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Canadian Medical Imaging Inventory 2022–2023: The Medical Imaging Team

CMII Report

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Abbreviations

CIHI	Canadian Institute for Health Information
CMII	Canadian Medical Imaging Inventory
FTE	full-time equivalent
MRT	medical radiation technologist

Key Messages

- A workforce comprising medical radiation technologists (MRTs), radiologists, nuclear medicine specialists, medical imaging physicists, and other medical staff is essential for the delivery of medical imaging services.
- There is wide variation in the numbers of staff in each profession in Canada, ranging from 45 positions located in 6 provinces for medical imaging physicists to 25,000 positions located across all provinces and territories for MRTs.
- Data from 2022–2023 suggest that the number of full-time staff has not grown at the same pace as the volume of exams. Sufficient staffing is needed to ensure the sustainable operation and delivery of medical imaging services that is supported by investment in the workforce through equitable education and training opportunities.
- According to a Canadian Medical Imaging Inventory (CMII) report on wait time strategies, staffing shortages may extend wait times and may lead to disruptions in service delivery.
- Managing the growing demand for imaging services and clearing the backlog of exams deferred during the pandemic has exacerbated existing staffing shortages and contributed to increased workloads and decreased staff well-being.
- The adoption of supportive tools and technologies — such as clinical decision support tools, automated order entry, and AI-driven solutions — may assist the workforce by creating efficiencies, improving image quality, and increasing access to medical imaging.

What Is the Context?

Medical imaging has transformed the delivery of health care by enabling the early detection of disease and improving patient outcomes.[1-3] The medical imaging team, comprising physicians, technologists, physicists, sonographers, and other medical staff, is responsible for providing essential imaging services within the health care system in Canada.[1,4] These services include the use of routine advanced medical imaging technologies, such as CT, MRI, PET-CT, SPECT, SPECT-CT, and PET-MRI (Appendix 1).[5,6]

Demand for imaging exams has been shown to exceed capacity in some settings, leading to long wait times.[3,7] Factors such as expanding clinical indications, aging of the population, and increasing incidence of diseases such as cancer have contributed to the greater demand for imaging.[8] Excessive wait times can result in adverse outcomes for patients, and lead to inefficiencies and increased costs.[9]

In 2023, wait times for medically necessary elective CT exams exceeded the recommended 30-day maximum target[3] in all provinces (data for territories were not available), apart from Quebec, with a national average wait time of 46 days.[7] Similarly, for MRI, wait times exceeded the 30-day recommended maximum target in all provinces (data for territories were not available), with a national average wait time of 90 days.[7] This is consistent with trends over time which show an ongoing challenge in timely access to imaging.[7]

The COVID-19 pandemic exacerbated existing challenges in imaging departments. Reports of increased workloads, high stress, exhaustion, and reported decreased well-being among health care professionals are believed to contribute to an observed trend in staffing shortages.[10-13] These human resource shortages limit the hours that machines can operate and, in some instances, have led to shutdowns and service disruptions.[14-16]

As demand for imaging services increases, decision-makers, administrators, and regulators face complex health human resource decisions, with a focus on strong recruitment and retention policies and strategies to build a resilient and sustainable workforce.

The CMII was created in 2015 to better understand the medical imaging landscape in Canada and to track, compare, and map trends over time related to the availability, distribution, technical specifications, and use of advanced imaging equipment in Canada (i.e., CT, MRI, PET-CT, PET-MRI, SPECT, and SPECT-CT). This is the fourth iteration of the CMII since CADTH resumed the collection of these data in 2015.[17-19] Previously, the Canadian Institute for Health Information (CIHI) collected data on medical imaging technologies in Canada from 2003 to 2012.[20-23]

The CMII collects data through a survey conducted approximately once every 2 years and, among other data elements, reports on the use of strategies for improving appropriate imaging, enhancing system efficiencies, reducing wait lists, and addressing other systemic challenges. Through this work, the CMII provides health care decision-makers with information on the imaging landscape in Canada that may be used to identify and address service and medical equipment gaps and inform strategic planning.

This report summarizes medical imaging team–related findings from the 2022–2023 national CMII survey and other sources.

What Did We Do?

The purpose of this CMII report is to present data on the current medical imaging team and health human resource landscape in Canada for 2022–2023. This report is a component of a series of publications produced as part of the CMII national survey, which includes CT, MRI, PET-CT, SPECT-CT, SPECT, and PET-MRI.

Why Did We Do This?

The CMII provides information on the medical imaging landscape across Canada to help support health care decision-making. Robust data are required to ensure health systems can deliver the imaging required to provide timely, safe, patient-centred care; improve health outcomes; and deliver health care efficiencies. The CMII also reports on data relating to the health human resources and wait times for advanced imaging equipment in Canada. Further details on the purpose of the CMII is described in the *Canadian Medical Imaging Inventory 2022–2023: Provincial and Territorial Overview* report located on the [CMII website](#).

Methods Overview

Data were collected on 6 imaging modalities, primarily using a web-based self-report survey that was sent to all identified health care facilities with advanced imaging equipment in Canada (refer to *Canadian Medical Imaging Inventory 2022–2023: Methods*). Data were supplemented with information from provincial and territorial validators who are senior medical imaging–related health care decision-makers. As well, data from peer reviewers, literature searches, CIHI, and previous iterations of CMII data were incorporated into the report. Both English and French versions of the survey were provided.

The CMII survey collected the following data:

- number and location of imaging equipment
- volume of exams
- hours of equipment operation
- age of imaging equipment
- technical specifications of machines
- adoption of new and emerging supportive tools and technologies
- imaging storing and communication services.

The survey opened on May 5, 2023, and primary data collection and validator responses were collected up until October 31, 2023. The full data collection and analysis strategy, including survey development, respondent identification, sources of data used, and data validation procedures can be found in the *Canadian Medical Imaging Inventory 2022–2023: Methods* report on the CMII website.

The CMII also presents data from both the survey and other sources relating to human resources, funding structures, ordering and referral practices, and the adoption of tools that may support appropriate imaging, system efficiencies, and wait list reductions.

Comparisons between data from Canada and data from other Organisation for Economic Co-operation and Development countries are reported, as are trends and projections on imaging capacity.

Response Rate for the 2022–2023 National Survey

A total of 504 sites were invited to participate in the survey. Data on modalities and unit counts were available for 467 sites (92.7%).

A 100% participation rate was received from publicly funded facilities (i.e., hospitals) in 7 provinces and all territories. The participation rate for the remaining provinces ranged from 51% to 93% for publicly funded facilities.

A complete response rate was received for unit counts and exam volumes by provincial and territorial validators, while the response rate varied for other survey questions. A total of 308 sites provided updated or new information (72%), reflecting an increased response rate of 34% since the CMII 2019–2020 survey.

While the overall survey participation rate was high, in some instances, not all survey questions were answered. This may lead to a nonresponse bias, which may result in the overgeneralization of some findings. To enable readers to assess the representativeness of each data point, the number of sites that responded to each question are included with the reported data.

Provincial and territorial validators provided high-level information for nonresponding publicly funded health facilities. Data obtained from the previous survey iteration, and from other sources (e.g., personal communications, websites of health care facilities), were used to inform the status of the remaining sites. Data from free-standing sites with private imaging capacity supplemented data for public capacity; detailed information for private imaging facilities is limited due to the low number of survey responses.

The survey questions and full data collection and analysis strategy, including survey development, respondent identification, sources of data used, and data validation procedures can be found in the *Canadian Medical Imaging Inventory 2022–2023: Methods* report on the CMII website.

Medical Imaging Team Overview

Advanced medical imaging teams usually comprise multidisciplinary professionals, including MRTs, radiologists, nuclear medicine specialists, medical imaging physicists, biomedical engineers, and other support staff. These skilled professionals work collaboratively to provider numerous services, including:[9,21,24-26]

- evaluating exam appropriateness
- preparing patients for exams
- image acquisition
- reading and interpreting exams and reporting findings
- radiation safety and quality assurance
- designing, installing, operating, and maintaining equipment
- managing the day-to-day operations of an imaging department.

Close collaboration between team members is required to deliver optimal patient care; advance a better understanding of the policies, protocols, and practices for specific exams; promote appropriate imaging; and ensure patient safety. The size, composition, distribution, and interrelationships of these professionals varies depending on the type of imaging facility, its size, its geographical location, and the expertise required to perform specific exams.[6,26]

Role in Assessing Appropriate Imaging

More than **9.5 million** advanced imaging **exams** were conducted in Canada in **2022–2023**, reflecting a **12% increase** since the **2019–2020** CMII survey.[27] As imaging exam volumes continue to increase in Canada, so too does the rate of low-value exam referrals, which can impact exam wait times.[28]

An imaging exam referral may be considered inappropriate (i.e., low value) for several reasons:[4,29-31]

- referring physician practice patterns
- an exam's inability to contribute to patient management
- the performance of an exam at the incorrect time in a patient's care pathway
- failure to obtain imaging when indicated
- inadequate referral information.

One of the responsibilities of the medical imaging team is to evaluate exam requests to ensure there is appropriate alignment between the requested imaging and a patient's clinical history. Evidence has indicated the following:[4,29-35]

- **Between 10% and 25%** of medical imaging **exams** conducted annually are considered **unnecessary** or **low value**.
- **Low-value scanning** may result in **unnecessary exposure** to ionizing **radiation** and/or contrast material as well as **increased** health spending **costs.**
- **Radiologists consulting** with **referring providers** may **reduce low-value** scanning by at least **20%.**
- In Canada, the estimated **5-year cost** associated with **low-value** scanning in early-stage **breast cancer** was estimated between **$4.4 million** and **$6.8 million**.

Ensuring patients receive an appropriate examination at the most appropriate time is critical for patient care and safety, and to reduce health care system costs.[29,30,36]

Scope of Practice

The CMII reports on data relating to the main professionals working in imaging department: MRTs, radiologists, nuclear medicine specialists, and medical imaging physicists.

Medical Radiation Technologist Practice

There are 4 different subspecialties of MRTs, including magnetic resonance technologists, nuclear medicine technologists, radiation therapists, and radiological technologists.[37,38]

MRTs produce high-quality diagnostic images or carry out diagnostic procedures using ionizing radiation. They use their scientific knowledge, technical competence, and patient interaction skills to provide safe and accurate imaging procedures.[39] The scope of practice of MRTs includes, but is not limited to, the following:[37-39]

- deliver high-quality care to ensure optimal patient outcomes through the acquisition of images or the planning and delivery of ionizing radiation for therapeutic purposes
- collaborate with other health care professionals to optimize patient diagnostic and treatment services through the gathering of information to plan for the exam or treatment, adapting protocols to accommodate patient needs, and ensuring optimal patient positioning

- apply knowledge of radiation protection and safety for patients, families, and other health care colleagues and providers
- evaluate images for technical quality and determine if additional images are necessary
- identify, prepare, and/or administer prescribed pharmaceuticals under the supervision of a physician
- monitor patient status and respond to any change in condition
- demonstrate ongoing commitment to education and training.

Radiologist Practice

Radiologists are physicians who specialize in the field of medical imaging to diagnose and treat illness.[40] Radiologists interpret imaging procedures including MRI, CT, nuclear medicine, ultrasound, and X-ray. There are also numerous interventions performed by radiologists — from biopsies throughout the body to locoregional therapies for cancer to vascular interventions, such as aortic aneurysm repairs and uterine fibroid embolization. Radiologists are integral in population screening programs (e.g., for breast cancer and lung cancer) in appropriately selected patients.[40] Using a variety of follow-up imaging, they monitor efficacy of ongoing patient therapies. The scope of a radiologist's practice varies depending on their provincial regulatory bodies or authorities and their area of specialization; however, they often include:[40-42]

- review of medical histories to chose best imaging for a patient's symptoms
- prioritize requests for investigation and liaise with referring physicians
- supervise technologists in performing imaging exams
- analyse medical images to find abnormalities or provide a diagnosis
- correlate medical image findings with other examinations and prior tests
- direct patient care as part of their medical report or when participating in multidisciplinary case conferences
- recommend further appropriate examinations or treatments when necessary and confer with referring physicians
- establish radiation safety protocols for patients and staff.

Nuclear Medicine Specialist Practice

Nuclear medicine specialists are medical physicians who use their knowledge of radiation biology, radiopharmacy, and nuclear physics to diagnose and treat a broad spectrum of conditions in patients.[43] The main imaging modalities used by these specialists include planar imaging, SPECT, SPECT-CT, PET-CT, and PET-MRI.

The scope of practice of nuclear medicine specialists includes but is not limited to the following:[43,44]

- advise physicians on the appropriate nuclear medicine diagnostic exam to address the clinical investigation
- perform clinical assessment of patients, correlate the results with other clinical investigations, and select the optimal procedural protocol

- supervise and support technologists in performing nuclear medicine exams, interpret results, and provide a timely report
- advise on the therapeutic use of nuclear medicine by assessing patients, developing treatment plans, administering treatment, and assessing treatment safety and efficacy
- provide emergency medicine to patients related to nuclear medicine diagnosis or treatment
- manage the activities and oversee the workflow of nuclear medicine departments
- establish radiation safety protocols and for isotope generation, storage, dosage, use, and disposal
- advise facilities on the purchase of new equipment and isotopes and develop new protocols for diagnosis and treatment
- identify, prepare, and/or administer prescribed pharmaceuticals
- demonstrate ongoing commitment to education and training.

Imaging Medical Physicist Practice

There are 3 certifications for imaging medical physicists in Canada: diagnostic radiological physics (X-ray), MRI, and nuclear medicine physics. Certified imaging medical physicists specialize in optimizing the use and functionality of medical imaging equipment. They work with X-ray, fluoroscopy, mammography, CT, MRI, nuclear medicine, and ultrasound.[45] Most certified imaging medical physicists work in hospital imaging departments.

Their main responsibilities may include:

- accreditation of imaging equipment
- equipment selection and purchasing
- acceptance testing to ensure that equipment specifications are met and are safe to use
- periodic performance audits of imaging equipment
- equipment safety testing for patient and staff dose estimates and radiation protection.

Number of Full-Time Imaging Professionals in Canada

The rising demands for imaging services has placed greater emphasis on understanding the availability of full-time equivalent (FTE) positions in the medical imaging profession in Canada.

The number of FTE advanced imaging professionals by province and territory for MRTs, radiologists, nuclear medicine specialists, and imaging medical physicists is presented in Table 1. The latest publicly available data for the number of practising professionals for radiology and nuclear medicine is from 2019; given reports of current staffing shortages, this number is likely underestimated.[3,46,47] The number of full-time trained professionals per million people (i.e., per capita) was calculated using 2023 population estimates.[48]

The overall counts of FTE positions included in this report represent the number of total available positions reported in Canada, which may not reflect the total number of filled or vacant positions at the time of this report. In addition, the counts do not capture the geographical disparity that exists in the distribution of positions throughout Canada, particularly in provinces and territories with large rural and remote areas.

- In **2022–2023**, **MRTs** comprised the **largest professional group** within the advanced imaging workforce, followed by radiologists, nuclear medicine specialists, and imaging medical physicists.
- **MRTs and radiologists** practiced in all provinces and territories, while **nuclear medicine specialists** practiced in **9 provinces** and **imaging medical physicists** practiced in **6 provinces**.

Number of Trained MRTs

- A total of **25,752** FTE **MRTs were reported to** practice in all **13 provinces** and **territories**, ranging from 40 to 11,174. The highest number of FTE MRTs was in Ontario, Quebec, and Alberta.
- There were approximately **646 FTE MRTs per million** people in Canada, ranging from 305.8 per million people to 779.5 per million people. The jurisdictions with the **greatest** density of MRTs **per capita** were **Quebec,** Newfoundland and Labrador, and Nova Scotia.

Number of Radiologists

- A total of **2,602 radiologists were reported to** practice in all **13 provinces** and **1 territory**, ranging from 1 to 933. The highest number of radiologists were in Ontario, Quebec, and British Columbia.
- There were approximately **65 radiologists per million** people in Canada, ranging from 7.6 per million people to 103.1 per million people. The jurisdictions with the **greatest density** of radiologists **per capita** were **Newfoundland and Labrador**, Nova Scotia, and Quebec.

Number of Nuclear Medicine Specialists

- A total of **284 nuclear medicine specialists** were reported to practice in **9 provinces**, ranging from 3 to 116. The highest number of nuclear medicine specialists were in Quebec, Ontario, and Alberta.
- There were approximately **7 nuclear medicine specialists per million** people in Canada, ranging from 3.6 per million people to 13.1 per million people. The jurisdictions with the **greatest density** of nuclear medicine specialists **per capita** were Quebec, Nova Scotia, and Newfoundland and Labrador.
- There may be some overlap with individuals identified as both radiologists and nuclear medicine specialists due to a trend in hiring doctors with dual Royal College of Physicians and Surgeons of Canada fellowships in nuclear medicine and radiology.

Number of Imaging Medical Physicists

- A total of **45 imaging medical physicists were reported to** practice in **6 provinces**, ranging from 2 to 17. The highest number of imaging medical physicist were in Ontario, Alberta, British Columbia, and Quebec.
- There was approximately **1 imaging medical physicist per million** people in Canada, ranging from 0.7 per million people to 2.8 per million people. The jurisdictions with the **greatest density** of imaging medical physicists **per capita** were Manitoba, Alberta, and Nova Scotia.

- The number of imaging medical physicists was low across Canada; there were no designated imaging medical physicists in 4 provinces and in all territories.

Table 1: Numbers of Medical Radiation Technologists, Radiologists, Nuclear Medicine Specialists, and Imaging Medical Physicists in Canada, 2022–2023

Province or territory	Medical radiation technologists		Radiologists		Nuclear medicine specialists		Imaging medical physicists[a]	
	Count	Per million population[b]	Count	Per million population[b]	Count	Per million population[b]	Count	Per million population[b]
Alberta	2,411	512.6	293	62.3	29	6.2	10	2.1
British Columbia	1,838	338.0	316	58.1	28	5.1	6	1.1
Manitoba	893	618.3	90	62.3	7	4.8	4	2.8
New Brunswick	604	726.3	56	67.3	3	3.6	0	0.0
Newfoundland and Labrador	391	732.6	55	103.1	4	7.5	0	0.0
Nova Scotia	767	732.4	84	80.2	9	8.6	2	1.9
Ontario	11,174	720.9	933	60.2	82	5.3	17	1.1
Prince Edward Island	108	613.2	9	51.1	0[c]	0.0	0[d]	0.0
Quebec	6,884	779.5	686	77.7	116	13.1	6	0.7
Saskatchewan	642	525.6	79	64.7	6	4.9	0	0.0
Territories[e]	40	305.8	1	7.6	0	0.0	0	0.0
Canada	**25,752**	**646.1**	**2,602**	**65.3**	**284**	**7.1**	**45**	**1.1**

[a]Khadija Cutcher, Membership and Education Coordinator, Canadian Organization of Medical Physicists, ON: personal communication, Aug 21, 2023.

[b]The population (estimated) as of first quarter, 2023.[48]

[c]Although not reported by the Canadian Medical Association, there is 1 radiologist practising in Prince Edward Island who is fellowship trained in nuclear medicine (Grant McKenna, Health PEI, Queen Elizabeth Hospital, PE: personal communication, Oct 20, 2020).

[d]There is 1 imaging medical physicist practising in Prince Edward Island who is certified in mammography (Grant McKenna, Health PEI, Queen Elizabeth Hospital, PE: personal communication, Oct 20, 2020).

[e]Territories = Northwest Territories, Nunavut, and Yukon.

Sources: CIHI (2021),[12] CADTH (2019),[10] CADTH (2019).[11]

MRTs in Canada: Results From the CMII National Survey

The CMII national survey asked the 467 participating facilities to provide information on the number of FTE MRTs assigned to each of the following advanced imaging modalities at the site level: CT, MRI, PET-CT, SPECT-CT, SPECT, and PET-MRI. Data from CMII 2022–2023 were compared with the CMII 2019–2020 survey results.[27]

An FTE position for a MRT is considered to amount to an 8-hour workday, 5 days per week. The reported number of FTE MRTs may not reflect the total number of filled FTE MRTs for a specific modality, but rather the total number of budgeted positions. Data were derived from the survey question: “How many FTE technologists are assigned to all units (collective number of FTEs for all units)?” Although most jurisdictions reported fewer FTE MRTs per capita since 2019–2020 for most modalities, the low response rate to this question, along with some jurisdictions reporting higher MRT counts for 2022–2023, limits the reliability of these findings.

FTE MRTs for CT Units

Number of CT MRTs per Site in Canada, 2022–2023

- For **CT**, there was an average of **6 FTE MRTs** reported to be employed **per site**, ranging from 1 to 28 (Table 2).
- On average, there were approximately **31 FTE MRTs** operating **CT equipment per million** people in Canada. The jurisdictions with the **greatest density** of **MRT**s per million people were **Yukon** (112.6 per million people), **Nunavut** (73.7 per million people), and **Newfoundland and Labrador** (65.6 per million people).

Table 2: Numbers of FTE MRTs for CT Units, 2022–2023

Province or territory	Number of reporting sites	Total FTE MRTs	Average FTE MRTs per site (minimum to maximum)	FTE MRTs per million population[a]	Population[a]
Alberta	37	187	5.1 (1 to 19)	39.8	4,703,772
British Columbia	35	246	7 (1 to 26)	45.2	5,437,722
Manitoba	16	85.2	6.2 (3 to 20.6)	59.0	1,444,190
New Brunswick	8	47	5.9 (3 to 12)	56.5	831,618
Newfoundland and Labrador	11	35	3.2 (1 to 7)	65.6	533,710
Northwest Territories	1	2	2 (2 to 2)	43.8	45,668
Nova Scotia	8	51	6.4 (3 to 16)	48.7	1,047,232
Nunavut	1	3	3 (3 to 3)	73.7	40,715
Ontario	54	357	6.6 (1 to 18)	23	15,500,632
Prince Edward Island	2	8	4 (3 to 5)	45.4	176,113
Quebec	21	140	6.7 (1 to 28)	15.9	8,831,257
Saskatchewan	13	70	5.4 (2 to 12)	57.3	1,221,439
Yukon	1	5	5 (5 to 5)	112.6	44,412
Canada	**208**	**1,236.2**	**6 (1 to 28)**	**31**	**39,858,480**

FTE = full-time equivalent; MRT = medical radiation technologist.

Notes: Data were available for 208 of 394 sites across all jurisdictions with CT capacity.

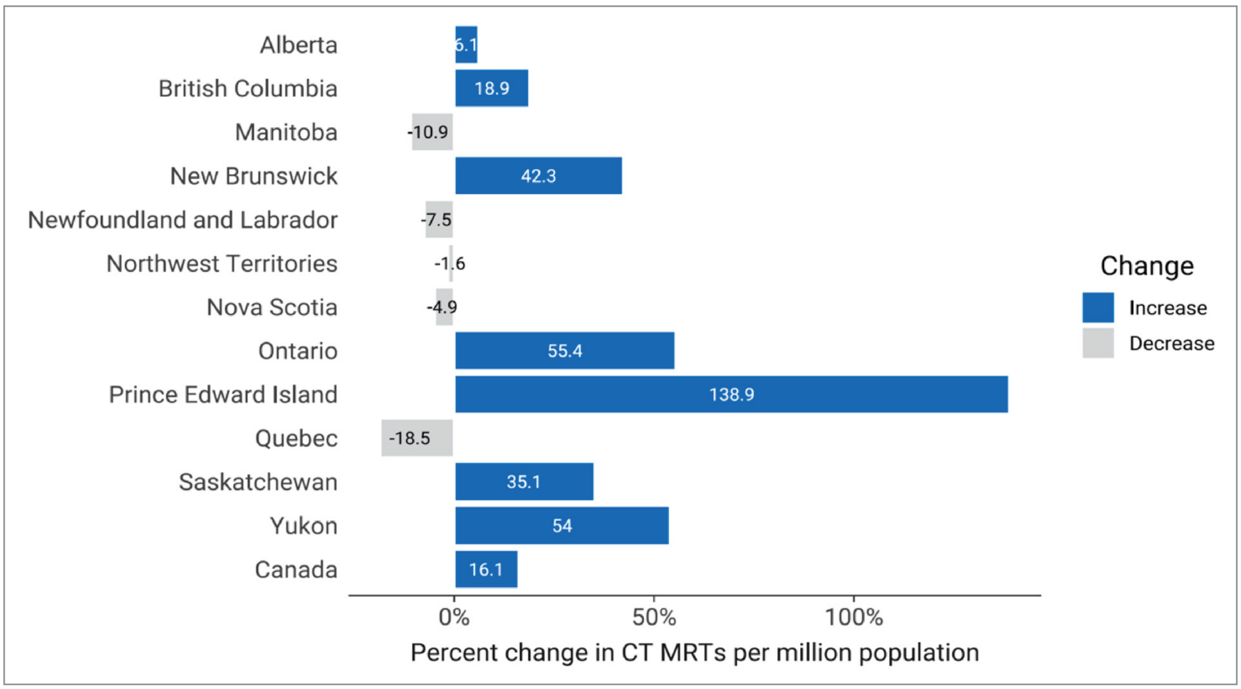
Data derived from the survey question: “How many full-time equivalents (FTE) technologists are assigned to all units (collective number of FTEs for all units)?”

[a]The population (estimated) as of first quarter, 2023.[48]

Change in the Number of CT MRTs Since the 2019–2020 CMII Survey

- Since 2019–2020, the **number of reported FTE MRTs operating CT equipment** in Canada has **increased** by **22.5%,** from 1,009 to 1,236.
- Since 2019–2020, the estimated density of **FTE CT MRTs per capita** has increased by **16.1%** in Canada (Figure 1). **Prince Edward Island, Ontario, and Yukon** have experienced the **highest increase** in number of **MRTs per million** people of all jurisdictions with CT capacity, increasing by 138.9%, 55.4%, and 54%, respectively.

Figure 1: Percentage Change in FTE MRTs for CT Units per Million Population, 2019–2020 to 2022–2023



FTE = full-time equivalent; MRT = medical radiation technologist.

Notes: For 2022–2023, data were available for 208 of 394 sites across all jurisdictions with CT capacity. For 2019–2020, data were available for 191 of 338 sites with CT capacity.

No data were available for Nunavut in the 2019–2020 survey.

Data derived from the survey question: "How many full-time equivalent (FTE) technologists are assigned to all units (collective number of FTEs for all units)?"

Sources: CADTH (2020),[27] CADTH (2024).

FTE MRTs for MRI Units

Number of MRI MRTs per Site in Canada, 2022–2023

- For **MRI,** there were approximately **7 FTE MRTs** reported to be employed **per site**, ranging from 2 to 23 (Table 3).

- On average, there were approximately **22 FTE MRTs** operating **MRI equipment per million** people in Canada. The jurisdictions with the **greatest density** of MRTs per million people were **Manitoba** (54.7 per million people), **Yukon** (45 per million people), and **British Columbia** (38.8 per million people).

Table 3: Numbers of FTE MRTs for MRI Units, 2022–2023

Province or territory	Number of reporting sites	Total FTE MRTs	Average FTE MRTs per site (minimum to maximum)	FTE MRTs per million population[a]	Population[a]
Alberta	19	142	7.5 (2 to 22)	30.2	4,703,772
British Columbia	27	211	7.8 (3 to 23)	38.8	5,437,722
Manitoba	9	79	5.8 (2 to 13)	54.7	1,444,190
New Brunswick	7	31	4.4 (2 to 8)	37.3	831,618
Newfoundland and Labrador	3	12	4 (4 to 4)	22.5	533,710
Northwest Territories	—	—	—	—	45,668
Nova Scotia	5	20	4 (2 to 5)	19.1	1,047,232
Nunavut	—	—	—	—	40,715
Ontario	36	261	7.2 (2 to 19)	16.8	15,500,632
Prince Edward Island	1	3	3 (3 to 3)	17	176,113
Quebec	13	80	6.2 (2 to 22)	9.1	8,831,257
Saskatchewan	5	45	9 (3 to 18)	36.8	1,221,439
Yukon	1	2	2 (2 to 2)	45	44,412
Canada	**126**	**886**	**6.8 (2 to 23)**	**22.2**	**39,858,480**

— = not applicable; FTE = full-time equivalent; MRT = medical radiation technologist.

Notes: Data were available for 126 of 296 sites across all jurisdictions with MRI capacity.

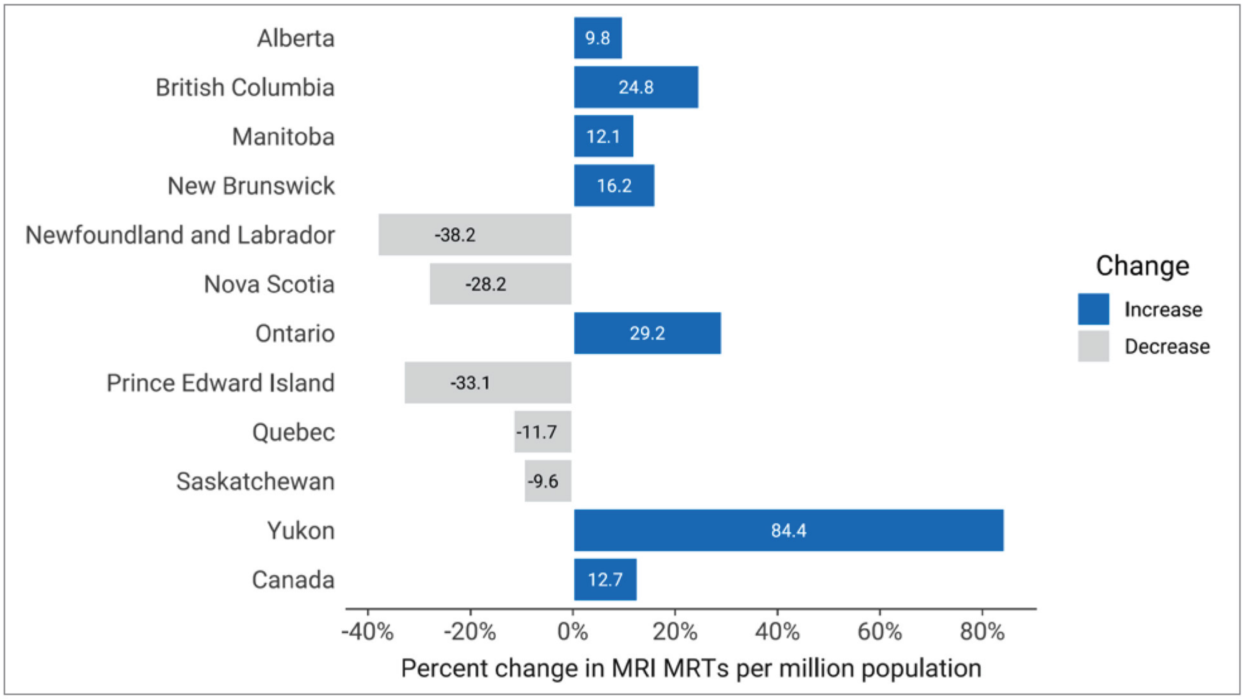
Data derived from the survey question: "How many full-time equivalent (FTE) technologists are assigned to all units (collective number of FTEs for all units)?"

[a]The population (estimated) as of first quarter, 2023.[48]

Change in the Number of MRI MRTs Since the 2019–2020 CMII Survey

- Since 2019–2020, the **number of reported FTE trained MRTs operating MRI equipment** in Canada has **increased** by **18.4%,** from 748 to 886.
- Since 2019–2020, the estimated density of **FTE MRI MRTs per capita** has increased by **12.7%** in Canada (Figure 2). **Yukon, Ontario, and British Columbia** have experienced the **highest increase** in number of **MRTs per million** people of all jurisdictions with MRI capacity, increasing by 84.4%, 29.2%, and 24.8%, respectively.

Figure 2: Percentage Change in FTE MRTs for MRI Units per Million Population, 2019–2020 to 2022–2023



FTE = full-time equivalent; MRT = medical radiation technologist.

Notes: For 2022–2023, data were available for 126 of 296 sites across all jurisdictions with MRI capacity. For 2019–2020, data were available for 118 of 214 sites with MRI capacity.

No data were available for Nunavut in the 2019–2020 survey. There is no MRI capacity reported in the Northwest Territories.

Data derived from the survey question: “How many full-time equivalent (FTE) technologists are assigned to all units (collective number of FTEs for all units)?”

Sources: CADTH (2020),[27] CADTH (2024).

FTE MRTs for PET-CT and PET-MRI Units

Number of PET-CT and PET-MRI MRTs per Site in Canada, 2022–2023

- For **PET-CT**, there were approximately **4 FTE MRTs** reported to be employed **per site,** ranging from 1 to 9 (Table 4).
- On average, there were approximately **2 FTE MRT** operating **PET-CT equipment per million** people in Canada. The jurisdictions with the **greatest density** of MRTs per million people were **Saskatchewan** (6.5 per million people), **Newfoundland and Labrador** (5.6 per million people), and **Nova Scotia** (3.8 per million people).
- For **PET-MRI, 2** FTE MRTs were assigned to the 1 site that reported information for FTE.

Table 4: Numbers of FTE MRTs for PET-CT Units, 2022–2023

Province or territory	Number of reporting sites	Total FTE MRTs	Average FTE MRTs per site (minimum to maximum)	FTE MRTs per million population[a]	Population[a]
Alberta	4	16	4 (3 to 5)	3.4	4,703,772
British Columbia	NR	NR	NR	NR	5,437,722
Manitoba	1	3	3 (3 to 3)	2.1	1,444,190
New Brunswick	1	2	2 (2 to 2)	2.4	831,618
Newfoundland and Labrador	1	3	3 (3 to 3)	5.6	533,710
Northwest Territories	—	—	—	—	45,668
Nova Scotia	1	4	4 (4 to 4)	3.8	1,047,232
Nunavut	—	—	—	—	40,715
Ontario	10	36	3.6 (1 to 7)	2.3	15,500,632
Prince Edward Island	—	—	—	—	176,113
Quebec	6	22	3.7 (2 to 9)	2.5	8,831,257
Saskatchewan	1	8	8 (8 to 8)	6.5	1,221,439
Yukon	—	—	—	—	44,412
Canada	**25**	**94**	**3.8 (1 to 9)**	**2.4**	**39,858,480**

— = not applicable; FTE = full-time equivalent; MRT = medical radiation technologist; NR = not reported.

Notes: Survey response data were available for 25 of 52 sites across 8 of 9 jurisdictions with PET-CT capacity. No data were available for British Columbia.

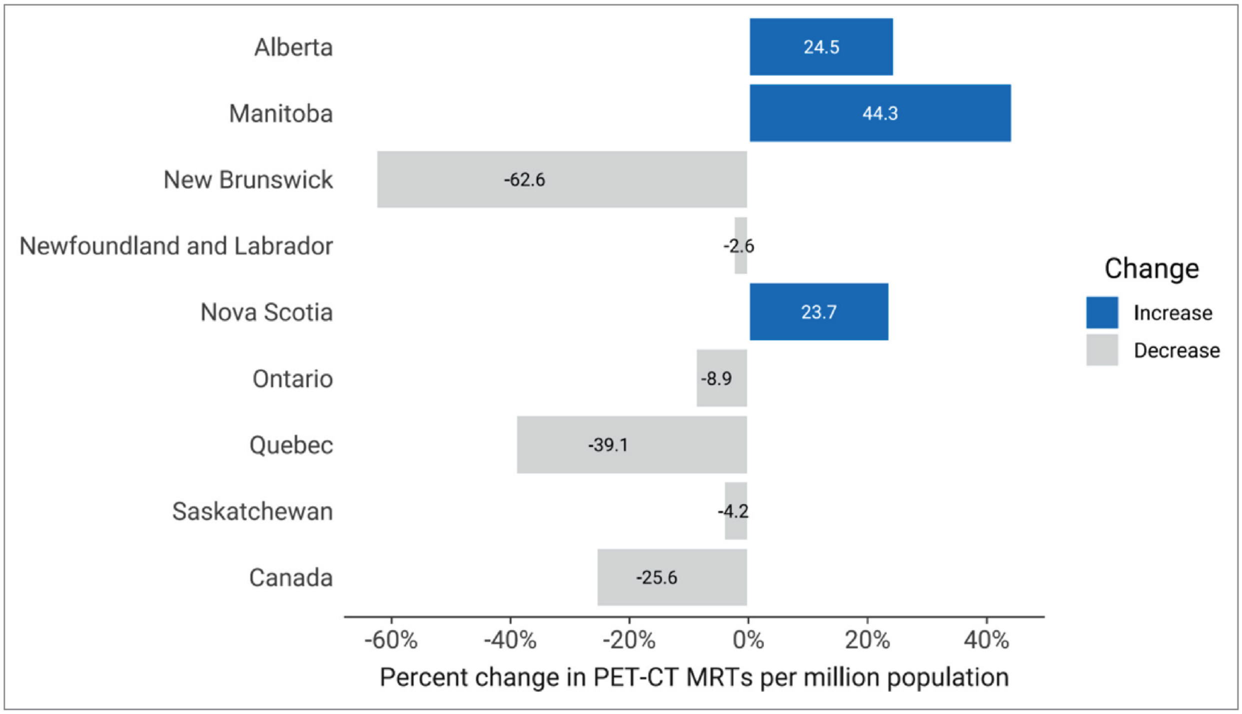
Data derived from the survey question: "How many full-time equivalent (FTE) technologists are assigned to all units (collective number of FTEs for all units)?"

[a]The population (estimated) as of first quarter, 2023.[48]

Change in the Number of PET-CT MRTs Since the 2019–2020 CMII Survey

- Since 2019–2020, the reported **number of FTE trained MRT operating PET-CT equipment** in Canada has **decreased** by **23%,** from 122 to 94.
- Since 2019–2020, the estimated density of **FTE PET-CT MRTs per capita** has **decreased** by **25%** in Canada, from 3.2 to 2.4 (Figure 3). **Manitoba**, **Alberta**, and **Nova Scotia** reported an **increase** in the number of MRT per million people, increasing by 40%, 25.9%, and 22.6%, respectively. All other jurisdictions with PET-CT capacity reported a decrease.

Figure 3: Percentage Change in FTE MRTs for PET-CT Units per Million Population, 2019–2020 to 2022–2023



FTE = full-time equivalent; MRT = medical radiation technologist.

Notes: For 2022–2023, data were available for 25 of 52 sites with PET-CT capacity. For 2019–2020, data were available for 24 of 44 sites with PET-CT capacity.

No responses were received from British Columbia for the 2022–2023 survey. There is no PET-CT capacity reported in Yukon, the Northwest Territories, Nunavut, and Prince Edward Island.

Data derived from the survey question: "How many full-time equivalent (FTE) technologists are assigned to all units (collective number of FTEs for all units)?"

Sources: CADTH (2020),[27] CADTH (2024).

FTE MRTs for SPECT-CT Units

Number of SPECT-CT MRTs per Site in Canada, 2022–2023

- For **SPECT-CT**, there were approximately **4 FTE MRTs** reported to be employed **per site,** ranging from 1 to 18 (Table 5).
- On average, Canada has an estimated **10** FTE MRT operating SPECT-CT equipment per million people. The jurisdictions with the **greatest density** of **MRTs** per million people were **Newfoundland and Labrador** (28.1 per million people), **Manitoba** (25.6 per million people), and **New Brunswick** (18 per million people).

Table 5: Numbers of FTE MRTs for SPECT-CT Units, 2022–2023

Province or territory	Number of reporting sites	Total FTE MRTs	Average FTE MRTs per site (minimum to maximum)	FTE MRTs per million population	Population[a]
Alberta	19	76	4 (1 to 9)	16.2	4,703,772
British Columbia	18	85	4.7 (2 to 10)	15.6	5,437,722
Manitoba	5[b]	37	7.4 (3 to 14)	25.6	1,444,190
New Brunswick	4	15	3.8 (2 to 6)	18	831,618
Newfoundland and Labrador	3	15	5 (2 to 10)	28.1	533,710
Northwest Territories	—	—	—	—	45,668
Nova Scotia	3	7	2.3 (2 to 3)	6.7	1,047,232
Nunavut	—	—	—	—	40,715
Ontario	28	97	3.5 (1 to 12)	6.3	15,500,632
Prince Edward Island	1	3	3 (3 to 3)	17	176,113
Quebec	12	58	4.8 (1 to 18)	6.6	8,831,257
Saskatchewan	3	17	5.7 (1 to 8)	13.9	1,221,439
Yukon	—	—	—	—	44,412
Canada	**96**	**410**	**4.3 (1 to 18)**	**10.3**	**39,858,480**

— = not applicable; FTE = full-time equivalent; MRT = medical radiation technologist.

Notes: Data were available for 96 of 180 sites with SPECT-CT capacity.

Data derived from the survey question: "How many full-time equivalents (FTE) technologists are assigned to all units (collective number of FTEs for all units)?"

[a]The population (estimated) as of first quarter, 2023.[48]

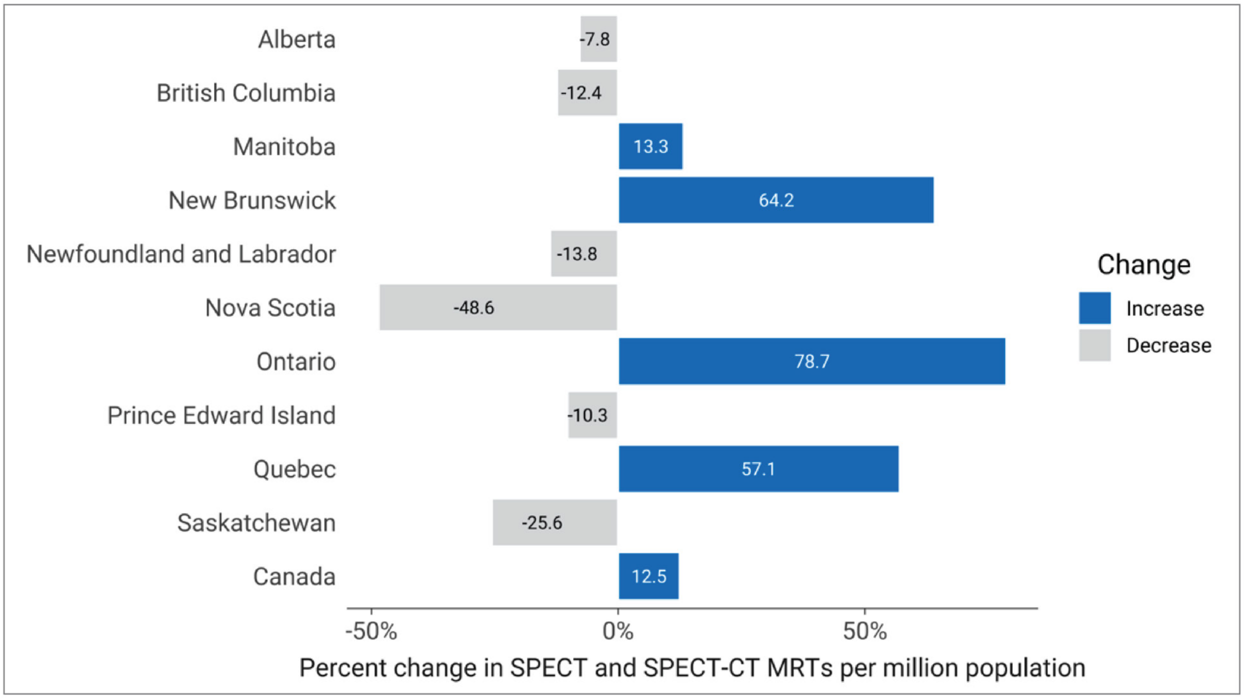
[b]Combined SPECT and SPECT-CT FTE MRT count.

Change in the Number of SPECT-CT and SPECT MRTs Since the 2019–2020 CMII Survey

In the 2019–2020 CMII survey, FTE MRTs for SPECT and SPECT-CT were reported as a combined total. For consistency, the 2022–2023 FTE MRT counts for SPECT-CT and SPECT have been combined and are summarized in this section on SPECT-CT.

- Since 2019–2020, the **number of reported FTE trained MRTs operating SPECT-CT** and **SPECT equipment** in Canada has increased by **18.5%,** from 546 to 647.
- Since 2019–2020, the estimated density of **FTE SPECT MRTs per capita** has **increased** by **12.5%** in Canada, **although most provinces** experienced a **decrease** in the number of MRTs per capita (Figure 4). **Manitoba, New Brunswick, Ontario, and Quebec** reported **increased** MRT density per capita.

Figure 4: Percentage Change in FTE Trained MRTs for SPECT-CT and SPECT Units per Million Population, 2019–2020 to 2022–2023



FTE = full-time equivalent; MRT = medical radiation technologist.

Notes: For 2022–2023, data were available for 96 of 180 sites with SPECT-CT capacity and for 62 of 138 sites with SPECT capacity. For 2019–2020, data were available for 87 of 138 sites with SPECT-CT or SPECT capacity.

There is no SPECT-CT or SPECT capacity reported in Yukon, the Northwest Territories, and Nunavut.

Data derived from the survey question: “How many full-time equivalent (FTE) technologists are assigned to all units (collective number of FTEs for all units)?”

Sources: CADTH (2020),[27] CADTH (2024).

FTE MRTs for SPECT Units

Number of SPECT MRTs per site in Canada, 2022–2023

- For SPECT, there were approximately **4 FTE MRTs** reported to be employed **per site**, ranging from 1 to 18 (Table 6).
- On average, there were approximately **6 FTE** trained **MRT** operating **SPECT equipment per million** people in Canada. The jurisdictions with the **greatest density** of **MRT**s per million people were **Saskatchewan** (16.4 per million people), **New Brunswick** (15.6 per million people), **and Alberta** (14.5 per million people).

Table 6: Numbers of FTE Trained MRTs for SPECT Units, 2022–2023

Province or territory	Number of reporting sites	Total FTE MRTs	Average FTE MRTs per site (minimum to maximum)	FTE MRTs per million population	Population[a]
Alberta	14	68	4.9 (2 to 9)	14.5	4,703,772
British Columbia	5	16	3.2 (1 to 10)	2.9	5,437,722
Manitoba	0[b]	—	—	—	1,444,190
New Brunswick	4	13	3.2 (2 to 6)	15.6	831,618
Newfoundland and Labrador	0	NR	NR	NR	533,710
Northwest Territories	—	—	—	—	45,668
Nova Scotia	4	9	2.2 (2 to 3)	8.6	1,047,232
Nunavut	—	—	—	—	40,715
Ontario	24	83	3.5 (1 to 12)	5.4	15,500,632
Prince Edward Island	—	—	—	—	176,113
Quebec	9	28	3.1 (2 to 11)	3.2	8,831,257
Saskatchewan	2	20	10 (2 to 18)	16.4	1,221,439
Yukon	—	—	—	—	44,412
Canada	**62**	**237**	**3.8 (1 to 18)**	**5.9**	**39,858,480**

— = not applicable; FTE = full-time equivalent; MRT = medical radiation technologist; NR = not reported.

Note: Survey response data available for 62 of 138 sites across 8 of 9 jurisdictions with SPECT capacity. No data were available for Newfoundland and Labrador.

Data derived from the survey question: "How many full-time equivalent (FTE) technologists are assigned to all units (collective number of FTEs for all units)?"

[a]The population (estimated) as of first quarter, 2023.[48]

[b]Combined SPECT-CT and SPECT FTE MRT count are reported in Table 5.

Trends in Practising MRTs Relative to CT and MRI Exam Volumes

Imaging exam volumes are increasing in Canada, as is the demand for highly skilled MRTs that support these diagnostic procedures that are often central to a patient's care journey.[39,49] Identifying trends in exam and MRT patterns over time can help inform planning and decisions around human resources, service delivery, and equipment investments.[50]

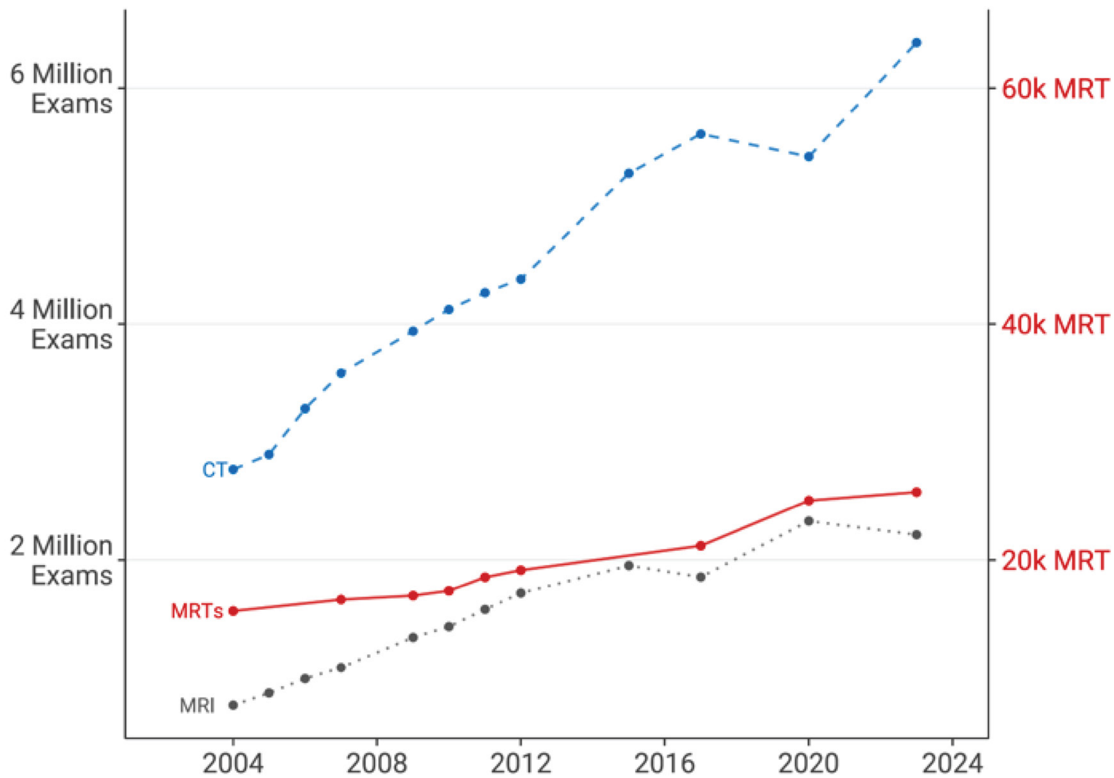
Trend data are drawn from current and previous iterations of the CMII national survey. Before 2015, data on exams were from CIHI. CIHI data were also used for MRT staffing counts. Total volumes of public CT and MRI examinations, MRT counts, and totals per capita for Canada for the years 2004 to 2022–2023 are presented subsequently.

Volume of Exams and Number of MRTs, 2004 to 2022–2023

Since 2004, there has been a **rapid increase** in the **volume** of **publicly** funded **CT** and **MRI exams** in Canada. The number of available FTE **MRT positions** in Canada has experienced a **slower stable increase** over time, suggesting that the number of full-time MRT positions in Canada has not kept pace with exam growth. **Since 2004**, Canada's **population** has **increased** by **24.4%**, from 32,039,959 to 39,858,480 people in 2022–2023.[20,48]

- The **overall volume** of **CT exams** in Canada **increased** by **130.7%**, from 2,767,849 exams in 2004 to 6,385,665 exams in 2022–2023 (Figure 5).
- The **overall volume** of **MRI exams** in Canada **increased** by **188.2%**, from 768,302 exams in 2004 to 2,214,157 exams in 2022–2023 (Figure 5).
- The **overall number** of **MRT** positions in Canada **increased** by **64.4%**, from 15,667 positions in 2004 to 25,752 positions in 2022–2023 (Figure 5).

Figure 5: Total Reported CT and MRT Exam Volumes and Number of Trained MRTs in Canada, 2004 to 2022–2023



k = thousand; MRT = medical radiation technologist.

Exam sources: CIHI (2003),[20] CIHI (2007),[21] CIHI (2012),[51] CADTH (2015),[17] CADTH (2017),[19] CADTH (2020),[27] CADTH (2024).

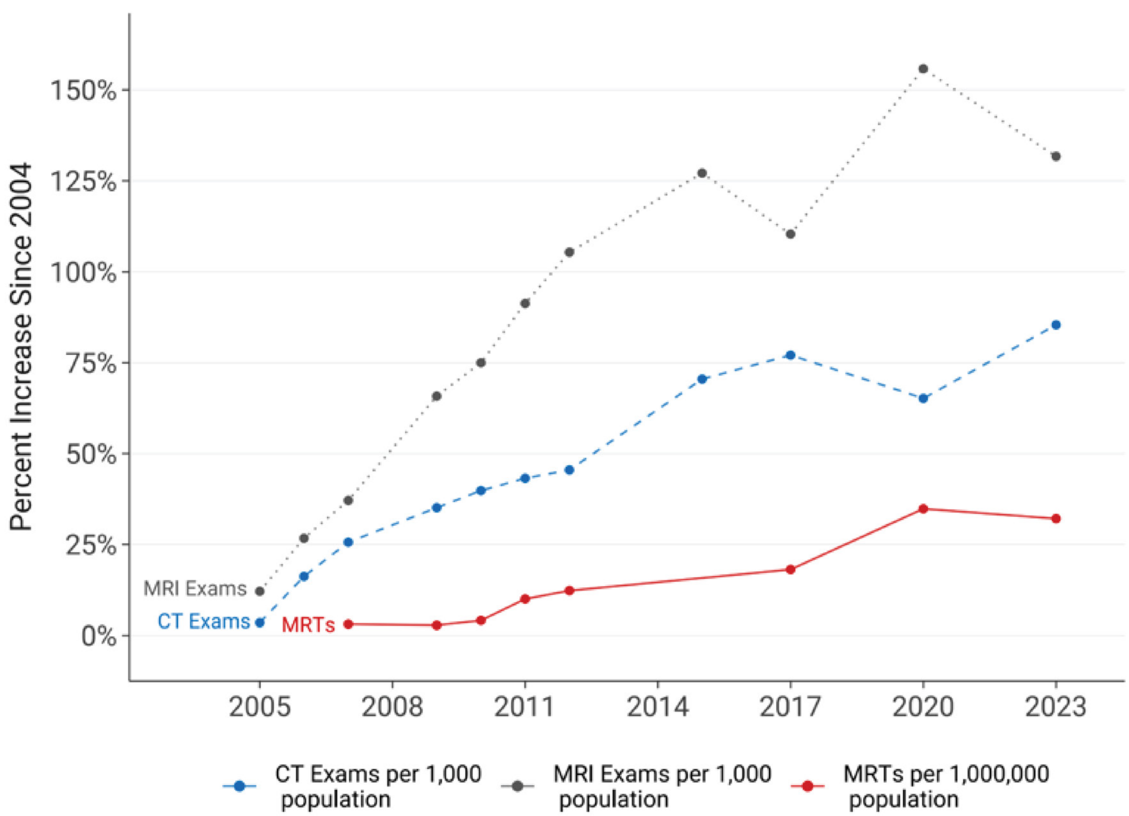
MRT source: CIHI (2004 to 2021).[12,52-54]

Changes per Capita in Volume of CT and MRI Exams Relative to the Number of MRTs

Since 2004, there has been a **rapid increase** in the **volume** of **publicly** funded **CT** and **MRI exams per 1,000 people** in Canada.[17-23] The number of available full-time **MRT positions per million people** in Canada has experienced a **slower increase** over time, keeping similar pace with population growth during this period.[12,52-54]

- **CT exam volume** in Canada has experienced an **85.4% growth rate**, increasing from 86.4 exams per 1,000 people in 2004 to 160.2 exams per thousand people in 2022–2023 (Figure 6).
- **MRI exam volume** in Canada has experienced a **131.7% growth rate**, increasing from 24.0 exams per 1,000 people in 2004 to 55.6 exams per thousand people in 2022–2023 (Figure 6).
- The **number** of **MRT** positions Canada has experienced a **32.1% growth rate**, increasing from 489.0 positions per million people in 2004 to 646.1 positions per million people in 2022–2023 (Figure 6).

Figure 6: Percentage Increase in CT and MRI Exam Volumes and the Number of MRTs per Capita in Canada Since 2004



MRT = medical radiation technologist.

Exam sources: CIHI (2003),[20] CIHI (2007),[21] CIHI (2012),[51] CADTH (2015),[17] CADTH (2017),[19] CADTH (2020),[27] CADTH (2024).

MRT source: CIHI (2004 to 2021).[12,52-54]

Health Human Resources

Without considering health human resources, investing in new equipment may not achieve the increased capacity required to meet growing imaging demand. Reported medical imaging staff shortages in the context of increasing service demand has contributed to extended wait times, limited access to services, poor staff well-being, and reduced quality of patient care.[33,34]

Staffing

There have been reports of an increasing shortage of trained medical imaging staff in Canada.[55] The following factors, among others, have been identified through a literature review as contributing to the shortage, which has also been described as negatively impacting staff well-being:[13,56]

COVID-19–Related Factors

The COVID-19 pandemic exacerbated existing staff shortages within the health care system in Canada.[10-13,56] Postponed diagnostic imaging and resulting medical treatment during this time put increased strain on medical imaging teams in Canada.[57]

- When **compared** to **the prepandemic period**, there are now **fewer full-time professionals** in **practice across Canada** (Figure 7), with medical physicists experiencing the largest decline per million people (9.7%).[10-12,27]
- There are now **fewer MRTs** in practice per **million population**, while the **volume** of **CT** and **MRI exams** per technologist has **increased** since **2019**.[12,27,58]

Population-Related Factors

- **Older adults** often have complex health care needs that **require more health care services** than younger patients. In 2020, it was estimated that **older adults** represented **47%, 22%, and 46%** of **total exams volumes** in Canada for CT, MRI, and PET-CT, respectively.[59]
- The **older adult population** along with an increasing **incidence of diseases** such as cancer may exacerbate the already rising need for additional medical imaging equipment in Canada.[59,60]
- **An older workforce** has also led to a **loss of expertise** as radiologists and technologists **retire**.[47]

Equipment and Innovation Factors

- **Less efficient** and **older equipment** or a **lack of access** to imaging **equipment,** especially in remote or rural areas, can lead to long wait times and increased patient load.[61,62]
- **Limited innovative** technological, diagnostic screening, and radiation therapy enhancements, including **digital solutions** and teleradiology, can lead to **less efficient workflows** and higher imaging staff workloads.[63-65]

Training, Hiring, and Retention Factors

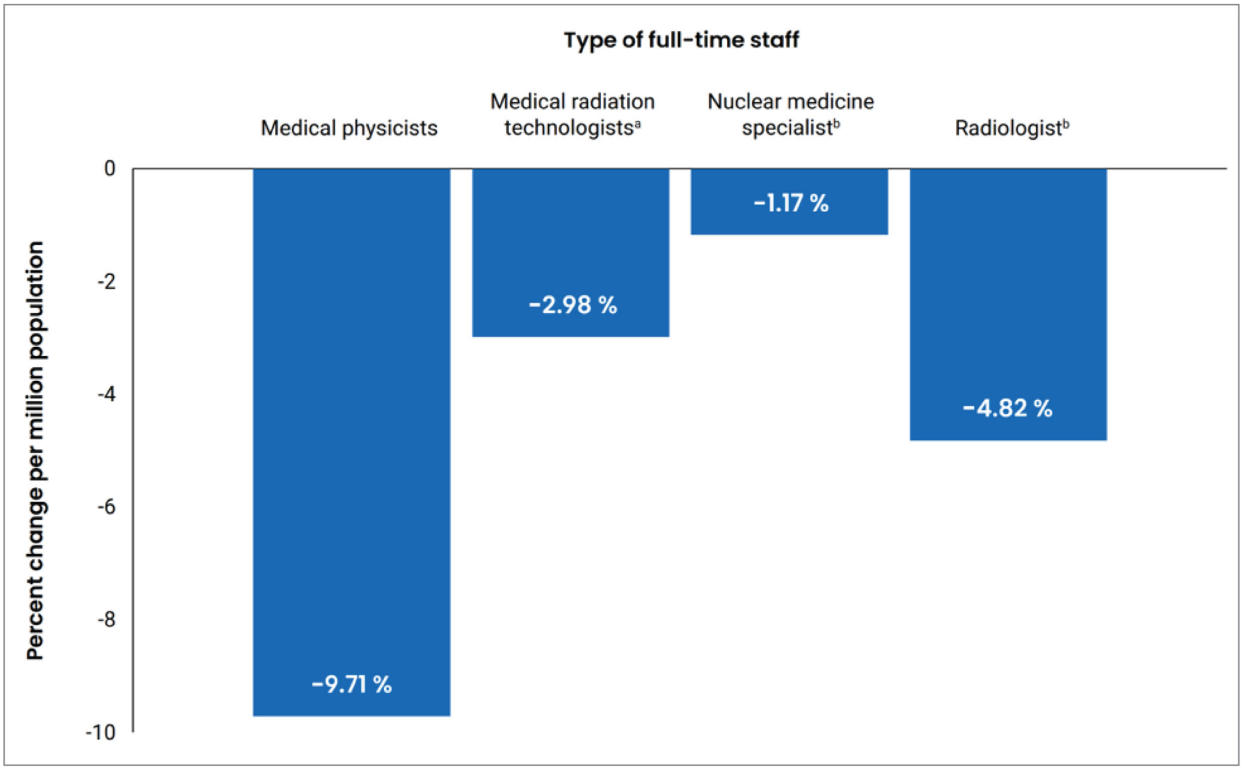
Some of the identified training, hiring, and retention factors identified in the literature include:

- increased **hiring demand**, prompted by installation of new imaging equipment, as well as **expanding clinical indications** for imaging equipment[3,7]
- **geographical** and **organizational** financial **constraints** to support employing and retaining highly trained professionals[61]
- **limited recruitment** and **retention incentives**, career and promotion opportunities, and investment in positions outside of urban areas[46,62,66]
- education and training **opportunities** that are **limited to larger urban centres** and may have limited funding, training incentives, or **insufficient accessibility supports** for students to complete training[15,66]
- **limited intraprofessional backup** and support in **rural** or **remote** areas as well as health care infrastructure constraints and isolated work environments.[62]

Professional Well-Being Factors

- **Stress** and **mental health concerns** among medical imaging staff are reported to have **worsened** compared to the **prepandemic** period.[13,14,33,40,67-70] A national mental health survey of a sample of MRTs in 2023 found that compared to 2018:[71]
  - emotional **exhaustion** increased by **94%**, **depersonalization** increased by **106%,** and feelings of **reduced** personal **accomplishment grew by 21%**
  - there was a **2-fold increase** in the number of participants that reported having a serious **mental health issue.**
- **Staff well-being** may be linked to increased **workloads**, **health** and **safety** considerations, **management** practices, and workflow protocols.[66,72,73]
- **Organizational factors** have been linked to staff mental and physical well-being:[66,72,73]
  - Since 2018, medical imaging team **professionals** have reported a **42% increased workload** and up to **25% decrease** in feelings of **trust**, **respect**, and **safety** in the workplace.[71]
- Stress and **poor mental and/or physical health** contribute to overall decreased well-being, increased **absenteeism**, and underperformance, and have a potential negative impact on patient care.[13,67,68]
- An **increasing number** of **staff** are reportedly **leaving the profession** in Canada, thus exacerbating existing shortages of imaging staff:[71]
  - **Since 2018**, the reported **vacancy rates** for **MRT positions** have **increased** more than **2-fold**, **3-fold**, and **4-fold** for **CT**, **nuclear medicine**, and **MRI**, respectively.

Figure 7: Percentage Change in Staff per Million Population, 2019 to 2022–2023



[a] Medical radiation technologist data from 2021.

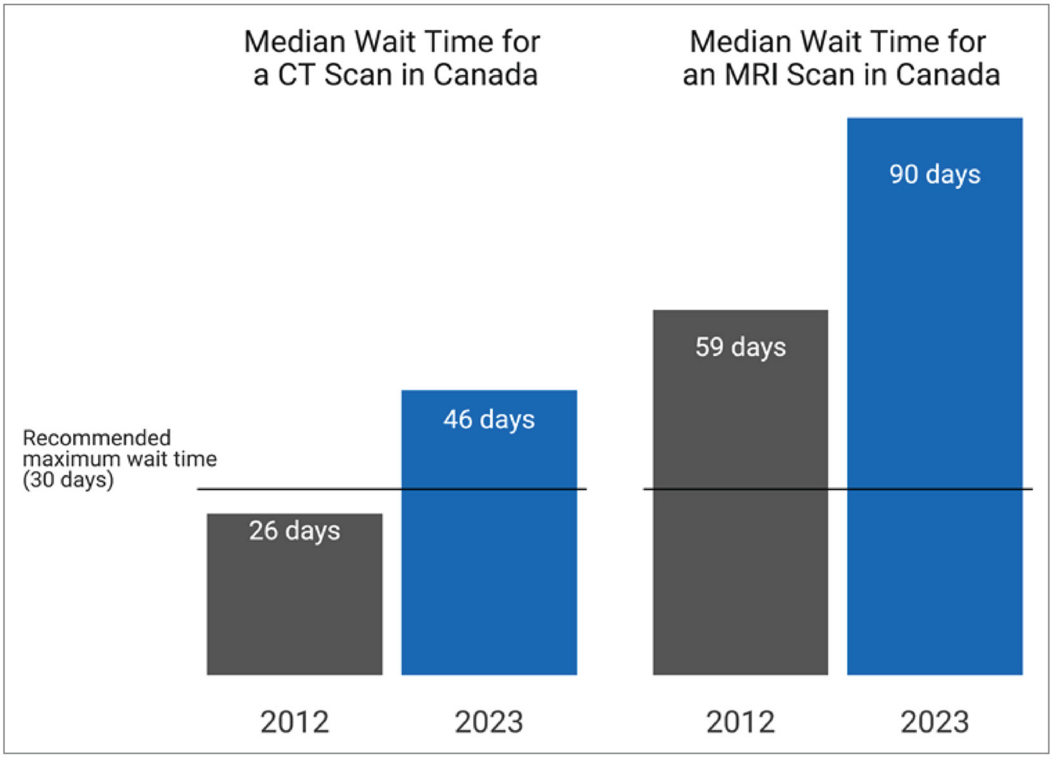
[b] Nuclear medicine specialist and radiologist data from 2019. Assumed unchanged staff retention since 2019 and increased population growth.[10,11]

Wait Times in Canada

Wait times for medical imaging appear to be exacerbated by increased service demand and reduced staffing.[74] **There are several reports of patients waiting beyond the recommended wait times for CT and MRI of 30 days.**[7,75-77]

- Between 2012 and 2023, the median wait time for CT increased by 77% (from 26 to 46 days) and the wait time for MRI increased by 53% (from 59 to 90 days) (Figure 8).[7,75]
- **Funding challenges, less efficient equipment**, and **low-value exam** volumes are reported to **contribute to growing wait times.**[25,74,78]

Figure 8: Median Wait Times for a CT and MRI Exam, 2012 and 2022–2023



Strategies to Support Health Human Resources

Several strategies have been recommended by organizations in Canada and internationally as well as studies to help support health and human resourcing. These include:[3,62,67,73,74,79-82]

- **investment** in **innovative** medical **technologies** and **replacement** of obsolete **equipment**
- developing a **robust health human resources strategy** for medical imaging departments
- prioritize enhancing management practices and leadership training to **promote** a **healthy, safe, and respectful workplace** environment to improve staff well-being and retention
- invest in the hiring and retention and training practices to **improve diversity** and **cultural competency** in the **workforce**
- ensure **equitable distribution** of e**quipment** and **incentivize professionals** to practice in underserved regions
- increase **rural** and **remote education opportunities** during radiology training
- implement clinical decision support systems, appropriateness criteria, and other tools to **streamline referral** and **scheduling processes** and communication (e.g., referral pathway, booking, intake).

Limitations of Findings

- Counts for the number of imaging professional by discipline were limited to the most recent publicly available year. Although count data for imaging medical physicists were available for 2023, most recent data for MRTs were limited to 2021, and counts from 2019 were retrieved for both radiologists and nuclear medicine professionals. It was presumed that the number of professionals in these disciplines remained constant over time and population growth increased, which may not accurately reflect the rapidly changing imaging team environment.
- The counts were limited to the number of posted or available positions for imaging professionals or the number of professionals actively registered with a professional association. This does not account for the number of filled or vacant positions, or the number of professionals on leave, listed as inactive, or retired. Consequently, this approach may not accurately represent the current number of professionals in practice, potentially leading to overestimated staffing values.
- This report includes self-reported survey and questionnaire data from multiple sources and therefore sampling bias, response bias, and low response rates for some questions may limit the generalizability of findings.
- For specific survey questions, the accuracy of the data in this report relies in part on the survey participants' personal knowledge of their particular health care setting (e.g., number of FTE MRT). For these survey questions, recall bias cannot be avoided because we were unable to assess whether all information was visually verified and based on real-time observations or whether questions were answered from memory. As a result, the accuracy and completeness of the reporting may be impacted.
- Since 2015, the CMII national survey forms have been prepopulated with responses from sites that participated in previous CMII national survey iterations. Invited survey respondents are asked to update their data to reflect the status at the time of responding to the survey. If the survey was not updated for this iteration, it was assumed that no changes had been made from the previous CMII survey response. Although this method improved survey respondent engagement and reduced fatigue, not all data may be up-to-date in some instances for some sites.
- For feasibility, the CMII survey has been restricted to 6 advanced imaging modalities, creating a bias toward urban areas. This focus bias does not capture alternative imaging options, such as ultrasound or X-ray, that are available outside these regions, especially in remote or rural areas where patients would otherwise need to travel or be transferred significant distances for imaging.

What Else Are We Doing?

This *Canadian Medical Imaging Inventory 2022–2023: The Medical Imaging Team* report is part of a series of publications that is part of a series of publications produced based on the CMII national survey.

The following additional publications, which can be found on the CMII website, are available to provide jurisdiction-level information on medical imaging modalities and resources:

- *Canadian Medical Imaging Inventory 2022–2023: Provincial and Territorial Overview*
- *Canadian Medical Imaging Inventory 2022–2023: CT*
- *Canadian Medical Imaging Inventory 2022–2023: MRI*
- *Canadian Medical Imaging Inventory 2022–2023: PET-CT and PET-MRI*
- *Canadian Medical Imaging Inventory 2022–2023: SPECT and SPECT-CT*
- provincial and territorial summaries

What Else Have We Done?

The following are other CMII-related reports released in 2023 to 2024 in response to specific decision-maker needs and are published on the CMII website:

- General Ultrasound Examination Volumes per Sonographer 8-Hour Workday
- Average Volume of MRI Exams Conducted per Hour Across Canada
- Implications of ChatGPT on Radiology Workflow
- Use of MRI and CT in Private Imaging Facilities in Canada: Service Report
- Optimizing the Use of Iodinated Contrast Media: Conservation Strategies Used Across Canada During the 2022 Shortage
- Imaging Implementation Advice Panel: Guidance for PSMA-PET Implementation
- Individuals' Access to Medical Imaging Results via Patient Portals
- Privately Operated Medical Imaging Facilities Across Canada
- Optimizing the Use of Iodinated Contrast Media for CT: Managing Shortages and Planning for a Sustainable and Secure Supply
- Wait List Strategies for CT and MRI *Scans*

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Appendix 1: Introduction to Imaging Modalities Collected in 2022–2023

Note that this appendix has not been copy-edited.

CT

CT employs X-rays as a source of ionizing radiation, sensitive radiation detectors, and computer analysis to create cross-sectional images of the body, including the head, heart, lungs, cardiovascular system, musculoskeletal system, abdomen, pelvis, and spine.[83] Specialties that routinely employ CT include neurology, cardiology, oncology, internal medicine, orthopedics, and emergency trauma care.

The main advantages of CT are its speed, which enables rapid imaging and diagnosis in urgent situations, and its ability to visualize fine details in bone, lungs, and other organs.[83,84] CT involves exposure to ionizing radiation, which means that the risks and benefits of its use in pregnancy, in young children, and of repeated use must be assessed.[83]

MRI

MRI uses powerful electromagnetic and radiofrequency fields and computation to produce cross-sectional images of the body, including the head, neck, cardiovascular system, breast, abdomen, pelvis, musculoskeletal system, and spine.[85] Specialties that commonly employ MRI include neurology, gastroenterology, cardiology, oncology, internal medicine, orthopedics, and emergency services.[85]

MRI does not use ionizing radiation, and therefore may be preferred when CT and MRI would provide comparable information, for example, when imaging children.[85] MRI provides high sensitivity and soft-tissue details, especially in the abdomen and pelvis, allowing for visualization of anatomy and pathologies. In oncology, this assists early diagnosis, staging and re-staging, identification of treatment response, and detection of recurrence in various cancers.[85]

A challenge of MRI is that exams can take up to an hour or more, and patients must remain motionless within a narrow enclosure. It may not be suitable for people with claustrophobia, those who cannot lie flat for prolonged periods, or those who are obese.[85] The magnetic fields and radiofrequencies used in MRI are incompatible with many common implantable medical devices, such as deep brain stimulators, cochlear implants, and pacemakers.[85,86] All people undergoing an MRI exam must be screened beforehand to identify any potentially contraindicated devices or metallic foreign bodies.[85-87]

Nuclear Medicine (SPECT and PET)

SPECT

In nuclear medicine imaging, trace amounts of radiopharmaceuticals are administered to patients intravenously or by injection (e.g., subcutaneously or intradermally), ingestion, or inhalation to visualize areas of radioisotope uptake within the body.[11,88] Depending on the radiopharmaceutical administered, the function (i.e., physiology) of almost any organ system can be observed. Nuclear medicine gamma cameras detect the gamma rays emanating from the radioisotope and form flat images; most cameras are also capable of cross-sectional imaging (SPECT).[89]

Nuclear medicine exams identify and evaluate a variety of pathologies, including cancer, heart disease, as well as gastrointestinal, endocrine, and neurological disorders. Medical specialties that commonly use SPECT imaging include oncology, neurology, cardiology, internal medicine, orthopedics, pediatrics, pneumology, and infectious disease.[11,88]

PET

PET uses injection of a sugar or other metabolic tracer labelled with a positron-emitting radioisotope, sensitive radiation detector cameras, and powerful computers to detect and visualize areas of increased metabolism, such as tumours. It creates three-dimensional images of regions of interest, such as brain, bone, and heart.[90,91]

The main advantage of PET (and its successor PET-CT) imaging is the ability to precisely quantify metabolic processes (e.g., the rate of glucose metabolism) and, depending on the pathology, to more accurately localize abnormalities. PET-radiolabelled sugar (i.e.,^{18}F-FDG) is the most common PET tracer currently used in Canada, but other tracers are becoming available, especially for cardiac and neurological imaging. Another advantage of PET-CT imaging is that the whole body can be imaged, which is useful for assessing tumour spread or recurrence.

Medical specialties that commonly use PET imaging include oncology, neurology, psychiatry, cardiology, pediatrics, and infectious disease.

Hybrid Medical Imaging Technologies (SPECT-CT, PET-CT, and PET-MRI)

Hybrid imaging combines 2 or more imaging modalities to take advantage of the characteristics of each. Therefore, hybrid imaging can simultaneously provide high anatomic detail and metabolic and/or physiological function, enabling more accurate diagnosis, better care pathways, refined treatment regimes, and improved patient outcomes.[92]

SPECT-CT

SPECT-CT combines SPECT and CT to create three-dimensional images of the body part of interest, such as brain, bone, and heart. Its main advantage is that it offers both metabolic and physiologic information, coupled with the resolution of CT. During a hybrid SPECT-CT, both scans are performed in sequence; the images are then computationally aligned with each other to show anatomic and functional detail, and to enable attenuation correction of the SPECT signal. Medical specialties that commonly use SPECT-CT imaging include oncology, neurology, cardiology, internal medicine, and orthopedics.

The challenges of SPECT-CT are those of the component modalities, both of which involve exposure to ionizing radiation,[93] and concerns about availability of radioisotopes.

PET-CT

PET-CT combines the modalities of PET and CT, creating three-dimensional images of the body part of interest, such as brain, bone, and lung. Both scans are performed in sequence during a single session, and the images are computationally aligned.[94] PET-CT is commonly used in oncology to diagnose and stage various cancers, such as lung, gastrointestinal, colorectal, breast, and thyroid cancer. Additionally, PET-CT is commonly employed to diagnose neurologic, cardiovascular, infectious, and inflammatory pathologies, and the CT component is used to detect coronary artery calcification, a marker of coronary atheroscleosis.[92]

The main advantage of PET-CT is the ability to demonstrate metabolic information with the precise anatomic detail of multislice high resolution CT images; as a result, PET-CT has replaced PET in Canada. Medical specialties that commonly use PET-CT imaging include oncology, neurology, cardiology, internal medicine, and orthopedics.

The challenges of PET-CT are those of the component modalities, both of which involve exposure to ionizing radiation.[92,95,96] The radioisotopes used in PET-CT have a half-life measured in hours, so imaging depends on availability of a cyclotron and transportation.

PET-MRI

PET-MRI combines PET with MRI,[97] permitting high-sensitivity metabolic imaging with high resolution of soft-tissue detail, enabling visualization of anatomy and pathologies not commonly attainable with other modalities. The 2 scans are performed in tandem, and the images are then computationally aligned. PET-MRI is the newest combination to reach clinical use and has applications in oncology, neurology, cardiology, internal medicine, and orthopedics.[98,99]

PET-MRI requires injection of radioisotope tracers and therefore requires the same risk-benefit assessment as other nuclear medicine imaging modalities for females of reproductive age and children.[100,101] Since the CT component is replaced by MRI, X-ray exposure is avoided; however, the hazards of magnetic fields remain.[100,101] The radioisotopes have a short half-life, requiring proximity to a cyclotron. The units and their infrastructure requirements are extremely expensive.

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