSH and RAH, resistive unit at RMH) and the form of the maintenance contract. At RNSH, routine maintenance is performed at week-ends to allow more time for scanning patients during the week. There are increased maintenance costs because of this 'out-of-hours' work.

Variable costs

Variable costs (the proportion of expenditure that varies with each patient) represent a relatively small proportion - less than 10 per cent - of MRI operating expenditure. Details for each of the three units are given in Table 5.

TABLE 5
PRELIMINARY OPERATING EXPENDITURE DATA
FOR THREE MRI UNITS FOR JULY 1987-MARCH 1988

	RNSH	RMH	RAH
Film	38,638	30,245	34,133
Film processing	3,483	-	881
Electricity	4,435	15,009	21,279
Cryogens	58,333 (a)	- (b)	10,874 (c)
General Supplies/spares	12,222	25,919	2,005
Other	2,890	1,036	3,405
	120,001	72,209	72,577

(a) Expenditure on cryogens September 1987-March 1988
(b) Cryogens not used at RMH
(c) Cryogens provided under purchase contract at RAH during July 1987-February 1988

An important variable component is the cost of cryogens used in the RNSH and RAH units. RNSH currently has a contract for $100,000 per annum for this item which is expected to increase to $120,000 in the next financial year. RAH has had cryogens covered by the initial purchase contract until the end of February 1988, after which expenditure on these materials is expected to be $140,000 to $160,000 per annum. The resistive units at RMH and PAH operate on electricity which costs approximately $20,000 per annum so that there are differences in operating expenditure of the order of $100,000 per annum as compared with superconductive units.

Indirect Costs

Indirect costs represent an allocation of hospital overheads associated with the operation of the MRI units in a public hospital environment. Indirect costs include allowances for such items as office staff, administration, engineering, catering and laundry. The variation in these costs reflects the particular operating and administrative structures at each hospital. In percentage terms, indirect costs appear

lower at RMH than at RNSH and RAH. The experience of the hospitals in assessing these costs is currently subject to review.

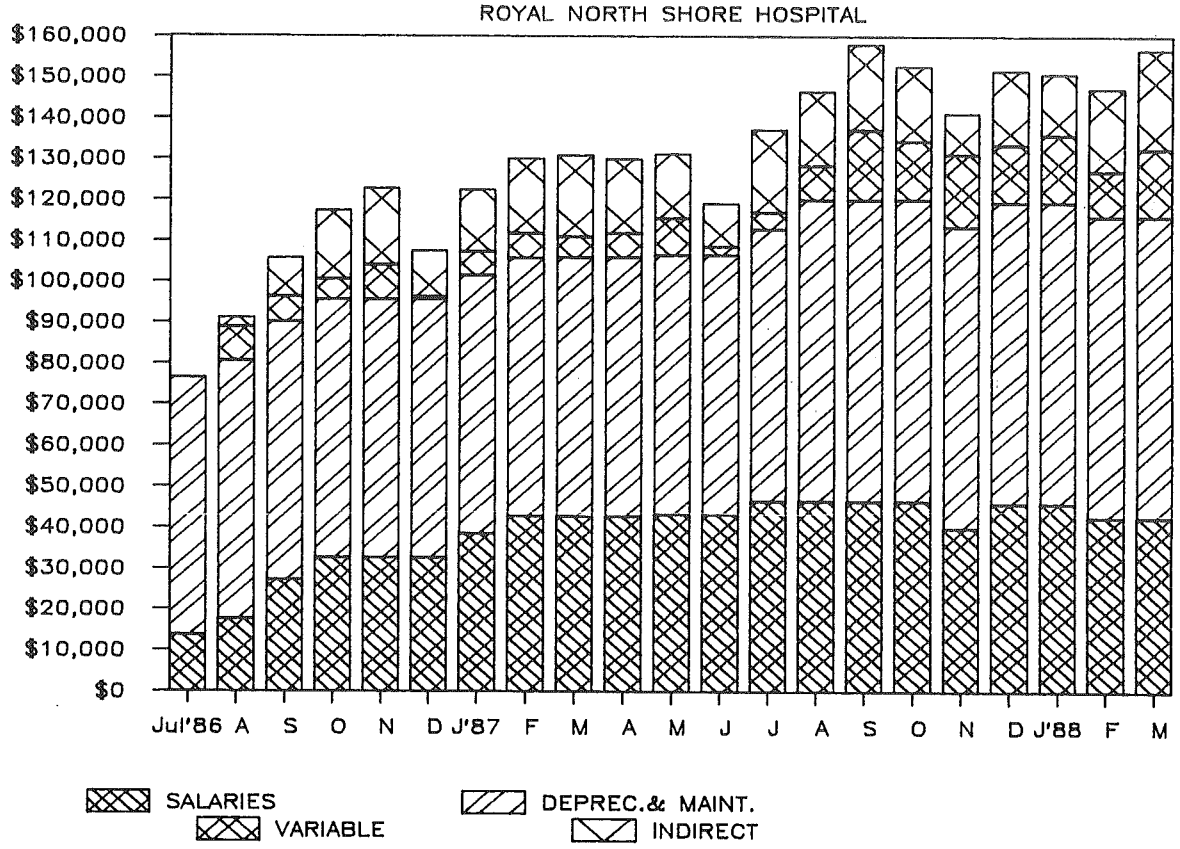
Costs per patient examined

Figures 7-9 show details of month to month expenditure for each MRI unit and also the cost per patient examined, based on the throughput data in Section 1 of Appendix A. Figure 10 shows average cost per scan for each unit, with and without a component for depreciation. Average costs per scan over the period are summarised in Table 6.

FIGURE 7

ACTUAL EXPENDITURE – JULY 1986–MARCH 1988

ROYAL NORTH SHORE HOSPITAL



COST PER SCAN – JULY 1986–MARCH 1988

ROYAL NORTH SHORE HOSPITAL

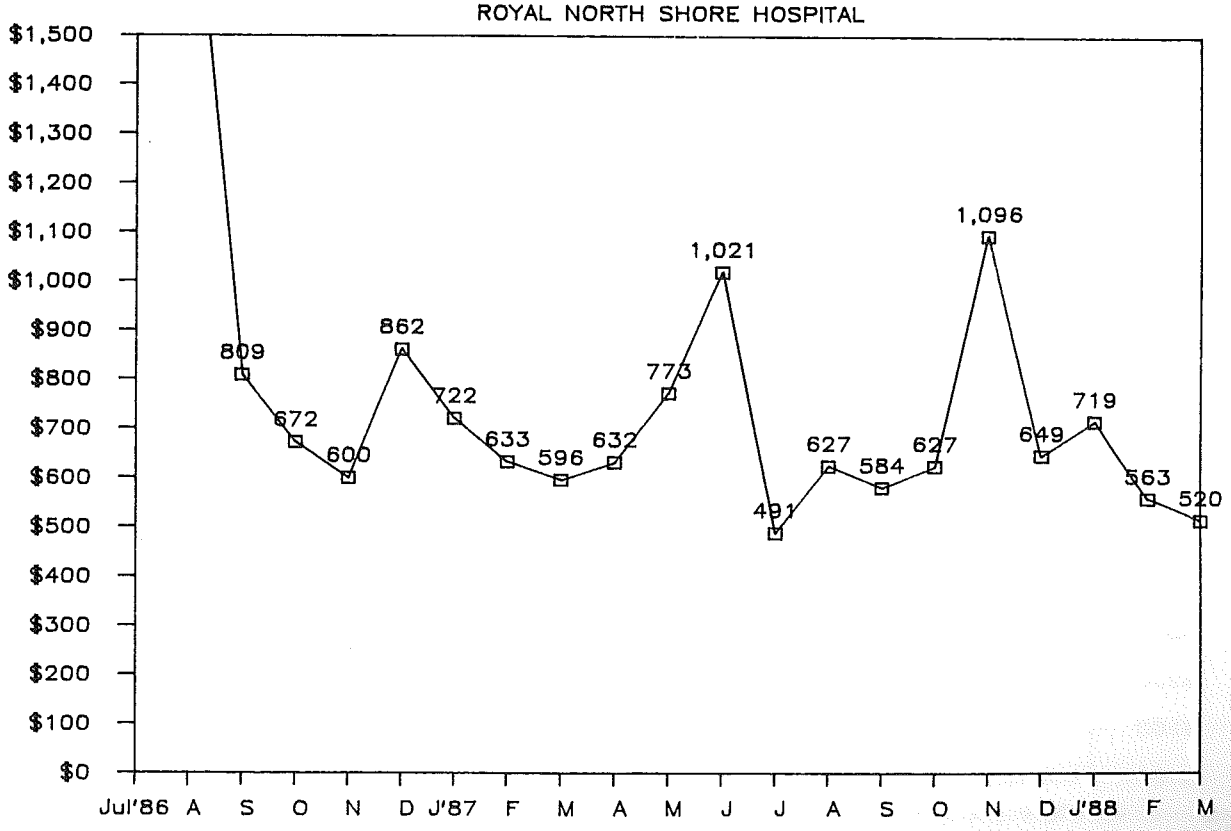
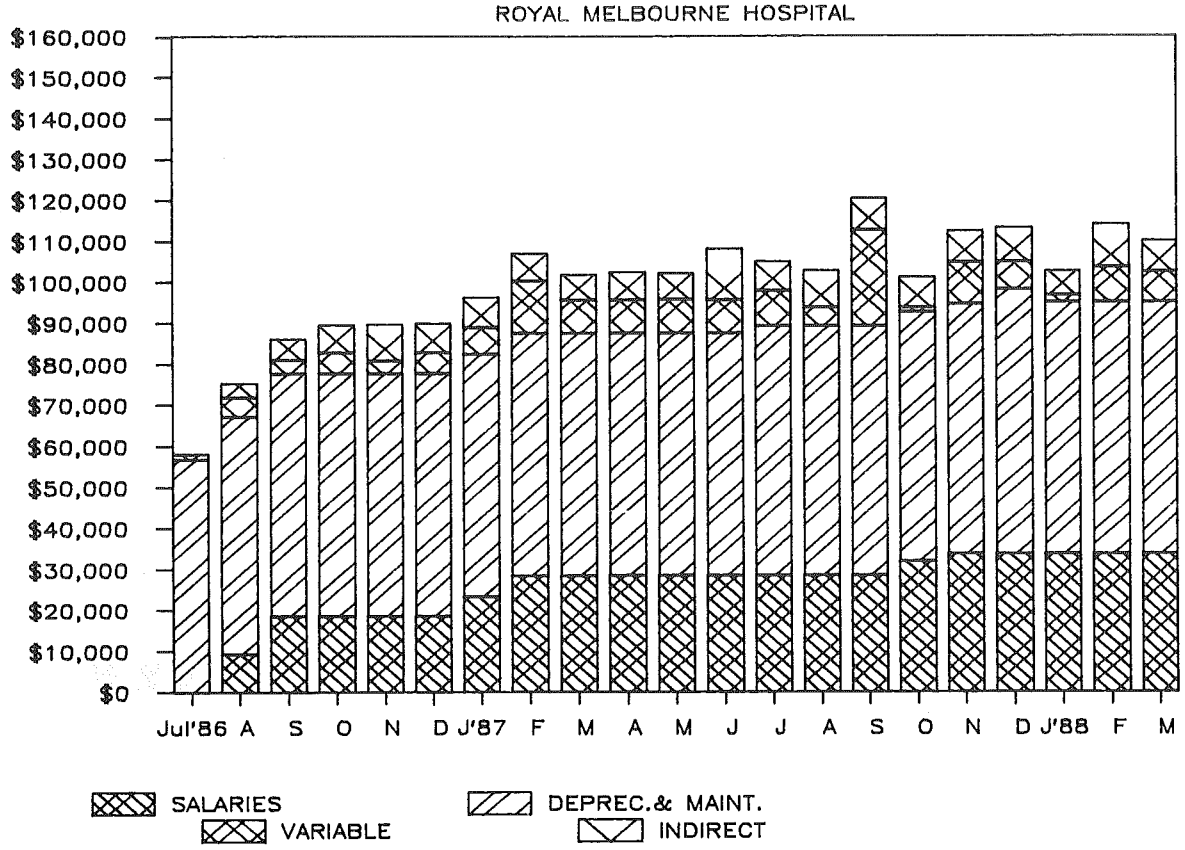


FIGURE 8

ACTUAL EXPENDITURE – JULY 1986–MARCH 1988

ROYAL MELBOURNE HOSPITAL



COST PER SCAN – JULY 1986–MARCH 1988

ROYAL MELBOURNE HOSPITAL

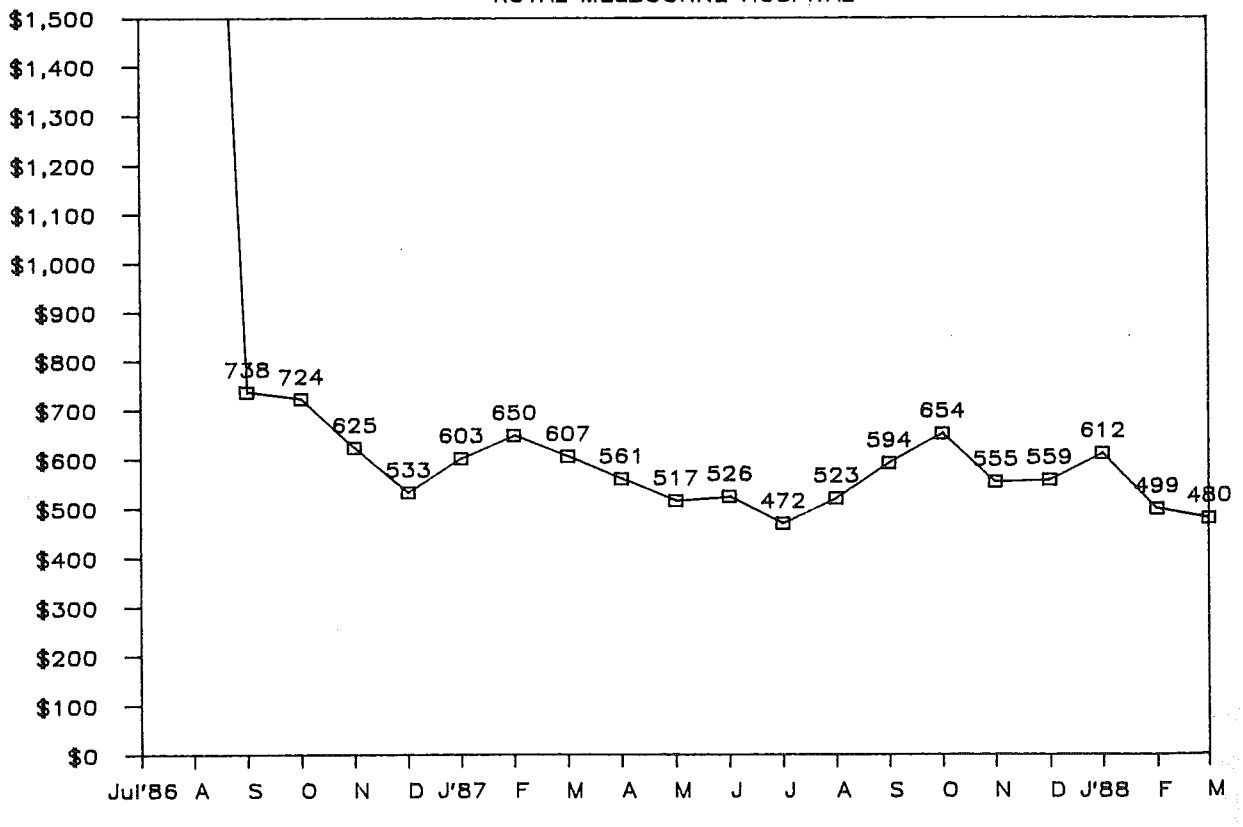
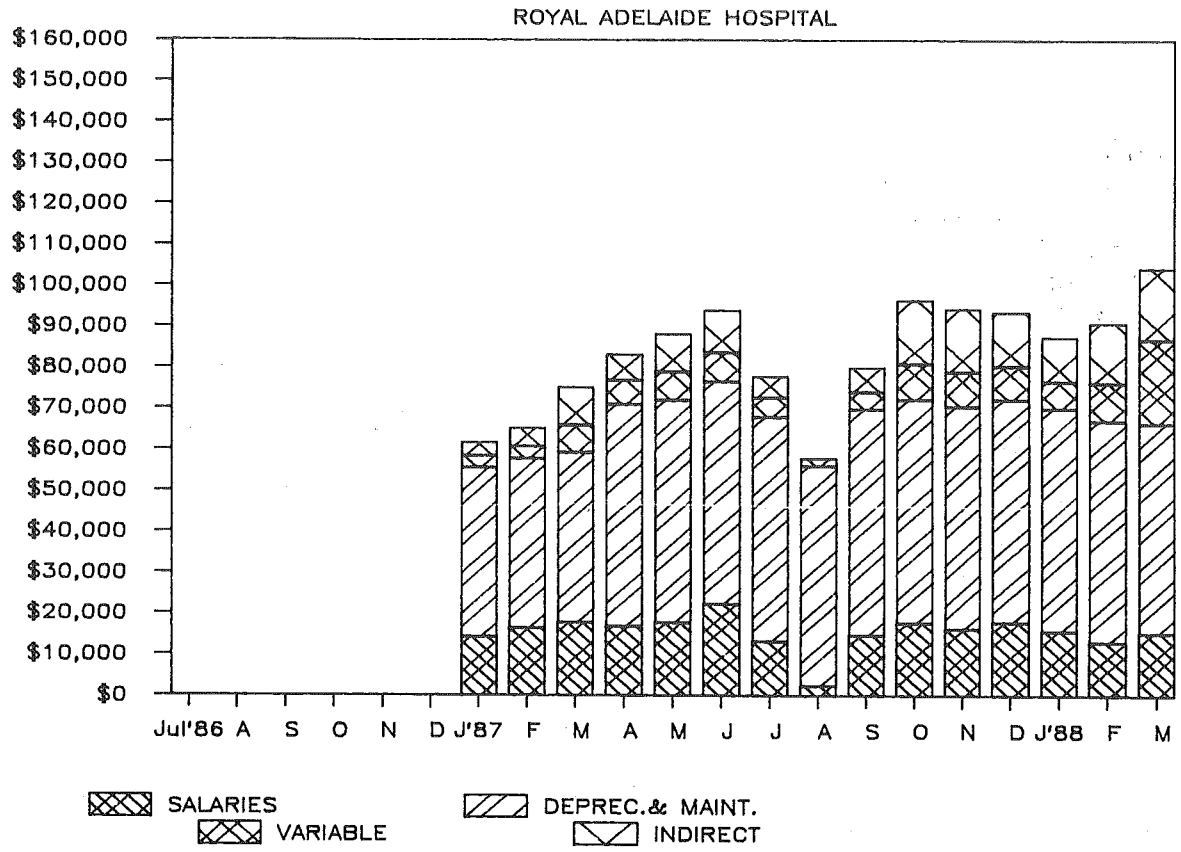


FIGURE 9

ACTUAL EXPENDITURE – JULY 1986–MARCH 1988



COST PER SCAN – JULY 1986–MARCH 1988

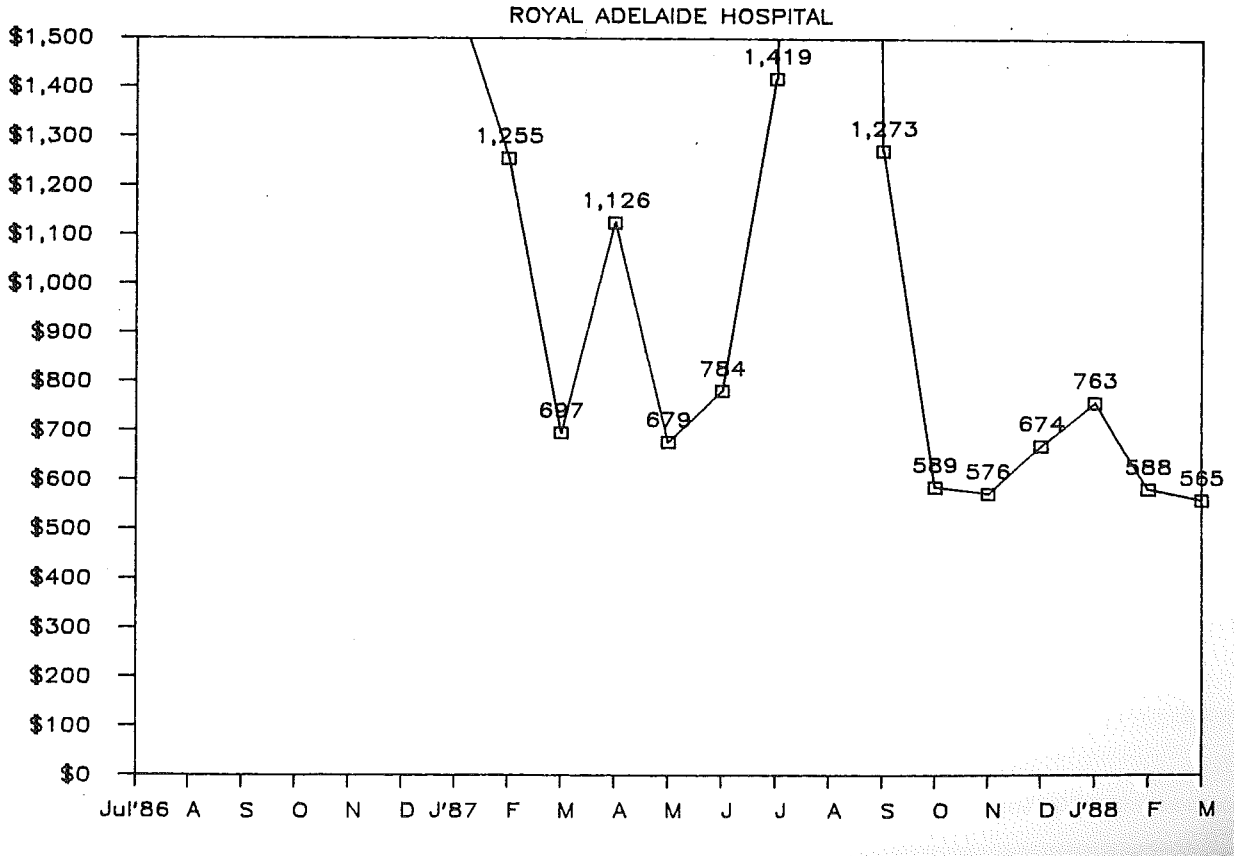


TABLE 6
COSTS PER SCAN AT THREE MRI UNITS
JULY 1987 - MARCH 1988

	RNSH	RMH	RAH[a]	
Number of months	9	9	9	6
Number of scans	2 166	1 811	1 040	922
Average scans per month	241	201	116	154
Highest	302	230	185	185
Lowest	129	155	0	115
Average cost per scan	$621	$543	$754	$616
Highest (b)	$1 096	$645	-	$895
Lowest (b)	$520	$472	$565	$565

(a) RAH data are given both with and without the period of unscheduled downtime associated with the quench.
(b) Highest and lowest figures relates to cost per scan in a particular month.

If the costs of depreciation are ignored, average costs per scan at each unit were RNSH $409, RMH $286 and RAH $401.

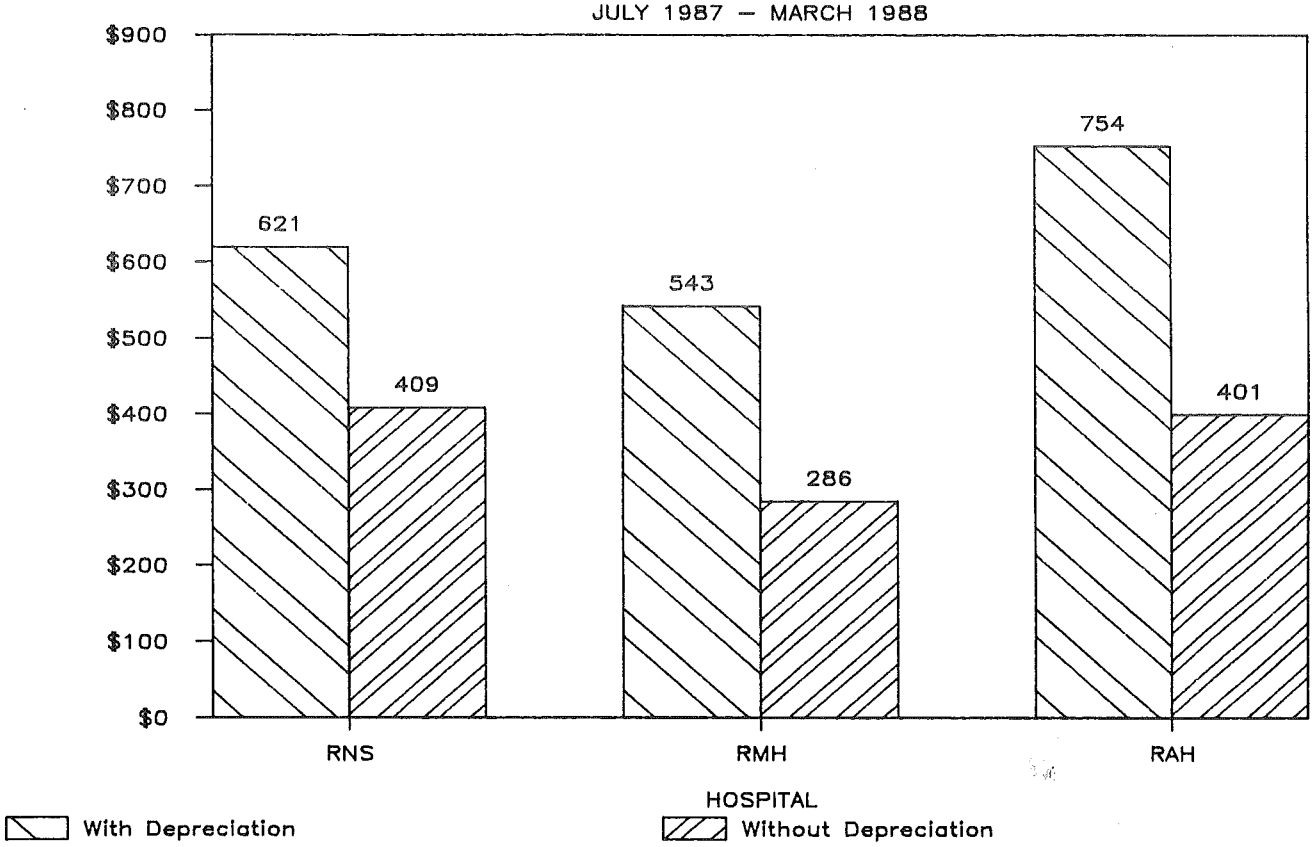
Costs per scan varied considerably between the different units, and from month to month. Unscheduled downtime decreased available instrument time at each site. The most significant incident, resulting in downtime of 57 days, occurred at Royal Adelaide Hospital.

Because of the variations in site and equipment, salary costs, servicibility and daily hours of operation, the data on cost per scan have to be considered with some caution. It is not yet certain that the highest patient throughputs achieved by the units can be maintained consistently.

FIGURE 10

AVERAGE COST PER SCAN AT THREE MRI UNITS

JULY 1987 – MARCH 1988



FOLLOW-UP STUDIES

As mentioned in the first interim report, a number of follow-up studies on specific conditions, called vertical studies, have been conducted at each hospital. These studies are in addition to the data collected on each patient in the MDS and are designed to assess the usefulness of MRI in diagnosis and management in particular disease categories.

The majority of the studies relate to studies of the brain and spine. Areas of interest have included the identification of syrinx, stroke and tumour, use of MRI in examinations of complex partial seizures associated with epilepsy and the confirmation of suspected multiple sclerosis.

Brief details of some initial vertical studies are given below. Further details will be given in future reports from the Technical Committee and in publications prepared by staff at the MRI units.

Royal Melbourne Hospital

- MRI in Hindbrain Stroke
  25 patients, 25 age matched controls
  MRI provides additional information concerning infarct site, extent and pathogenesis in patients with posterior circulation infarction. This information has the potential to determine which patients may benefit from full anti-coagulant therapy which has been shown to lead to improved outcomes in patients with large vessel thrombosis.

- MRI in Complex Partial Seizures (temporal lobe epilepsy)
  60 patients.
  MRI is superior in accuracy to CT in the context of complex partial seizures and is the preferred examination where surgical management is under consideration.

- MRI in Epilepsy
  298 patients
  MRI is approximately equal to CT in accuracy of diagnosis of causes of Grand Mal type epilepsy.

- MRI in Syringomyelia
  70 Patients
  MRI has high sensitivity in detecting syrinx and differentiating from tumour.

- MRI in Multiple Sclerosis
  40 patients
  MRI is valuable in the assessment of patients with possible MS. Although MS is a clinical diagnosis, MRI is considered to be the preferred imaging modality to assist in the diagnosis.

- MRI of the Knee
  50 patients
  MRI could replace arthrography as an adjunct to arthroscopy. MRI showed 95% accuracy, and was particularly good at detecting posterior cruciate ligament damage.

Royal North Shore Hospital

- Follow up of MDS Data

  Follow up data were obtained on 1610 patients previously examined at the MRI unit. The study showed very high MRI accuracy and significant increment over pre-MRI diagnostic accuracy (62%). Referring clinicians considered MRI helpful in achieving diagnosis in 1225 of 1547 cases, in patient management (660/974) and in patient outcome (278/840).

- MRI of Head

- MRI of Cerebral Tumours
  300 patients
  MRI appears to have little diagnostic or management value in the majority of supratentorial tumours (unless CT is equivocal) but has advantages in midline and posterior fossa tumours

- MRI in Paediatric Patients
  50 patients
  MRI is useful in pre-operative localization of primary brain tumours to assist selection of surgical approach.

- MRI and Spinal Cord

- Using surface coils to provide high resolution and thin slices, MRI is more sensitive than CT/myelography in the diagnosis of spinal cord syrinx, tumour, atrophy and myelopathy.

- MRI is as accurate and less invasive than CT/myelography in diagnosing extrinsic spinal cord compression from metastases, infection or tumour.

- MRI is capable of showing cord grey and white matter structure and of demonstrating cord demyelination in multiple sclerosis.

Royal Adelaide Hospital

- Use of Gadolinium DTPA

  Eighteen cases have been studied with 5 follow up examinations in patients with intracranial neoplasms. Uptake by the tumour tissue has been disappointing and the lack of uniformity in uptake makes interpretation difficult.

- MRI in Carcinoma of the Prostate

  The critical staging of carcinoma of the prostate has been disappointing with the difficulty being positive identification of neoplastic tissue.

- MRI in Multiple Sclerosis

  A large data base on clinical, CT, MRI and pathological findings has now been accumulated. Correlation of this material is pending.

- Blood Brain Barrier Studies

  Projects on the blood brain barrier following intrathecal injection of contrast, and CT/MRI correlation in stroke have been abandoned due to difficulty of scheduling MRI examination at short notice.
  The 5 completed blood brain barrier examinations showed no difference on the pre and post examination MRI.

- Patient Acceptance of MRI (Modified WHO Form)

  An ongoing study with 120 completed new data forms, following a pilot study of 100 cases.

Princess Alexandra Hospital

- MRI of Basal Space Occupying Lesions

  38 cases - 31 abnormal : 7 normal

  The aim of this project is to compare the sensitivity and specificity of MRI vs CT in patients with clinically suspected basal space occupying lesions. CT may or may not be normal in these patients. This group is heterogeneous and includes cerebellar lesions, extra-axial cranial nerve abnormalities as well as base of skull, bony and meningeal abnormalities.

  Radiologists felt that MRI was better than CT in over half the normal and abnormal cases, and indispensable in about 30% of the abnormal cases. Early clinical follow up indicates that the clinicians felt MRI was indispensable in 20% and helpful in the remainder.

- MRI of Brain Stem Pathology

  32 cases - 17 abnormal : 15 normal

  This study is comparing MRI with CT in diagnostic accuracy of patients with a clinically suspicious brain stem lesion.

  Radiologists rated MRI as being better than CT in almost all the abnormal cases and half the normal cases. MRI was rated as being indispensable in over 30% of the abnormal cases. Early follow up suggests that clinicians felt MRI was either indispensable or helpful in almost all cases.

  These opinions reflect the problems of artefacts in CT of the brain.

- MRI in Cases of AIDS - Pre-dementia

  10 cases - 1 abnormal : 9 normal

  The purpose of this study is to compare sensitivity of CT and MR in detecting abnormalities prior to the clinical phase of HIV - associated dementia. These results will be compared with the known parameters in a pre-clinical phase which include CSF biochemical evidence of HIV infection and neuropsychological testing. This group will be studied at six monthly intervals.

Most of the cases were diagnosed by MRI as being normal. MRI was not thought to be better than the normal CT's. However, in the abnormal case, MRI was thought to be better than CT, by the radiologist.

7 returns from clinicians indicate that MRI did not change diagnosis, management or prognosis and was thought to be unhelpful in 2 cases and misleading in 5. This assessment was made on the basis that there was biochemical evidence of central nervous disease not demonstrated by MRI.

- Acute Cervical Spine Trauma

25 cases -

A study of a number of patients with cervical cord injury to compare MRI findings with clinical state and ultimate prognosis. All the cases have been abnormal; 3 have had comparative CT.

MRI was thought to be either indispensable (9 cases) or helpful (16 cases) in the managment of all patients by both radiologists and clincians.

It was useful in that it was able to demonstrate the probable presence of cord injury. Therapeutic and prognostic implications have yet to be assessed.

CONSENSUS STATEMENT
CURRENT CONCEPTS OF CLINICAL EFFICACY OF MRI
AUSTRALIAN POSITION, MAY 1988

This consensus statement is largely based on the experience gained at the MRI units at the four hospitals which have operated scanners in the MRI program. It reflects the considered opinion of the radiologists responsible for the MRI services at those hospitals. Account has also been taken of relevant overseas data(2-9). This collection of opinion relates particularly to comparison with other imaging modalities. The specific comments will require further consideration as technical developments with MRI become available, additional experience is gained with gadolinium contrast material and additional data are obtained on the influence of MRI on patient management.

A) GENERAL

GENERAL COMMENTS ON MRI EFFICACY

MRI is, at present, largely a tertiary, complementary diagnostic imaging modality.

It is used either to improve diagnostic accuracy when other tests are negative or equivocal, when there is strong clinical suspicion of disease, or to improve surgical or other management planning when the diagnosis is already known.

In some situations (eg syringomyelia, congenital spinal disease, posterior fossa/cerebello-pontine angle tumours) it may entirely replace other tests (eg myelography, air contrast, CT) which are substantially less accurate and/or more invasive.

In other situations (eg hemispheric brain tumours, lumbar disc protrusions) when other tests, such as CT, can be as accurate, MRI is not usually or initially indicated because it is currently more expensive and of limited availability. However, balanced against this is the fact that it does not expose the patient to potentially harmful ionising radiation or to adverse reactions from iodinated contrast media.

MRI is not indicated for screening of asymptomatic or mildly symptomatic patients because of the present lack of understanding of the range of 'normal ageing' appearances, and their lack of correlation with patient management and outcome.

MRI images depend on complex, widely variable and, as yet, incompletely understood parameters. There is concern that this may result in false positive diagnoses, especially where MRI is used alone as a screening test, or used as the initial test.

An alternative view, especially in the USA, is that as MRI is more sensitive than other methods in the detection of most structural macroscopic disease of brain and spine, it should be used as the initial imaging test, with any abnormal results being further characterised by CT or other tests. In view of the current Australian availability (6 MRI units and nearly 200 CT units) and cost (MRI examinations cost 3-4 times as much as CT examinations) and the sometimes limited therapeutic impact, this approach is not supported. Future significant changes in costs, accuracy or therapy would require review of this position.

For several reasons (availability, cost, medical and diagnostic efficacy), the specific comments on indications for MRI which follow are based upon the assumption that MRI is a tertiary and complementary imaging examination, requested only by independent specialists for appropriate indications.

OTHER GENERAL POINTS

Contrast enhancement in MRI

- Paramagnetic contrast agents such as gadolinium - DTPA may improve both sensitivity and specificity of MRI in particular disease situations (eg meningeal disease, meningioma, spinal tumour).

- These contrast media are not yet commercially available in Australia except under research conditions.

Patient acceptance of MRI

- While a significant proportion of patients find an MRI examination to be unpleasant, less than 1% have refused it due to claustrophobia.

Patient safety

- The presence of heart pacemakers, ferromagnetic intracranial aneurysm clips, and ferromagnetic foreign bodies in the orbit are the only absolute contraindications to MRI examination.

- Metallic surgical prostheses cause local image artefact but have not caused heating or other problems.

- The local environment of the MRI magnet and examination room must be restricted to exclude loose metallic objects so that these do not become projectiles in the magnetic field.

Other than these contraindications and necessary precautions, no hazards to patients from MRI as a result of exposure to magnetic fields and radiofrequency radiation have been demonstrated.

MRI in Pregnancy

The risk to the fetus from MRI is unknown, and while no data suggesting hazard have been published, its use in examination of pregnant women is not recommended.

B) SPECIFIC APPLICATIONS OF MRI

MRI OF THE BRAIN

MRI of Brain Tumours

i) **Hemispheric (Supratentorial) Tumours**

Technically adequate CT can be as accurate as MRI and is the preferred examination. MRI is only required if CT is negative or equivocal and strong clinical suspicion persists. The major limitations of MRI are inaccuracy with calcified lesions or with subarachnoid space disease, and difficulty in distinguishing between tumour, oedema or other lesions. Small and/or calcified meningiomas may not be readily demonstrable by MRI.

ii) **Brainstem, Pituitary, Cerebello-Pontine Angle, Skull Base and Foramen Magnum Tumours**

MRI is preferred as the initial imaging examination as it is most accurate method, and also provides multiplane images for management purposes.

iii) MRI may be useful for multiple plane display of already diagnosed tumour for surgical or other management.

MRI of Cerebrovascular Disease

i) **Acute stroke management** usually requires CT alone as an imaging procedure. MRI is not usually necessary.

ii) **Mid-brain/Posterior Fossa Stroke** is more accurately diagnosed by MRI if imaging is required for patient management.

iii) **Cerebrovascular Malformations** are usually accurately shown by CT, with the exception of 'cryptic' or cavernous haemangiomas when MRI is more accurate and is the preferred examination.

iv) **Lacunar Type Lesions** are most accurately shown by MRI, especially in mid-brain and brain-stem, when imaging is required for clinical management.

MRI in Multiple Sclerosis (MS)

i) **Clinically Definite MS**

- MS is primarily a clinical, not an imaging diagnosis

- MRI is not usually required for confirmation of a clinically definite diagnosis.

- If an imaging procedure is required, MRI is the procedure of choice.

- CT is adequate to exclude other differential diagnoses, if necessary.

ii) **Clinically Possible or Probable MS**

- MRI is the imaging examination of choice to confirm clinically possible/probable diagnosis when this is necessary for management.

- However, abnormalities shown by MRI are not specific for MS. Both false negative results (especially in younger age groups or early in disease course) and false positive results (especially in older age groups) occur.

MRI in other Demyelinating Diseases

- Where clinical selection is possible MRI is the preferred examination, but in practice an indefinite clinical presentation will result in an initial CT examination, with MRI for additional information.

MRI in Temporal Lobe Epilepsy (Complex Partial Seizures)

- MRI is the preferred examination especially where surgical management is under consideration.

- CT is usually sufficient for other forms of epilepsy.

MRI in Acute Cerebral Trauma

- CT is the preferred examination because of its greater accuracy in detection of acute haemorrhage and because of the difficulties of managing sick or restless patients in the MRI unit.

MRI in Dementia

- This is a clinical diagnosis and if imaging is required, CT is adequate. MRI is at present considered a research investigation only.

MRI in Subarachnoid Haemorrhage

- MRI is not indicated.

MRI in CNS Infection (Cerebritis, Encephalitis, AIDS)

- MRI is more accurate than CT and is the preferred examination.

- MRI is not accurate in detection of meningitis, meningeal infiltration or disease of any aetiology. Contrast enhanced CT is preferable.

MRI of Orbits

- CT is the preferred examination, as movement artefacts reduce MRI image quality and accuracy.

MRI of Congenital Disease and Obstructive Hydrocephalus

- MRI is the preferred examination for third ventricular, aqueduct or foramen magnum lesions. Its value in the so-called 'normal pressure hydrocephalus' is not proven.

MRI of Difficult Diagnostic Problems

- MRI may be indicated when diagnostic results of CT or angiography or other tests conflict with experienced and appropriate specialist medical opinion.

MRI OF THE SPINE

The sagittal display possible with spinal MRI is a major advantage over CT and the avoidance of spinal injections a major advantage over myelography.

Syringomyelia and Congenital Disorders

- MRI is the preferred examination and is able to replace both myelography and CT.

MRI of Spinal Tumours

i) Surface coils, suppression of motion artefacts and a complete T1 to T2 range of images are necessary for adequate MRI of spinal tumours. Different types of MRI unit with varying field strengths may different image quality and accuracy and thus reliability in diagnosis of spinal tumours.
Technically inadequate or equivocal studies should always be complemented by conventional myelography and/or CT.

ii) MRI is, in the most favourable circumstances, able to accurately show cord, subarachnoid space, and adjacent extrathecal tissues, and is then able to replace myelography and/or CT and be the initial and only imaging test.

iii) MRI is well suited to the demonstration of extradural metastatic cancer, where it avoids painful multiple spinal injections, and is able to show multiple sites of involvement. Availability of MRI units is the major limitation for this presentation - diagnosis and treatment is required on presentation to avoid acute spinal compression and irreversible paraplegia.

Accurate localisation of the level of the disease is desirable to avoid unduly prolonged MRI examinations.

iv) MRI of small or multiple subarachnoid tumours (eg 'drop' metasteses) is not as accurate as myelography. Gadolinium enhancement may improve MRI accuracy.

MRI of Cervical Myelopathy

- MRI is accurate in identifying the level and extent of cord compression and is able to replace myelography or CT.

MRI of Cervical Radiculopathy

- CT/myelography is the examination of choice as MRI is as yet unable to consistently identify nerve roots adjacent to dense bony osteophytes.

MRI of Low Back Pain and Sciatica

- Technically adequate CT is as accurate as MRI for lumbar disc protrusion and is the examination of choice. MRI may be useful if CT is equivocal and clinical suspicion is strong.

- Low back pain alone is not an indication for MRI or CT as they seldom contribute to patient management.

- Post-surgical 'failed back' examination for the differentiation of recurrent disc or fibrosis is inaccurate by both CT and MRI.

- Evaluation of disc degeneration by MRI is at present of questionable value, as the significance of signal alterations, especially in older age groups, is unknown.

MRI OF ABDOMEN

- MRI has a limited role. It is a complementary test when the many other available tests are equivocal and strong clinical suspicion exists. It is not a primary diagnostic method. MRI image quality is degraded by motion artefact in this region.

MRI of Liver

- The role of MRI is still being established. Other tests are often more accurate, and there are conflicting reports of MRI adequacy.

- High field MRI effectiveness is poor due to motion artefacts, but it may be accurate in characterising benign haemangioma of liver and in excluding multiple metastases when surgery is planned.

- Mid field MRI may be less prone to motion artefacts, and may prove to be as accurate as any other test for metastatic disease.

MRI of Kidney

- CT is the preferred method of examination. MRI of kidney may be useful to show renal vein extension in already diagnosed cancer of the kidney.

MRI of Adrenals

- CT is the preferred method of examination.

- MRI of adrenals may be able to characterise non-functioning adrenal adenomas and thus alter patient management.

MRI of Abdominal Vessels

- MRI can be useful to define patent or occluded arteries and veins (eg surgical shunts) non-invasively if ultrasound is unavailable or equivocal.

MRI OF THE PELVIS

While MRI can display disease in multiple planes there is still insufficient experience to know if, in comparison with other tests (especially ultrasound and CT), MRI provides any better diagnosis or staging which alters management.

Despite several optimistic overseas reports on the accuracy of MRI for staging purposes, for example in cervical cancer, it is felt that further experience is required before any firm recommendation can be made.

MRI OF THE MUSCULO-SKELETAL SYSTEM

MRI of Joints

- MRI of joint regions (knee, hip, ankle, shoulder, temporomandibular) appears to be accurate in showing diseases of articular cartilages, subarticular bone, and adjacent ligaments, and may be able to avoid or reduce the need for arthrograms and arthroscopy.

MRI of Bones/Marrow

- MRI is accurate in the diagnosis and staging of tumours and infections of bone and bone marrow. Its use is especially of value in patients where other tests are equivocal and there is a strong clinical suspicion.

MRI of the Soft Tissues

- MRI has great potential in the imaging of soft tissues and can demonstrate mass lesions in multiple planes, enabling more precise surgical or therapy planning.

MRI OF THE CARDIOVASCULAR SYSTEM

- At present, MRI of the heart is not indicated as it is unable to produce equal or better diagnostic and management results than the many other current tests (ultrasound, nuclear medicine, angiography).

- Future improvements in gating and pulse sequences will probably provide better images and functional data which will then need to be evaluated against other tests. Overseas reports suggest that congenital cardiac disease, in particular, may then be best studied by MRI.

- MRI is a complementary method of demonstrating pericardial and intra-cardiac tumours.

- MRI may be of value in the diagnosis of aneurysm and dissection.

MRI OF NECK, NASOPHARYNX AND SINUSES

- Multiplanar MRI may be useful for staging cancers of nasopharynx, mouth, etc to show the extent of direct and secondary spread.

MRI IN PAEDIATRICS

- MRI of anatomical regions and diseases, as outlined above, is of equal or greater benefit in paediatrics as it may enable use of invasive alternative tests, such as angiography or myelography, to be avoided. Such tests have potentially greater risks in children than in adults.

- Movement artefact is an increased problem in MRI of children, who frequently require sedation or occasionally anaesthesia.

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APPENDIX A

MRI ASSESSMENT PROJECT

MINIMUM DATA SET

ANALYSIS OF ACTIVITY TO 30 MARCH 1988

1. STATISTICAL DATA ON NUMBER OF SCANS

1.1 Total MRI Scans by Hospital

	RNS	RMH	RAH	PAH	
1986					
August	179 (a)	24 (b)	–	–	
September		117 (b)	–	–	
October	175 (b)	124 (b)	–	–	
November	205	144	–	–	
December	125	169	–	–	
1987					
January	170	160	39 (b)	–	
February	206	165	52 (b)	–	
March	220	168	108 (b)	–	
April	206	183	74	–	
May	170 (c)	198	130	–	
June	117 (c)	206	120	–	
July	280	223	55 (c)	–	
August	234	197	– (c)	–	
September	271	203	63 (c)	–	
October	244	155 (c)	164	49 (b)	
November	129 (c)	203	164	115 (b)	
December	234	203	139	107 (b)	
1988					
January	210	168	115	109	
February	262	229	155	133	
March	302	230	185	166	
	3760	3469	1563	679	9471 (d)
	3939	3469	1563	679	9650 (Scans)

(a) Data were not collected on 179 scans at RNSH during Aug/Sept 1986.

(b) The first three months of operation at each unit are considered to be "pilot".
RNSH and RMH were pilot during Aug/Sept/Oct 1986
RAH was pilot during Jan/Feb/Mar 1987
PAH was pilot during Oct/Nov/Dec 1987

(c) Unscheduled downtime.

(d) Total number of scans on which data were collected (MDS Forms).

MDS Forms are the Minimum Data Set collected during each scan.

1.2 Number of "Active" MRI Scans x Hospital

	RNS	RMH	RAH	PAH	
1986					
November	209	144	-	-	
December	125	169	-	-	
1987					
January	170	160	(Prelim)	-	
February	206	165	(Prelim)	-	
March	220	168	(Prelim)	-	
April	206	183	74	-	
May	170	198	130	-	
June	117	206	120	-	
July	280	223	55	-	
August	234	197	-	-	
September	271	203	63	-	
October	244	155	164	(Prelim)	
November	129	203	164	(Prelim)	
December	234	203	139	(Prelim)	
1988					
January	210	168	115	109	
February	262	229	155	133	
March	302	230	185	166	
	3589	3204	1364	408	8565

Active scans are defined as those performed after the initial period of pilot operation.

1.3 Number of Repeat Scans (% x Hospital)

Patients with	RNS %	RNS Nos	RMH %	RMH Nos	RAH %	RAH Nos
1 scan	94	3112	95	2904	91	1131
2 scans	5	149	4	144	8	94
3 scans	1	31	1	15	1	13
4 scans	–	8	–	4	–	1
Not stated	–	1	–	–	–	–
	100%	3301	100%	3067	100%	1239

Patients with	PAH %	PAH Nos	Total %	Total Nos
1 scan	94	365	94	7512
2 scans	6	22	5	409
3 scans	–	2	1	61
4 scans	–	1	–	14
Not stated	–	–	–	1
	100%	390	100%	7997

The number of patients examined was 7997.

N.B. A patient may require more than one scan, therefore the number of patients examined is less than the total number of scans.

1.4 Scans Completed

	RNS		RMH		RAH	
	%	Nos	%	Nos	%	Nos
MRI Completed	97	3480	96	3088	97	1309
* Not Completed	3	109	4	116	3	55
	100%	3589	100%	3204	100%	1364

	PAH		Total	
	%	Nos	%	
MRI Completed	97	395	97	8272
* Not Completed	3	13	3	293
	100%	408	100%	8565

* Analysis of Scans Not Completed

	RNS	RMH	RAH	PAH	Total
	Nos	Nos	Nos	Nos	
Patient too ill	8	21	5	1	35
Claustrophobia	57	50	34	8	149
Other	44	45	16	4	109
	109	116	55	13	293

2. PATIENT STATUS ANALYSIS

2.1 Inpatient/Outpatient

	RNS %	RMH %	RAH %	PAH %
Inpatient	31	31	29	45
Outpatient	69	69	71	55
	100%	100%	100%	100%

2.2 Source of Referral of Patients

	RNS %	RMH %	RAH %	PAH %
Same Hospital	22	23	38	41
Other Hospital	39	32	33	27
Non-Hospital	39	45	29	32
	100%	100%	100%	100%

2.3 Public/Private Patients

	RNS %	RMH %	RAH %	PAH %
Public	35	53	50	61
Private	65	47	50	39
	100%	100%	100%	100%

2.4 Workers' Compensation Cases

	RNS % (nos)	RMH % (nos)	RAH % (nos)
Workers Comp.	1 (43)	7 (236)	4 (59)
Third Party	0 (8)	2 (57)	1 (12)
Other	99	91	95
	100%	100%	100%

	PAH % (nos)	Total % (nos)	
Workers Comp.	1 (4)	4	342
Third Party	0 (0)	1	77
Other	99	95	8146
	100%	100%	8565

2.5 Patient Mobility Status

Status	RNS %	RMH %	RAH %	PAH %	Total %
Walking	79	78	81	81	79
Wheelchair	8	12	10	8	10
Stretcher	13	10	9	11	11
	100%	100%	100%	100%	100%

2.6 Patient Activity Status

Status	RNS %	RMH %	RAH %	PAH %	Total %
Full activity	55	46	62	42	52
Limited activity	38	41	24	34	38
No activity, manages self	2	4	2	6	3
No activity, domestic support	3	5	3	2	3
No activity, health aid	1	2	0	1	1
Institutional health care	1	2	9	15	3
	100%	100%	100%	100%	100%

2.7 Age of Patients

Age	Males %	Females %	Total %
0	0 (4)	0 (9)	0
1- 9	4	3	3
10-19	11	11	11
20-29	14	16	15
30-39	18	20	19
40-49	19	20	19
50-59	15	13	14
60-69	13	11	12
70-79	5	5	6
80-89	1	1	1
	100%	100%	100%
	(4346)	(4219)	(8565)

2.8 Patient Time in Room Percentage by Region Examined

1. Head

Time(min)	RNS %	RMH %	RAH %	PAH %	Total %
0-30	19	15	8	7	15
31-60	69	58	79	72	67
61-75	9	21	10	10	13
76 +	3	6	3	11	5
	100%	100%	100%	100%	100%

2. Spine

Time(min)	RNS %	RMH %	RAH %	PAH %	Total %
0-30	3	4	5	1	4
31-60	41	49	62	59	47
61-75	27	25	22	21	25
76 +	29	22	11	19	24
	100%	100%	100%	100%	100%

3. Total

Time(min)	RNS %	RMH %	RAH %	PAH %	Total %
0-30	13	10	7	4	10
31-60	59	49	73	63	57
61-75	15	23	13	14	18
76 +	13	18	7	19	15
	100%	100%	100%	100%	100%

3. ANALYSIS OF PATIENT HISTORY DATA

3.1 Symptoms (4951 Head Examinations)

SYMPTOM (ICD-9)	RNSH %	RMH %	RAH %
Epilepsy (345, 780.3)	13	16	16
Paralysis/Weakness (342-344, 780.7)	10	11	12
Headache (784.0)	12	9	10
Eye Disorder (360-379)	10	10	10
Sensation Disturbance (782.0)	7	12	4
Lack of Co-ordination (781.3)	5	7	8
Gait Disturbance (781.2)	5	5	2
Mental Disturbance (290-319)	4	4	4
Dizziness (780.4)	3	4	3
Ear Disorder (380-389)	3	2	13
Speech Disorder (784.5)	2	2	2
Endocrine Disorder (240-279)	2	<1	1
Other/Not Specified	24	18	15

3.2 Signs (4951 Head Examinations)

SIGN (ICD-9)	RNSH %	RMH %	RAH %
Eye Disturbance (360-379)	13	14	9
Paralysis/Weakness (342.344, 780.7)	9	13	11
Lack of Co-ordination (781.3)	9	8	8
Gait (781.2)	2	5	4
Skin Sensation Disturbance (782.0)	4	3	2
Abnormal Reflex (796.1)	3	2	<1
Mental Disturbance (290-319)	2	2	2
Crainial/Neurological Disturbance (350-352)	3	1	4
Ear Disturbance (380-389)	2	2	11
Endocrine (240-279)	2	2	2
Neurological/Hereditary/ Degenerative (330-339)	1	1	1
Epilepsy (345, 780.3)	2	<1	2
Speech Disturbance (784.5)	1	1	1
Peripheral Neuropathy/Myopathy (353-359)	1	<1	-
Normal (V70-9)	4	1	-
Other/Not specified	42	44	43

4. ANALYSIS OF PATIENT MRI EXAMINATIONS

4.1 Region Studied by Hospital (%)

	RNS %	RMH %	RAH %	PAH %	Total %
Head	60	55	66	58	59
Spine	29	22	19	21	25
Other	11	23	15	21	16
	100%	100%	100%	100%	100%

4.2 Comparison with CT (%)

	RNS %	RMH %	RAH %	PAH %	Total %
MRI greatly superior	8	12	10	16	10
MRI superior	37	33	34	38	35
Equal	21	9	28	22	18
CT superior	2	3	3	3	3
CT greatly superior	0	1	-	1	-
* CT not done	32	42	25	20	34
	100%	100%	100%	100%	100%

* Analysis of "CT Not Done"

	RNS	RMH	RAH	PAH	Total
Head	20%	29%	19%	7%	22%
Spine	51%	52%	37%	41%	49%

4.3 Region by CT Availability (%)

1. Head

	RNS %	RMH %	RAH %	PAH %	Total %
CT available	70	69	76	90	72
CT not available	15	6	7	4	10
CT not stated	15	25	17	6	18
	100%	100%	100%	100%	100%

2. Spine

	RNS %	RMH %	RAH %	PAH %	Total %
CT available	46	48	59	58	49
CT not available	8	2	6	1	6
CT not stated	44	50	35	41	45
	100%	100%	100%	100%	100%

4.4 Region by MRI Findings (%)

1. Head

		RNS %	RMH %	RAH %	PAH %	Total %
MRI	Normal	32	39	39	29	36
	Abnormal	65	60	59	71	62
	Equivocal	3	1	2	-	2
		100%	100%	100%	100%	100%

2. Spine

		RNS %	RMH %	RAH %	PAH %	Total %
MRI	Normal	27	24	27	29	26
	Abnormal	68	75	72	71	71
	Equivocal	5	1	1	-	3
		100%	100%	100%	100%	100%

Total

		RNS %	RMH %	RAH %	PAH %	Total %
MRI	Normal	30	34	35	30	32
	Abnormal	66	65	63	70	65
	Equivocal	4	1	2	-	3
		100%	100%	100%	100%	100%

4.5.1 MRI DIAGNOSES (HEAD STUDIES)

ROYAL NORTH SHORE HOSPITAL

	MALES		FEMALES		TOTAL	
	Number	%	Number	%	Number	%
Normal (.12*)	321	31.9	412	35.8	733	34.0
Neoplastic (.3*)	297	29.5	262	22.8	559	25.9
Degen.Dis.White Matter(.87)	70	7.0	172	14.9	242	11.2
Vascular Disorder (.7*)	150	14.9	132	11.5	282	13.1
Congenital/Devel.(.14*)	52	5.2	59	5.1	111	5.1
Trauma Effect (.4*)	44	4.4	42	3.6	86	4.0
Atrophy (.83*)	28	2.8	24	2.1	52	2.4
Hydrocephalus (.82*)	17	1.7	11	1.0	28	1.3
Inflammation Effect (.2*)	11	1.1	9	0.8	20	0.9
Degen.Dis.Grey Matter(.88)	3	0.3	5	0.4	8	0.4
Other	13	1.3	23	2.0	36	1.7
Total	1006	100.0	1151	100.0	2157	100.0

4.5.2 MRI DIAGNOSES (HEAD STUDIES)

ROYAL MELBOURNE HOSPITAL

	MALES		FEMALES		TOTAL	
	Number	%	Number	%	Number	%
Normal (.12*)	321	35.7	419	41.9	740	39.0
Degen.Dis.White Matter(.87)	97	10.8	186	18.6	283	14.9
Neoplastic (.3*)	174	19.4	146	14.6	320	16.9
Vascular Disorder (.7*)	145	16.1	122	12.2	267	14.1
Congenital/Devel.(.14*)	40	4.4	39	3.9	79	4.2
Atrophy (.83*)	38	4.2	27	2.7	65	3.4
Trauma Effect (.4*)	35	3.9	24	2.4	59	3.1
Hydrocephalus (.82*)	7	0.8	9	0.9	16	0.8
Degen.Dis.Grey Matter(.88)	1	0.1	7	0.7	8	0.4
Inflammation Effect (.2*)	15	1.7	7	0.7	22	1.2
Other	26	2.9	13	1.3	39	2.1
Total	899	100.0	999	100.0	1898	100.0

4.5.3 MRI DIAGNOSES (HEAD STUDIES)

ROYAL ADELAIDE HOSPITAL

	MALES		FEMALES		TOTAL	
	Number	%	Number	%	Number	%
Normal (.12*)	174	39.2	174	38.5	348	38.8
Neoplastic (.3*)	98	22.1	105	23.2	203	22.7
Degen.Dis.White Matter(.87)	52	11.7	73	16.2	125	14.0
Vascular Disorder (.7*)	37	8.3	42	9.3	79	8.8
Atrophy (.83*)	36	8.1	16	3.5	52	5.8
Inflammation Effect (.2*)	6	1.4	12	2.7	18	2.0
Trauma Effect (.4*)	18	4.1	8	1.8	26	2.9
Congenital/Devel.(.14*)	7	1.6	6	1.3	13	1.5
Hydrocephalus (.82*)	4	0.9	5	1.1	9	1.0
Degen.Dis.Grey Matter(.88)	3	0.7	4	0.9	7	0.8
Other	9	2.0	7	1.5	16	1.8
Total	444	100.0	452	100.0	896	100.0
Overall Total	2349		2602		4951	

4.6 Aid to Radiologist

	RNS %		RMH %		RAH %	
Indispensable	13	82%	38	93%	14	93%
Helpful	69		55		79	
No assistance	18		7		7	
Misleading	0		0		0	
	100%		100%		100%	

	PAH %		Total %	
Indispensable	16	84%	23	88%
Helpful	68		65	
No assistance	16		12	
Misleading	0		0	
	100%		100%	

4.7 Test Indication (%)

	RNS %	RMH %	RAH %	PAH %	Total %
Rule out disease	23	16	25	7	20
Disease present, diagnosis uncertain, test for further information	56	68	45	62	59
Plan management	21	16	30	31	21
	100%	100%	100%	100%	100%

APPENDIX B

MRI UNIT QUENCH, ROYAL ADELAIDE HOSPITAL

15th JULY, 1987

The 'quench' process in a superconductive magnet has been described by Morneburg(1) as meaning 'that the magnet windings either completely or partially change over into the normal conducting conditions'. During the process a rapid transfer of energy takes place, creating heat through electrical resistance in the normally conducting state which results in an increase in the evaporation rate of the cryogens, particularly helium. The rate of 'boil off' can be great enough to force out the air in the magnet room, creating a potentially life threatening situation for patients and staff. Where the rate of 'boil off' is controlled, and the escaping gas vented via a quench pipe to the outside atmosphere, there is no danger to life from low oxygen levels in the magnet room.

The incident at Royal Adelaide Hospital is considered to have been a 'controlled' quench and although staff were evacuated there was no indication of low oxygen levels in the magnet room.

The operator noted that the MR imaging sequence aborted with a message at the console and at the same time a staff member who was in the magnet room initiated the audible patient alarm upon hearing 'crackling and whistling' noises around the magnet bore. Ice was observed around the quench pipe due to condensation both inside and outside the magnet room. The section of quench pipe in the roof gave the appearance of 'smoking' due to the cold gas escaping into the warm atmosphere. Within 10 minutes the site engineer confirmed that the magnetic field was lost and the level of cryogens was zero.

Initial attempts were made to keep the magnet cool for possible re-ramping by filling with 1,250 litres of helium and a subsequent 1,000 litres of nitrogen. All of these cryogens were lost to 'boil off' and the integrity of the vacuum space between the various vessels inside the cryostat was questioned.

Following extensive on-site testing a leak was found at the top of the cryostat in the nitrogen vessel. The suspected cause of the quench was therefore considered to be a gradual

loss of vacuum between the vessels resulting in warming of the magnet windings to the critical point where they became normally conductive.

A replacement magnet and cryostat were provided under warranty. Downtime of 57 days was incurred including 16 days leak testing, 30 days for delivery and installation and 11 days to cool, ramp and tune the system.

1. Morneburg H., (1983) Factors in the site determination and planning for a Magnetom. Electromedica. 51: No. 2., 65-72.

APPENDIX C

MRI ASSESSMENT PROGRAM
PUBLICATIONS, CONFERENCE PAPERS

Benness, G, et al (MRI Technical Committee)	Magnetic Resonance Imaging Evaluation: Preliminary Utilization and Application Report. (Med J Australia, in press)
Crowe BL, Hailey DM	Recording of Costs in Public Hospitals' MRI Units - Interim Report, July 1986 - June 1987. Ninth Australian Conference in Health Economics, Canberra, September 1987.
Hailey DM	Evaluation of MRI in Australia: The Interaction of Health Technology Assessment with Government Policy. Meeting of the International Society of Technology Assessment in Health Care, Rotterdam, May 1987.
Blome S	Magnetic Resonance - The Impact on CT Diagnosis in the Central Nervous System. RACR Annual Conference, October 1987.
Davies RP, Sorby WS	MRI - A Paediatric Perspective. RACR Annual Conference, October 1987.
Loneragan R, Doust B, Brazier D	MRI Evaluation of Cerebello - pontine Angle Tumours. RACR Annual Conference, October 1987.
Sorby WS	An Evaluation of Magnetic Resonance Imaging at Royal North Shore Hospital 1986-1987. (In preparation for Med J Australia).

Sorby WS	Overview of MRI in Australia Presentation to MRI Section Meeting RACR Annual Conference, October 1987
Sorby WS	Presentation of Data from the Australia CT and MRI Comparison Study. Paper presented to the Neurosurgical Society of Australasia, August 1987.
Williamson PM, Burgess IA	Magnetic Resonance Imaging and Epilepsy: The Experience of the Royal North Shore Hospital of Sydney. Paper delivered to the Epilepsy Workshop, Austin Hospital, Melbourne 1987.
Wilkinson IA	The Diagnostic Value of Magnetic Resonance Imaging and CT in Convulsive Disorders of Childhood. November 1987.
Storey E	MRI in the Diagnosis of Multiple Sclerosis (Abstract submitted to Clinical and Experimental Neurology, 1988).
Tress BM	MRI in Epilepsy - Epilepsy Workshop. Eds. Donnan GA, Vajda FJE. Proceedings of Workshop held at the Austin Hospital, Melbourne, - November 1987. (In press)
Tress BM, Davis S, Dowling R	An Evaluation of MRI versus CT in the Diagnosis of Posterior Circulation Infarction. Paper presented to the Neurosurgical Society of Australasia, August 1987.

Tress BM	MRI in Intracranial Haemorrhage - Perspectives in Stroke. Eds. Donnan GA, Vajda FJE. Proceedings of Workshop held at the Austin Hospital Melbourne, November 1986.
Lieschke GJ, Davis S, Tress BM, Ebeling P	Spontaneous internal carotid artery dissection presenting as hypoglossal nerve palsy. Stroke (In press).
Condon PM, Robertson AR	Magnetic Resonance Imaging: Project Planning and Management of a Superconductive MRI Installation. (Submitted to Australasian Radiology, April 1988)
Condon PM	Magnetic Resonance Imaging Technology - Seminar Proceedings 6-8 June 1987, Royal Adelaide Hospital, Adelaide.
Condon PM, Robertson AR, Lennon-George J	Magnetic Resonance Imaging and Intracranial Aneurysm Clips. (Submitted to Australasian Radiology)
Condon PM	Report of the Pilot Study into Patient Acceptance of MRI Examinations. Royal Adelaide Hospital, South Australia, August 1987.
Lennon-George J	Introduction to the Basic Principles of Magnetic Resonance Imaging. Royal Adelaide Hospital, South Australia, June 1987.
Robertson AR, Condon PM	Magnetic Resonance Characteristics of Malignant Tissues and Lymph Nodes. (submitted to Australasian Radiology).

Robertson AR	Magnetic Resonance Imaging of the Extremities Australasian Radiology. 1987
Robertson AR, Morris L	General Anaesthesia in Magnetic Resonance Installations. (submitted to Clinical Radiology).
Robertson AR, Alcock M	Magnetic Resonance Imaging of a CT Isodense Colloid Cyst of the 3rd Ventricle (submitted to Clinical Radiology).
Vaughan B , Brown G	Magnetic Resonance Imaging - Physics and Technical Aspects. Royal Adelaide Hospital, South Australia, 1987.

APPENDIX D

1 ORGANISATION OF THE PROGRAM

The MRI Program involves operation of five MRI units in public hospitals and the evaluation of the cost utilisation and efficacy of the technology over a period of two years at each unit. Some details of the five units are given below.

INFORMATION ON THE UNITS IN THE MRI PROGRAM

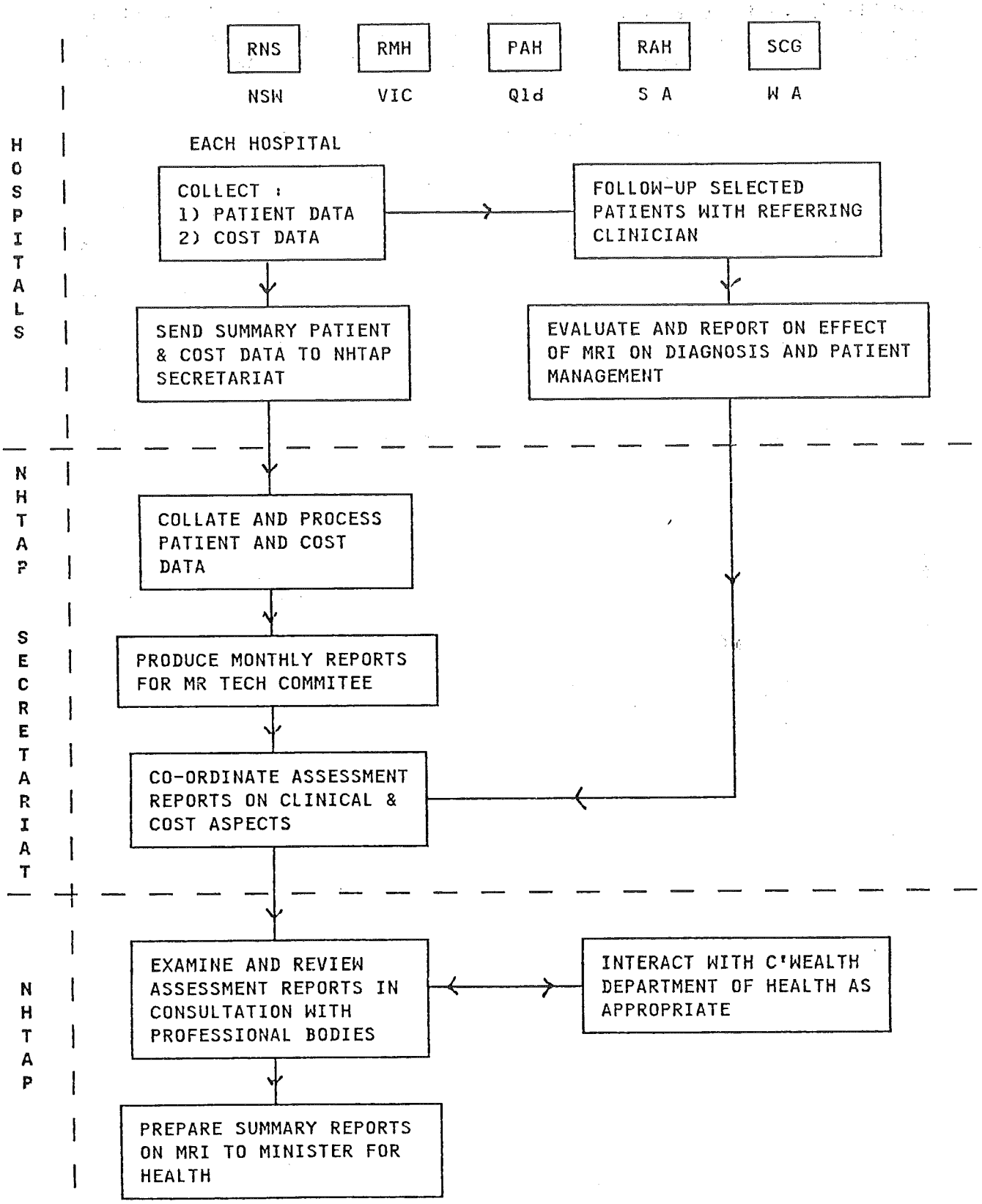
State	Hospital	MRI Unit	Date of Start Up
NSW	Royal North Shore Hospital	GE 1.5T	August 1986
Vic	Royal Melbourne Hospital	FONAR 0.3T	August 1986
SA	Royal Adelaide Hospital	SIEMENS 1.0T	January 1987
Qld	Princess Alexandra Hospital	FONAR 0.3T	September 1987
WA	Sir Charles Gairdner Hospital	PHILIPS 1.5T	April 1988

The program is a joint project between the Commonwealth and State Governments. It is co-ordinated by the National Health Technology Advisory Panel (NHTAP) and managed by the Panel's MRI Technical Committee. Administrative support is provided by the NHTAP Secretariat. Organisational structure of the program is outlined on the next page.

The information collected on each patient comprises the Minimum Data Set (MDS). A copy of the MDS form is included in this Appendix.

MRI ASSESSMENT PROGRAM

MRI units provide scans to 20,000 patients over two years



1 MAR 1987

RNS
ROYAL NORTH SHORE HOSPITAL

NATIONAL HEALTH TECHNOLOGY ADVISORY PANEL
MRI ASSESSMENT PROGRAM

NB : Retain form in MRI unit at hospital

Patient's Name

SURNAME INITIALS

A. HOSPITAL IDENTIFICATION DATA

1. Patient's hospital record number: RNS 1

2. Date of MRI examination: (For example 01/07/86) / /

3. Number of previous MRI examinations: (0-9)
(ie has this patient been scanned before, if so how many times)

4. Name of examining radiologist: . . . . . .
(Please use BLOCK LETTERS)
please enter initials

5. Name of referring clinician: . . . . . .

specialty: . . . . . .
(Please use BLOCK LETTERS)
3 digit specialty code, eg 009
see alphabetical master list

B. PATIENT DATA

6. Patient status:
(Please tick appropriate box)

THIS HOSPITAL 1	OTHER HOSPITAL 2	NON-HOSPITAL 3
PUBLIC PATIENT 1	PRIVATE PATIENT 2	
IN-PATIENT 1	OUT-PATIENT 2	

7. Is patient entitled to:

	YES	NO
Worker's compensation	Y	N
Third party	Y	N

8. Patient's address, Suburb: . . . . . .

State: . . . . . Postcode

9. Patient's age: (for example 09)

10. Patient's sex: (Enter M or F)

11. Patient's health at time of examination: (Please tick one box)

Full activity (Work/Home/School/Retired)	1
Limited activity due to illness	2
No activity due to illness, but manages self	3
No activity due to illness, needs domestic support	4
No activity due to illness, needs health aid (community nurse etc.)	5
Institutional health care	6

12. Patient mobility: (Please tick one box)

Walking	1
Wheelchair	2
Stretcher	3

13. Regions to be examined: (More than one region may be examined, up to 3 regions. Please score one region if only minor overlap occurs.)

CODE	H=Head	S=Spine	N=Neck	C=Chest	A=Abdomen	P=Pelvis	L=Limbs

Region1 ☐
Region2 ☐
Region3 ☐

14. Was MRI examination completed: (Please tick one box)

Yes ☐ 1 → GO TO Q.16

No ☐ 2

15. Reason for non-completion: (Please tick one box and then go to Q.16 and then go to Q.26)

Patient too ill	1
Claustrophobia	2
Other	3

16. Total patient time in the room: (for example 1:05) ☐:☐☐

C. PATIENT HISTORY

17. Test indication:
(Please indicate MAJOR reason for MRI examination)

Rule out disease, patient possibly normal	1
Disease present, diagnosis uncertain, test for further information	2
Diagnosis already established, more information required for treatment	3

Please give description and ICD number from ICD codebook. Please use BLOCK LETTERS.

18. Major symptom relevant to exam: (If none please code 0.0)

. . . . . .ICD-9-CM ☐☐☐.☐☐

Major sign relevant to exam: (If none please code 0.0)

. . . . . .ICD-9-CM ☐☐☐.☐☐

19. Pre MRI studies:(Only comment on the report from relevant studies)

STUDY	DONE		AVAILABLE		REPORTED FINDINGS		
	YES	NO	YES	NO	NOR	ABNOR	EQUIVOCAL
	(Tick one box)						
	Y	N	Y	N	N	A	E
Ultra Sound	☐	☐	☐	☐	☐	☐	☐
Nuclear Med	☐	☐	☐	☐	☐	☐	☐
X-Ray ☐	☐	☐	☐	☐	☐	☐	☐
CT	☐	☐	☐	☐	☐	☐	☐

X-Ray type	no.
Plain	1
Contrast	2
Myelogram	3
Mammogram	4
Angiogram	5

Please give description and ACR code from ACR codebook. Please use BLOCK LETTERS.

20. Pre MRI diagnosis: Differential Diagnosis

. . . . . .ACR1 ☐☐☐.☐☐☐☐

. . . . . 2 ☐☐☐.☐☐☐☐

. . . . . 3 ☐☐☐.☐☐☐☐

D. MR IMAGING STUDY

21. MRI study:

STUDY	REPORTED FINDINGS			WITH CONTRAST	
	NOR	ABNOR	EQUIVOCAL	YES	NO
	(Tick one box)				
	N	A	E	Y	N
MRI	☐	☐	☐	☐	☐

Please give description and ACR code from ACR codebook. Please use BLOCK LETTERS.
(If unable to determine probability, please enter 0 for Prob Code)

22. MR Imaging report study:

Differential Diagnosis — Prob Code

. . . . . ACR1 [ ][ ][ ].[ ][ ][ ][ ] [ ]

. . . . . 2 [ ][ ][ ].[ ][ ][ ][ ] [ ]

. . . . . 3 [ ][ ][ ].[ ][ ][ ][ ] [ ]

23. Other diagnoses:

Other Diagnosis

. . . . . ACR1 [ ][ ][ ].[ ][ ][ ][ ]

. . . . . 2 [ ][ ][ ].[ ][ ][ ][ ]

SUBJECTIVE ASSESSMENT AT TIME OF MRI DIAGNOSIS

24. Comparison with CT study: (Please tick one box In relation to Q.17)

MRI greatly superior	[ ] 1	CT superior	[ ] 4
MRI superior	[ ] 2	CT greatly superior	[ ] 5
Equal	[ ] 3	CT not done or CT technically inadequate	[ ] 6

25. Aid to examining radiologist in diagnosis: (Rate the effect of MRI in terms of assistance in arriving at a diagnosis. Please tick one box)

Indispensable	[ ] 1	None	[ ] 3
Helpful	[ ] 2	Misleading	[ ] 4

26. MRI Director please sign: . . . . . [ ][ ][ ]

please enter initials

HOSPITAL USE ONLY

Please give description and ACR code from ACR codebook. Please use BLOCK LETTERS.

27. Final diagnosis:

. . . . . ACR1 [ ][ ][ ].[ ][ ][ ][ ]

. . . . . 2 [ ][ ][ ].[ ][ ][ ][ ]

. . . . . 3 [ ][ ][ ].[ ][ ][ ][ ]

28. How final diagnosis determined: (Please tick one box)

Clinical	[ ] 1	Surgery	[ ] 3
Pathology	[ ] 2	Autopsy	[ ] 4