CLINICAL SERVICE PLANNNING FOR THE DEPARTMENT OF MEDICAL IMAGING HOSPITALS SOUTH
DRAFT REPORT

Prepared for Office of the Chief Executive, Hospitals South

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knowledge into practice

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Project context

The Department of Medical Imaging – Hospitals South (DMI) provides diagnostic services to inpatients, emergency department presentations and outpatients. Services are provided across a range of modalities: computed tomography (CT), magnetic resonance imaging (MRI), X-ray, ultrasound, fluoroscopy, bone mineral density and nuclear medicine modalities (positron emission tomography (PET) and gamma camera-based imaging). The DMI also provides interventional radiology, a sub-specialty service where minimally invasive procedures are performed using radiological guidance.

As the only Level 6 medical imaging service in the State,[1] the DMI has a more complex service profile and supports higher acuity patients than other sites. It provides some interventional radiology procedures not available elsewhere in Tasmania and co-ordinates interstate referral where necessary.

The DMI is experiencing several service pressures associated with increasing demand for services, service capacity constraints, insufficient and poorly configured service delivery spaces, ageing diagnostic equipment, and workforce recruitment and retention challenges.

Clinical service planning is required to identify future service development opportunities and ensure the DMI is positioned to meet the needs of THS South and the various statewide service initiatives for which medical imaging is an important component of care.[2]

Methodology

This Clinical Service Planning report is underpinned by evidence from a literature review, analysis of service data, a site visit, and workshops with key members of DMI staff.

We performed a rapid review of the peer-reviewed and ‘grey’ literature that describes new and emerging trends and technologies in radiology practice that may impact the future infrastructure needs of the DMI in the medium to long-term. A copy of the review is available in Appendix A of this document.

We analysed raw DMI service data provided by the THS. The data represented DMI activity from 2018-2022. We performed data linking for ED presentations and admitted patients. We also supplemented the data set with population data relevant to Southern Tasmania and RHH activity data. The data analysis was used to identify activity sources, trends and projections to inform clinical service planning. A copy of the data analysis is presented as Appendix B of this document.

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[1] Tasmanian Role Delineation Framework for Health Services (2023). Accessed at https://www.health.tas.gov.au/campaigns/tasmanian-role-delineation-framework. Accessed on 29 June 2023.

[2] Statewide Elective Surgery Four Year Plan 2021-2025, Transforming Outpatient Services 2022-26.

We undertook a series of six modality-specific workshops with key staff of the DMI to describe current service provision, explore perceived service barriers and opportunities and consider future service needs.

Analysis of private sector data was not performed as it was outside the scope of this project.

Areas for action

Medical imaging (also described as radiology) is a core service of critical importance in clinical care. It is used early and often in patient care pathways to improve the speed and accuracy of diagnosis, guide treatment, and improve patient outcomes.

However, DMI is experiencing significant service pressures and is already unable to meet current demand, while at the same time there are rapidly evolving requirements to introduce and provide access to new imaging technology.

To meet current and evolving medical imaging needs, significant investment in facilities, equipment and workforce is required.

Urgent and ongoing action is needed as part of a multifaceted and coordinated approach to restore DMI capacity and position the service for the future in a safe, effective and sustainable way.

Action 1: Expanding capacity to meet demand

The DMI cannot meet current demand for services. Outpatient services are increasingly being outsourced at considerable cost to Hospitals-South. More capacity is required across all major modalities.

Demand for most medical imaging modalities of the DMI has been rising year-on-year. Rising demand has been driven by increasing hospital activity, increased use of diagnostics in the emergency department for time-critical diagnosis, and broader indications for use of diagnostic imaging.

Demand for imaging services has outstripped capacity, consequently existing resources have been preferentially directed towards acute diagnostics (inpatient and emergency department care). As a result, capacity to provide outpatient diagnostics has decreased in critical high-volume services (CT, MRI, Ultrasound, X-ray).

Patients unable to access outpatient diagnostics in a timely manner have been directed to access private imaging services. [redacted] Private imaging services are also facing resource constraints, one private provider invoices Hospitals-South for services at a higher rate than the MBS rebate .

Future demand for public sector medical imaging modalities in southern Tasmania is being driven by the effect of an increasing and ageing population, with higher utilisation in older, sicker patient cohorts and by a significant trend of increased use independent of demographic changes. While overall population is projected to increase by about 0.8%, the increasing proportion of older residents is projected to increase demand for medical imaging services by 1.5%. The additional projected trend increase based on recent year activity is an annual: 2% for X-ray (conventional radiology), BMD, fluoroscopy and RFA; 4% for CT, MRI and Ultrasound; and 5% for angiography, PET, non-PET nuclear medicine. Table 1 shows the projected expected demand for three, five and ten years.

Table 1: Modality projections, based on population changes and historical trend adjustments

	Base	Population adjusted			Population and trend adjusted			Average annual change
Modality	**2022**	**2025**	**2027**	**2032**	**2025**	**2027**	**2032**	**2022-25**
Angio	3638	3816	3944	4236	4293	4799	6271	5.7%
BMD	626	681	718	796	722	792	971	4.9%
CR	62443	65229	67145	71313	69222	74134	86930	3.5%
CT	24650	25975	26899	28961	29219	32726	42870	5.8%
Fluor	2170	2248	2302	2431	2385	2542	2963	3.2%
ICT	144	149	152	160	158	168	195	3.1%
MRI	6105	6360	6540	6954	7154	7957	10293	5.4%
N Med*	2977	3147	3267	3543	3643	4170	5772	7.0%
PET	3164	3332	3455	3743	3857	4409	6096	6.8%
RFA	959	991	1015	1078	1051	1121	1448	3.1%
US	13606	14064	14363	14946	15820	17475	22124	5.2%
Total	**120482**	**125990**	**129801**	**138162**	**137523**	**150293**	**185933**	**4.5%**

**Note: Nuclear medicine figures may be over-represented due to modality substitution practices associated with limited access to other high-volume modalities.*

Increased imaging capacity is required in the main high-volume growth modalities (CT, MRI, Ultrasound, PET and conventional X-ray) to meet current and future demand.

Table 2 summarises the projected increase in the number of procedures (2025-2040) compared with the number performed in 2022.

Table 2: Projected increase in annual number of procedures, modality, 2025-2040

Modality	2022	2025	2027	2032	2040
Angiography	3638	655	1161	2633	3426
BMD	626	96	166	345	467
CR	62443	6779	11691	24487	35483
CT	24650	4569	8076	18220	23643
Fluoroscopy	2170	215	372	793	1168
Intraoperative CT	144	14	24	51	75
MRI	6105	1049	1852	4188	5490
Nuclear medicine	2977	666	1193	2795	3525
PET	3164	693	1245	2932	3704
RFA	959	92	162	489	673
Ultrasound	13606	2214	3869	8518	11317
Total	**120482**	**17041**	**29811**	**65451**	**88970**

Table 3 outlines the current capacity, planned increases in capacity, and unplanned future need based on demand projections for the five key growth modalities.

To meet future demand, substantial investment is required to increase capacity. Further detail is provided in the modality-specific sections of this report and data analysis report in Appendix B.

Table 3: Modality capacity current, planned and unplanned

Modality	Current scanners/rooms	Planned increase	Unplanned future increase required (current to 2040)
CT	3 (ED, radiology, theatre)	2 (angiosuite, ED)	2-3 (1-2 community, DMI, 0-1 DEM – 7,500 annual procedures in each)
Ultrasound	7 rooms + portable	1 portable (angiosuite)	3 rooms (outpatient and ED - 3000+ procedures in each)
MRI	2 (radiology)	Nil	2 (outpatients – 3000+ procedures in each)
PET	1	Nil	1 (nuclear med – 3000+ procedures)
X-ray	6 rooms plus portable	1 (ED)	4 rooms (outpatient, inpatient satellite, radiology) Portable units

Much of the increased imaging equipment required to meet projected demand is currently unplanned and unbudgeted. Some modalities, such as MRI and PET, require highly specialised infrastructure to support safe and effective use of the equipment.

In addition to new acquisitions, existing medical imaging equipment require scheduled upgrades and replacement. Regular asset replacement is necessary for patient safety, efficiency, service continuity, and to access Medicare Benefits revenue.

A capital equipment plan is required to navigate the procurement and replacement of sufficient diagnostic imaging equipment to meet service demand. Due to the high cost of diagnostic imaging equipment, and the specific facility requirements for some items, the medical imaging capital equipment plan should be developed in consultation with Finance, Infrastructure and Clinical Service Planning areas.

Alongside expansion, opportunity exists to ensure that medical imaging resources are used judiciously and in accordance with best practice principles. Quality and safety initiatives such as the Choosing Wisely program highlight the importance of evidence-based use of medical imaging diagnostics, adhering to recognised repeat scan intervals and optimising imaging record sharing to prevent unnecessary repeat imaging at care transitions.

Due to the high cost of imaging and the patient safety risks associated with some imaging modalities, investment in evidence-based patient pathways to diagnosis and targeted quality and safety initiatives to drive judicious use of medical imaging interventions should be actively pursued.

Action 2: Creating spaces that deliver contemporary care

The current medical imaging footprint cannot accommodate the additional equipment, facilities and staff required to meet growing demand and provide contemporary models of care.

Outpatient imaging should be largely relocated from the acute RHH campus to a community-based location. Relocation supports improved outpatient service access and creates capacity on the acute site to accommodate growth in acute service delivery and evolving models of care.

DMI services are largely delivered on the acute site of the RHH campus from the main radiology/nuclear medicine area of H Block and designated spaces within the Department of Emergency Medicine (DEM). A smaller volume of services is provided from non-acute sites (clinics and New Norfolk district hospital).

The DMI has outgrown its current space allocation. Facilities are too small to support current care volumes. Insufficient waiting areas are affecting diagnostic throughput efficiencies. Clinical areas do not provide patients with sufficient privacy, and the department has no isolation rooms or infrastructure to safely manage patients with infectious disease.

Staff work areas are crowded and some technical and nursing staff have no dedicated space to perform administrative tasks. Items of equipment line the halls of the radiology wing (H Block) as there is insufficient room to store these items appropriately.

Outpatient imaging is largely provided on acute sites. Lower-complexity outpatient imaging involving X-ray, DEXA, Ultrasound, CT, and MRI can be provided in a non-acute location. Movement of lower-complexity outpatient imaging from the acute hospital site to a community-based location enables separation of acute and non-acute diagnostics, improves efficiency of work flow, reduces wait times for both acute and non-acute imaging and improving access and convenience for ambulatory patients.

Table 4 shows the current and projected volumes of imaging by referral source. Sufficient outpatient volumes exist in X-ray, US, CT and MRI to warrant the establishment of a community-based diagnostics hub. The Outpatient totals include the estimated number of procedures currently performed on behalf of the hospital by private imaging services, as these would ideally revert to public sector provision if capacity was available.

Table 4: Key modality number of procedures, referral location, 2022

	Current annual volumes (2022)			**Projected volumes (2025)**		
Modality	Inpatient	Emergency	Outpatient*	Inpatient	Emergency	Outpatient*
X-ray	20871	31451	11153	24726	36755	13105
CT	8470	12844	5148	10071	15193	6102
MRI	2074	136	4795	2294	149	5301
Ultrasound	4046	1647	9233	4727	1892	10735

The establishment of a community-based location frees up space to accommodate acute-specific modalities of growth and to redesign existing space to better support contemporary models of care for higher-acuity patients with acute diagnostic imaging needs and interventional radiology requirements.

The main radiology space (H Block) lacks areas to efficiently prepare waiting patients requiring general anaesthesia and effectively observe patients in recovery phase post-procedure. As imaging becomes increasing complex and interventional radiology case load increases, more high-acuity support facilities will be required on the acute hospital site.

Action 3: Optimising patient flows for improved efficiency

The efficiency of medical imaging throughput is affected by delays in patient transfers and a lack of appropriate waiting space. Dedicated transfer services and re-design of acute imaging spaces are required to improve patient flow efficiency.

The efficient movement of patients from ward areas or emergency department to medical imaging (and return after imaging) is of critical importance to efficient imaging workflow.

Patients are transported throughout the hospital to receive imaging services. Patient transfer services are provided by hospital orderlies who work as part of the hospital orderly workforce pool. Patients requiring a clinical escort are also supported by a nurse.

Delays in patient transfer result in 'downtime' between scans. This reduces throughput, increases wait times, increases time taken to diagnosis and can extend patient length of stay. Staff from all medical imaging modalities report poor access to orderly services, frequent delays in patient transport, and regular avoidable 'downtime' due to patient transfer delays.

Patient transfer delays are most significant in high-volume imaging modalities (CT, X-ray) and those modalities that require considerable preparation of patients prior to scanning (MRI and PET).

To improve efficient throughput of acute patients and optimal use of imaging resources (equipment and staff), improvements are required to patient transfer access and timeliness. This may be achieved by prioritising a sub-set of orderlies from the orderly pool to provide transfer of patients to and from medical imaging services or the establishment of dedicated orderly positions allocated specifically to the DMI workforce.

Efficient imaging throughput is also dependent on the effective queuing of patients. Queuing patients in readiness for their scans reduces downtime between scans and improves efficiency. Ideally, for a high-volume service such as CT two patients should be waiting while the first patient is receiving their scan. The space required for queuing is relatively modest for ambulatory patients, but a significant proportion of patients from the ward and the emergency department require transfer by bed.

Current medical imaging wait spaces are far too small to enable queuing of patients transferred by bed. Patients in high-volume areas such as CT are transferred and scanned one at a time, resulting in downtime between scans as that could be avoided with larger waiting spaces and improved patient flow design.

Action 4: Investing in robust and secure digital infrastructure

Investment in digital infrastructure is required to keep pace with new and emerging medical imaging technologies.

Medical imaging is a highly digitised area of clinical practice with unique information technology needs. New and emerging technologies such as artificial intelligence and machine learning, virtual and augmented reality and nanotechnology are expected to reshape medical imaging practice into the future.

Robust digital infrastructure is required to support current and future practice. The State's current PACS (picture archiving and communications system) is nearing end of lifecycle and will shortly be unsupported by technical back-up. This represents a significant risk that requires urgent attention.

Upgrades of critical digital infrastructure are also required to position the DMI for emerging technological advancements. The DMI will need access to high-speed networks for fast image transmission, cloud-based storage able to handle and process huge amounts of medical imaging data, new data management systems for the collection, collation analysis and report of data, and advanced cybersecurity to maintain patient privacy.

At this stage, it is unclear how the Government's *10-year Digital Health Transformation Strategy* will align with the specialised and growing digital needs of medical imaging. It is essential that DMI clinical experts and digital technology leads develop a partnered approach to planning and progressing the technological infrastructure improvements and innovations required to meet current and future medical imaging requirements.

Action 5: Increasing workforce and organisational capacity

Increase utilisation of existing DMI equipment and infrastructure

In the main DMI the major modalities of CT, MRI, PET and ultrasound operate largely on an extended weekday model, with often substantial on-call, recall obligations.

Increasing utilisation of expensive equipment and technologies where demand exists requires access to effective rostering, which at RHH will mean the introduction of extended weekday and / or scheduled weekend lists. It will require the recruitment of more staff but provides the most immediate mechanism to meet escalating demands for medical imaging services. Clearly open and careful negotiation with staff and their representatives will be needed to achieve mutually satisfactory outcomes.

Identify opportunities to support allied health specialisation and incentivise career development.

Staff need support from the organisation for career progression, access to education and training, and personal and leadership development. Radiographers and other allied health staff with specialist skills are essential to the effectiveness of DMI. The appointment of in-house educators is an important part of building dedicated capacity.

Develop a DMI workforce strategy.

The development of a DMI workforce recruitment and retention strategy is likely to be beneficial in providing a framework and structure to ensure the department can identify and access required staff and build a platform for staff retention, leadership and succession.

Action 6: Working collaboratively for change

The DMI requires investment and reform to meet current service challenges and prepare for future service demand. Strong leadership and a collaborative approach are critical to realising the change necessary.

To increase medical imaging capacity in line with service needs, the DMI needs significant investment in equipment, facilities, digital infrastructure, and workforce.

The need for change is urgent. The resourcing needs of the DMI have not kept pace with hospital demand and technological advances leading to substantial shortfalls in available capacity. To reverse this trend and to reposition the DMI for the future, strong clinical, managerial and executive leadership is required.

Expert Medical Imaging staff, together with leaders of Infrastructure Services, Information Technology Services, Human Resources, and Finance and Procurement Services, will need to work collaboratively to implement a bold, multifaceted and interdependent renewal program that includes:

Investment in facilities

To accommodate the additional equipment and workforce required, more space is needed beyond the existing DMI footprint. Identification of new space or spaces to decant outpatient activity is a priority. Once outpatient activity has been relocated, refurbishment of existing facilities can commence to improve service efficiency and facilitate contemporary care.

The urgent and future needs of the DMI will need to be considered in the context of the larger RHH redevelopment project and other health infrastructure projects in progress. An infrastructure business case is required, led by Infrastructure Services in consultation with the RHH development team and DMI management. Opportunities to leverage existing project funding in the short term should be investigated whilst simultaneously seeking dedicated funding for the medium to long-term development of medical imaging services.

Investment in equipment

Significant investment in new equipment is required to meet growing demand. Upgrade and replacement of existing equipment is also required. The DMI requires support from Infrastructure and Finance to develop a Capital Asset Plan that will guide the staging, financing, procurement and installation of imaging equipment from now until 2040.

Alignment with IT investment

The Department of Health is currently undertaking an extensive digital transformation program. IT Service leaders must engage with DMI experts immediately to ensure that the current critical digital infrastructure needs of the DMI are actioned with urgency and future needs are addressed in the broader digital transformation program.

Investment in workforce

DMI should undertake a structured process to assess, identify and understand the key factors for existing and prospective employees, especially allied health staff and medical staff specialists (both fulltime and part-time) that influence their interest and recruitment and on-going work at RHH. In parallel with is assessment consideration must be given to:

- Continuing to build the size of the workforce as this promotes stability for existing staff, is more attractive to new staff and allows increased workforce flexibility and rostering.
- Providing access to in-house, and support external education and training, especially with a view to developing the specialisation of the allied health and medical staff and ensuring capability with new technologies.
- Identifying specific incentives to encourage allied health staff specialisation and career progression.
- Developing an understanding of individual employee career paths and work to identify and develop future service leaders.
- Ensuring sufficient administration and support staff (including orderlies) to facilitate optimal patient flow.

Medical imaging overview

Future of medical imaging

The field of medical imaging has seen significant technological advancements in recent years. It is expected that this trend will continue with advances occurring at a much faster rate than in the 20th century. Technological advances are improving how radiologists, radiographers and sonographers work, providing clearer images and interfacing with machines that deliver results quickly and accurately.

Advances are predicted across most imaging modalities, with rapid technological advancement particularly predicted for magnetic resonance (MR), positron emission tomography (PET), ultrasound and computed tomography (CT).

New and emerging technologies that are also expected to reshape medical imaging practice. These advances aim to improve the accuracy of diagnoses, increase scanning efficiency, and improve patient outcomes. These technologies include:

- **Artificial Intelligence (AI) and Machine Learning (ML)** allowing streamlined analysis and the interpretation of large amounts of medical imaging data, leading to fast and accurate diagnoses
- **Virtual and augmented reality** to create 3-dimensional medical images for use in interventional procedures and surgical and medical device domains
- **Nanotechnology** to develop more precise and targeted imaging techniques for improved accuracy of diagnoses.

Implementation in these new technologies will require significant investment in medical imaging equipment and other new infrastructure includes:

- **Cloud-based storage:** With the increasing use of AI and machine learning algorithms in radiology, large amounts of medical imaging data will need to be stored and processed quickly. Cloud-based storage systems will be necessary to handle the vast amounts of data generated by these technologies and to ensure easy access to medical images across different healthcare facilities
- **High-speed networks**: With the increasing use of remote consultations and telemedicine, high-speed networks will be necessary to ensure fast and reliable transmission of medical images and other data between healthcare providers.
- **Data Management Systems:** As the amount of medical imaging data continues to increase, data management systems will be necessary to help radiologists collect, collate, analyse and report data effectively. These systems will need to be highly efficient, scalable, and secure.
- **Advanced Cybersecurity:** With the increasing use of digital infrastructure in radiology, cybersecurity will become more critical than ever. Advanced cybersecurity measures will be necessary to protect medical data from cyber threats and ensure patient privacy.

Medical imaging departments worldwide are experiencing staff shortages while facing increased work load. The use of effective digitalisation to improve operational performance and support efficiencies is an area of focus. Digital solutions including remote scanning software, customised dashboards to track targets and KPIs, and digital platforms that enable data-driven decisions along the patient pathway can facilitate smart workflows, reduce workload, maximise asset utilisation and boost workforce productivity.

DMI activity

The DMI provides diagnostic and interventional services to inpatients, emergency department presentations and outpatients across a range of modalities. As the only Level 6 public medical imaging service in the State,[3] the DMI also provides some statewide services and coordinates interstate referral where necessary.

The DMI is a core service provider, meaning that medical imaging services are provided to patients across almost every medical and surgical discipline. As such, demand for medical imaging services correlates closely with hospital admission activity, outpatient activity and emergency presentation rates.

RHH activity trends

Population growth rates are highest in Southern Tasmania compared to the rest of the State. Southern Tasmania has experienced 6.6% population growth from 2018-2022. The Southern Tasmania population is predicted to grow a further 4.1% by 2027 and 7.7% by 2032.

RHH activity over the past five years (2018-2022) has increased significantly, with emergency department presentations rising by 16.2%. This has a flow-on effect to the DMI as over 40% of all emergency department presentations receive radiology services.

The number of overnight admitted patients has increased by 16.6% over the past five years at the RHH. 38% of overnight admitted patients require radiology services. During this same time, length of stay for overnight admitted patients has increased by almost 23%, and activity has increased on average by 12,600 bed-days per year.

Medical imaging activity trends

As hospital activity increases, so too does demand for medical imaging. A review of five-year activity data for the DMI (see Figure 1 below) shows a 10% increase in activity for acute-diagnostic imaging (inpatients and emergency presentations) and decreasing outpatient activity (-7.8% over five years).

The reduction in outpatient activity is not due to reduced demand but rather capacity constraints. Acute diagnostic imaging activity, which is growing in volume and complexity, has been prioritised, displacing outpatient service capacity. As a result, outpatient activity is increasingly outsourced to the private sector.

Outsourced activity

A significant and growing proportion of patients with time-sensitive imaging requirements are referred via DMI to private medical imaging services. These services are then billed by the private provider to DMI. However, some medical practitioners are referring patients directly to external providers without an initial referral to the DMI. Business Information

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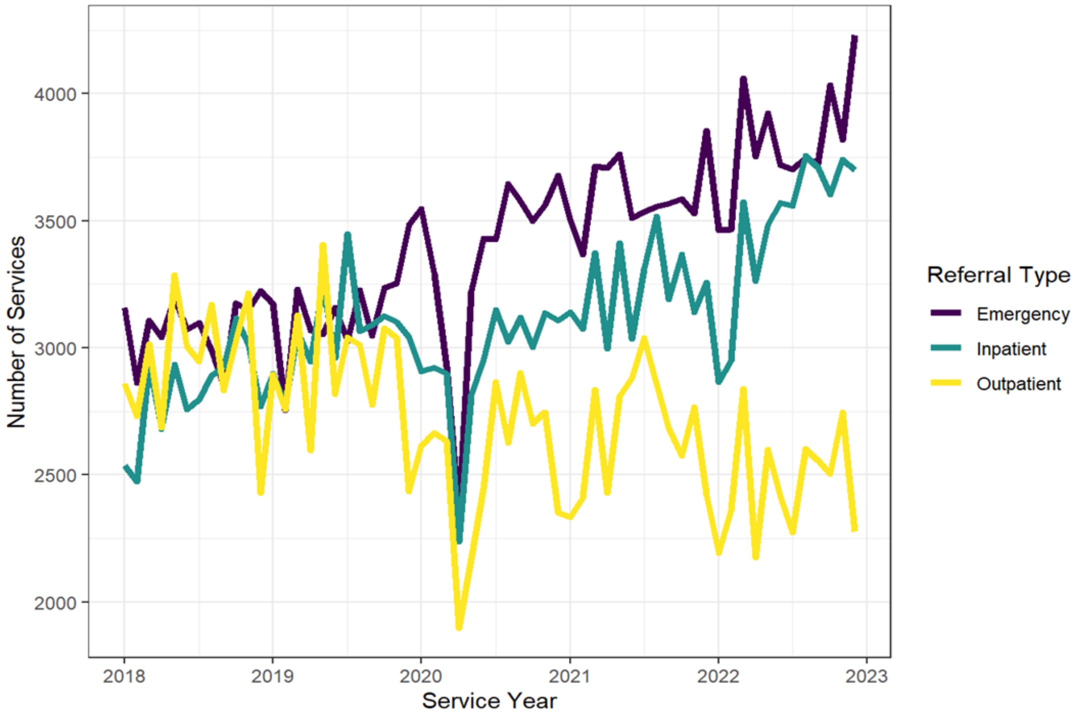
[3] TRDF

Business Information

[redacted] There are no contracts in place between Hospitals South and private medical imaging providers, which raises issues of oversight and value-for-money of these arrangements.

Efforts are in train by medical imaging staff to re-route referrals through the DMI to ensure better control of this work. However, outsourcing of a proportion of outpatient services is expected to continue until DMI capacity can be increased.

Figure 1 Rates of activity by referral source (2018-2022)



Activity by modality

Five-year activity trends demonstrate growth across most major medical imaging modalities, but the rates of growth are smaller than expected due to service capacity constraints.

The DMI provides nine key imaging modalities. High-volume modalities include X-ray, CT, Ultrasound and MRI. Lower-volume modalities include angiography, nuclear medicine, PET, Fluoroscopy and bone mineral density.

Later in this report more detail is provided about the high-volume/high-growth modalities (current and emerging): CT, ultrasound, MRI, X-ray, and PET.

Medical imaging facilities - overview

The DMI operates out of a number of locations. The majority of services are provided on the acute campus of the RHH from the main imaging area (H-Block) or the imaging areas within the emergency department. The current footprint occupied by the DMI on the RHH campus is highly constrained.

Table 5: Location of medical imaging modalities

Service location	Modalities provided
Medical imaging unit Ground floor H-Block RHH	All modalities except for angiogram, interoperative CT
Emergency Department RHH	X-ray, CT, Ultrasound
Wellington Clinics, Wellington St	Ultrasound, X-ray
Liverpool Clinics, Liverpool St	X-ray
Angiosuite, K Block RHH	Angiography and Intervention
Interoperative CT, theatre RHH	CT
New Norfolk District Hospital	X-ray
Mobile services provided on RHH wards	Ultrasound, X-ray

Medical imaging unit (H-Block)

The medical imaging unit located on H-Block consists of two wings, the radiology wing and the nuclear medicine wing. Both wings share a central patient waiting area.

The radiology wing is crowded, with insufficient space for:

Patient preparation and observation

- The patient waiting areas are too small, particularly for inpatients transferred to medical imaging by bed. This delays patient throughput and increases scanner downtime as patients cannot be prepared and queued for efficient scanning.
- The patient observation space allocated is too small to enable the observation of a number of patients. It also impedes an efficient flow of patients. Those requiring post-anaesthesia observation are at times transferred to recover in theatres due to a lack of suitable facilities in the medical imaging area.

Infection control

- There are no isolation rooms or facilities within the medical imaging area to safely care for infectious patients.

Equipment storage

- Equipment lines the corridors and walkways of the radiology area due to insufficient storage facilities.

Staff

- Staff are crowded in clinical, administration and common areas. Some staff have no allocated space in which they can perform administrative tasks. There is no workspace for new medical staff currently being recruited.
- Clinical staff are increasingly involved in multidisciplinary case conferences and access to video conferencing space (and equipment) is challenging in the current footprint.

The medical imaging unit requires expansion and redesign to meet current service needs. It will not be feasible to accommodate the growing infrastructure needs of the DMI on the H-Block site. It will be necessary to relocate some medical imaging services to alternative locations to free-up space for redesign of the H-Block area.

Nuclear medicine

The nuclear medicine wing is more spacious than the radiology wing, but requires some relatively minor modifications.

- The stress test room is too small to accommodate the patient, staff and equipment required, particularly if the patient is transferred by bed. The current room poses a safety risk as there is insufficient room to respond to a code blue event without moving the patient into the corridor. The likelihood of a code blue event is increased when performing stress testing.
- A private space for patients to wait in the nuclear medicine area is required. Patients currently wait in the corridor.
- A workspace is required for nuclear medicine technicians, as they have no designated work area outside of the control room.

More significant modification of the nuclear medicine site will be required in the medium term to accommodate an additional PET scanner and more uptake rooms.

Department of Emergency Medicine

The imaging areas in the DEM (X-ray, CT and ultrasound) do not have sufficient patient waiting areas. The ultrasound room is very small.

Plans to expand the medical imaging footprint are being considered as part of the DEM Redevelopment Project. The expansion will include additional spaces for CT, ultrasound and X-ray.

It is essential that expert staff of the DMI are engaged in the DEM redevelopment design to ensure the medical imaging spaces will support safe and efficient service delivery.

Angiosuite

The new angiosuite is located in K-Block. The old angiosuite is under redevelopment, with completion planned for April 2024. The second angiosuite will provide sufficient capacity for future growth of services, although some patient flow modifications may be required as part of a medical imaging unit (H-block) redevelopment.

Medical imaging equipment

Services Australia uses a Location Specific Practice Number (LSPN) to identify sites providing diagnostic imaging and/or radiation oncology services. Practices must be registered with Services Australia and achieve accreditation to be eligible to claim Medicare benefits.

The LSPN record lists the diagnostic equipment used by the site and the age of the equipment. Medicare benefits are not payable for services provided using imaging equipment that has exceeded its ‘effective life age’. The effective life age for most equipment is 10 years for new equipment, with an extension of up to 15 years for recognised equipment upgrades. This requirement is called 'capital sensitivity'. It is intended to encourage providers to replace ageing equipment.

The DMI LSPN record is due to be updated. Review of internal equipment records collated by DMI staff indicates some items of equipment do not comply with capital sensitivity.

- Fixed X-ray (four units)
- Mobile X-ray (one unit)
- Mobile radioscopy (one unit)
- SPECT camera (one unit, replacement scheduled for later this year)

A number of equipment items are currently within effective life age but will require upgrade or replacement within the next five years, this includes an MRI scanner, ultrasound machines, x-ray machines and a bone mineral densitometer.

The DMI also use a range of other medical equipment that is not required to be recorded on the LSPN but does require replacement when approaching end-of-life. Some items listed on this schedule are due for replacement now.

Asset replacement is an ongoing requirement for the delivery of high-quality medical imaging services. Technological advances can provide reduced radiation dose requirements for patients, improved image quality for increased diagnostic accuracy, increased clinical decision-making support, reduced scan times, and minimise the need for repeat scans.

Failing to replace ageing equipment increases the risk of service interruption due to equipment breakdown and withdrawal of manufacturer support. Exceeding capital sensitivity thresholds also results in lost Medicare Benefits revenue.

A systematic approach to equipment replacement is necessary as part of an overarching capital equipment plan for the DMI.

The medical imaging capital equipment plan should include asset replacement according to the recognised lifecycle for each equipment type and the purchase of additional equipment required to meet forecast demand. Each purchase (replacement or additional) provides an opportunity to invest in new technology and consider the optimal location of services as service activity patterns change.

Due to the high cost of some diagnostic imaging equipment, the specific facility requirements, and the ongoing equipment servicing needs, the DMI capital equipment plan should be developed in consultation with Finance, Infrastructure and Clinical Service Planning areas.

Digital Technology

Robust digital infrastructure to support data collection, collation, management and storage is an essential enabler of medical imaging services.

The Radiology Information Systems and Picture Archiving and Communications System (RIS PACS) stores information, digital images and results for access by public hospital clinicians. The PACS system used by the DMI and other public hospital medical imaging providers in Tasmania is in urgent need of upgrade.

The process of upgrading the PACS component of the system has been delayed, and the product is now nearing end-of-lifecycle, at which time the system will no longer have access to technical support. This represents a significant risk to the THS. A PACS upgrade is urgently required. The specialised technology support and investment needs of medical imaging services are often not well understood, even by those working in eHealth areas. As such, it is essential that the DMI workforce includes sufficient staff with IT expertise, and dedicated time, to support the RIS PACS system.

It is also critical that DMI experts and eHealth leads collaborate early when planning future eHealth initiatives. The Tasmanian Government released a 10-year Digital Health Transformation Strategy in 2022, with an anticipated investment allocation of $476 million. The high-level strategy recognises the need to include medical imaging in a broader system integration program (such as linking RIS PACS to the electronic medical record and enabling electronic referrals for medical imaging). However, there is an absence of detail about how the government intends to invest in new technologies that are of increasing importance for the delivery of high-quality and efficient medical imaging services. Essential infrastructure such as high-speed data networks, cloud-based storage, robust cyber security and data management and analysis systems that include artificial intelligence and machine learning technologies require detailed planning now to inform the rollout of the Digital Health Transformation and position the DMI – and other medical imaging services providing public services – for the future.

Due to the specialised nature of medical imaging technology needs currently and the growing need for investment in advanced technologies into the future, expert DMI staff and digital technology leads need to develop a partnered approach to planning and progressing the technological infrastructure improvements and innovations required to meet current and future service requirements.

Workforce

The DMI workforce is broadly composed of medical specialists, medical trainees / registrars, medical imaging specialists, nuclear medicine technologists, nursing and administration / management and support. Table 6 based on the DHHS establishment details of 26 June 2023 shows that in a number of employment classifications there is a staffing shortfall compared with budgeted FTE. Significant deficits exist for nuclear medicine specialists, radiologists, radiographers and sonographers. These shortfalls may be filled with locum or contract staff, or contracts with external providers.

Table 6: DMI employee classification, budget and actual FTE, 26 June 2023

Classification	Budget	Actual
Nuclear Med / Administration	2.0	1.7
Nuclear Med / PET technologists	5.5	5.9
Nuclear Med specialists	4.8	2.3
Nuclear Med registrar	0.4	0.0
Radiology Administration	23.0	18.3
DMI Nursing	16.6	16.0

Classification	Budget	Actual
Radiography	63.5	59.2
Sonography	9.6	8.0
Radiology specialists	14.9	11.7
Radiology registrars	7.0	10.0
Medical specialists	1.0	0.6

The staffing situation at RHH is by no means unique with many hospitals in Australia and overseas facing similar problems.

The ability to recruit and retain a qualified workforce is dependent upon a number of usually inter-related factors, which in combination are often unique to a particular staff member. Pay and conditions, personal links with the health service and the community, staff development initiatives, both clinical and leadership, and a supportive work environment are all important in potential staff decision-making.

Award pay rates

The easiest to quantify, and often a key consideration in any decision is the standard pay rate available. While total pay is modifiable by various loadings, on-call and recall arrangements, base pay rates provide a reasonable basis of interstate comparison.

The applicable agreements in Tasmania for diagnostic radiography/medical imaging, sonography and nuclear medicine technology is the *Tasmania: Allied Health Professional Public Sector Union Agreement (No 2 of 2022)*. It is also for example the agreement for radiation oncology medicine physicists but who have profession specific arrangements and a separate pay schedule compared with other allied health professions.

Table 7 provides a comparison of the annual base pay for Tasmania, NSW, Victoria and Queensland for a standardised 38 hour week for DMI allied health staff. The comparison has been standardised on the basis of the number of post-graduate years and expected routine progression. Unlike other jurisdictions compared here Tasmania uniquely has a final year student level AHPA A which may provide a worthwhile mechanism to socialise prospective future employees.

Also of note are the two competency / personal progression points in the Tasmanian award, with the second one determining progression to the personally and organisationally important senior radiographer / sonographer level (AHP3-2).

The award rates of pay beyond year twelve continue in similar increments in Tasmania as in other jurisdictions, with the differences largely maintained into the senior specialist and management levels.

Current Tasmanian pay rates (at 27 June 2023) were largely favourable compared with Victoria, however from post-graduate year 3 onwards (Classification AHP1-4) the rates were significantly unfavourable compared with New South Wales and Queensland. The differential increases to 17-27%, by year six, at the first Tasmanian career progression point.

After the key second career progression point in the Tasmanian award, where staff qualify for specialist radiographer / sonographer / technologist classification, which is both an important professional and organisational achievement, the difference is 24-33%. Having a full complement of specialist allied health staff is important in allowing flexible and sustainable rosters and workflow.

Table 7: DMI allied health pay rate comparison, Tasmania and other jurisdictions

Year Post Grad	Tas Cat	Tas 1 Dec 2022	NSW	Vic	Qld	Diff with NSW	Diff with Qld
0	AHPA A	$65,206	n/a	n/a	n/a	n/a	n/a
1	AHP1-2	$69,117	$72,982	$52,801	$73,796	6%	7%
2	AHP1-3	$73,275	$75,709	$56,836	$80,851	3%	10%
3	AHP1-4	$75,739	$85,883	$67,850	$85,711	13%	13%
4	AHP1-5	$79,965	$97,660	$71,292	$91,305	22%	14%
5	AHP1-6	$80,756	$102,419	$75,655	$94,848	27%	17%
Progress point							
6	AHP2-1	$84,193	$105,722	$78,946	$99,092	26%	18%
7	AHP2-2	$88,421	$113,727	$82,540	$103,332	29%	17%
8	AHP2-3	$92,645	$117,527	$86,731	$108,466	27%	17%
9	AHP2-4	$96,883	$120,790	$90,709	$119,651	25%	24%
10	AHP2-5	$101,108	$134,029	$96,283	$122,145	33%	21%
11	AHP2-6	$104,493	$137,755	$99,700	$125,336	32%	20%
Progress point							
12	AHP3-2	$103,608	$137,755	$99,856	$128,751	33%	24%

New pay rates for registrars have just been implemented which provide a substantial increase with effect from 1 July 2023. The base pay rates are now favourable for radiology trainees compared to New South Wales and Victorian colleagues (see Table 8).

Comparisons for VMO specialists are also relatively straight forward as the figures presented here are based on an annualised hourly rate. New South Wales is notable in only having two classification levels which ensures that relatively junior specialists who work on a sessional or hourly basis start at a high pay rate compared to other states. This provides a strong incentive to develop a mixed public / private practice from an early career stage, which historically has been proven advantageous to the public sector as it provides roster flexibility and stability. It also opens up opportunities for these radiologists to extend the breadth of their work and participate in research, education and training.

Table 8: DMI medical staff annual pay rates Tasmania and other jurisdictions

Classification	Tasmania	NSW	Victoria
Registrar range	$131k-$181k	$107k-$151k	$126k-$173k
Staff specialist no Private Practice	$210k-$288k	$252k-$355k	$207k-$328k
Staff specialist with PP increment	$283k-$388k	$252k-$497k	$256k-$404k
VMO specialist	$295k-$445k	$465k-$499k	$322k-$479k

At the senior levels VMO specialists are on largely comparable rates of pay.

The comparison for staff specialists is more complicated as each jurisdiction has various private practice payment arrangements in place, which are not necessarily part of the basic award arrangements. At the base rate with no private practice increment

Tasmanian staff specialists are at a pay disadvantage compared to their interstate colleagues, especially with increasing seniority, where the difference about 14% with Victoria and 24% compared to New South Wales.

The Tasmanian award describes a private practice increment for North West Tasmania specialists only of 35%, which has been used to provide an indicative comparison with other states, which narrows the difference with Victoria to about 4%, but the NSW advantage increases to about 29%.

Other factors that impact work

General

Having regard for the demonstrable difficulties in building full rosters, where they are established with permanent staff rather than reliance on contract or locum staff, there is an important beneficial effect in sustaining the work environment.

The development of a DMI workforce recruitment and retention strategy is likely to be beneficial in providing a framework and structure to ensure the department can identify and access required staff and build a platform for staff retention, leadership and succession.

Issues raised by staff during this consultation include seeking support from the organisation for career progression, access to education and training, and personal and leadership development. Radiographers and other allied health staff with specialist skills are essential to the effectiveness of DMI. The appointment of in-house educators is an important part of building dedicated capacity.

Maintenance of skills also requires regular rotation through all clinical areas including emergency, acute and specialty areas.

The structure of the allied health award specifies two distinct career progression points which provide an opportunity for the organisation to explicitly establish and maintain mechanisms to ensure staff are supported to progress in a planned way.

There will be opportunities to increase the scope of practice for specialist and non-specialist staff. For example, uptake of point of care ultrasound, provides an opportunity to deliver targeted training to other clinical staff who over time will likely decrease demand on specialist staff.

Organisational

In the main DMI the major modalities of CT, MRI, PET and ultrasound operate largely on an extended weekday model, with often substantial on-call, recall obligations.

Increasing utilisation of expensive equipment and technologies where demand exists requires access to effective rostering, which at RHH will mean the introduction of extended weekday and / or scheduled weekend lists.

Clearly this will be a major organisational task mandating the involvement of all DMI staff, hospital orderly staff, and hospital and union representatives. It will require the recruitment of more staff but provides the most immediate mechanism to meet escalating demands for medical imaging services.

Projected future workforce requirements

The analysis prepared for this report shows a substantial projected increase in demand for all medical imaging modalities, with the capacity to meet this demand directly linked to the availability of qualified staff. At the simplest level the increase in projected demand compared to current activity (see Table 2). Table 9 shows the projected number of staff compared with current budget FTE. However, in most classifications the actual FTE is less, often substantially less than budget, so projections described here are from a higher base, which understates the overall workforce issues.

Table 9: Staff levels Budget and Actual and projected increased in Budget FTE, 2025-2027

Classification	2023 Budget FTE	2023 Actual FTE	2025 projected budget FTE	2027 projected budget FTE	Estimated additional budget FTE 2025-2027
Nuclear Med / Administration	2.0	1.7	2.4	2.8	0.4-0.8
Nuclear Med / PET technologists	5.5	5.9	6.7	7.7	1.2-2.2
Nuclear Med specialists	4.8	2.3	5.9	6.7	1.1-1.9
Nuclear Med registrar	0.4	0.0	0.5	0.6	0.1-0.2
DMI Administration	23.0	18.3	26.0	28.8	3.0-5.8
DMI Radiology Nursing	16.6	16.0	18.9	20.8	2.3-4.2
DMI Radiography	63.5	59.2	71.8	78.1	8.3-14.6
DMI Radiology specialists	14.9	11.7	16.8	18.3	1.9-3.4
DMI Radiology registrars	7.0	10.0	7.9	8.6	na
DMI Medical specialists	1.0	0.6	1.1	1.2	0.5-0.6
DMI Sonography	9.6	8.0	11.2	12.3	1.6-2.7

As noted above recruitment of additional staff is required now to meet current work demands and to prepare for extended weekday or new weekend shifts. This will require an enhanced and creative recruitment approach to more effectively compete with employers in other jurisdictions.

The introduction of extended hours of operation will also increase the DMI requirement for hospital orderlies. Although they are not included in the current DMI establishment, access to sufficient orderly staff during extended operational hours will be necessary.

The introduction of a new service such as a community medical imaging hub would require the development of a new workforce model which would lead to some transfer of the FTE projected above, while no doubt also requiring the recruitment of additional staff.

Computed Tomography (CT)

Horizon view

CT scanning is a high-volume diagnostic tool that is a core component of medical imaging services. Demand for CT imaging has increased rapidly in recent years and is expected to continue to be a key contributor to increasing medical imaging demand in the future.

Rapid advancements in CT technology have increased the utility of the modality across a range of medical and surgical disciplines. CT technology is expected to continue to evolve, resulting in further improvements in image quality, faster scan times and reduced radiation exposure for patients.

Spectral CT is predicted to become more widely used and photon-counting CT may replace current CT detector technology. Multimodal imaging with CT and PET is rapidly evolving in key clinical areas such as cardiovascular disease and oncology.

Portable CT scanning is also a tool of increasing importance in hospital practice, facilitating bedside scanning for critically ill patients that would otherwise experience significant risk during transport.

The use of interoperative CT is also expected to grow substantially in key areas such as lesion and tumour identification during neurosurgery and cancer surgeries.

Current service offering

The DMI provides CT imaging services from three sites on the RHH main campus:

- One CT in the main radiology area (H Block)
- One CT in the Emergency Department
- One mobile intraoperative CT (Airo) in theatre.

An additional two CT scanners are planned for the RHH main campus:

- An AngioCT (DSA-CT) for the new angiosuite which is scheduled to open in April 2024. It is a hybrid machine that can also be configured to provide independent CT imaging.

- A second CT within the emergency department is planned for installation in approximately three years' time as part of the RHH DEM Redevelopment Project.

CT service hours of operation are extended due to high levels of planned and unplanned demand. CT image acquisition services are available 7 days a week from 7.30am to 11pm. The intraoperative CT operates from 7am to 3pm daily on weekdays.

Image reading services are available 24 hours a day, 7 days a week, using a combination of in-house and outsourced radiologist services.

Service activity

Almost half (49%) of all CT services delivered by the DMI are provided to DEM patients. Inpatients account for 32% of service occasions, and outpatients the remaining 19%.

CT services have experienced significant growth however service capacity has not kept pace with service demand. As such, CT services for acute patients have been prioritised, and CT services for outpatients have been increasingly delayed or outsourced, resulting in an average annual reduction in outpatient services of 4.2% per year.

Service streams and resource utilisation

Table 10 shows the number of procedures performed by the three CT scanners in the last three years. The number has remained relatively flat for the main DMI site, the use of intraoperative CT is slowly evolving and the DEM scanner has increased numbers by more than 20% in two years.

Table 10: CT procedures, RHH sites, 2020-2022

Resource Description	2020	2021	2022
DMI CT Room 1	9117	9141	9300
CT DEM	12503	13857	15331
Intra-Operative CT	18	159	155
Total	21638	23157	24786

Emergency

The percentage of DEM patients requiring CT services has increased over the past five years from 11.5% to 15.2%. Data also demonstrates increasing rates of CT services with increasing age.

CT imaging is critical to facilitating rapid triage and management of many patients presenting to the ED. The use of CT is expected to continue to grow, aiding in emergent diagnosis and treatment, and contributing to improved patient throughput.

Inpatient

Around 6.7% of all overnight admitted patients require CT services. Older inpatients have a higher rate of CT service use (for example, over 10% of inpatients aged 75+ years require a CT scan).

Interoperative CT services commenced in 2020 as an initiative of the neurosurgery department. Total intraoperative CT numbers are low at around 150 service occasions per year. DMI staff report that interoperative CT activity is being referred to a private provider despite capacity within the DMI to provide this service.

Outpatient

Outpatient CT services have decreased over time. This is not an indication of reducing demand for outpatient CT services. Rather, it indicates capacity constraints. Growing wait times for outpatient CT services due to a lack of capacity has resulted in increased referral of outpatient CT services to local private providers.

Service limitations

The DMI has been constrained from fully responding to the growing demand for CT services due to a combination of workforce and infrastructure factors.

Current service efficiency is affected by barriers to patient flow

The main radiology area provides CT services to inpatients and outpatients. Mixing acute and non-acute patient streams reduces workflow efficiency, increases inpatient wait times and reduces patient satisfaction. Low-complexity outpatient CT services should be provided in a community setting.

Patient flow is limited by insufficient waiting space in the main radiology CT area and the CT area of the DEM. Patients requiring CT are often transported by bed, but there is insufficient room to accommodate patient beds near the CT areas, and rather than queuing patients for seamless flow through the CT scanner, patients are transported to the service one at a time resulting in 'downtime' between scans.

A lack of timely access to orderlies to transfer inpatients from the wards to the main radiology area is also affecting patient flow. The DMI is largely reliant on the general pool of orderly staff to transfer patients to imaging services. Access to orderlies is variable, and patient transfer delays affect the efficiency of the service.

Current service capacity is limited by hours of operation

Current CT service capacity is limited by hours of operation. There is sufficient demand to warrant 24/7 on-site CT image acquisition, but reluctance to move to a 24-hour radiographer roster due to workforce constraints.

Radiographer staff of the DMI are currently rostered onsite from 7am to 11pm and provide an on-call service for the remaining hours. On-call staff are routinely called in to provide CT services. The DMI is experiencing cost over-runs due to high on-call costs. Service capacity could be increased, and service costs potentially reduced by moving to a 24/7 onsite service model.

Table 11 shows annual activity for each site for each day of the week in 2022. Activity reflects a constant daily demand for the DEM scanner, while the other two scanners are used fairly consistently on weekdays, but less so on weekends.

Table 11: CT procedures, RHH sites, day of the week, 2022

Day of week	CT DEM RHH	DMI CT room 1	Intra-Operative CT
Monday	2190	1524	42
Tuesday	2227	1637	28
Wednesday	2128	1742	20
Thursday	2175	1662	27
Friday	2135	1682	26
Saturday	2324	545	7
Sunday	2152	508	5
Total	15331	9300	155

Table 12 sets out a summary analysis about the potential increase in throughput the DMI CT scanner if there were extended hours on weekdays and scheduled sessions on weekends. Using procedure start time data the peak hours of operation are weekdays from 8am until 6pm. Using annualised data applied over 250 working days (excluding public holidays), the average number of scans is estimated to be 2.9 per hour, which is favourable compared with international benchmarks. Allowing for somewhat less work intensity of 2.5 scans per hour on weekday evenings 6-8pm and weekends (9 am-5 pm), the estimated additional number of annual scans would be 2311, which would represent a 25% increase on the current workload of 9300 procedures.

Table 12: DMI CT Room1 activity, current and extended rostered hours

Session	Procedures 2022	Average number per hour	Number of additional scans at rate of 2.5 / hour
Weekday peak hours (8am until 6pm)	7322	2.9	-
Weekdays (6pm-8pm)	277	0.6	973
Saturday (9am-5pm)	343	0.9	657
Sunday (9am-5pm)	319	0.8	681

Transition to a 24/7 onsite service would require careful negotiation with staff and unions. Staff salaries will be affected when shifting from on-call to shift work rates. Further, only a proportion of staff have employment arrangements that include a requirement to work an overnight shift.

Intraoperative CT is not used to capacity.

The mobile interoperative CT (Airo) is currently under-utilised. It provides approximately 150 service episodes per year (3 per week). The Airo requires staffing by a radiographer (1FTE) with specialised skills for interoperative CT.

The current throughput is insufficient to support service efficiency and risks dipping below threshold requirements for staff skills maintenance.

There is anecdotal evidence that some interoperative CT activity is referred to private providers despite capacity within the RHH to provide this service.

International literature indicates that interoperative CT demand is increasing and will continue to increase in areas such as neurosurgery and oncology surgery. Engagement with relevant surgical disciplines is required to understand why surgeries with an interoperative CT component are being referred to private providers, and explore options to increase the utility/efficiency of the service.

Demand projections

Table A10 summarises the demand projections for CT procedures. It is estimated that the demand will increase by 19% by 2025 and 33% in 2027 from 2022 levels due to the combined impact of an increasing and ageing population and annual trend increase of 4%.

As described above a significant number of CT scans are currently outsourced to private service providers. If these services were provided in-house the increase in demand over 2022 levels would increase to 27% and 34% respectively. It is not possible from available data to estimate what the future demand for intraoperative CT will be, but clearly there is substantial available capacity to meet likely future demand.

Table 13: CT demand projections, 2025-2032

Year	Caseload population + trend adjusted	Increase number compared with 2022	Caseload population + trend adjusted + outsourced reclaimed	Increase number compared with 2022
2022	24650	-	24650	-
2025	29220	4570	31366	6716
2027	32728	8078	35131	10481
2032	42870	18130	45273	20623

Based on international benchmarks and local experience it is expected that a caseload of about 2.5 scans per hour should be achieved, which on a standard eight hour shift represents 20 a day, 100-140 a week depending on operating days, and an annual caseload of 5000-7080 having regard for public holidays.

Based on the above projections, which use a baseline of current availability rather than actual potential demand which presumably is greater, an additional CT scanner will be needed by 2025 and up to three will be needed by 2032, which could be located in the DEM, a new community hub, and /or the main DMI.

Opportunities for future service delivery

Increased patient throughput

Opportunity exists to increase the efficient use of CT infrastructure that enables maximal service delivery, through:

- Transfer of low-complexity outpatient CT services to a community-based diagnostic hub.
- Redesign of CT spaces located in the main radiology area (H Block) and the DEM to include sufficient space for three patient beds. One space for the bed of the patient receiving a scan, and two spaces for waiting patients. Additional space for an observation area to accommodate patients after imaging is also required.
- Transition towards a 24/7 onsite CT service on the main RHH hospital campus.
- Access to dedicated orderly services to ensure timely retrieval and return of inpatients to ward areas. Orderlies may be dedicated staff of the DMI or prioritised within the orderly workforce pool.
- Exploring of opportunities to increase the utility and efficiency of the interoperative CT service with surgical discipline representatives.

Outpatient capacity

Expanded outpatient CT capacity is required as a priority as the current outsourcing of outpatient services is costly.

In the immediate term (commencing April 2024), DMI management intends to utilise downtime in the Angiosuite to claw back outsourcing of outpatient CT services. With two angiosuites in operation, there will be a window of opportunity to use the hybrid machine of the new angiosuite to scan outpatients between scheduled acute sessions. This increase in capacity will only be temporary as acute sessions will increase with rising demand over time.

For efficiency and accessibility, outpatient CT services should be provided in a community-based setting unless patient or procedural risk necessitates care delivery on an acute site. To enable sufficient throughput of outpatient CT to meet growing demand, an additional CT scanner is required in the short term [1-3 years], and a second CT scanner will be required in the medium to long term.

Emergency Department capacity

Rapidly increasing demand for CT services in the DEM has already been recognised. The RHH ED Redevelopment project includes an additional CT to increase capacity in the short term.

The current CT operates at a high level of efficiency over the course of the day, but with highest average throughput from late morning to mid-evening.

Inpatient capacity

The shift of most outpatient CT from the acute site and the increase in DEM CT capacity will enable the streaming of inpatient CT services through the CT located in the main radiology area (H Block). Redevelopment of the DMI (H-Block) area should include capacity to install a second CT scanner onsite in the medium to long term for inpatient imaging.

Enablers of future care

Facilities

- Establish a community-based diagnostic hub that includes one CT scanner for low complexity CT imaging of outpatients [1-3 years] and capacity to install a second scanner in the medium to long term.
- Increase waiting space allocations and an observation space adjacent to the CT scanners in the DEM and main radiology area (H Block). [1-3 years, and as part of DEM redevelopment project].
- Install a second CT scanner in the DEM [as per the redevelopment project] and ensure that there is additional space for a third scanner to be installed in the medium to long term, if required.
- Install a second CT scanner in the main radiology department to meet future demand [medium to long term].

Imaging equipment

New CT imaging equipment requirements include:

- Replacement of the existing CT scanner in the ED [approved, September 2023]
- New DSA-CT for the angiosuite redevelopment [approved, April 2024]
- One new CT scanner for the community-based diagnostics hub [1-3 years] with a possible second CT scanner [medium to long term]

- One additional CT scanner for the ED [one with the ED redevelopment project, and potentially another in the medium to long term]
- Replace the CT scanner in the main radiology area at end of lifecycle - consider photon counting technology
- One additional inpatient CT scanner in the main radiology area [medium to long term]

Ultrasound

Horizon view

Ultrasound as a non-ionizing imaging procedure, is one of the most important diagnostic imaging tools in everyday clinical practice. The demand and scope of ultrasound services are predicted to continue to grow.

Ultrasound technology is expected to become more portable and easier to use. This will support the increasing use of point-of-care-ultrasound (POCUS).

New and emerging ultrasound technologies such as contrast enhanced ultrasound (CEUS) and interventional procedures (for example, sonographically controlled microwave ablation) will become increasingly important in diagnostic imaging and interventional medicine alongside CT and MRI.

Key clinical areas anticipated to be impacted by technological advances in ultrasound include:

- Cardiology with advances in 3D echocardiography.
- Gynaecology and obstetrics with 3D and 4D imaging technology for detailed visualisation of the foetus and reproductive organs.
- Oncology with sonographically guided tissue acquisition and ablative tumour therapy.

As ultrasound services become increasingly interventional, the facilities in which these services are provided will need to accommodate new ultrasound technologies and higher patient acuity. Staff providing ultrasound services will require further qualifications, expertise and specialisation.

Current service offering

The Department of Medical Imaging provides ultrasound services via:

- Five ultrasound rooms in the main radiology area (H Block)
- One ultrasound room in the Emergency Department
- One ultrasound room in the Women's Clinic of the Wellington Centre.
- Portable ultrasound used in inpatient ward rooms that are not affected by electrical interference

An additional portable ultrasound is planned for inclusion in the new angiosuite currently under development.

Ultrasound services are provided from 8.30am to 5pm during weekdays. An on-call service is provided after after-hours and on weekends.

Ultrasound services provided include a comprehensive range of conventional ultrasound services and some advanced technologies including contrast enhanced ultrasound imaging and sonoelastography.

Service activity

Overview

The majority of ultrasound services are provided to outpatients (60%), followed by inpatients (29%) and DEM patients (11%).

Demand for ultrasound services is increasing, but service growth has been limited by workforce capacity. Growth in ultrasound services has led to prioritisation of inpatient services (4.8% growth annually) and DEM (4.3% growth annually). To accommodate this growth, outpatient service activity has remained static. Additional outpatient demand has been informally outsourced to local private providers. Frequently outsourced ultrasound services include obstetric, pelvic, abdominal, renal and shoulder imaging.

Service streams

Emergency

Approximately 2% of all ED presentations require an ultrasound. Ultrasound is most frequently requested in hepatobiliary, gynaecological and obstetric illness. As DEM presentations increase, demand for ultrasound is expected to increase.

Inpatient

Around 9% of all overnight admitted patients require ultrasound services. Inpatient demand for ultrasound services increases with age. As the population ages, demand for ultrasound is also expected to increase.

Outpatient

Although ultrasound services are required by male and female patients across all ages, the majority of outpatient ultrasound services (73%) are for women of childbearing age (18-44 years). Children (0-17 years) are the second largest outpatient cohort (14%). As a non-ionising modality, ultrasound is often used preferentially in children for safety.

Service limitations

Current ultrasound service capacity is limited by workforce availability.

Currently, the DMI does not have enough sonographers to meet demand. Difficulties in recruiting and retaining accredited sonographers is commonplace in Australia and other developed countries. Sonographer scarcity is exacerbated in Tasmania as accredited sonographer programs are not available in the State, and there is considerable competition for accredited sonographers with the private sector.

Current workflows are inefficient leading to increasing wait-times

The timeliness of ultrasound services for emergency and inpatient service streams is affected by the volume of non-acute ultrasound services occurring on-site in the main campus of the DMI. Opportunity exists to improve workflow efficiency through more effective streaming of acute and non-acute services.

Current infrastructure will not accommodate future demand and scope expansion

The current footprint for ultrasound services in the main imaging area (H Block) and the DEM is insufficient to meet future demand for ultrasound services. Further, current ultrasound facilities require modification to accommodate the growing use of contrast enhanced and interventional ultrasound technologies in the medium to long term.

Demand projections

Table 14 shows the number of procedures by site and day of the week, As noted above the main ultrasound suite operates during normal weekday business hours, with on-call services available at other times, which is reflected in these data.

Table 14: Ultrasound procedures, RHH sites, day of the week, 2022

Row Labels	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
Room 1	369	544	431	474	425	131	122	2496
Room 2	353	443	421	383	465	9	3	2077
Room 3	378	476	450	570	486	133	96	2589
Room 4	461	531	591	463	508	6	3	2563
Room 5	313	419	411	417	463	0	0	2023
Portable US	144	147	109	336	106	42	29	913
Women's Health	0	0	1	3	21	0	0	25
DEM US Room	128	147	149	151	125	105	103	908
Total	2146	2707	2563	2797	2599	426	356	13594

Taking account of staff rosters and availability utilisation of the main ultrasound rooms is currently about 75% for weekday sessions.

Table 15 summarises the demand projections for ultrasound procedures. It is estimated that the demand will increase by 16% by 2025 and 28% in 2027 due to the combined impact of an increasing and ageing population and annual trend increase of 4%.

As described above a significant number of ultrasounds are currently outsourced to private service providers. If these services were provided in-house the increase in demand over 2022 levels would increase to 28% and 43% respectively.

Table 15: Ultrasound demand projections, 2025-2032

Year	Caseload population + trend adjusted	Increase number compared with 2022	Caseload population + trend adjusted + outsourced reclaimed	Increase number compared with 2022
2022	13606	n/a	13606	n/a
2025	15820	2214	17354	3748
2027	17476	3870	19357	5751
2032	22124	8518	24505	10899

Full utilisation of the current main ultrasound suite through a full staffing profile would expect to increase current throughput by 3500-4000 cases. Increasing use of the Women's Health room will also increase overall capacity. Overall, there should be sufficient rooms and equipment to meet total projected demand until 2027, assuming the requisite number of staff are available, without any change in the type and complexity of ultrasound performed. Ultrasound services in community-based hubs could be expected to provide annually about 3500 services per room.

Opportunities for future service delivery

Separation of acute and non-acute services for service expansion, improved timeliness of ultrasound services and increased patient satisfaction

Streaming of emergency, inpatient and outpatient workflows supports the efficiency of diagnostic imaging, reduces wait times and improves patient satisfaction[4].

The three streams of ultrasound services should be provided from the following locations:

- Non-complex outpatient ultrasound services are to be provided from a community-located diagnostics hub. Design of the ultrasound clinical and waiting spaces should support the care needs of women and children as the key users of this service area.
- Inpatient services and advanced ultrasound technologies are to be provided from the main DMI location of H Block RHH. The current space will require modification to accommodate the higher care needs of patients receiving advanced ultrasound diagnostics and treatments.
- Emergency ultrasound services will continue to be provided from the emergency department. Expanded ultrasound facilities will be required within the DEM to accommodate growing emergency needs.

Targeted use of point of care ultrasound (POCUS)

The use of POCUS by the non-sonographer workforce is an area of growing interest, particularly in time-critical areas such as the DEM. The use of POCUS by appropriately trained staff can increase diagnostic speed and accuracy and potentially reduce requests for some sonographer-performed ultrasounds. However, quality POCUS training and support requires sonographer educators and tutors.

Sonographers form a small clinical workforce, which is difficult to recruit and retain. Allocation of sonographers to POCUS training and support would need to be carefully targeted to ensure that the investment of time and resources results in positive patient outcomes and a reduction of sonographer-provided ultrasound requests in key areas.

Adoption of new and emerging technology

To keep pace with new and evolving technological advances in ultrasound, investment in equipment and support for staff education and training is required. This includes:

- Replacement of ageing technology in accordance with an overarching DMI capital asset plan.

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[4] NHS (2020) Diagnostics: Recovery and Renewal. Report of the Independent Review of Diagnostic Services for NHS England. Available from https://www.england.nhs.uk/publication/diagnostics-recovery-and-renewal-report-of-the-independent-review-of-diagnostic-services-for-nhs-england/ accessed on 28 June 2023.

- Targeted investment in POCUS equipment and training.
- Adoption of advanced technology as it becomes available .
- Education and training support for sonographers seeking to attain sub-specialisation in evolving areas of ultrasound that will benefit the DMI and its patients.

Enablers of future care

Facilities

Establishment of a community-based diagnostic hub that includes four ultrasound rooms with ensuite and a family-friendly waiting area [1-3 years], which would permit a caseload of about 12,000 procedures, which would cover future demand projections and free up two to three of the DMI rooms for the introduction of new, advanced ultrasound technologies.

Increase ultrasound capacity in the DEM from one room (current) to two rooms to ensure optimal flexibility when a number of patients require assessment at the same, time-critical stage. Ensure rooms are of sufficient size and located in proximity to CT and X-ray facilities [as per the ED redevelopment project].

Redesign the ultrasound area in medical imaging (H block) to accommodate inpatient and interventional ultrasound services. Increase the patient waiting space to accommodate more patients waiting in beds and establish an observation area for pre-and post-procedural patients.[Commencing on establishment of the community hub]

Imaging equipment

New imaging requirements include:

- Bariatric-quality ultrasound machine [immediate, approved in process]
- Ultrasound equipment for angiosuite [approved, 2024]
- Replace end-of-life ultrasound equipment [2024]
- Ultrasound equipment for four new ultrasound rooms in community hub [1-3 years]
- Ultrasound equipment for additional ultrasound room in ED [to align with ED redevelopment project]
- Increase POCUS ultrasound availability in accordance with a targeted POCUS strategy [1-3 years]
- Investment in contrast enhanced and interventional ultrasound technologies [medium to long term].

Magnetic Resonance Imaging (MRI)

Horizon view

MRI is a preferred radiological modality as it provides excellent soft-tissue contrast useful for disease detection, diagnosis and treatment monitoring.

Innovations such as parallel imaging and compressed sensing have led to significant scan time reductions, and the move towards higher static magnetic field strengths has increased sensitivity and improved image quality.

MRI technology is expected to continue to evolve, particularly in areas such as magnetic resonance elastography (MRE), magnetic resonance angiogram (MRA), and multiparametric MRI.

MRI is expected to be increasingly used as part of a multimodal approach to identifying and tracking disease in areas such as cardiovascular disease, Alzheimer's disease and Parkinson's disease.

Hybrid integration of MR with PET is growing as a useful innovation, particularly in neurology and neuro-oncology. Hybrid MR-PET supports improved diagnostic accuracy compared to PET/CT and reduces patient radiation exposure.

Current service offering

The Department of Medical Imaging provides MRI from the nuclear medicine wing of the main radiology area (H Block).

The unit has two MRI scanners in back-to-back configuration with a control area in between.

- The first MRI scanner (1.5T) is due for an upgrade in 2024. This scanner was originally purchased by the Menzies Institute. It is used for inpatient imaging and Menzies research subjects from 9am to 5pm daily.
- The second MRI scanner (3T) provides MRI services to outpatients from 7am to 7pm.

On-call MRI acquisition services are available after hours and on the weekend. Image reading services are available 24 hours a day, 7 days a week, using a combination of in-house and outsourced radiologist services.

Service activity

Almost two-thirds of all MRI services are provided to outpatients (65%). Inpatients receive 30% of all MRI services. Only a very small percentage of MRI services (4%) are provided to ED patients.

Table 16 shows the number of MR procedures performed by location and year, with relative maintenance of throughput in the inpatient / research scanner, but a substantial reduction in the main outpatient MR scanner in 2022.

Table 16: MRI procedures, RHH sites, 2020-2022

Resource description	2020	2021	2022
MR Room 1	3696	3844	3333
MR Room 2 (1.5T)	2882	2867	2772
Total	6578	6711	6105

Reduced service activity at the RHH is not due to a reduction in demand but rather due to a lack of capacity. As a result, additional outpatient demand has been informally outsourced to local private providers.

Weekend MRI services are regularly provided to inpatients and to a lesser degree DEM patients. Outpatient MRI services are only provided on weekdays.

Around 5% of all overnight admitted patients require an MRI during their admission. Data suggests inpatient MRI wait times have increased over the past five years. Increased MRI wait times can prevent timely discharge and increase length of stay.

Service limitations

Current MRI capacity is limited by hours of operation

Patients are experiencing long wait times for MRI. During a recent site visit, 25 inpatients were on the waiting list for MRI. Delays in imaging can prevent timely diagnosis and increase hospital length of stay.

Doctors of the RHH are aware that outpatients are experiencing long wait times for MRI. Some are choosing to refer patients to private providers for a timelier service.

MRI throughput is limited by staffing. A minimum of three radiographers are required to run both scanners. MRI scanners are run for limited hours during the day and as an on-call service on the weekend. The hours of operation are insufficient to meet demand.

Table 17 confirms that the MR scanners operate predominantly on week days. In 2021 97% of scans performed in MR Room1 were performed on weekdays between 7am and 6pm and in 2022 that was 95%.

Table 17: MR procedures, RHH sites, day of the week, 2022

Day	MR Room1	MR Room 2 (1.5T)	Total
Monday	609	489	1098
Tuesday	615	567	1182
Wednesday	732	510	1242
Thursday	589	525	1114
Friday	721	510	1231
Saturday	32	95	127
Sunday	35	76	111
Total	3333	2772	6105

Table 18 summarises the day, time and hourly rate of scans performed in 2021 and 2022 in the main MR room. From the available data it is not possible to determine the reason for the decrease in throughput. It is estimated that extended weekday sessions and scheduled weekend work could increase activity by about 40%.

Table 18: Annual number of procedures MR Room 1, hour of the day, 2022

	2021	2021 number per hour	2022	2022 number per hour	Number of additional scans at 1.15 / hour
Weekday (0700-1800 hours)	3726	1.36	3167	1.15	-
Weekdays (1800-1900 hours)	87	0.35	59	0.24	228
Weekdays (1900-2000 hours)	1	0.004	8	0.032	278
Saturday (0900-1700 hours)	1	0.003	30	0.08	430
Sunday (0900-1700 hours)	3	0.008	31	0.08	429
Other	26	nr	38	nr	-

The MRI scanners could be run for longer shifts each day and dedicated shifts on the weekend (rather than an on-call service) but this would require more staffing. It will also require negotiation with staff as a move towards more shift work will affect radiographer rates of pay.

Outpatient service flow is interrupted by inpatient service needs

Patients waiting for an MRI are prioritised according to clinical need. Urgent inpatient MRI needs are prioritised, interrupting the efficient flow of less urgent outpatient scans. Inpatient and outpatient scanning should be separated to support efficient patient flows.

MRI facilities do not support an efficient flow of patients with complex scan requirements

The number of patients (adult and children) requiring MRI with sedation or general anaesthetic is increasing. The MRI waiting and patient preparation area is not large enough to accommodate patients requiring general anaesthetic without affecting the workflow of the entire unit. Patients requiring general anaesthetic, and the staff supporting them, occupy most of the available space in the waiting and preparation area. This halts the preparation of other patients in the area and affects patient throughput. After an MRI, post-anaesthesia patients require observation in either the MRI waiting space or transfer to theatre recovery. Staff estimate the time taken to scan one patient with general anaesthetic (including pre and post scan support) is equivalent to the time taken to scan three patients under normal conditions.

The MRI space is not configured to efficiently support and scan patients with sedation and general anaesthesia requirements.

Reduced efficiency due to delays in patient transfers

Staff report patient transfers from the ward to the MRI scanning area are often delayed by lack of timely access to orderlies and long transit times from some ward areas (for example K Block). Patient transfer delays result in unnecessary downtime between scans and exacerbate MRI wait times.

Demand projections

Table 19 summarises the demand projections for MR procedures. It is estimated that the demand will increase by 17% by 2025 and 20% in 2027 due to the combined impact of an increasing and ageing population and annual trend increase of 4%.

As described above a significant number of MR scans are currently outsourced to private service providers. If these services were provided in-house the increase in demand over 2022 levels would increase to 27% and 37% respectively.

Table 19: MR demand projections, 2025-2027

Year	Caseload population + trend adjusted	Increase number compared with 2022	Caseload population + trend adjusted + outsourced reclaimed	Increase number compared with 2022
2022	6105	n/a	6105	n/a
2025	7154	1049	7744	1639
2027	7957	1852	8334	2229
2032	10293	4188	10781	4676

Using 2021 activity of 3726 cases in normal work hours, it would be expected that the new MR scanner could be operated at a similar intensity, bringing an annual caseload of about 7500 cases, which would fall short of the expected 2027 demand, however extended weekday and scheduled weekend lists could cover this gap.

A shift of lower complexity, outpatients to a community-based hub would free up DMI capacity for complex procedures and streamline patient flows.

Opportunities for future service delivery

Provide timely and accessible MRI services

The timeliness and throughput of patients requiring MRI services can be improved by

- Transitioning MRI services to a seven-day per week on-site service with extended hours of operation to enable clawback of outsourced services [commencing 2023]
- Transfer non-complex outpatient MRI services from H Block to a community-based diagnostics hub to improve throughput of outpatient MRI services and increase patient convenience [1-3 years]
- Retain the current MRI space on H Block for inpatient and complex outpatient scans. Reconfigure the MRI space to support workflows for complex MRI scans. [1-3 years]

Increase MRI scanning capacity in line with growing demand.

The majority of current and projected MRI services are provided to outpatients. As outpatient demand grows over time ,additional MRI scanner capacity should be provided in a community-based setting to facilitate access.

Enabling strategies

Facilities

A community-based diagnostics hub with infrastructure to accommodate one MRI scanner in the short term [1-3 years] and a second scanner in the medium to long term.

Reconfigure the current MRI space on H Block to support complex scan workflows, including:

- Increasing the size of the patient waiting and preparation area to facilitate patients requiring sedation or general anaesthesia.
- Access to an observation area for post anaesthesia patients (this can be a shared space with other modalities).

Imaging equipment

The following MRI upgrades and equipment are required:

- Upgrade the 1.5T scanner [2024]
- Two new MRI scanners for the community-based hub, one in the short term [1-3 years] and one in the medium to long term, with consideration of introducing a hybrid MRI scanner as the technology becomes more available.

Positron Emission Tomography (PET)

Horizon view

PET is a nuclear medicine technology that uses positron emitting radionuclides to image and quantify metabolic, biochemical and/or physiological functions of the body.

The clinical applications of PET are expanding rapidly. Novel PET tracers are in continual development. New research radiotracers are being developed for neuroimaging applications with possible clinical applications in the diagnosis and management of a range of CNS-related conditions.

Immune-specific PET imaging is under research in cancer immunotherapy. Currently at preclinical stage, techniques may help guide the clinical management of cancer patients treated with immunotherapy and are likely to have applications outside of oncology for other diseases in which the immune system plays a role.

PET scanners are expected to become more precise, with higher resolution images and faster scan times. A new generation of total body PET (TBP) scanners have recently been developed that are a potentially disruptive technology.

Expanded use of PET and technological developments will likely require more PET capability within hospitals and capacity to accommodate newer generation machines. Increasing PET activity is also likely to curb or reduce demand for more traditional nuclear medicine technologies over time.

Current service offering

The DMI has one PET scanner located in the nuclear medicine wing of the main diagnostic imaging area (H Block). The scanner is relatively new and reported to be in good working order.

PET services operate on weekdays. Operating hours are dependent on isotope availability. Isotope is flown in from Melbourne each weekday at around 11am.

Service activity

Ninety per cent of DMI PET services are provided to outpatients. The remaining 10% of services are provided to inpatients.

Until 2020 the DMI owned and operated the only PET scanner in Tasmania. In 2020 a second PET scanner operated by a private provider commenced service in Hobart. More recently, another private provider has commenced operations of a third scanner located in Northern Tasmania.

The operation of additional PET scanners initially reduced DMI PET activity however, by 2022, activity was again increasing despite significantly more total capacity in Tasmania.

Table 20: Number of nuclear medicine and PET procedures, location, 2020-2022

Resource location	2020	2021	2022
NM injection Room1	320	300	206
Nuclear Medicine Room 1	1362	1266	1907
Nuclear Medicine Room 2	1016	1249	867
RHH PET-CT	2592	3060	3200
Total	5290	5875	6180

Table 21 confirms the day and time availability of PET services. Noting the limiting factor of availability of isotopes, scheduling of the service to weekends or extended weekday availability would be a mechanism available to help meet expected strong, increased demand.

Table 21: PET procedures, day and time of day, 2022

Time	Mon	Tue	Wed	Thur	Fri	Sun	Total
8 AM	26	52	64	60	45	0	247
9 AM	123	202	209	185	163	0	882
10 AM	151	199	148	138	164	0	800
11 AM	135	131	173	115	125	0	679
12 PM	67	85	94	74	55	0	375
1 PM	39	34	32	21	33	0	159
2 PM	9	8	11	15	3	0	46
3 PM	2	2	1	3	0	1	9
4 PM	1	0	1	0	1	0	3
Total	553	713	733	611	589	1	3200

An annual throughput of 3200 represents 12.8 cases per workday at an average of 38 minutes per case for an eight-hour day, which is consistent with international benchmarks.

Service limitations

Competition with the private sector for PET services

There are three PET scanners in Tasmania leading to a degree of competition that did not exist before 2020. However, as the utility of PET continues to increase, demand is expected to continue to grow over time.

Radioisotope production

The facilities required to produce radioisotopes are not available in Tasmania. As such, radioisotope is flown from Melbourne daily for patients requiring PET. As the demand and utility of PET continues to grow, a Tasmanian-based radioisotope production facility may become more viable.

The production of radioisotopes requires a particle accelerator known as a cyclotron. Cyclotron facilities are very costly with high capital costs (cyclotron purchase and specialised facilities) and significant ongoing operational costs.

A comprehensive feasibility study would be required to determine the viability of local radioisotope production. This specialised study should include exploration of public-private partnerships or collaborative investment arrangements to ease upfront capital burden and ensure sufficient demand to warrant ongoing operational costs.

Workforce

The small and specialised nuclear medicine workforce faces significant challenges across Australia, with nuclear medicine physician retirement outnumbering Fellow output and difficulty attracting sufficient nuclear medicine technicians to meet growing service demand. These challenges are also reflected in the profile of the Tasmanian nuclear medicine workforce.

Demand projections

Table 22 summarises the demand projections for PET and non-PET nuclear medicine. It is estimated that the demand for PET will increase by 22% by 2025 and 39% in 2027 due to the combined impact of an increasing and ageing population and annual trend increase of 5%.

Table 22: PET and nuclear medicine demand projections, 2025-2032

Year	PET Caseload population + trend adjusted	PET increase number compared with 2022	Other nuclear medicine caseload population + trend adjusted	Other NM increase number compared with 2022
2022	3164	-	2977	-
2025	3857	693	3643	666
2027	4409	1245	4170	1193
2032	6096	2932	5772	2795

The expected increase in PET demand in 2025 is equivalent to about eight hours work per week and 16 hours work by 2027, which may be met by increased weekday throughput by extended lists, or scheduling weekend work or with the availability of more efficient treatment strategies becoming available.

Opportunities for future service delivery

PET demand projections indicate an additional PET scanner will be required in the medium term [7-10 years].

Although the majority of PET services are provided to outpatients, it is recommended that the second PET is installed in the current location for PET services on the acute RHH campus. Whilst the new PET and related infrastructure could be located in a community location with the required supporting infrastructure, the nuclear medicine workforce is unlikely to have the capacity to provide PET services from two locations.

Enablers of future care

Facilities

Remodelling of the existing nuclear medicine space to include a second PET scanner in the medium term [7-10 years].

Increase in uptake rooms to accommodate increased throughput due to activity from an additional scanner and reduced scanning times as technology evolves [7-10 years]

Imaging equipment

An additional PET in the medium term [7-10 years] with consideration of a total body or large field PET for increased throughput and utility. Note: total body/large view PET scanners require different shielding and support space design considerations compared to conventional PET.

Conventional Radiography (X-ray)

Horizon view

X-ray is a low-cost, high-volume medical imaging modality. Access to X-ray has increased with the expansion of mobile X-ray units, community-based imaging locations, and delivery of urgent care outside of acute hospital sites.

In some areas of clinical practice, conventional X-ray is being superseded by newer technologies such as CT. Demand for conventional X-ray is expected to continue to grow but not at the same rate as other high-growth modalities.

Current service offering

The DMI provides X-ray services from a range of locations, including:

- Two X-ray rooms in the main radiology area on H Block. These rooms are mainly used for inpatient and some specialist outpatient X-ray.
- One X-ray room in the emergency department. This is the busiest X-ray area. It operates 24/7.
- One X-ray room at Wellington Clinics operated five days per week. This site has a high orthopaedic case load.
- One new X-ray room at Liverpool clinics operated 1.5 days per week.
- X-ray services provided one day per week at the New Norfolk District Hospital.
- Mobile X-ray services.

An additional X-ray room is planned for the ED as part of the RHH ED redevelopment project.

Service activity

The DMI provides over 60,000 X-ray services per year. Almost one-half (49%) of all X-ray services are provided to DEM patients, a third to inpatients and the remaining (19%) for outpatients.

Table 23 summarises the time and location of conventional x-rays performed in RHH, excluding smaller volume units and theatres. Currently the DEM XR room 1 undertakes about 50% of total hospital activity, with about 12.5% performed at the Wellington Centre.

Table 23: Conventional x-rays, annual number per hour and site, 2022

Time	ED Room1	X-ray Room1	X-ray Room 2	Resus X-ray	Mobile ICU	Mobile Wards	Wellington Room 3	Total
12 AM	842	1	12	106	63	130	0	1154
1 AM	711	10	17	58	52	103	0	951
2 AM	598	5	9	87	42	103	0	844
3 AM	614	5	10	69	37	69	0	804
4 AM	500	2	11	70	28	69	0	680
5 AM	457	1	17	66	95	82	0	718
6 AM	443	20	13	69	2667	209	14	3435
7 AM	453	1	15	73	646	57	15	1260

Time	ED Room1	X-ray Room1	X-ray Room 2	Resus X-ray	Mobile ICU	Mobile Wards	Wellington Room 3	Total
8 AM	760	161	177	69	129	156	529	1981
9 AM	1267	487	640	88	51	258	1074	3865
10 AM	1599	678	645	146	55	301	1502	4926
11 AM	1592	753	642	156	72	256	772	4243
12 PM	1524	537	610	127	81	195	393	3467
1 PM	1666	517	575	160	109	309	828	4164
2 PM	2422	493	586	191	147	308	1367	5514
3 PM	2307	441	586	189	112	326	841	4802
4 PM	2203	324	554	170	111	304	238	3904
5 PM	2096	114	297	158	74	208	0	2947
6 PM	1636	45	108	131	87	193	3	2203
7 PM	1642	47	146	147	104	217	0	2303
8 PM	1488	54	103	117	73	181	4	2020
9 PM	1509	42	68	146	33	152	0	1950
10 PM	1280	11	33	103	74	127	1	1629
11 PM	912	8	32	103	52	107	0	1214
Total	**30521**	**4757**	**5906**	**2799**	**4994**	**4420**	**7581**	**60978**

There is an ongoing requirement for access to X-ray for inpatients from mid-afternoon (4pm) until mid-evening (8-9pm).

Service limitations

Patient throughput delays

X-ray is a high-volume modality. Delays in patient throughput can significantly affect the timeliness and efficiency of the service.

Services located on the RHH campus report frequent patient delays due to long patient transit times from the ward to the imaging areas.

Access to orderlies for patient transfer is limited, particularly as X-ray is not a scheduled service, so patients do not receive a booking time. Patient transport for scheduled services (such as MRI) are prioritised, resulting in delays in X-ray throughput and a backlog of patients at the end of the day when the orderly pool is low, and DMI staff numbers are reduced.

Patient throughput is also impeded due to a lack of waiting space to support the effective queuing of patients before X-ray and the post-imaging observation area is too small to accommodate the volume of patients requiring imaging services.

Insufficient staffing allocation

DMI has not received a staffing allocation for the new X-ray room in the Liverpool St Clinics area. It is currently being operated at 1.5 days per week using staff from the existing radiographer pool. However, this is not a sustainable model going forward. If appropriately staffed the clinic could operate full-time to increase outpatient X-ray capacity, potentially up to the throughput of the Wellington Clinic.

Demand projections

Table 24 summarises the demand projections for X-ray. It is estimated that the demand will increase by 11% by 2025 and 19% in 2027 due to the combined impact of an increasing and ageing population and annual trend increase of 2%. Optimising use of the Liverpool St X-ray room would to a large extent accommodate the projected increase in demand by 2025.

Table 24: X-ray demand projections, 2025-2032

Year	Caseload population + trend adjusted	Change compared with 2022
2022	62443	-
2025	69222	6779
2027	74134	11691
2032	86930	24487

Opportunities for future service delivery

There are opportunities to increase X-ray capacity to meet demand beyond 2025 by:

- Allocating a staffing budget to the DMI for the full-time operation of the new X-ray room in the Liverpool St Clinics area [immediately].
- Developing a satellite X-ray location close to high volume inpatient areas (for example K Block, A Block or in between in the old EMUA location). Service delivery from a satellite location would decrease inpatient transfer times and increase service delivery capacity [1-3 years].
- Include X-ray services in a community-based hub for low-complexity outpatient medical imaging services [1-3 years].
- Add an additional X-ray room in the DEM [already included in the ED redevelopment project].
- Remodel existing X-ray facilities in the radiology area (H Block) to improve patient throughput [1-3 years] and accommodate an additional X-ray room in the medium term [5 years].

Enablers of future care

Facilities

- Develop a satellite X-ray space in the RHH close to high-volume ward areas [1-3 years].
- Include two X-ray rooms in a community-based medical imaging hub [1-3 years] and allocate space for a further two rooms in the medium to long term.
- Redevelop the main radiology space for improved patient flow with expanded waiting and observation spaces [1-3 years].
- Add a second X-ray room to the emergency department [as described in the RHH ED redevelopment project plan].

Equipment

- One X-ray machine and supporting equipment for RHH satellite space. Consider also using this space as a base for additional mobile units.
- One additional X-ray machine with supporting equipment for the Emergency Department [as part of the ED redevelopment project].
- Two X-ray machines and supporting equipment for a community-based medical imaging hub. Consider an additional two X-ray machines with supporting equipment in the medium to long term.
- One additional X-ray machine and supporting equipment for the radiology area (H Block) in the medium term [5 years].

Appendix 1: Literature Review

Background

The Department of Medical Imaging (DMI) at the Royal Hobart Hospital (RHH) currently provides a broad range of radiology services for the Tasmanian Health Service (THS) – South, including Computed Tomography (CT), Magnetic Resonance Imaging (MRI), x-ray, ultrasound, fluoroscopy, bone mineral density and Nuclear Medicine modalities, Positron Emission Tomography (PET) and Gamma Camera based imaging.

The DMI is experiencing significant and substantial growth in demand for services. Provision of DMI services is physically constrained within its current RHH footprint.

The DMI requires the development of a Clinical Service Plan (CSP) to identify current and future challenges to delivering radiological services and to outline strategies as to how the DMI can best respond. The planning horizon for the CSP is to the year 2040, which would align with other Tasmanian health planning.

KP Health have been engaged to support development of the CSP. A key component of service planning is this rapid review of the literature that describes new and emerging trends and technologies in radiology practice that may impact on the infrastructure needs of the DMI to 2040.

Review methods

This rapid review of the peer-reviewed and 'grey' literature was conducted to identify five years of English language publications (including publications where an English language translation was available) published between January 2019 and April 2023.

Searches of the peer-reviewed literature were conducted in PubMed and the Cochrane Library. The 'grey' literature was searched using Google and Bing.

Evidence from Australia and other countries with comparable health systems to Australia (UK, US, Europe, Canada and NZ) was sought.

MeSH search terms and key words that were used to conduct searches included:

- Radiology (MeSH)
- Radiography (MeSH)
- Radiology, Information Systems (MeSH)
- Radiology Department, Hospital (MeSH)
- Diagnostic Imaging (MeSH)
- Technolog* (keyword), innovat* (key word), develop* (key word), emerg* (key word), trend* (key word)

Materials of broad relevance were imported into an Endnote Library and were coded by a single reviewer to identify included publications. There were 242 publications included in the Endnote Library, of which 52 publications were included in the literature review.

What new and emerging trends are anticipated in radiology by 2040?

Radiology is a field that has already seen significant technological advancements in recent years, and it is expected that this trend will continue in the coming years. Advancements in radiology are occurring at a much faster rate than in the 20th century. Technological advancements are improving the way radiologists work, providing clearer images and interacting with machines that deliver results quickly and accurately.

New and emerging technologies that may reshape radiology by the year 2040 include the following:

1. New and enhanced medical imaging techniques. These are discussed in detail below in the following sections.
2. Artificial Intelligence (AI) and Machine Learning (ML): The use of AI and ML algorithms in radiology has already started to gain momentum, and it is expected to become more prevalent in the coming years. Applications of AI and ML include streamlining the analysis and interpretation of large amounts of medical imaging data, which can lead to faster and more accurate diagnoses.(1-3)
3. Virtual and Augmented Reality: Virtual and augmented reality technologies may be used to create 3-dimensional medical images. These technologies have a range of applications, particularly in interventional procedures, surgical and medical device domains.(4-6)
4. Nanotechnology: In radiology, nanotechnology could be used to develop more precise and targeted imaging techniques that may improve accuracy of diagnoses.(7)

Many of these technologies are still in their early stages of development. As a result, the extent of their adoption into radiology practice is uncertain.

What advances in imaging techniques are anticipated over the next 20 years?

Advances are predicted across most imaging modalities, with rapid technological advancement particularly predicted for magnetic resonance (MR), positron emission tomography (PET), ultrasound and computed tomography (CT).

- Magnetic Resonance Imaging (MRI) Scanners: MRI technology is expected to continue to evolve, with higher field strengths and faster scanning times. This will allow radiologists to obtain more detailed images of the body and reduce the time required for a scan.(3)
- PET: PET scanners are expected to become more precise, with higher resolution images and faster scan times. Radiotracers may also become more specific, allowing for the identification of more specific disease processes.(8)
- Ultrasound: Ultrasound technology is expected to become more portable and easier to use, allowing for wider use in remote and rural areas. 3D and 4D ultrasound may also become more widely available, providing more detailed images of the fetus and other organs.
- CT: CT technology is also expected to continue to evolve, with improved image quality and reduced radiation exposure for patients. Dual-energy CT, which can differentiate between different types of tissue, is also likely to become more widely used. Photon-counting CT may replace current CT detector technology.(3)

There is potential to improve the accuracy of diagnoses, reduce the time required for scans, and improve patient outcomes. However, the implementation of these technologies will require significant investment and collaboration across different healthcare organizations and technology providers.

Magnetic resonance technologies

MRI continues to evolve, broadening its applications in radiology.(9) Due to its excellent soft-tissue contrast and the huge variety of accessible tissue- and physiological-parameters, MRI is often preferred to other radiological modalities. Innovations in the field of MR have been parallel imaging and compressed sensing, leading to significant scanning time reductions, and the move towards higher static magnetic field strengths, which led to increased sensitivity and improved image quality.(10) Improvements in workflow and the use of artificial intelligence are among many current trends seen in this field, which may further broaden the use of MRI (11-13).

The mechanical properties of soft tissues are closely associated with a variety of diseases. This motivates the development of elastography techniques in which tissue mechanical properties are quantitatively estimated through imaging. Magnetic resonance elastography (MRE) is a non-invasive phase-contrast MR technique wherein shear modulus of soft tissue can be spatially and temporally estimated.(14) Magnetic resonance elastography (MRE) has recently emerged as a reliable, high-resolution, and especially sensitive technique that can noninvasively characterize tissue biomechanical properties (i.e., viscoelasticity) in vivo in the living human brain. Progress in brain MRE technology has provided unique insights into healthy brain aging, neurodegeneration, and structure-function relationships. It is potentially valuable role as an imaging biomarker of neurodegeneration. MRE sensitivity may be particularly useful for assessing the efficacy of rehabilitation strategies, assisting in differentiating between dementia subtypes, and in understanding the causal mechanisms of disease which may lead to eventual pharmacotherapeutic development.(15)

The technology behind MRA is developing. New developments expand the reliability and range of clinical applications for non-contrast MRA, along with functional MRA capabilities not available with CTA or CEMRA.(16)

Expanded use of MR and technological developments will likely require more MR machines, and newer technology machines, to be available within hospital radiology departments. Developments in MR technology and their application to multimodal imaging in cardiovascular disease, cancer and neurology are discussed in more detail below.

Positron emission tomography

The clinical applications of PET are expanding rapidly. The use of PET imaging agents in oncology, cardiovascular disease, and neurodegenerative disease shows the potential of PET in evaluating the molecular and biological characteristics of numerous diseases. These agents provide information for designing therapeutic strategies for individual patients. Novel PET tracers are in continual development and many have potential use in clinical and research settings.(17)

New research radiotracers are being developed for neuroimaging applications and may have clinical applications in diagnosis and management of a range of CNS-related conditions, including:(18)

- mood disorders
- schizophrenia,
- autism spectrum disorder,
- addiction
- traumatic brain injury
- stroke,
- epilepsy,
- neurogenerative diseases,
- neuroinflammatory diseases,
- neuro-oncology,
- pain,
- behaviour studies (e.g., behaviour problems and symptoms of dementia).

Immune-specific PET imaging is under research in cancer immunotherapy. Currently at preclinical stage, techniques may help guide clinical management of cancer patients treated with immunotherapy and likely have applications outside of oncology for other diseases in which the immune system plays a role.(19)

A new generation of total body PET (TBP) scanners have recently been developed that are a potentially disruptive technology. Total body PET scanners were initially built for whole-body nonhuman primate imaging, but further development of the technology has led to recent introduction of the first TBP scanners for human imaging. The clinical scanners have up to 2-m fields of view, compared with approximately a 20-cm field of view for the current generation of scanners. The increase in solid angle provided by TBP scanners is providing 4- to 5-fold gains in scanner sensitivity, and with further improvements, TBP scanners are projected to provide a 40-fold gain in sensitivity and 6-fold increases in S/N ratio. The new opportunities arising from this development are multi-fold; for example, TBP may enable practitioners to scan patients:(18)

- in shorter time periods (using the current standard radiotracer dose),
- at the same time—that is, simultaneous multi-patient imaging studies whereby patients could be positioned, for example, head to head,
- for extended time periods (using the current standard radiotracer dose),
- with several-fold lower radiation and mass doses,
- dynamically, enabling the acquisition of whole-body pharmacokinetics, and
- allow the study of different body system interactions (e.g., gut–brain or spleen–brain dynamics in the context of neuroinflammatory diseases, and so on),
- enable image-derived input function, and
- test new mathematical models for possible non-invasive metabolite correction by acquiring liver, bladder, kidney, and blood pool kinetics.

Expanded use of PET and technological developments will likely require more PET capability within hospitals, and capacity to accommodate newer generation machines. Developments in PET technology and their application to multimodal imaging in cardiovascular disease, cancer and neurology are discussed in more detail below.

Ultrasound

The use of point-of-care ultrasound (POCUS) by non-radiologists has dramatically increased. Although this may USS demand in some areas, new and emerging ultrasound technologies will result in increased ultrasound infrastructure requirements within radiology departments (3, 20).

Ultrasound as a non-ionizing imaging procedure is one of the most important diagnostic procedures in everyday clinical practice. The technology is widely used. Due to constant technical innovations, sonographic procedures, such as contrast-enhanced ultrasound (CEUS), sonoelastography, new microvascular Doppler modalities and, as an example of interventional procedures, sonographically controlled microwave ablation (MWA), are becoming increasingly important in diagnostic imaging and interventional medicine alongside CT and MRI. However, this also requires greater expertise, specialization and qualification on the part of users. Contrast-enhanced ultrasound (CEUS), microvascular Doppler modalities, fusion imaging and elastography complement B-scan ultrasound and conventional Doppler procedures for various problems. Microwave ablation (MWA) has a place as an ablative procedure for local tumour therapy in different organ systems and can be performed under ultrasound guidance.(21)

Endoscopic ultrasound (EUS) is progressing to include tissue acquisition, which provided the basis for therapeutic procedures. Even as interventional EUS develops, there is ongoing progress in EUS diagnostic capabilities due to improved imaging systems, better needles for tissue acquisition and development of enhanced imaging functions such as contrast harmonic EUS (CHEUS) and EUS elastography. Its clinical utility is growing in terms of gastrointestinal cancer staging, the evaluation of pancreaticobiliary disorders and tissue acquisition. Enhanced imaging techniques such as CHEUS and EUS elastography are increasingly used (22).

Computerised tomography

CT scanning, which started to be developed around 1970, is nowadays a main tool of radiology in daily clinical work. The demand for CT imaging is predicted to increase as there is a greater requirement for minimally invasive procedures and the improved advancements in CT technology. Advances in CT scan technology include reducing radiation, faster scan speeds and improved image quality.(3)

Novel scanning techniques reduce radiation exposure. Some CT scan methods lower radiation exposure splitting full X-ray beams into thin beamlets can deliver the same quality of image at a much-reduced radiation dose. In addition, newer CT detector technology, which measures the amount of radiation transmitted through the body, provides more accurate level of radiation exposure.(23)

Newer 256-slide CT scan diagnostic imaging equipment takes super-fast pictures and provides more visual details than previous iterations of CT technology. Image reconstruction technology (IR) in CT also continues to evolve, generating tomographic images from X-ray projection data acquired at many different angles around the patient, which in turn improves image quality and reduces radiation.(24)

Spectral CT technology (also called dual-source/dual-energy CT) is another trend that is becoming more and more integrated into major CT vendors technologies. Spectral CT breaks down X-ray photos by chemical elements, based on viewing one part of the body at two different kV energies, with a dual-source CT scanner. Instead of scanning a patient several times using different energies to focus on different tissue types, spectral CT technology provides different views from a single scan. This can create contrast and non-contrast images created from one single scan.(23, 24)

Portable CT scanning is also emerging as an important radiological tool in hospital practice. Portable CT scanners offers fast CT deployment to hospitals and radiology units and has been especially beneficial to treatment of patients by reducing the risk to patients during transportation and increased risk during the treatment process.(23, 24)

Discipline-specific advances in imaging techniques

Much of the evolution in radiology infrastructure is specific to different disease types and areas of clinical practice. Population ageing, together with a growing chronic disease burden, will increase demand for radiology in cardiovascular, cancer and neurology disciplines. Examples of how new and emerging radiological modalities, and their role in multimodal imaging in specific disease areas, are described below.

Cardiovascular disease

Atherosclerotic plaque rupture is the primary mechanism responsible for myocardial infarction and stroke, the top two killers worldwide. Despite being potentially fatal, the ubiquitous prevalence of atherosclerosis amongst the middle aged and elderly renders individual events relatively rare. This makes the accurate prediction of MI and stroke challenging. Advances in imaging techniques now allow detailed assessments of plaque morphology and disease activity.(25) Both CT and MR can identify certain unstable plaque characteristics thought to be associated with an increased risk of rupture and events. PET imaging allows the activity of distinct pathological processes associated with atherosclerosis to be measured, differentiating patients with inactive and active disease states. Hybrid integration of PET with CT or MR shows promise for an accurate assessment of not only plaque burden and morphology but plaque biology too.(26-28)

Cardiovascular computed tomography (CCT) has undergone rapid maturation over the last decade and is now of proven clinical utility in the diagnosis and management of coronary artery disease, in guiding structural heart disease intervention, and in the diagnosis and treatment of congenital heart disease. Further advances in hardware and advanced analytics may increase the role of CCT cardiac imaging.(29, 30)

The ongoing refinements in 3-dimensional (3D) echocardiography technology continue to expand the scope of this imaging modality in clinical cardiology by offering new features that stem from the ability to image the heart in its complete dimensionality. Over the years, countless publications have described these benefits and tested new frontiers where 3D echocardiographic imaging seemed to offer promising ways to improve patients' care. These include improved techniques for chamber quantification and novel ways to visualize cardiac valves, including 3D printing, virtual reality, and holography.(4, 31)

Advances in vascular imaging have improved evaluation of atherosclerotic plaque progression and vascular inflammatory changes. Future development of intravascular imaging modalities, such as optical coherence tomography-intravascular ultrasound, optical coherence tomography-near-infrared autofluorescence, polarized-sensitive optical coherence tomography, and micro-optical coherence tomography, are anticipated for better management of patients with cardiovascular disease.(32)

Cancer

The role of multimodality imaging in oncology is rapidly evolving. There is continuously growing interest in comprehensive multivariable imaging evaluations to guide oncological practice. For example, in abdominal oncology, published research papers involving multimodality PET(/CT)+MRI combinations show an increase in numbers over time, both for retrospective combinations of PET/CT and MRI, as well as hybrid PET/MRI. Main areas of research included new PET-tracers, visual PET(/CT)+MRI assessment for staging, and semi-quantitative analysis of PET-parameters compared to or combined with MRI-parameters as predictive biomarkers.(33)

Over the last decade, patients with diverse forms of locally advanced or metastatic cancer, such as melanoma, lung cancers, and many blood-borne malignancies, have seen their life expectancies increasing significantly. However, many patients remain unresponsive to treatment, and others experience toxic side effects. Understanding cellular and molecular mechanisms underlying these variables is aided through non-invasive imaging techniques. An example of such is immuno-PET (Positron Emission Tomography), which employs radiolabelled antibodies to detect specific molecules of interest. Nanobodies, as the smallest derived antibody fragments, have been trialled in preclinical models and, more recently, in clinical early-stage studies as well. Their merit stems from their high affinity and specificity towards a target, among other factors.

Furthermore, their small size (~14 kDa) allows them to easily disperse through the bloodstream and reach tissues in a reliable and uniform manner (34).

Mammography has moved towards 3-dimensional tomosynthesis systems. This modality reduces false positives and unnecessary biopsies. Additional technological changes are anticipated in breast imaging technology. Breast MRE is a non-ionizing, cross-sectional MR imaging technique that provides for quantitative viscoelastic properties, including tissue stiffness, elasticity, and viscosity, of breast tissues. Currently, the technique continues to evolve as research surrounding the use of MRE in breast tissue is still developing.(35, 36) Contrast-enhanced mammography (CEM) may have future utility in breast imaging. Intravenous iodinated contrast materials are used in CEM to enhance the visualization of tumour neovascularity. After injection, imaging is performed with dual-energy digital mammography, which helps provide a low-energy image and a recombined or iodine image that depict enhancing lesions in the breast. CEM has been demonstrated to help improve accuracy compared with digital. It has also been demonstrated to approach the accuracy of breast MRI in preoperative staging of patients with breast cancer and in monitoring response after neoadjuvant chemotherapy. There are early encouraging results from trials evaluating CEM in the screening of women who are at an increased risk of breast cancer. Although CEM is a promising tool, it slightly increases radiation dose and carries a small risk of adverse reactions to contrast materials.(37, 38)

Multiparametric MRI (mpMRI) is the "state of the art" management tool for patients with suspicion of prostate cancer. Several investigations have shown comparable diagnostic accuracy of biparametric (bpMRI) and mpMRI for the detection of prostate cancer. The advantage of abandoning contrast-enhanced sequences improves operational logistics, lowering costs, acquisition time, and side effects. The main limitations of bpMRI are that most studies comparing non-contrast with contrast MRI come from centres with high expertise that might not be reproducible in the general community setting. Our ageing population will likely result in increased demand for MRI-based investigations for prostate disease.(39)

Neurology

Observing Alzheimer's disease (AD) pathological changes in vivo with neuroimaging provides invaluable opportunities to understand and predict the course of disease. Neuroimaging AD biomarkers also allow for real-time tracking of disease modifying treatment in clinical trials. Multimodal imaging using PET and MRI approaches are being used for diagnosis and staging. The most recent advances in human neuroimaging of Alzheimer's disease focus on positron emission tomography (PET) markers of Aβ and tau, structural atrophy, and functional dysconnectivity (with magnetic resonance imaging [MRI]) (40).

Recent advancements in hardware, sequences, methods, analyses, and applications of human neuroimaging techniques utilized to assess epilepsy. These structural, functional, and metabolic assessments include magnetic resonance imaging (MRI), positron emission tomography (PET), and magnetoencephalography (MEG). Advancements that highlight non-invasive neuroimaging techniques used to study the whole brain.(41)

Imaging biomarkers in Parkinson's disease (PD) are increasingly important for monitoring progression in clinical trials and also have the potential to improve clinical care and management. Magnetic resonance imaging (diffusion imaging, neuromelanin-sensitive imaging, iron-sensitive imaging, T1-weighted imaging), positron emission tomography/single-photon emission computed tomography dopaminergic, serotonergic, and cholinergic imaging as well as metabolic and cerebral blood flow network neuroimaging biomarkers may have applications in diagnosis and monitoring rate of disease progression.(42)

Gastroenterology

Inflammatory bowel disease is defined by a chronic relapsing and remitting inflammation of the gastrointestinal tract, with intestinal fibrosis being a major complication. The current diagnosis of IBD relies on endoscopy, which is invasive and does not provide information on the presence of extraluminal complications and molecular aspect of the disease. Cross-sectional imaging modalities such as computed tomography enterography (CTE), magnetic resonance enterography (MRE), positron emission tomography (PET), single photon emission computed tomography (SPECT), and hybrid modalities have demonstrated high accuracy for the diagnosis of IBD and can provide both functional and morphological information when combined with the use of molecular imaging probes.(43)

What new infrastructure will radiology need by 2040?

The radiology field continues to evolve towards digital techniques, practices and infrastructure. In addition to medical imaging equipment, other new infrastructure will be required to keep up with the changing technology and patient needs by 2040.

1. Cloud-based storage: With the increasing use of AI and machine learning algorithms in radiology, large amounts of medical imaging data will need to be stored and processed quickly. Cloud-based storage systems will be necessary to handle the vast amounts of data generated by these technologies and to ensure easy access to medical images across different healthcare facilities.(44)
2. High-speed networks: With the increasing use of remote consultations and telemedicine, high-speed networks will be necessary to ensure fast and reliable transmission of medical images and other data between healthcare providers.(3)
3. Data Management Systems: As the amount of medical imaging data continues to increase, data management systems will be necessary to help radiologists collect, collate, analyse and report data effectively. These systems will need to be highly efficient, scalable, and secure.(45)
4. Advanced Cybersecurity: With the increasing use of digital infrastructure in radiology, cybersecurity will become more critical than ever. Advanced cybersecurity measures will be necessary to protect medical data from cyber threats and ensure patient privacy.(3)

Along with staff shortages, radiology and imaging departments worldwide are faced with additional pressures like increasing workload. Digitalization can unlock a whole new level of operational performance as well as hidden potential for improvements, helping you operate more efficiently. Digital solutions like remote scanning software, customized dashboards to track targets and KPIs, and digital platforms that enable data-driven decisions along the entire patient pathway can empower you to simplify operations and create smart workflows to help reduce the workload and boost workforce productivity. With innovative solutions that optimize asset utilization and help increase efficiency, you can dedicate more time and focus on providing best possible patient care.

Artificial intelligence and machine learning

One of the most pressing concerns in radiology today is the exponential growth of data and the shortage of medical staff to handle this complex and ever-increasing amount of data. Intelligent solutions support radiologists in making better informed clinical decisions and adding value along the patient journey. Through superior integration and interpretation of data and creation of actionable insights, AI-powered solutions pave the way for shaping clinical decisions in radiology and assist radiologists and clinicians in making the right decision for every patient.

Data science is likely to lead to major changes in imaging. Problems with timing, efficiency, and missed diagnoses occur at all stages of the imaging chain. The primary purpose of AI is for better decision-making to improve patient outcomes. Moreover, the growing population and shrinking human resources make it necessary to use technology to make the overall process of radiology more effective with fewer resources.

Artificial Intelligence is already found in many aspects of radiology practice, including:(46)

- Auto-segmentation of various human body parts in 3D post-processing.
- Using computers and multiple technologies for detecting cancer.
- NLP (Natural language processing) to simplify paramount reporting results.

The application of artificial intelligence (AI) is dependent on robust data; the application of appropriate computational approaches and tools; and validation of its clinical application to image segmentation, automated measurements, and eventually, automated diagnosis. AI may reduce cost and improve value at the stages of image acquisition, interpretation, and decision-making.(47)

A systematic review of 50 studies by Hung et al. (2020) investigated the current clinical applications and diagnostic performance of AI in dental and maxillofacial radiology. Most studies focused on AI applications for an automated localization of cephalometric landmarks, diagnosis of osteoporosis, classification/segmentation of maxillofacial cysts and/or tumours, and identification of periodontitis/periapical disease. The performance of AI models varies among different algorithms, necessitating further work to verify the reliability and applicability of the AI models prior to transferring these models into clinical practice.(48)

There is a rapidly growing and exciting literature involving the use of machine learning to make out of sample predictions about clinical progression in Alzheimer's Disease (40).

Radiomics

Recent advancements in imaging technology and analysis methods have led to an analytic framework known as radiomics. This framework extracts comprehensive high-dimensional features from imaging data and performs data mining to build analytical models for improved decision-support.(49) Its features include many categories spanning texture and shape; thus, it can provide abundant information for precision medicine. Many studies of prostate radiomics have shown promising results in the assessment of pathological features, prediction of treatment response, and stratification of risk groups (49-51).

Radiomics and radiogenomics may change the practice of medicine, particularly for patients with colorectal cancer. Radiomics corresponds to the extraction and analysis of numerous quantitative imaging features from conventional imaging modalities in correlation with several endpoints, including the prediction of pathology, genomics, therapeutic response, and clinical outcome. In radiogenomics, qualitative and/or quantitative imaging features are extracted and correlated with genetic profiles of the imaged tissue. Thus far, several studies have evaluated the use of radiomics and radiogenomics in patients with colorectal cancer; however, there are challenges to be overcome before its routine implementation including challenges related to sample size, model design and interpretability, and the lack of robust multicenter validation set.(52)

Summary

Radiology is one of the younger branches of medicine but it has revolutionised the way medicine is practiced. We can expect to see significant changes in radiology practice over the next 20 years as technology continues to evolve at a rapid pace. Overall, the infrastructure changes required by the radiology field by the year 2040 will be driven by:

- continued advancements in medical imaging techniques.
- the ongoing digital transformation of radiology and the resulting need for data collection, collation, management and storage associated with this.
- a need for greater efficiency in the context of growing use of radiology in clinical practice together with workforce constraints that hamper our ability to process such large numbers of radiological investigations.

These changes will require significant investment and collaboration across different healthcare organizations and technology providers.

Advances are predicted across most imaging modalities. The breadth of clinical applications for radiology to support improved clinical service delivery is also predicted to continue to grow. This has the potential to improve the accuracy of diagnoses, reduce the time required for scans, and improve patient outcomes. However, the implementation of these technologies will require increased radiology infrastructure, including more machines and a larger radiology workforce.

Supporting digital infrastructure will also be required to keep up with changes in radiology technology. High speed networks, data management systems and advanced cybersecurity will be required to support radiology practice as it continues to evolve.

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Appendix 2: Data analysis and forecasting

A. General findings

The THS provided DMI service activity data from 2018-2022 with data for the calendar years 2020-2022 used for demand projections. Where possible the data was linked to emergency department presentations and admitted inpatient episodes, which provided procedure specific age cohort, diagnosis and length of stay information. This has allowed projections to reflect the current and expected increase in relative demand and utilisation by older patient cohorts.

Demand projections have used medium population estimates developed by the Tasmanian Department of Finance, based on the outcome of the 2021 census.

In general terms the projected age mix will increase population related demand by 1.5% per annum compared with an overall increase in population of about 0.8%.

An additional adjustment reflecting above population demand at RHH and increased utility of the various medical imaging modalities has also been made. In the absence of the availability of national public hospital comparators, the adjustment applied has taken account of recent RHH trends, current private sector access in Tasmania measured by Medicare billing[5] compared with other jurisdictions and demand projections established by NHS Scotland[6].

Table A1 shows the change in rate of Medicare (predominantly private sector) billing in Tasmania and nationally over the last five years.

Table A1: Medicare billing rates, modality, jurisdiction, 2018/19-2022/23

	Ultrasound	CT	Diagnostic radiology	PET	Other Nuclear Medicine
Tasmania per capita rate compared with national rate in 2022/23	64%	81%	93%	108%	97%
Tasmania annual per capita change 2018-2023	-0.9%	1.4%	-2.9%	20.1%	-0.1%
Australia annual per capita change 2018-2023	0.8%	4.6%	-1.2%	18.3%	0.5%

Key issues are:

- Ultrasound per capita rates have historically been low in Tasmania compared with elsewhere, however this has further deteriorated over the last five years with an annual reduction of 0.9% compared with increases elsewhere. The Tasmanian per capita rate is now just 64% of the national average.

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[5] Australian Department of Human Services, Medicare Statistics: accessed on 21 August 2023, available at http://medicarestatistics.humanservices.gov.au/

[6] NHS Scotland, Diagnostic Imaging Workforce Plan for Scotland, May 2023

- CT rates have increased at an annual rate of 1.4% compared with a national average of 4.6%, with current per capita rates in Tasmania at 81% of national averages.
- Diagnostic (Conventional) Radiology / X-ray rates have fallen more in Tasmania compared with other jurisdictions, noting a national downward trend and are currently about 7% less than average.
- Consistent with the rest of Australia PET use has increased by about 20% each year over the last five years and is now above the national rate by about 8%. As identified below, a significant proportion of RHH PET services are billed to Medicare, and being only one of three providers in Tasmania, RHH activity has significant influence on these figures.
- There has been a change in how other Nuclear Medicine data is presented but utilisation in Tasmania is in line with, though slightly below the rest of Australia.

Tasmania-specific MRI data is not publicly available, however nationally utilisation is flat, increasing by less than 1% per capita for each of the last five years, which presumably reflects Commonwealth restrictions on the number of Medicare eligible machines, which is below international comparisons.

Demand projections

Table A2 shows the number of procedures performed by each diagnostic imaging modality at RHH at a 2022 baseline. The population adjusted columns reflect, as described above, the change in projected demand from a 2022 baseline using age cohort data for each modality. The annual trend adjustment applied in addition to the population estimates are:

- 2% for BMD, conventional radiology, fluoroscopy, intraoperative CT and RFA
- 4% for angiography, CT, MRI and ultrasound
- 5% for PET and other nuclear medicine.

Table A2: Modality projections, based on population changes and trend adjustments, 2025-2032

	Base	Population adjusted			Population and trend adjusted			Average annual change
Modality	**2022**	**2025**	**2027**	**2032**	**2025**	**2027**	**2032**	**2022-25**
Angio	3638	3816	3944	4236	4293	4799	6271	5.7%
BMD	626	681	718	796	722	792	971	4.9%
CR	62443	65229	67145	71313	69222	74134	86930	3.5%
CT	24650	25975	26899	28961	29219	32726	42870	5.8%
Fluor	2170	2248	2302	2431	2385	2542	2963	3.2%
ICT	144	149	152	160	158	168	195	3.1%
MRI	6105	6360	6540	6954	7154	7957	10293	5.4%
N Med	2977	3147	3267	3543	3643	4170	5772	7.0%
PET	3164	3332	3455	3743	3857	4409	6096	6.8%
RFA	959	991	1015	1078	1051	1121	1448	3.1%
US	13606	14064	14363	14946	15820	17475	22124	5.2%
Total	120482	125990	129801	138162	137523	150293	185933	4.5%

Key issues with the historical data and projections include:

- There was a significant increase in angiography activity in 2020-2021, but which appears to have since stabilised in 2022, which presumably reflects access to a new angiography suite in K Block, therefore the trend adjustment applied is less than the historical data would indicate.

- Conventional radiology at RHH has increased steadily in recent years in contrast to private sector activity.

- As noted above, there has been a substantial increase in PET throughput, which in the context of RHH is recognised to be in part due to increased service efficiency.

- There has been a significant, but until recently not fully documented direct referral from RHH clinicians to external private imaging services. Business Information [redacted]

Table A3: RHH outsourced MI procedures, May 2023 and annualised, demand impact

Modality	May 2023	Annualised number	Change to 2022 activity if performed by RHH
X-ray / CR	86	1032	1.7%
CT	151	1812	7.4%
MRI	75	900	14.7%
Ultrasound	110	1320	9.7%
Other	46	552	-
Total	468	5616	4.7%

If this outsourced activity was returned to RHH the overall effect would be a 4.7% increase in demand, ranging from 1.7% for conventional radiography to 14.7% for MR imaging.

Billing of RHH diagnostic imaging procedures

A proportion of diagnostic imaging procedures performed in public hospitals are eligible to raise private accounts for Medicare, private health insurers, other compensable schemes including motor accident and workplace injury, and overseas visitors.

We have used historic billing to provide some indication about future prospects for any additional facilities, such as a community hub. Please note these figures are indicative only and further investigation by the THS will be required to more accurately determine billing eligibility.

Business Information [redacted].

Table A4: RHH medical imaging procedures invoiced, referral source, 2020-2022

Business Information

[redacted]

Table A5 shows the number and proportion of invoices raised by modality and referral source in 2022.

Table A5: RHH invoices, modality, referral source, 2022

Business Information

[redacted]

B. Modality Summary - Computed Tomography (CT)

The DMI provides CT imaging services from three sites on the RHH main campus:

- One CT in the main radiology area (H Block)
- One CT in the Emergency Department
- One mobile intraoperative CT (Airo) in theatre.

Table A7 summarises annual CT activity at RHH. There has been strong and consistent growth in the throughput of the CT in DEM, with steady use of the DMI CT. On available data the intra-operative CT is currently used sparingly.

Table A7: CT procedures, RHH sites, 2020-2022

Resource Description	2020	2021	2022
DMI CT Room 1	9117	9141	9300
CT DEM	12503	13857	15331
Intra-Operative CT	18	159	155
Total	21638	23157	24786

Table A8 shows annual activity for each site for each day of the week in 2022. Activity reflects a constant daily demand for the DEM scanner, while the other two scanners are used fairly consistently on weekdays, but less so on weekends.

Table A8: CT procedures, RHH sites, day of the week, 2022

Day of week	CT DEM RHH	DMI CT room 1	Intra-Operative CT
Monday	2190	1524	42
Tuesday	2227	1637	28
Wednesday	2128	1742	20
Thursday	2175	1662	27
Friday	2135	1682	26
Saturday	2324	545	7
Sunday	2152	508	5
Total	15331	9300	155

Figure A1 shows a comparison of the annual number of procedures for the DEM and DMI CT scanners for each of the day (procedure start time). As expected, it shows substantial DEM caseload throughout the day, which peaks in the early afternoon through to the late evening. On average, least activity occurs between 0500-0700 hours in the morning,

The DMI CT scanner activity reflects the usual business hours of the department, with peak rates from 0800-1500 hours, which exceed those of the DEM scanner, then a steady decrease in procedure numbers during the rest of the day.

Figure A1: Procedure start time, annual number of procedures, CT site

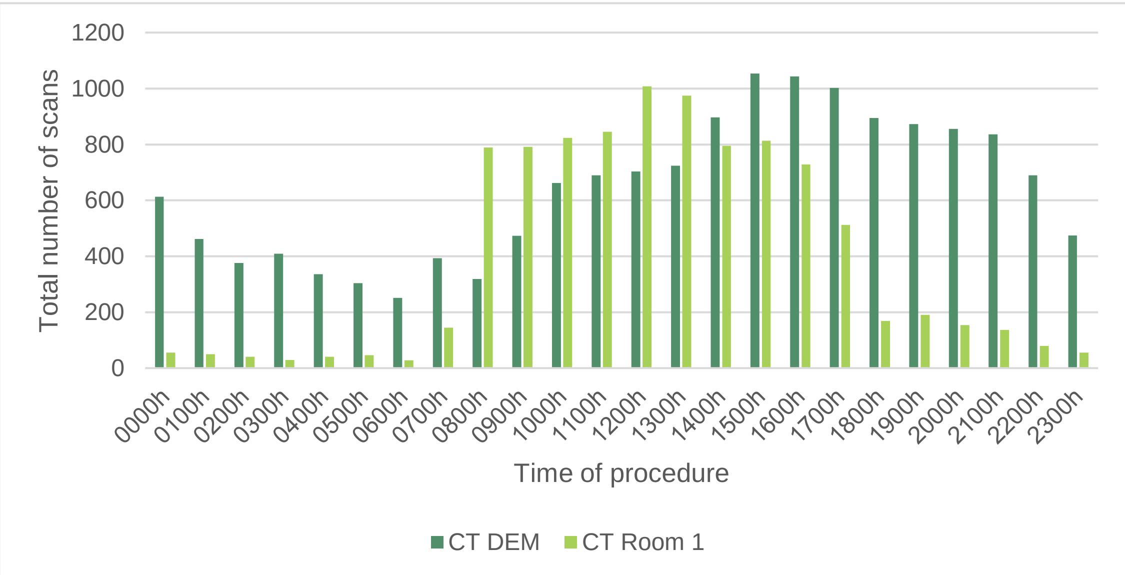

Table A9 sets out a summary analysis about the potential increase in throughput the DMI CT scanner if there were extended hours on weekdays and scheduled sessions on weekends. Using procedure start time data the peak hours of operation are weekdays from 8 am until 6 pm. Using annualised data applied over 250 working days (excluding public holidays), the average number of scans is estimated to be 2.9 per hour, which is favourable compared with international benchmarks. Allowing for somewhat less work intensity of 2.5 scans per hour on weekday evenings 6-8pm and weekends (9 am-5 pm), the estimated additional number of annual scans would be 2311, which would represent a 25% increase on the current workload of 9300 procedures.

Table A9: DMI CT Room1 activity, current and extended rostered hours

Session	Procedures 2022	Average number per hour	Number of additional scans at rate of 2.5 / hour
Weekday peak hours (8 am until 6 pm)	7322	2.9	-
Weekdays (6pm-8pm)	277	0.6	973
Saturday (9am-5pm)	343	0.9	657
Sunday (9am-5pm)	319	0.8	681

Clearly any changes to scheduled work are absolutely dependent on the availability of qualified staff, willing to work these rosters.

Demand projections

Table A10 summarises the demand projections for CT procedures. It is estimated that the demand will increase by 19% by 2025 and 33% in 2027 due to the combined impact of an increasing and ageing population and annual trend increase of 4%. It is not possible from available data to estimate what the future demand for intraoperative CT will be, but clearly there is substantial available capacity to meet likely future demand.

As described above a significant number of CT scans are currently outsourced to private service providers. If these services were provided in-house the increase in demand over 2022 levels would increase to 27% and 34% respectively.

The projected increased demand of 8000-10000 additional procedures by 2027 would be able to be accommodated by the new DEM CT scanner. Expected demand by 2032 could be met by two DEM CT scanners operating 24 hours per day and the DEM scanner working extended or additional shifts.

Table A10: CT demand projections, 2025-2032

Year	Caseload population + trend adjusted	Increase number compared with 2022	Caseload population + trend adjusted + outsourced reclaimed	Increase number compared with 2022
2022	24650	-	24650	-
2025	29220	4570	31366	6716
2027	32728	8078	35131	10481
2032	42870	18130	45273	20623

The new CT scanner in the angiosuite will also have an impact on demand for other CT scanners. In 2022 there were more than 4000 CT angiograms performed on the DEM and DMI scanners (see Table A11). It is likely a substantial proportion of these patients would be investigated in the new angiosuite and relieve some demand pressures on the DMI and DEM scanners.

Table A11: CT angiograms, time of day, scanner location, 2022

Time	CT DEM	CT DMI	Total
0000-0800 hours	583	72	655
0800- 1600 hours	1000	804	1804
1600-2400 hours	1282	368	1650
All	2865	1244	4109

C. Modality Summary – Ultrasound

The Department of Medical Imaging provides the following ultrasound services:

- Five ultrasound rooms in the main radiology area (H Block)
- An ultrasound room in the ED and in the Women's Clinic of the Wellington Centre
- A portable ultrasound used in inpatient ward rooms.

Table A11 summarises ultrasound activity for 2020-2022, with a steady increase overall. The main ultrasound rooms are used intensively, especially rooms 1, 3 and 4. Both the portable and ED facilities have been used increasingly in 2022 compared with the previous two years. Noting that the Women's Health room had only just come online by the end of 2022.

Table A11: Ultrasound procedures, RHH site, 2020-2022

Site	2020	2021	2022
RHH Ultrasound Room 1	2670	2499	2496
RHH Ultrasound Room 2	2066	2131	2089
RHH Ultrasound Room 3	2520	2490	2589
RHH Ultrasound Room 4	2467	2337	2563
RHH Ultrasound Room 5	1987	2033	2023
RHH Portable Ultrasound Room 6	408	616	913
Women's Health Consult Room 11	0	0	25
DEM US Room	570	663	908
Total	12688	12769	13606

Table A12 shows the number of procedures by site and day of the week, As noted above the main ultrasound suite operates during normal weekday business hours, with on-call services available at other times, which is reflected in these data.

Table A12: Ultrasound procedures, RHH sites, day of the week, 2022

Row Labels	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
Room 1	369	544	431	474	425	131	122	2496
Room 2	353	443	421	383	465	9	3	2077
Room 3	378	476	450	570	486	133	96	2589
Room 4	461	531	591	463	508	6	3	2563
Room 5	313	419	411	417	463	0	0	2023
Portable US	144	147	109	336	106	42	29	913
Women's Health	0	0	1	3	21	0	0	25
ED US Room	128	147	149	151	125	105	103	908
Total	2146	2707	2563	2797	2599	426	356	13594

Table A13 shows the annual average number of ultrasound procedures in time blocks, with peak activity in the morning session, a wind-down for lunch and then a return to high levels during the afternoon. There are a limited number of procedures after 5 pm and on weekends.

Table A14 sets out a summary analysis about the potential increase in ultrasound throughput if there were scheduled sessions on weekends. Using procedure start time data the peak hours of operation are weekdays from 8 am until 5 pm. Using annualised data applied over 250 working days (excluding public holidays), the average number of scans is estimated to be 8.8 per day if all the five main ultrasound rooms are used. However due to staff shortages and review of recent rosters suggests that actual utilisation is closer to 75%, which would suggest a rate closer to 11-12 per day, which is still somewhat less than local and international benchmarks. While weekend work is spread over a number of rooms, it maybe able to be consolidated in one, which would suggest almost another 600 ultrasounds could be scheduled.

Table A14: Ultrasound procedures, annual average number per hour, time of the day, 2022

Session	5 main US room procedures 2022	Average number per day / room	Number of additional scans at rate of 11 / day
Weekday peak hours (8 am until 5 pm)	11013	11-12	-
Saturday (9am-5pm)	263	5.3	287
Sunday (9am-5pm)	202	4.0	298

Demand projections

Table A15 summarises the demand projections for ultrasound procedures. It is estimated that the demand will increase by 16% by 2025 and 28% in 2027 due to the combined impact of an increasing and ageing population and annual trend increase of 4%.

As described above a significant number of ultrasounds are currently outsourced to private service providers. If these services were provided in-house the increase in demand over 2022 levels would increase to 28% and 43% respectively.

Table A15: Ultrasound demand projections, 2025-2032

Year	Caseload population + trend adjusted	Increase number compared with 2022	Caseload population + trend adjusted + outsourced reclaimed	Increase number compared with 2022
2022	13606	n/a	13606	n/a
2025	15820	2214	17354	3748
2027	17476	3870	19357	5751
2032	22124	8518	24505	10899

Full utilisation of the current main ultrasound suite through a full staffing profile would expect to increase current throughput by 3500-4000 cases. Increasing use of the Women's Health room will also increase overall capacity. Overall, there should be sufficient rooms and equipment to meet projected demand until 2027, assuming the requisite number of staff are available.

D. Modality Summary - MRI

The Department of Medical Imaging provides MRI from the nuclear medicine wing of the main radiology area (H Block).

The unit has two MRI scanners in back-to-back configuration with a control area in between.

- The first MRI scanner (1.5T) is due for an upgrade in 2024
- The second MRI scanner (3T) provides MRI services to outpatients from 7am to 7pm.

Table A16 shows the number of MR procedures performed by location and year, with relative maintenance of throughput in the inpatient / research scanner, but a substantial reduction in the main outpatient MR scanner in 2022.

Table A17: MRI procedures, RHH sites, 2020-2022

Resource description	2020	2021	2022
MR Room 1	3696	3844	3333
MR Room 2 (1.5T)	2882	2867	2772
Total	6578	6711	6105

Table A17 confirms that the MR scanners operate predominantly on week days. In 2021 97% of scans performed in MR Room1 were performed on weekdays between 7am and 6pm. In 2022 that was 95%.

Table A17: MR procedures, RHH sites, day of the week, 2022

Day	MR Room1	MR Room 2 (1.5T)	Total
Monday	609	489	1098
Tuesday	615	567	1182
Wednesday	732	510	1242
Thursday	589	525	1114
Friday	721	510	1231
Saturday	32	95	127
Sunday	35	76	111
Total	3333	2772	6105

Table A19 summarises the day, time and hourly rate of scans performed in 2021 and 2022 in the main MR room. From the available data it is not possible to determine the reason for the decrease in throughput. It is estimated that extended weekday sessions and scheduled weekend work could increase activity by about 40%.

Table A19: Annual number of procedures MR Room 1, hour of the day, 2022

	2021	2021 number per hour	2022	2022 number per hour	Number of additional scans at 1.15 / hour
Weekday (0700-1800 hours)	3726	1.36	3167	1.15	-
Weekdays (1800-1900 hours)	87	0.35	59	0.24	228
Weekdays (1900-2000 hours)	1	0.004	8	0.032	278
Saturday (0900-1700 hours)	1	0.003	30	0.08	430
Sunday (0900-1700 hours)	3	0.008	31	0.08	429
Other	26	nr	38	nr	-
	3844		3333		1365

Demand projections

Table A20 summarises the demand projections for MR procedures. It is estimated that the demand will increase by 17% by 2025 and 20% in 2027 due to the combined impact of an increasing and ageing population and annual trend increase of 4%.

As described above a significant number of MR scans are currently outsourced to private service providers. If these services were provided in-house the increase in demand over 2022 levels would increase to 27% and 37% respectively.

Table A20: MR demand projections, 2025-2027

Year	Caseload population + trend adjusted	Increase number compared with 2022	Caseload population + trend adjusted + outsourced reclaimed	Increase number compared with 2022
2022	6105	n/a	6105	n/a
2025	7154	1049	7744	1639
2027	7957	1852	8334	2229
2032	10293	4188	10781	4676

Using 2021 activity of 3726 cases in normal work hours, it would be expected that the new MR scanner could be operated at a similar intensity, bringing an annual caseload of about 7500 cases, which would fall short of the expected 2027 demand, however scheduled weekend lists could cover this gap.

E. Modality Summary – PET

The DMI has one PET scanner located in the nuclear medicine wing of the main diagnostic imaging area (H Block). The scanner is relatively new and reported to be in good working order.

PET services operate on weekdays. Operating hours are dependent on isotope availability. Isotope is flown in from Melbourne each weekday at around 11 am.

There has been a substantial increase in PET services since 2020, with an increase of 18% in 2021 and a further 5% in 2022.

Table A21 confirms the day and time availability of PET services. Extension of the service to weekends or extended weekday availability would be a mechanism available to help meet expected strong, increased demand.

Table A21: PET procedures, day and time of day, 2022

Time	Mon	Tue	Wed	Thur	Fri	Sun	Total
8 AM	26	52	64	60	45	0	247
9 AM	123	202	209	185	163	0	882
10 AM	151	199	148	138	164	0	800
11 AM	135	131	173	115	125	0	679
12 PM	67	85	94	74	55	0	375
1 PM	39	34	32	21	33	0	159
2 PM	9	8	11	15	3	0	46
3 PM	2	2	1	3	0	1	9
4 PM	1	0	1	0	1	0	3
Total	553	713	733	611	589	1	3200

An annual throughput of 3200 represents 12.8 cases per workday at an average of 38 minutes per case for an eight hour day, which is consistent with international benchmarks.

Demand projections

Table A22 summarises the demand projections for PET and non-PET nuclear medicine. It is estimated that the demand for PET will increase by 22% by 2025 and 39% in 2027 due to the combined impact of an increasing and ageing population and annual trend increase of 5%.

Table A22: PET and nuclear medicine demand projections, 2025-2032

Year	PET Caseload population + trend adjusted	PET increase number compared with 2022	Other nuclear medicine caseload population + trend adjusted	Other NM increase number compared with 2022
2022	3164	-	2977	-
2025	3857	693	3643	666
2027	4409	1245	4170	1193
2032	6096	2932	5772	2795

The expected increase in PET demand in 2025 is equivalent to about one days work of 8 hours, which may be met by increased weekday throughput with more efficient treatment strategies becoming available.

F. Modality Summary – Conventional radiology

The DMI provides X-ray services from a range of locations, including:

- Two X-ray rooms in the main radiology area on H Block. These rooms are mainly used for inpatient and some specialist outpatient X-ray.

- One X-ray room in the emergency department. This is the busiest X-ray area. It operates 24/7.
- One X-ray room at Wellington Clinics operated five days per week. This site has a high orthopaedic case load.
- One new X-ray room at Liverpool clinics operated 1.5 days per week.
- X-ray services provided one day per week at the New Norfolk District Hospital.
- Mobile X-ray services.

Table A23 summarises the time and location of conventional x-rays performed in RHH, excluding critical care areas and theatres. Currently the ED XR room 1 undertakes about 50% of total hospital activity, with about 12.5% performed at the Wellington Centre.

Table A23: Conventional x-rays, annual number per hour and site, 2022

Time	ED Room1	X-Ray Room1	X-Ray Room 2	Resus X-Ray	Mobile ICU	Mobile Wards	Wellington Room 3	Total
12 AM	842	1	12	106	63	130	0	1154
1 AM	711	10	17	58	52	103	0	951
2 AM	598	5	9	87	42	103	0	844
3 AM	614	5	10	69	37	69	0	804
4 AM	500	2	11	70	28	69	0	680
5 AM	457	1	17	66	95	82	0	718
6 AM	443	20	13	69	2667	209	14	3435
7 AM	453	1	15	73	646	57	15	1260
8 AM	760	161	177	69	129	156	529	1981
9 AM	1267	487	640	88	51	258	1074	3865
10 AM	1599	678	645	146	55	301	1502	4926
11 AM	1592	753	642	156	72	256	772	4243
12 PM	1524	537	610	127	81	195	393	3467
1 PM	1666	517	575	160	109	309	828	4164
2 PM	2422	493	586	191	147	308	1367	5514
3 PM	2307	441	586	189	112	326	841	4802
4 PM	2203	324	554	170	111	304	238	3904
5 PM	2096	114	297	158	74	208	0	2947
6 PM	1636	45	108	131	87	193	3	2203
7 PM	1642	47	146	147	104	217	0	2303
8 PM	1488	54	103	117	73	181	4	2020
9 PM	1509	42	68	146	33	152	0	1950
10 PM	1280	11	33	103	74	127	1	1629
11 PM	912	8	32	103	52	107	0	1214
Total	**30521**	**4757**	**5906**	**2799**	**4994**	**4420**	**7581**	**60978**

Demand projections

Table A24 summarises the demand projections for conventional radiology. It is estimated that the demand will increase by 11% by 2025 and 19% in 2027 due to the combined impact of an increasing and ageing population and annual trend increase of 2%. The additional X-ray room planned for the DEM should provide sufficient capacity to meet overall projected increase in demand.

Table A24: Conventional radiology demand projections, 2025-2032

Year	Caseload population + trend adjusted	Change compared with 2022
2022	62443	-
2025	69222	6779
2027	74134	11691
2032	86930	24487