MRI ASSESSMENT PROGRAM

THIRD INTERIM REPORT

A REPORT BY THE

MRI TECHNICAL COMMITTEE

OF THE

NATIONAL HEALTH TECHNOLOGY ADVISORY PANEL

JANUARY 1989

AUSTRALIAN INSTITUTE OF HEALTH

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MRI ASSESSMENT PROGRAM

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EXECUTIVE SUMMARY

- This report presents usage, cost and efficacy data from the MRI Assessment Program, and continues the analysis given in previous publications.

- Analysis has been performed on data from 11,858 examinations relating to 10,796 patients examined by the MRI units at Royal North Shore (RNSH), Royal Melbourne (RMH), Royal Adelaide (RAH), and Princess Alexandra (PAH) hospitals.

- Throughputs for 1987/88 at RNSH and RMH were 2991 and 2441 scans respectively. Recent experience suggests that annual throughputs of 3300 scans at RNSH and 2600 at RMH may be achievable under current operating schedules.

- MRI continued to be used mainly for examination of the head (58%) and spine (26%). Most head examinations (82%) were completed in under 1 hour. The majority of spinal examinations (78%) were completed within 75 minutes.

- Comparisons were made between MRI and CT in 73% of head scans and 50% of spinal scans. In most of these cases MRI was considered to be superior (69%) or equal (27%) to CT, with CT being considered superior in 4% of cases.

- Average costs per scan for July 1987 - June, 1988 not including a component for interest or leasing charges, were $607 at RNSH and $537 at RMH. These costs would reduce to $551 (RNSH) and $504 (RMH) at throughputs of 3300 and 2600 scans/year respectively.

- Average costs per scan at RAH and PAH were $687 and $725 respectively over the period July 1987-June 1988. These costs should decrease as throughput increases at both units.

- Following the completion of the two year assessment period at RNSH and RMH, a separate report has been prepared on the audited cost data from these units.

- A preliminary cost comparison of MRI with other diagnostic procedures for six selected conditions suggests that in these cases MRI may be no more costly than alternative investigations.

- Brief details are given of more detailed follow-up studies being conducted at each MRI unit.

INTRODUCTION

This third interim Report from the MRI Technical Committee of the National Health Technology Advisory Panel (NHTAP) covers the period to the end of July 1988 and continues the presentation and collection of data from the MRI Assessment Program given in earlier publications (1,2). The basis of the Program is the collection of data at each of five MRI units for a period of two years. Basic data collection has now been completed for the first two units at Royal North Shore Hospital (RNSH) and Royal Melbourne Hospital (RMH). Detailed analysis of data from the unit at Sir Charles Gairdner Hospital (SCGH) will be included in subsequent reports.

INFORMATION ON THE UNITS IN THE MRI PROGRAM

State	Hospital	MRI Scanner	Date of Start Up
NSW	Royal North Shore Hospital (RNSH)	GE 1.5T	Aug 1986
VIC	Royal Melbourne Hospital (RMH)	FONAR 0.3T	Aug 1986
SA	Royal Adelaide Hospital (RAH)	SIEMENS 1.0T	Jan 1987
QLD	Princess Alexandra Hospital (PAH)	FONAR 0.3T	Sept 1987
WA	Sir Charles Gairdner Hospital (SCGH)	PHILIPS 1.5T	Apr 1988

Detailed data from patient examinations to 31 July 1988 are contained in Appendix A. A report on the collection of cost data at RNSH and RMH for the financial year 1987/88, following the completion of an audit by Coopers and Lybrand, WD Scott, is included in Appendix B which also contains a preliminary comparison of costs of MRI with those of alternative diagnostic strategies for six selected conditions.

As well as basic patient and cost data collection, follow-up studies are being conducted at each MRI unit. These involve the detailed examination and follow-up of patients in selected categories to further define the usefulness of MRI in diagnosis and management. Results from these studies form the basis of the consensus statement developed by the MRI Technical Committee, which was published in the Second Interim Report (2).

The consensus statement has now been issued as a separate document (3) and is intended as a guide to decisions on the use of MRI in Australia. The Committee continues to hold the views, expressed in the consensus statement, that MRI is a tertiary diagnostic method which should be seen as complementary to other imaging examinations, and requested only by specialists for patients with appropriate indications.

MINIMUM DATA SET ANALYSIS

A feature of the MRI Assessment Program has been the collection of a Minimum Data Set (MDS) on each patient receiving a scan at participating MRI units. The content of the MDS has been described in an initial overview of the program (4). As at 31 July 1988, data on some 13,294 scans had been processed. These included 9362 from RNSH and RMH which had completed collection of the MDS.

Numbers of Examinations

Up to 31 July 1988, some 11,858 "active" scans (Appendix A, 1.2) had been undertaken at RNS, RMH, RAH and PAH. Data from 1436 examinations performed during the first three months of operation at each MRI unit (regarded as a pilot period) will be dealt with separately.

Appendix A contains results of analysis performed on data from scans relating to 10,796 patients, of whom 898 (8%) had two or more scans. The number of completed examinations was 11,430. Some 428 scans (4%) were not completed due to patient discomfort or technical difficulties.

The number of scans performed each month to July 1988 for RNSH, RMH, RAH and PAH is shown in Figure 1. Throughput at RNSH for July 1987 to June 1988 was 2991 scans. The throughput for the period February-July 1988 was 1658 scans, suggesting the possibility of an annual throughput of approximately 3300 scans at that hospital. The RNSH unit operates on a five days per week, two-shift basis plus one shift on Saturday.

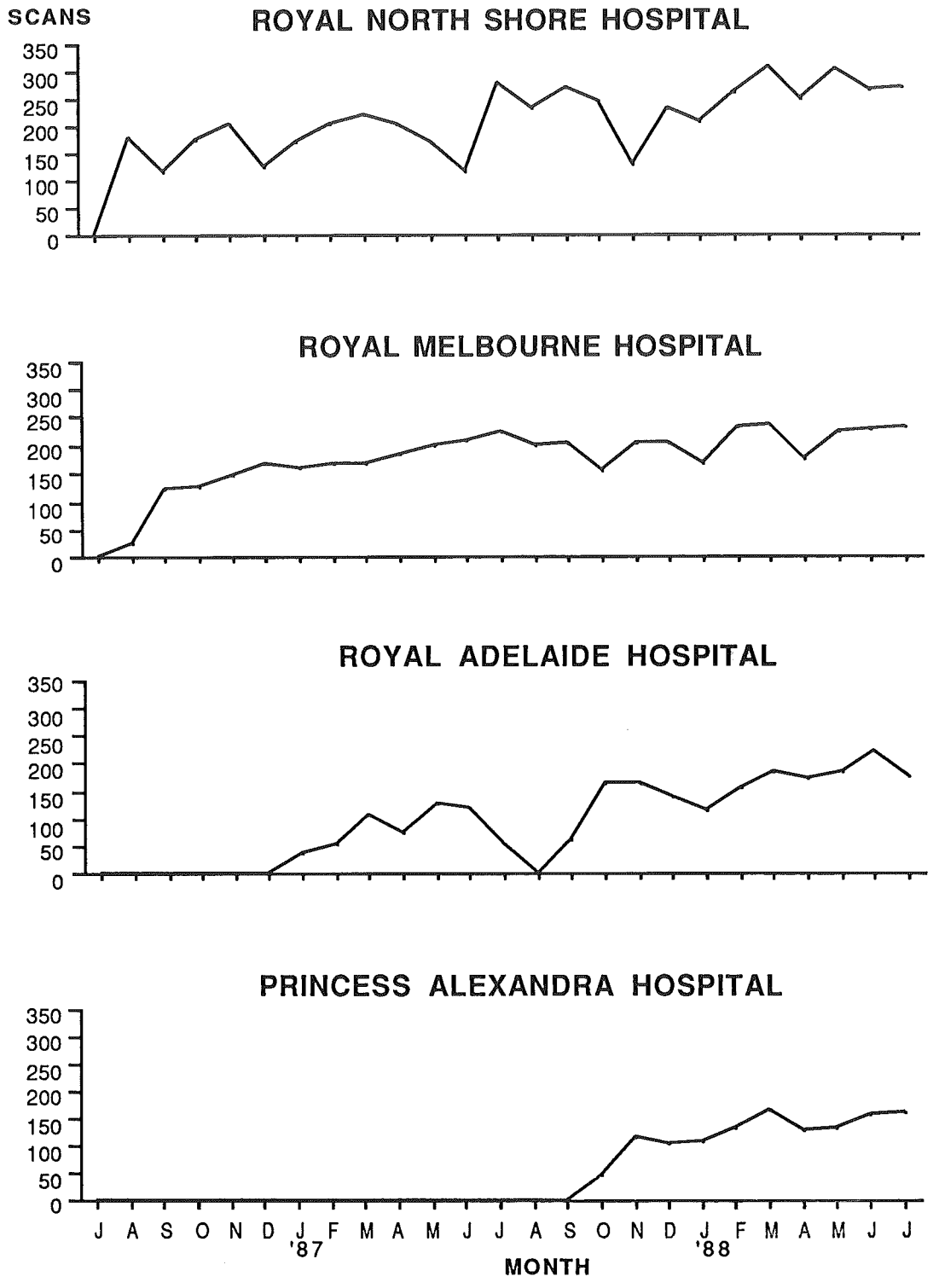
A similar analysis for RMH shows throughput for 1987/88 of 2441 scans with more recent data indicating that an annual rate of 2600 scans per annum may be possible, working on the

basis of an extended single shift for five days per week, plus one shift on Saturday. Both RNSH and RMH have been able to increase throughput in response to an increased demand for services.

The throughput figures for RAH have also increased. For the period February 1988-July 1988, 1094 scans were performed giving an estimated annual throughput of 2200 per annum (single shift basis), and indicating that earlier problems associated with a magnet quench have been overcome. PAH is continuing to operate on a single shift basis and performed 884 scans over the six months to end July 1988.

FIGURE 1

NUMBER OF SCANS PER MONTH AT FOUR MRI UNITS
July 1986 - July 1988



Patient Residence

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

TABLE 1

DISTRIBUTION OF PATIENT RESIDENCE

Patient Residence	Numbers	Percent
RNSH		
Sydney Metropolitan	3153	67
NSW Rural	833	18
Wollongong Region	239	5
Newcastle Region	209	5
ACT Region	137	3
Other	112	2
RMH		
Melbourne Metropolitan	2963	73
Victorian Rural	643	16
Geelong Region	157	4
Tasmania	162	4
Other	139	3
RAH		
Adelaide Metropolitan	1691	80
SA Rural	325	15
Darwin	22	1
Other	80	4
PAH		
Brisbane Metropolitan	470	47
Queensland Rural	328	33
Gold Coast	124	13
NSW Rural	57	6
Other	14	1

In view of the increased demand for MRI services in New South Wales, an analysis of patients scanned at RNSH over the period November 1986 to July 1988 was made to determine the distribution of place of residence in the Sydney Metropolitan Area (Table 2). The residential locations are approximate, as postcodes do not correspond exactly to health regions.

TABLE 2

ANALYSIS OF RESIDENCE OF RNSH PATIENTS FROM SYDNEY METROPOLITAN AREA BY POSTCODE AND HEALTH REGION

November 1986 - July 1988

Health Region	Numbers	%
Northern Sydney	1331	42
Western Sydney	379	12
South Western Sydney	375	12
Southern Sydney	343	11
Central Sydney	286	9
Eastern Sydney	266	9
Wentworth	173	5

Note: Analysis performed by allocating postcode of patient to most appropriate Metropolitan Health Region.

Patient Health Status

An analysis of patient status is provided in Section 2 of Appendix A. The majority of scans (approximately 70%) continued to be performed on outpatients. This usage of MRI reflects a pattern of patients being examined on an outpatient basis whenever possible, thus avoiding the high costs of overnight stays in hospital. A high proportion of patients scanned at RNSH and RMH were from other hospitals, reflecting the regional nature of the service provided by these units. Most patients were classified as mobile having either full activity (54%) or limited activity (35%) reflecting the ambulatory state of the majority who present for MRI scans. By contrast, patients who present at hospital for CT scans, such as accident or stroke cases, are usually critically ill.

The age of adult patients (Section 2-7) was representative of the overall population distribution with 71% of the patients being over 30 years of age. Numbers of paediatric cases continued to be low, with only 4% of patients being under 10 years of age, and 9% under 16.

As differing criteria are used between hospitals for the classification of public and private patients, the figures for this item are indicative only of health insurance status. The number of Workers' Compensation and Third Party Insurance cases continued to be low, amounting to 5% of total patients. The low number (1%) at RNSH may reflect the referral of such cases to a private MRI unit in NSW.

Time of Examination

The time taken for MRI examinations (as measured by patient time in room) continued to decline, with some 19% of head examinations at RNSH and 16% at RMH being completed in under 30 minutes. In comparison, only 7% of head examinations at PAH and RAH, which have less experience, were completed in this time. Spinal cases, which are often more complex examinations involving a number of regions, continued to take longer than head examinations, with 78% being completed in 75 minutes. When all patient examinations are considered, 68% of scans were completed in under one hour, and 86% within 75 minutes. The MRI scan is only one component of the MRI examination. Patient preparation and technical and administrative functions all contribute to the overall time taken.

Patient History

Data on the patients' presenting signs and symptoms for head examinations are in Section 3 of Appendix A. These data are coded by hospital staff on examination of patients in accordance with the International Classification of Disease Code (9th Revision) (ICD-9).

Analysis of the region examined by MRI (Section 4.1) continued to show a dominance of head (58%) and spinal (26%) examinations. However, at RMH examination of other regions, mainly abdomen and joints, rose to 22% of scans. The overall concentration on head and spinal examinations is in accordance with the views of the Consensus Statement on the Clinical Efficacy of MRI (3).

Associated with the selection of patients is the trend shown in the reasons given for the MRI tests being undertaken (Section 4.8). The categories "Disease Present" and "Plan Management" covered 82% of cases as compared with 74% of the cases analysed in the First Interim Report and 80% in the Second Interim Report (1,2). As the demand for MRI scans increases, patients with suspected disease may be more likely to be given priority over patients who are considered to fall into the "Rule Out Disease" category. The increase in the "Plan Management" category from 16% of cases covered in the First Interim Report to 22% of the total at 31 July 1988 may indicate the value of MRI in providing multiple views of anatomy to assist in the management of patients with serious illness requiring surgery.

Examination by Radiologists

Section 4 of Appendix A provides a summary of the findings of the radiologists who performed the MRI examinations. Such findings represent the opinion of the radiologist at the time of the MRI examination and are not a final diagnosis. The

most common finding was MRI abnormal (65%) with a further 3% equivocal. In 32% of cases, no abnormality was detected by the MRI scan at the time of examination. In general, the finding of MRI abnormal in a large proportion of both head (62%) and spinal (72%) examinations reflects the selection of patients considered by referring specialists to have disease and supports their judgements and those of hospital radiologists in giving these patients priority. These abnormal MRI findings have to be confirmed by the referring clinicians who have access to additional information. In the patients selected for MRI examinations of the head (Section 4.5), the most common abnormalities recorded were neoplastic disease, vascular disorder, and degenerative disease involving white matter. These findings reflect the ability of MRI to identify or exclude macroscopic disease.

When data on spinal examinations were considered, a difference was apparent between RNSH and RMH. RNSH (Section 4.6) reported no abnormality detected (NAD) in 30% of such cases and degenerative disc disorder in 26%. RMH reported degenerative disc disorder in 43% of spinal examinations and NAD in 23%. At RMH, a considerable number of patients were referred for MRI scanning when surgery was being considered. In these circumstances, the MRI examination was sought by referring clinicians as an alternative to more invasive procedures such as discography.

The reported distribution of spinal examination data from RAH was similar to that of RMH, while at PAH the most common finding was neoplasm (23%), followed by degenerative disc disease (22%) and NAD (20%). Further analysis of spinal examinations will be included in later reports.

Comparisons between MRI and relevant CT examinations were made by the examining radiologists in 73% of head scans and 50% of spinal scans (Section 4.3). Comparisons were not possible in those spinal examinations where the alternative examination was a myelogram or a discogram (rather than CT). In the cases where a relevant CT examination was available, (Section 4.2.2), 69% of MRI examinations were considered to be superior to CT and 27% to be equally good. CT was considered superior to MRI in 4% of cases. These judgements represent the views of radiologists at the time of the MRI examination, before the final diagnosis was available. Overall, radiologists (Section 4.7) considered that the MRI examination was either indispensable or helpful in 88% of cases (RNSH 81%, RMH 94%, RAH 92%, PAH 90%).

In summary, it appears that a pattern of use of MRI is emerging at the units which have completed the two year assessment period (RNSH, RMH). When specialists consider that MRI can provide useful information, they refer patients with suspected disease to the units for MRI scans.

The majority of patients are then reported as abnormal and most MRI scans are considered to be superior to CT (when available and relevant) and indispensable or helpful in arriving at the radiological diagnosis.

COST DATA ANALYSIS

Comparative cost data on the four MRI units for financial year 1987/88 are included in this section. Data on the SCGH unit will be considered in future reports.

Operating Costs

The approach taken in the collection of cost data has been to treat the MRI units in a consistent manner. This has presented some difficulties, given that the units have differences in operating structures and staffing. Comparisons of the cost of MRI services depend to an extent on the costing methods used by individual hospitals. This appears particularly to be the case when indirect costs are considered. The reasons for variation in methodology in the collection of indirect costs between public hospitals seem complex and deserve further study. However, indirect costs are only a component of overall costs and variations between hospitals in this area do not greately affect the overall cost structures.

The Technical Committee has adopted the following approaches, recommended by Coopers and Lybrand, W D Scott, who have been consultants to the committee for cost data collection procedures.

(1) where maintenance has been included in the capital purchase price, following the manufacturer's policy of providing the first year's maintenance "free", it has been decided to deduct the equivalent figure for one year's maintenance from the capital cost and to show the first year's maintenance as an operating cost, thus reducing the amount which is depreciated over five years. This decision was influenced by the fact that the evaluation program was being conducted over a two year period and it was considered important to reflect realistically the cost of maintenance of capital equipment in the analysis;

(2) because of the differing contracts for the supply of cryogens at the two sites operating superconductive machines (RNSH and RAH) it has been decided to leave the costs of the first year's cryogens in the original capital cost and to collect cryogen costs from the date when the hospitals actually commenced payment for cryogens;

(3) depreciation is calculated on a straight line basis, the equipment over five years and the site over ten years. In the case of RMH and PAH where modifications were made to existing buildings, a notional annual rental of $200 per square metre has been added to the site costs to provide comparability with the purpose-built sites at the other units. Interest and leasing charges associated with the acquisition of capital equipment have not been included as the machines were funded through government grants; and

(4) specialist salaries have been adjusted to include private practice allowances, where appropriate. This approach is based on the premise that the salary costs recorded should reflect the actual cost of recruiting and retaining a specialist in a public hospital.

The operating costs for the four MRI units for the period July 1987 - June 1988 are shown in Table 3 and Figure 2.

TABLE 3

COST DATA FOR FOUR MRI UNITS
JULY 1987 - JUNE 1988

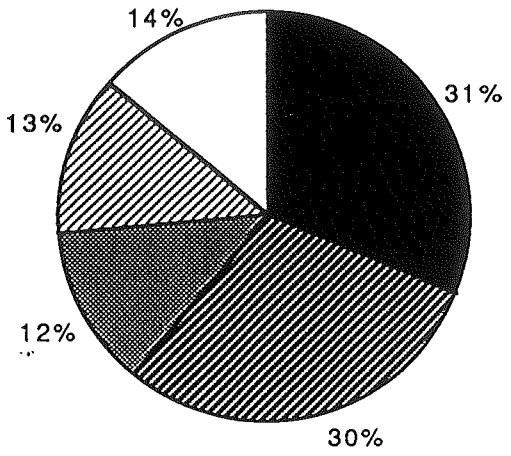
	RNSH	RMH	RAH(a)	PAH(b) (9 mth only)
	$	$	$	$
Depreciation - site and equipment	573,061	602,014	489,684	426,797
Salaries and allowances	537,181	380,494	173,979	183,377
Maintenance	225,862	107,500	159,183	74,997
Variable Costs	230,208	88,714	136,664(c)	50,706
Indirect Costs	250,521	132,818	153,514	63,669
	1,816,833	1,311,540	1,113,024	799,546

(a) Expenditure at RAH reduced due to shut down during during July - September 1987.
(b) PAH operational October 1978 - June 1988
(c) RAH cryogen costs cover period March - June 1988 and include a component for freight from Sydney to Adelaide.

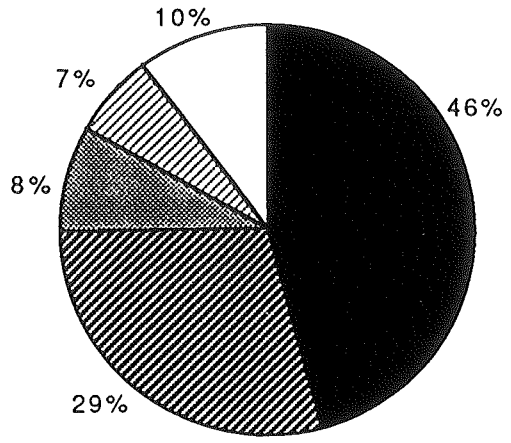
FIGURE 2

COST DATA ANALYSIS AT FOUR MRI UNITS
July 1987 - June 1988

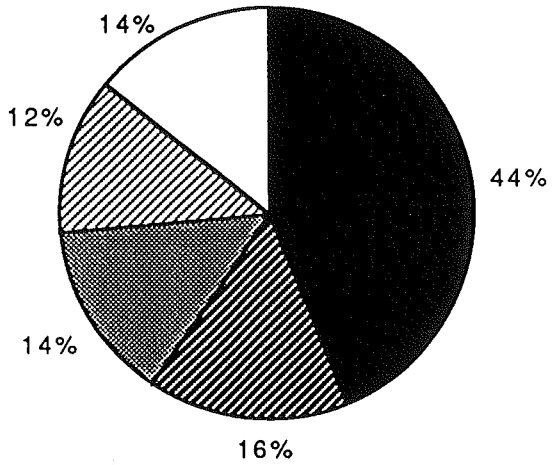
ROYAL NORTH SHORE HOSPITAL



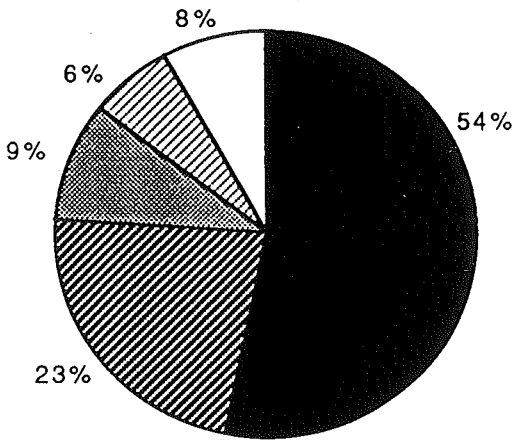
ROYAL MELBOURNE HOSPITAL

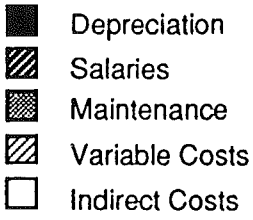


ROYAL ADELAIDE HOSPITAL



PRINCESS ALEXANDRA HOSPITAL





Depreciation of Site and Equipment

The variations in the figures for depreciation reflect the differing capital costs of the MRI units. The depreciation amount for PAH for 12 months would be $569,063.

Depreciation of capital and site costs represent a fixed overhead. The greater the number of MRI scans performed, the less the depreciation component will contribute to the average cost per scan.

Salaries and Allowances

Salaries continued to vary widely between the units. RNSH operates on a two shift basis and employs two radiologists, whereas RMH operates an extended single shift plus Saturday, employing one radiologist.

RAH makes sessional payments to visiting medical officers rather than employing a radiologist associated specifically with the MRI unit, which accounts for the lower salary figure for that unit. Also, the RAH unit was shut down during July-September 1987, during which time specialist salaries were not paid.

PAH salaries for radiologists are calculated on the basis of half the salaries of two hospital radiologists and do not include a significant private practice component. The total salary cost will continue to vary widely between units, the variation representing differing State awards, methods of remuneration, numbers of private patients scanned, numbers of staff employed, and hours of operation.

Maintenance

Maintenance costs vary with the type of MRI unit and the maintenance policies of each supplier. In addition, RNSH has an "out of hours" maintenance contract to allow more time for scanning of patients during the working week which costs an additional $90,000 per annum. The resistive MRI units (RMH, PAH) have lower maintenance costs of the order of $100,000 for a full year.

Variable Costs

Variable costs for the period are shown in Table 4. The major difference in variable costs between the four MRI units is the cost of cryogens for the superconductive MRI units at RNSH and RAH. RNSH variable costs include $140,000 for cryogens. The RAH unit commenced paying for cryogens in March 1988 and incurred an expenditure of $51,472 for the period March-June 1988. It is anticipated that a full years'

cryogen costs at RAH will be of the order of $160,000 per annum, a higher figure than that for RNSH due in part to additional delivery charges to Adelaide.

The consumption of electricity at the four units shows wide variation. The cost of electricity might be expected to be higher for the resistive MRI units at RMH and PAH. However, the machines can be switched off when not in use, whereas the superconductive MRI machines (RNSH, RAH) require continuous power.

TABLE 4

PRELIMINARY OPERATING EXPENDITURE DATA FOR FOUR MRI UNITS FOR JULY 1987 - JUNE 1988

	RNSH	RMH	RAH	PAH (a) (9 months only)
	$	$	$	$
Film	58,206	30,245	48,012	26,008
Film Processing	4,754	-	1,341	5,576
Electricity	5,634	17,346	27,565	8,913
Cryogens	140,000	- (b)	51,472(c)	- (b)
General Supplies/Spares	17,338	34,999	2,454	1,285
Other	4,276	6,124	5,820	8,924
	230,208	88,714	136,664	50,706

(a) PAH operational from October 1987-June 1988
(b) Cryogens not used at RMH or PAH
(c) Cryogens provided under purchase contract at RAH during July 1987-February 1988. Cryogen costs shown cover period March - June 1988 and include a component for freight from Sydney to Adelaide.

The RMH machine is similar to the PAH machine (Fonar) but operates for a longer period and this is reflected in the differing costs of electricity. The RAH figure for electricity appears high, given that the magnet is cooled by cryogens. There are additional electricity costs associated with air conditioning of the MRI suite at that hospital, and these will be subject to further monitoring.

Although there are differences in variable costs between the MRI units these amount to only 6-7% of total costs for resistive units and 12%-13% for superconductive units.

Indirect Costs

Indirect costs represent an allocation of hospital overheads associated with the operation of MRI units in a public hospital environment. These costs are based on figures published in the annual reports of the hospitals and include allowances for such items as office staff, administrative overheads, engineering, catering and laundry. The variation in these costs reflects the particular operating and administrative structures at each hospital.

Average Cost Per Patient MRI Scan

A comparison of average costs per scan for the four MRI units for the period July 1987 - June 1988 is shown in Table 5.

TABLE 5

AVERAGE COST PER SCAN AT FOUR MRI UNITS

JULY 1987 - JUNE 1988

	RNSH	RMH	RAH(a)	PAH(b)
Number of Months	12	12	12	9
Number of Scans	2991	2441	1619	1102
Average cost per Scan (c)	$607	$537	$687	$725

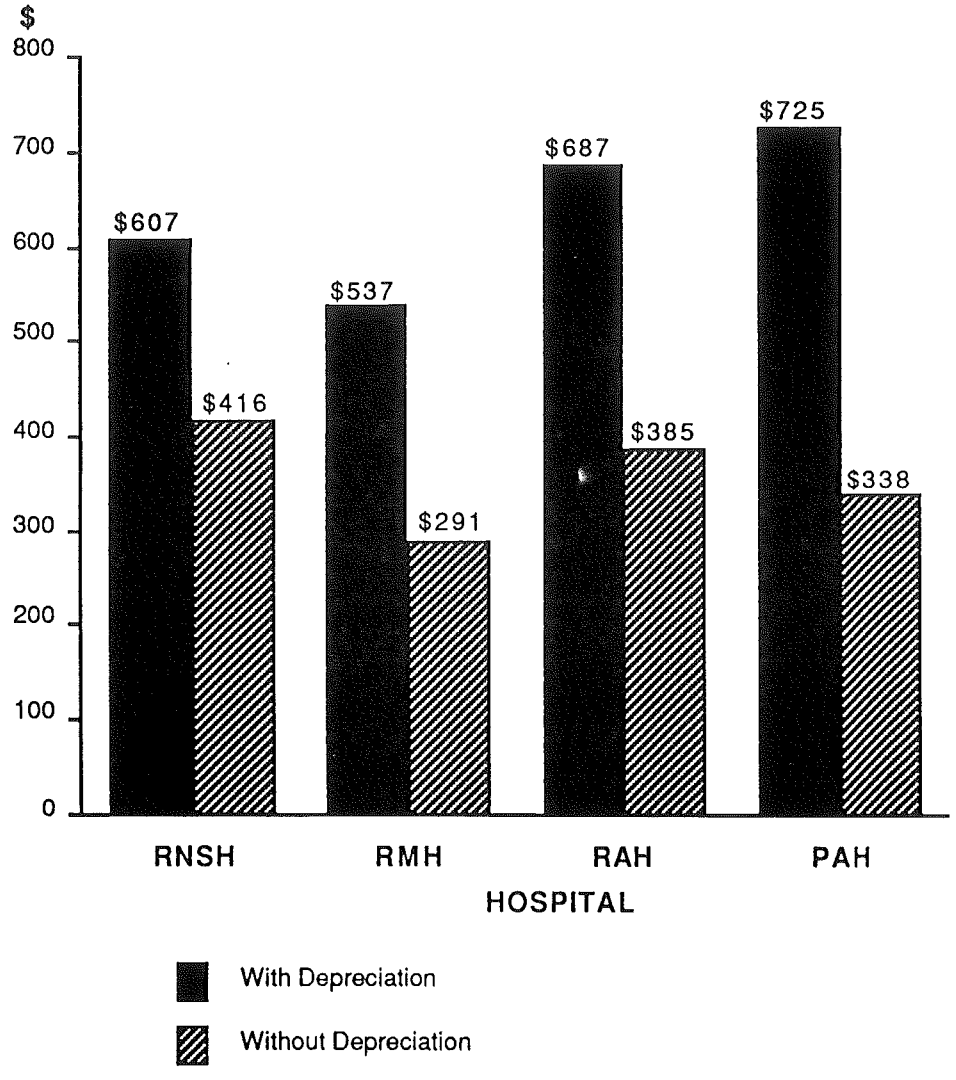
(a) RAH experienced unscheduled downtime during July-September 1987,
(b) PAH commenced operation in October 1987.
(c) Average cost per scan calculated by dividing total costs (Table 3) by number of scans.

If the costs of depreciation are ignored, the average costs per scan at each unit were RNSH $416, RMH $291, RAH $385 and PAH $338. The average costs per scan with and without depreciation are shown in Figure 3. Interest and leasing charges are not included in these figures as the machines were funded through goverment grants.

Average costs per scan varied considerably between the different units. The quench at RAH was the most significant interruption to patient throughput and has resulted in higher average costs per scan at that unit. The PAH average cost reflects the first nine month's experience at that unit and it is anticipated that average costs will decrease as throughput increases. The average cost per scan (Table 5) would reduce to $551 at RNSH and $504 at RMH should throughput rise to 3300 and 2600 scans per annum at these units respectively.

FIGURE 3

AVERAGE COST PER SCAN AT FOUR MRI UNITS
July 1987 - June 1988



FOLLOW-UP STUDIES

Follow-up studies on specific conditions (vertical studies) have continued at each hospital. These studies are intended to further define the usefulness of MRI in diagnosis and management of various diseases and conditions.

Brief details of some of these studies are given below. Further details will be given in publications prepared by staff at the MRI units.

Royal Melbourne Hospital

- MRI in Carcinoma of the Cervix:

  10 patients. The results do not yet support overseas data which suggest that MRI is highly accurate in staging carcinomas of the cervix.

- MRI of the Shoulder Joint:

  17 patients. MRI appears to be relatively sensitive to acute rotator cuff tears (7/9 patients), raising the prospect that it could replace shoulder arthrography for diagnosing that condition. Furthermore, the clear depiction by MRI of atrophy of the associated muscle groups may influence a decision on whether or not to operate on patients with chronic tears.

- MRI in Perthe's Disease:

  Pilot study - 5 patients. MRI is more sensitive than CT in demonstrating bone and cartilage abnormalities on both sides of the hip joint.

- MRI in Coarctation of the Aorta:

  10 patients. Plain MRI studies have proved so effective in the demonstration of the extent of coarctation in children that MRI is now routinely used for post-operative evaluation of the aorta, rather than angiography.

- MRI in Anorexia Nervosa:

  Pilot study - 5 patients. MRI more closely depicts the extent of brain shrinkage than CT and will be used to assess any change in brain size with treatment.

- MRI in Alzheimer's Disease Management:

  10 patients. MRI appears to offer no advantage over CT in the diagnosis of Alzheimer's disease, other than in the elimination of multi-infarct dementia in some cases. Treatment has not yet produced changes detectable by MRI.

- Development and Trial of a Cognitive-behavioural Treatment Package for "MRI Refusers":

  Pilot Study. 4 patients. Elements of systematic desensitisation and modelling are integral to the treatment plan, which includes relaxation training, biofeedback and graded exposure. Initial results are promising.

- The Role of Laboratory and Paraclinical Investigations in the Diagnosis of Multiple Sclerosis:

  137 patients. Retrospective study comparing the usefulness of CSF biochemistry, MRI, and visual evoked responses (VER) in supporting the clinical diagnosis of MS. Oligoclonal bands in the CSF were of the same order of accuracy as MRI with both techniques being far more sensitive than VER.

- Cervical Cord Artefacts in MRI:

  Because a midline stripe seen in many standard sagittal MRI scans of the cervical cord can simulate syringomyelia, experiments in vitro and in vivo were conducted to determine its nature and means of overcoming it. It was confirmed to be a computer-induced truncation artefact, and was overcome by increasing the number of phase encoding levels, phase encoding in an alternative axis, and performing axial scans as well.

- MRI in Renal Transplants:

  Pilot study. 8 patients. MRI shown not to be completely accurate (as suggested by overseas publications) in differentiating rejection from acute tubular necrosis and vascular compromise.

- MRI in the Evaluation of Body Fluids:

  Examination of several fluids in vitro and in vivo have shown that T1 measurements are too variable ($\pm$20%) to aid in the differentiation of urine from pus and cyst fluid.

- MRI in the Evaluation of Disc Degeneration:

  50 patients. Patterns of degeneration of lumbar intervertebral discs in patients presenting with low back

pain and new neurological signs have been completed and will be compared with those of asymptomatic volunteers.

. Normal MRI Appearances of the Lumbar Spine in a Cohort of Twins:

100 asymptomatic male volunteer twins between the ages of 20 and 70 years, comprised of 30 pairs of monozygous and 20 pairs of dizygous twins, together with 100 brothers of the twins, will undergo MRI of the lumbar spine. The range of normal appearances will be established and genetic influences investigated, allowing more scientific assessment of patients presenting with back pain.

Royal Adelaide Hospital

. Use of Gadolinium DTPA:

A study of patients with intracranial neoplasms has been undertaken and a report is being prepared. Further studies are being commenced of tumours in other parts of the body, particularly spine, pelvic and musculo-skeletal areas.

. MRI in Carcinoma of the Prostate:

A study measuring the prostate in three dimensions before and after surgery and correlating this with the weight of tissue removed has been performed and the results are being evaluated.

. MRI in Multiple Sclerosis:

Correlation of data on clinical, CT, MRI and pathological findings from M.S. cases is being undertaken.

. Patient acceptance of MRI (Modified WHO Form):

An ongoing study of 500 patients is being undertaken following on from a pilot study of 100 cases.

Royal North Shore Hospital

. Follow-up of MDS Data

Follow-up data were obtained on 2092 patients examined at the MRI unit. The study showed very high MRI accuracy and significant increment over pre-MRI diagnostic accuracy (64%). Referring clinicians considered MRI helpful in achieving diagnosis in 1512 of 2024 responses, in patient management (935/1466) and in patient outcome (415/1292).

Princess Alexandra Hospital

. Equivocal C.T.:

Comparison of MRI and CT in those patients with a high clinical suspicion of cerebral abnormality and an equivocal CT scan. 106 patients - 88 abnormal : 15 normal : 1 equivocal: 2 no imaging. The radiologists considered that MRI was greatly superior or superior to CT in 85 patients equal to CT in 17, with CT better than MRI in 2 cases. For radiological diagnosis, MRI is considered to have a significant role as a tertiary diagnostic procedure in this category. Evaluation of follow-up reviews will determine if clinicians find MRI to have the same utility.

. Multiple Sclerosis:

Comparison of the accuracy and sensitivity of MR imaging with those of CT and clinical assessment in patients thought to have multiple sclerosis. 157 cases - 99 abnormal : 55 normal : 2 equivocal: 1 no imaging.
In the abnormal cases, radiologists considered that MRI, as compared to CT, was greatly superior in 5 cases, superior in 82 cases and equal in 4 cases. In 8 patients, the CT was not done or was technically inadequate. In the group considered to be normal on imaging, MRI was felt to be superior to CT in 24 cases and equal in 27 cases. General experience would now strongly favour the increased utility of a negative MRI study in suspected MS compared with a negative CT study.

. Basal Space Occupying Lesions:

Comparison of 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.

64 cases - 48 abnormal : 14 normal : 2 equivocal.
In the abnormal group, MRI was considered indispensable in 19 and superior in 12 cases compared to CT, but equal in 13. In 4 cases CT was superior. Subtle bone erosion is still better identified on CT than MRI but is very rarely the only abnormality evident on initial clinical presentation.

. Brain Stem Pathology:

Comparison of diagnostic accuracy of CT and MRI in cases where there is a clinical suspicion of a brain stem lesion. 53 cases - 30 abnormal : 22 normal : 1 no

imaging. Radiologists rated MRI as being better than CT in almost all the abnormal cases and half the normal cases. It was rated as being indispensable in over 30% of the abnormal cases. Early clinical follow-up in 12 cases would suggest that clinicians felt that MRI was either indispensable or helpful in almost all normal cases. These opinions reflect the problems of artefacts in CT of the brain stem and the value of MRI sagittal plane imaging.

. Pituitary Abnormalities:

Comparison of the accuracy of MRI and CT in detection of abnormality and extent of abnormality in patients with pituitary abnormalities either demonstrated on CT or suggested through biochemical evidence. 53 cases - 42 abnormal : 11 normal. MRI was considered to be better than CT in over 95% of cases but only indispensable in 1. The vast majority of cases have been macro-tumours and it would not be possible to identify the radiological utility of MRI in micro-tumours of the pituitary.

. Focal Epilepsy:

Comparison of sensitivity of MRI with CT in diagnosing a structural lesion as a cause for focal epilepsy. These patients would be newly diagnosed and most will have had a normal CT examination. Patients with multiple metastases diagnosed by CT, would be excluded from the group. 39 cases - 17 abnormal: 22 normal. In no case was MRI considered to be inferior to CT. In four cases, only MRI identified abnormal pathology.

. Ventricular Abnormalities:

Assessment of a group of patients suspected of having ventricular or intraventricular abnormalities. 33 cases - 26 abnormal : 7 normal. Although only indispensable on radiological grounds in 2 cases, MRI was consistently considered to be useful in confirming or excluding possible CT-diagnosed pathology, thus significantly raising the level of clinical confidence in both positive and negative findings.

. Acoustic Neuromas:

In cases where CT showed an acoustic neuroma, MRI and CT were compared to assess extent of the tumour. In those cases in which a contrast CT was negative, air cisternography was compared with the MRI examination. 22 cases - 12 abnormal : 10 normal. In no case was MRI considered to be worse than CT and in 2 abnormal cases MRI was considered indispensable. There have been too few cases of purely intracanalicular tumours to know what the

false positive or false negative rates of MRI are compared with those for air cisternography.

. Primary Bone Tumours:

Comparison of MRI data with CT and post operative findings on the tumour site and extent of invasion of adjacent structures. 38 cases - 33 abnormal : 4 normal : 1 no imaging. When comparative CT was performed, in the 33 abnormal cases MRI was considered indispensable in 7 and never of lesser utility than CT.

. Syringomyelia:

Comparison of sensitivity and specificity of CT myelography and MR imaging in patients with suspected syringomyelia. 45 cases - 30 abnormal : 14 normal : 1 no imaging. MRI was considered to be better than CT in almost all cases. In the limited number of clinical follow-ups, the clinicians would agree with this assessment. One large syrinx was "missed" on MRI because only the cervical cord was imaged as requested. The CT protocol found a thoracic syrinx.

Sir Charles Gairdner Hospital

. MRI in the assessment of disc degeneration; comparison of MRI with post discogram CT:

A prospective study in a group of patients who are thought to have pain of disc origin. The patients are initially examined by MRI utilising sagittal T-1 and heavily T-2 weighted sequences in addition to axial T-1 weighted studies. The MRI findings are documented. The patients then go on to have a discogram followed by a discogram CT in a separate institution and the findings of the discogram CT are documented without knowledge of the MRI findings. The MRI studies and the discogram CT studies are then evaluated jointly by the MRI radiologist, the discographer and by the orthopaedic

surgeon in question. Some discrepancies between the two types of examinations are emerging.

. MRI assessment in the evaluation of spinal trauma; comparison with CT:

Patients with longstanding spinal cord trauma, previously investigated by CT, myelography and post myelogram CT have been evaluated with MRI and the two studies are being compared. It is already apparent that MRI is superior to the other imaging techniques, but evaluation is not complete.

- MRI and CT comparison in patients with first seizures:

  A group of patients presenting with their first seizure, with a normal CT and normal clinical examination, are being examined by MRI to define areas of possible parenchymal brain abnormality. Twenty patients have been examined to date and it is apparent that some have abnormalities shown on MRI which are not apparent on CT.

- MRI in the assessment of pituitary tumours:

  Patients with clinical and CT features of a pituitary tumour are being examined by MRI to evaluate its role in this area. Since the commencement of this study patients have not required angiography in the pre-operative work-up of pituitary tumours as information regarding the position of carotid arteries etc. is provided in a non-invasive manner.

- MRI in the assessment of paraplegia of non-traumatic origin:

  A number of patients, previously investigated for paraplegia thought to be on a vascular basis have been examined by MRI. An interesting array of the lesions of the spinal cord have been demonstrated in this group of patients.

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(1) MRI Technical Committee - National Health Technology Advisory Panel.
MRI Assessment Program - First Interim Report.
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MRI Assessment Program - Second Interim Report.
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(3) MRI Technical Committee, National Health Technology Advisory Panel.
MRI Assessment Program - Consensus Statement on Clinical Efficacy of MRI.
Australian Institute of Health, Canberra, May 1988.

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Magnetic Resonance Imaging Evaluation - Preliminary Utilisation and Application Report.
Med. J Aust. 1988; 149: 60-66.

APPENDIX A

MINIMUM DATA SET

ANALYSIS OF ACTIVITY TO 31 JULY 1988

1. DATA ON NUMBER OF SCANS

1.1 Total MRI Scans by Hospital

	RNSH	RMH	RAH	PAH	SCGH	
1986						
August	179 (a)	24 (b)	-	-		
September		117 (b)	-			
October	171 (b)	124 (b)	-	-		
November	209	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	263	230	155	133		
March	309	234	185	169		
April	248	176	172	130		
May	304	221	184	133	87 (b)	
June	265	228	223	157	138 (b)	
July	269	230	175	162	126 (b)	
	4854	4329	2317	1264	351	13,115 (d)
	5033	4329	2317	1264	351	13,294 (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/Oct 1986, RAH during Jan/Mar 1987, PAH during Oct/Dec 1987 and SCGH during May/July 1988

(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 by Hospital

	RNSH	RMH	RAH	PAH	SCGH	
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	263	230	155	133 -		
March	309	234	185	169 -		
April	248	172	130	-		
May	304	221	184	133	(Prelim)	
June	265	228	223	157	(Prelim)	
July	269	230	175	162	(Prelim)	
	4683	4064	2118	993	-	11,858

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

1.3 Number of Repeat Scans (% by Hospital)

Patients with	RNS %	RNS Nos	RMH %	RMH Nos	RAH %	RAH Nos
1 scan	92	3917	92	3458	90	1703
2 scans	6	267	7	269	9	163
3 scans	1	51	1	16	1	27
4 scans	<1	17	<1	5	–	2
5 scans	–	1	–	–	–	–
6 scans		1	–	–	–	–
	100%	4254	100%	3748	100%	1895

Patients with	PAH %	PAH Nos	Total %	Total Nos
1 scan	91	820	92	9898
2 scans	8	68	7	767
3 scans	1	8	1	102
4 scans	–	2	<1	26
5 scans	–	1	–	2
6 scans	–	–	–	1
	100%	899	100%	10796

The number of patients examined was 10,796.

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	
	%	No.	%	No.	%	No.
MRI Completed	97	4540	97	3925	97	2014
* Not Completed	3	143	3	139	3	104
	100%	4683	100%	4064	100%	2118

	PAH		Total	
	%	No.	%	No.
MRI Completed	96	951	96	11,430
* Not Completed	4	42	4	428
	100%	993	100%	11,858

* Analysis of Scans Not Completed

	RNS	RMH	RAH	PAH	Total
	No.	No.	No.	No.	No.
Patient too ill	8	24	9	6	47
Claustrophobia	82	57	72	25	236
Other	53	58	23	11	148
	143	139	104	42	428

2. PATIENT STATUS ANALYSIS

2.1 Inpatient/Outpatient

	RNS %	RMH %	RAH %	PAH %
Inpatient	30	30	27	44
Outpatient	70	70	73	56
	100%	100%	100%	100%

2.2 Source of Referral of Patients

	RNS %	RMH %	RAH %	PAH %
Same Hospital	21	22	36	43
Other Hospital	38	32	34	26
Non-Hospital	41	46	31	31
	100%	100%	100%	100%

2.3 Public/Private Patients

	RNS %	RMH %	RAH %	PAH %
Public	42	52	48	56
Private	58	48	52	44
	100%	100%	100%	100%

2.4 Workers' Compensation Cases

	RNS %	RNS (no.)	RMH %	RMH (no.)	RAH %	RAH (no.)
Workers Comp.	1	(60)	7	(299)	7	(148)
Third Party	0	(10)	2	(76)	2	(32)
Other	99		91		91	
	100%		100%		100%	

	PAH %	PAH (no.)	Total %	Total (no.)
Workers Comp.	1	(12)	4	519
Third Party	0	(1)	1	119
Other	99		5	11,220
	100%		100%	11,858

2.5 Patient Mobility Status

Status	RNS %	RMH %	RAH %	PAH %	Total %
Walking	79	78	84	80	80
Wheelchair	8	12	9	7	9
Stretcher	13	10	7	13	11
	100%	100%	100%	100%	100%

2.6 Patient Activity Status

Status	RNS %	RMH %	RAH %	PAH %	Total %
Full activity	61	47	59	37	54
Limited activity	34	41	27	37	35
No activity, manages self	2	4	3	5	3
No activity, domestic support	2	4	3	3	3
No activity, health aid	1	2	0	1	1
Institutional health care	<1	2	8	17	4
	100%	100%	100%	100%	100%

2.7 Age of Patients

Age	Males %	Females %	Total %
0	0 (7)	0 (11)	0
1- 9	4	3	4
10-19	10	11	10
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	6	5	6
80-89	1	1	1
	100%	100%	100%
	(6040)	(5818)	(11,858)

2.8 Patient Time in Room Percentage by Region Examined

1. Head

Time(min)	RNS %	RMH %	RAH %	PAH %	Total %
0-30	19	16	7	7	15
31-60	69	57	81	69	67
61-75	9	21	9	13	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	7	1	4
31-60	40	49	62	64	48
61-75	28	26	21	19	26
76 +	29	21	10	16	22
	100%	100%	100%	100%	100%

3. Total

Time(min)	RNS %	RMH %	RAH %	PAH %	Total %
0-30	12	10	8	6	10
31-60	58	49	73	61	58
61-75	16	23	14	16	18
76 +	14	18	5	17	14
	100%	100%	100%	100%	100%

3. ANALYSIS OF PATIENT HISTORY DATA

3.1 Symptoms (6993 Head Examinations)

SYMPTOM (ICD-9)	RNSH %	RMH %	RAH %	PAH %
Epilepsy (345, 780.3)	14	16	16	10
Paralysis/Weakness (342-344, 780.7)	9	10	10	11
Headache (784.0)	12	9	11	14
Eye Disorder (360-379)	10	11	9	12
Sensation Disturbance (782.0)	7	12	4	6
Lack of Co-ordination (781.3)	5	7	7	6
Gait Disturbance (781.2)	4	4	3	3
Mental Disturbance (290-319)	4	4	4	4
Dizziness (780.4)	3	3	4	3
Ear Disorder (380-389)	3	3	12	4
Speech Disorder (784.5)	2	2	2	1
Endocrine Disorder (240-279)	2	1	2	1
Other/Not Specified	25	18	16	25

3.2 Signs (6993 Head Examinations)

SIGN (ICD-9)	RNSH %	RMH %	RAH %	PAH %
Eye Disturbance (360-379)	13	14	9	18
Paralysis/Weakness (342.344, 780.7)	6	11	9	12
Lack of Co-ordination (781.3)	9	7	8	9
Gait (781.2)	2	4	3	1
Skin Sensation Disturbance (782.0)	4	5	2	4
Abnormal Reflex (796.1)	2	1	<1	3
Mental Disturbance (290-319)	1	3	2	2
Crainial/Neurological Disturbance (350-352)	3	2	4	4
Ear Disturbance (380-389)	2	3	10	3
Endocrine (240-279)	2	2	2	2
Neurological/Hereditary/ Degenerative (330-339)	1	1	<1	1
Epilepsy (345, 780.3)	3	1	2	1
Speech Disturbance (784.5)	1	1	1	<1
Peripheral Neuropathy/Myopathy (353-359)	1	<1	-	-
Normal (V70-9)	4	1	-	18
Other/Not specified	46	44	48	22

4. ANALYSIS OF PATIENT MRI EXAMINATIONS

4.1 Region Studied by Hospital (%)

	RNS %	RMH %	RAH %	PAH %	Total %
Head	59	55	62	58	58
Spine	29	23	23	21	26
Other	12	22	15	21	16
	100%	100%	100%	100%	100%

4.2.1. Comparison with CT (%)

	RNS %	RMH %	RAH %	PAH %	Total %
MRI greatly superior	7	13	8	13	10
MRI superior	36	38	30	42	36
Equal	21	8	27	21	18
CT superior	2	3	3	3	3
CT greatly superior	0	1	-	1	-
* CT not done	34	37	32	20	33
	100%	100%	100%	100%	100%

4.2.2. Comparison with CT (%) (- Excluding "CT Not Done")

	RNS %	RMH %	RAH %	PAH %	Total %
MRI greatly superior) MRI superior)	64	82	57	70	69
Equal CT superior)	32	13	38	26	27
CT greatly superior)	4	5	5	4	4
	100%	100%	100%	100%	100%

4.3 Region by CT Availability (%)

1. Head

	RNS %	RMH %	RAH %	PAH %	Total %
CT available	69	73	72	91	73
CT not available	15	6	9	4	10
CT not stated	16	21	19	5	17
	100%	100%	100%	100%	100%

2. Spine

	RNS %	RMH %	RAH %	PAH %	Total %
CT available	45	54	57	57	50
CT not available	8	2	7	2	5
CT not stated	47	44	36	41	45
	100%	100%	100%	100%	100%

4.4 Region by MRI Findings (%)

1. Head

		RNS %	RMH %	RAH %	PAH %	Total %
MRI	NAD	33	40	39	30	36
	Abnormal	64	59	58	69	62
	Equivocal	3	1	3	1	2
		100%	100%	100%	100%	100%

2. Spine

		RNS %	RMH %	RAH %	PAH %	Total %
MRI	NAD	27	24	23	25	25
	Abnormal	68	75	75	74	72
	Equivocal	5	1	2	1	3
		100%	100%	100%	100%	100%

Total

		RNS %	RMH %	RAH %	PAH %	Total %
MRI	NAD	30	34	34	29	32
	Abnormal	66	65	64	70	65
	Equivocal	4	1	2	1	3
		100%	100%	100%	100%	100%

NAD = No Abnormality Detected

4.5.1 MRI DIAGNOSES (HEAD STUDIES)

ROYAL NORTH SHORE HOSPITAL

Diagnosis (A.C.R. Code)	MALES Number	%	FEMALES Number	%	TOTAL Number	%
No Abnormality Detected(.12*)	408	31	539	37	947	34
Neoplastic(.3*)	395	30	331	23	726	26
Vascular Disorder (.7*)	188	15	157	11	345	13
Degen.Dis.White Matter(.87*)	91	7	212	15	303	11
Trauma Effect (.4*)	60	5	52	3	112	4
Congenital/Devel.(.14*)	58	5	71	5	129	5
Atrophy (.83*)	36	3	28	2	64	2
Hydrocephalus (.82*)	23	2	12	1	35	1
Inflammation Effect (.2*)	15	1	13	1	28	1
Degen.Dis.Grey Matter(.88*)	5	<1	8	<1	13	1
Other	18	1	27	2	45	2
Total	1297	100	1450	100	2747	100

4.5.2 MRI DIAGNOSES (HEAD STUDIES)

ROYAL MELBOURNE HOSPITAL

Diagnosis (A.C.R. Code)	MALES Number	%	FEMALES Number	%	TOTAL Number	%
No Abnormality Detected (.12*)	417	37	517	41	934	39
Neoplastic (.3*)	226	20	191	15	417	18
Vascular Disorder (.7*)	188	17	148	12	336	14
Degen.Dis.White Matter(.87*)	120	11	230	18	350	15
Congenital/Devel.(.14*)	49	4	52	4	101	4
Atrophy (.83*)	41	3	35	3	76	3
Trauma Effect (.4*)	41	3	34	3	75	3
Inflammation Effect (.2*)	19	2	8	1	27	1
Hydrocephalus (.82*)	8	1	9	1	17	1
Degen.Dis.Grey Matter(.88*)	1	<1	8	1	9	<1
Other	27	2	18	1	45	2
Total	1137	100	1250	100	2387	100

4.5.3 MRI DIAGNOSES (HEAD STUDIES)

ROYAL ADELAIDE HOSPITAL

Diagnosis (A.C.R. Code)	MALES Number	%	FEMALES Number	%	TOTAL Number	%
No Abnormality Detected (.12*)	234	38	262	40	496	39
Neoplastic (.3*)	148	24	157	24	305	24
Degen.Dis.White Matter(.87*)	74	12	89	14	163	13
Vascular Disorder (.7*)	59	9	61	9	120	9
Atrophy (.83*)	45	7	22	3	67	5
Trauma Effect (.4*)	23	4	17	3	40	3
Inflammation Effect (.2*)	11	2	15	2	26	2
Congenital/Devel.(.14*)	9	1	9	1	18	1
Hydrocephalus (.82*)	6	1	6	1	12	1
Degen.Dis.Grey Matter(.88*)	3	<1	4	1	7	1
Other	12	2	12	2	24	2
Total	624	100	654	100	1278	100

4.5.4 MRI DIAGNOSES (HEAD STUDIES)

PRINCESS ALEXANDRA HOSPITAL

Diagnosis (A.C.R. Code)	MALES Number	%	FEMALES Number	%	TOTAL Number	%
Neoplastic (.3*)	105	36	86	30	191	33
No Abnormality Detected (.12*)	84	29	99	34	183	32
Degen.Dis.White Matter(.87*)	21	7	50	17	71	12
Inflammation Effect (.2*)	15	5	5	2	20	3
Vascular Disorder (.7*)	18	6	17	6	35	6
Trauma Effect (.4*)	16	5	7	2	23	4
Congenital/Devel.(.14*)	12	4	12	4	24	4
Atrophy (.83*)	9	3	5	2	14	2
Degen.Dis.Grey Matter(.88*)	2	1	0	0	2	<1
Hydrocephalus (.82*)	1	1	2	1	3	1
Other	9	3	6	2	15	3
Total	292	100	289	100	581	100
Overall Total	3350		3643		6993	

4.6.1 MRI DIAGNOSES (SPINE STUDIES)

ROYAL NORTH SHORE HOSPITAL

Diagnosis (A.C.R. Code)	MALES Number	MALES %	FEMALES Number	FEMALES %	TOTAL Number	TOTAL %
No Abnormality Detected (.12*)	202	28	198	32	400	30
Degenerative Disc Disorder (.77*,.78*)	191	26	165	27	356	26
Syrinx (.368*)	67	9	63	10	130	10
Neoplasm (.3* not .368*)	59	8	55	9	114	8
Congenital/Devel.(.14* - .19*)	50	7	46	7	96	7
Post Operative Complication (.45*)	34	4	39	6	73	5
Trauma (Fractures & Dislocations) (.45*)	28	4	8	1	36	3
Other	99	14	48	8	147	11
Total	730	100	622	100	1352	100

4.6.2 MRI DIAGNOSES (SPINE STUDIES)

ROYAL MELBOURNE HOSPITAL

Diagnosis (A.C.R. Code)	MALES Number	MALES %	FEMALES Number	FEMALES %	TOTAL Number	TOTAL %
Degenerative Disc Disorder (.77*,.78*)	286	46	189	39	475	43
No Abnormality Detected (.12*)	116	19	145	30	261	23
Syrinx (.368*)	78	12	46	9	124	11
Neoplasm (.3* not .368*)	46	7	26	5	72	6
Post Operative Complication (.45*)	26	4	25	5	51	5
Trauma (Fractures & Dislocations) (.45*)	13	2	8	2	21	2
Congenital/Devel.(.14* - .19*)	12	2	12	2	24	2
Other	53	8	38	8	91	8
Total	630	100	489	100	1119	100

4.6.3 MRI DIAGNOSES (SPINE STUDIES)

ROYAL ADELAIDE HOSPITAL

Diagnosis (A.C.R. Code)	MALES Number	MALES %	FEMALES Number	FEMALES %	TOTAL Number	TOTAL %
Degenerative Disc Disorder (.77*,.78*)	137	50	88	40	225	46
No Abnormality Detected (.12*)	66	24	54	25	120	24
Congenital/Devel.(.14* - .19*)	17	6	12	5	29	6
Neoplasm (.3* not .368*)	14	5	20	9	34	7
Syrinx (.368*)	13	5	16	7	29	6
Post Operative Complication (.45*)	6	2	10	5	16	3
Trauma (Fractures & Dislocations) (.45*)	6	2	6	3	12	2
Other	17	6	14	6	31	6
Total	276	100	220	100	496	100

4.6.4 MRI DIAGNOSES (SPINE STUDIES)

PRINCESS ALEXANDRA HOSPITAL

Diagnosis (A.C.R. Code)	MALES Number	MALES %	FEMALES Number	FEMALES %	TOTAL Number	TOTAL %
Neoplasm (.3* not .368*)	34	26	10	17	44	23
Degenerative Disc Disorder (.77*,.78*)	28	21	14	24	42	22
No Abnormality Detected (.12*)	23	17	15	25	38	20
Trauma (Fractures & Dislocations) (.45*)	12	9	0	0	12	6
Syrinx (.368*)	10	8	2	3	12	6
Congenital/Devel.(.14* - .19*)	8	6	5	9	13	7
Post Operative Complication (.45*)	5	4	9	15	14	7
Other	12	9	4	7	16	9
Total	132	100	59	100	191	100
Overall Total	1768		1390		3158	

4.7 Aid to Radiologist

	RNS %		RMH %		RAH %	
Indispensable	13)	81%	35)	94%	13)	92%
Helpful	68)		59)		79)	
No assistance	19		6		8	
Misleading	0		0		0	
	100%		100%		100%	

	PAH %		Total %	
Indispensable	13)	90%	21)	88%
Helpful	77)		67)	
No assistance	10		12	
Misleading	0		0	
	100%		100%	

4.8 Test Indication (%)

	RNS %	RMH %	RAH %	PAH %	Total %
Rule out disease	22	12	24	7	18
Disease present, diagnosis uncertain, test for further information	57	72	46	59	60
Plan management	21	16	30	34	22
	100%	100%	100%	100%	100%

APPENDIX B

REPORT ON COLLECTION OF COST DATA AT ROYAL NORTH SHORE HOSPITAL AND ROYAL MELBOURNE HOSPITAL 1987-1988

Cost data for the the financial year 1987/88 from the MRI units at Royal North Shore Hospital (RNSH) and Royal Melbourne Hospital (RMH) have been collected and analysed. The second year of operation, July 1987-June 1988 was selected for a detailed cost analysis as both units had overcome initial problems and could be considered to be fully operational. The data have been audited by Coopers and Lybrand, WD Scott to ensure that they were collected on a uniform basis in the manner outlined in the original protocol agreed to by the MRI Technical Committee.

The practices adopted in the collection of cost data have been outlined in the section on cost data analysis (p.10).

OVERVIEW OF COST DATA RNSH AND RMH 1987-88

The cost data for RNSH and RMH for financial year 1987/88 are presented in Table 1.

TABLE 1

COST DATA FOR RNSH AND RMH MRI UNITS

July 1987 - June 1988

	RNSH	RMH	(Difference)
Salaries	$537,181	$380,494	$156,687
Depreciation and Rental	$573,061	$602,014	($28,953)
Maintenance	$225,862	$107,500	$118,362
Variable Costs	$230,208	$88,714	$141,494
Indirect Costs	$250,521	$132,818	$117,703
Total	$1,816,833	$1,311,540	$505,293
Number of scans	2991	2441	
Average cost per scan	$607	$537	

The RNSH expenditure was $505,293 greater than that of RMH for the year, resulting in an average cost of $607 per scan at RNSH as compared with $537 per scan at RMH. The following major factors were involved in the difference:

- Salary costs were greater at RNSH, due in part to both staffing policies (2 shift operation) and differences in State awards for radiology staff; (p.13)

- Maintenance costs were greater at RNSH, due in part to the policy of having maintenance performed on an "out of hours" contract basis;

- Variable costs were greater at RNSH, due to the use of cryogens in the superconductive unit (p.13).

- Indirect costs were greater at RNSH than at RMH. These costs may reflect a different case-mix between RNSH and RMH and differing policies in overall hospital staffing (p.14).

RNSH considers that the higher total costs for its unit are justified by the level of diagnostic services provided. The greater expenditure on staff has resulted in higher patient throughput on the MRI unit, achieving greater utilisation of high capital cost equipment.

Analysis of Cost Data

Salaries

As noted previously, RNSH operated its unit on a two shift basis, whereas RMH operated on an extended shift basis amounting to 63 hours per week. For the year ending 30 June 1988, RNSH employed 11.7 full-time equivalent staff, whereas RMH employed 8.9 staff. The designations of the staff are shown in Table 2.

TABLE 2

STAFFING OF MRI UNITS

30 June 1988

	RNSH	RMH
Radiologist	2	1
Senior Radiographer	2	1
Radiographer	3	3
Sister	1	1
Receptionist	2	1
Medical Records Officer	-	1
Porter	1	0.5
Scientific Officer	0.2	-
Cleaner	0.5	0.4
Total	11.7	8.9
Number of scans	2991	2441
Scans performed per staff member	256	274
Salary Cost per Scan	$180	$156

From these data it would appear that the two shift operation at RNSH is 15% more costly in terms of staffing when compared to the extended shift operated by RMH. The major difference in total salaries between the two units is the requirement for a second radiologist at RNSH which results in a RNSH salary for radiologists of 2 x $108,071 or $216,142 for the year, compared with the figure of $134,800 for RMH, a difference of $81,342 per annum. The two shift operation at RNSH also involved a second receptionist ($19,363) required to ensure efficient patient scheduling. The employment of two senior radiographers at RNSH for a salary total of $59,244 for the year involved greater costs than the employment of one senior radiographer at RMH operating an extended shift at an annual cost of $41,041.

In summary, the annual salary cost of RNSH were $156,687 greater than RMH. The RNSH method of operation enabled the MRI unit to perform 2991 scans for the year, 23% more than RMH, for a salary cost increase of 15% per scan.

When considering the differences in total salaries paid at each MRI unit, the following factors, in addition to rates of pay, should be taken into account:

- the differing arrangements for the allocation of private practice income to staff specialists;
- the differing approaches to training of staff at each hospital and consequent levels of supervision;
- the varying amounts of teaching, seminars, and research conducted by the two units;
- the difficulties in scheduling patients, given that RNSH was providing a service for a larger number of referring hospitals and specialist;s
- the benefits of a two shift operation which allow the provision of an additional radiologist to provide back-up for other areas of the radiology department, such as CT and film reading.

Maintenance Costs

The 'out of hours' contract used by RNSH under which routine maintenance was performed at weekends involved an additional cost of approximately $90,000 per annum. This factor, plus the differing approaches to service by the two suppliers of equipment, accounts for the higher maintenance costs at RNSH of $225,862 per annum, a difference of $118,362 as compared with RMH.

Variable Costs

The data on variable costs provide an interesting comparison between superconductive and resistive MRI units. These units represent differing approaches to MRI, with the magnet in the GE superconductive unit being cooled by cryogens (liquid nitrogen and helium) and that in the Fonar resistive unit by water. The costs of cryogens were of the order of $140,000 per annum which resulted in the GE superconductive MRI unit being more costly to operate. The Fonar unit had higher electricity costs ($17,346 p.a. vs $5,634 p.a.) as would be expected with operation of a resistive magnet.

Film costs were greater at RNSH ($58,206 vs $30,245), while computer storage media costs were greater at RMH ($34,999 vs $17,338). These costs reflect the differing modes of operation at the two units. Overall, the difference in variable costs between the units ($141,494) was mainly due to the cost of the cryogens at RNSH.

Indirect Costs

Indirect costs for the financial year 1987/88 are given in Table 3. They represented 13.5% of expenditure at RNSH and 10.1% at RMH. Indirect costs are the proportion of overheads allocated to each MRI patient scanned by the unit. The cost differential of $117,703 is only partly explained by the greater number of scans performed at RNSH.

While the calculation of indirect costs is based on the published data in the Annual Report of each hospital, the possibility that each hospital might have adopted a different approach at the individual item level to account for overhead costs cannot be ignored. On the other hand, there is no reason to suppose that each hospital should have the same ratio of direct to indirect costs, or that they should have the same case-mix or ratio of staff to patients. It is considered that the indirect costs collected at each MRI unit fairly reflect the differences between the two hospitals in this area, based on the agreed formula applied to both institutions on a uniform basis.

TABLE 3

ANALYSIS OF INDIRECT COSTS OF MRI UNITS

July 1988 - June 1988

	RNSH	RMH
Indirect costs	$250,521	$132,818
Total costs	$1,816,833	$1,311,540
Indirect/Total (%)	13.5%	10.1%
Number of scans	2991	2441
Indirect cost per scan	$83.76	$54.41

Depreciation Costs

Table 4 shows the capital and site costs for the two MRI units.

TABLE 4

CAPITAL COST OF MRI UNITS RNSH AND RMH

	RNSH GE 1.5T (superconductive)	RMH FONAR 0.3T (resistive)
Equipment	$2,499,116	$2,752,241
Site	$732,380	$295,538
Minor capital costs	-	$10,062
Total	$3,231,496	$3,057,841

A rental figure of $200 per square metre per annum ($20,000) has been added to the RMH site costs to allow for the modifications made to approximately 100 square metres of an existing building. This procedure ensures that site costs at RMH are considered on the same basis as those of RNSH, which undertook the construction of a purpose built site for the MRI unit. Table 5 describes components of monthly depreciation for each unit, including the notional rental allocated to RMH.

TABLE 5

MONTHLY DEPRECIATION ON MRI UNITS

	RNSH	RMH
	$	$
Equipment	41,652	45,870
Minor Capital	-	168
Site	6,103	2,463
Notional rental	-	1,667
Total	$47,755	$50,168

The monthly depreciation figure for RMH was slightly higher than that of RNSH, reflecting the greater capital cost of the RMH unit. Total depreciation and rental for the financial year 1987/88 was $573,061 for RNSH and $602,014 for RMH. The contribution of depreciation (capital equipment and site) and rental to average costs per MRI scan at each unit is shown in Table 6.

TABLE 6

DEPRECIATION COSTS FOR MRI UNITS

July 1987 - June 1988

	RNSH	RMH
Depreciation and rental	$573,061	$602,014
Number of scans	2991	2441
Average depreciation cost per scan	$191	$246

RMH average costs for depreciation and rental are higher than RNSH due both to greater overall capital costs and lower throughput at the RMH unit. This points to the advantage of operating expensive capital equipment for as long as possible to gain maximum benefit from the investment.

Operating Costs

Operating costs (i.e. all costs excluding depreciation and rental) for the RNSH and RMH MRI units for financial year 1987/88 are shown in Table 7 and Figure 4.

TABLE 7

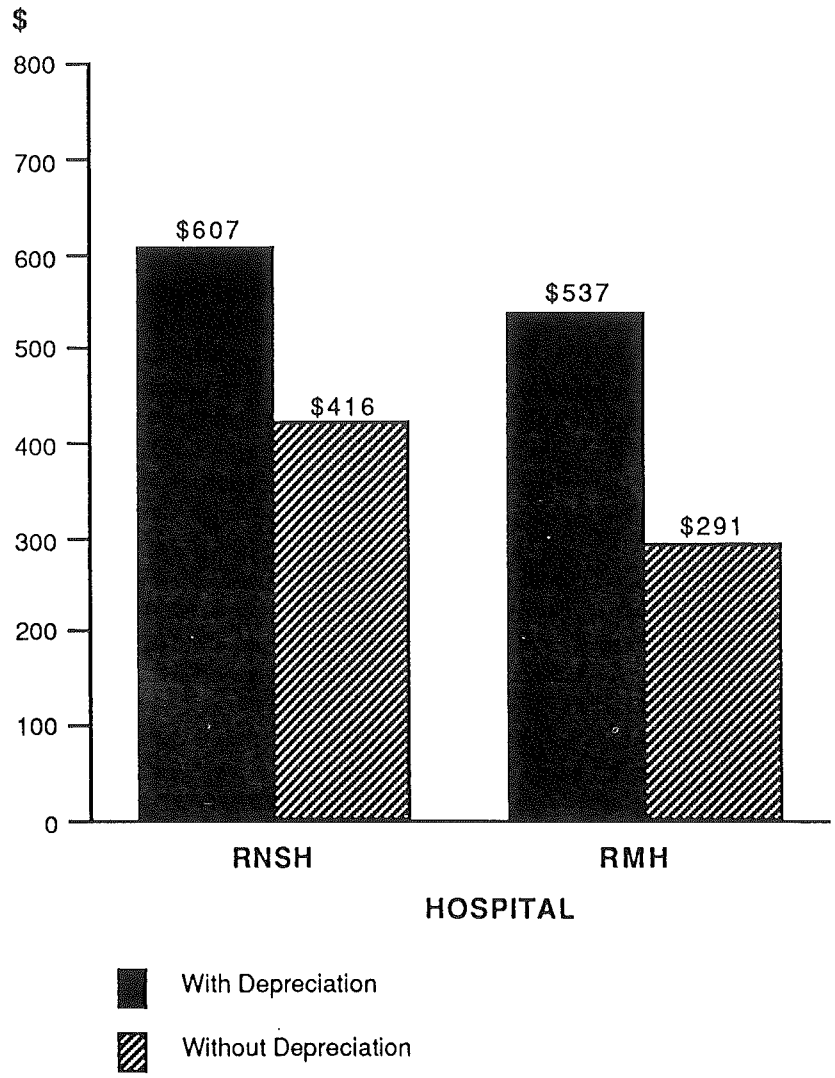
OPERATING COST DATA FOR RNSH AND RMH MRI UNITS

July 1987 - June 1988

	RNSH	RMH
Total costs	$1,816,833	$1,311,540
Less Depreciation and rental	$573,061	$602,014
Operating costs	$1,243,772	$709,526
Number of scans	2991	2441
Average operating cost per scan	$416	$291

FIGURE 4

AVERAGE COST PER SCAN AT TWO MRI UNITS
July 1987 - June 1988



The cost of an MRI scan at the two MRI units can be disaggregated into operating and depreciation/rental components (Table 8) RNSH had higher operating costs per scan but lower depreciation costs per scan than RMH.

TABLE 8

COMPONENTS OF TOTAL COSTS FOR RNSH AND RMH MRI UNITS

	RNSH		RMH	
Operating costs	$416	69%	$291	54%
Depreciation and rental	$191	31%	$246	46%
Total	$607	100%	$537	100%

A point of interest is that, although debate on the cost of MRI scanners has emphasised their high capital cost, the larger part of the cost per scan (RNSH 69%, RMH 54%) was associated with the operating costs of the units. As depreciation costs are fixed, the area of operating costs is the one which provides scope for greater efficiency in reducing expenditure and maximising the numbers of patients scanned.

COMPARISON OF COST OF MRI SCANS WITH THOSE OF ALTERNATIVE DIAGNOSTIC PROCEDURES

In this section, the costs of MRI examinations are compared with those of alternative diagnostic procedures in six nominated conditions. The MRI Technical Committee considers that in examinations to assess the presence of each of these conditions, MRI is the method of choice and has the potential to replace other diagnostic procedures. (1)

For the purposes of comparison with alternative diagnostic examinations it was necessary to take account of the cost of raising capital for the MRI units, as the measures of cost for the other diagnostic methods included a component for capital costs. A figure of 14% per annum reducing was selected as the average prime interest rate during 1988 and representative of the rate that might be suitable for the purchase of capital equipment by government (2). This interest rate was applied to the capital costs of the MRI scanners and other equipment. On that basis, an addition of $209,926 was made to the annual MRI costs of RNSH and $231,188 to those of RMH. The notional costs of providing MRI services at RNSH and RMH, after allowing for 14% reducing interest on capital equipment, are shown in Table 9.

TABLE 9

COMPARATIVE COST OF MRI UNITS

Including 14% p.a. Reducing Interest on Capital Equipment over 5 Years

1987/88

	RNSH	RMH
Depreciation and rental	$573,061	$602,014
Interest on MRI unit	$209,926	$231,188
Operating costs	$1,243,772	$709,526
Total	$2,026,759	$1,542,728
Number of scans	2991	2441
Average notional cost per scan	$678	$632

On the above basis, the notional cost of an MRI scan would be composed of the components shown in Table 10, giving a notional figure of $678 per scan for RNSH and $632 for RMH.

TABLE 10

COMPONENTS OF TOTAL COST PER SCAN FOR RNSH AND RMH MRI UNITS

	RNSH		RMH	
Depreciation and rental	$191	28%	$246	39%
Interest on MRI unit	$71	10%	$95	15%
Operating costs	$416	62%	$291	46%
Total	$678		$632	

Following the discussion put forward in the Consensus Statement on the Clinical Efficacy of MRI by the MRI Technical Committee, six medical conditions were selected where use of MRI was considered to be of major benefit in diagnosis, with the potential to entirely replace alternative diagnostic approaches. These conditions, listed in Table 11, cover some 1500 patients examined during the MRI program and represent 19% and 17% respectively of the workload at the RNSH and RMH units over the period November 1986 to June 1988.

TABLE 11

CASES EXAMINED BY MRI FOR SPECIFIC CONDITIONS

November 1986 - June 1988

Condition	RNSH	RMH
Acoustic Neuroma	50	57
Syringomyelia	290	203
Posterior Fossa Tumour	258	205
Pituitary Adenoma	91	32
Cervical Spinal Myelopathy	70	36
Temporal Lobe Epilepsy	98	138
Number of cases	857	671
Total scans in period	4412	3840
Cases as percentage of total scans	19%	17%

In consultation with hospital specialists, an estimate was made of the cost of providing non-MRI diagnostic services for the selected patients, costs being based on Medicare Benefits Schedule (MBS) fees. Details of the non-MRI services and their costs are shown in Table 12. Use of some of these is associated with 1 or 2 day stay in hospital, which has been costed at $500.

TABLE 12

TYPES AND COSTS OF NON-MRI DIAGNOSTIC PROCEDURES

Procedure	Cost, $
Plain X-ray	40
Spinal X-ray	70
CT, iv contrast	168
CT, air contrast	310
CT, intrathecal contrast	240
Patient preparation	146
Myelogram	104
DSA	500

Note: Medicare Benefits Schedule fees used for cost estimates.

The non-MRI diagnostic procedures for each of the selected conditions were as follows:

Suspected Acoustic Neuroma

A. Plain X-ray; CT with iv contrast; CT with air contrast and associated lumbar puncture; 1-2 day stay in hospital to overcoming headache, vomiting etc.

(This approach includes the use of air contrast CT, a less frequently used procedure used to exclude the presence of very small neuromas). Total cost: $1,018. Number of patients: RNSH 13, RMH 14.

B. Plain X-ray; CT with iv contrast. Total cost: $208.

Number of patients: RNSH 37, RMH 43.

Suspected Syringomyelia

Spinal X-ray, patient preparation, myelogram, CT with iv contrast after 4 hours and after 8-12 hours, 1-2 day stay in hospital. Total cost: $1,516.

Suspected Posterior Fossa Tumour

A. Plain X-ray; CT with iv contrast, CT with intrathecal contrast and lumbar puncture, 1-2 day stay in hospital. Total cost: $948.

B. Plain X-ray; CT with iv contrast. Total cost: $208.

For the purposes of this analysis, it is assumed that 50% of patients are examined on an outpatient basis, using approach B, which would apply to 129 patients at RNSH and 102 at RMH.

Radiology departments consider that the distribution of cases between the two approaches will vary, depending on the age and severity of illness of the patients.

Suspected Pituitary Adenoma

Plain X-ray; CT with iv contrast (100 mL); DSA to locate carotid artery (40-50 mL contrast), 1-2 day stay in hospital for observation between CT and DSA studies. Total cost $1,208.

Suspected Cervical Spinal Myelopathy

A. Plain cervical X-ray; patient preparation; myelogram; CT with iv contrast after 4 hours; 1-2 day stay in hospital. Total cost: $958.

B. Plain cervical X-ray; patient preparation; myelogram; CT after 4 hours. Total cost: $458.

For the purposes of the analysis, it is assumed that 50% of patients are examined on an outpatient basis (approach B), applicable to 35 cases at RNSH and 18 at RMH. The distribution will vary depending on the age and severity of illness of the patients.

Suspected Temporal Lobe Epilepsy

Plain X-ray, CT with iv contrast, 1-2 day stay in hospital for observation. Total cost: $708.

A comparison of MRI services with alternative procedures was made at two levels, one based on the notional cost to the hospitals of MRI scans (RNSH $678, RMH $632) and one based on the recommended AMA fee level (3) as at 30 June 1988, for each type of MRI unit (RNSH $885, RMH $760). The MRI costing was based on the assumption that patients would proceed directly to MRI. The results of these comparisons are shown in Table 13.

TABLE 13

COMPARISON OF EXISTING DIAGNOSTIC COSTS AND MRI COSTS FOR SIX CONDITIONS
NOVEMBER 1986 – JUNE 1988

	Number of Cases	Non-MRI Diagnostic Costs	Alterantive 1 MRI Notional Costs (Adjusted Hospital Data)	Alterantive 1 Variation	Alternative 2 MRI Notional Costs (Recommended AMA Fees)	Alternative 2 Variation
ROYAL NORTH SHORE HOSPITAL						
		$	$	$	$	$
Acoustic Neuroma	50	20,930	33,900	(12,970)	44,250	(23,320)
Syringomyelia	290	335,240	196,620	138,620	256,650	78,590
Posterior Fossa Tumour	258	149,124	174,924	(25,800)	228,330	(79,206)
Pituitary Adenoma	91	109,928	61,698	48,230	80,535	29,393
Cervical Spinal Myelopathy	70	49,560	47,460	2,100	61,950	(12,390)
Temporal Lobe Epilepsy	98	69,384	66,444	2,940	86,730	(17,346)
Total	857	734,166	581,046	+153,120	758,445	(24,279)
ROYAL MELBOURNE HOSPITAL						
		$	$	$	$	$
Acoustic Neuroma	57	23,196	36,024	(12,828)	43,320	(20,124)
Syringomyelia	203	234,668	128,296	106,372	154,280	(80,388)
Posterior Fossa Tumour	205	118,860	129,560	(10,700)	155,800	(36,940)
Pituitary Adenoma	32	38,656	20,224	18,432	24,320	14,336
Cervical Spinal Myelopathy	36	25,488	22,752	2,736	27,360	(1,872)
Temporal Lobe Epilepsy	138	97,704	87,216	10,488	104,880	(7,176)
Total	611	538,572	424,072	+114,500	509,960	+ 28,612

The data in Table 13 suggest that the cost of MRI examinations may be similar to established diagnostic procedures for selected conditions where MRI is considered to be the method of choice and can entirely replace the older methods.

DISCUSSION

The collection of cost data at RNSH and RMH over the past two years has involved a structured program intended to capture the actual costs of providing high cost diagnostic services in public teaching hospitals. A uniform protocol for cost data collection was designed with the agreement of the hospitals. At the end of the two year period the cost data were subject to audit and audited data have been used in this report.

A number of points emerge. Not unexpectedly, the high field superconductive MRI unit was more expensive to operate than the low field resistive unit, mainly because of higher maintenance and variable costs. As the major component associated with such higher operating costs is the cost of cryogens, it would seem reasonable to operate superconductive MRI machines for longer daily schedules to increase the number of scans performed, and thus reduce the average cost per scan. This procedure has in fact been followed by RNSH, enabling that unit to go some way towards satisfying the demand for MRI scans and at the same time to reduce costs per scan. Increased salary costs associated with longer hours of operation partially offset such savings.

The depreciation cost per scan was 29% higher for RMH than for RNSH, the difference being due to both the higher cost of capital equipment at RMH and the greater throughput at RNSH. However, the difference in depreciation costs was offset by the difference in operating costs. The RNSH operating costs were 43% higher than those of RMH. Thus, overall, there was only a 13% difference between the two units in costs per scan (RNSH $607, RMH $537).

There was a gradual improvement in throughput at both units during 1987/88. Data for the period February - July 1988, suggest that an annual throughput of 3300 scans a year is achievable at RNSH. If such a throughput were achieved and the total costs of operation (Table 1) remained stable, then the average cost for a scan at RNSH would fall from $607 to approximately $551 and the full benefits of RNSH staffing a second shift would begin to appear. On the assumption that RMH throughput improved from 2441 to 2600 scans per year, there would then be a difference of approximately 9% (RNSH $551, RMH $504) in costs between the two units.

The comparison of the notional MRI costs with the costs of alternative diagnostic procedures has the limitation that primary data from the assessment program are matched against negotiated fees determined through a complex process which includes consideration of private sector cost structures. However, if the six conditions selected for analysis, which accounted for 18% of the workload at the two MRI units, are considered as a group, there is little difference between MRI and non-MRI costs if the AMA fees are used and a cost advantage for MRI if the data from the assessment program are compared with MBS fees for the existing procedures.

In the model used here, interest charges on capital costs associated with the MRI unit sites have not been included. If the same interest rate (14% per annum reducing) is used for the site costs, the effect is to raise the cost per scan by $19 for the RNSH unit and by $9 for RMH (taking interest as not applicable to the notional rental). These variations make little difference to the overall comparison with alterantive diagnostic approaches.

In the conditions considered, the opinion of the Technical Committee is that MRI has significant advantages over existing diagnostic methods. These advantages include improvements to quality of life such as avoidance of injection of contrast media and of the need for overnight stays in hospital. The analysis suggests that MRI, in addition to such technical advantages, may also have cost advantages in some situations. Such cost advantages might increase should MRI units raise their throughput by use of longer operating schedules and application of improved software packages. Cost advantages would of course not exist should MRI be used in addition to the existing diagnostic methods.

Further cost analysis on data from the other hospitals in the MRI program will be presented in future reports and comparisons made with non-MRI diagnostic methods used in a number of other conditions.

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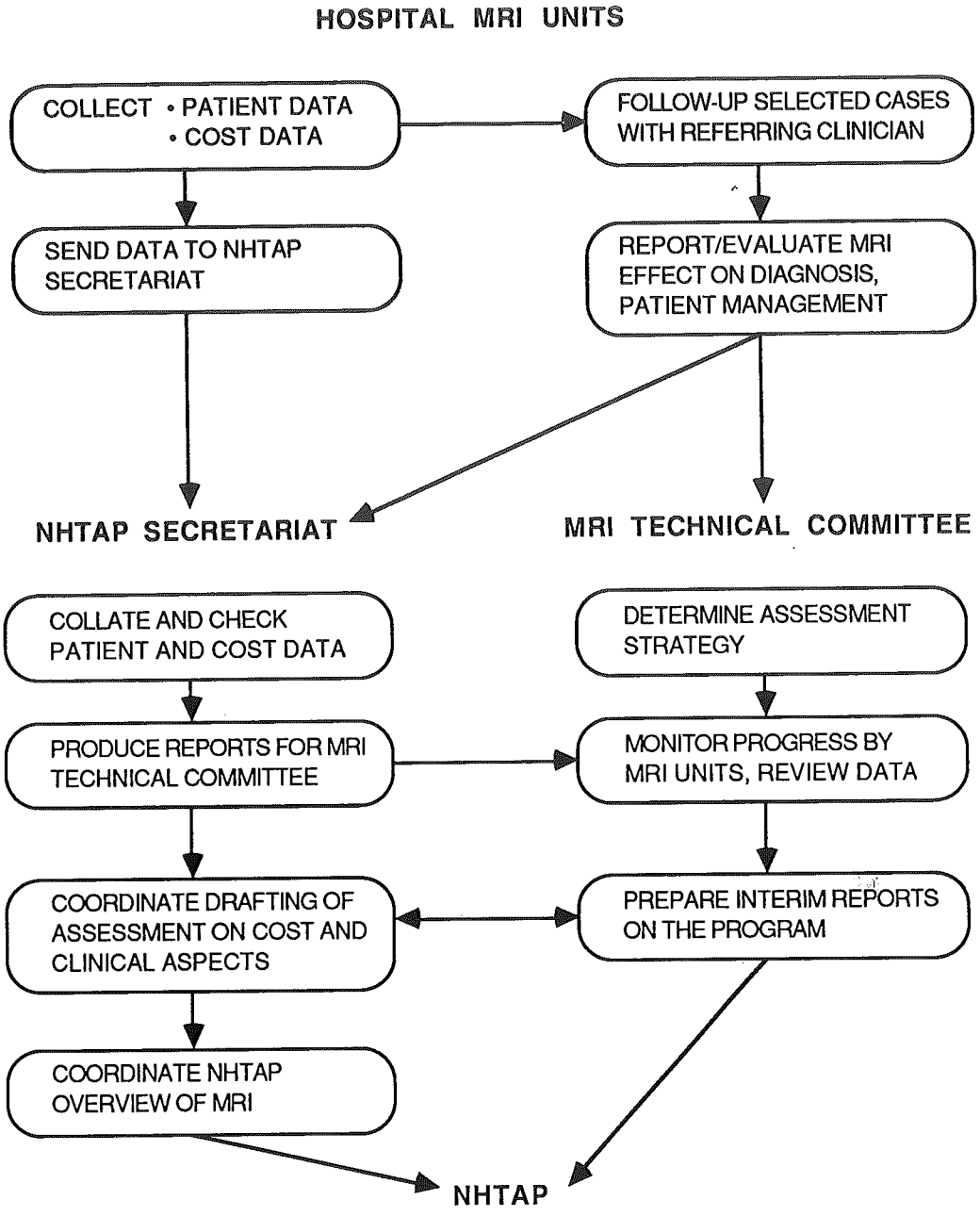
APPENDIX D

ORGANISATION OF MRI ASSESSMENT PROGRAM



- EXAMINE AND REVIEW ASSESSMENT REPORTS
- PROVIDE ADVICE TO HEALTH AUTHORITIES AS REQUESTED
- PREPARE OVERVIEW REPORTS ON MRI FOR GOVERNMENTS AND OTHERS