

Medical Imaging

Medical Imaging in Canada
2007



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for Health Information

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Medical Imaging in Canada, 2007

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This report could not have been produced without the generous support and assistance of many other individuals and organizations, including the many hospitals and other facilities that completed the survey on medical imaging technology in Canada.

Highlights

Chapter 1: Medical Imaging in Practice—Evolution of Technology and Emerging Applications

This chapter provides information about recent developments in the evolution of diagnostic imaging equipment.

- Data from the Canadian MIS Database indicate that basic X-ray and ultrasound still account for nearly 80% of all medical imaging examinations in Canadian hospitals.
- Although the capabilities of different imaging technologies differ for some applications, there are areas where they overlap. For example, both computed tomography (CT) and magnetic resonance imaging (MRI) can be used to scan the head, but their benefits, risks and limitations vary.
- More than 70% of new CT scanners installed in Canada in 2005 and 2006 had 64 slices. More slices means improved images, greater imaging speed and volume coverage.
- Some newer closed-bore scanners have a shorter tube and greater aperture to help reduce the feeling of claustrophobia and accommodate large patients.
- There is a consensus among experts that combined positron emission tomography and computed tomography (PET/CT) scanners have improved performance relative to PET scanners as they combine the functional imaging advantage of PET with the anatomical detail shown by CT. In Canada, there are now more PET/CT scanners than PET scanners. All PET/CT scanners were installed in the five years before 2007.
- In contrast to PET, whose most important application is in oncology, single-photon emission computed tomography's (SPECT) functional imaging is more focused on organ function, such as the heart, lungs, kidneys, gall bladder, liver and thyroid. Combined SPECT/CT technology provides both functional information and anatomical detail.
- PET/MRI scanners are now being developed. A new PET/MRI machine developed by Siemens acquires MRI and PET images of the brain simultaneously.

Chapter 2: Imaging Technologies—Supply and Costs

This chapter provides an overview of the supply and distribution of imaging devices in Canada, their age, technological characteristics and costs. International comparisons are also presented on the supply of selected types of medical imaging equipment.

- In 1990, 17 years after their introduction, there were 198 CT scanners installed and operational in Canada. By 2007, the number of CT scanners had reached 419, more than double the number in 1990. MRI scanners were introduced at a later date and their number was still quite low in 1990 (19). By 2007, 222 MRI scanners were installed and operational, more than 10 times the number of scanners in 1990.
- The first hybrid PET/CT scanner was installed in Canada in 2002. From that time to January 1, 2007, 17 PET/CT scanners were added. As of January 1, 2007, there were more PET/CT scanners installed and operational (18) than there were PET scanners (13).

- As of January 1, 2007, there was just one MRI scanner for every 1.9 CTs in Canada. Newfoundland and Labrador had the lowest ratio of MRIs to CTs (1:3.7), while Alberta had the highest ratio, with 1 MRI scanner for every 1.5 CTs.
- Between 2003 and 2007, the average age of equipment increased slightly for angiography suite, catheterization laboratories and nuclear medicine (by 0.1 to 0.3 years) and more substantially for MRI (by 1 year). It diminished slightly for CT (by 0.2 years) and decreased by 1.3 years for PET and PET/CT.
- In 2007, CT included a larger share of equipment with a high number of slices (16 or more) than three years before. Nuclear medicine included a higher share of dual-head cameras than four years before. Also, in 2007, PET/CTs accounted for 58% of total PET scanners and PET/CT scanners taken together, compared with only 7% in 2003.
- The number of MRI scanners in free-standing (or non-hospital) imaging facilities grew from 2 in 1998 to 41 in 2007. The number of CT scanners in free-standing facilities increased from 2 in 2000 to 21 in 2007.
- Hospitals and free-standing facilities have equipment of similar age for CT and MRI, while free-standing facilities have younger equipment for nuclear medicine and PET and PET/CT.
- The average age of CT scanners installed in Canadian hospitals is 4.6 years. The CT scanners with the highest average age are found in Nova Scotia (6.5 years), Quebec (6.2 years) and Newfoundland and Labrador (5.1 years).
- The average age of MRI scanners installed in Canadian hospitals is 5.4 years. MRI scanners in the Atlantic provinces, with the exception of New Brunswick, and in British Columbia are less than five years of age, on average. The MRI scanners with the highest average age (6.5) are found in Saskatchewan.
- Overall, 67% of the imaging equipment captured in the 2007 National Survey of Selected Medical Imaging Equipments had images routed to a picture archiving and communications system (PACS), up from 50% in 2004.
- For hospital-based equipment captured in the survey, funding for operating costs comes primarily from provincial and territorial governments. Additional secondary funding sources also exist. For example, some hospitals provide CT and MRI services funded by other payers in off hours. In contrast, the private sector (private health insurance and households) provides most of the funds to finance the operation of machines housed in free-standing imaging facilities.
- At 6.1 MRI scanners per million population on January 1, 2006, Canada was below the median of Organisation for Economic Co-operation and Development (OECD) countries in 2005 (6.9). For CT, with 12.1 scanners per million population on January 1, 2006, Canada is also below the 2005 OECD median (14.7). The Canadian count of scanners is as of January 1, 2006. While a few OECD countries indicated that their counts were as of December 31, 2005, most countries did not specify the precise date of their counts in 2005. Intensity of operation of scanners may vary between countries and, consequently, low rates of scanners do not necessarily mean low rates of exams.
- When compared with the OECD countries that reported the number of gamma cameras to the Eurostat, Canada is among the countries with the highest rates of gamma cameras per million population.

Chapter 3: Utilization of Medical Imaging Services

This chapter provides an analysis of statistics on the utilization of medical imaging equipment (number of exams and number of hours in operation) in Canada and selected countries.

- The number of MRI and CT exams per 1,000 population in Canada increased by 42.9% and 27.9%, respectively, from 2003–2004 to 2006–2007.
- At the Canada level, between 2003–2004 and 2006–2007, the increase in the number of exams was greater than in the number of scanners, both for MRI and CT. In the case of MRI, a 27% growth in the number of scanners led to a 47% growth in the number of exams. In the case of CT, a 12% growth in the number of scanners led to a 32% growth in the number of exams.
- For jurisdictions with MRI scanners in free-standing facilities (Quebec, Ontario, Manitoba, Alberta and B.C.), the average number of MRI exams per scanner was 5,970 in the hospital setting, compared with 2,530 in the free-standing setting in 2006–2007.
- For jurisdictions with CT scanners in free-standing facilities (Quebec, Ontario, Alberta and B.C.), the average number of CT exams per scanner was 9,506 in the hospital setting, compared with 2,160 in the free-standing setting in 2006–2007.

Chapter 4: Medical Imaging Professionals

This chapter profiles the women and men who make imaging services possible. This chapter includes information about the training, availability and work life of these medical professionals.

- Canada's 16,464 medical radiation technologists (MRTs) made up the bulk of the medical imaging workforce in 2006. They include radiological, nuclear medicine, radiation therapy and magnetic resonance technologists.
- Seventy-four percent of MRTs are radiological technologists.
- There were approximately 2,900 sonographers (also known as ultrasonographers) practising across Canada in 2006.
- Canada's 2,034 diagnostic radiology physicians supervise and interpret X-rays, CT scans, mammography and other imaging modalities in the study, diagnosis and treatment of disease and injury.
- Nuclear medicine physicians (about 200 in Canada in 2006) are primarily concerned with the use of radioactive materials in the study, diagnosis and treatment of disease.
- On average, about 1% of active physician specialists in diagnostic radiology left Canada annually between 1991 and 2006, although about half returned within this period. The resulting cumulative total loss of diagnostic radiology physicians over the 16-year period amounts to approximately 6% of the total supply of diagnostic radiology physicians in 2006.
- The average age of imaging professionals is rising. Between 1996 and 2006, the average age increased for all types of medical imaging professionals, but more so for medical sonographers.

- In medical imaging, about 8 in 10 technologists were women, compared with about 2 in 10 physician imaging specialists.
- The level of education required to work in medical imaging varies from profession to profession. For example, it may take from two to four years to become a magnetic resonance imaging technologist following high school graduation. For pediatric radiology physicians and neuroradiology physicians, training may take 14 years.

About This Report

In the past century, we have witnessed dramatic technological changes in the field of medicine. The same is true for medical imaging. For example, X-rays were just starting to be used for medical purposes in the late 1890s. Today, radiologists can read X-rays and other diagnostic images produced thousands of kilometres away in a matter of minutes. Surgical procedures that once required several days of hospitalization are now being performed on an outpatient basis. And more sophisticated forms of medical imaging, such as the ability to generate images of almost any structure within the body, are becoming essential to the provision of general and specialized medical care and treatment.

Nevertheless, little is known about the actual use of these technologies in Canada. This report aims to address this gap. It is meant to serve as a consolidated reference of what we know about medical imaging across Canada, helping to inform decisions as we move forward. We look in particular at the numbers of different kinds of machines in Canada and how they are used, as well as the skilled health professionals who operate the equipment and interpret results. In general, we tend to focus on a selection of more recent imaging technologies for which the information base is strongest. Many of the issues that we highlight, however, may apply across the spectrum of imaging technologies.

The report is divided into four chapters:

Chapter 1: Imaging in Practice—Evolution of Technology and Emerging Applications. Included in this chapter is information about the way these technologies are evolving, as well as emerging applications for their use and an overview of the available information on imaging technologies in Canada today.

Chapter 2: Imaging Technologies—Supply and Cost provides an overview of the available information on the supply of imaging equipment and where in the country machines are located. It also provides information on factors affecting how much imaging technology we have, including the cost of purchasing imaging equipment.

Chapter 3: Utilization of Imaging Services. The focus of this chapter is on statistics about utilization of medical imaging equipment (number of exams and number of hours in operation) on an annual basis and to assess the level of intensity in the operation of medical imaging equipment.

Chapter 4: Medical Imaging Professionals profiles the women and men who make imaging services possible. This chapter includes information about the training, availability and work life of these medical professionals.

Where possible, the report includes national and international comparisons. It also includes a Fast Facts section in Appendix A. Fast Facts provides an expanded range of comparative data on medical imaging technologies across the country.

What's New in This Report

Medical Imaging in Canada, 2007 draws on new data and analysis from CIHI, as well as research produced at provincial or territorial, national and international levels to explore what we know and don't know about medical imaging in Canada. Examples of the kinds of new information contained in this report are listed below:

- The number, age and distribution of selected medical imaging technologies located in hospitals and free-standing imaging facilities across Canada as of January 1, 2007, and how these characteristics have changed over time;
- How selected imaging technologies are being used in various settings;
- The proportion of hospital spending on medical imaging services in selected provinces; and
- A methodological notes section that provides information on methods and data quality.

For More Information

Highlights and the full text of *Medical Imaging in Canada, 2007* are available free of charge in both official languages on the CIHI website at www.cihi.ca. To order additional print copies of the report (a nominal charge applies to cover printing, shipping and handling costs), please contact:

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This report is only part of what you can find at our website (www.cihi.ca). On the day that *Medical Imaging in Canada, 2007* is released and in the weeks and months following, we will be adding more information to what is already available electronically. For example, it will be possible to:

- Download free copies of the report in English or French;
- Download report highlights and an index of the report's contents; and
- Download data from the 2003, 2004, 2005, 2006 and 2007 National Survey of Selected Medical Imaging Equipment.

We welcome comments and suggestions about this report and about how to make future reports more useful and informative. Please email them to nhex@cihi.ca.

Chapter 1: Imaging in Practice—Evolution of Technology and Emerging Applications

Health technology, including medical imaging technology, is an indispensable part of any nation's health care system. The World Health Organization (WHO) defines diagnostic imaging as "a means to take pictures of the structure and processes of the body and make them visible or 'accessible' to the human eye. It encompasses the use of ionizing radiation (e.g. basic X-ray, computed tomography, nuclear medicine or scintigraphy), ultrasound, magnetic resonance and a few other highly sophisticated procedures."¹

According to the WHO, the assumption is that diagnostic imaging is needed in some 20% to 30% of medical cases worldwide, as clinical considerations alone are not sufficient to make a correct diagnosis. Of those cases that require diagnostic imaging, some 80% to 90% of diagnostic problems can generally be solved using "basic" X-ray and/or ultrasound examinations.¹

The Canadian experience seems to follow along the same lines. Basic X-ray and ultrasound examinations together accounted for nearly 80% of all medical imaging examinations (excluding angiography) in hospitals in 2005–2006 (Figure 1).

X-ray examinations, including mammography, represented 64% of examinations, while the share of ultrasound was 14%. Computed tomography (CT), nuclear medicine, magnetic resonance imaging (MRI) and cardiac catheterization accounted for 12%, 6%, 3% and 1%, respectively, of all medical imaging examinations.

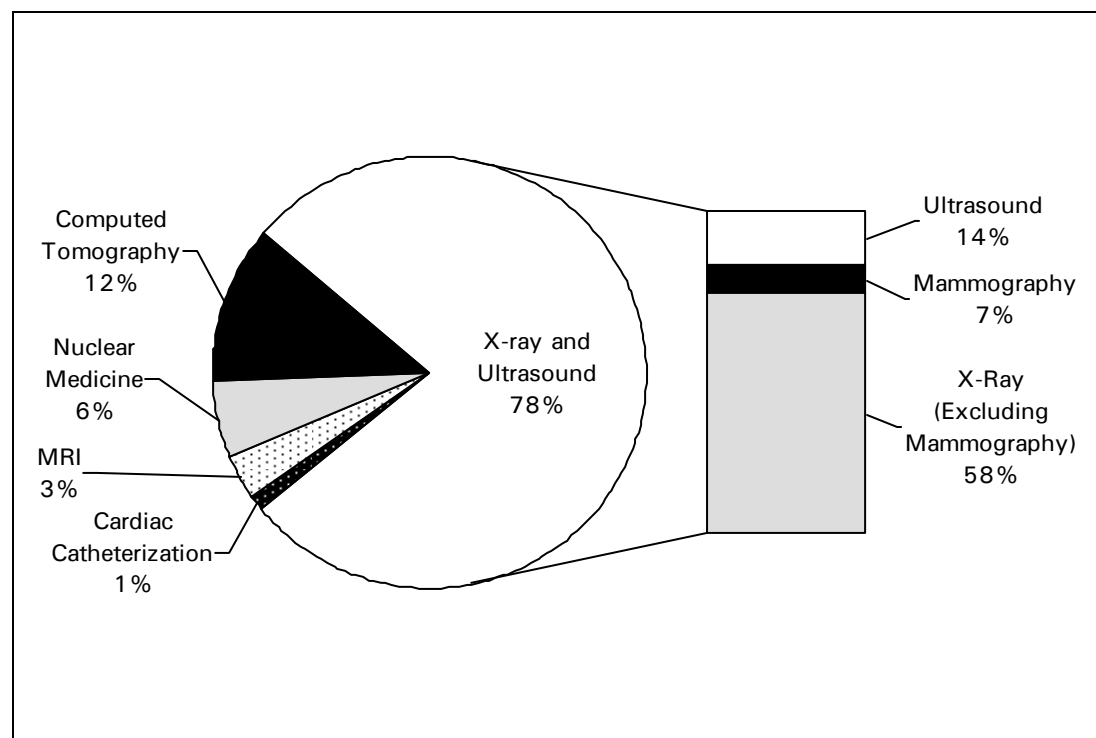
Percentage distribution of problems that require diagnostic imaging as estimated by the WHO (all problems that require diagnostic imaging = 100%):

Chest problems	40%
Accidents and injuries	20%
Pregnancy-related problems	15%
Abdominal problems	10%
Musculoskeletal problems	10%
Other	5%

Source

World Health Organization, Department of Essential Health Technologies, *Essential Diagnostic Imaging*, [online], cited October 5, 2007, from <<http://www.who.int/eht/en/DiagnosticImaging.pdf>>.

Figure 1 Percentage Distribution of Diagnostic Imaging Examinations in Hospitals, Canada, Excluding Quebec, 2005–2006



Notes

- a) Examinations in Quebec hospitals are excluded as they are not reported according to the *Standards for Management Information Systems in Canadian Health Services Organizations* (MIS Standards).
- b) Excludes angiography studies.

Source

Canadian MIS Database, Canadian Institute for Health Information.

The Right Tool for the Right Job

Medical imaging may be done for many reasons: screening patients at risk for a disease, reducing uncertainty about a diagnosis to reassure patients and caregivers, assisting with decisions about care choices, assessing treatments and prognoses and/or guiding surgery or other interventions.^{2, 3}

Deciding which is the best tool (or tools) to use in each of these contexts for different patients is challenging, particularly given the ongoing evolution of imaging technologies, research evidence and practice patterns. Often, a particular type of imaging is of obvious, undisputed value for some groups of patients or types of research. Other cases are less clear. For example, although the capabilities of MRI and CT differ for specific applications, there are areas where the modalities overlap. While both CT and MRI may be used to scan the head, benefits and risks differ. The Canadian Association of Radiologists indicates the following benefits, risks and limitations of the two technologies for scanning of the head (text under the headings “CT Scanning of the Head” and “MRI Scanning of the Head” are adapted from the organization’s website).⁴

CT Scanning of the Head⁴

Benefits

- CT of the head is now widely available and is performed in a relatively short time, at a reasonable cost—especially when compared to MRI.
- The exam shows some changes in bone better than any other imaging method.
- It readily detects bleeding.
- The exam is used for stroke detection.
- It provides detailed images of bone, soft tissue and blood vessels.
- CT is the method of choice for rapidly screening trauma victims to detect internal bleeding or other life-threatening conditions.
- CT angiography depicts brain blood vessels, revealing aneurysms and blockages.

Risks

- CT does involve exposure to radiation in the form of X-rays, but the benefit of an accurate diagnosis far outweighs the risk. The effective radiation dose from this procedure is about 2 milliseiverts (mSv), which is about the same as the average person receives from background radiation in eight months.
- Women should always inform their doctor or X-ray technologist if there is any possibility that they are pregnant.
- Nursing mothers should wait 24 hours after contrast injection before resuming breastfeeding.
- The risk of serious allergic reaction to iodine-containing contrast material is rare, and personnel working at CT units are well equipped to deal with them.

Limitations

- Compared with MRI scans, the precise details of soft tissue (particularly the brain) are less visible on CT scans. CT is not sensitive in detecting some inflammatory conditions of the brain, such as multiple sclerosis.
- Compared to conventional angiography, computed tomography angiography (CTA) may, in some cases, not be as sensitive in the detection of aneurysms and arteriovenous malformations of the brain.

Safety of Medical Imaging

Medical imaging tests, like other health care interventions, are rarely risk free. For instance, X-rays carry risks associated with radiation exposure. Technologies that do not use ionizing radiation may pose other risks. Examples include potential mechanical, thermal and biological effects.⁵ For many patients, the potential benefits of the information obtained from tests clearly outweigh foreseeable risks, including the consequences that may arise from false-positive or false-negative findings.⁶ For others, careful consideration of potential benefits, costs and risks is required. In some cases, the best option is to rely on approaches used for centuries, such as careful observation or feeling a joint to check for a break. This balance may vary from test to test, place to place, patient to patient and over time.⁷

MRI Scanning of the Head⁴

Benefits

- Images of the brain and other head structures are clearer and more detailed than with other imaging methods.
- MRI contrast material is less likely to produce an allergic reaction than the iodine-based materials used for conventional X-rays and CT scanning.
- Exposure to radiation is avoided.
- MRI enables the detection of abnormalities that might be obscured by bone tissue with other imaging methods.
- A variant called magnetic resonance angiography (MRA) provides detailed images of blood vessels in the brain—oftentimes without the need for contrast material. The risk of an allergic reaction from MRA contrast is extremely low, and kidney damage does not occur.
- New MRI systems can depict brain function, and in this way detect a cerebrovascular accident at a very early stage.

Risks

- An undetected metal implant may be affected by the strong magnetic field.
- MRI is generally avoided in the first 12 weeks of pregnancy. Doctors usually use other methods of imaging, such as ultrasound, on pregnant women unless there is a strong medical reason.

Limitations

- Conventional X-rays provide a better image of bone, and CT is preferred for patients with severe bleeding. MRI may not always distinguish between tumour tissue and edema fluid, and does not detect calcium when this is present within a tumour. In most cases the exam is safe for patients with metal implants, but there are a few exceptions, so patients should inform the technician of any implants prior to the test. The exam must be used cautiously in early pregnancy. MRI often costs more than CT scanning.

Nuclear Medicine

While both CT and MRI are generally used to obtain anatomic details of body tissues and organs, thus enabling the physician to detect anomalies in anatomy, nuclear medicine provides images of organ function. The evaluation of organ function is helpful in diagnosing tumours, infection and other disorders. The physiologic images are developed based on the detection of energy emitted from a radioactive substance given to the patient, usually intravenously. The radioactive substance or radiopharmaceutical that is used is determined by what part of the body is under study, since some compounds collect in specific organs better than others. The radiopharmaceutical collects in the organ under study and gives off energy as gamma rays. A nuclear medicine camera detects the rays and works with a computer to produce images of organ function. Nuclear medicine cameras include regular gamma cameras used in general nuclear medicine, but also special detectors for single-photon emission computed tomography (SPECT) and positron emission tomography (PET).

The Canadian Association of Radiologists indicates the following benefits, risks and limitations of general nuclear medicine (adapted from the organization's website).⁴

Benefits

- The functional information provided by nuclear medicine examinations is unique and currently unattainable by using other imaging procedures. For many diseases, nuclear medicine studies yield the most useful information needed to make a diagnosis and to determine appropriate treatment, if any.
- Nuclear medicine is much less traumatic than exploratory surgery, and allergic reaction to the radiopharmaceutical material is extremely rare.

Risks

- Because the doses of radiopharmaceutical administered are very small, nuclear medicine procedures result in exposure to a small dose of radiation. Nuclear medicine has been used for more than five decades, and there are no known long-term adverse effects from such low-dose exposure.
- In general, exposure to radiation during pregnancy should be kept to a minimum.
- Allergic reactions to the radiopharmaceutical can occur, but are extremely rare.

Limitations

- Nuclear medicine procedures are time-consuming. They involve administration of a radiopharmaceutical, obtaining images and interpreting the results. It can take hours to days for the radiopharmaceutical to accumulate in the part of the body under study. Imaging can take up to three hours to perform, though new equipment is available that can substantially shorten the procedure time.

Positron Emission Tomography

PET is a type of nuclear medicine most often used to detect cancerous tumours or examine the effect of cancer therapy. It may also be used to detect some brain disorders and diseases of the heart. PET imaging involves the acquisition of physiologic images based on the detection of positrons (tiny particles emitted from a radioactive substance administered to the patient). The Canadian Association of Radiologists indicates the following benefits, risks and limitations of PET, which may differ somewhat from those of general nuclear medicine (adapted from the organization's website).⁴

Benefits

- Because PET allows study of body function, it can help physicians detect alterations in biochemical processes that suggest disease before changes in anatomy are apparent on other imaging tests such as CT or MRI scans.

Risks

- Because the radioactivity is very short-lived, radiation exposure is extremely low. The amount of the radioactive substance is so small that it does not affect the normal processes of the body.

- The radioactive substance may expose the fetus of patients who are pregnant or the infants of women who are breastfeeding to radiation. The risk to the fetus or infant should be considered related to the potential information gain from the result of the PET examination.

Limitations

- PET can give false results if a patient's chemical balances are not normal. Specifically, test results of diabetic patients or patients who have eaten within several hours prior to the examination can be adversely affected because of blood sugar or blood insulin levels.
- Also, because the radioactive substance decays quickly and is effective for a short period of time, it must be produced in a laboratory near the PET scanner. It is important for the patient to be on time for the appointment and to receive the radioactive substance at the scheduled time. PET must be done by a radiologist who has specialized in nuclear medicine and has substantial experience with PET. Most large medical centres now have PET services available to their patients. Medicare and insurance companies cover many of the applications of PET, and coverage continues to increase.
- Finally, the value of a PET scan is enhanced when it is part of a larger diagnostic work-up. This often entails comparison of the PET scan with other imaging studies such as CT or MRI.

The following sections focus on the evolution of high-tech modalities generally well implemented in Canada—computed tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography (PET)—as well as the characteristics of the machines installed in Canada and emerging applications due to recent technological advances. Fusion technology adopted more recently—combined positron emission tomography and computed tomography (PET/CT) and combined single-photon emission computed tomography and computed tomography (SPECT/CT)—is also considered. Finally, emerging or future types of fusion technologies are briefly discussed.

Computed Tomography

Physicians use CT scans for diagnosing a wide and changing range of conditions, such as head injury, chest trauma and musculoskeletal fractures.

According to the 2005 Health Services Access Survey data, about 1,116,000 Canadians aged 15 and older (4.3% of all Canadians aged 15+) reported that they had had a non-emergency CT scanⁱ in the previous 12 months. The leading reason for these tests, accounting for 18% of scans, was neurological or brain disorders, followed by fractures or problems of joints (16%). About 48% did not specify a reason for their CT scans. Most respondents (96%) stated that their CT scan was done in a hospital or public clinic.⁸

Computed tomography (or CT), also known as “computer assisted tomography” (or CAT), is used to create three-dimensional images of the structures within the body. CT scans use X-ray images processed by a computer to create virtual slices of the part of the body being examined. A computer then processes the data to create images that show a cross-section of body tissues and organs.

Evolution of Technology: From Single-Slice Conventional Scanning to Spiral Multi-Slice Scanning

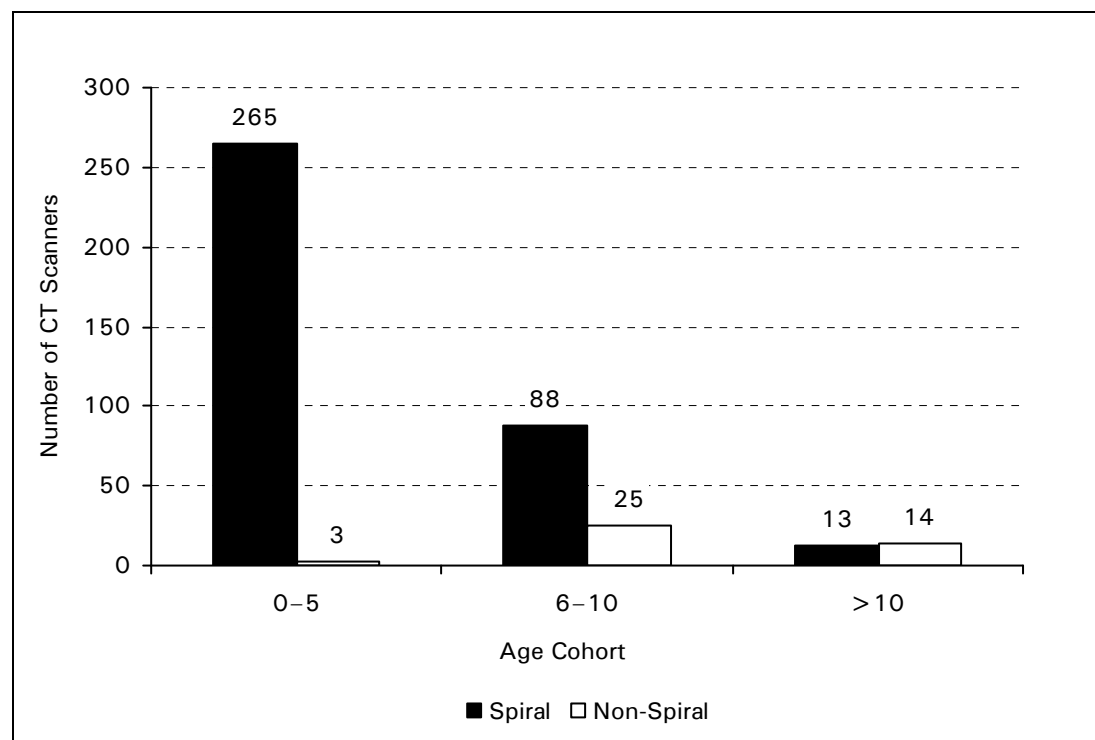
The first medical CT scanner in Canada was installed at the Montréal Neurological Institute in 1973.⁹ The number of CT scanners installed in Canada increased by about a hundred units in each of the next three decades: in 1983, 98 hospitals reported performing CT examinations (some hospitals might have had more than one scanner);¹⁰ in 1993 and 2003, there were 216 and 325 CT scanners, respectively.^{11, 12} In 2007, there were 419 CT scanners installed and operational.¹³

Two major components of a CT scanner are a gantry (a frame housing an X-ray tube and a detector array, with a large opening into which the patient is inserted lying on a table) and a computer processor. The gantry takes consecutive images or rotates around the patient, gathering data that are converted to images by the computer processor. All original or early scanners (until 1987) used conventional or non-spiral scanning: the patient was moved forward, when the gantry had come to a complete stop after a rotation, by an increment equal to the slice thickness. Non-spiral scanning is relatively slow and resulting images are prone to artefacts caused by movement.^{14, 15} Relatively few scanners currently installed in Canada still use this original technology.

Of the 408 CT scanners installed and operational as of January 1, 2007, for which information on the type of technology was available, only 42 scanners were non-spiral scanners. More than half of the non-spiral scanners (25) were between 6 and 10 years old. Three were 5 years old or younger and 14 were older than 10 years (Figure 2).

i. Booked or planned scan provided on an outpatient or inpatient basis; does not refer to scan provided through an admission to the hospital emergency room as a result of, for example, an accident or life-threatening situation.

Figure 2 Number of CT Scanners, by Age Cohort, by Technology, Canada, as of January 1, 2007



Note

Excludes 11 CT scanners for which the type of technology (spiral or non-spiral) was not reported.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Slip-ring technology, introduced in 1988, allows continuous rotation of the gantry and, as the patient is moved, a spiral or helical scan is obtained, hence the name “spiral” or “helical” CT. It permits data to be acquired rapidly, reduces artefacts due to movement and increases resolution.^{14, 15}

As of January 1, 2007, about 90% of CT scanners were spiral CTs, more than two-thirds of them installed in the preceding five years.

A further technological advance, multi-detector CTs (MDCTs), which are a newer generation of spiral CTs with multiple detectors, have a greater imaging speed and detection capacity than single-slice spiral CTs. An MDCT allows multiple image slices to be simultaneously acquired during a single rotation of the X-ray tube. MDCTs with the capacity to simultaneously acquire an increasing number of slices have been introduced over the years. In 1998, the introduction of four-slice CT scanners resulted in improvements in imaging of the chest and abdomen, among other body sites. In 2001, with the availability of 16-slice acquisition, the use of CT expanded to include vascular investigations.¹⁶ Scanners with an even greater number of slices (32, 40 and 64) appeared thereafter. CTs with a capacity of 64 simultaneous slices have been on the market since 2004, with five units installed in Canadian hospitals in that year. In the two following years, there was a remarkable growth in the number of 64-slice scanners installed in Canada, when they represented more than

70% of the new CT installations. This is similar to the situation that exists in the United States, where a 2006 survey of buying intention of decision-makers in hospitals and imaging centres indicated that nearly 75% of sites that planned to add a CT scanner planned to purchase a 64-slice scanner.¹⁷

Experts agree that, in contrast to the 4- and 16-slice scanners, which had a rather short product cycle time, 64-slice CT upgradeable for future technical advances seems to be where the industry will settle. It brings clinical gains (for example, improved images, greater imaging speed and volume coverage) and enables non-invasive cardiac imaging and virtual colonoscopy. However, 64-slice CT is not without challenges for the data network and storage systems, as it generates a tremendous amount of data, producing several thousand images in just a few seconds.^{17, 18}

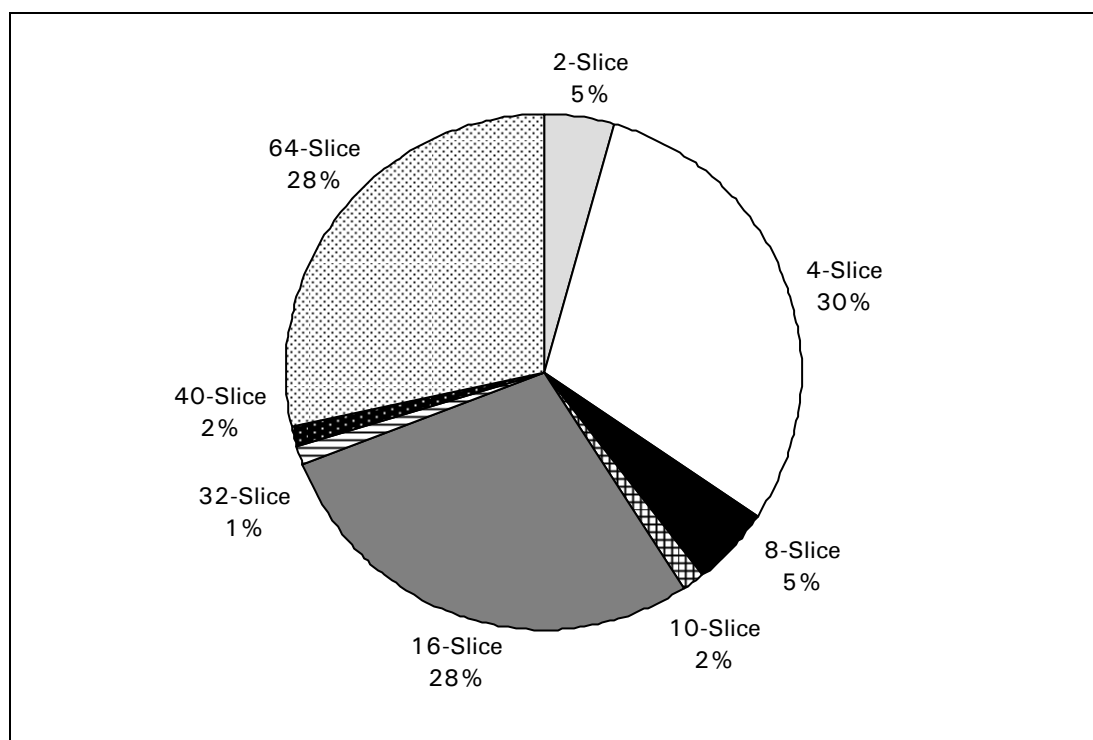
As of January 1, 2007, of the 374 CT scanners for which the number of slices was reported in the National Survey of Selected Medical Imaging Equipment, 332 were MDCTs. About 60% of MDCTs had 16 slices or more. At the higher end of the technology, 28% of MDCTs had the capacity to simultaneously acquire 64 slices (Figure 3).

Toshiba's 256-slice CT is expected to win approval for general clinical use in 2008. Offering four times the coverage of 64-slice CT, the 256-slice scanner has the ability to image in one rotation 12.8 cm of body tissues or organs (the entire heart or an entire joint, or most of the brain, lungs or liver). By contrast, a 64-slice CT covers 3.2 cm per image and requires several rotations to scan an organ. The new scanner can perform the same test as the 64-slice scanner with one-eighth to one-third the dose of radiation. More slices also means a better image.

Source

Johns Hopkins Housing and Testing Only 256-Slice CT Scanner in North America, [online], cited September 17, 2007, from <http://www.hopkinsmedicine.org/Press_releases/2007/03_26b_07.html>.

Figure 3 **Distribution of MDCT Scanners, by Slice, Canada, as of January 1, 2007**



Note

As of January 1, 2007, there were 419 CT scanners installed and operational in Canada, but the number of slices was reported for only 374 scanners. Of these 374 scanners, 42 were one-slice scanners and 332 were MDCT scanners. The distribution in Figure 3 pertains to the 332 MDCT scanners.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

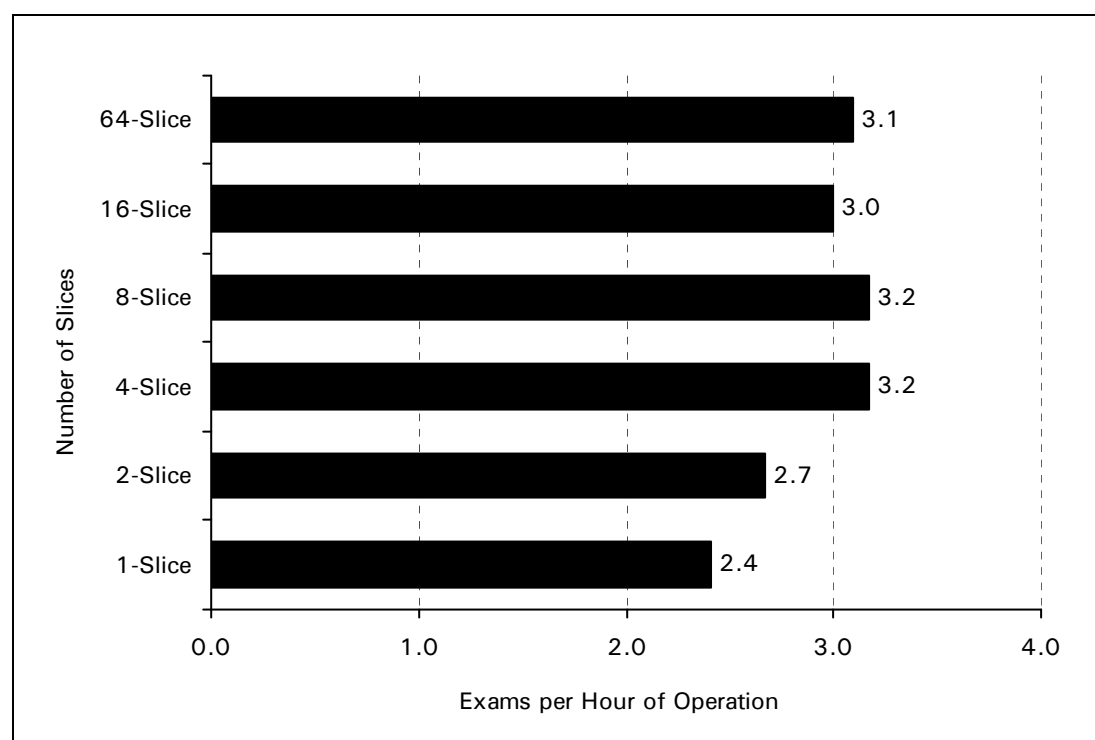
Some of the cited clinical advantages of MDCT scanners over conventional CT scanners for general scanning purposes are as follow:¹⁹

- MDCT has faster and better spatial resolution, covers more volume and uses contrast media more efficiently.
- MDCT may be used for pediatrics, geriatrics, bariatrics and cardiology.
- MDCT may replace other more invasive or cumbersome procedures.
- MDCT has faster scanning times.
- MDCT images can be sent straight to the software, but efficient image management is necessary.

Although more slices means faster scanning times, in practice this may not translate into a greater throughput per hour, as the time of preparation of the patient for the exam may not be reduced. Irrespective of the number of slices of the MDCT system, scanning times are generally of short duration relative to the preparation of the patient. A 16-slice scan can usually be obtained during a single breath hold (less than 30 seconds).⁴ Such speed is beneficial in all patients who have to stay still during the scan, but especially in populations in which the length of scanning was often problematic with non-spiral scans, such as

elderly, pediatric or critically ill patients.⁴ Data from the 2007 National Survey of Selected Medical Imaging Equipment indicate that the average number of exams per hour of operation remains quite constant among scanners with 4 to 64 slices in Canadian hospitals.

Figure 4 Average Number of Exams per Hour of Operation of CT Scanners Older Than One Year, in Hospitals, by Slice, Canada, 2006–2007



Note

Based on the annual number of exams and the average weekly hours of operation for the year from April 1, 2006, to March 31, 2007, reported in the 2007 National Survey of Selected Medical Imaging Equipment and assuming 50 weeks of operation per year.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

A cited disadvantage of MDCT scanners is a higher radiation dose than conventional CT or other imaging tools. Ionizing radiation doses from CT examination are among the highest of those for any diagnostic imaging modality. The effective dose from diagnostic medical exposure is measured in millisieverts (mSv). Conventional single-slice CT scanners deliver effective doses of 2.3 mSv, 8 mSv and 10 mSv, respectively, for a typical head, chest and abdomen or pelvis examination. This is a radiation dose equivalent to 115, 400 and 500 chest X-rays, respectively. For perspective, the amount of radiation that one gets from background, or natural, sources is 2 mSv or 3 mSv per year.^{19, 20, 21} With the increased use of CT, there has been an increase in average effective dose of hospital patients. For example, at the Vancouver General Hospital, the average annual patient effective dose almost doubled between 1991 and 2002.²² MDCT may even produce higher radiation doses than a conventional CT because of higher X-ray tube currents that are necessary for multiple slices. A 2005 study found that the effective dose from MDCT scans was greater than the effective dose from conventional single-slice scans by 13.1% for head and neck,

29.0% for chest and 35.8% for abdomen and pelvis.²³ Ideally, the minimum radiation dose should be used to provide the required diagnostic image quality. The best method for achieving the greatest patient dose reduction from CT examinations is the utilization of CT protocol parameters that minimize radiation exposure without compromising the required diagnostic image quality. However, a 2006 survey conducted in 20 Ontario hospitals (18 responded) with 64-slice CT scanners by the Centre for Global eHealth Innovation of the University Health Network found that significant variations in CT protocols, and therefore in radiation doses, exist between hospitals in Ontario. The Centre recommended that methods to help share best-practice CT protocols between health care institutions be developed. It also recommended that the distribution of radiation dose from various CT examinations in Ontario be determined and diagnostic reference-dose levels be established (reference-dose levels can be used to identify institutions that consistently use higher radiation doses for the same clinical conditions compared to other institutions).²³

Another survey conducted in 2004 in 18 hospitals of B.C., where most of the scanners were MDCT scanners, found that the average patient dose varied greatly from hospital to hospital for the same type of exam. The largest range was found for CT of the abdomen, for which the effective dose varied from 3.6 mSv to 26.5 mSv. For head CT, the range was 1.7 mSv to 4.9 mSv; for chest CT, it was 3.8 mSv to 26 mSv; and for pelvic CT, it was 3.5 mSv to 15.5 mSv.²⁴

On many MDCT scanners, CT manufacturers have added the capability to vary the X-ray tube current according to the size of the patient and the X-ray attenuationⁱⁱ of the body part being scanned. The tube current may be automatically reduced at some angular tube positions, at which the X-ray attenuation of a patient is smaller (for example, posterior–anterior scan angle versus lateral) and at locations at which the anatomy is less attenuating (for example, chest versus abdomen). With dose reduction and X-ray optimization techniques, CT scans can be performed with a radiation dose that is as low as reasonably achievable without compromising the resulting images.^{19, 25, 26} However, the current state of practice is not necessarily the best practice. For example, the 2004 survey conducted in 18 hospitals in B.C., where most of the scanners were MDCT scanners, found out that only three hospitals used automatic dose-reduction systems for any of the exams.²⁴ A 2006 survey conducted in 20 Ontario hospitals revealed significant variations in practice between hospitals in the use of automatic exposure control.²³

MDCT scanners also cost more than conventional scanners. Additional hardware and software costs may be incurred to make use of the full capabilities of MDCT, and there may be additional annual service (maintenance) costs.¹⁹ In 2003, acquisition costs for a new spiral CT ranged from \$375,000 to \$1.6 million (U.S. dollars), the cost for MDCTs being at the high end (more than U.S.\$1.2 million).^{14, 15}

CT scanning is an increasingly used modality for the diagnosis of injuries and diseases. It is most notably used for clinical investigations of the abdomen/pelvis and the brain. The introduction of multi-slice CTs with very short scan time has opened the door to new applications, such as coronary angiography and screening tests (for example, calcium

ii. X-ray attenuation is the loss of energy of the X-ray beam as it passes through the body part to transmit measurements to the detector array.

scoring for coronary disease, low-dose CT of the chest to detect malignancy in high-risk groups and CT colonography for colorectal cancer screening).^{15, 27} However, these emerging applications are still being assessed.

Magnetic Resonance Imaging

MRI was first applied clinically in 1978 when two prototype clinical medical resonance imagers were installed in the United Kingdom.²⁸ In Canada, the first three MRI scanners were installed in late 1982 and early 1983, at St. Joseph's Hospital, London; University of British Columbia Hospital, Vancouver; and Princess Margaret Hospital, Toronto. At that time, MRI was primarily used for research. In 1985, St. Joseph's hospital became the first Canadian hospital to utilize MRI primarily for clinical services.^{9, 29, 30}

According to the Health Services Access Survey conducted by Statistics Canada in 2005, it is estimated that approximately 1,012,000 Canadians aged 15 and over (3.9% of Canadians age 15+) had had a non-emergency MRI scanⁱⁱⁱ in the previous 12 months. About 35% were scans of joints and/or fractures, followed by tests for neurological or brain disorders (19%).^{iv} As with CT scans, most patients (89%) underwent their MRI tests in hospitals or public clinics.⁸

Evolution of the Technology

MRI uses radio-frequency waves and a strong magnetic field to provide a picture of internal organs and tissues. The technology is used in the diagnosis of a broad range of pathologic conditions in all parts of the body, including cancer, heart and vascular disease, stroke and joint and musculoskeletal disorders.³¹

All MRI systems consist of certain basic components, regardless of their size, type or level of sophistication.³⁰

1. Magnet—generally surrounds the subject; generates a homogeneous magnetic field.
2. Radio-frequency coils and receiver—including the source of radio-frequency signals used to excite the nuclei of atoms (transmitter) and the unit to detect the energy emitted from the nuclei upon relaxation when returning to their previous state (receiver).

Magnetic resonance imaging (MRI) uses three components to create detailed images of the inside of the body—hydrogen atoms in the tissues, a strong external magnet and intermittent radio waves. In a strong magnetic field, atoms tend to line up like iron filings around a bar magnet. A pulse of radiofrequency radiation (like that used in a microwave oven) disturbs that alignment. When the atoms return to their former state, they emit the energy from the radiation that reveals their molecular environment and spatial location. For example, the nucleus of a hydrogen atom in a molecule of fat will emit a different signal than a hydrogen atom in the protein of muscle.

MRI can provide detailed images of all tissues except bone (where the protons are tightly bound and less susceptible to magnetic influence). Images are created using algorithms similar to those used in CT. MRI techniques can be enhanced by injected agents such as gadolinium chelates, much as radiography is enhanced by contrast materials.

iii. Booked or planned scan provided on an outpatient or inpatient basis; does not refer to scan provided through an admission to the hospital emergency room as a result of, for example, an accident or life-threatening situation.

iv. The reason for the MRI was unspecified in 35% of all cases.

3. Computer and display system—convert the radio-frequency signals produced by the nuclei into an image.

The conventional MRI unit has a closed cylindrical magnet in which the patient must lie totally still for several seconds at a time, and consequently may feel “closed-in” or truly claustrophobic. The “open-bore” systems are wider and shorter and do not fully enclose the patient. Some newer units are open on all sides.³¹

Of the 222 MRI scanners installed and operational in Canada as of January 1, 2007, the type of bore was reported for 219 scanners, only 9 of which were open bore. Most scanners were installed within the previous five years. Among the 210 closed-bore scanners, 54% were 5 years old or less, while 39% were from 6 to 10 years old, and the remaining 7% were older than 10 years. A slightly higher proportion of the 9 open-bore scanners were 5 years old or less (56%), while 33% were between 6 and 10 years old, and 11% were more than 10 years of age.

Figure 5 Number of MRI Scanners, by Age Cohort, by Technology, Canada, as of January 1, 2007



Note

As of January 1, 2007, there were 222 MRI scanners installed and operational in Canada, but the type of bore (open or closed) was reported for only 219 scanners. The distribution in Figure 5 pertains to the 219 scanners.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

The magnetic field strength of the magnet is measured in units of Tesla. The magnetic field strength of a Tesla is about twenty thousand times the Earth’s magnetic field.²⁵ Typically, the open-bore scanners have low magnetic field strength (0.35 Tesla or

below) and require longer examination time than closed-bore systems. Newer open-bore scanners, however, include machines with mid-field strengths (0.5 Tesla to 1.0 Tesla) and improved image quality. Five of the nine open-bore scanners installed in Canada as of January 1, 2007, had a field strength of 0.35 Tesla or below while four had higher field strengths. A large proportion of the open-bore scanners are found in free-standing facilities (private clinics). Low-field strength models are a lower-cost option for free-standing facilities that do not have a large caseload.

Open-bore scanners offer advantages to large patients who cannot fit in the tube aperture of closed-bore scanners and to those who suffer from claustrophobia. They are also useful in intra-operative imaging and image-guided interventions because of the easy access to the patient. Some newer closed-bore scanners have a shorter tube than traditional closed-bore systems. This allows the patient's head to lie outside the tube for many examinations. The ends of the tube may also be flared, which shortens the perceived length of the tube and helps reduce the feelings of claustrophobia if the head needs to be inside the tube. Also, the newer scanners have a wider tube aperture than the traditional closed-bore scanners to accommodate large patients. The availability of wide-diameter short-tube 1.5-Tesla closed-bore systems could reduce the appeal of truly open-bore scanners that do not fully enclose the patient. However, the distinction between closed bore and open bore is somewhat blurred by the marketing strategy of equipment manufacturers such as Siemens and Philips that advertise as open-bore their scanners with wide inner bore diameters or a short tube but that still enclose the patient from all sides.^{17, 32-34}

In the early 1980s, only MRI scanners with 0.5 Tesla and below were available for clinical application. In the mid- to late-1980s, the international trend was toward the acquisition of the higher-field strength systems (1.5 Tesla). However, there was a reversal of the trend in the early 1990s, when an increasing proportion of scanners with lower field strength were installed in many countries, with the exception of Canada.³⁰

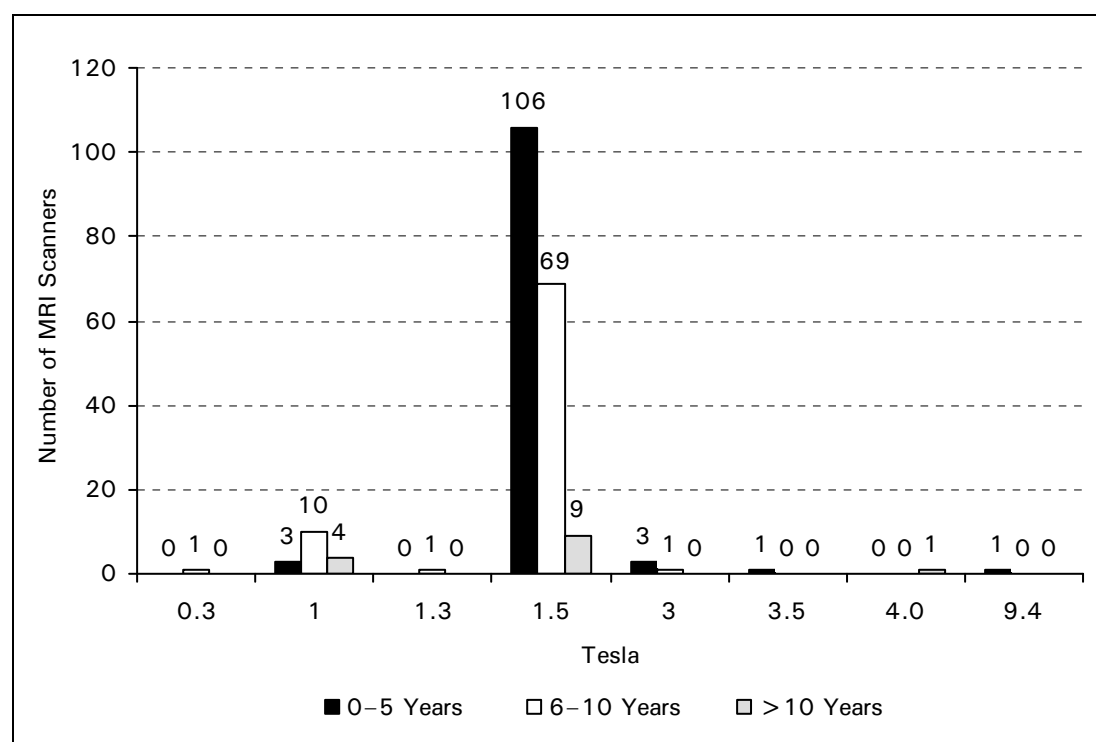
In the 1990s, MRI magnets available for clinical applications had a maximum field strength of 2 Tesla. Higher field strengths were generally used for research purposes.³⁰ In 2001, 3-Tesla MRIs were introduced for clinical applications in the U.S.³⁵ Higher field strengths, such as 1.5 Tesla or higher, generally mean better images and faster acquisition time, with the capability of doing spectroscopy and new applications such as functional imaging, angiography, spectroscopy and molecular imaging.^{27, 35} Members of the MRI and CT Expert Panel of Ontario's Wait Time Strategy stated that the minimum standard for MRI scanners in Ontario hospitals should be a 1.5-Tesla magnet, with the capacity of doing MRI angiography and perfusion studies.²⁷

The field strength is not the only factor in determining performance. For conventional applications, current technology has narrowed the gap between lower and higher field systems with new pulse sequences and improved coils for increased signal-to-noise ratio (higher signal-to-noise ratio means nicer-looking images) and spatial resolution (allows differentiation between adjacent structures of the body) for routine imaging, and more sophisticated gradient designs to improve field strength per metre for faster echo times, smaller fields of view and thinner slices. Low- and mid-field systems have gained diagnostic recognition while competing with high-field systems for image quality. Stand-up units and dedicated extremity systems for spine and joint studies have gained recognition in the U.S. orthopedic community.³⁶

As of January 1, 2007, 191 of the 219 MRI scanners for which field strength was reported in Canada had a field strength of 1.5 Tesla or higher (87%). By comparison, only 67% of all MRI scanners in the U.S. in 2006 had such high field strength. However, in the U.S., more than half of the scanners are installed in non-hospitals, and these tend to have lower field strength. In American hospitals, 84% of all scanners had a field strength of 1.5 Tesla or higher,³⁷ similar to the proportion in Canadian hospitals (91%). In Canada, 27 of the 38 scanners installed in clinics for which field strength was reported had a magnetic field strength of 1.5 Tesla or higher (71%), while 6 scanners had 1-Tesla or 1.3-Tesla magnets (16%) and the remaining 5 scanners (13%) had a field strength lower than 1 Tesla.

Of the 210 closed-bore MRI scanners installed in Canada for which field strength was reported, 191 had a field strength of 1.5 Tesla or higher (91%). By contrast, all the open-bore scanners had a field strength of 0.5 Tesla or lower.

Figure 6 Number of MRI Scanners and Field Strength, by Age Cohort, Closed Bore, Canada, as of January 1, 2007



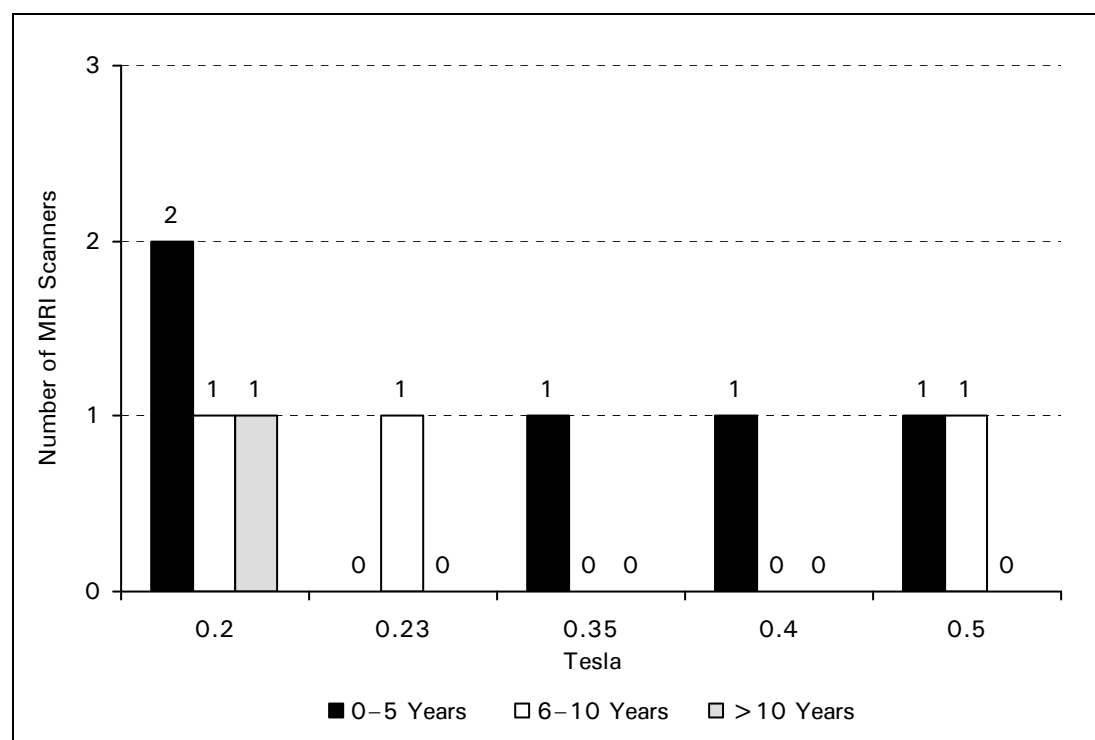
Note

Of the four scanners with field strength of 3 Tesla, one is used exclusively for research and another one is used mainly for research. The scanner with field strength of 3.5 Tesla is used mainly for research. The two scanners with field strength of 4 Tesla and 9.4 Tesla are used exclusively for research.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure 7 Number of MRI Scanners and Field Strength, by Age Cohort, Open Bore, Canada, as of January 1, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

In 2006, in the U.S., scanners with a magnetic field strength greater than 1.5 Tesla represented only 3% and 2% of all MRI scanners installed in hospitals and non-hospital sites, respectively. By contrast, the proportion of 1.5-Tesla MRIs reached 81% in hospitals and 47% in non-hospital sites.³⁷ However, there are indications that the share of scanners with a field strength higher than 1.5 Tesla may increase significantly in the near future. A 2006 survey of buying intention of 434 decision-makers in American hospitals and imaging centres indicated that 43% of sites that planned to add an MRI scanner planned to purchase a 3-Tesla system, a technology that provides thinner slices of organs or joints and therefore finer detailed images than 1.5-Tesla systems. Despite their higher costs, 3-Tesla scanners are gaining further acceptance in the U.S., particularly for brain imaging, musculoskeletal imaging and magnetic resonance angiography.¹⁷

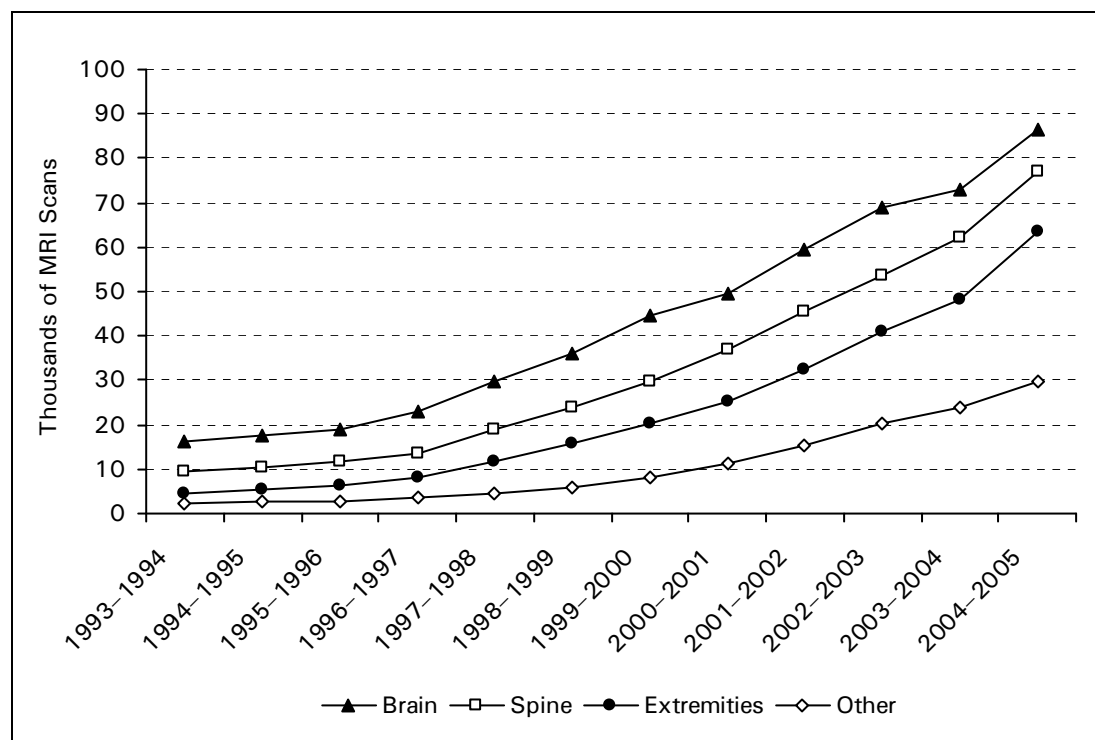
Magnetic resonance spectroscopy (MRS) is an option on high-field strength MRI systems available from several manufacturers. MRS measures chemical entities at the cellular level. It provides data on tissue biochemistry. For example, in the management of prostate cancer, MRS has been used to measure cellular metabolites, including citrate, creatine and choline. Citrate has been suggested as a marker for discriminating between areas with prostate cancer and surrounding disease-free tissue. In its 2003 assessment, the Canadian Coordinating Office for Health Technology Assessment (CCOHTA) found the accuracy of MRS and MRI used in combination for the diagnosis of prostate cancer to be better than that of MRI alone, though the improvement seems to be modest.³⁸

Clinical indications for cardiovascular magnetic resonance in ischemic heart disease include regional and global function, perfusion, viability and coronary angiography.²⁵ In 2003, the Medical Advisory Secretariat (MAS) of the Ontario Ministry of Health and Long-Term Care conducted a literature review of functional cardiac MRI in the assessment of viability and perfusion. The MAS concluded that there is some evidence that the accuracy of functional cardiac MRI compares favourably with alternate imaging techniques (such as SPECT, PET and echocardiography) for the assessment of myocardial viability and perfusion.

More recently, in 2005 and 2006, the Canadian Agency for Drugs and Technologies in Health (CADTH, formerly called the Canadian Coordinating Office for Health Technology Assessment or CCOTHA) summarized the evidence from clinical systematic review and economic evaluations published between 2000 and November 2004 concerning the clinical and cost-effectiveness of CT and MRI in the investigation of specific clinical conditions of the chest and the cardiovascular, neurological and urological systems. Promising clinical evidence for the use of CT and MRI was found in the investigation of carotid artery disease, peripheral vascular disease (diseases of blood vessels outside the heart and brain), pulmonary embolism, renal artery stenosis and stroke. Clinical evidence is more cautious for their use in the investigation of cerebral aneurysms, coronary artery disease and lung cancer screening, and sparse for headaches, head injuries and seizures. No clinical evidence was found, from systematic reviews, for the use of CT and MRI in the investigation of cerebral arteriovenous malformations or urolithiasis screening. The review of economic evaluations suggested that CT and MRI are cost-effective for peripheral vascular disease and stroke. The evidence for cost-effectiveness was limited for renal artery stenosis and head injury, and equivocal for lung-cancer screening, pulmonary embolism, carotid artery disease and cerebral aneurysms. CADTH indicated that there is a lack of high-quality studies to address the clinical and cost-effectiveness of CT and MRI for various conditions, and that most studies suggested that more research is needed to investigate the benefits of CT and MRI as compared with traditional technologies. It also indicated that because of the rapid advance of CT and MRI technologies, findings from the systematic reviews may not be sufficiently contemporary in some instances to be useful to clinicians and decision-makers.³⁹

As in other parts of the world, available provincial administrative data suggest that scan rates have increased in recent years, and applications of the technology have changed.^{40, 41} For example, researchers from Ontario's Institute for Clinical Evaluative Sciences (ICES) showed that the number of outpatient MRI scans in the province increased between 1993–1994 and 2004–2005, as indicated in Figure 8.

Figure 8 **Number of Outpatient MRI Scans, by Body Site, Ontario, 1993–1994 to 2004–2005**



Note

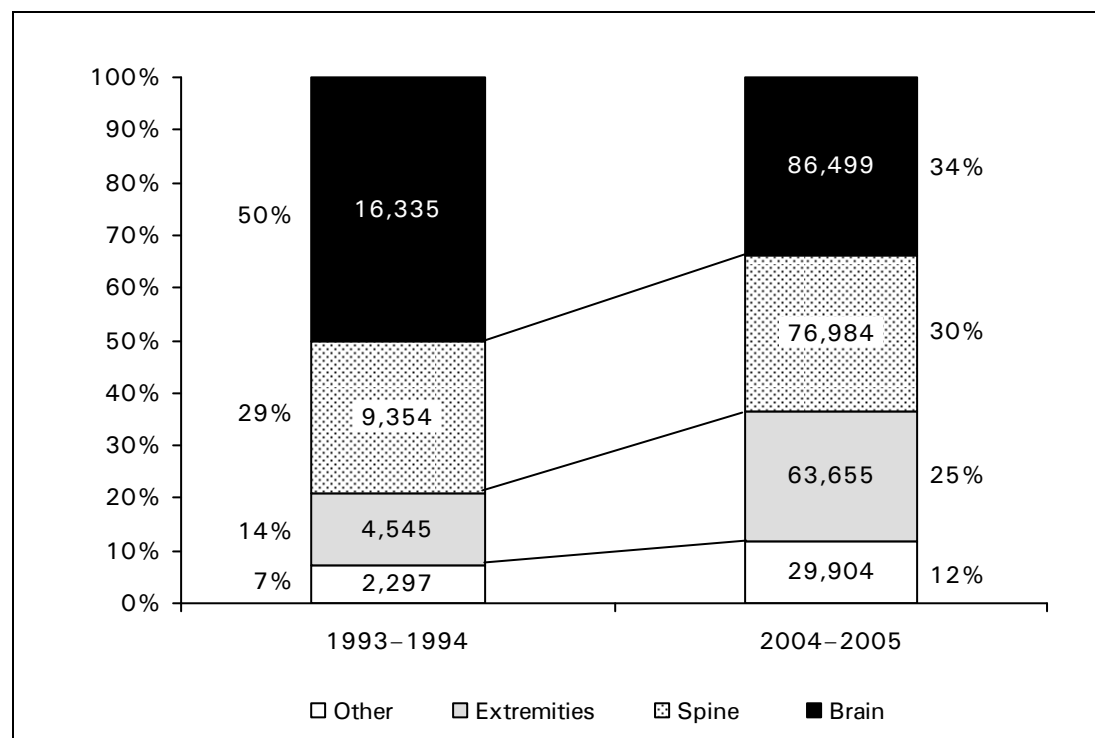
"Other" includes MRI scans for abdomen, pelvis, chest and neck.

Sources

Access to Health Services in Ontario, 1st and 2nd Editions: ICES Atlas (Toronto: Institute for Clinical Evaluation Sciences, 2005 and 2006).

Although scanning of the brain remains the most frequent type of MRI, its share of total MRI scans diminished from 50% to 34% over the decade. Scans of the spine and the extremities represented 30% and 25%, respectively, of all outpatient MRI scans in Ontario in 2004–2005, while 12% of the scans were on other areas such as abdomen, pelvis, chest and neck (Figure 9).

Figure 9 Distribution of Outpatient MRI Scans, by Type, Ontario, 1993–1994 and 2004–2005



Note

"Other" includes MRI scans for abdomen, pelvis, chest and neck.

Sources

Access to Health Services in Ontario, 1st and 2nd Editions: ICES Atlas (Toronto: Institute for Clinical Evaluation Sciences, 2005 and 2006).

While the share of scanning of the brain declined in Ontario, the proportion remained higher than in the U.S. In 2006, scanning of the brain was the second most frequent type of MRI procedure in the U.S. (25%), after procedures on the spine (27%).³⁷

MRIs of the spine are the second most common type of outpatient MRI scan in Ontario. The utilization of MRIs of the spine increased more markedly than the utilization of CT scans of the spine over the period 1996–1997 to 2005–2006 in Ontario. MRI scans of the spine increased by 590%, while CT scans of the spine increased by 71%. Meanwhile, the number of spine X-rays increased by only 17%.⁴²

Positron Emission Tomography and Combined Positron Emission Tomography and Computed Tomography

PET, a type of nuclear medicine examination now most commonly used to detect cancerous tumours, some brain disorders and diseases of the heart and other organs by creating images that measure biochemical processes in the body, was introduced in the early 1970s.⁴³ A decade later, PET still remained a low-resolution, low-sensitivity, single-slice design. An important advance occurred in the late 1980s with the introduction of three-dimensional PET for brain imaging. Successful implementation

Positron emission tomography (PET) scanners create images by detecting subatomic particles emitted from a tracer radioactive substance injected into a patient. When the radionuclide decays, it emits positrons (positively charged electrons, also called “beta plus” [β^+] particles), which, when they collide with an electron, generate energy in the form of two gamma rays emitted at 180 degrees to each other. The detection of these gamma rays permits the creation of an image of the distribution of the radionuclide, slice by slice, within certain organs of the body. The sectional images that are created can be used to evaluate some functions in the body.

of 3-D methodology for whole-body imaging followed in the mid-1990s.⁴⁴ Despite technical improvements and an increasing interest in its clinical uses, PET has evolved slowly as a clinical tool relative to other imaging modalities such as CT or MRI. The fact that PET was initially developed for research purposes and that it is an expensive technology requiring access to a nearby cyclotron to produce short-lived radioactive molecules (positron-emitting tracers) were important barriers limiting PET’s acceptance and use in clinical medicine.⁴⁵ However, an increasing number of PET scanners were installed in industrialized countries in the late 1990s, particularly the U.S., Germany and Japan.⁴⁴ By the year 2000, the U.S. had more than 300 PET centres, while Germany had more than 60. Japan had about 40 PET scanners. Small and medium-sized European countries generally had only a few PET scanners, with the exception of Belgium, which had nine. Larger European countries, such as the U.K., Russia, France and Italy, each had fewer than a dozen scanners. Canada had eight PET scanners.⁴⁶ A recent development involves combining functional and anatomical imaging from PET and CT in the same display. The prototype PET/CT was installed at the University of Pittsburgh PET Facility in 1998 for clinical evaluation. The first commercial PET/CT scanner was installed in 2001.⁴⁴

PET scanning is used extensively in the U.S. In 2005–2006, 1,725 hospital and non-hospital sites in the U.S. offered PET imaging. Nearly 1,000 of these sites provided the services in a mobile van, typically for one to two days a week. In 2005, there were 326 PET scanners sold in the U.S. (608 scanners sold in the rest of the world). Some 1.2 million PET procedures were performed in the U.S. in 2005 (an increase of 24% over 2004). Although the dominant focus of PET is still in oncology, applications in cardiology are increasing, particularly rubidium PET studies for myocardial perfusion. Myocardial viability studies with PET should also benefit from the introduction of fast, multi-slice PET/CT scanners suitable for cardiac imaging. PET/CT scanners have become the preferred technology for PET imaging. In 2005, PET/CT comprised 95% of total PET billings in the U.S. (compared with 79% in 2003).^{47, 48}

In contrast to the U.S., widespread clinical implementation and access to PET for routine clinical care has been delayed in Canada and many other countries by the high capital and operating costs of the equipment⁴⁹ and a perceived need to more fully assess its appropriateness for specific clinical applications. A 2001 report by the Agence d'évaluation des technologies et des modes d'intervention de la santé (AÉTMIS) in Quebec found PET to be useful in several areas of oncology, neurology and cardiology, and recommended its gradual deployment for specific applications.⁴⁶ The Ontario Institute for Clinical Evaluation Sciences (ICES) also published a report on PET assessment in 2001 and suggested that some 24,000 patients with oncologic and seizure disorders might benefit from PET. However, the Ontario study found no evidence of the clinical utility of PET in cardiology or in the diagnosis or symptomatic management of dementia.⁵⁰ Until 2004, ICES posted on its website regular updates confirming PET's usefulness in oncology. In 2003, the Norwegian Centre for Health Technology Assessment published a report on the clinical use of PET that updated the findings of a report produced four years earlier on behalf of the International Network of Agencies for Health Technology Assessment.⁴⁵ The 2003 report summarized the conclusions of recent health technology assessment (HTA) reports and systematic reviews of relevance. The Norwegian Centre reported that PET was found to be more accurate than other diagnostic procedures for several indications in oncology, mainly in diagnosing non-small cell lung cancer and solitary pulmonary nodules, in staging of Hodgkin's disease, in identifying metastasis from malignant melanoma and colorectal cancer and in finding tumours in the head and neck.⁵¹ Following the report, the Norwegian ministry of health allocated money to establish a PET facility at the National Cancer Hospital.⁵² In May 2004, the Ontario Health Technology Advisory Committee (OHTAC) endorsed a recommendation from the Provincial PET Steering Committee that any patient in Ontario with a non-biopsiable single pulmonary nodule should be offered a PET scan. Single pulmonary nodules are circumscribed lesions seen on lung imaging and for which there is uncertainty as to whether these are malignant.

In some cases these lesions cannot be easily biopsied for anatomical reasons or if patients have comorbid conditions that make the biopsy risky.⁵³ In 2005, the Minister for Health and Ageing in Australia accepted the recommendation by the Australian Medical Services Advisory Committee supporting public funding for PET for solitary pulmonary nodules and non-small cell cancer, as well as for use prior to surgery in patients with refractory epilepsy (PET provides additional localizing information in some patients, of whom a proportion will have good post-surgical outcomes as a consequence).^{54, 55}

In 2005, OHTAC reviewed the effectiveness of PET for the assessment of myocardial viability and concluded that the addition of PET to other myocardial viability studies would identify some patients who might benefit from revascularization, but would not have been identified as appropriate candidates using thallium SPECT (the most commonly used test for myocardial viability in Ontario) or dobutamine echocardiography.⁵⁶

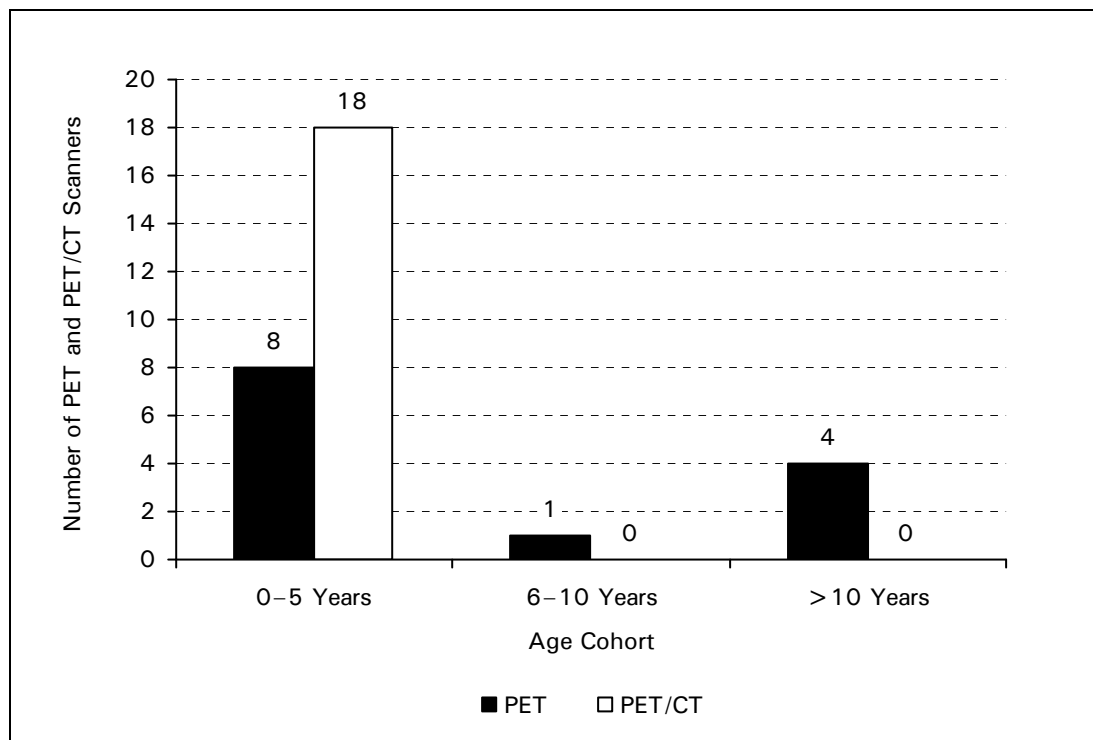
The Department of Health of England found the evidence of benefit from PET scanning, in 2005, sufficiently robust to support the establishment of facilities across the country. The department estimated that in the immediate future cancer would account for around 85% to 90% of PET scanning utilization, with much smaller numbers of scans being required for neurological and cardiac conditions. Within cancer, the evidence of benefit from PET was found to be the strongest for patients with lung cancer, lymphoma and colorectal cancer, with the evidence also accumulating for head and neck cancer, esophageal cancer, brain

tumours and a range of less common cancers. The department stated that, based on current evidence and consensus among experts, provision should be made for around 800 scans per million population per year over the following three to five years. The Department of Health of England indicated that there is a clear consensus among experts that PET/CT scanners have considerable advantages over single PET as they combine the functional imaging advantages of PET with the anatomical detail shown by CT. In August 2005, among the 15 scanners providing clinical PET services in England, 12 were PET/CT scanners. Among the five scanners exclusively for research, only one was a PET/CT scanner.⁵⁷

Similarly to the Department of Health in England, the Agence nationale d'accréditation et d'évaluation en santé in France stated in a 2005 document published by La Haute Autorité de santé that the scientific community unanimously considers that PET/CT has improved performance relative to single PET. In 2004, the French ministry of health authorized one PET or PET/CT scanner per 800,000 population. In June 2004, a questionnaire was sent to the 60 sites in France that had been authorized to install PET systems. Among the 55 respondents, 9 indicated that they had already installed a PET; 46 indicated that they had already installed or were planning to install a PET/CT.⁵⁸

The new hybrid technology of PET/CT is also gaining faster acceptance in Canada than PET on its own. A 2004 document prepared for the Canadian Association of Radiologists identified PET/CT as a driver shaping the future of medical imaging in Canada. It is stated that because PET/CT allows one test to provide both functional and structural images, it may soon replace the diagnostic images obtained from traditional nuclear medicine, which places a radiation source inside the body to produce a functional image.⁵⁹ As of January 1, 2007, there were 18 PET/CT scanners in Canada, five more than there were PET scanners. All 18 PET/CT scanners were 5 years old or younger, compared with only 8 PET scanners. One PET scanner was between 6 and 10 years old and four were older than 10 years. Most PET and PET/CT scanners can accommodate full-body scanning. Only three PET scanners and one PET/CT scanner have small apertures that can accommodate only the head (information on aperture is missing for two PET/CT scanners). Of the head scanners, two were installed in the previous 5 years while the other two were older than 10 years. Among the PET scanners, four were reported to be used exclusively in clinical practice and four exclusively in research. Five scanners were used in both clinical practice and research. Five of the 18 PET/CT systems were reported as being used only in clinical practice while four were exclusively for research and the other nine were used in both clinical practice and research.

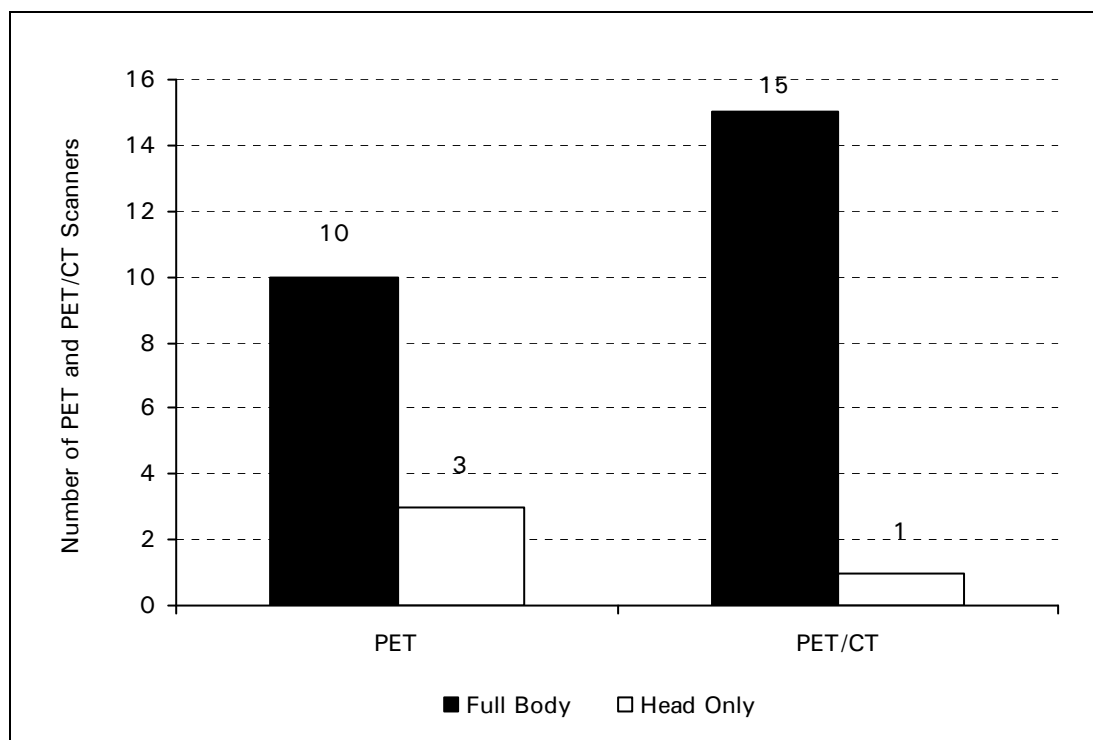
Figure 10 Number of PET Scanners and PET/CT Scanners, by Age Cohort, Canada, as of January 1, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure 11 Number of PET Scanners and PET/CT Scanners, by Technology, Canada, as of January 1, 2007



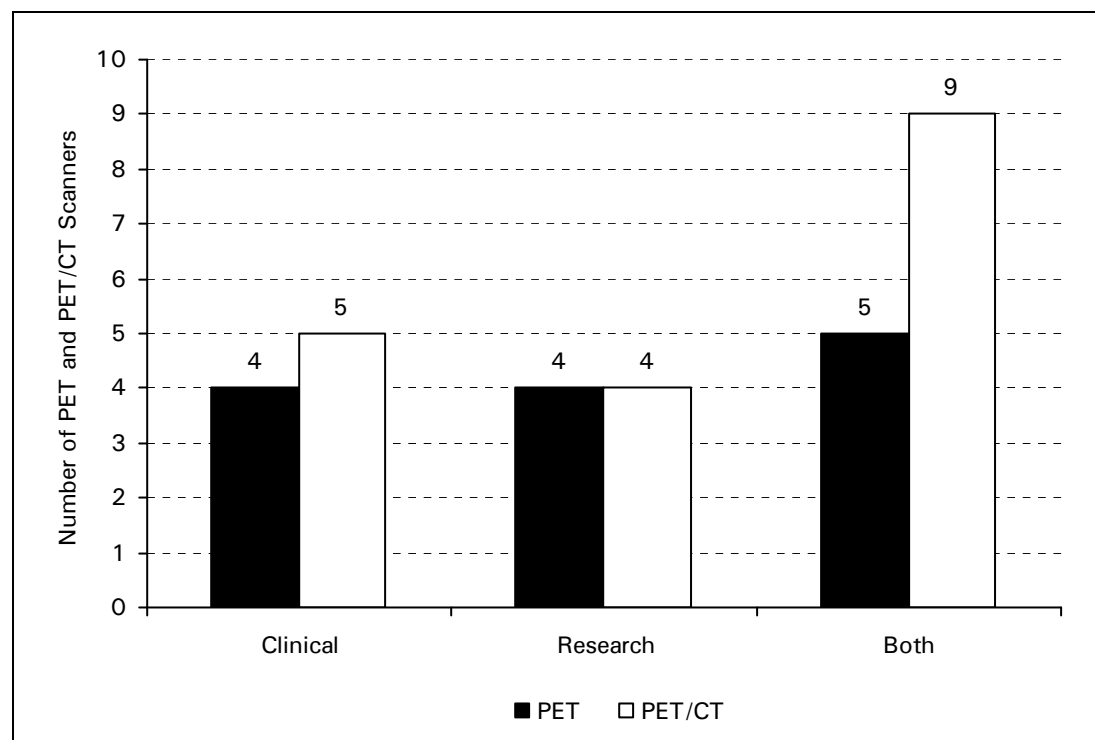
Note

Information on aperture (full body or head only) was reported for all 13 PET scanners installed and operational as of January 1, 2007. However, such information was reported for only 16 of the 18 PET/CT scanners.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure 12 Purpose of PET Scanners and PET/CT Scanners, Canada, as of January 1, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Combined Single-Photon Emission Computed Tomography and Computed Tomography

Single-photon emission computed tomography is a nuclear medicine technology introduced in the 1970s. Similarly to PET, SPECT uses radioactive tracers and a scanner to record data that a computer constructs into two- or three-dimensional images. A small amount of a radioactive drug is injected into a vein and a scanner is used to make detailed images of areas inside the body where the radioactive material is taken up by the cells. SPECT can give information about blood flow to tissues and chemical reactions (metabolism) in the body. One of the benefits of SPECT over PET is that, typically, the radiopharmaceuticals used for SPECT offer a relatively slow decay rate compared with FDG (fluorodeoxyglucose) used for PET. As a result, handling radioactive agents is simplified. A number of SPECT radiopharmaceuticals incorporate antibody and peptide formulations that can be targeted to specific tissue receptors, allowing the radiologist to differentiate between healthy and diseased tissue. While SPECT has applications in general nuclear medicine, neurology and oncology, most of the 15.8 million SPECT studies performed in the U.S. in 2004 were in cardiology. In contrast to PET, whose most important application is in oncology, where the whole-body imaging is used to identify tumours at their source and scan for metastatic disease that might be remote from the source, SPECT is more focused on organ function, such as for the heart, lungs, kidneys, gall bladder, liver and thyroid.^{60, 61}

Since its commercial introduction by GE Healthcare in 1999, the hybrid technology that combines SPECT with CT has been steadily winning converts in the U.S. There are now newer generations of SPECT/CT scanners on the market, including systems manufactured by Siemens and Philips. SPECT/CT provides the functional information from a nuclear scan with the anatomic detail of CT.^{62, 63} The latest data available indicate that 35 SPECT/CT scanners are installed in Canada. As of January 1, 2007, 16 hybrid scanners were installed and operational in Canada, excluding Ontario. Data for Ontario were unavailable as of January 1, 2007, but 19 SPECT/CT scanners were reported by the Ontario Ministry of Health and Long-Term Care as installed and in operation as of July 31, 2008.

Emerging Types of Fusion Technology

Combined Positron Emission Tomography and Magnetic Resonance Imaging

The PET/MRI scanner is a further evolution of earlier hybrid scanners, PET/CT and SPECT/CT.⁶⁴

While PET/CT and SPECT/CT acquire functional and structural images sequentially, a new PET/MRI machine developed by Siemens, which debuted in 2006, acquires MRI and PET images of the brain simultaneously for the same imaging volume, and therefore produces a higher degree of registration. Siemens' PET/MRI scanner is a non-commercially available prototype dedicated brain PET scanner that is inserted into a commercial 3-Tesla MRI scanner.⁶⁵

PET/MRI is said to be an imaging technology that brings the exceptional soft-tissue contrast and high specificity of MRI together with PET's sensitivity in assessing physiological and metabolic state. Future possibilities for the PET/MRI system include enabling physicians to make a more sound determination of both cognitive impairment and atrophy. Also, PET/MRI could be combined with new emergency neurological biomarkers, which could strengthen the assessment of the condition or, in stroke patients, the technology could enable physicians to evaluate brain tissues that could be salvaged following a stroke.^{65, 66}

Biomedical Multi-Modality Hybrid Imaging Project

The Lawson Health Research Institute and St. Joseph's Health Care, both in London, Ontario, are leading a multidisciplinary international initiative known as the Biomedical Multi-Modality Hybrid Imaging Project. A goal of the \$26.9-million research project that will involve 105 researchers, including 23 from outside Canada, is to combine diverse imaging modalities like MRI, PET and CT into a single technological platform for diagnostic use. The research team plans to investigate many leading-edge imaging technologies, including the emerging form known as photo-acoustic imaging, a hybridization of laser and ultrasound technology.⁶⁷

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Chapter 2: Imaging Technologies—Supply and Costs

The appropriate numbers and types of equipment needed to supply Canadians with medical imaging services are debated. This chapter addresses the availability of medical imaging equipment at the national level as well as among the provinces and territories. For selected modalities, the chapter also examines age and technological characteristics of the equipment, extent of connection to picture archiving and communications systems (PACS) and costs. Finally, the chapter provides some international comparisons of the supply of medical imaging technologies. The supply of equipment needs to be considered in the context of many factors, such as the proportion of imaging devices actually used to provide care, the intensity of utilization of the equipment, the number and mix of medical imaging professionals and the circumstances in which imaging technologies are utilized.

How Many Medical Imaging Devices Are There in Canada?

Many different kinds of imaging devices are used in clinical practice today, from new types of equipment that are still in development to well-established technologies. Overall, we know more about the numbers and distribution of some newer technologies than about several of the more common ones, such as X-ray and ultrasound, which were shown in Figure 1 of the preceding chapter to account for nearly 80% of all medical imaging examinations in Canadian hospitals.

CIHI's National Survey of Selected Medical Imaging Equipment, conducted in 2007, tracked nine types of imaging equipment including two types of fusion technology. As was done in the four preceding surveys, CIHI retained the services of ProMed Associates Ltd., a diagnostic imaging consulting firm headquartered in Vancouver, to coordinate the data collection. In order to obtain comprehensive coverage of all selected types of imaging equipment in Canada, ProMed Associates Ltd. contacted the presidents and CEOs of every health region in Canada and asked them to distribute the data request to managers or heads of imaging departments of hospitals within their regions. In some cases, data were submitted online by the participants, while in others, data submission was sought if the managers indicated that they had at least one of the selected types of imaging equipment. ProMed Associates Ltd. also directly contacted managers or heads of imaging departments in hospitals that were already known to have the selected types of equipment. In addition, ProMed Associates Ltd. sent data requests to managers/owners of private medical imaging clinics (also called free-standing facilities) that had been identified as having the selected types of imaging equipment. This identification was made through various means, such as ProMed's own investigations, information from imaging equipment manufacturers, associations of medical imaging professionals, Health Canada and websites of private clinics. Participants were requested to report equipment installed and operational as of January 1, 2007. The data collection was carried out between April 17, 2007, and June 30, 2007, with follow-up to mid-October. There were five hospitals and 16 private imaging clinics that were unable to complete the survey or declined to participate. The number of imaging devices in these non-reporting facilities in 2007 was imputed based on information collected in previous surveys or available from other sources such as websites of private clinics. The provincial and territorial ministries of health were also asked to validate the survey data on the number of computed tomography scanners, magnetic

resonance imaging scanners, positron emission tomography scanners and fusion technology scanners. A relatively small number of scanners that were not captured in the survey were identified through this validation process. According to the 2007 survey, supplemented by information on scanners from provincial and territorial ministries of health, the following number of imaging devices were installed and operational as of January 1, 2007, for eightⁱ selected types of imaging equipment:ⁱⁱ

- 419 CT scanners;
- 222 MRI scanners;
- 603 nuclear medicine cameras;
- 118 catheterization laboratories;
- 179 angiography suites;
- 13 PET scanners;
- 18 PET/CT scanners (fusion technology); and
- 16 SPECT/CT scanners (fusion technology) outside of Ontario as of January 1, 2007, and 19 in Ontario as of July 31, 2008.ⁱⁱⁱ

These imaging technologies were introduced into clinical practice at different times, and their adoption rates vary. For example, the number of CT and MRI scanners has grown significantly but at different pace since they were introduced in Canada (in 1973 and 1982, respectively). Figure 13 shows that in 1990, 17 years after their introduction, there were 198 CT scanners installed in Canada. By 2007, the number of CT scanners had reached 419, more than double the number in 1990. MRI scanners were introduced at a later date and their number was 19 in 1990. By 2007, 222 MRI scanners were installed, more than 10 times the number of scanners in 1990. There was a particularly high rate of installation of MRI scanners in the period from 1997 to 2001, when 75 MRI scanners were installed compared with only 58 CT scanners. From 2001 to 2006, more CT scanners (116) than MRI scanners (92) were installed.

-
- i. The count of bone mineral densitometers reported in the National Survey of Selected Medical Imaging Equipment is not shown in this report as it does not include units in hospitals and free-standing facilities that were not surveyed for bone mineral densitometers because they did not have any of the other eight types of selected medical imaging equipment.
- ii. For more information on the survey process and coverage and data limitations, see the Methodological Notes in Appendix B.
- iii. Data for Ontario were unavailable as of January 1, 2007, but 19 SPECT/CT scanners were reported by the Ontario Ministry of Health and Long-Term Care as installed and operational in Ontario hospitals as of July 31, 2008.

About the National Survey of Selected Medical Imaging Equipment

Over a period of many years, the Canadian Coordinating Office for Health Technology Assessment (CCOHTA), renamed the Canadian Agency for Drugs and Technology in Health in April 2006, conducted surveys on the number, distribution and key characteristics of selected imaging technologies in Canadian hospitals. Following discussions with CCOHTA, CIHI has conducted similar surveys since 2003. Basic information on the CIHI surveys is provided below. For more information, see CIHI's website at www.cihi.ca.

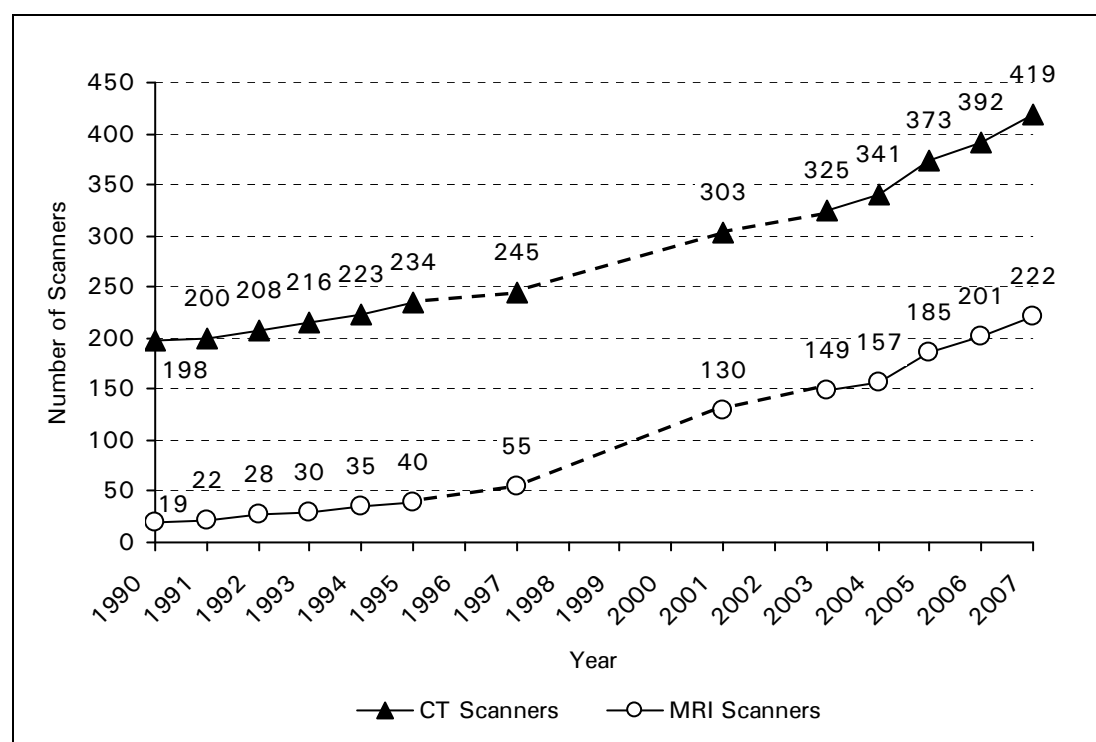
What's Included: The CIHI annual surveys from 2003 to 2007 tracked data on medical imaging equipment installed and operational in Canadian hospitals and free-standing imaging facilities (sometimes also called "non-hospital," "community-based" and/or "private" facilities) as of January 1 of each year. The imaging equipment covered by the 2003, 2004 and 2005 surveys (angiography suites, catheterization labs, CT scanners, MRI scanners, nuclear medicine cameras and PET scanners) was the same as that surveyed by CCOHTA in 2001. The 2006 and 2007 surveys also covered the same type of imaging equipment, but two types of fusion technology (PET/CT and SPECT/CT) were added and information was requested on bone mineral densitometers (previously listed under nuclear medicine). PET/CT scanners were identified separately from PET and CT scanners back to 2002, the first year in which they were installed in Canada, based on the year of installation reported in the 2006 survey, when they were first recorded separately. This fusion technology combines functional and anatomical imaging from PET and CT in the same display. Data were also collected on another type of fusion technology, SPECT/CT (recorded separately from nuclear medicine for the first time in the 2006 survey).

The Survey Process: In 2003, CIHI retained the services of ProMed Associates Ltd. to coordinate the annual collection of data. ProMed contacted health regions and hospitals and relevant free-standing imaging facilities across Canada. Various medical and technical organizations, and provincial and territorial ministries of health, were asked to encourage participation in the voluntary survey. Most respondents completed the survey through a bilingual website. To maximize response rates, ProMed Associates Ltd. completed numerous rounds of follow-up with respondents. For the 2007 survey, the data collection was carried out between April 17, 2007, and June 30, 2007, with follow-up to mid-October. At that time, 513 (96.1%) of the 534 known facilities had submitted their data, but there were five hospitals and 16 private facilities that had been unable to complete the survey or declined to participate. The number of imaging devices in these non-reporting facilities was imputed based on information collected in previous surveys. The number of medical imaging devices so imputed accounted for 3.2% of all imaging devices for the selected types of imaging equipment.

Validating the Results: To ensure that the coverage was as complete as possible, responses to the 2007 survey were cross-checked against results from CIHI's 2006 survey, lists from medical imaging technology manufacturers when provided, published lists of equipment (for example, research reports and health directories), through discussions with health associations and data reported by hospitals and health regions to CIHI's Canadian MIS Database.

In addition, ProMed Associates Ltd. reviewed information submitted and contacted participants for follow-up where required.

The provincial and territorial ministries of health were also asked to validate the survey data on the number of computed tomography scanners, magnetic resonance imaging scanners, positron emission tomography scanners and fusion technology scanners. A relatively small number of scanners that were not captured in the survey were identified through this validation process. For the list of these scanners, see Table B.2 in Appendix B.

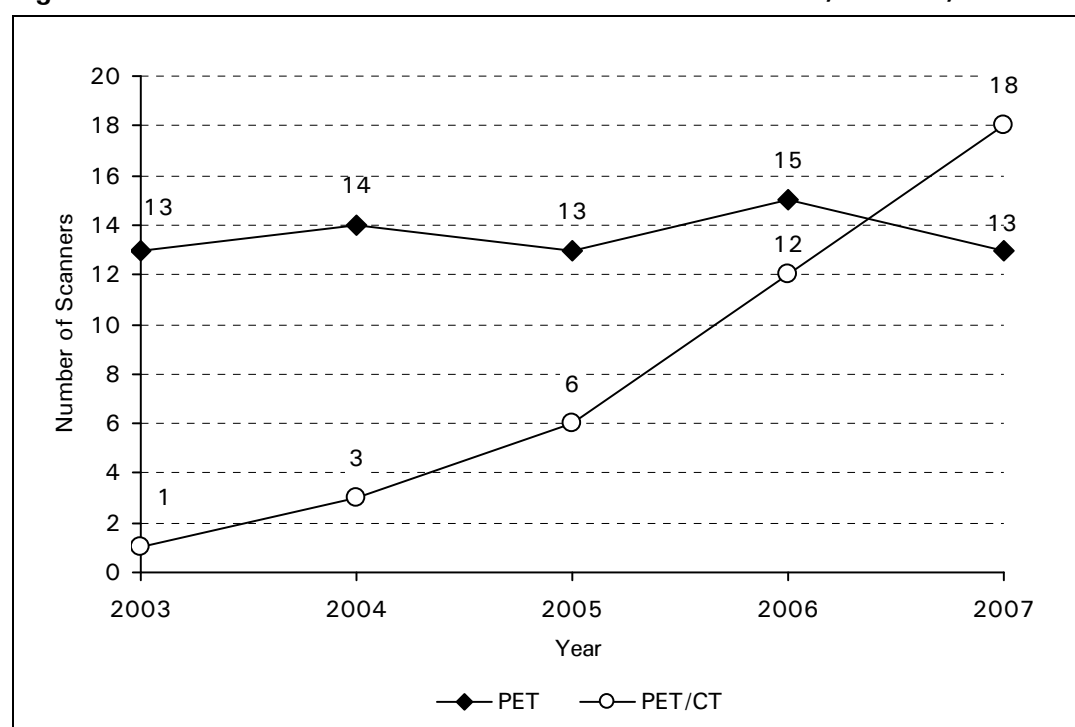
Figure 13 Number of MRI and CT Scanners, Canada, 1990 to 2007**Notes**

- The numbers of MRI and CT scanners in free-standing imaging facilities were imputed for years prior to 2003 based on data collected in the 2003 National Survey of Selected Medical Imaging Equipment.
- Inventories were not conducted annually. A dotted line is drawn between data points spanning two years or more.
- Quebec data were incomplete for 2000; therefore, all 2000 data are excluded.
- Includes scanners used for diagnostic or therapeutic purposes (for example, cancer treatment planning) and for research.

Sources

OECD Health Data 2007, OECD (for 1990); National Inventory of Selected Imaging Equipment, Canadian Coordinating Office for Health Technology Assessment (for the years 1991 to 2001); National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information from provincial ministries of health (for the years 2003 to 2007).

PET, a type of nuclear medicine most commonly used to detect cancerous tumours, some brain disorders and diseases of the heart and other organs by creating images that measure biochemical processes in the body, has been adopted slowly as a clinical tool relative to other imaging modalities, such as CT and MRI. However, the new hybrid technology of PET/CT, which allows one test to provide both a functional and structural image, is gaining faster acceptance than PET on its own. Figure 14 shows that more PET/CT scanners than PET scanners were installed in recent years.

Figure 14 Number of PET Scanners and PET/CT Scanners, Canada, 2003 to 2007**Notes**

- PET/CT scanners were identified separately from PET and CT for the first time in the 2006 National Survey of Selected Medical Imaging Equipment. The number of PET/CT scanners for years prior to 2006 was imputed based on the year of installation indicated in the 2006 survey.
- Includes scanners used for clinical purposes and for research.

Source

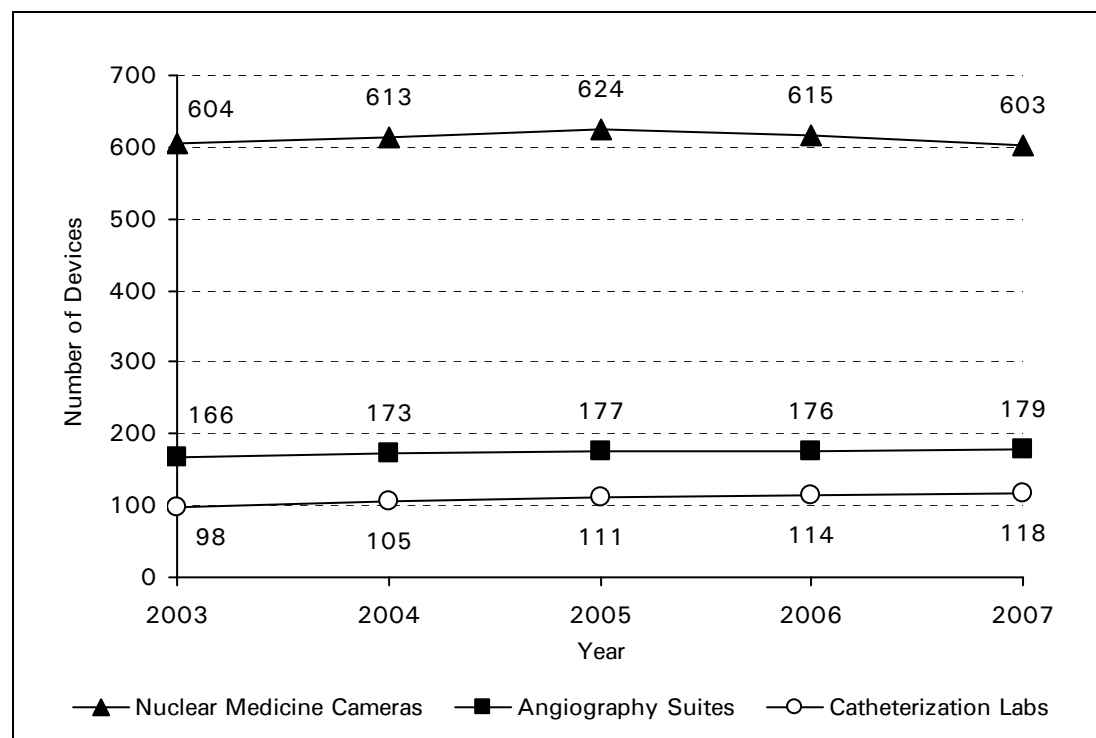
National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information from provincial ministries of health (for the years 2006 and 2007).

While PET/CT is gaining clinical acceptance, another hybrid technology (SPECT/CT) that combines single-photon emission computed tomography with computed tomography is just starting to be adopted in Canada. This technology was first commercialized in 1999 but the improved diagnostic quality of the newer generations of hybrid scanners makes it more attractive. Similarly to PET/CT, it combined functional metabolic imaging with CT anatomical imaging. However, in SPECT, different radioactive materials are used that emit a single photon rather than a positron as in PET. As of January 1, 2007, only 16 SPECT/CT scanners were reported as installed and operational in Canada, excluding Ontario. Data for Ontario were unavailable as of January 1, 2007, but 19 SPECT/CT scanners were reported by the Ontario Ministry of Health and Long-Term Care as installed and in operation as of July 31, 2008 (see Appendix A, Table A.7).

Other types of equipment tracked by the National Survey of Selected Medical Imaging Equipment include nuclear medicine cameras, angiography suites and catheterization laboratories.

Figure 15 shows that the number of nuclear medicine cameras in Canada, by far the most numerous type of equipment included in the national survey remained relatively unchanged at around 600 over the period from 2003 to 2007. The number of angiography suites increased from 166 in 2003 to 179 in 2007. The number of catheterization laboratories increased in each year, from 98 in 2003 to 118 in 2007.

Figure 15 Number of Nuclear Medicine Cameras, Angiography Suites and Catheterization Laboratories, Canada, 2003 to 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

What accounts for the variations in the speed with which different innovative technologies are adopted and diffused? A number of factors may be involved, including the functional capability of the innovation, usefulness and cost of the new equipment, practice patterns, health policies, funding mechanisms and attitudes toward new technologies.^{1, 2, 3}

The Supply per Million Population and Distribution of Imaging Technologies Among the Provinces and Territories

Most Canadians receive imaging services in the province or territory where they live, although some travel within their jurisdiction or to other parts of the country for care. All provinces now have nuclear medicine cameras, CT scanners and MRI machines, as well as other imaging technologies, such as X-ray and ultrasound services. Table 1 reports the numbers of medical imaging devices per million population in the provinces and territories by type of technology as of January 1, 2007.

Table 1 Number of Devices and Number of Devices per Million Population (Rate) of Selected Imaging Technologies, by Jurisdiction, as of January 1, 2007

Jurisdiction	Nuclear Medicine Cameras		CT Scanners		Angiography Suites		MRI Scanners	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate
N.L.	11	21.6	11	21.6	3	5.9	3	5.9
P.E.I.	2	14.5	2	14.5	-	-	1	7.2
N.S.	23	24.6	16	17.1	5	5.4	6	6.4
N.B.	17	22.7	15	20.0	9	12.0	5	6.7
Que.	152	19.8	119	15.5	42	5.5	67	8.7
Ont.	250	19.6	130	10.2	74	5.8	72	5.7
Man.	16	13.6	19	16.1	5	4.2	8	6.8
Sask.	13	13.1	15	15.2	5	5.1	4	4.0
Alta.	57	16.6	41	12.0	15	4.4	27	7.9
B.C.	62	14.3	49	11.3	21	4.8	29	6.7
Y.T.	-	-	1	32.3	-	-	-	-
N.W.T.	-	-	1	23.6	-	-	-	-
Nun.	-	-	-	-	-	-	-	-
Canada	603	18.4	419	12.8	179	5.5	222	6.8
Jurisdiction	Catheterization Laboratories		PET Scanners		Fusion Tech. PET/CT Scanners		Fusion Tech. SPECT/CT Scanners	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate
N.L.	2	3.9	-	-	-	-	-	-
P.E.I.	-	-	-	-	-	-	-	-
N.S.	5	5.4	-	-	-	-	-	-
N.B.	3	4.0	-	-	1	1.3	1	1.3
Que.	26	3.4	4	0.5	7	0.9	9	1.2
Ont.	50	3.9	5	0.4	7	0.6	19*	1.5*
Man.	5	4.2	1	0.9	-	-	-	-
Sask.	4	4.0	-	-	-	-	3	3.0
Alta.	11	3.2	1	0.3	2	0.6	-	-
B.C.	12	2.8	2	0.5	1	0.2	3	0.7
Y.T.	-	-	-	-	-	-	-	-
N.W.T.	-	-	-	-	-	-	-	-
Nun.	-	-	-	-	-	-	-	-
Canada	118	3.6	13	0.4	18	0.5	35*	1.6*

Notes

- * Ontario data are as of July 31, 2008. Since no data on SPECT/CT scanners were reported for Ontario in the 2007 survey, the number of SPECT/CT scanners confirmed by the Ontario Ministry of Health and Long-Term Care as installed and operational in Ontario hospitals as of July 31, 2008, is included here, instead.
- a) - Not applicable.
- b) Includes medical imaging equipment in both hospitals and free-standing facilities.
- c) Includes imputation for 21 non-reporting facilities based on information collected in previous surveys: New Brunswick (1); Quebec (14); Ontario (1); Alberta (4); B.C. (1).
- d) Includes CT scanners used exclusively for cancer treatment: New Brunswick (2); Ontario (5); Manitoba (1); Saskatchewan (2); Alberta (3) and for research: Nova Scotia (1); Quebec (1); Ontario (4); B.C. (1).
- e) Includes MRI scanners used exclusively for research: Quebec (1); Ontario (4); Alberta (1); B.C. (1).
- f) Includes PET scanners used exclusively for research: Ontario (3); B.C. (1).
- g) Includes PET/CT scanners used exclusively for research: Quebec (1); Ontario (3).
- h) The number of scanners in Ontario and British Columbia is an estimation.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, 2007, supplemented by information on number of scanners from provincial ministries of health.

Numbers of units per million population vary across the country. For example, Table 1 indicates that as of January 1, 2007, Ontario, with the largest population among the jurisdictions, had the largest number of CT scanners (130). Yet it had the fewest CT machines per million population (10.2). In contrast, with one CT scanner, the Yukon Territory has the highest ratio (32.2).

In some cases, it is also helpful to consider the mix of equipment available in a jurisdiction. For example, although the capabilities of MRIs and CTs differ for specific applications, there are areas where the modalities overlap.^{iv} As a result, some suggest that a high availability of CT services might reduce the acquisition of MRIs.⁴ Interestingly, Table 1 reports that Newfoundland and Labrador, the province with the highest number of CTs per million population (21.6), has the third-lowest rate of MRIs (5.9). On the other hand, Alberta has the highest number of MRIs per million population (7.9) but fewer CTs (12.0) than most jurisdictions.

Table 2 provides data comparing the ratio of MRIs to CTs. As of January 1, 2007, there was one MRI for every 1.9 CTs in Canada. Saskatchewan had the lowest ratio of MRIs to CTs (1:3.8), while Alberta had the highest ratio, with one MRI scanner for every 1.5 CTs.

Table 2 Ratios of MRIs to CTs in Hospitals and Free-Standing Imaging Facilities, by Jurisdiction and Canada, as of January 1, 2007

Jurisdiction	MRI:CT Ratio
N.L.	1:3.7
P.E.I.	1:2.0
N.S.	1:2.7
N.B.	1:3.0
Que.	1:1.8
Ont.	1:1.8
Man.	1:2.4
Sask.	1:3.8
Alta.	1:1.5
B.C.	1:1.7
Y.T.	-
N.W.T.	-
Nun.	-
Canada	1:1.9

Note

- Not applicable.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, 2007, supplemented by information from provincial ministries of health.

iv. See section The Right Tool for the Right Job in Chapter 1 for a discussion of the respective benefits, risks and limitations of scanning of the head by CT and MRI, an area where the two modalities overlap.

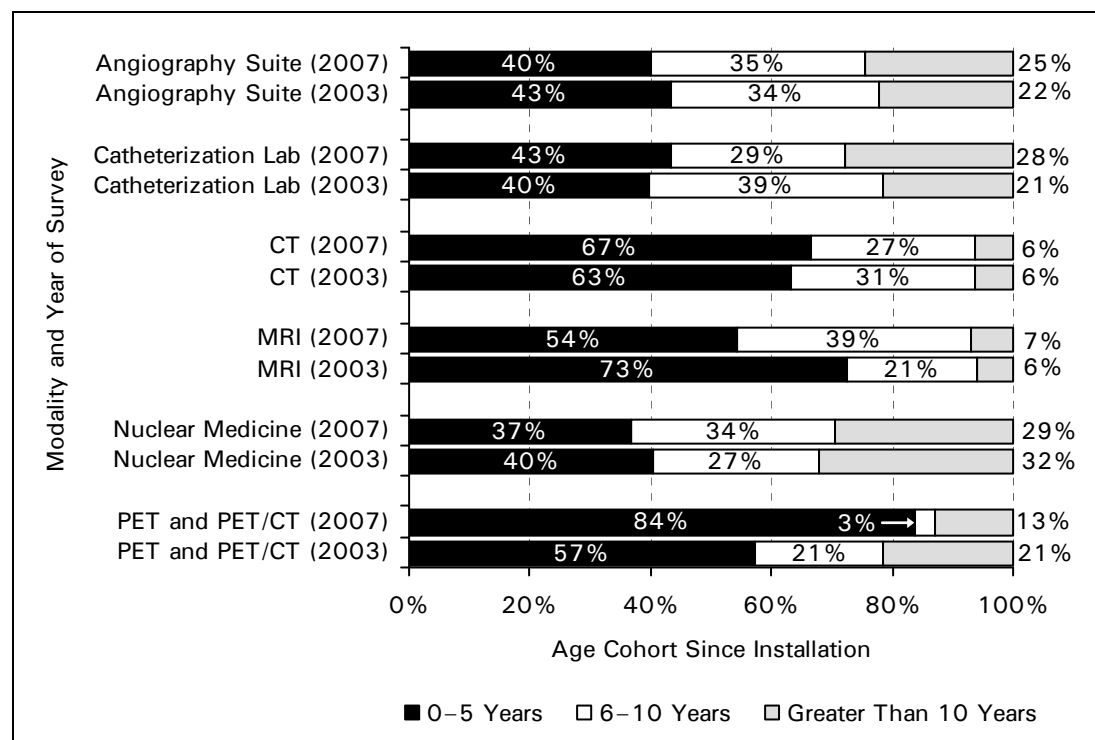
Age of Equipment and Technological Characteristics Within Each Modality

The age of Canada's medical imaging equipment varies considerably across the selected modalities (Figure 16). For the expensive high-end imaging modalities, such as CT, MRI and PET and PET/CT, most of the equipment was installed between 2001 and 2006. This is a possible indication of the increasing use and acceptance of these technologies in the health sector. Also, PET/CT is a new technology that was introduced in Canada as recently as 2002. The survey reports that, while around 40% of equipment for angiography, catheterization and nuclear medicine was five years old or less at the beginning of 2007, 54% of MRIs, 67% of CTs and 84% of PETs and PET/CTs were in this age cohort.

The proportion of equipment in the 0-to-5-year age cohort increased for three modalities between 2003 and 2007, while it decreased for the other three. The increase was very substantial for PETs and PET/CTs (27 percentage points), but more moderate for catheterization laboratories and CTs (three or four percentage points). By contrast, the proportion of equipment for angiography and nuclear medicine decreased by three percentage points. Although more MRI scanners were installed in 2007 than in 2003, the proportion of MRIs in the 0-to-5-year age cohort decreased by 19 percentage points, whereas there was an increase of similar magnitude in the 6-to-10-year age cohort. This is explained by the particularly high rate of installation of MRI scanners in the period from 1997 to 2003, when 94 scanners were installed. Most of these scanners appeared in the 0-to-5-year age cohort in the 2003 survey. However, by 2007, they had moved to the 6-to-10-year age cohort.

Nuclear medicine and catheterization laboratories had the highest proportions of equipment older than 10 years, in both 2003 and 2007 (between 21% and 32%, depending on the year). In both years, CT and MRI were the two modalities with the lowest proportion of equipment older than 10 years (6% and 7%, respectively).

Figure 16 Distribution of Selected Medical Imaging Equipment, by Age Cohort Since Installation, 2003 and 2007, Canada



Note

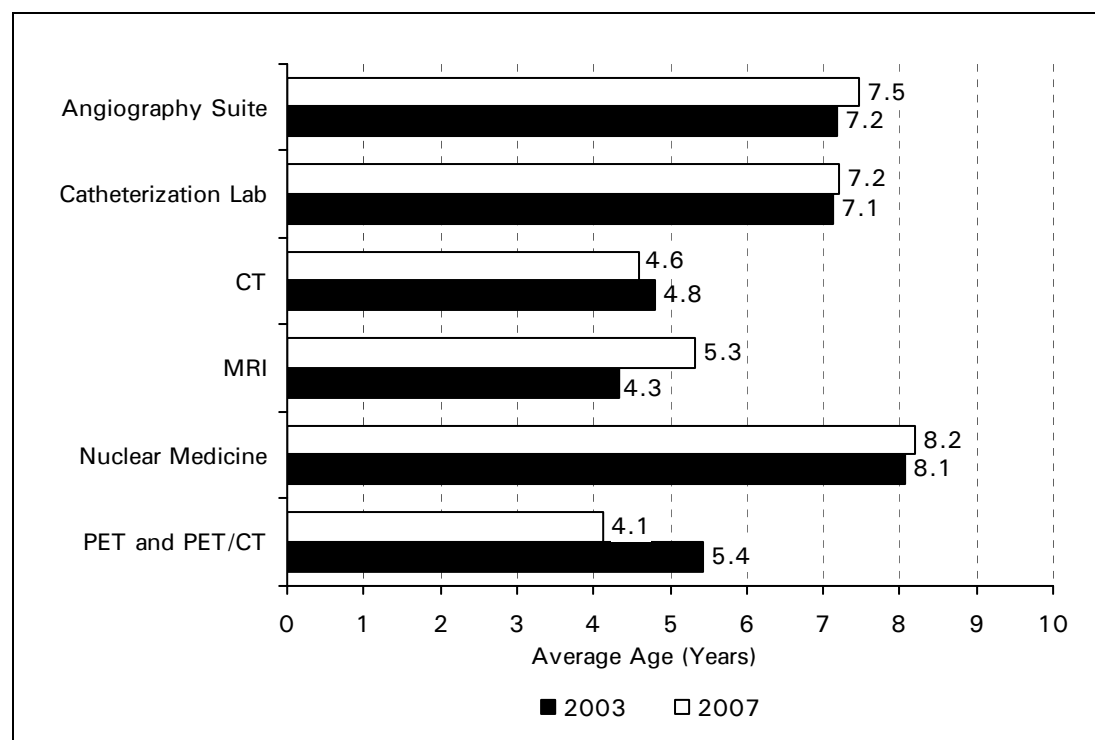
Age cohorts are calculated based on the year of the survey minus the year of equipment installation. Some components of the equipment might have been upgraded since installation, but information on the date or type of upgrades is not collected in the survey.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information on scanners from provincial ministries of health.

Between 2003 and 2007, the average age of equipment increased slightly for angiography suite, catheterization laboratories and nuclear medicine (by 0.1 to 0.3 years) and more substantially for MRI (by 1 year). It diminished slightly for CT (by 0.2 years) and decreased by 1.3 years for PET and PET/CT (Figure 17).

Figure 17 Average Age of Selected Medical Imaging Equipment, 2003 and 2007, Canada



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information on scanners from provincial ministries of health.

The age of equipment may matter for a number of reasons. According to the Canadian Association of Radiologists, outdated equipment may carry a higher risk of failure or breakdown, which may disrupt imaging services.⁵ Furthermore, the association suggests that it may be more difficult to obtain spare parts for older equipment, that there may be cost implications (that is, maintenance fees) involved when updating older equipment and that older units may produce poorer-quality images. At the same time, upgrading or replacing equipment can be costly, both in terms of capital costs and for other reasons, such as retraining staff.

The Canadian Association of Radiologists indicates that the useful life of medical imaging equipment varies by modality and recommends the following lifecycle:⁵

- Angiography: 7 years
- CT: 8 years
- MRI: 6 years
- Nuclear medicine: 10 years

The European Coordination Committee of the Radiological and Electromedical Industries recommends that at least 60% of the installed equipment base be 5 years old or younger, that no more than 30% be between 6 and 10 years old and that no more than 10% be older than 10 years (Table 3).

Table 3 Rules for the Evaluation of Medical Equipment

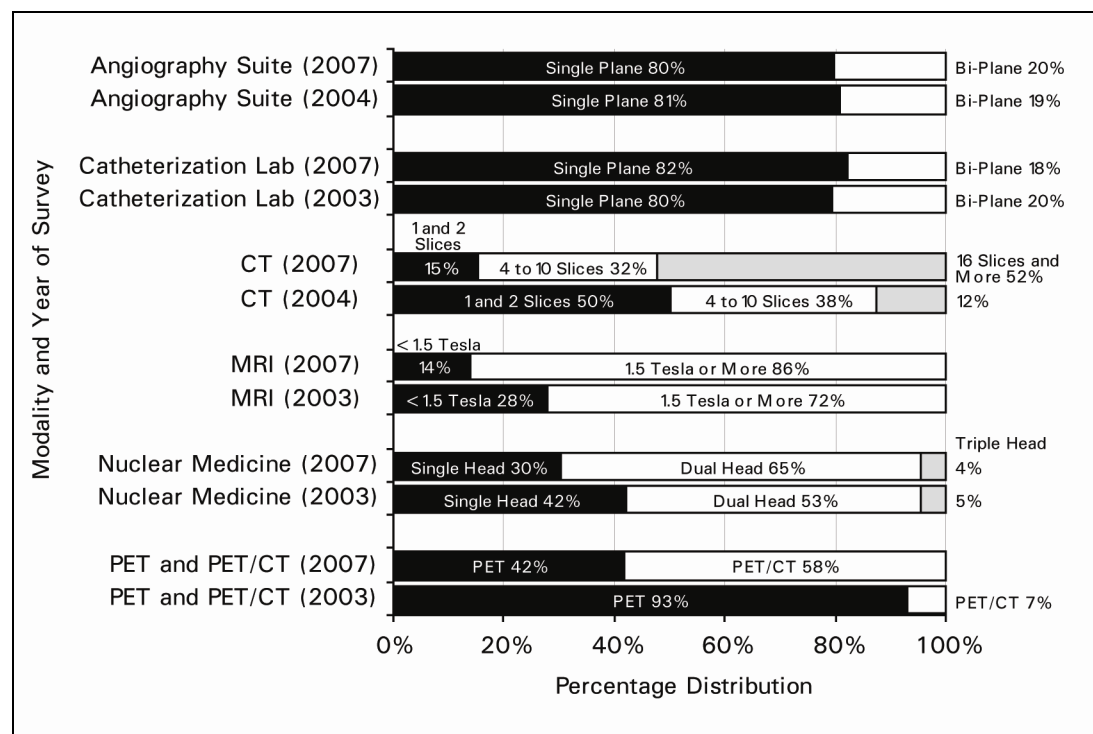
Age of Equipment	Rules
Up to 5 Years Old	<ul style="list-style-type: none"> • Reflects current state of technology • Offers economic and reasonable upgrade measures • At least 60% of the installed equipment base should be younger than 5 years
6 to 10 Years Old	<ul style="list-style-type: none"> • Still fit for use but requires replacement strategies to be developed • Not more than 30% of the installed equipment base should be between 6 and 10 years old
Older Than 10 Years	<ul style="list-style-type: none"> • No longer state-of-the-art technology • Not more than 10% of the installed base can be tolerated to be older than 10 years • Replacement is essential

Source

European Coordination Committee of the Radiological and Electromedical Industries (reproduced from the *MRI and CT Expert Panel Phase I Report*, Ontario Ministry of Health and Long-Term Care, April 2005).

Figure 18 shows that the technological characteristics of the equipment had changed in 2007 relative to 2003 or 2004 for CT and nuclear medicine. In 2007, these two modalities included a larger share of equipment at the higher end of the technology than three or four years before. Also, in 2007, PET/CTs accounted for 58% of total PET and PET/CT scanners, compared with only 7% in 2003.

Figure 18 Distribution of Selected Medical Imaging Equipment, by Technological Characteristics, 2003 (or 2004) and 2007, Canada



Note

Data on the number of slices of CT scanners and the number of heads of nuclear medicine cameras were first collected in the 2004 survey.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

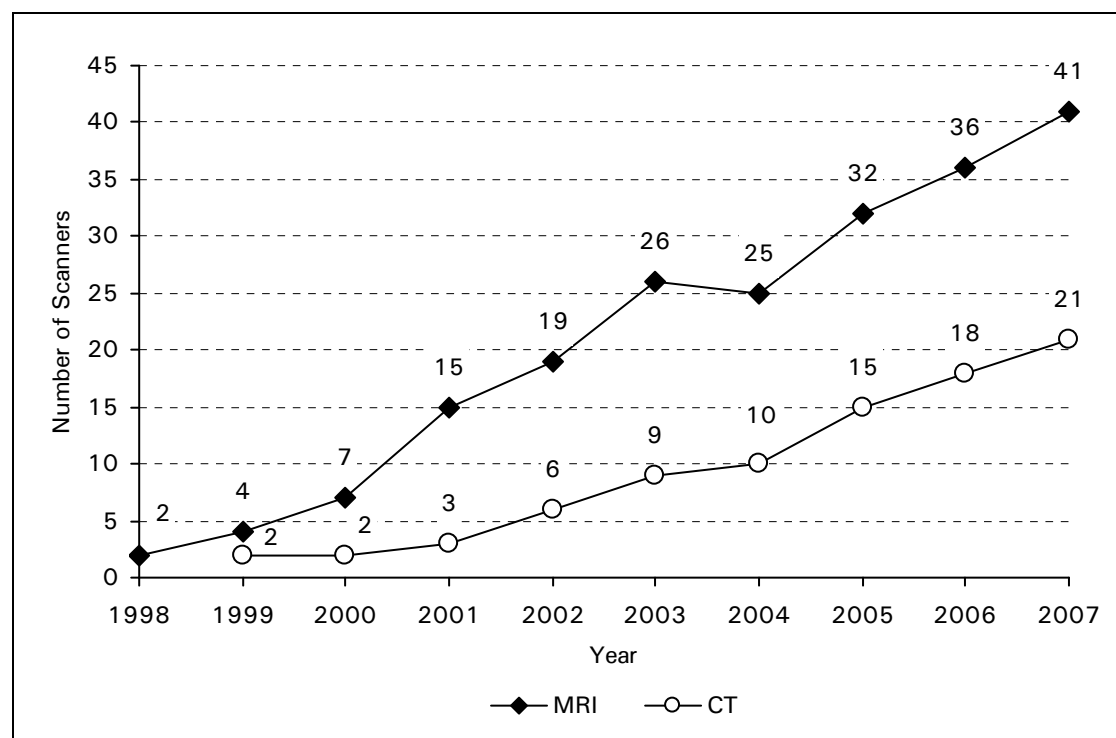
Where Imaging Technologies Are Located

Hospitals typically offer a range of medical imaging services, but some types of imaging are also available elsewhere. For example, in Canada there is a well-established practice of free-standing facilities offering X-ray and ultrasound services.

The extent to which imaging services are available outside of hospitals varies by imaging technology. Services such as CT and MRI, for instance, tend to be located in densely populated areas and are generally found in teaching and large community hospitals. However, in the 10 years or so before 2007, these services have been increasingly found in free-standing (or non-hospital) imaging facilities. Figure 19 shows that the number of MRIs in free-standing (or non-hospital) imaging facilities grew from 2 in 1998 to 41 in 2007. The number of CT scanners in free-standing facilities increased from 2 in 2000 to

21 in 2007. As of January 2007, about 5% of CTs and 18% of MRIs were in free-standing facilities (for locations of selected imaging technology equipment across Canada, see Appendix A, Table A.7).

Figure 19 Number of MRI and CT Scanners in Free-Standing Imaging Facilities, Canada, 1998 to 2007



Note

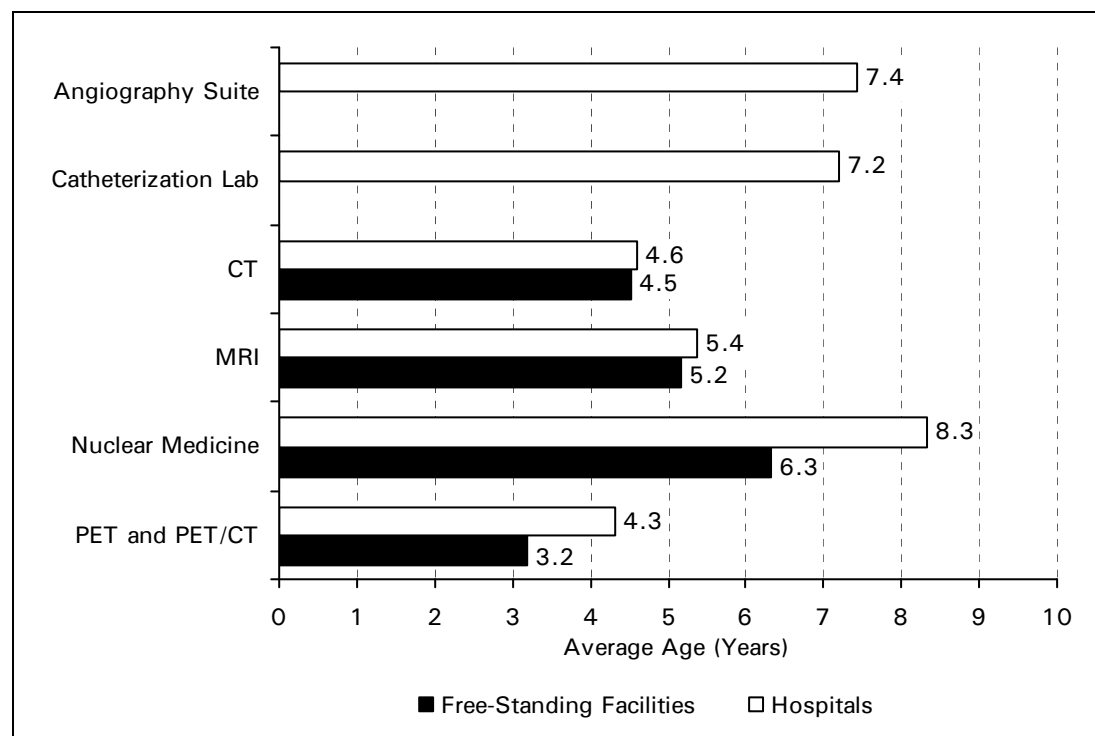
The number of MRI scanners in free-standing facilities does not include the MRI scanner that started operation in November 2005 at the Pan Am Community Clinic in Manitoba. Although located in the community and not in a hospital, this publicly funded scanner is counted with other publicly funded scanners in hospitals.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information from provincial ministries of health.

Figure 20 indicates that the average age of medical imaging equipment varies across modalities, but also sometimes between hospitals and free-standing facilities for the same modality. Hospitals and free-standing facilities have similar average ages of equipment for CT and MRI, while free-standing facilities have younger equipment for nuclear medicine and PET and PET/CT.

Figure 20 Average Age of Selected Medical Imaging Equipment, Hospitals and Free-Standing Facilities, Canada, as of January 1, 2007



Notes

- Catheterization laboratories are found only in hospitals. There is only one free-standing facility with an angiography suite (not shown in Figure 20).
- Free-standing facilities do not include the MRI scanner at the Pan Am Community Clinic in Manitoba. Although located in the community and not in a hospital, this publicly funded scanner is included with other publicly funded scanners in hospitals.

Source

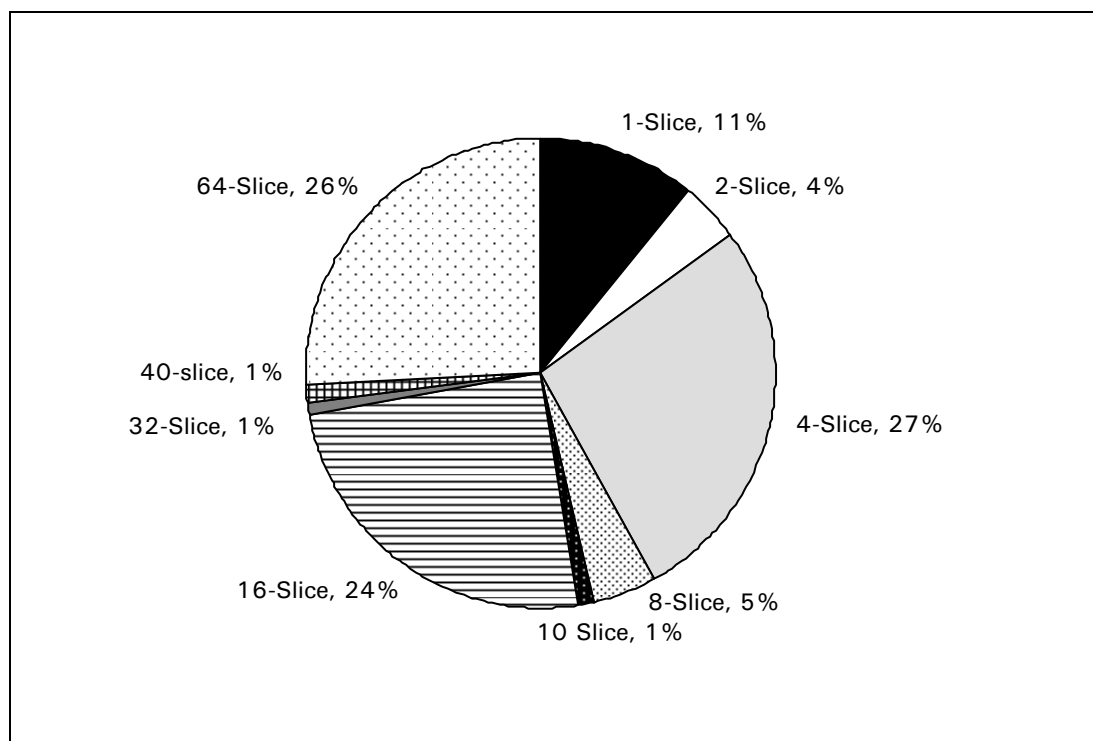
National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information on scanners from provincial ministries of health.

Figures 21 to 26 show that for the same modality, equipment in hospitals and free-standing facilities may have different technological characteristics, such as number of slices of CTs, field strength (Tesla) of MRIs^v and number of heads of nuclear medicine cameras. A higher proportion of CT scanners in hospitals than in free-standing facilities have 16 slices or more, while 1-slice scanners account for a higher proportion of scanners in free-standing facilities. Similarly, a greater percentage of MRI scanners in hospitals than in free-standing facilities have a magnetic field strength of 1.5 Tesla or more. In hospitals,

v. See the sections Computed Tomography and Magnetic Resonance Imaging in Chapter 1 for a discussion of technological characteristics of CT and MRI scanners.

62% of the nuclear medicine cameras have two or three heads, while in free-standing facilities one head is by far the predominant configuration (83%). A two-head camera can acquire information simultaneously on two planes in much less time than a single-head camera would take to acquire the same information sequentially. A two-head or a three-head camera has improved performance and can also be used in more applications than a single-head camera.

Figure 21 Distribution of CT Scanners in Hospitals, by Slice, Canada, as of January 1, 2007



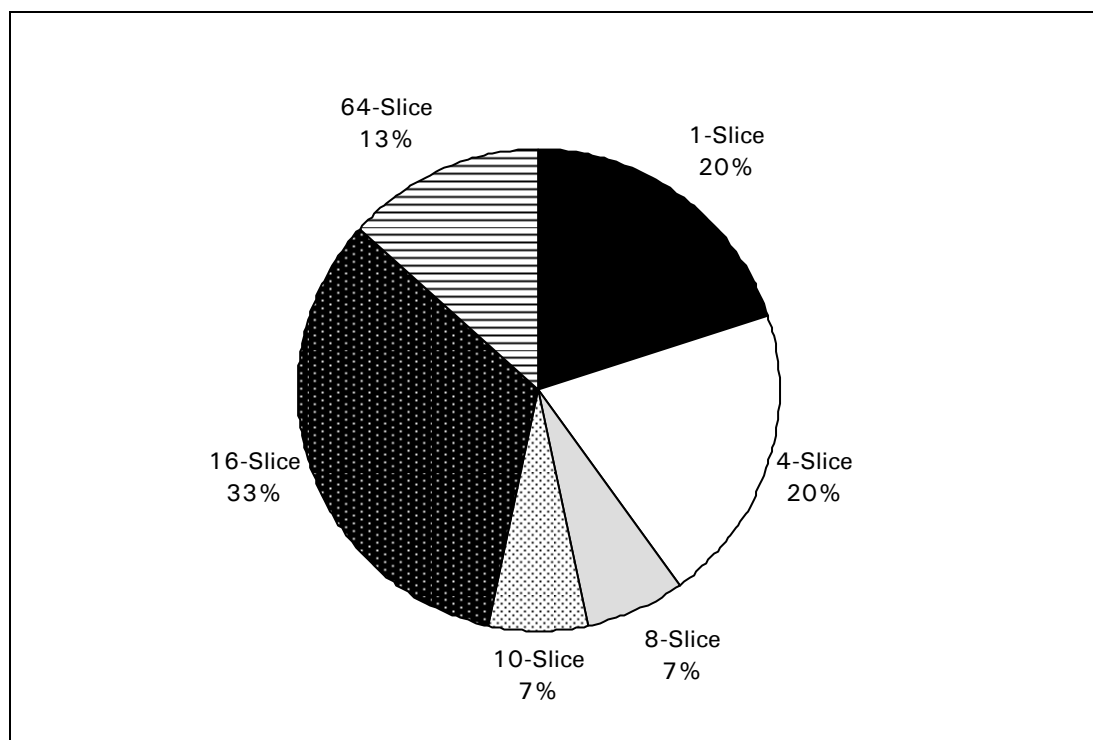
Note

As of January 1, 2007, there were 398 CT scanners installed and operational in hospitals, but the number of slices was reported for only 359 scanners.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure 22 Distribution of CT Scanners in Free-Standing Facilities, by Slice, Canada, as of January 1, 2007



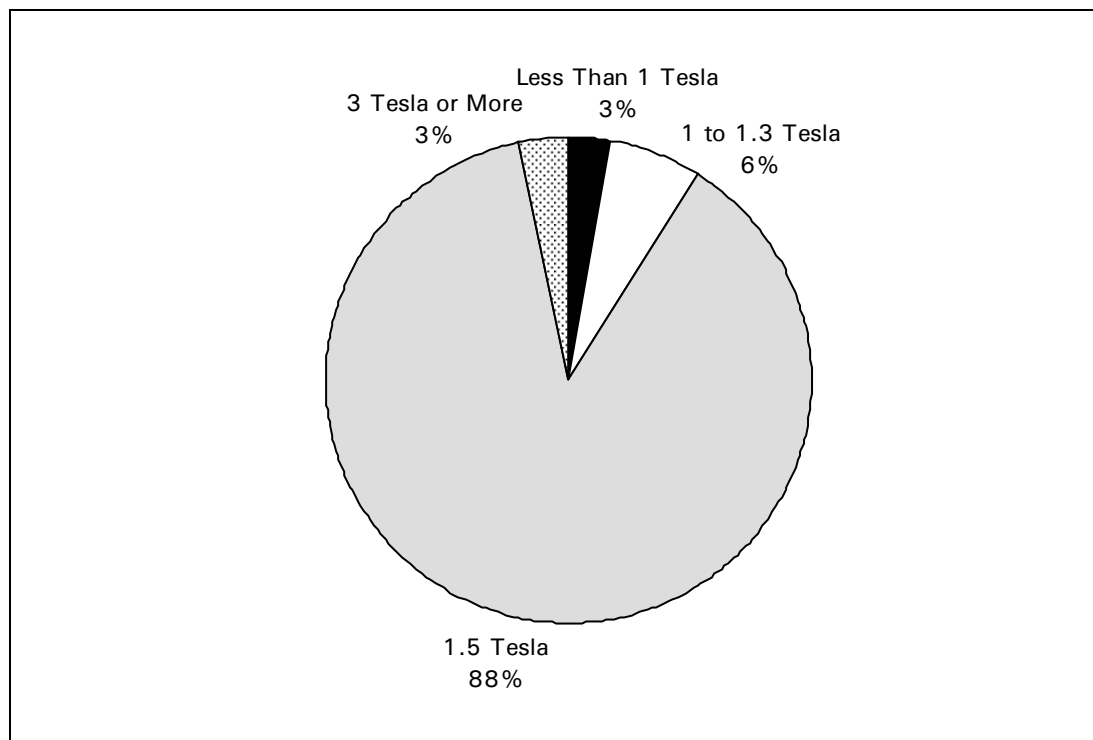
Note

As of January 1, 2007, there were 21 CT scanners installed and operational in free-standing facilities, but the number of slices was reported for only 15 scanners.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure 23 **Distribution of MRI Scanners in Hospitals, by Field Strength, Canada, as of January 1, 2007**



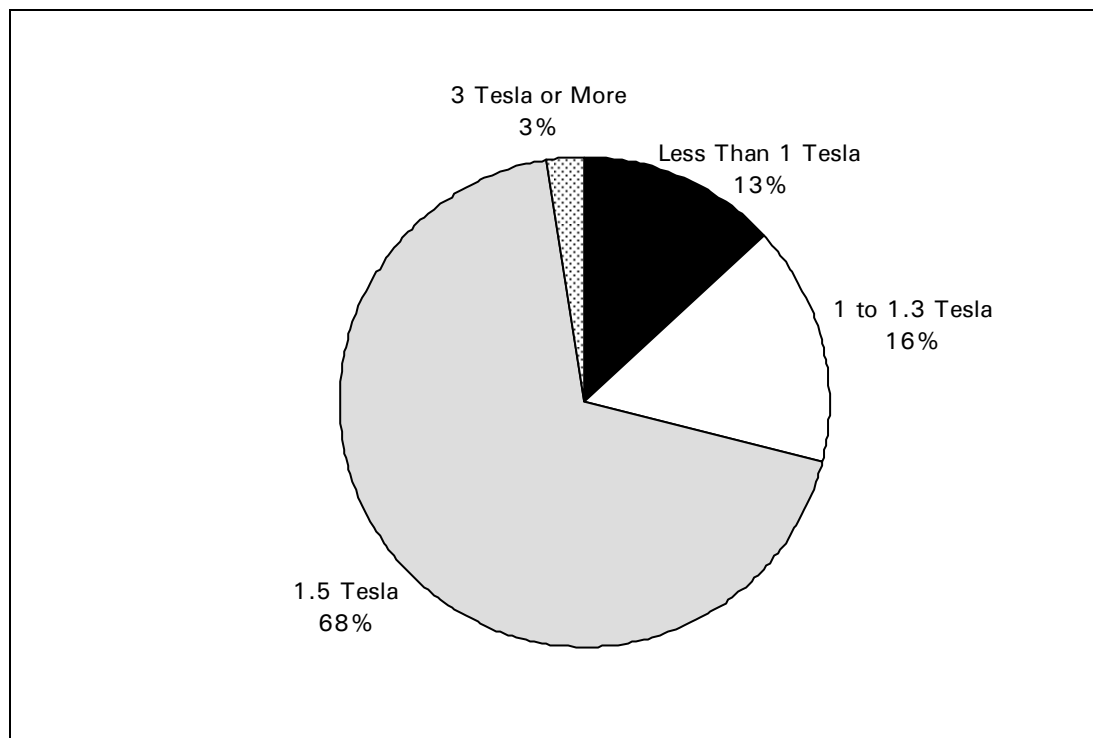
Note

The distribution in Figure 23 pertains to all 181 MRI scanners installed and operational in hospitals as of January 1, 2007.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure 24 Distribution of MRI Scanners in Free-Standing Facilities, by Field Strength, Canada, as of January 1, 2007



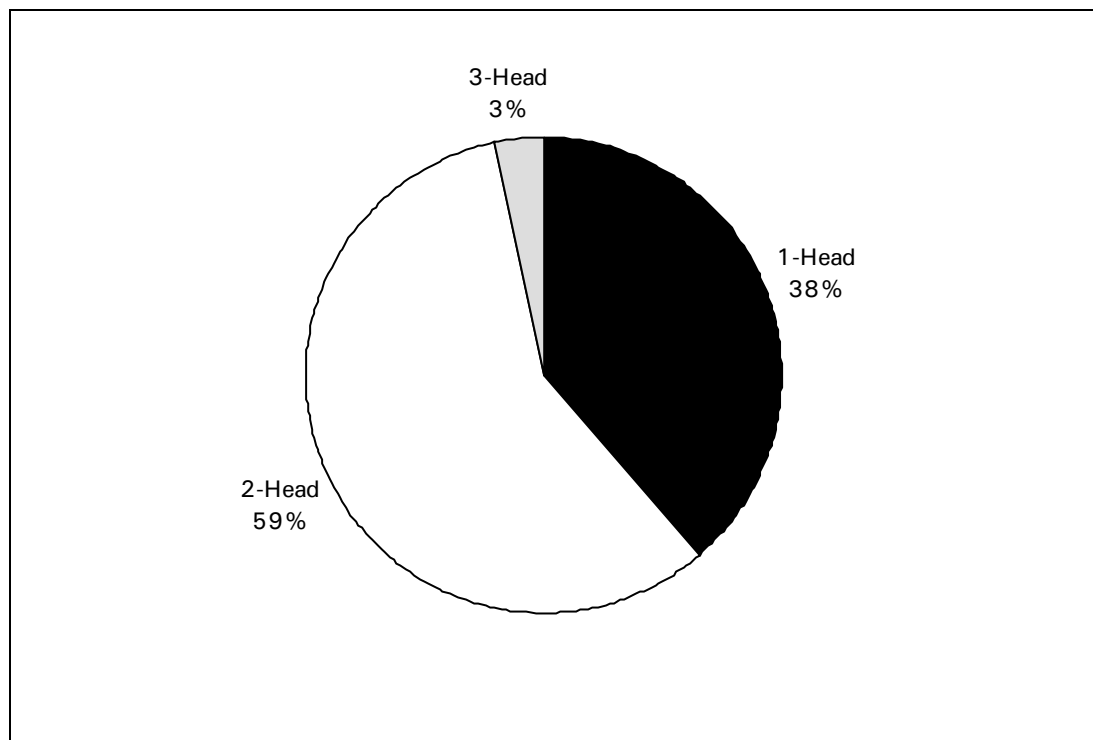
Notes

- a) Free-standing facilities do not include the MRI scanner at the Pan Am Community Clinic in Manitoba. Although located in the community and not in a hospital, this publicly funded scanner is included with other publicly funded scanners in hospitals.
- b) As of January 1, 2007, there were 41 MRI scanners installed and operational in free-standing facilities, but field strength was reported for only 38 scanners.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

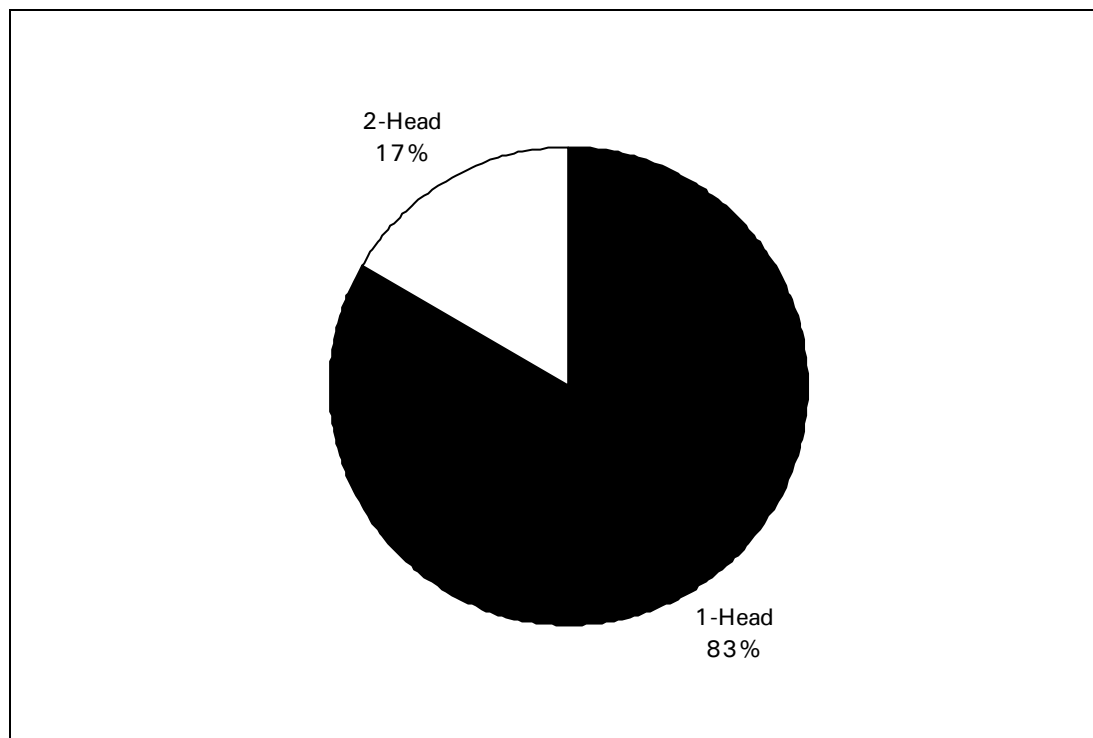
Figure 25 Distribution of Gamma Cameras in Hospitals, by Number of Heads, Canada, as of January 1, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure 26 Distribution of Gamma Cameras in Free-Standing Facilities, by Number of Heads, Canada, as of January 1, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

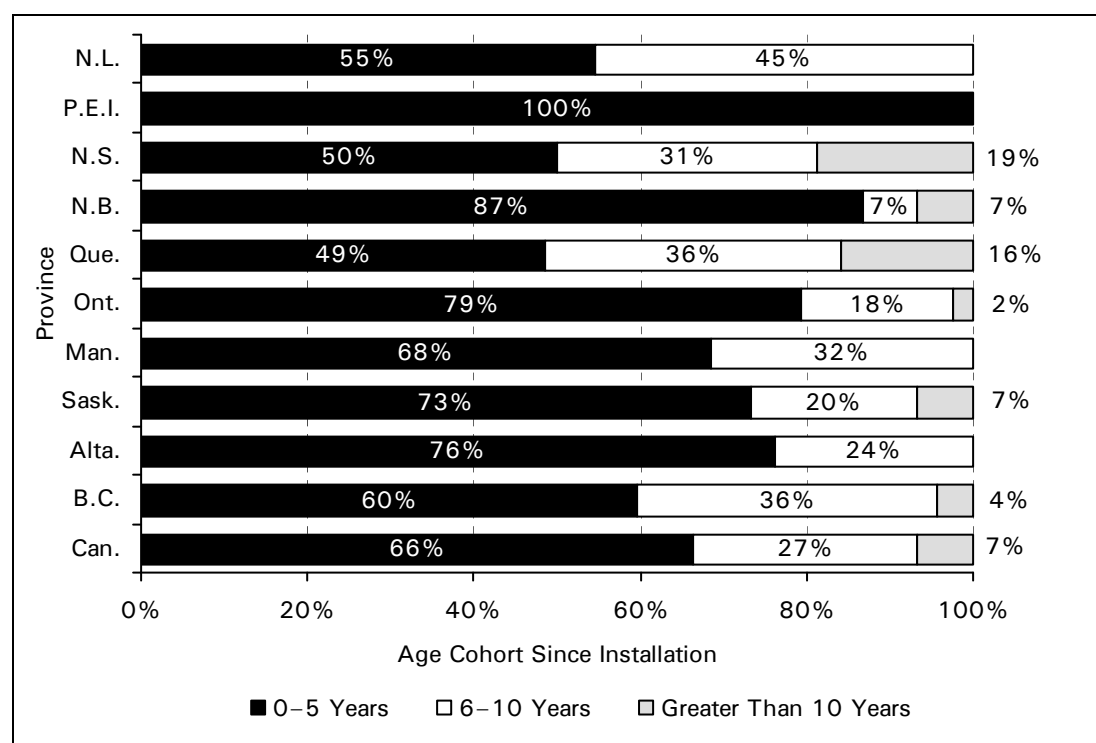
CT and MRI scanners in free-standing facilities are found in only four and six provinces, respectively, with most of their operation privately funded. All provinces, however, have CT and MRI scanners in hospitals, where almost all their operating costs are covered by public insurance. The following two sections discuss differences in the age and technological characteristics of scanners installed in the hospitals of individual provinces.

Age and Technological Characteristics (Number of Slices) of CT Scanners in Hospitals by Province

As of January 1, 2007, the proportion of hospital CT scanners in the age cohort 0 to 5 years varied considerably among the provinces (Figure 27). P.E.I. and New Brunswick had the highest proportion of newer scanners, 100% and 87%, respectively. The proportion ranged between 79% and 73% for a second group of provinces (Ontario, Alberta and Saskatchewan), and between 68% and 50% for a third group (Manitoba, B.C., Newfoundland and Labrador and Nova Scotia). Quebec had the lowest percentage of CT scanners 5 years old or less (49%).

Newfoundland and Labrador, P.E.I., Manitoba and Alberta had no CT scanners older than 10 years, and Ontario and B.C. reported fewer than 5% of their scanners in this age cohort. In New Brunswick and Saskatchewan, 7% of scanners were more than 10 years of age. In Quebec and Nova Scotia, 16% and 19%, respectively, of CT scanners were older than 10 years.

Figure 27 Distribution of CT Scanners in Hospitals, by Age Cohort Since Installation, by Province, Canada, as of January 1, 2007



Notes

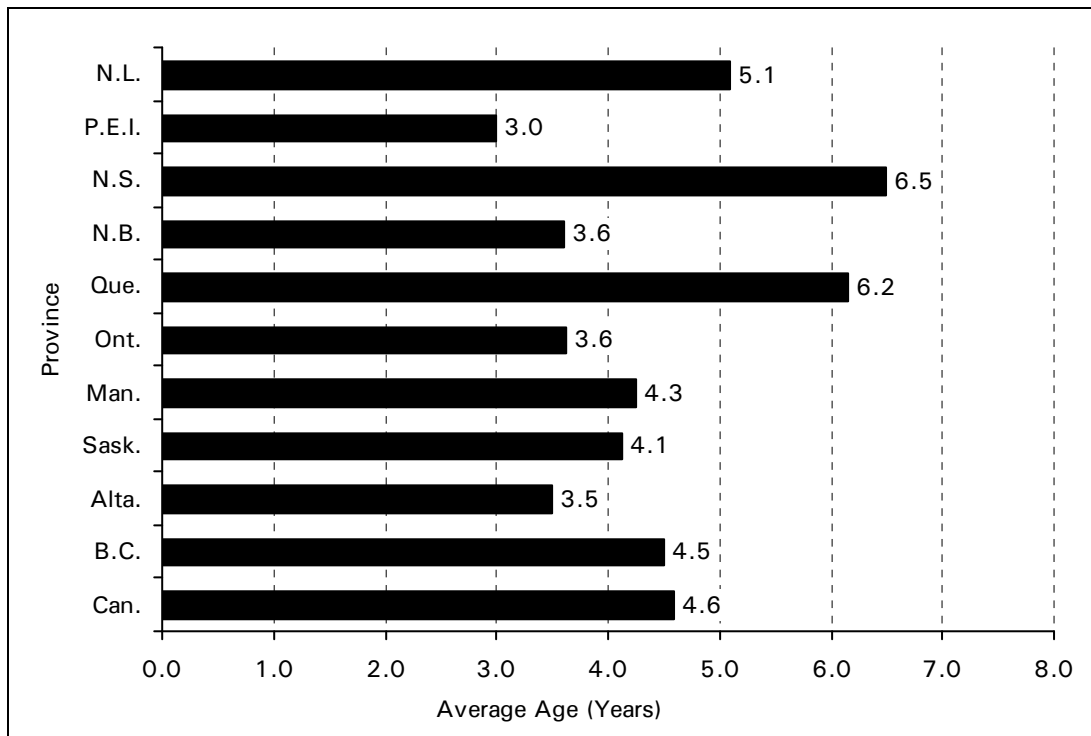
- Age cohorts are calculated based on the year of the survey minus the year of equipment installation. Some components of the equipment might have been upgraded since installation but information on the date or type of upgrades is not collected in the survey.
- The Yukon and the Northwest Territories are not shown. They each have only one CT scanner (0 to 5 years). Nunavut has no CT scanners.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information from provincial ministries of health.

Figure 28 indicates that CT scanners in P.E.I., New Brunswick, Ontario and Alberta are less than 4 years of age, on average. A second group of provinces that includes Saskatchewan, Manitoba and B.C. has scanners with an average age between 4 and 5 years. The scanners with the highest average age are found in Nova Scotia, Quebec and Newfoundland and Labrador.

Figure 28 Average Age of CT Scanners in Hospitals, by Province, Canada, as of January 1, 2007



Note

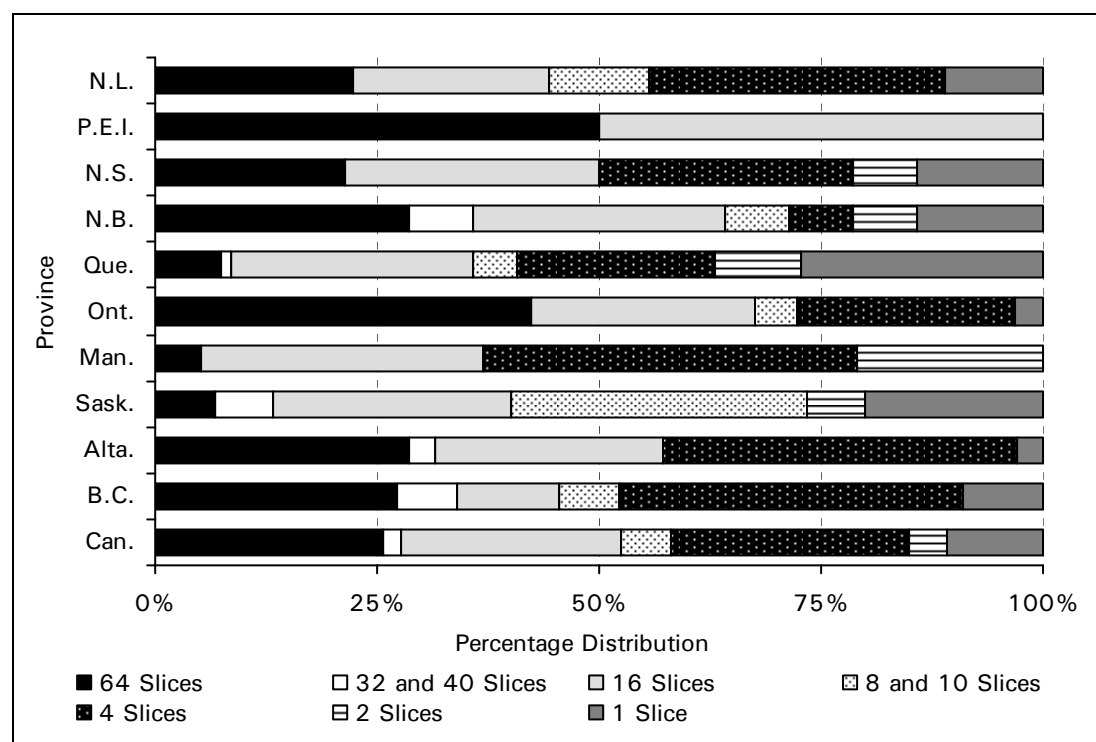
The Yukon and the Northwest Territories are not shown. They each have only one CT scanner (5 and 2 years old, respectively). Nunavut has no CT scanners.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information from provincial ministries of health.

Most of the CT scanners in Canada have either 64 slices, 16 slices, 4 slices or 1 slice. Few scanners have 32, 40, 10 or 8 slices. Figure 29 shows that P.E.I. has the highest share of 64-slice scanners (although it has only one such scanner), followed by Ontario, New Brunswick and Alberta. In these four provinces, more than 50% of the scanners have at least 16 slices, while in Nova Scotia exactly 50% of scanners have at least 16 slices. Quebec has the highest proportion of one-slice scanners, followed by Saskatchewan, Nova Scotia and New Brunswick. Quebec is the only province where more than one-quarter of the scanners have only one slice.

Figure 29 Distribution of CT Scanners in Hospitals, by Slice, by Province, Canada, as of January 1, 2007



Notes

- The Yukon and the Northwest Territories are not shown. They each have only one CT scanner (with 4 and 16 slices, respectively). Nunavut has no CT scanners.
- As of January 1, 2007, there were 398 CT scanners installed and operational in Canadian hospitals, but the number of slices was reported for only 359 scanners.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Age and Technological Characteristics (Field Strength) of MRI Scanners in Hospitals by Province

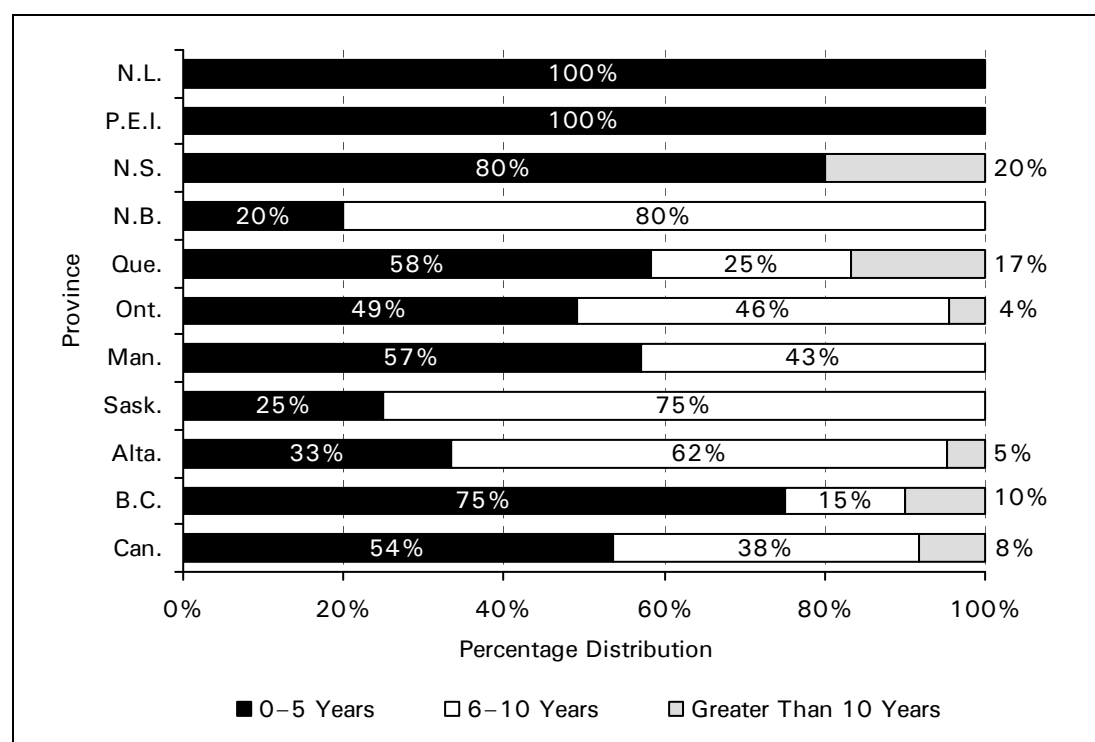
As of January 1, 2007, the proportion of MRI scanners in hospitals in the age cohort 0 to 5 years varied substantially among the provinces (Figure 30). All three scanners in Newfoundland and Labrador and the single scanner in P.E.I., along with 80% of the scanners in Nova Scotia and 75% of the scanners in B.C., fall within this younger age cohort. The proportion ranged between 58% and 49% for a second group of provinces (Quebec, Manitoba and Ontario). The proportion of MRI scanners 5 years old or less for a

third group of provinces (Alberta, Saskatchewan and New Brunswick) varied between 33% and 20%.

Eighty percent of scanners in New Brunswick, 75% of scanners in Saskatchewan and slightly more than 60% of scanners in Alberta were between 6 and 10 years old. In Ontario, Manitoba, Quebec and B.C., 46%, 43%, 25% and 15% of scanners, respectively, were in the age cohort 6 to 10 years. Newfoundland and Labrador, P.E.I. and Nova Scotia did not report any scanners in this age cohort.

Similarly to their CT scanners, Newfoundland and Labrador, P.E.I., New Brunswick and Manitoba had no MRI scanners older than 10 years. Saskatchewan also reported no MRI scanners in this age cohort. The proportion of scanners more than 10 years of age was only 4% in Ontario and 5% in Alberta. It was, however, considerably higher in B.C. (10%) and Quebec (17%), and reached 20% in Nova Scotia.

Figure 30 Distribution of MRI Scanners in Hospitals, by Age Cohort, by Province, Canada, as of January 1, 2007



Notes

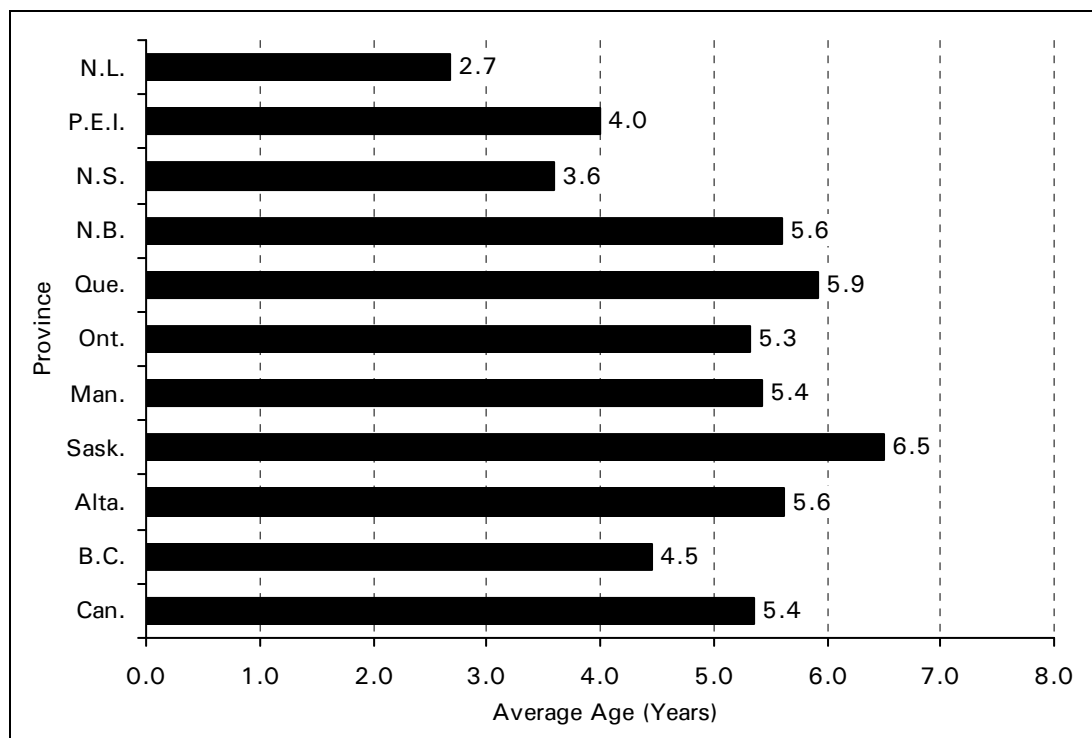
- Age cohorts are calculated based on the year of the survey minus the year of equipment installation. Some components of the equipment might have been upgraded since installation, but information on the date or type of upgrades is not collected in the survey.
- There are no MRI scanners in the territories.
- Although located in the community and not in a hospital, the publicly funded scanner at the Pan Am Community Clinic in Manitoba is included with other publicly funded scanners in hospitals.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information from provincial ministries of health.

MRI scanners in Newfoundland and Labrador, P.E.I., Nova Scotia and B.C. are less than 5 years of age, on average. A second group of provinces that includes New Brunswick, Quebec, Ontario, Manitoba and Alberta has scanners with an average age between 5 and 6 years. The scanners with the highest average age are found in Saskatchewan (Figure 31).

Figure 31 Average Age of MRI Scanners in Hospitals, by Province, Canada, as of January 1, 2007



Notes

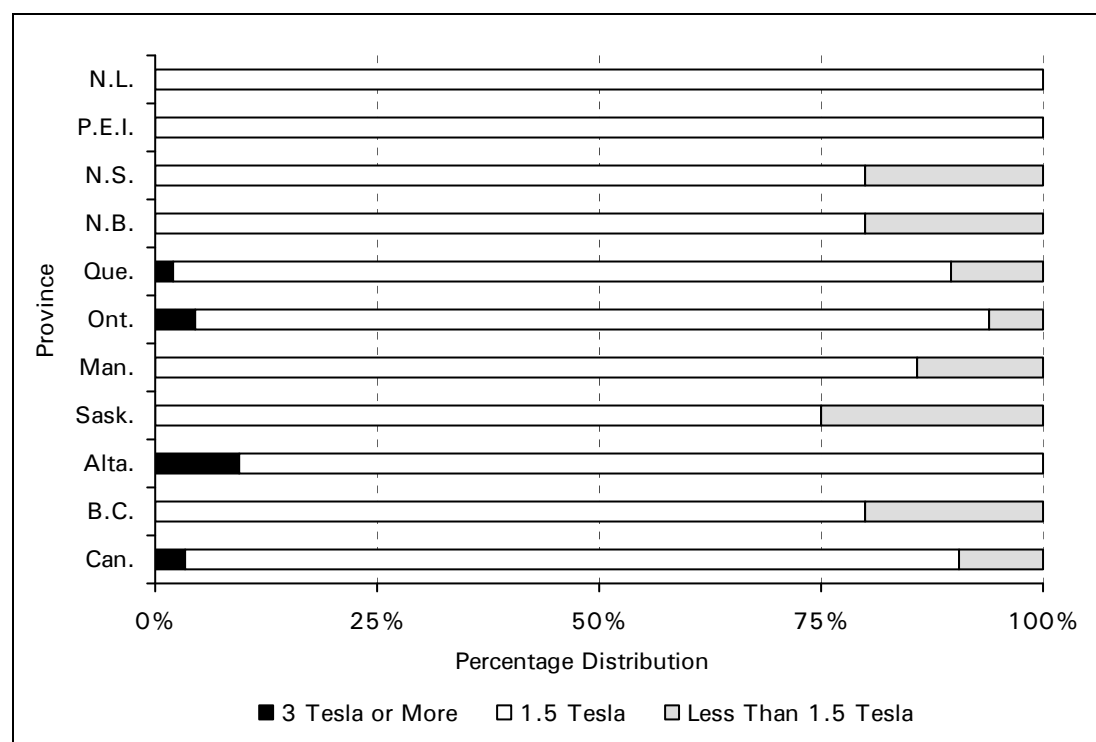
- a) There are no MRI scanners in the territories.
- b) Although located in the community and not in a hospital, the publicly funded scanner at the Pan Am Community Clinic in Manitoba is included with other publicly funded scanners in hospitals.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, supplemented by information from provincial ministries of health.

Figure 32 shows that 1.5 Tesla is by far the predominant field strength of MRI scanners in all provinces. However, a significant proportion of scanners in Saskatchewan (25%) and in Nova Scotia, New Brunswick and B.C. (20%) have a lower field strength. In the other provinces, the proportion of scanners with less than 1.5 Tesla ranges between 0% in Newfoundland and Labrador, P.E.I. and Alberta and 14% in Manitoba. Alberta, Ontario and Quebec have some scanners with 3 Tesla or more. These high-magnetic field scanners are mostly used for research, with only a few 3-Tesla scanners starting to be used for clinical purposes.

Figure 32 Distribution of MRI Scanners in Hospitals, by Field Strength, by Province, Canada, as of January 1, 2007



Notes

- a) There are no MRI scanners in the territories.
- b) Although located in the community and not in a hospital, the publicly funded scanner at the Pan Am Community Clinic in Manitoba is included with other publicly funded scanners in hospitals.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Picture Archiving and Communications Systems

With the advent of digital imaging technologies comes the potential to acquire, review, distribute and archive image information electronically. In the late 1970s and early 1980s, the concept of a picture archiving and communications system (PACS) was born.⁶ A PACS allows images to be stored in a central location (PACS server) and transmitted to any workstation linked to the storage server.

A PACS has many components and involves several related technologies. The general components of a PACS include the following:

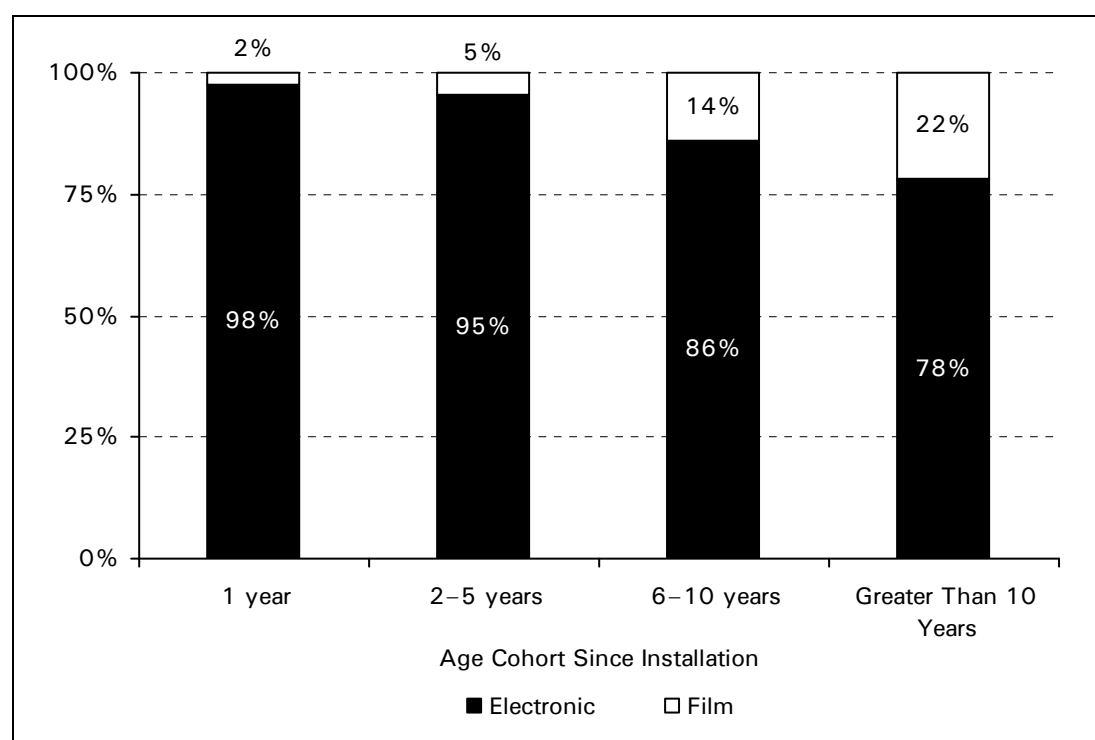
1. Acquisition devices that acquire digital images that are stored by the PACS. There are many modalities that produce images in digital format, for instance, CT, MRI, nuclear medicine cameras and ultrasonography. Most recently, radiography and mammography have made the transition to digital; however, for analogue equipment, a digital acquisition device or modality, such as computed radiography (CR) or digital radiography (DR), is necessary for converting analogue images to digital.
2. Image servers (or PACS servers) track all image information, including the locations, attributes and images themselves.
3. Display stations or workstations throughout health facilities allow health professionals to view images.
4. Storage and archive systems provide permanent or long-term storage of radiology images.
5. A communications infrastructure (IT network) provides an electronic medium, allowing the exchange of information.

Other technologies, such as a hospital information system (HIS) or a radiology information system (RIS), are needed for a PACS to be most useful for a radiologist to interpret images. HISs and RISs contain non-image patient information that is vital to the radiologist when determining the results of the diagnostic exam. However, communication between these systems is not always compatible. PACS uses the standard, called Digital Imaging and Communications in Medicine (DICOM), for the transmission and storage of digital images; HISs and RISs use the common standard of Health Level-7 (HL7) for interpreting patient information. International organizations, such as Integrating the Healthcare Enterprise (IHE), are working with health care professionals and industry vendors to promote the coordination of DICOM and HL7 standards to enhance interoperability among health systems.⁷⁻¹⁰

Going Filmless

More and more selected medical imaging equipment being installed in Canada can store images in electronic format, and is therefore capable of supporting a PACS. Equipment installed prior to the early 1990s is less likely to have the capability of recording images in an electronic format. However, equipment upgrades and new software can enable older equipment to connect to a PACS. The 2007 National Survey of Selected Medical Imaging Equipment, which does not include X-ray or ultrasound units, indicated that 22% of equipment installed prior to 1997 still used film. By contrast, only 2% of equipment installed in 2006 uses film to record images (Figure 33).

Figure 33 Percentage of Medical Imaging Equipment With Electronic Storage Capacity, by Age Cohort Since Installation, Canada, as of January 1, 2007



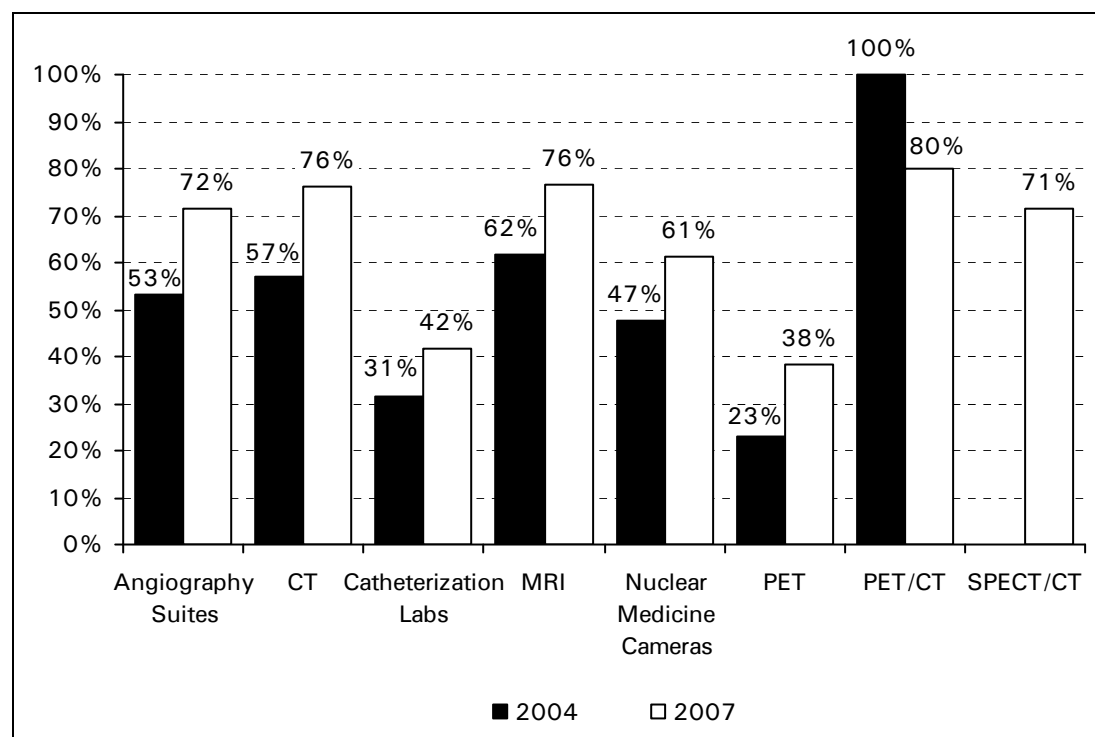
Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Comparing equipment installed in Canada as of January 1 of 2004 and 2007 shows a trend toward PACS capabilities for all modalities with the exception of PET/CT scanners (Figure 34). The decrease in the percentage of PET/CT scanners routing to a PACS is explained by the fact that all three scanners installed and operational as of January 1, 2004, had PACS capabilities, whereas this was not the case for all PET/CTs installed thereafter. Overall, 67% of the imaging equipment captured in the 2007 survey had images routed to a PACS, up from 51% in 2004. This can include either viewing capabilities in the radiology department or viewing capabilities in strategic areas of the health facility. A higher proportion of equipment in hospitals (68%) than in free-standing facilities (48%) were routed to a PACS in 2007.

Figure 35 shows that for all imaging equipment, PACS penetration rates vary considerably across the provinces and territories. Part of the variation in the overall penetration rates might be due to the different mix of equipment captured by the survey across the provinces and territories.

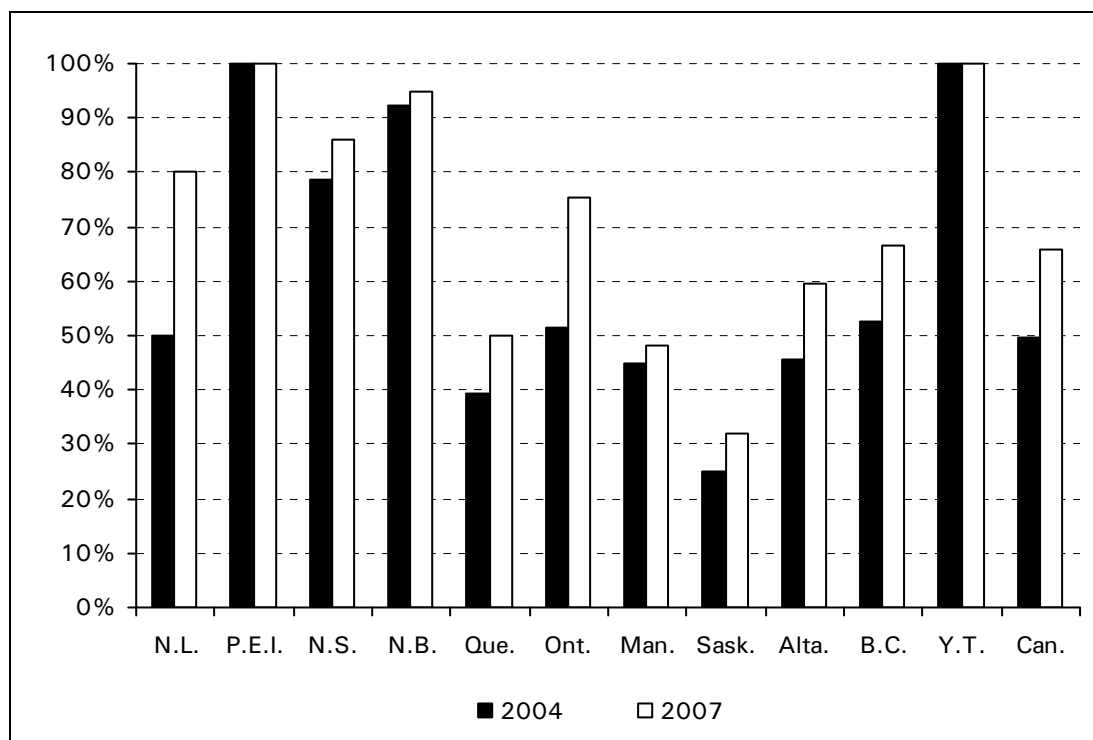
Figure 34 Percentage of Medical Imaging Equipment Where PACS Are Available, by Type of Technology, Canada, as of January 1, 2004 and 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure 35 Percentage of Medical Imaging Equipment Where PACS Are Available, by Province/Territory, Canada, as of January 1, 2004 and 2007



Note

The Northwest Territories and Nunavut are not shown in Figure 35, as they each have only one imaging device among the selected medical imaging equipment, and neither device is routed to a PACS.

Source

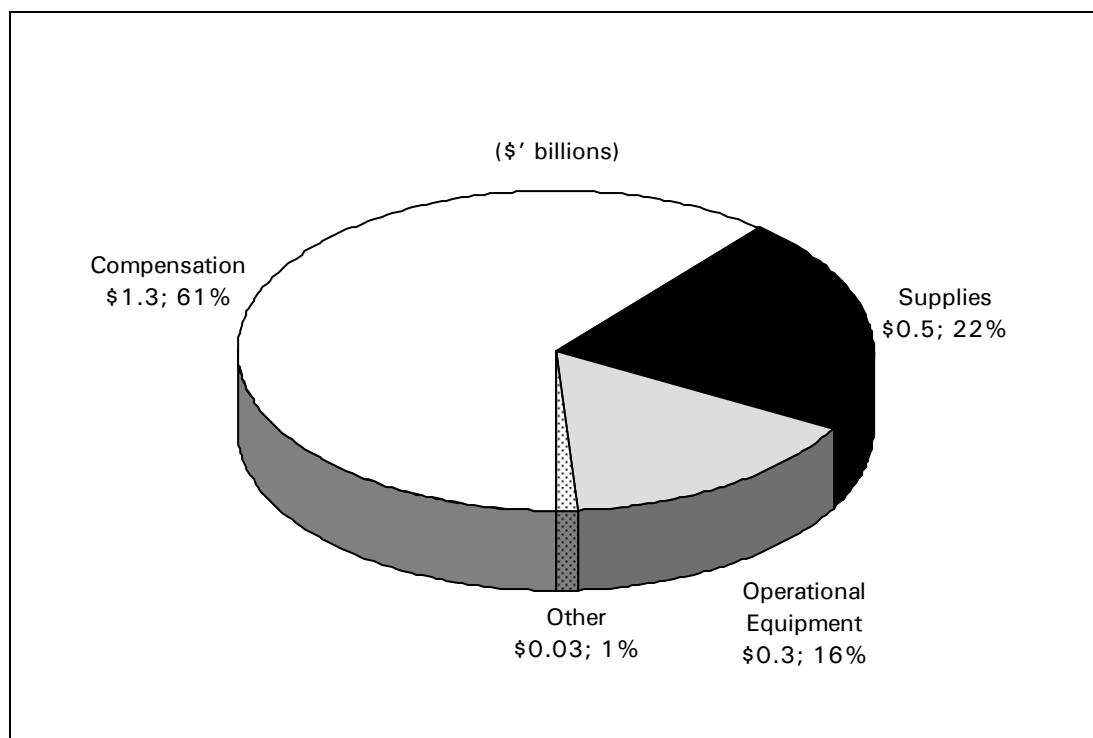
National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

The Cost of Imaging

Operating Costs

Canadians spend billions of dollars each year on imaging services. The professionals who operate and maintain the equipment must be paid, related parts and supplies must be purchased and overhead costs must be included. In 2005–2006, Canadian hospitals reported an estimated \$2.2 billion for the operation of diagnostic imaging services; this is up from the \$2.0 billion reported in 2004–2005. Figure 36 outlines the distribution of these expenses for 2005–2006 across four broad areas of expenditure.

Figure 36 Distribution of Diagnostic Imaging Operating Expenses in Canadian Hospitals, 2005–2006



Note

Includes all hospitals that reported MIS data to their respective provincial or territorial ministry of health.

Source

Canadian MIS Database, Canadian Institute for Health Information.

Total operating costs vary widely, depending on the type of imaging, the complexity of the images required, salary and fee levels and other factors. Although medical imaging technologies have become essential tools in health care, there is little comparable information on the costs of providing these services across the country.

Where the Money Comes From

Many imaging facilities are located in hospitals (public and private), but there is also a well-established tradition in Canada of free-standing imaging facilities, which may be for profit or not for profit. In some cases, they are led by entrepreneurs, often health professionals delivering the services; in others, they are owned by commercial corporate organizations.

Free-standing imaging facilities range from specialized services run by physicians, radiologists, dentists and chiropractors to mammography programs or broad-based imaging centres offering a wide range of tests. The use of hospital-based and free-standing imaging facilities differs slightly among imaging modalities. For example, according to the Statistics Canada Health Services Access Survey, 96% of Canadians who reported having had a non-emergency angiography in 2005 said that they underwent their test in a hospital or public clinic. The proportion was similar for CT scans (96%) and MRIs (89%).¹¹

Irrespective of the type of facility in which the examination occurs, funding can come from a variety of sources, such as provincial and territorial health insurance programs, other public payers (for example, workers' compensation boards or the federal government) and/or individuals or their insurance plans. Who pays for the services can depend on many factors, for instance, why the examination is required, what type of examination is needed and where the facility is located.

Most funding for medical imaging comes from provincial and territorial governments, but funding approaches vary by technology and jurisdiction. In some cases, there are also differences between how physicians' professional fees are funded and payments for hospital or other facility operating costs. For example, physicians may receive fee-for-service payments for their professional services, while other operating costs may be included in hospital/health-region global budgets. Alternatively, the fee-for-service payment may include both a professional and a technical component, covering all operating costs.

According to the 2007 National Survey of Selected Medical Imaging Equipment, both hospital-based and free-standing imaging services receive operating funding from various sources, but the mix of funding differs. For hospital-based equipment captured in the survey, funding for operating costs comes primarily from provincial and territorial governments. Additional secondary funding sources also exist. For example, some hospitals provide CT and MRI services funded by other payers in off hours. In contrast, the private sector (private health insurance and households) provides most of the funds to finance the operation of machines housed in free-standing imaging facilities (Table 4).

Table 4 Percentage Distribution of Operating Revenue by Source for Selected Types of Medical Imaging Equipment and Number of Devices for Which Sources of Funds Were Reported in Hospitals and Free-Standing Imaging Facilities, Canada, as of January 1, 2007

Sources of Operating Funds	Hospitals			Free-Standing Facilities		
	CT	MRI	Nuclear Medicine	CT	MRI	Nuclear Medicine
Provincial Government	94.9%	93.2%	96.6%	7.1%	3.9%	33.2%
Workers' Compensation Boards	0.3%	0.8%	0.1%	7.1%	3.7%	1.7%
Private Health Insurance, Other Private Insurance, Out-of-Pocket Payments	0.2%	0.5%	0.6%	69.6%	80.3%	65.0%
Other Types of Funding	4.0%	3.7%	2.3%	15.0%	11.9%	0.0%
Number of Imaging Devices for Which Sources of Funds Were Reported	335	141	463	14	26	38
Number of Imaging Devices Installed and Operational	398	181	564	21	41	39

Notes

- a) Percentage distribution of operating revenue pertains only to imaging devices for which sources of funds were reported (for example, 335 CT scanners out of 398 CT scanners in hospitals).
- b) Percentages may not add up to 100% due to rounding.
- c) "Other Types of Funding" includes "Federal Government," "Research Grants" and "Other."

Source

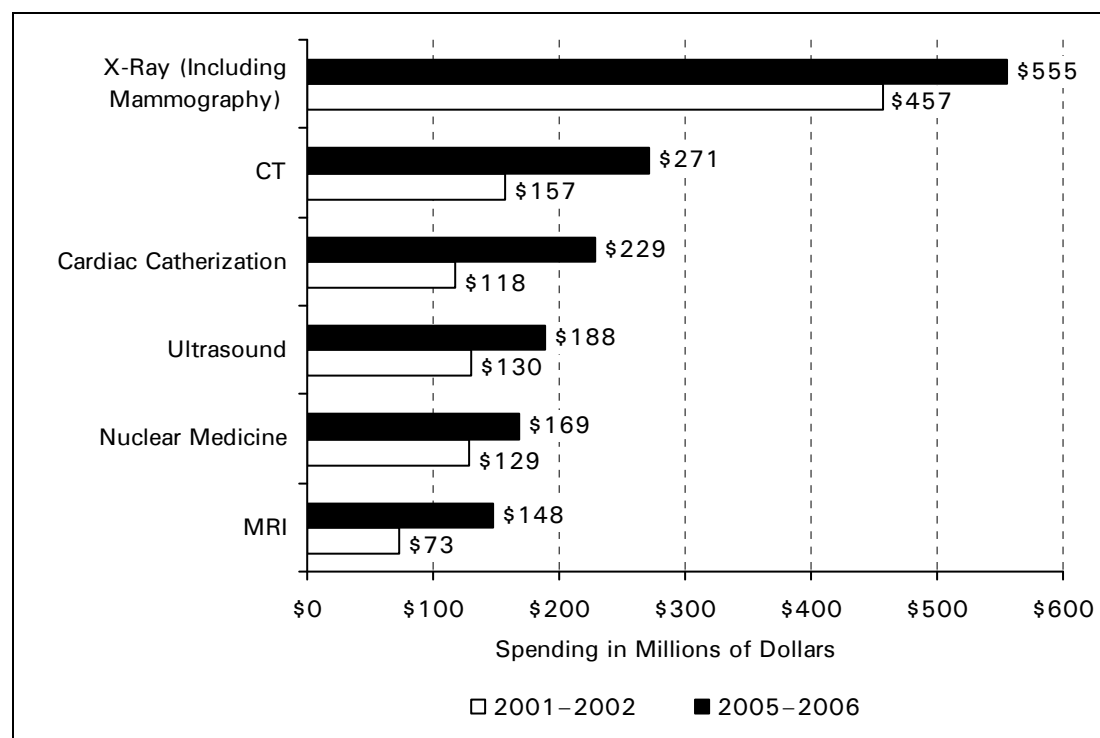
National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Where the Money Goes

Medical imaging tests vary greatly in their complexity and the resources required to perform them. In most hospitals, common tests account for the bulk of overall operating expenditures on diagnostic imaging. Hospitals in five provinces (Newfoundland and Labrador, Nova Scotia, Ontario, Manitoba and B.C.) reported their operating expenses by type of medical imaging equipment to CIHI in a consistent way over the period from 2001–2002 to 2005–2006, based on the *Standards for Management Information Systems in Canadian Health Service Organizations* (MIS Standards). Therefore, the data for these five provinces are considered the best available provincial and territorial data on operating expenses by type of medical imaging equipment in CIHI's Canadian MIS Database (CMDDB). Figure 37 shows that, in 2005–2006, hospitals in the five provinces spent on X-ray and mammography more than twice what they spent on CT or cardiac catheterization, approximately three times as much as what they spent on either ultrasound or nuclear medicine, and almost four times as much as what they spent on MRI. However, while the spending on MRI was still the lowest in 2005–2006, MRI had the highest percentage increase in operating expenses of all six types of imaging equipment between 2001–2002 and 2005–2006 (103%), followed by cardiac catheterization (94%) and CT (73%). In contrast to MRI, spending on X-ray was still by far the highest in 2005–2006, but X-ray

had the lowest percentage increase in operating expenses of the six types of imaging equipment between 2001–2002 and 2005–2006 (21%), followed by nuclear medicine (31%) and ultrasound (45%).

Figure 37 Hospital Operating Expenses by Type of Medical Imaging Equipment in Five Provinces (Newfoundland and Labrador, Nova Scotia, Ontario, Manitoba and B.C.), 2001–2002 and 2005–2006



Note

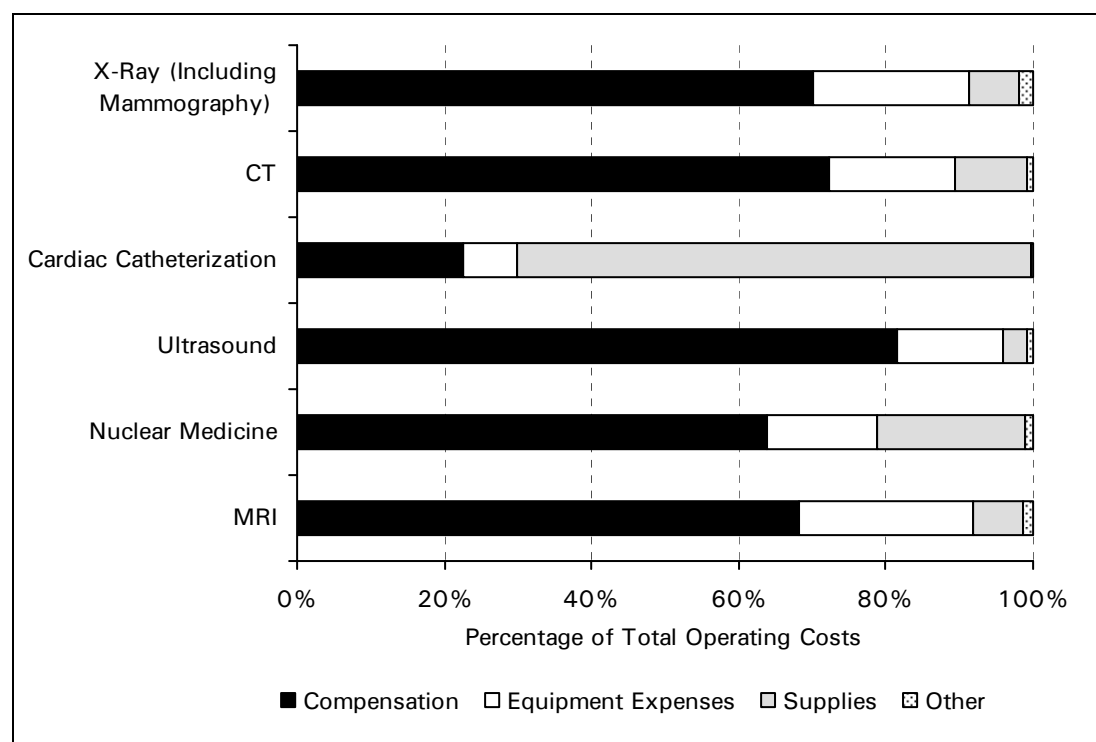
The data for the five provinces are considered the best available provincial and territorial data on hospital operating expenses by type of medical imaging equipment, over the period from 2001–2002 to 2005–2006, in the Canadian MIS Database (CMDDB) at CIHI.

Source

Canadian MIS Database, Canadian Institute for Health Information.

In the five provinces where comparable data are available for 2001–2002 to 2005–2006, types of operating expenses also vary according to imaging modalities. As reported in Figure 38, for all imaging technologies (with the exception of cardiac catheterization), salaries paid to health professionals account for more than 60% of total operating costs in the five provinces. For cardiac catheterization, medical supplies used to perform the procedure take up the majority of spending (70%). The share of operational equipment expenses is the highest for MRI (24%).

Figure 38 Distribution of Hospital Operating Expenses for Selected Types of Medical Imaging Equipment in Five Provinces (Newfoundland and Labrador, Nova Scotia, Ontario, Manitoba and B.C.), 2005–2006



Notes

- a) "Other" includes sundries, referred-out services and building and grounds expenses.
- b) The data for the five provinces are considered the best available provincial and territorial data on hospital operating expenses by type of medical imaging equipment in the Canadian MIS Database (CMDB) at CIHI.

Source

Canadian MIS Database, Canadian Institute of Health Information.

Capital Funding

Equipment purchases or leases by free-standing facilities are funded by the owners of the facilities, often the health professionals delivering the services; in other cases, the facilities are owned by corporate organizations.

Many provincial and territorial governments fund the purchase and replacement of non-major equipment in hospitals through regular health-region/hospital operating funds.¹² Funds for specific larger projects in hospitals, on the other hand, may be allocated directly by the ministry of health or through regional health authorities. Such purchases are often also funded at least partly through non-governmental sources such as hospital foundations and private funding agencies, among others. Some are also partly or wholly paid for by research grants. For example, a study of funding sources for MRI equipment in Canada in 1997 reported that about 23% of the capital spending for the national inventory of MRI scanners was provided by direct government grants.¹³ Although in many provinces hospitals and their communities are responsible for some component (usually less than 50%) of the funding for major new equipment, the final decision as to whether or not to buy almost always rests with the ministry of health. Exceptions to this rule tend to be purchases of major diagnostic equipment funded from private philanthropic sources, often without the approval of the provincial ministry and without guarantee that future operating costs will be covered by the provincial ministry.¹⁴

As part of the September 2000, February 2003 and September 2004 federal–provincial–territorial agreements on health care, the federal government also played an important role in funding medical imaging and other equipment. The federal government provided \$3 billion in total to provinces and territories over five years in support of investments in diagnostic and medical equipment to improve access to publicly funded diagnostic services, including:¹⁵

- \$1 billion over two years (2000–2001 and 2001–2002) through the 2000 Medical Equipment Fund (MEF) to assist provinces and territories in the acquisition of medical diagnostic and treatment equipment (such as MRI machines, CAT scanners and radiation therapy machines);
- \$1.5 billion over three years (2003–2004, 2004–2005 and 2005–2006) through the 2003 Diagnostic and Medical Equipment Fund (D/MEF) in support of specialized staff training and acquisition of equipment; and
- An additional \$500 million for medical equipment in 2004–2005 through the 2004 agreement on the *10-Year Plan to Strengthen Health Care*.

Although there exists a published estimate of total capital costs in the health care sector in Canada (\$6.8 billion in 2006),¹⁶ the share of medical imaging equipment is unknown. However, one may obtain some appreciation of the level of Canada's capital spending on medical imaging equipment in 2006 based on available information on the number of devices installed during the year in the information on cost per medical imaging device in 2005 and 2006 published by some provinces. According to the National Survey of Selected Medical Imaging Equipment of 2007, supplemented by information from provincial

ministries of health, the equipment installed during 2006 is as follows (some of the machines were new additions, while others replaced machines that had come to the end of their lifecycle):

- 53 CT scanners;
- 26 MRI scanners;
- 41 nuclear medicine cameras;
- 10 catheterization laboratories;
- 19 angiography suites;
- 6 PET/CT scanners (fusion technology); and
- 7 SPECT/CT scanners (fusion technology).

Information on capital costs per unit of medical imaging equipment or on total costs for a specific number of units, available from websites of provincial governments, is presented below. The costs pertain to units installed, or that were planned to be installed, in 2005 or 2006.

Newfoundland and Labrador^{17, 18}

CT

2005 and 2006 installations:

- Health Science Centre and St. Clare's Hospital, St. John's, two 64-slice CT scanners (replacing existing scanners) = \$2 million (represents $\frac{2}{3}$ of cost).
- Burin Peninsula Health Care Centre, Burin, one 16-slice CT scanner (new addition) = \$1.55 million (\$1.15 million for equipment and \$0.4 billion in renovation costs).

MRI

2005 and 2006 installations:

- Western Memorial Regional Hospital, Corner Brook, one 1.5-Tesla MRI scanner (new addition) = \$4.1 million.
- Janeway Children's Health and Rehabilitation Centre, St. John's, one 1.5-Tesla MRI scanner (new addition) = \$2.6 million (represents $\frac{2}{3}$ of cost).

Nuclear Medicine Gamma Cameras

2005 and 2006 installations:

- Health Sciences Centre, St. John's, three nuclear medicine dual-head gamma cameras (replacements) = \$1.8 million.
- Western Memorial Regional Hospital, Corner Brook, one nuclear medicine dual-head gamma camera (new addition) = \$0.8 million.

Nova Scotia^{19, 20}

MRI

2005 announcement by Department of Health:

- Halifax, Yarmouth, Kentville, Antigonish and New Glasgow, five 1.5-Tesla MRI scanners (one replacement and four new additions) = \$12.5 million (represents $\frac{3}{4}$ of cost).

PET/CT

2005 announcement by Department of Health:

- QEII Capital District Health Authority, one PET/CT (new addition) = \$5.5 million for project.

*New Brunswick*²¹⁻²⁴

CT

2006 installations:

- Moncton Hospital, Moncton, one 64-slice CT scanner (new addition) = \$1.6 million.
- Campbellton Regional Hospital, Campbellton, one 40-slice CT scanner (replacing existing scanner) = \$1.2 million.

MRI

2006 installations:

- Bathurst, Miramichi and Campbellton, one mobile 1.5-Tesla MRI scanner (replacing existing scanner) = \$3 million.

PET/CT

2005 announcement by premier of New Brunswick:

- Dr. Georges-L. Dumont Regional Hospital, Moncton, and Saint John Regional Hospital, two PT/CT scanners = more than \$6 million for purchase and installation of the two scanners, plus \$1 million in renovation costs.

*Quebec*²⁵

CT

2005 and 2006 installations:

- Centre de santé du Granit, Lac-Mégantic, one CT scanner (new addition) = \$0.835 million.
- Centre de santé de Chibougamau, Chibougamau, one CT scanner (new addition) = \$1.437 million (government subsidy only).

2005 announcement of government subsidy by Minister of Health and Social Services:

- Hôpital des Monts, Sainte-Anne-des-Monts, one CT scanner (new addition) = \$1.415 million.
- Cité de la Santé de Laval, Laval, one CT scanner = \$1.3 million.
- Hôpital Laval, Quebec City, one CT scanner = \$1.5 million.
- Hôtel-Dieu de Saint-Jérôme, one CT scanner (replacement) = \$1.3 million.

- Hôpital général du Lakeshore, Montréal, one CT scanner (replacement) = \$1.2 million.

2006 announcement of government subsidy by Minister of Health and Social Services:

- Centre de santé et de services sociaux (CSSS) des îles, îles-de-la-Madeleine, one CT scanner (replacement) = \$1.2 million.
- CSSS Maria-Chapdelaine, Dolbeau-Mistassini, one CT scanner (replacement) = \$1.1 million.
- CSSS de la Haute-Yamaska, Granby, one CT scanner (replacement) = \$1.3 million.
- Cité de la Santé, Laval, one CT scanner = \$1.3 million.
- Hôpital régional de Rimouski, one CT scanner = \$1.3 million.
- Hôpital Maisonneuve-Rosemont, one CT scanner = \$1.5 million.
- Hôpital de Hull, Gatineau, one CT scanner = \$1.655 million.

MRI

2006 installation:

- Centre hospitalier Beauce-Etchemin, Saint-Georges-de-Beauce, one 1.5-Tesla MRI scanner (new addition) = \$2.756 million (government subsidy only).

2005 announcement of government subsidy by Minister of Health and Social Services:

- Hôpital Saint-Sacrement, Quebec City, one MRI scanner (new addition) = \$2.9 million.
- Hôpital du Haut-Richelieu, Saint-Jean-sur-Richelieu, one MRI scanner (new addition) = \$2.8 million.
- Centre hospitalier régional du Suroît, Salaberry-de-Valleyfield, one MRI scanner (new addition) = \$2.8 million.

2006 announcement of government subsidy by Minister of Health and Social Services:

- CSSS de Lac-Saint-Jean-Est, Alma, one MRI scanner (new addition) = \$2.3 million.
- Hôtel-Dieu de Montréal, one MRI scanner = \$2.5 million.

2006 announcement of inauguration by Minister of Health and Social Services:

- CSSS de la Baie-des-Chaleurs, Maria, one mobile MRI scanner (new addition) = \$2.9 million (government subsidy only).

Nuclear Medicine Gamma Cameras

2006 installation:

- Centre hospitalier Centre-Mauricie, Shawinigan, one nuclear medicine dual-head gamma camera = \$0.65 million (government subsidy only).

PET

2006 announcement of inauguration by Minister of Health and Social Services:

- Hôtel-Dieu de Québec, Quebec City, one PET scanner (new addition) = \$3 million (government subsidy only).

Ontario^{26, 27}

CT

2005 announcement of government funding by the Minister of Health and Long-Term Care:

- Replacement of 26 CT scanners at 23 hospitals = \$45.3 million.

MRI

2005 announcement of government funding by the Minister of Health and Long-Term Care:

- Replacement of seven MRI scanners at seven hospitals = \$21 million.

Cardiac Catheterization

2005 announcement of government funding by the Minister of Health and Long-Term Care:

- Sudbury General Hospital, Sudbury, one cardiac catheterization machine = \$1.67 million.

Manitoba^{28, 29}

MRI

2005 news release by Government of Manitoba:

- Pam Am Clinic, Winnipeg, one 1.5-Tesla MRI scanner (new addition) = \$3.5 million.

2006 news release by Government of Manitoba:

- Health Sciences Centre, Winnipeg, upgrade of one MRI scanner = \$1.2 million.

*Saskatchewan*³⁰

MRI

2006 news release by Government of Saskatchewan:

- Regina General Hospital, one MRI 1.5-Tesla scanner (new addition) = \$4.6 million.

*Alberta*³¹

MRI

2005

- Expected cost of purchase and installation of each new MRI scanner: \$5 to \$10 million.

*British Columbia*³²

CT

2005

- Vancouver Coastal Health Authority, Vancouver General Hospital, one 64-slice CT scanner (replacing existing scanner) = \$2.1 million.

2006

- Fraser Health Authority, Royal Columbian Hospital, New Westminster, one 64-slice CT scanner (new addition) = \$3.5 million.
- Vancouver Island Health Authority, Royal Jubilee Hospitals, Victoria, one 64-slice CT scanner (new addition) = \$2.7 million.

MRI

2005

- Vancouver Coastal Health Authority, UBC Hospital, one 1.5-Tesla MRI scanner (upgrade) = \$1.6 million.

MRI and CT

2005

- Interior Health Authority, one mobile 1.5-Tesla MRI scanner for Kootenay Boundary Regional Hospital, South Kootenay Regional Hospital and Penticton Regional Hospital (new addition) and one 32-slice CT scanner at Kelowna General Hospital (new addition) = \$4.6 million.

PET/CT

2005

- Provincial Health Services Authority, BC Cancer Agency, Vancouver Cancer Centre, one PET/CT scanner = \$5.1 million.
- Provincial Health Services Authority, radiopharmaceutical laboratory and cyclotron = \$6.4 million.

The capital cost per CT scanner ranges from about \$1 million to \$1.5 million in Newfoundland and Labrador, New Brunswick and Quebec, but it is as high as \$3 million in B.C. Ontario reported an average cost of \$1.7 million for 26 CT scanners.

The capital cost per MRI scanner is about \$3 million in most provinces, but it is reported to be over \$5 million in Alberta. Ontario reported an average cost of \$3 million for seven MRI scanners.

Nova Scotia and B.C. reported capital costs of over \$5 million per PET/CT scanner, and Newfoundland and Labrador and Quebec indicated capital costs of over \$0.6 million per nuclear medicine camera.

Using the Ontario average capital cost for CT and MRI and the total number of units installed in Canada in 2006, the following estimated total capital spending on CT and MRI is obtained for 2006:

Estimated total capital spending on CT and MRI in Canada in 2006

- CT: 53 units at \$1.7 million per unit = \$90 million
- MRI: 26 units at \$3 million per unit = \$78 million

In addition, total capital spending on the six PET/CTs installed in 2006 may be estimated at around \$30 million, based on the unit cost reported by Nova Scotia and B.C. Total capital costs for 41 nuclear medicine cameras may also be estimated at about \$25 million, based on the unit cost reported by Newfoundland and Labrador and Quebec.

New additions of equipment tend to cost more than replacements because of additional infrastructure costs. The above estimated costs for CT and MRI may, therefore, be considered fairly conservative as they are based on average replacement costs in Ontario.

Capital costs in 2006 are not estimated for the other types of imaging equipment due to lack of information on average cost per device, but they should also be quite substantial.

Some recent provincial governments' commitments or initiatives to renew or upgrade MRI and CT equipment are not reflected in the above estimates for 2006, such as in Nova Scotia, where the average age of the CT scanners was higher than the national average (see Figure 28), and in Quebec and New Brunswick, where the average age of the MRI scanners was higher than the national average (see Figure 31).

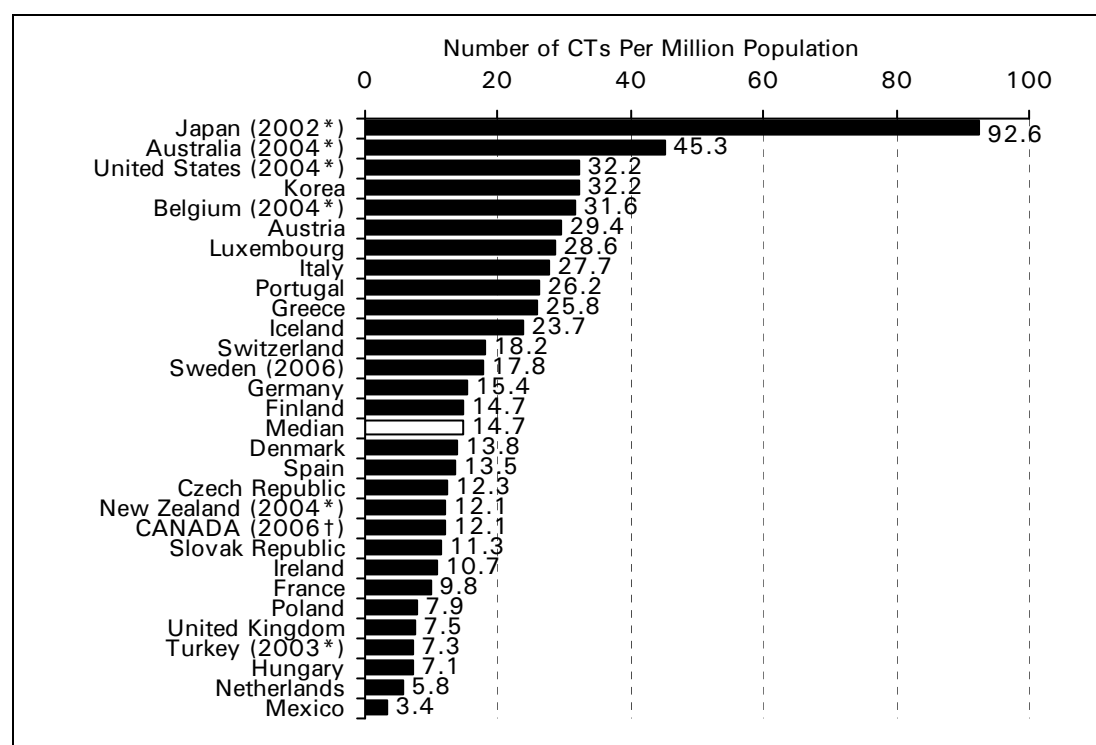
In the June 2007 progress report for Nova Scotia, the government committed to phase in new MRI units in Yarmouth, Kentville, Pictou, New Glasgow and Antigonish, and also to the replacement of two aging units in Halifax.³³

The provincial government of Quebec announced an investment of nearly \$117 million in 2007 to buy defibrillators, MRI scanners and radiotherapy scanners. This investment was in the context of an agreement signed with the federal government aimed at specifically upgrading hospital equipment.^{34, 35}

In addition, the government of New Brunswick announced an investment of \$1.8 million for 2006–2007 to begin construction of an expansion to the diagnostic imaging department at the Dr. Everett Chalmers Regional Hospital in Fredericton to house a fixed MRI unit.³⁶

The International Context

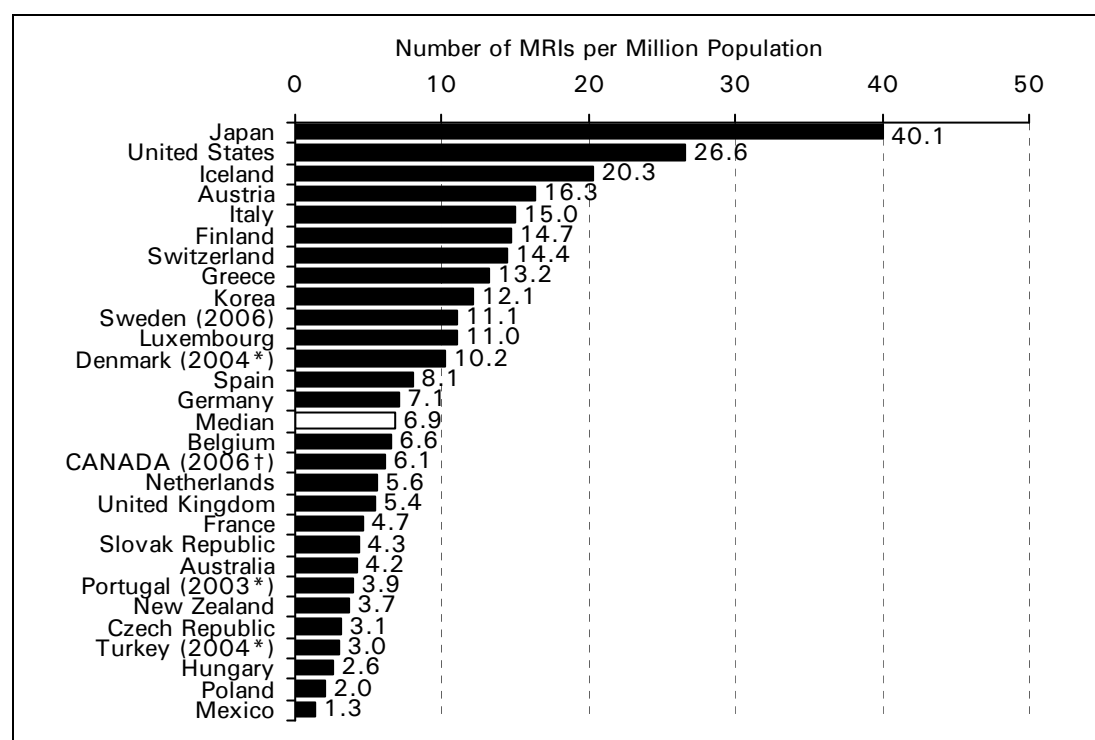
Internationally, the Organisation for Economic Co-operation and Development (OECD) has reported large variations in the supply of medical imaging technologies among member countries. According to available data, Japan has a much higher supply of high-technology medical imaging equipment than other countries. Even among the other countries, the variation is considerable. For instance, Figure 39 indicates that, in 2005, the per million population ratio of CT scanners for the U.S. was almost triple that of Canada and more than four times that of the U.K. Figure 40 illustrates a similar picture for MRIs. The Canadian count of scanners is as of January 1, 2006. While a few OECD countries indicated that their count was as of December 31, 2005, most countries did not specify the precise date of their count in 2005.

Figure 39 Number of CT Scanners per Million Population in OECD Countries, 2005**Notes**

- a) In Mexico, only scanners located in public institutions are included.
 - b) In Canada, units located in both hospitals and free-standing imaging facilities are included. Data are as of January 1, 2006.
 - c) In Japan, units located in hospitals and general clinics are counted. The latest complete data available are for 2002. The 2005 data are not shown as they are only available for spiral CTs in hospitals (35.1 per million population).
 - d) In the U.K., the data refer only to scanners in the public sector.
 - e) In the U.S., units located in both hospitals and non-hospital sites are included. CT units in U.S. territories are not included.
 - f) In Germany, data on medical technology include equipment installed in acute care hospitals and in prevention and rehabilitation homes. The figure comprises CT units as well as PET units.
 - g) In Hungary, scanners in military hospitals and in the health institutes of Hungarian State Railways are not included.
 - h) In the Netherlands, the number of hospitals possessing a CT scanner is reported, rather than the number of scanners.
 - i) In Spain, only scanners located in hospitals are included.
- * Latest year for which data are available.
† As of January 1, 2006.

Sources

OECD Health Data 2007, OECD, for all countries except Sweden and Canada; Belgian Health Care Knowledge Centre, *HTA of Diagnostic Resonance Imaging*, KCE report vol. 37C, 2006, for Sweden; National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, for Canada.

Figure 40 Number of MRI Scanners per Million Population in OECD Countries, 2005**Notes**

- a) In Mexico, only units located in public institutions are included.
 - b) In Canada, units located in both hospitals and free-standing imaging facilities are included. Data are as of January 1, 2006.
 - c) In Japan, units located in hospitals and general clinics are counted.
 - d) In the U.K., the data refer only to units in the public sector.
 - e) In the U.S., units located in both hospitals and non-hospital sites are included. MRI units in U.S. territories are not included.
 - f) In Germany, data on medical technology include equipment installed in acute care hospitals and in prevention and rehabilitation homes.
 - g) In Hungary, units in military hospitals and in the health institutes of Hungarian State Railways are not included.
 - h) In Australia, units approved for billing to Medicare only are included. In 1999, these units represented about 60% of the total units. The proportion in 2005 is unknown.
 - i) In the Netherlands, the number of hospitals possessing a MRI unit is reported, rather than the number of units.
 - j) In Spain, only units located in hospitals are included.
- * Latest year for which data are available.
† As of January 1, 2006.

Sources

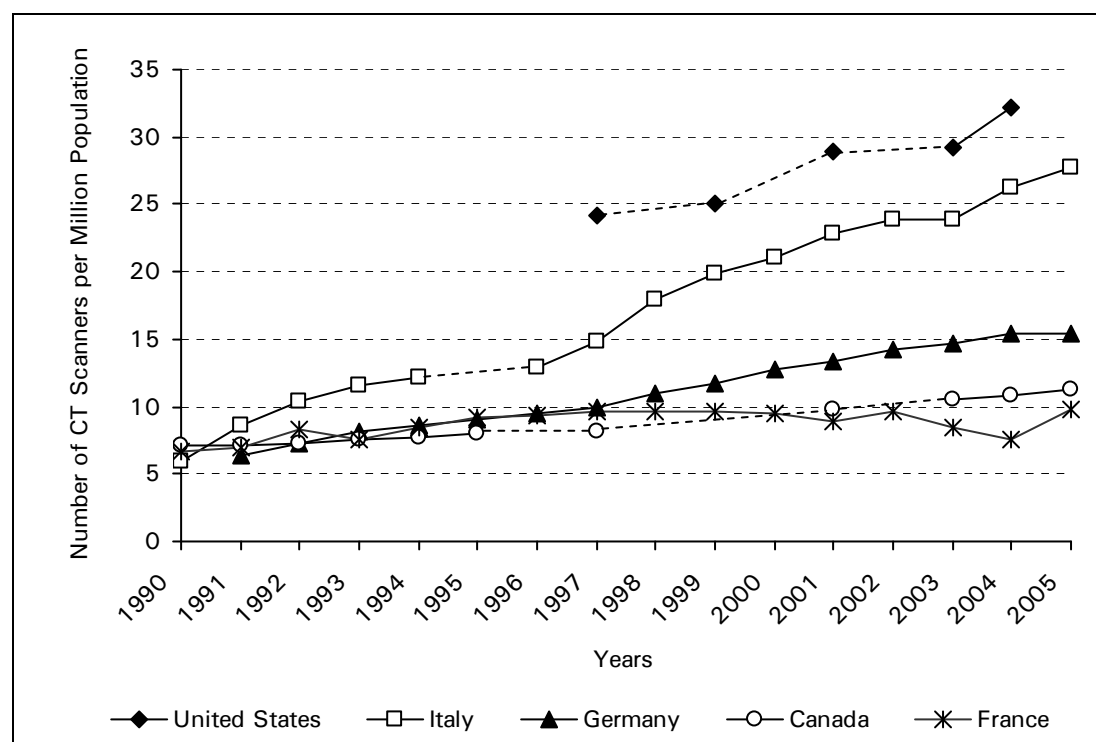
OECD Health Data 2007, OECD, for all countries except Sweden and Canada; Belgian Health Care Knowledge Centre, *HTA of Diagnostic Resonance Imaging*, KCE report vol. 37C, 2006, for Sweden; National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, for Canada.

A wide range of factors may explain the variations in the international supply pattern of medical imaging services and technologies. In the case of Japan, for example, the high rate of MRIs per million population (40.1) has been partly attributed to the market situation of the medical engineering industry, as well as socio-cultural factors such as a bias toward new technologies.³⁷ Furthermore, decisions by individual countries about which types of imaging technology to invest in, and how many machines to acquire, may depend on a variety of domestic factors, including the state of the assessment of the appropriateness of a particular technology's use in different clinical situations and environments.

Canada, with 6.1 MRI scanners per million population, is below the median of OECD countries (6.9). For CT, Canada, with 12.1 scanners per million population, is also below the OECD median (14.7). Intensity of operation of scanners may vary between countries and, consequently, low rates of scanners does not necessarily mean low rates of exams. Unfortunately, while the number of CT and MRI scanners is reported to the OECD, the number of exams is not reported. For a comparison of the number of exams per 1,000 population between Canada and other countries, see Chapter 3 of this report.

All OECD countries where data are available reported more CTs and MRIs over time, but some acquired the technologies at a faster rate than others. For example, Figure 41 reports that, throughout the 1990s, the number of CTs per million population in Canada grew less quickly than in Italy or the U.S., but at about the same rate as in other developed countries, such as France and Germany.

Figure 41 Number of CT Scanners per Million Population in Selected G8 Countries for Which Time Series Were Available, 1990 to 2005



Notes

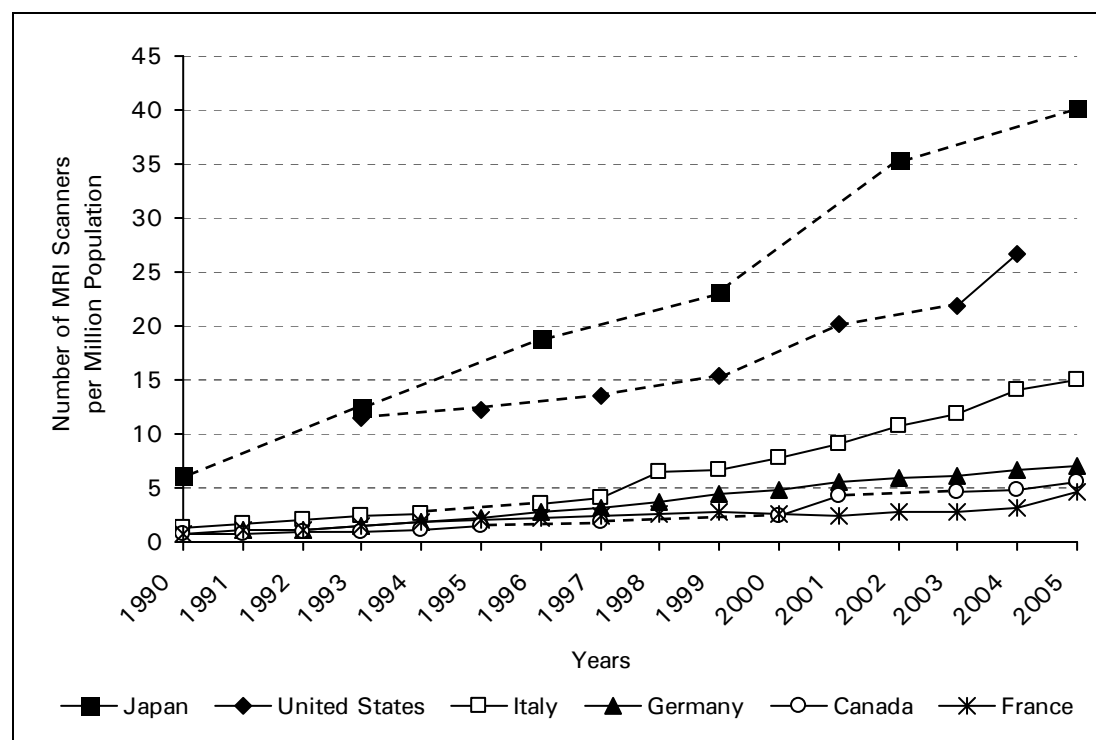
- Annual data on the number of machines are not available for every country. A dotted line is drawn between data points spanning two years or more.
- The U.K. was not included due to varying geographical coverage across years.
- Japan reported very high numbers of CT scanners per million population (55.2 in 1990 and 92.6 in 2002, representing a 68% growth between the two years). Japan is not shown in Figure 41 in order to improve clarity of trend comparisons of countries with similar values by removing the effect of the very high numbers on the data scale.
- The U.S. data reported in *OECD Health Data 2007* are from the Computed Tomography Census of IMV Limited, Medical Information Division. CT scanners in both hospital and non-hospital sites are included.
- Russia was not included, as data were unavailable.
- Units located in both hospitals and free-standing imaging facilities are included for Canada for all years. The number of CT scanners in free-standing imaging facilities was imputed for years prior to 2003, based on data collected in the 2003 National Survey of Selected Medical Imaging Equipment.

Sources

OECD Health Data 2007, OECD; National Survey of Selected Medical Imaging Equipment (2003, 2004 and 2005), Canadian Institute for Health Information.

Figure 42 reports that the growth in the number of MRI scanners in Canada was similar to that in France and Germany from 1990 to 2005. The number of MRI scanners in Japan, the U.S. and Italy grew at a more rapid rate than the number in Canada, Germany and France.

Figure 42 Number of MRI Scanners per Million Population in Selected G8 Countries for Which Time Series Were Available, 1990 to 2005



Notes

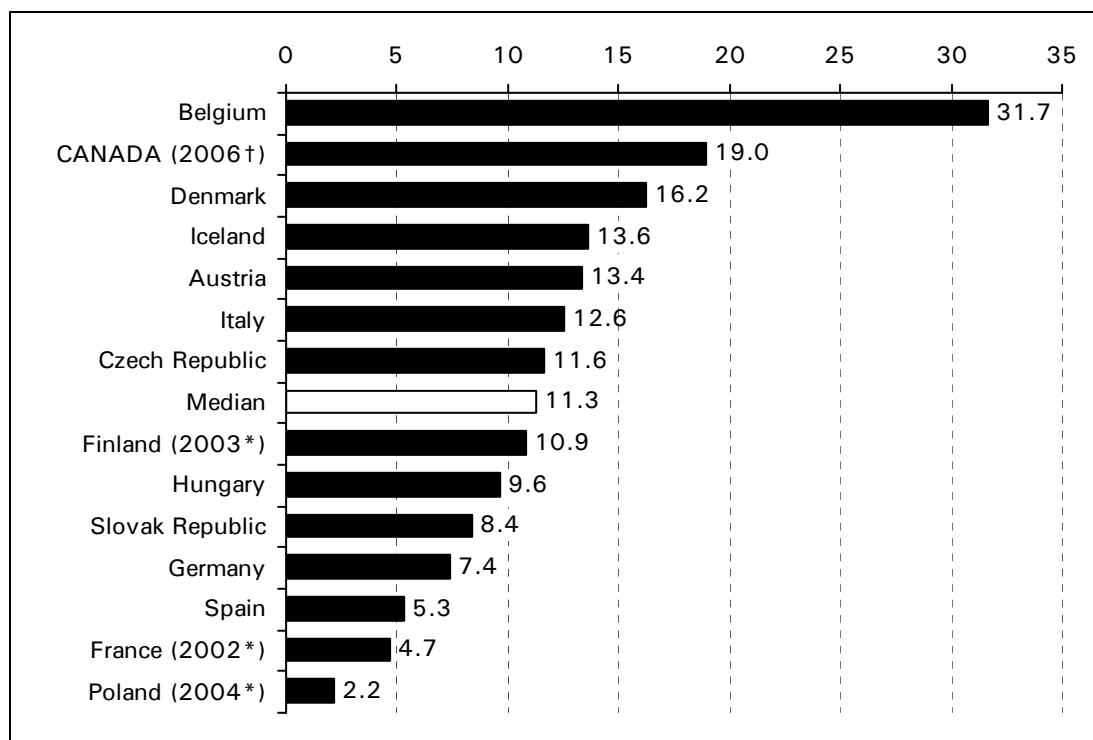
- Annual data on the number of machines are not available for every country. A dotted line is drawn between data points spanning two years or more.
- The U.K. was not included due to varying geographical coverage across years.
- There is a break in the Japanese series, as MRIs installed in the clinics are included for the first time in 2002. Data for earlier years include only MRI scanners in hospitals.
- The U.S. data reported in *OECD Health Data 2007* are from the Magnetic Resonance Imaging Census of IMV Limited, Medical Information Division. MRI scanners used for clinical purposes in both hospital and non-hospital sites are included. MRI scanners dedicated to research are excluded.
- Russia was not included, as data were unavailable.
- In Canada, units located in both hospitals and free-standing imaging facilities are included for all years. The number of MRI scanners in free-standing imaging facilities was imputed for years prior to 2003, based on data collected in the 2003 National Survey of Selected Medical Imaging Equipment.

Sources

OECD Health Data 2007, OECD; National Survey of Selected Medical Imaging Equipment (2003, 2004 and 2005), Canadian Institute for Health Information.

The Eurostat collects information on the number of gamma cameras, both hospital and non-hospital based, in European countries. A gamma camera (including single-photon emission computed tomography or SPECT) is used for a nuclear medicine procedure in which the camera rotates around the patient to register gamma-ray emissions from an isotope injected into the patient's body. The gathered data are processed by a computer to form a tomographic (cross-sectional) image. Figure 43 shows the number of gamma cameras per million population in 2005 in Canada and in OECD countries that reported to the Eurostat. Canada is among the countries with the highest rates of gamma cameras per million population.

Figure 43 Number of Gamma Cameras per Million Population in European Countries and Canada, 2005



Notes

- a) In Germany, data include equipment installed in acute care hospitals and in prevention and rehabilitation homes.
 - b) In Hungary, units in military hospitals and in the health institutes of Hungarian State Railways are not included.
 - c) In Spain, only units located in hospitals are included.
- * Latest year for which data are available.
† As of January 1, 2006.

Sources

Eurostat Health Care Statistics, 2007, Eurostat; National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

In its 2007 survey of high-tech medical imaging equipment, the Eurostat also collected data on the number of PET and PET/CT scanners (without distinction between the two technologies). PET imaging is best performed using a dedicated PET scanner. However, it is possible to acquire PET images using a conventional dual-head or multi-head gamma camera fitted with a coincidence detector. The quality of gamma-camera PET is considerably lower, and acquisition is slower. The number of PET scanners reported by some European countries might have included such gamma cameras. For this reason, the data on PET scanners collected in 2007 have not been released by the Eurostat. The 2008 survey questionnaire from the Eurostat will specifically ask that gamma cameras be excluded.

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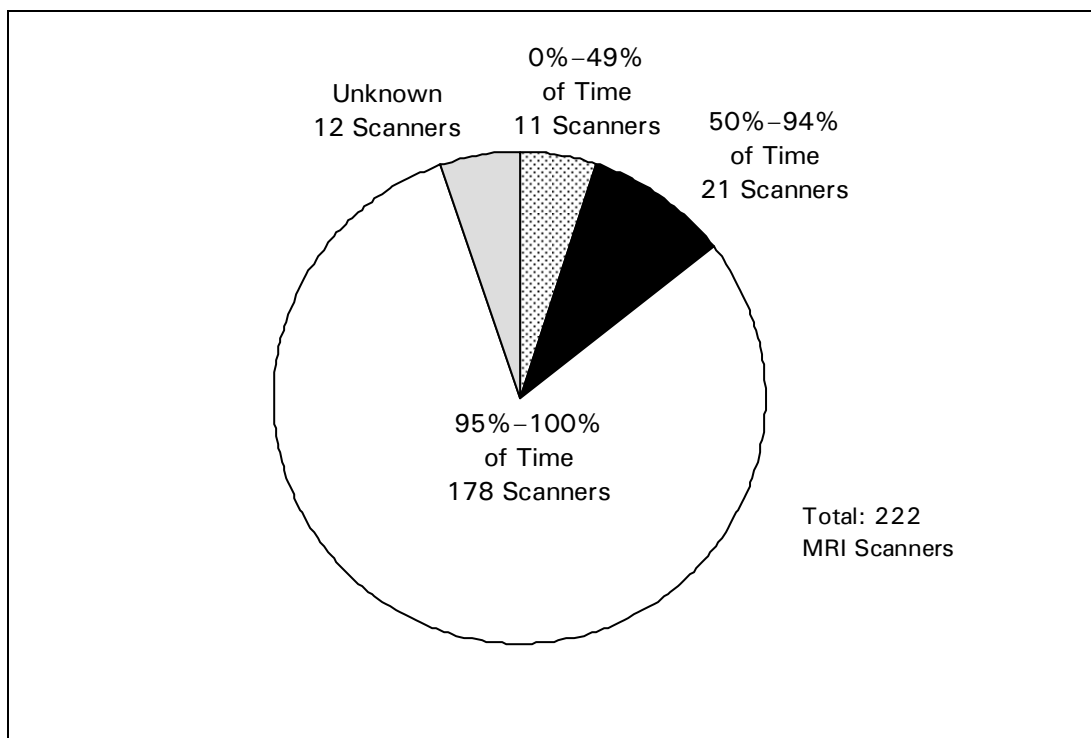
Chapter 3: Utilization of MRI and CT Technologies

This chapter presents the total number of MRI and CT exams, in each province and territory, and the rates per 1,000 population. It reports on three measures of utilization and workload for MRI and CT: the number of exams per scanner per year, the number of hours in operation per scanner per week and the number of exams per full-time equivalent (FTE) technologist. Number of exams per scanner is also reported for hospitals and free-standing facilities separately. Given that the number of MRI and CT scanners has increased in almost all the jurisdictions, the following question is then addressed: To what extent does this increase in supply translate to a proportional increase in utilization? Then, some performance indicators are compared to those in the U.S., England, Belgium, Denmark, Spain and Sweden.

Utilization of MRI and CT Scanners for Clinical Purposes Versus Research

This chapter addresses utilization of MRI and CT scanners for clinical purposes only. However, these scanners are not constantly used for this purpose. A few of them are used part of the time for research. Figures 44 and 45 show the number of MRI and CT scanners, respectively, by percentage of time the equipment is used for clinical purposes.

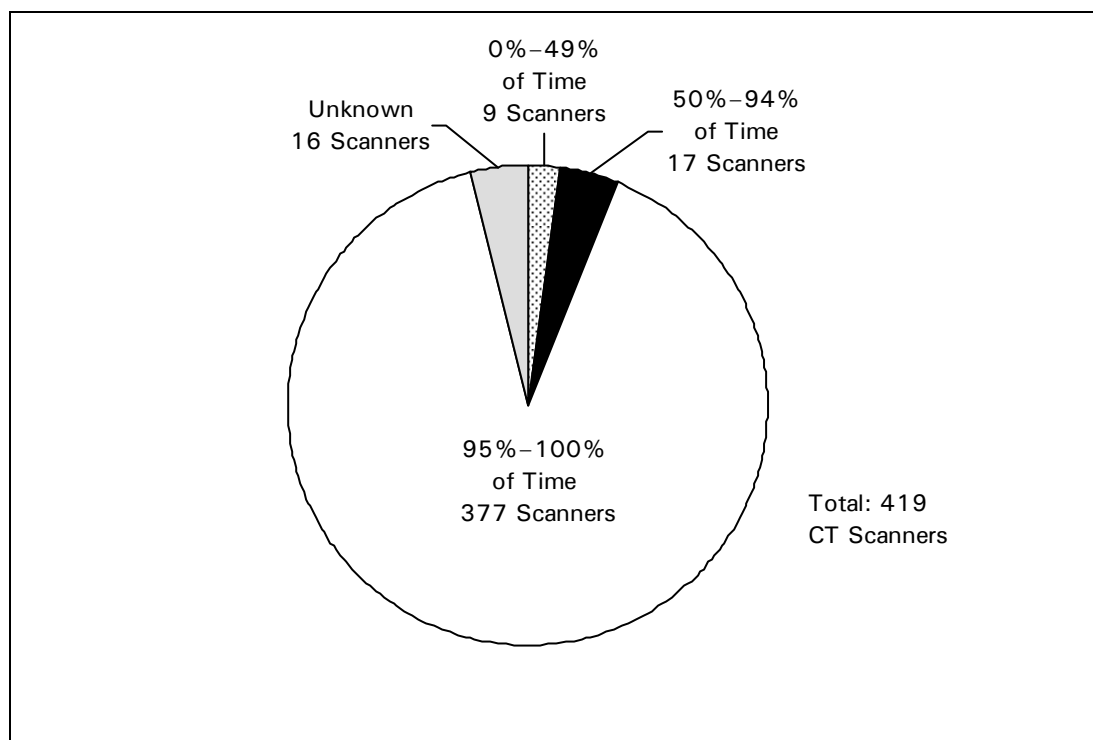
Figure 44 Number of MRI Scanners, by Percentage of Time the Equipment Is Used for Clinical Purposes, Canada, as of January 1, 2007



Source

National Survey of Selected Medical Imaging Equipment (2007), Canadian Institute for Health Information.

Figure 45 Number of CT Scanners, by Percentage of Time the Equipment Is Used for Clinical Purposes, Canada, as of January 1, 2007



Source

National Survey of Selected Medical Imaging Equipment (2007), Canadian Institute for Health Information.

It turns out that about 90% of the MRI scanners (199 out of 222) are used for clinical purposes half of the time or more; approximately 80% are used for clinical purposes virtually all the time (178 out of 222 are used for clinical purposes 95% to 100% of the time). Even though MRI scanners are mainly used for clinical purposes, the use of CT scanners for this purpose is even more widespread. About 94% of the CT scanners (394 out of 419) are used for clinical purposes half of the time or more; approximately 90% are used for clinical purposes virtually all the time (377 out of 419 are used for clinical purposes 95% to 100% of the time).

Number of MRI and CT Exams by Jurisdiction

The number of examsⁱ was collected only for MRI and CT in the 2004 National Survey of Selected Medical Imaging Equipment and for MRI, CT, PET/CT and SPECT/CT in the 2007 National Survey of Selected Medical Imaging Equipment. However, the discussion is focused mainly on MRI and CT exams.ⁱⁱ Respondents who indicated that their facility had

- i. An exam is defined as a technical investigation using an imaging modality to study one body structure, system or anatomical area that yields one or more views for diagnostic and/or therapeutic purposes (that is, one exam can include more than one scan). Exceptions include routinely ordered multiple body structures that by common practice or protocol are counted as one exam.
- ii. PET/CT scanners and SPECT/CT scanners were found in five and four jurisdictions, respectively, only. Moreover, only one jurisdiction reported SPECT/CT exams. So, number of exams from PET/CT and SPECT/CT scanners is excluded.

one or more of the four modalities were asked to report the number of exams performed during the fiscal year (April 1 to March 31) for the specified modality. Number of exams was imputed for scanners installed and in operation, but for which exams were not reported (for the imputation methods, see Appendix B).

Table 5 presents the total number of MRI and CT exams by jurisdiction and Canada, for 2003–2004 and 2006–2007. Note that the number of exams reported in this chapter is for scanners used 50% of the time or more for clinical purposes. No adjustment was made for the percentage of time; this means for a scanner that was used half of the time for clinical purposes and half of the time for research, all the exams were considered to be for clinical purposes. On the other hand, for a scanner that was used 49% or less of the time for clinical purposes and 51% or more of the time for research, all the exams were considered to be for research. The idea behind this approach is to exclude the scanners that are used for research most of the time.

Table 5 **Number of MRI and CT Exams, by Jurisdiction and Canada, 2003–2004 and 2006–2007**

Jurisdiction	MRI Exams		CT Exams	
	2003–2004	2006–2007	2003–2004	2006–2007
N.L.	5,856	8,544	52,428	68,434
P.E.I.	2,200	2,839	9,970	9,655
N.S.	22,485	24,584	122,717	130,818
N.B.	22,801	24,496	101,461	132,199
Que.	146,770	224,890	653,908	837,246
Ont.	324,186	446,681	909,813	1,193,705
Man.	17,825	38,028	105,298	131,099
Sask.	12,628	21,814	82,079	129,777
Alta.	85,096	139,516	254,637	367,557
B.C.	52,283	88,170	268,675	375,238
Y.T.	n/a	n/a	1,500	2,099
N.W.T.	n/a	n/a	1,750	2,770
Nun.	n/a	n/a	n/a	n/a
Canada	692,130	1,019,562	2,564,236	3,380,597

Note

n/a Not applicable.

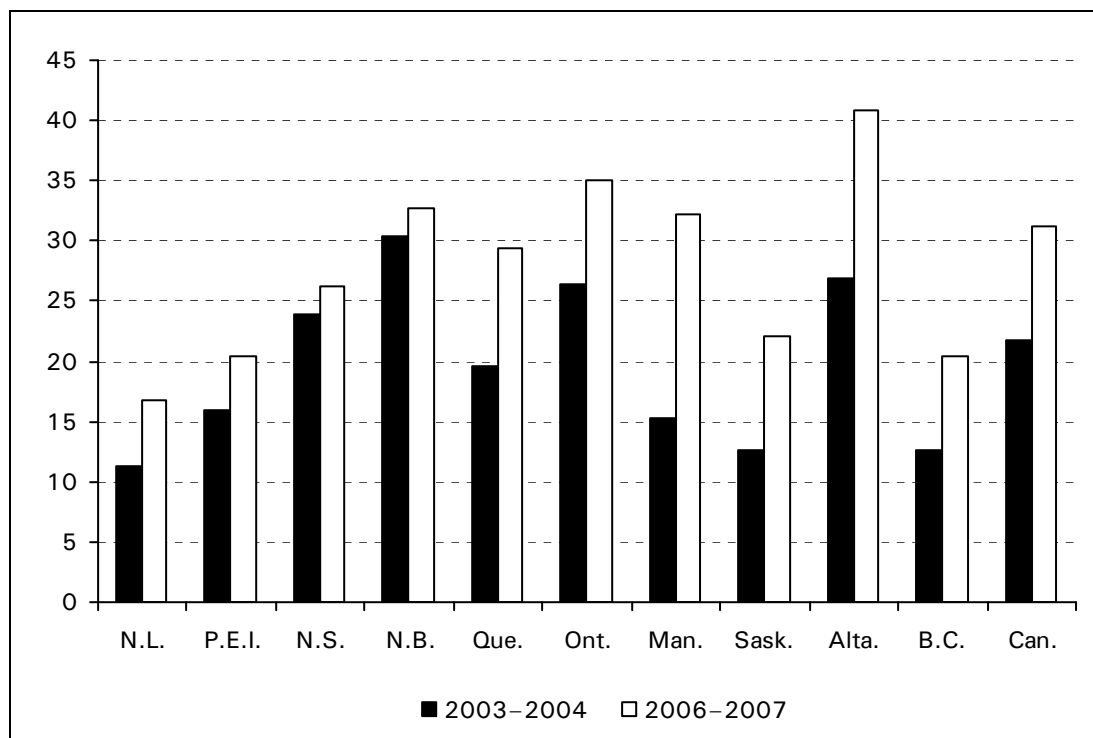
Source

National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information.

There were 1,019,562 MRI exams and 3,380,597 CT exams in Canada in 2006–2007. About 60% of these exams were performed in Ontario and Quebec, the two most populous provinces. In 2006–2007, the numbers of MRI exams were higher than in 2003–2004 in all provinces. The number of CT exams increased in 2006–2007 in all jurisdictions with the exception of P.E.I. At the national level, between 2003–2004 and 2006–2007, the number of MRI and CT exams increased at rates of 47.3% and 31.8%, respectively.

Figures 46 and 47, respectively, report the number of MRI and CT exams per 1,000 population.

Figure 46 Number of MRI Exams per 1,000 Population, by Jurisdiction and Canada, 2003–2004 and 2006–2007



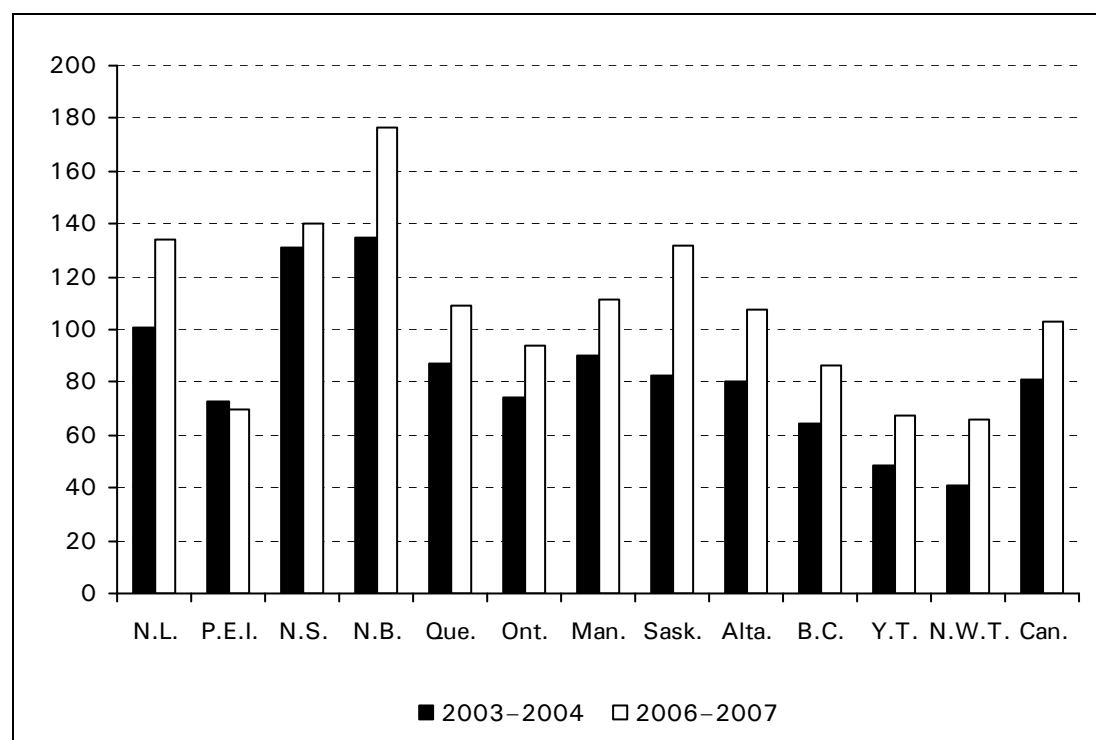
Note

The territories are excluded because they do not have MRI scanners.

Source

National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information; Statistics Canada.

Figure 47 Number of CT Exams per 1,000 Population, by Jurisdiction and Canada, 2003–2004 and 2006–2007



Note

Nunavut is excluded because there are no CT scanners in this territory.

Source

National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information; Statistics Canada.

In 2006–2007, MRI exams per 1,000 population ranged from 16.8 in Newfoundland and Labrador to 40.9 in Alberta. The Canadian average was 31.2, which represents an increase of 42.9% from 2003–2004. This increase may reflect a higher number of exams per user or a higher number of users among the general population, or a combination of both factors. Unfortunately, available data do not permit us to disentangle these two factors.

CT exams per 1,000 population, among the provinces, ranged from 69.7 in P.E.I. to 176.6 in New Brunswick in 2006–2007. The Canadian average reached 103.3,ⁱⁱⁱ an increase of 27.9% from 2003–2004.

Are Medical Imaging Scanners Operated Intensively?

Medical imaging equipment is generally associated with a large amount of capital and operating expenses, particularly for MRI and CT scanners. Given this fact, it could be interesting to know to what extent these pieces of equipment operate intensively or not.

iii. Due to their younger population, the territories have a low number of CT exams per 1,000 population. The territories are excluded from the range, but are included in the computation of the national average.

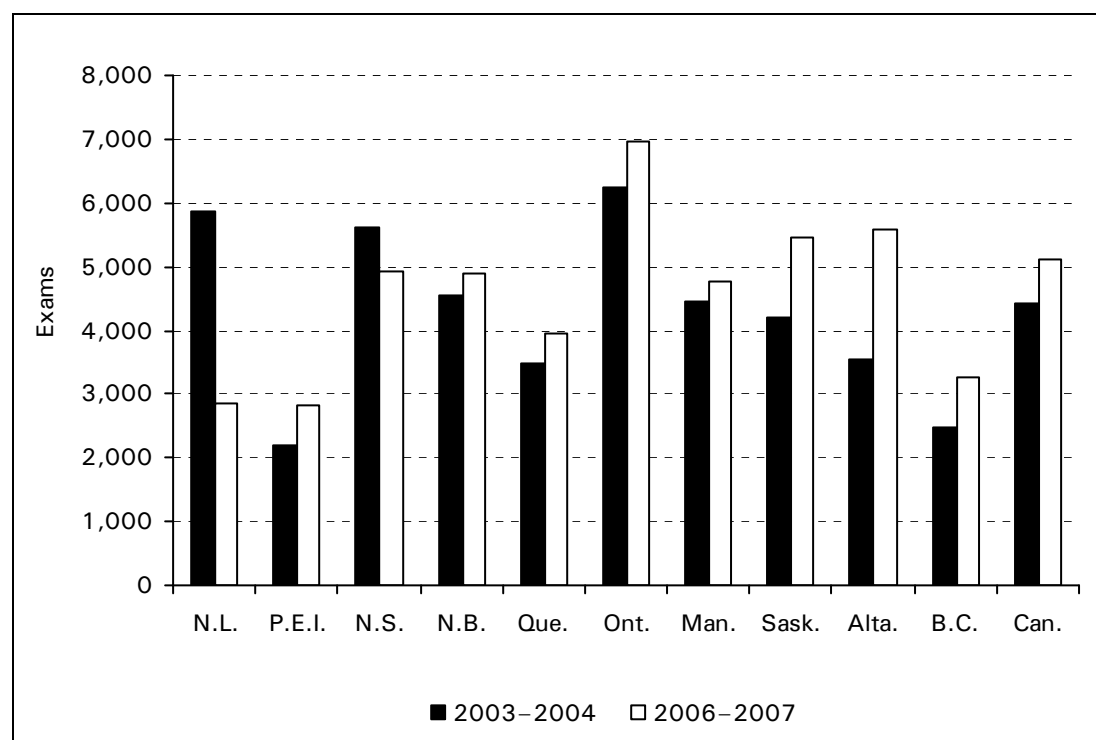
In order to assess the level of intensity in the use and operation of the pool of MRI and CT equipment in each jurisdiction and in Canada, three indicators of utilization and workload are used:

- Average number of exams per scanner per year;
- Average number of hours of operation per scanner per week; and
- Average number of exams per full-time equivalent (FTE) technologist.

Average Number of MRI and CT Exams per Scanner per Year

Average number of exams per scanner for a given jurisdiction is computed by dividing the total number of exams in the jurisdiction by the total number of scanners.^{iv} Figures 48 and 49 show the number of MRI and CT exams, respectively, per scanner for 2003–2004 and 2006–2007.

Figure 48 Average Number of MRI Exams per Machine per Year, by Jurisdiction and Canada, 2003–2004 and 2006–2007



Note

The territories are excluded because they do not have MRI scanners.

Source

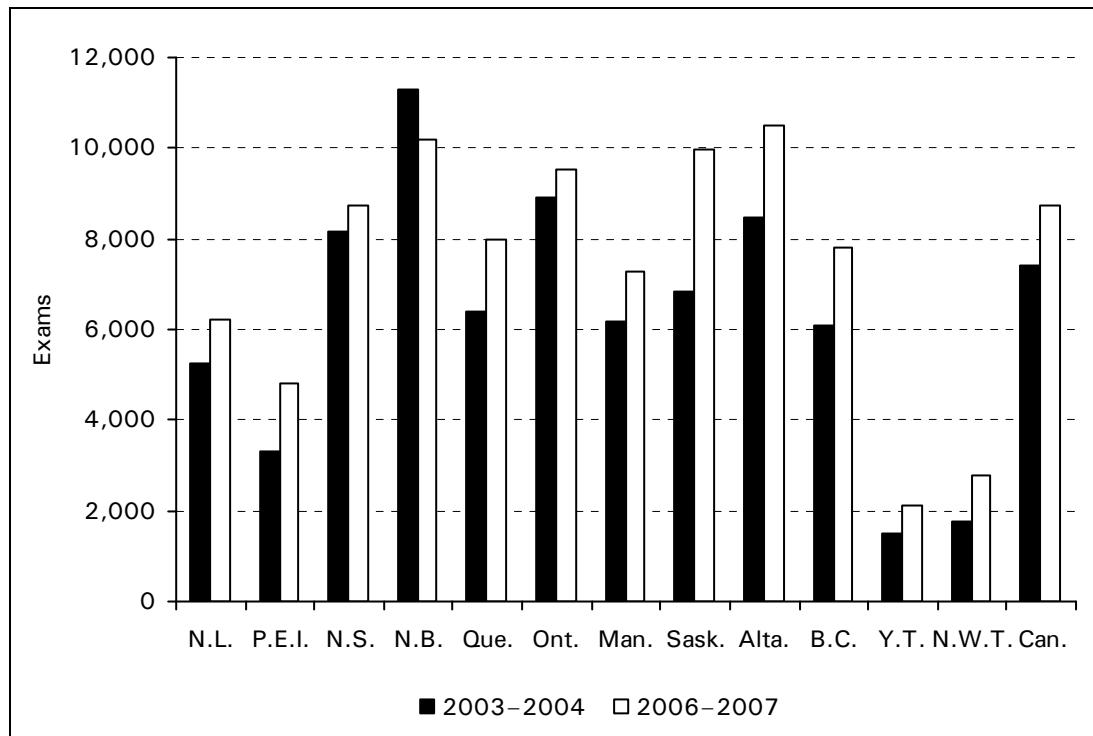
National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information.

iv. A mobile scanner is always counted as one scanner even though exams for this scanner may be reported by more than one site.

The average number of MRI exams performed per scanner in Canada was 5,123 in 2006–2007. This represents a substantial increase from the 1997 average (3,563) reported by Richard N. Rankin in the April 1999 issue of the *Canadian Association of Radiologists Journal*.¹ Among the provinces, the average number of exams per scanner in 2006–2007 ranged from 2,839 in P.E.I. to 6,979 in Ontario. In 2003–2004, the Canadian average was slightly lower than the average in 2006–2007, and the same two provinces held the lower and the upper limits of the range.

In 2006–2007, the number of exams per scanner decreased considerably in Newfoundland and Labrador, slightly in Nova Scotia. In these two cases, this was due to an increase in the denominator (the number of MRI scanners)—from one to three in Newfoundland and Labrador and from four to five in Nova Scotia.

Figure 49 Average Number of CT Exams per Machine per Year, by Jurisdiction and Canada, 2003–2004 and 2006–2007



Note

Nunavut is excluded because there are no CT scanners in this territory.

Source

National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information.

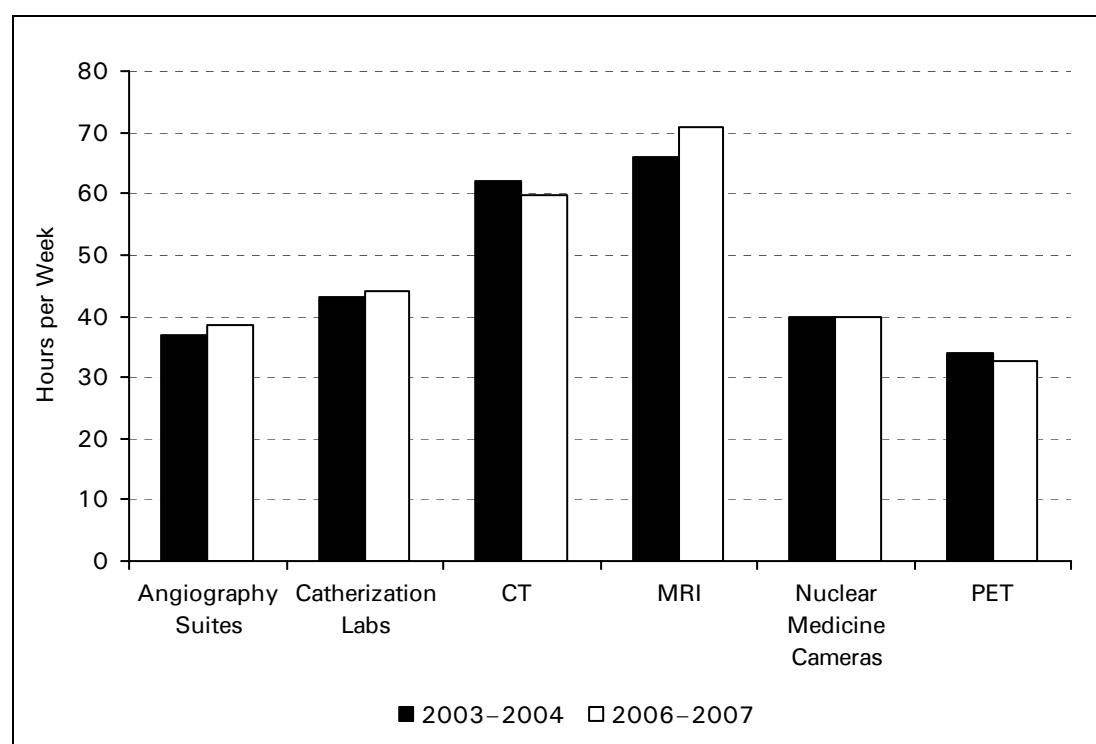
The average number of CT exams per scanner in Canada was 8,735 in 2006–2007. Among the provinces, the numbers ranged from 4,828 in P.E.I. to 10,502 in Alberta. In 2003–2004, the Canadian average was 7,411 exams per scanner, with the lower limits being held by P.E.I. and the upper limits being held by New Brunswick.

Average Hours of Operation of Medical Imaging Scanners per Week

The average operating time per week is another indicator of the level of utilization of medical imaging scanners. This information was collected in the National Survey of Selected Medical Imaging Equipment by asking respondents to report, for each type of equipment, the average number of hours the equipment was in operation on a weekly basis.

Average number of hours of operation by type of equipment per week for a given jurisdiction is computed by summing the average number of hours of operation per week reported for each scanner and dividing by the total number of scanners for which any hour of operation was reported. Figure 50 shows the average number of hours of operation per week by type of equipment in Canada. Table 6 provides the same information for each jurisdiction.

Figure 50 Average Number of Hours of Operation per Week, Selected Medical Imaging Technologies, Canada, 2003–2004 and 2006–2007



Source

National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information.

Table 6 Average Number of Hours of Operation per Week, Selected Medical Imaging Technologies, by Jurisdiction and Canada, 2003–2004 and 2006–2007

Jurisdiction	Appareils d'angiographie		Laboratoires de cathétérisme		Appareils de TDM		Appareils d'IRM		Caméras nucléaires		Appareils de TEP	
	2003–2004	2006–2007	2003–2004	2006–2007	2003–2004	2006–2007	2003–2004	2006–2007	2003–2004	2006–2007	2003–2004	2006–2007
N.L.	40	40	50	50	56	44	84	57	38	40	n/a	n/a
P.E.I.	10	n/a	n/a	n/a	37	40	40	40	45	45	n/a	n/a
N.S.	37	43	37	37	49	50	78	57	37	38	n/a	n/a
N.B.	29	31	40	40	45	52	43	42	41	40	n/a	n/a
Que.	35	35	41	41	67	56	58	54	41	39	33	30
Ont.	38	39	44	45	70	69	84	99	37	39	32	28
Man.	30	34	38	38	66	55	88	76	42	39	n/a	40
Sask.	50	50	44	46	46	59	52	68	40	40	n/a	n/a
Alta.	43	44	41	47	57	65	56	65	43	43	40	40
B.C.	37	41	49	49	52	54	54	55	43	45	28	34
Y.T.	n/a	n/a	n/a	n/a	35	38	n/a	n/a	n/a	n/a	n/a	n/a
N.W.T.	n/a	n/a	n/a	n/a	38	38	n/a	n/a	n/a	n/a	n/a	n/a
Nun.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Canada	37	39	43	44	62	60	66	71	40	40	34	33

Note

n/a Not applicable.

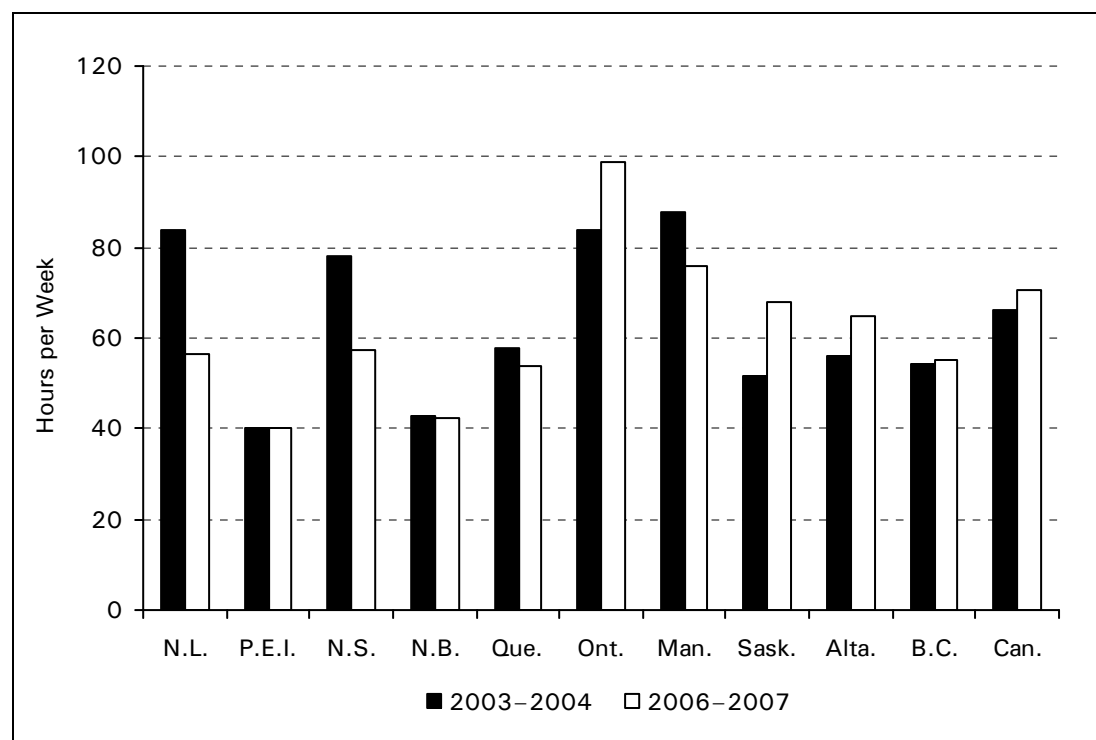
Source

National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information.

At the national level, the average number of hours of operation per week is generally higher for MRI and CT scanners than for the other types of equipment. For nuclear medicine cameras, angiography suites and catheterization labs, it tends to gravitate around a typical full-time workweek, while it is slightly lower for PET scanners. The pattern is similar for 2003–2004 and 2006–2007.

Figures 51 and 52 present the average number of hours of operation per week for MRI and CT scanners, respectively, in 2003–2004 and 2006–2007 by jurisdiction and Canada.

Figure 51 Average Number of Hours of Operation per Week, MRI Scanners, by Jurisdiction and Canada, 2003–2004 and 2006–2007



Note

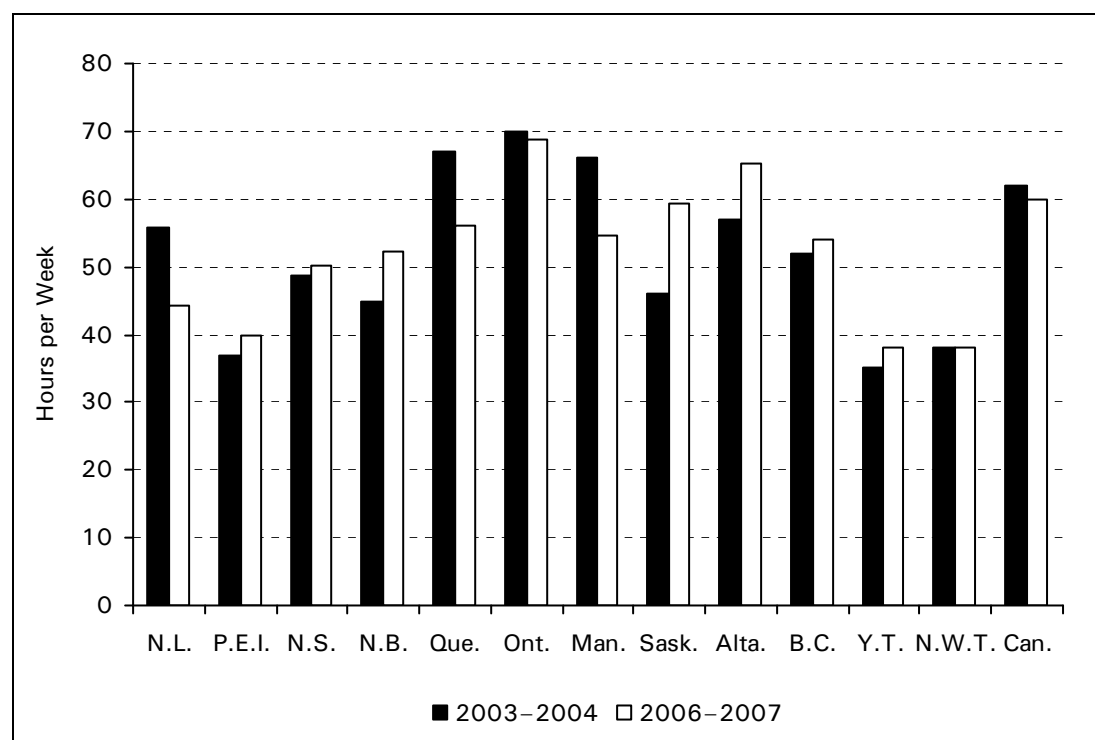
The territories are excluded because they do not have MRI scanners.

Source

National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information.

The average number of hours of operation per week for MRI scanners in 2006–2007 ranged from 40 hours in P.E.I. to 99 hours in Ontario. The Canadian average (71 hours) was higher than the 1997 average (64 hours) reported in the April 1999 issue of the *Canadian Association of Radiologists Journal*.¹ There is less variability in the number of hours of operation per week for CT scanners among provinces. In 2006–2007, the provincial averages ranged from 40 hours in P.E.I. to 69 hours in Ontario, with a national average of 60 hours.

Figure 52 Average Number of Hours of Operation per Week, CT Scanners, by Jurisdiction and Canada, 2003–2004 and 2006–2007



Note

Nunavut is excluded because there are no CT scanners in this territory.

Source

National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information.

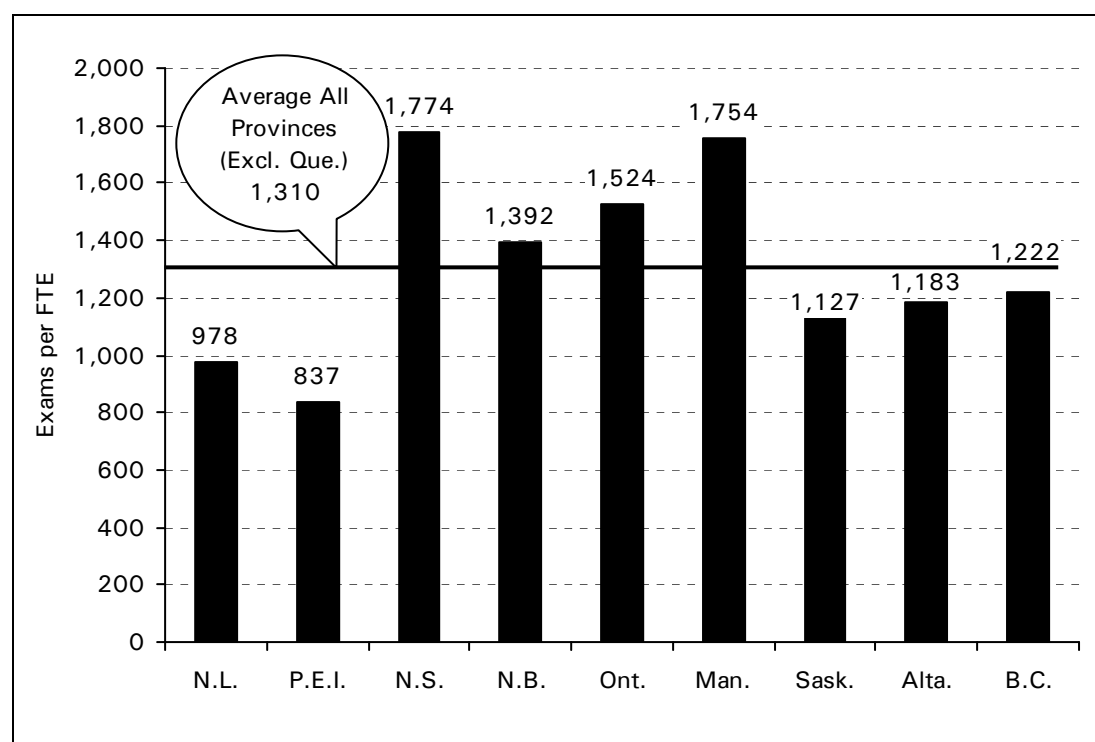
Jurisdictions with lower numbers of scanners per million population in 2006–2007 generally had longer hours of operation per week than jurisdictions with higher numbers of scanners per million population. This negative relationship between the number of scanners per million population and average hours of operation per week is stronger for CT than for MRI.^v

v. Based on a linear regression of the two variables, the coefficient of determination (R^2) = 0.81 for CT and 0.47 for MRI.

Average Number of Exams per FTE Technologist

Average number of exams per FTE technologist is a workload indicator that combines the efficiency of medical imaging equipment and the skills of medical imaging professionals. Average number of MRI exams per FTE for a given jurisdiction is the total number of MRI exams performed in hospitals for a one-year period divided by the total number of FTE technologists working in the MRI service. Total number of FTEs working in the MRI service is obtained from the Canadian MIS Database (CMDB) by summing earned hours of MRI technologists for a one-year period divided by 1950 (based on a 37.5-hour workweek and 52 weeks per year). The same method applies for CT. Figures 53 and 54 show average number of MRI and CT exams per FTE technologist for each province, except Quebec, for 2005–2006. All jurisdictions submit data on earned hours for unit-producing personnel by occupations in the CMDB, except Quebec and the territories. At the time of the analysis, CMDB data for 2006–2007 were not available.

Figure 53 Number of MRI Exams per FTE Technologist, by Province (Excluding Quebec), 2005–2006



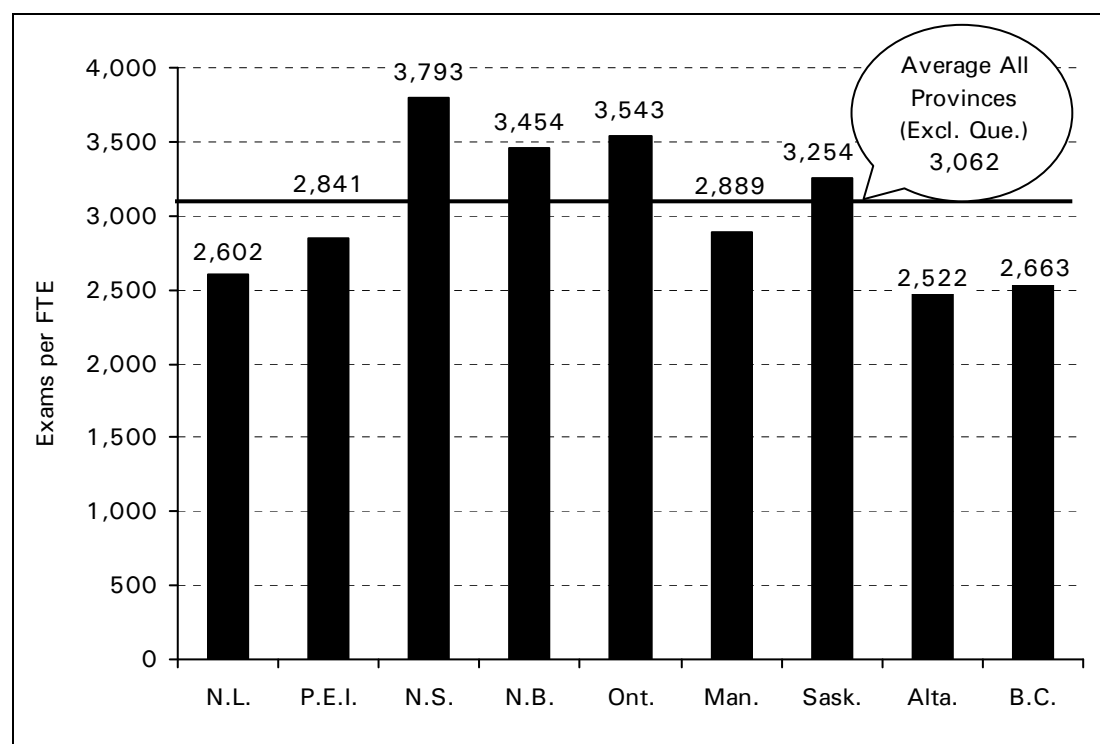
Notes

- The FTE analysis is based on FTE counts in hospitals and, therefore, only exams performed in hospitals are included.
- The territories are excluded because they do not have MRI scanners.

Sources

National Survey of Selected Medical Imaging Equipment (2006) and Canadian MIS Database (2005–2006), Canadian Institute for Health Information.

Figure 54 Number of CT Exams per FTE Technologist, by Province (Excluding Quebec), 2005–2006



Notes

- a) The FTE analysis is based on FTE counts in hospitals and, therefore, only exams performed in hospitals are included.
- b) The territories are excluded because of small number of cells.

Sources

National Survey of Selected Medical Imaging Equipment (2006) and Canadian MIS Database (2005–2006), Canadian Institute for Health Information.

Average number of MRI exams per FTE in 2005–2006 ranked from 837 in P.E.I. to 1,774 in Nova Scotia; the Canadian average was 1,310. Manitoba, Ontario and New Brunswick were also above the Canadian average. There was less variability in the average number of CT exams per FTE among the provinces. The numbers ranked from 2,522 in Alberta to 3,793 in Nova Scotia, with the Canadian average being 3,062. Ontario, New Brunswick and Saskatchewan were also above the Canadian average. In both cases, Quebec was excluded.^{vi}

Average number of exams per FTE in 2003–2004 was available only for New Brunswick and Ontario.^{vii} In 2005–2006, the number of CT exams per FTE in New Brunswick decreased by 14.9%. This was due to a considerable increase in the denominator (the

vi. The exclusion was due to the lack of mapping of Quebec statistical data with the Management Information System (MIS).

vii. Average number of MRI exams per FTE in 2003–2004 was 1,508 and 1,341, respectively, in Ontario and New Brunswick. Average number of CT exams per FTE in 2003–2004 was 3,273 and 4,058, respectively, in Ontario and New Brunswick.

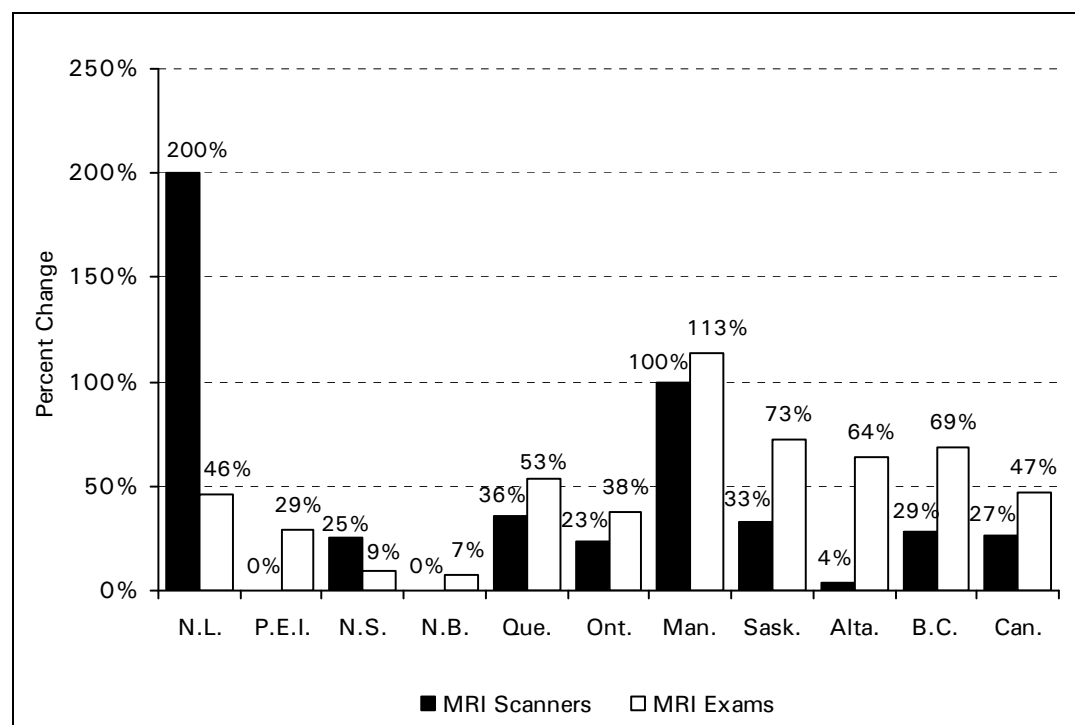
number of FTE technologists went from 25 in 2003–2004 to 33 in 2005–2006)^{viii} even though the numerator also increased (from 101,461 exams in 2003–2004 to 113,958 exams in 2005–2006).

In the other cases, the number of exams per FTE grew. For example, between 2003–2004 and 2005–2006, Ontario experienced an increase of 1.0% and 8.2% in the number of MRI and CT exams per FTE, respectively. New Brunswick kept about the same number of MRI exams per FTE in both periods.

Change in Number of Scanners Versus Change in Number of Exams

From 2003–2004 to 2006–2007, the number of MRI and CT scanners increased in Canada and in almost all the jurisdictions. To what extent does this increase in supply translate to an increase in utilization? Figures 55 and 56 show the change in number of scanners versus the change in number of exams for MRI and CT scanners, respectively.

Figure 55 Percentage Change in Number of MRI Scanners Versus Number of Exams, by Jurisdiction and Canada, 2003–2004 and 2006–2007



Note

The territories are excluded because they do not have MRI scanners.

Source

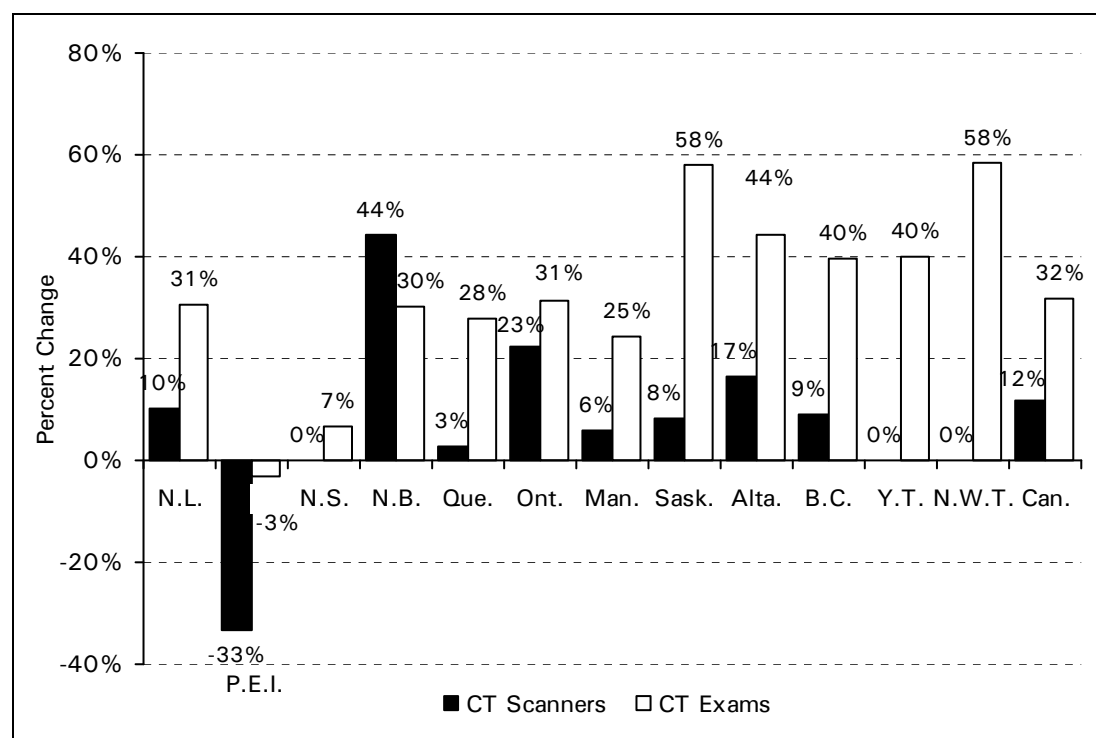
National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information.

At the Canada level, the increase in the number of exams was more than proportional to that in the number of scanners, both for MRI and CT. In the case of MRI, a 27% growth in the number of scanners led to a 47% growth in the number of exams (see Figure 55).

viii. In 2004–2005, there were 31 FTE technologists in New Brunswick.

However, the situation varied from one jurisdiction to another. The increase in the number of exams was less than proportional to that in the number of scanners for Newfoundland and Labrador and Nova Scotia, while for Quebec, Ontario, Manitoba, Saskatchewan, Alberta and B.C., the increase was more than proportional. Number of MRI scanners did not change in P.E.I. or New Brunswick. However, these two provinces still exhibited an increase in the number of MRI exams.

Figure 56 Percentage Change in Number of CT Scanners Versus Number of Exams, by Jurisdiction and Canada, 2003–2004 and 2006–2007



Note

Nunavut is excluded because there are no CT scanners in this territory.

Source

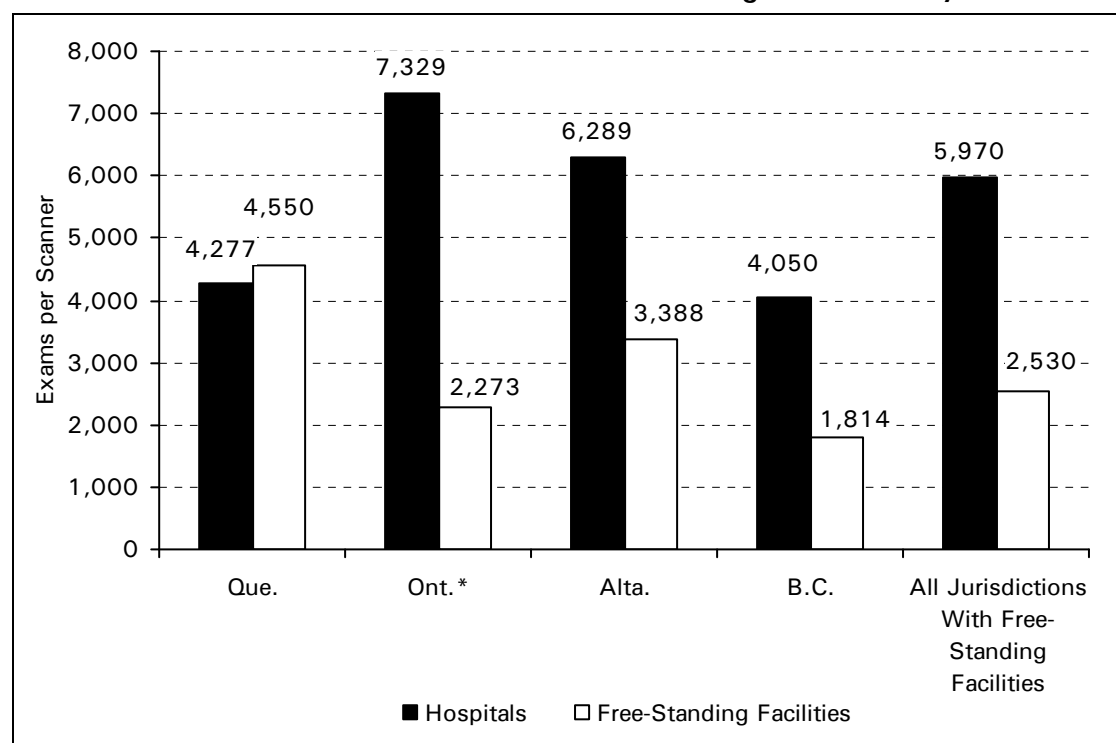
National Survey of Selected Medical Imaging Equipment (2004 and 2007), Canadian Institute for Health Information.

In the case of CT, a 12% growth in the number of scanners led to a 32% growth in the number of exams (see Figure 56). Again, the situation varied from one jurisdiction to another. The increase in the number of exams was less than proportional to that in the number of scanners for New Brunswick. However, for most of the provinces, the increase in the number of exams was more than proportional to that in the number of scanners. This was the case for Newfoundland and Labrador, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and B.C. It is worthwhile to note that Quebec increased its number of CT exams by 28% with very few additional scanners. In the case of P.E.I., there was a drop of 33% in the number of CT scanners (from three to two), but the number of CT exams declined only slightly, at 3%. Numbers of CT scanners did not change in the case of Nova Scotia, the Yukon or the Northwest Territories; however, these jurisdictions still exhibited an increase in the number of CT exams.

Average Number of Exams per Scanner in Hospitals Versus Free-Standing Facilities

In general, scanners in hospitals are used more intensively than scanners in free-standing facilities. For jurisdictions with MRI scanners in free-standing facilities (Nova Scotia, Quebec, Ontario, Manitoba, Alberta and B.C.), the average number of MRI exams per scanner was 5,970 in the hospital setting compared with 2,530 in the free-standing setting (see Figure 57). This suggests that hospitals perform about twice the number of MRI exams per scanner than free-standing facilities (a ratio of 2.4 to 1). However, the difference between the two settings in the intensity of utilization varied from one jurisdiction to another: in Quebec, the average number of exams per MRI scanner in free-standing facilities was slightly higher than in hospitals (4,550 versus 4,277) while in other provinces the hospital setting always performed more exams per scanner than the free-standing facilities. The biggest difference was in Ontario (7,329 MRI exams per scanner in hospitals versus 2,273 in free-standing settings, a 222.4% difference or a ratio of 3.2 to 1). So, scanners in free-standing facilities are more intensively used in Quebec than in any other jurisdiction.

Figure 57 Average Number of Exams per MRI Scanner in Hospitals Versus Free-Standing Facilities, Jurisdictions With Free-Standing Facilities Only, 2006–2007[†]



Notes

* There is only one free-standing facility reporting MRI exams in Ontario.

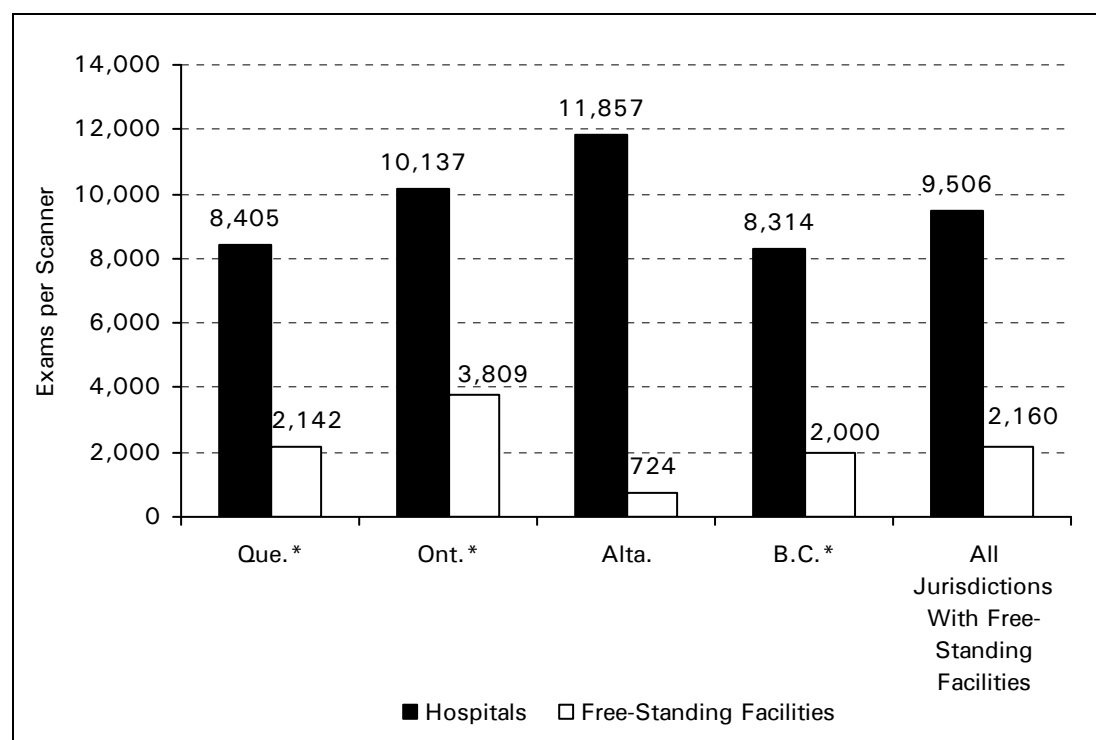
† All scanners in operation for one year or more and for which exams were reported. Jurisdictions with only one MRI scanner in free-standing facilities (Nova Scotia and Manitoba) are not shown separately. The MRI scanner at the Pan Am Community Clinic in Manitoba is counted with scanners in hospitals.

Source

National Survey of Selected Medical Imaging Equipment (2007), Canadian Institute for Health Information.

For jurisdictions with CT scanners in free-standing facilities (Quebec, Ontario, Alberta and B.C.), the average number of CT exams per scanner was 9,506 in the hospital setting compared with 2,160 in the free-standing setting (see Figure 58). Number of CT exams per scanner performed in hospitals was more than four times that in free-standing facilities (a ratio of 4.4 to 1). The difference between the two settings in the intensity of utilization was very substantial for each of the jurisdictions. Alberta was the jurisdiction with the highest difference (11,857 CT exams per scanner in hospitals versus 724 in free-standing facilities; a ratio of 16.4 to 1). So, utilization of CT scanners was consistently lower in free-standing facilities.

Figure 58 Average Number of Exams per CT Scanner in Hospitals Versus Free-Standing Facilities, Jurisdictions With Free-Standing Facilities Only, 2006–2007[†]



Notes

* There is only one free-standing facility reporting CT exams in Quebec, Ontario and B.C.

† All scanners in operation for one year or more and for which exams were reported.

Source

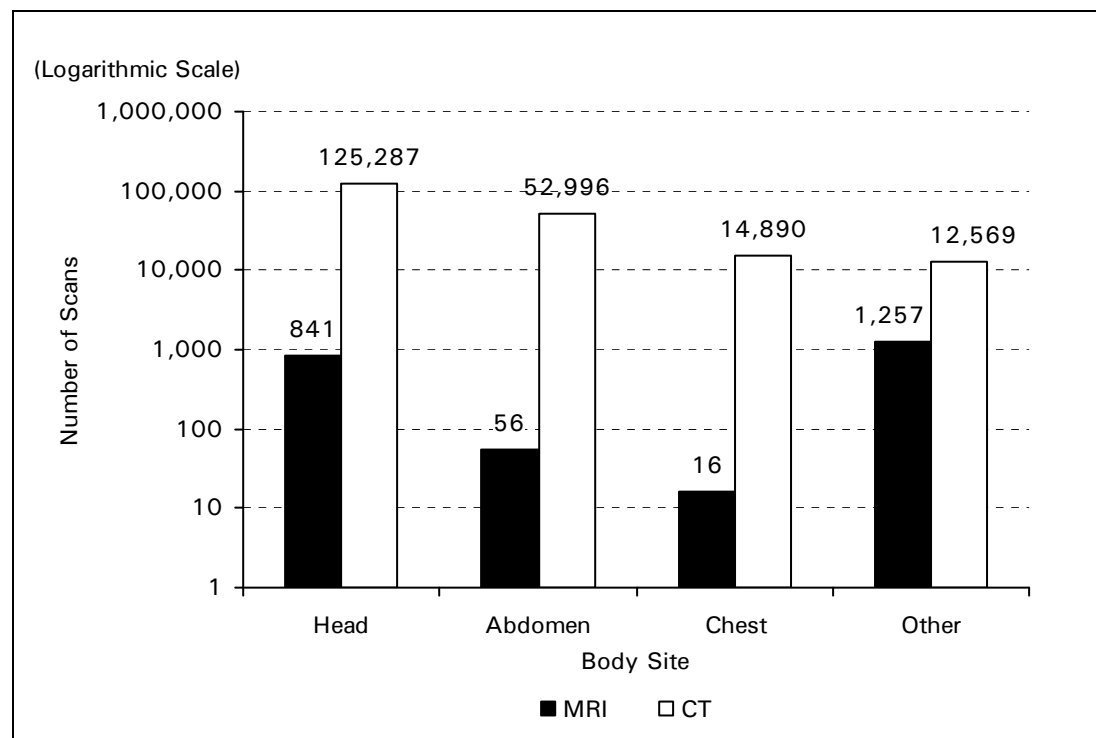
National Survey of Selected Medical Imaging Equipment (2007), Canadian Institute for Health Information.

Emergency Scans by Body Site, Selected Jurisdictions

MRI and CT scanners have some overlapping functions (see Chapter 1). CT is generally preferred for rapidly screening trauma victims to detect internal bleeding or other life-threatening conditions. Figure 59 shows the distribution of MRI and CT scans by body site for the jurisdictions reporting to the National Ambulatory Care Reporting System (NACRS). For 2005–2006, these jurisdictions were P.E.I., Nova Scotia, Ontario, B.C. and the Yukon. Of the 205,742 CT scans that were reported in 2005–2006 in emergency departments in

these jurisdictions,^{ix} 60.9% of these tests (125,287) were head scans and another 25.8% (52,996) were scans of the abdomen. By comparison, only 2,170 MRI scans were performed in total.

Figure 59 Number of MRI Scans and CT Scans, by Body Site in Emergency Departments, NACRS-Reporting Jurisdictions, 2005–2006



Notes

- a) The NACRS-reporting jurisdictions are P.E.I., Nova Scotia, Ontario, B.C. and the Yukon.
- b) "Other" includes scans not otherwise specified.

Source

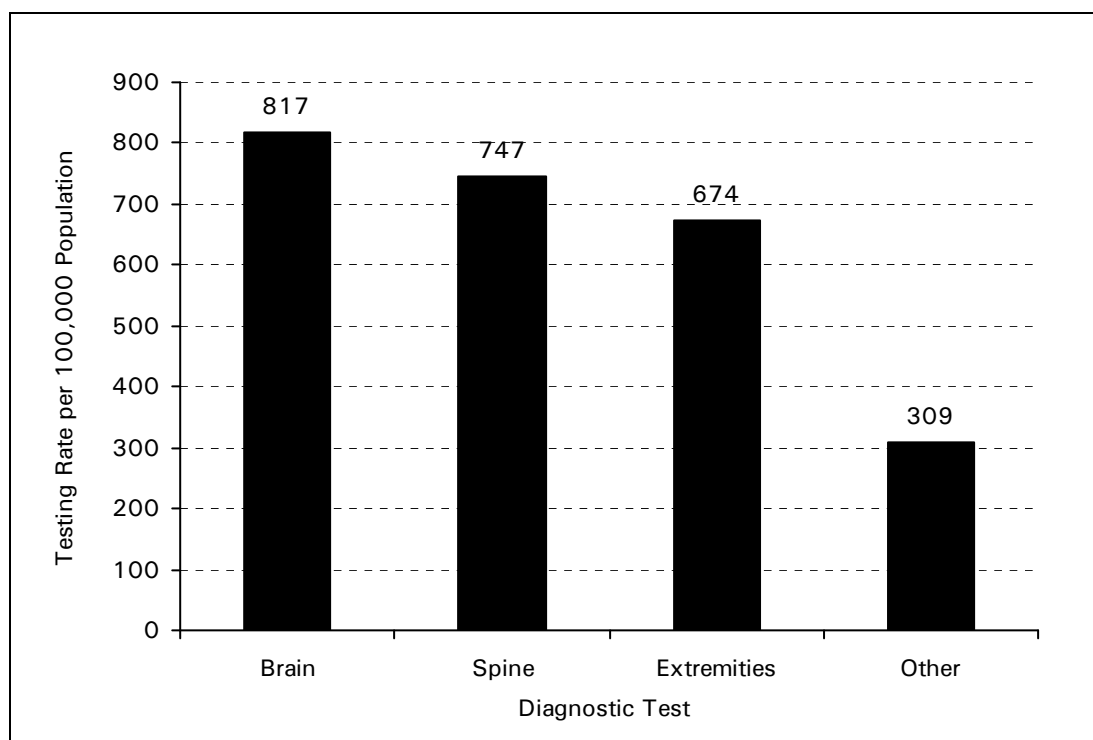
National Ambulatory Care Reporting System, Canadian Institute for Health Information.

ix. Ontario has the most comprehensive data reporting in NACRS. For example, 98.3% of the CT scans reported were in Ontario (202,218 out of 205,742).

Emergency and Non-Emergency Scans by Body Site, Ontario

The utilization of MRI and CT varies depending on whether the service is emergency or non-emergency and the body part being scanned. Figure 60 shows that for outpatients in Ontario, scanning of the brain is the most frequent type of MRI procedure, followed by scans on the spine and the extremities. By contrast, although scanning of the brain is the most frequent type of CT for emergency care in Ontario and in other NACRS-reporting jurisdictions, the most common type of CT scan for inpatients/outpatients is of the abdomen/pelvis, as indicated in Figure 61.

Figure 60 Testing Rate per 100,000 Population for MRI Exams by Anatomical Site, Ontario, 2005–2006



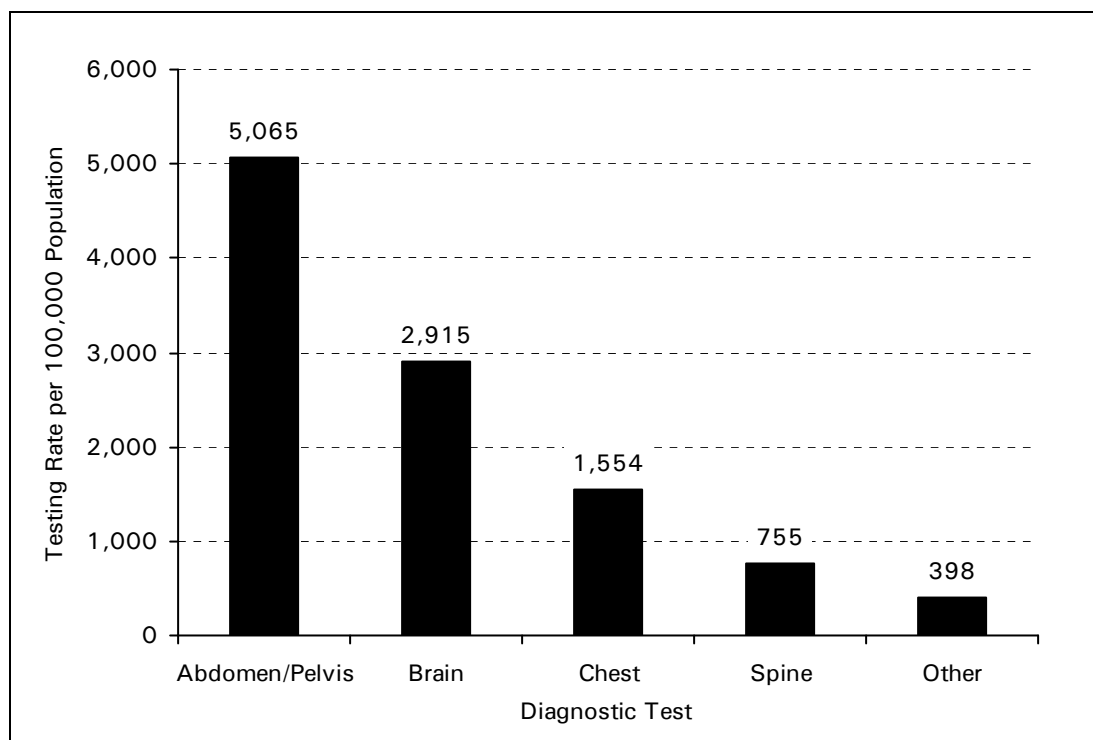
Notes

- a) "Other" includes scans not otherwise specified.
- b) MRI exams are for outpatients only.

Source

Institute for Clinical Evaluative Sciences, Diagnostic Services in Ontario: Descriptive Analysis and Jurisdictional Review (April 2007, Revised).

Figure 61 Testing Rate per 100,000 Population for CT Exams by Anatomical Site, Ontario, 2005–2006



Notes

- a) "Other" includes scans not otherwise specified.
- b) CT exams are for inpatients and outpatients

Source

Institute for Clinical Evaluative Sciences, Diagnostic Services in Ontario: Descriptive Analysis and Jurisdictional Review (April 2007, Revised).

International Comparisons

While the chapter on supply of medical imaging technologies provides comparisons on number of scanners for quite a number of OECD countries for which data were available, this chapter on utilization compares indicators with only the U.S., England, Belgium, Denmark, Spain and Sweden because such indicators are less readily available in other countries.

Table 7 compares MRI and CT exams per 1,000 population, per scanner and per FTE diagnostic imaging technologist, as well as hours of operation of scanners per week, among the above-mentioned countries for which indicators are available.

Table 7 Average Number of MRI and CT Exams per 1,000 Population, per Scanner, per FTE Technologist, and Average Number of Hours of Operation of Scanners per Week for Selected Countries, 2006–2007 or Latest Available Year

Country	Exams per 1,000 Population		Exams per Scanner		Exams per FTE		Hours of Operation per Scanner per Week	
	MRI	CT	MRI	CT	MRI	CT	MRI	CT
United States	88.9	207.4	3,460 ^a	6,108 ^b	1,175	1,960	69.1	58.0
England ^c	24.8	53.7	4,558	--	--	--	--	--
Belgium	43.0	138.3	6,584 ^d / 5,740 ^e	5,772 ^f / 4,810 ^g	--	--	--	--
Denmark	17.4	33.9	1,672	2,448	--	--	--	--
Spain	21.4	57.0	1,498	2,690	--	--	--	--
Sweden	38.9	88.9	3,500	5,000	--	--	--	--
Canada	31.2	103.3	5,123	8,735	1,310^h	3,062^h	70.7	59.9

Notes

-- Not available.

a) Based on exams performed in hospital sites with fixed MRI scanners.

b) Based on the total number of CT exams and total number of fixed CT scanners. It is implicitly assumed that the 0.8% of sites (65 out of 7,650) using mobile scanners perform a negligible number of exams.

c) Includes exams in the public sector only for 2006–2007. For this reason, exams per 1,000 population cannot be directly compared with Canada.

d) Based on 68 approved MRI scanners in 2004 (Source: ministry of public health).

e) Based on 78 MRI scanners for clinical purposes in 2004 (Source: Survey Struyven, Consilium Radiologicum).

f) Based on approximately 250 CT scanners in 2004 (Source: Consilium Radiologicum).

g) Based on approximately 300 CT scanners in 2004 (Source: OECD and COCIR or European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry).

h) Rates of exams per FTE for Canada are for 2005–2006 and exclude Quebec.

Sources

U.S.: IMV, Medical Information Division, Benchmark MRI and CT Reports, 2006; England: KH12 returns, UK Department of Health, Hospital Activity Statistics, 2006–2007 for number of exams, and communication with P. White, Health Horizons, Ltd. for number of scanners; Belgium, Denmark, Spain and Sweden: Belgian Health Care Knowledge Centre (KCE); 2006. KCE reports 37C (D/2006/10.273/34); Canada: National Survey of Selected Medical Imaging Equipment (2006 and 2007) and Canadian MIS Database, 2005–2006, Canadian Institute for Health Information.

Although the U.S. has more than four times as many MRI scanners per million population as Canada (see Figure 42), the number of MRI exams per 1,000 population performed in the U.S.^x was just 2.9 times that in Canada.^{2, 3} The number of MRI exams per scanner was 48.1% higher in Canada than in the U.S., explaining the smaller difference between the two countries in exams per 1,000 population than in scanners per million population. The number of MRI exams per FTE technologist was 11.5% higher in Canada than in the U.S. With regard to CT, the number of exams per 1,000 population in the U.S. was almost twice that in Canada. However, both the number of exams per scanner and the number of exams per FTE technologist were substantially higher in Canada than in the U.S. For both MRI and CT, the data indicate that even though the U.S. has more scanners per million population than Canada, the scanners were used more intensively in Canada. There is evidence of oversupply of some medical technology equipment in the U.S., including MRI and CT scanners.^{4, 5} Note that MRI and CT scanners were in operation for about the same number of hours in both Canada and the U.S.

The number of exams per 1,000 population and exams per scanner reported for England⁶ in Table 7 is for the public sector only. According to data reported in the section on Sources and Methods of *OECD Health Data 2007*,⁷ up to 24% of MRI scanners in England were in the private sector (estimate of 88 MRI scanners). Therefore, there is an underestimation of exams per 1,000 population in England. For this reason, no direct comparison can be made for the number of exams per 1,000 population between Canada and England. However, number of exams per scanner is not likely to be underestimated. Therefore, comparison can be made in the case of this indicator.

There were 12.4% more MRI exams per scanner in Canada than in England.^{xi} Within the U.K., a separate count of CT scanners for England was unavailable. Therefore, it was not possible to report CT exams per scanner for England.

A Belgian study⁸ reports average MRI and CT activity level per 1,000 population and per scanner for some selected countries or jurisdictions. It uses figures from the International Network of Agencies for Health Technology Assessment (INAHTA) survey. The figures are for 2004 and are used in the case of Belgium, Denmark, Spain and Sweden. However, it should be noted that most of the indicators for England, the U.S. and Canada are for 2006–2007.

Belgium scored higher than Canada for the number of MRI and CT exams per 1,000 population. The number of MRI and CT exams per 1,000 population was 38.0% and 33.9% higher, respectively, in Belgium than in Canada. Note that Belgium had 10% more MRI scanners per million population than Canada; it also had almost three times as many CT scanners per million population as Canada. Belgium also scored higher than Canada for number of MRI exams per scanner. However, this was not the case for number of CT exams per scanner. Using the highest estimates, Belgium performed about 30% more MRI exams per scanner than Canada, but Canada performed almost 50% more CT exams per scanner than Belgium.

x. A definition of exams is not provided in the U.S. report. However, further investigation suggests that an exam in the U.S. is defined as the number of scans relating to one body part.

xi. A definition of exams is not provided in the imaging and radio-diagnostics annual statistics for England. However, further investigation suggests that the data should be reported as one unit of activity for each time the scanner is operated.

On the other hand, Canada scored higher than Sweden in the utilization-based indicators, except for the number of MRI exams per 1,000 population, where Sweden performed 24.9% more.^{xii} It is interesting to note that even though Sweden had about 1.5 times as many CT scanners per million population as Canada, Canada still performed about 16% more CT exams per 1,000 population than Sweden. Finally, Canada scored higher than Denmark and Spain in both the number of MRI and CT exams per 1,000 population^{xiii} and the number of MRI and CT exams per scanner.

In spite of the fact that on average, Canada uses its MRI and CT scanners more intensively than the U.S. and some European Union countries, in some jurisdictions, both average number of exams and average number of hours in operation seem to indicate an underutilization of MRI and CT scanners (see figures 48 to 52 and Table 6). In an article entitled *Could MRI and CT Scanners Be Operated More Intensively in Canada*,⁹ it has been estimated that an additional 31% operating capacity may exist for MRI and 68% for CT without additional capital or infrastructure investments. These averages hide substantial provincial variations.

Many factors might explain the low number of exams performed per scanner in a given jurisdiction: insufficient operating funds, staffing unavailability, population density, geographic location, access, age of equipment, technical problems, etc.

xii. Sweden had almost twice as many MRI scanners per million population as Canada.

xiii. Even though both Denmark and Spain scored higher than Canada in the number of MRI and CT scanners per million population.

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4. P. B. Ginsburg and J. M. Grossman, "When The Price Isn't Right: How Inadvertent Payment Incentives Drive Medical Care," *Health Affairs—Web Exclusive* (August 9, 2005): pp. 376–384.
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8. P. Demaerel et al., *Magnetic Resonance Imaging. Health Technology Assessment (HTA)*. (Brussels, Belgium: Belgian Health Care Knowledge Centre [KCE], 2006) KCE reports 37C (D/2006/10.273/34).
9. R. Ariste and G. Fortin, "Could MRI and CT Scanners Be Operated More Intensively in Canada" *Healthcare Policy* 3, 1 (August 2007).

Chapter 4: Medical Imaging Professionals

Today's most sophisticated imaging technologies require skilled professionals to guide patients through the testing process; design, install, operate and maintain the equipment; interpret imaging results; and perform the many other functions that are essential to providing effective imaging services. This chapter focuses on what we know about the many professionals who work with X-rays, ultrasounds, MRIs, CTs and other types of medical imaging equipment.

Who's Who in Medical Imaging

Medical imaging professionals are a diverse group.ⁱ A growing and changing array of trained imaging professionals work together across the country. The size, composition, distribution and inter-relationships among these professionals can vary depending on the imaging facility, the geographic location of the facility and the exam being performed.

Imaging services often involve referring physicians who order imaging tests and inform patients of their results; technologists who operate the equipment and ensure patient safety; radiologists or nuclear medicine specialists who supervise the exams, read and interpret exam results and consult with referring physicians; nurses who assist with any clinical requirements, such as sedation, breast examination or injections; clerical staff who book appointments; medical physicists who ensure optimal performance of equipment; and service engineers who maintain and service equipment. Other professionals—such as dentists, chiropractors and obstetricians/gynecologists—may also use medical imaging equipment as part of the services that they offer to patients. Figure 62 reports the number of selected medical imaging professionals in 2006.

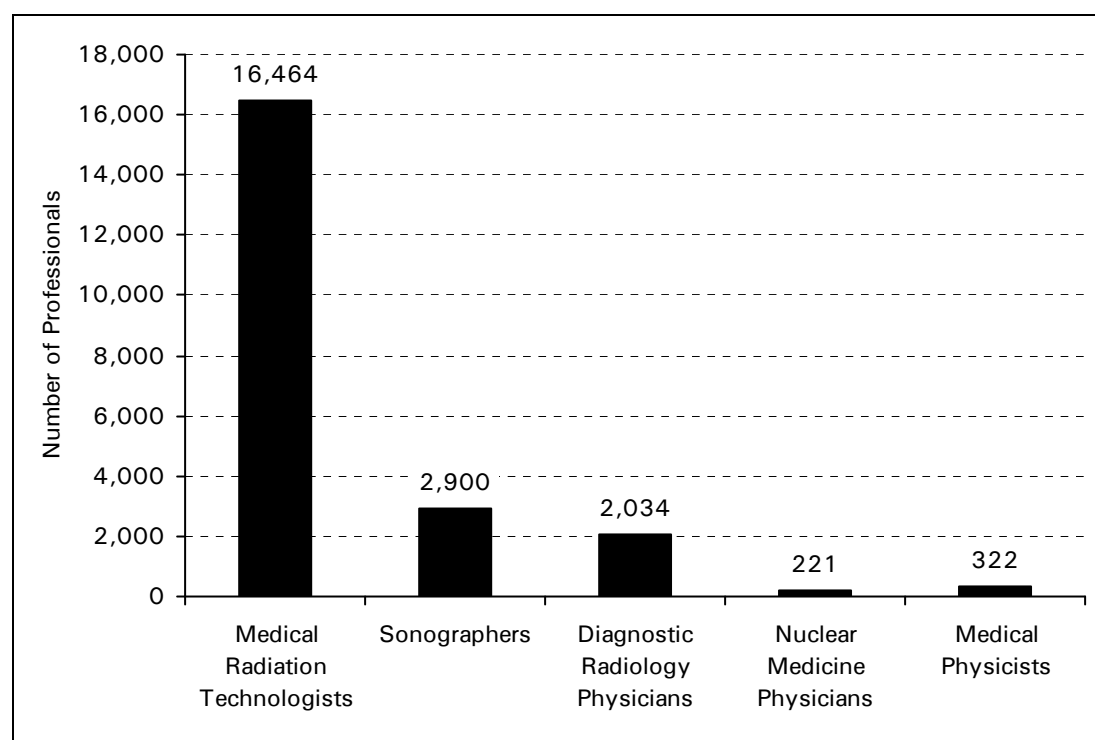
Medical Radiation Technologists

Canada's 16,464 medical radiation technologists (MRTs) made up the bulk of the medical imaging workforce in 2006. They include radiological, nuclear medicine, radiation therapyⁱⁱ and magnetic resonance technologists.

Radiological technologists, also called radiographers, comprised about 74% (12,255, see Appendix A, Table A.6) of all active MRTs in 2006. They often work in hospitals or free-standing imaging facilities to produce diagnostic X-ray images of specified parts of the body and conduct some therapeutic procedures. Radiological technologists may operate X-ray equipment including plain film radiography, mammography, angiography, fluoroscopy and computed tomography. A radiographer can further specialize in the area of magnetic resonance imaging.¹

i. Detailed role descriptions of physician specialists in imaging (<http://www.rcpsc.medical.org>), MRTs (<http://www.camrt.ca>), sonographers (<http://www.csdms.com>) and medical physicists (<http://www.medphys.ca>) can be found at their respective websites.

ii. For the purpose of this report we focus on diagnostic technologists (radiological, MRI and nuclear medicine technologists) rather than therapeutic sub-disciplines (radiation therapy).

Figure 62 Number of Selected Medical Imaging Professionals, Canada, 2006**Notes**

- a) MRT category includes radiological technologists, magnetic resonance technologists, nuclear medicine technologists and radiation therapists.
- b) Estimate for sonographers should be used with caution due to small size of survey sample.
- c) Physician data are as of December 31, 2006, and include physicians in clinical and/or non-clinical practice. Data exclude residents and physicians who are not licensed to provide clinical practice and those who have requested of the Business Information Group (formerly Southam Medical Group) that their data not be published. Specialty is based on most recent certified specialty, and data may differ from other sources of provincial or territorial physician data that categorize physicians on some other basis (for example, functional specialty, payment specialty or provisional licences). Diagnostic radiology and nuclear medicine physicians include certificants of the Royal College of Physicians and Surgeons of Canada or the Collège des médecins du Québec.
- d) Data for medical physicists include only those registered with the Canadian Organization of Medical Physicists.

Sources

Labour Force Survey, Statistics Canada (sonographer data); Scott's Medical Database, Canadian Institute for Health Information (physician data); Health Personnel Database, Canadian Institute for Health Information (medical physicists and MRT data).

Nuclear medicine technologists (NMTs) comprise about 11% of all MRTs. These professionals also work primarily in hospitals and in free-standing imaging facilities. The 1,781 NMTs across Canada (see Appendix A, Table A.5) administer radioactive materials (tracers) and operate special detectors (gamma cameras) and computers to produce diagnostic images of body function.¹ Nuclear medicine technologists may also assist with some treatment procedures, and some are trained to operate PET scanners. Like radiological technologists, NMTs can also further specialize in the field of magnetic resonance.

Sonographers

There were approximately 2,900 sonographers (also known as ultrasonographers) practising across Canada in 2006. They perform ultrasounds in various health care settings and report the initial technical findings to supervising clinicians.¹ They can be registered in one or more specialties, including general sonography, vascular sonography and cardiac sonography. In Quebec, they are grouped with MRTs and are regulated accordingly. In the rest of Canada, sonographers are considered a separate professional group.

Physician Specialists/Consultants in Imaging

Many types of physicians order and use the results of medical imaging in their practices. A smaller group provides imaging services. The Royal College of Physicians and Surgeons of Canada and the Collège des médecins du Québec recognize two specialties in medical imaging: diagnostic radiology and nuclear medicine.

Physicians in other specialties may also supervise, perform and interpret images in some situations. For example, cardiologists are often responsible for performing procedures with cardiac catheters; obstetricians and gynecologists may perform ultrasound examinations in emergency situations in the labour room and/or their private offices; emergency physicians are sometimes the first to read an X-ray; and other specialists, such as neurologists, oncologists and orthopedic surgeons, may use imaging equipment in their practices and/or refer patients for imaging tests.

Diagnostic radiology physicians supervise and interpret X-rays, CT scans, mammography and other imaging modalities in the study, diagnosis and treatment of disease and injury. They may also be responsible for determining the appropriateness of an exam, quality control and a number of clinical procedures. Canada's 2,034 diagnostic radiologists work both independently and with other physicians and health care professionals.³ In some cases, using interventional radiology, radiologists and other specialists also use imaging to guide surgery or to provide less invasive alternatives to surgery (for example, angioplasty).⁴

Who Orders Tests?

In Canada, many types of medical imaging require a referral by a physician. Who orders the exam may vary depending on the type of exam, policies/protocols in specific health regions or facilities, the reason the exam is being ordered, the available range of medical specialties, the geographic location of the ordering physician and other factors. For example, a 2003 report² by the Institute for Clinical Evaluative Sciences (ICES) showed that neurologists, family physicians, orthopedic surgeons and neurosurgeons order most outpatient MRI scans in Ontario. They accounted for 24%, 20%, 17% and 8% of scans, respectively.

The same report by ICES also showed that the distribution of MRI referrals varied depending on the kind of physician making the referral, the body site for which the MRI exam was ordered and where the physician worked. For example, neurologists were more likely to order an MRI scan of the head (41.5% of scans), compared with general practitioners/family physicians (GPs/FPs) (14.8%). Likewise, referrals for scans in northern Ontario were more likely to come from GPs/FPs (42% of scans) than those in southern Ontario (17%).

The Royal College of Physicians and Surgeons of Canada recognizes two subspecialties in diagnostic radiology: neuroradiology (diagnostic radiology of the central nervous system, brain, head, neck and spine using X-ray, MRI, CT and angiography) and pediatric radiology. These subspecialties are accredited but not certified. That is, there is no certification examination.

Nuclear medicine physiciansⁱⁱⁱ (221 in Canada in 2006) are primarily concerned with the use of radioactive materials in the study, diagnosis and treatment of disease.⁵ Nuclear medicine physicians are usually based in a hospital and/or university. In general, they are responsible for consulting with referring physicians on diagnoses and treatments, advising them on appropriate imaging procedures and deciding whether further investigations are needed. Other responsibilities might include supervising or administering procedures, overseeing daily operations and teaching junior colleagues and students.

Medical Physicists

Like many health care professionals, medical physicists fulfill a variety of roles and can work in clinical settings, regulatory agencies, industry, research and development, academia and other areas. In a clinical setting, medical physicists are principally active in radiation therapy and diagnostic imaging. For example, their responsibilities may include quality assurance of imaging systems, radiation safety, technical specification and acceptance of new equipment and development of specialized protocols to use the equipment in ways tailored to clinical need. Medical physicists also work in academic and research institutions. Research efforts in medical imaging concentrate primarily on developing new and improved methods of imaging body structure and function, with the ultimate goal of advancing the ability to diagnose and treat disease.⁶ In addition, as a result of their expertise with ionizing radiation, they are often appointed radiation safety officers within the settings where they work.

iii. Some radiologists also work in nuclear medicine.

Trends in Supply

Just as there is no agreed-upon national or international standard for how many MRI or CT scanners we should have, deciding on the best number and mix of medical imaging professionals to serve a particular community is challenging. Many factors come into play. Some relate to the characteristics of the area and the health needs of the people who live there. Others relate to how health services are organized and delivered; how clinical knowledge, practice patterns and technology evolve; how professionals are organized, both individually and together; and much more.

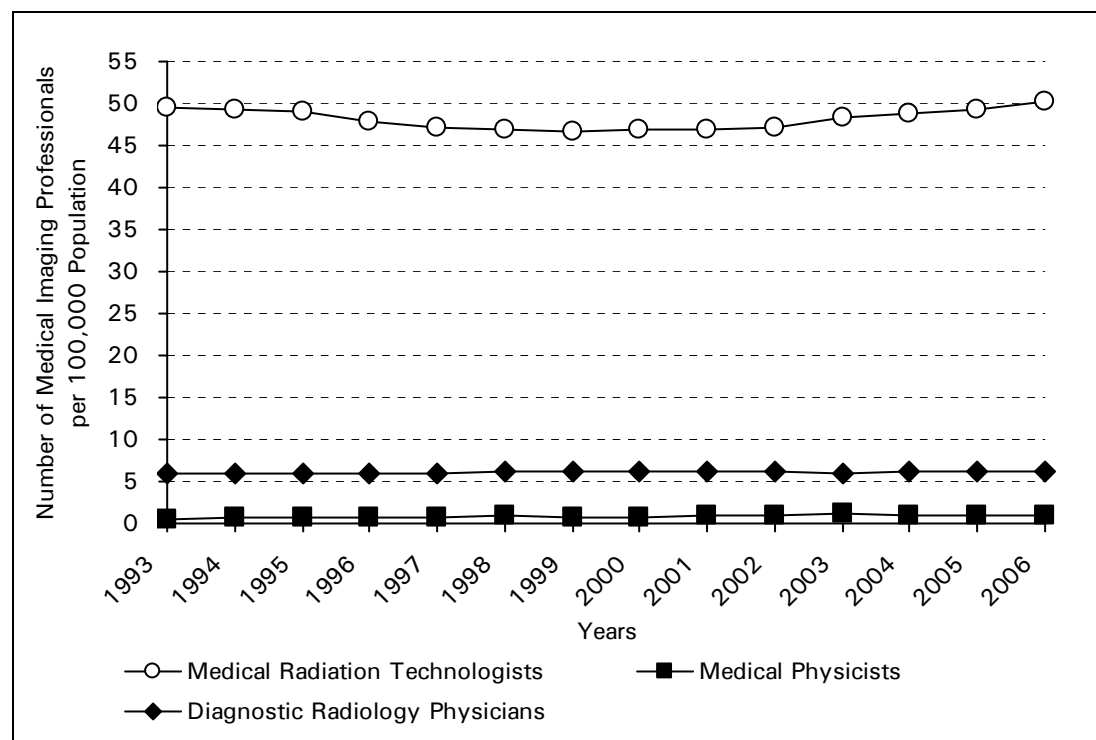
Nevertheless, tracking the supply and characteristics of health care providers can provide important insights for planning. For example, in 2006, for every one diagnostic radiologist, there were eight MRTs (as seen in Figure 63).

Numbers of professionals per 100,000 population were relatively stable for MRTs, diagnostic radiologists and medical physicists from 1993 to 2006 (Figure 63). As Chapter 2 showed, this period saw growth in some types of imaging equipment (for example, MRI and CT). There is some concern that there will not be enough professionals to properly run the increased number of devices.

Did You Know?

Questions about whether the available supply of imaging professionals does (or will) meet demand are not unique to Canada. For example, authors of an Australian study (2002)⁷ reported a shortfall in the number of radiologists and projected that, based on the status quo, future demands for radiology services would outweigh supply. Likewise, a report by the U.K.'s Royal College of Radiologists revealed that over 150 positions had remained unfilled for more than two years in 2000.⁸ Similar data about vacancy rates are not available across Canada, but pockets of information⁹ do exist.

Figure 63 Supply of Selected Medical Imaging Professionals per 100,000 Population, Canada, 1993 to 2006



Notes

- The data for MRTs only reflect those who are active members of the College of Medical Radiation Technologists of Ontario (Ontario data), l'Ordre des technologues en radiologie du Québec (Quebec data) and the Canadian Association of Medical Radiation Technologists (data for other provinces).
- The data for medical physicists represent those who are registered members of the Canadian Organization of Medical Physicists.
- The data for diagnostic radiology physicians are as of December 31 of the given year and include physicians in clinical and/or non-clinical practice. Data exclude residents and physicians who are not licensed to provide clinical practice and those who have requested of the Business Information Group (formerly Southam Medical Group) that their data not be published. Specialty is based on most recent certified specialty, and data may differ from other sources of provincial or territorial physician data that categorize physicians on some other basis (for example, functional specialty, payment specialty or provisional licences). Diagnostic radiology physicians include certificants of the Royal College of Physicians and Surgeons and Canada or the Collège des médecins du Québec.
- Physician data from 2000 do not reflect annual updates from the Government of the Yukon or the College of Physicians and Surgeons of Alberta.
- Physician data from 2002 do not reflect 4 of 12 monthly updates (September to December 2002) from the College of Physicians and Surgeons of Ontario.

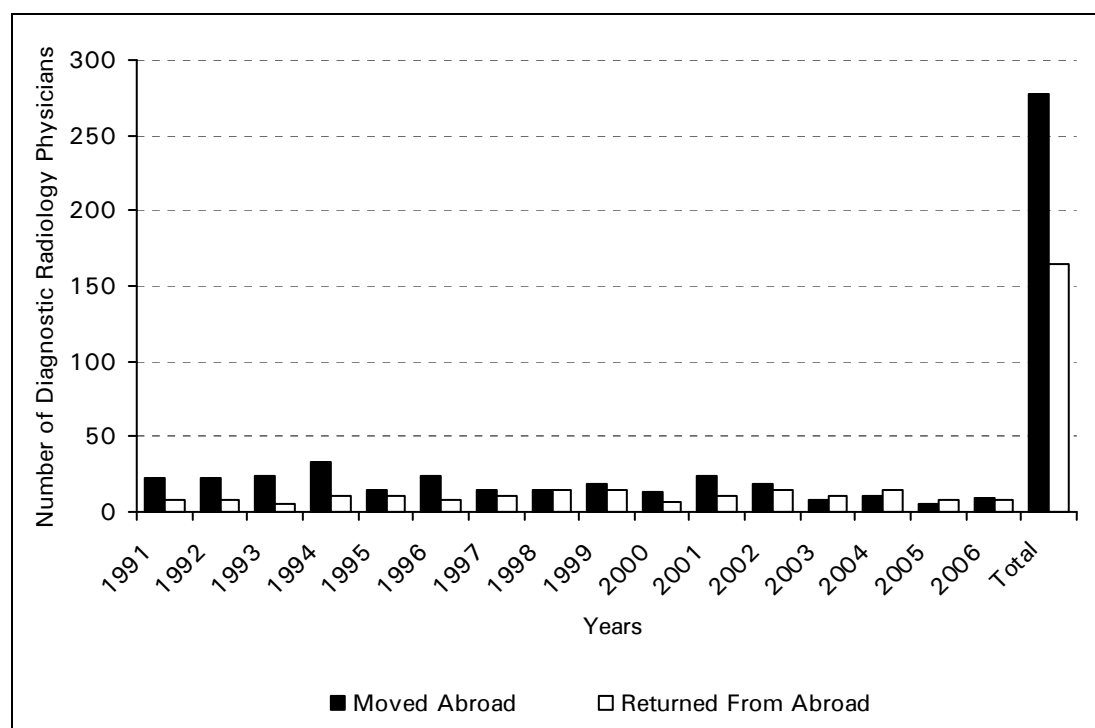
Sources

Health Personnel Database, Canadian Institute for Health Information (medical physicists and MRTs); Scott's Medical Database, Canadian Institute for Health Information (diagnostic radiology physicians); 1993 to 1995: Quarterly Demographic Statistics, Statistics Canada, catalogue no. 91-002-X1B, volume 17, no. 2, April–June 2003; 1996 to 2001: Quarterly Demographic Statistics, Statistics Canada, catalogue no. 91-002-X1B, volume 19, no. 3, July–September 2005; 2002 to 2006: Quarterly Demographic Statistics, Statistics Canada, catalogue no. 91-002-X1E, volume 21, no. 2, April–June 2007.

Moving Abroad

On average, about 1% of active physician specialists in diagnostic radiology left Canada annually between 1991 and 2006. The loss was partly compensated for by some physicians who returned from abroad in each year. Over the period 1991 to 2006, 277 diagnostic radiology physicians moved from Canada while 165 returned from abroad, resulting in a net loss of 112 physicians. The net loss accumulated over the 16-year period amounted to approximately 6% of the total supply of diagnostic radiology physicians in 2006. This loss may have been offset by foreign-trained specialists who migrated to Canada and became licensed to practise for the first time, but the number of physician specialists in imaging who did so is not known. After 2002, the number of physicians who moved abroad dropped by about one-half and for the first time in more than a decade, more diagnostic radiology physicians returned to Canada than moved abroad (see Figure 64).

Figure 64 Total Number of Diagnostic Radiology Physicians Who Moved Abroad and Returned From Abroad, Canada, 1991 to 2006



Notes

- Data are as of December 31 of given year and include physicians in clinical and/or non-clinical practice. Data exclude residents and physicians who are not licensed to provide clinical practice and those who have requested of the Business Information Group (formerly Southam Medical Group) that their data not be published. Specialty is based on most recent certified specialty, and data may differ from other sources of provincial or territorial physician data that categorize physicians on some other basis (for example, functional specialty, payment specialty or provisional licence). Diagnostic radiology physicians include certificants of the Royal College of Physicians and Surgeons of Canada and the Collège des médecins du Québec.
- Data from 2000 do not reflect annual updates from the Government of the Yukon or the College of Physicians and Surgeons of Alberta.
- Data from 2002 do not reflect 4 of 12 monthly updates (September to December 2002) from the College of Physicians and Surgeons of Ontario.
- Does not include foreign physicians who have not previously practised in Canada.

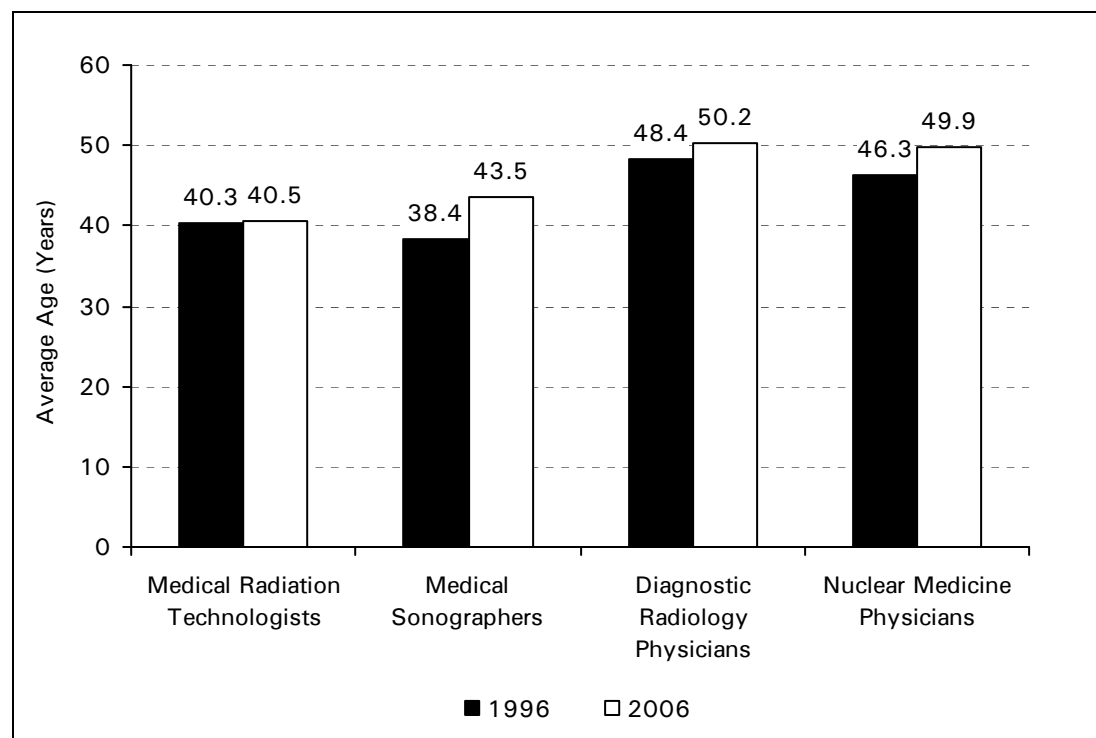
Source

Scott's Medical Database, Canadian Institute for Health Information.

Age and Aging

The average age differs according to the type of medical imaging professional. Between 1996 and 2006, the average age increased for all types of medical imaging professionals, but more so for medical sonographers (Figure 65).

Figure 65 Average Age of Selected Medical Imaging Professionals, Canada, 1996 and 2006



Notes

Scott's Medical Database:

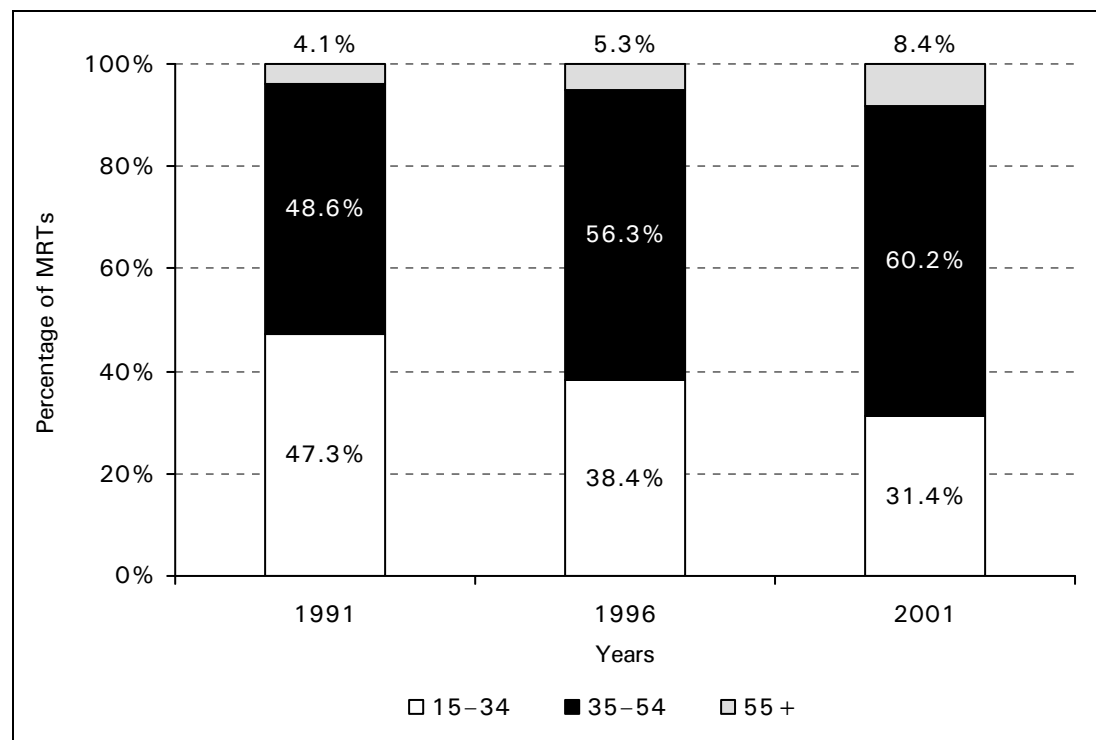
- Physician data are as of December 31, 1996 and 2006, and include physicians in clinical and/or non-clinical practice.
- Data exclude residents and physicians who are not licensed to provide clinical practice and those who have requested of the Business Information Group (formerly Southam Medical Group) that their data not be published. Specialty is based on most recent certified specialty, and data may differ from other sources of provincial or territorial physician data that categorize physicians on some other basis (for example, functional specialty, payment specialty or provisional licences). Diagnostic radiology and nuclear medicine physicians include certificants of the Royal College of Physicians and Surgeons of Canada and the Collège des médecins du Québec.

Sources

Labour Force Survey, Statistics Canada (MRT and sonography data); Scott's Medical Database, Canadian Institute for Health Information (physician data).

As baby boomers move toward retirement, the average age of Canadians is rising. That trend also holds for health professionals in general and imaging professionals in particular. Figure 66, derived from census data, shows that the proportion of the MRT workforce younger than 35 was 31% in 2001, down from 47% a decade earlier.

Figure 66 Percentage of MRTs by Age Group, Canada, 1991, 1996, and 2001



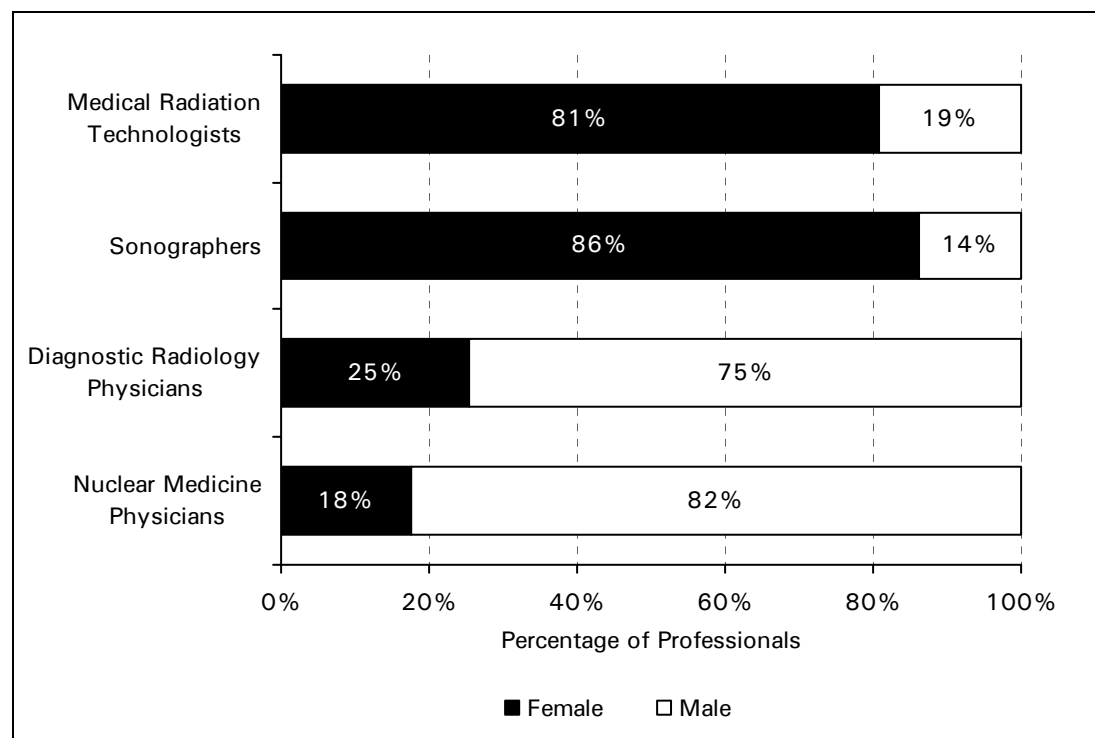
Source

Census of Canada, 1991, 1996 and 2001, Statistics Canada.

The Male/Female Mix

Overall, about 8 in 10 health professionals are female, but the mix differs from group to group. In medical imaging, about 8 in 10 technologists are women, compared with about 2 in 10 physician imaging specialists (see Figure 67). Why does this matter? Research suggests that female physicians tend to have different practice patterns from their male colleagues. Likewise, it has been suggested that with longer maternity leave benefits, additional staff will need to be hired to replace those on leave, possibly affecting the supply of health professionals, such as MRTs.¹⁰ The proportion of medical imaging professionals that were women increased between 1996 and 2006. It increased by 2 percentage points for both medical radiation technologists and sonographers and by 5 and 3 percentage points, respectively, for diagnostic radiology physicians and nuclear medicine physicians.

Figure 67 Percentage of Selected Medical Imaging Professionals, by Gender, Canada, 2006



Notes

Scott's Medical Database:

- Physician data are as of December 31, 2006, and include physicians in clinical and/or non-clinical practice.
- Data exclude residents and physicians who are not licensed to provide clinical practice and those who have requested of the Business Information Group (formerly Southam Medical Group) that their data not be published. Specialty is based on most recent certified specialty, and data may differ from other sources of provincial or territorial physician data that categorize physicians on some other basis (for example, functional specialty, payment specialty or provisional licences). Diagnostic radiology and nuclear medicine physicians include certificants of the Royal College of Physicians and Surgeons of Canada and the Collège des médecins du Québec.

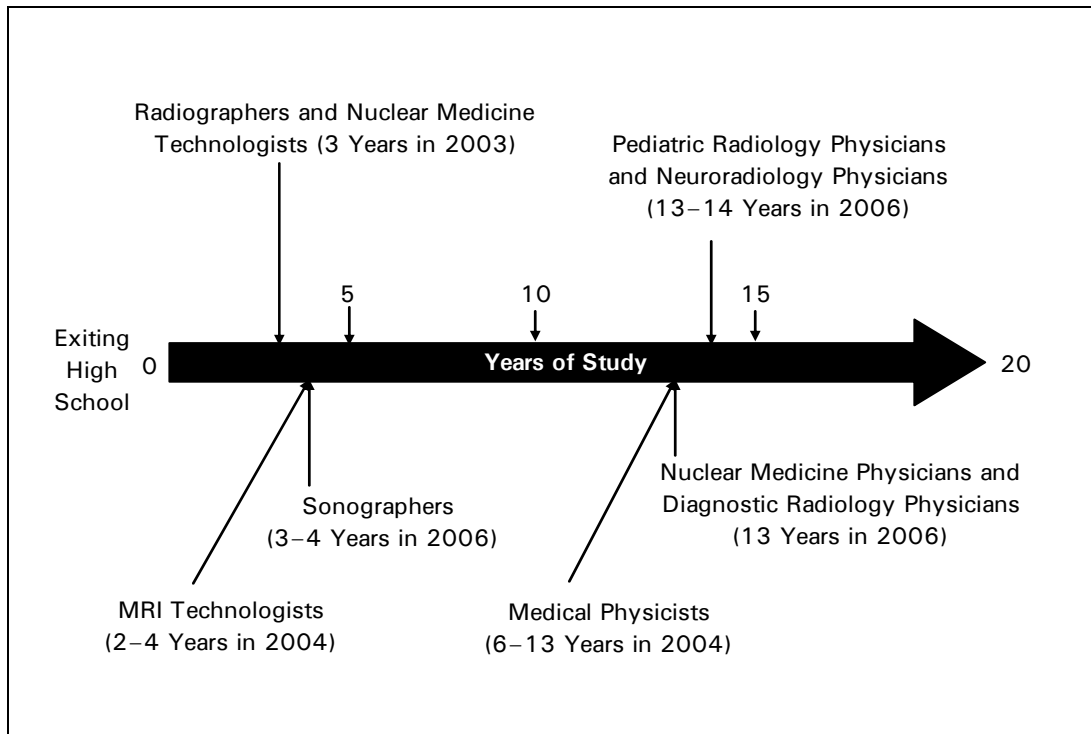
Sources

Labour Force Survey, Statistics Canada (MRT and sonographer data); Scott's Medical Database, Canadian Institute for Health Information (physician data).

Learning to Image

The level of education required to work in medical imaging varies from profession to profession and has changed over time. For example, it may take from two to four years to become a magnetic resonance imaging technologist following high school graduation. For pediatric radiology physicians and neuroradiology physicians, training may take 14 years, as reported in Figure 68.

Figure 68 Typical Duration of Training After High School Graduation for Entry Into Selected Medical Imaging Professions, Canada, 2006 or Latest Year Available



Sources

Certification Candidates Handbook, Canadian Association of Medical Radiation Technologists, 2004; Royal College of Physicians and Surgeons, <http://www.rcpsc.medical.org>; Canadian Organization of Medical Physicists and Canadian College of Physicists in Medicine, <http://www.medphys.ca>; Canadian Society of Diagnostic Medical Sonographers; *Health Personnel Trends in Canada, 1993–2004*, CIHI publication, 2006; *National Occupational Classification (NOC) 2001*, Human Resources and Skills Development Canada (HRSDC), Government of Canada.

Questions continue to be raised about how training requirements should (or should not) change in the future. Some point to the increasing complexity of medical radiation technology, the changing roles of members working in multidisciplinary teams and the increased acuity of patients seeking care as factors that are driving the demand for further education. Others counter with concerns about the ability to attract and retain adequate numbers of personnel whose training is well matched to the work they will be doing and about the costs of extended training.¹⁰ Ensuring appropriate clinical training opportunities for students, whether in shorter or longer programs, can also be an issue as they are dependent on the availability of programs and instructors/preceptors. Table 8 summarizes the number of current training programs across Canada for selected medical imaging professions.

Table 8 Distribution of Training Programs for Selected Medical Imaging Professions, by Province, 2006 or 2007

Province	Physician Specialties				Other Medical Imaging Professions				
	Diagnostic Radiology	Nuclear Medicine	Pediatric Radiology	Neuroradiology	Diagnostic Ultrasound (Sonography)*	Magnetic Resonance Imaging Technology*	Nuclear Medicine Technology*	Radiological Technology*	Medical Physics
N.L.	1				1			1	
P.E.I.								1	
N.S.	1	1		1	1		1	1	1
N.B.							2	5	
Que.	4	3	2	2			1	4	3
Ont.	5	2	1	3	3	1	1	7	7
Man.	1	1			1	1		1	1
Sask.	1							1	1
Alta.	2	1			2	2	1	2	2
B.C.	1	1			1	1	1	1	2
Total	16	9	3	6	9	5	7	24	17

Notes

- * Programs registered/accredited through the joint accreditation process managed by the Canadian Medical Association as of October 25, 2007.
- a) The above list covers most of the medical physics programs across Canada. Some smaller graduate physics programs that involve graduate students working on medical imaging projects may not be captured.
- b) Date of count of programs for physician specialties: diagnostic radiology (October 23, 2007), nuclear medicine (August 29, 2007), pediatric radiology (December 22, 2006), neuroradiology (December 23, 2006).
- c) Date of count of programs for other medical imaging professions except medical physics: diagnostic ultrasound, magnetic resonance imaging, nuclear medicine technology, radiological technology (October 25, 2007).
- d) Date of count of programs for medical physics not including residency programs: August 20, 2007.

Sources

Physician specialties: diagnostic radiology, nuclear medicine, pediatric radiology and neuroradiology. The Royal College of Physicians and Surgeons of Canada, [online], from <<http://rcpsc.medical.org/information/index.php>>.

Other medical imaging professions except medical physics: The Canadian Medical Association (list of medical imaging technology programs), [online], from <http://www.cma.ca/index.cfm/ci_id/19324/la_id/1.htm#list>.

Medical physicists, not including residency programs, [online], from <<http://www.medphys.ca/article.asp?id=79>>.

Medical radiation technology is one area in which training requirements are changing. Currently, MRTs require a college diploma from an accredited school to be eligible for certification in Canada. There are also degree programs in MRT, such as those at the British Columbia Institute of Technology and The Michener Institute (in affiliation with the University of Toronto). However, degrees are not yet required for entry to practice. In the early 1980s, the Canadian Association of Medical Radiation Technologists announced that, as of 2005, it will no longer permit diploma graduates to write the certification exam or to register as members of the association. However, this date has been extended to 2010 at the request of several provincial associations of MRTs. Internationally, it has been

reported that some countries—the U.S., the U.K. and Australia—all of which have held reciprocity agreements with Canada, are becoming less accepting of Canadian diploma graduates.¹

Changes in training have also occurred in other areas, including the following:

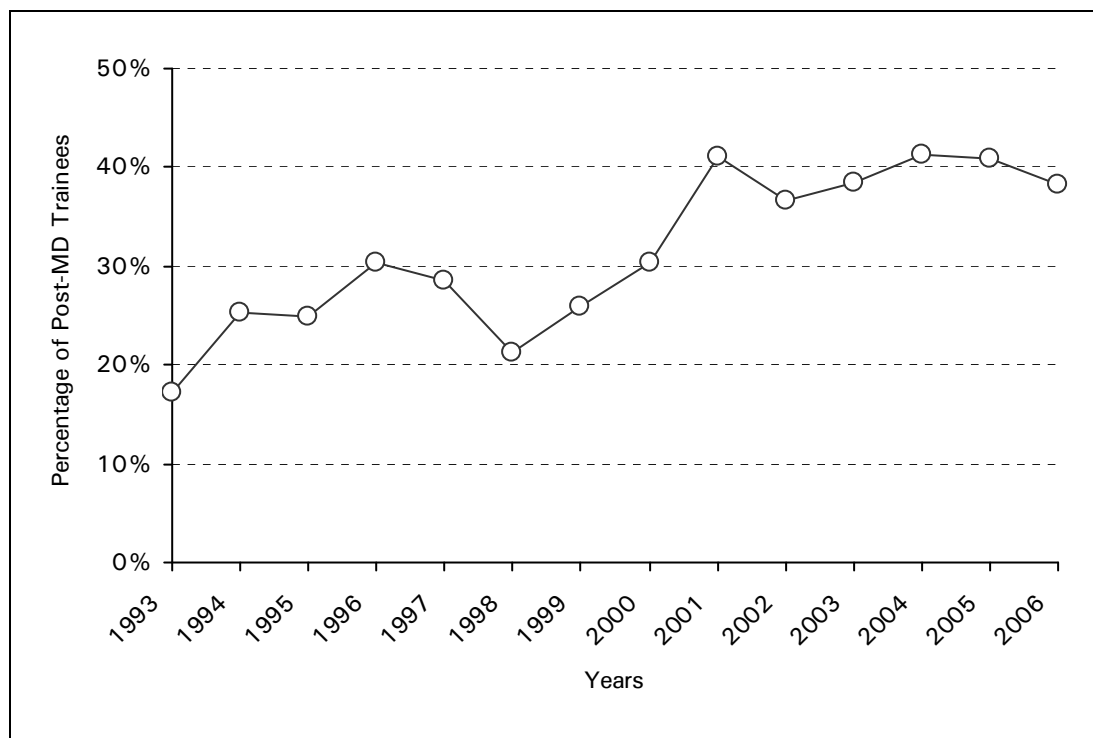
- Some employers require that medical imaging technologists be cross-trained, especially in remote and rural areas where it may not be practical to have a technologist in each subdiscipline. In response, some provinces are developing cross-training programs (for example, Newfoundland and Labrador).¹¹
- Sonographers have traditionally taken one-year post-diploma programs. However, some entry-level educational requirements have changed, and a number of three-year entry-level diploma programs and some four-year degree programs (for example, in Nova Scotia) have been developed.¹²
- Education for most medical imaging professionals is a life-long commitment because they must keep pace with the development of new imaging equipment, techniques and knowledge about best practices. For example, physician specialists are required to continue their education post-residency. The Royal College of Physicians and Surgeons established a Maintenance of Certification program that commenced in 2000. Fellows must participate in this program to receive and renew their fellowship and to use the College's designations.¹³

Training Physicians

Each year, dozens of new residents begin their specialist training. According to the Canadian Resident Matching Service, the number of clinical placements for physician specialists in imaging fluctuates slightly from year to year. In 1997 and 2006, there were, respectively, 41 and 71 diagnostic radiology positions and 4 and 7 nuclear medicine positions. Seventy-eight Canadian residency applicants listed diagnostic radiology as their first choice for specialty training in 2006, up from 44 in 1997. In contrast, not all nuclear medicine training positions were filled for years 1997 to 2006.

Each year, a number of international medical graduates (IMGs) also undertake residency training in Canada. Some are permanent residents or Canadian citizens. IMGs with visas represented a growing proportion of the total number of trainees who exited diagnostic radiology programs in Canada (17% in 1993 and 38% in 2006) as reported in Figure 69.

Figure 69 Percentage of Post-MD Trainees Exiting From Diagnostic Radiology Training Programs Who Are International Medical Graduates With Visas, Canada, 1993 to 2006



Source

Canadian Post-MD Education Registry.

Regulating and Certifying Imaging Professionals

For many health professionals, receiving a degree or diploma is only the first step. Graduates may also need to pass a certification examination or meet other requirements. Table 9 presents the regulatory status for selected medical imaging professionals across provinces and territories.

How Medical Imaging Professionals Are Regulated

- The Royal College of Physicians and Surgeons is the national certifying body for specialty and subspecialty physicians in all provinces except Quebec, where this role is fulfilled by the Collège des médecins du Québec. It is also responsible for setting and maintaining standards for post-graduate medical education, as well as for promoting continuing education.
- Medical radiation technologists (MRTs) who practise in Canada must first pass a certification examination administered by the Canadian Association of Medical Radiation Technologists (CAMRT). MRTs practising in Quebec can write the certification examination administered from the Ordre des technologues en radiologie du Québec (OTRQ). The CAMRT and the OTRQ have a reciprocal agreement for the certification of MRTs. Certification by CAMRT is recognized by publicly funded agencies in all provinces as the employment criteria for medical radiation technologists. CAMRT certification is an acknowledgement that a technologist or therapist has the skills, knowledge and judgment required to work in his or her discipline. Certified MRTs are expected to adhere to the CAMRT code of ethics.¹⁴
- Sonographers are currently only regulated in Quebec, where the responsible regulatory body is the Ordre des technologues en radiologie du Québec. Nevertheless, many employers in other jurisdictions may require that sonographers be registered with (or eligible for registration with) either the American Registry of Diagnostic Sonographers or the Canadian Association of Registered Diagnostic Ultrasound Professionals. Several provinces, in collaboration with professional associations, are in various stages of exploring self-regulation for sonographers.¹⁵
- Medical physicists are not currently regulated in Canada. However, medical physicists in a few jurisdictions have started the complex process of regulation under appropriate provincial legislation.

Table 9 Regulatory Status for Selected Medical Imaging Professions, by Jurisdiction, 2006

Jurisdiction	Medical Radiation Technologists [†]	Sonographers	Medical Physicists	Diagnostic Radiology Physicians	Nuclear Medicine Physicians
N.L.	*	×	×	✓	✓
P.E.I.	*	×	×	✓	✓
N.S.	✓	×	×	✓	✓
N.B.	✓	◆▶	×	✓	✓
Que.	✓	✓	×▶	✓	✓
Ont.	✓	◆▶	×	✓	✓
Man.	**	×	×	✓	✓
Sask.	✓	×	×	✓	✓
Alta.	✓	◆▶	×▶	✓	✓
B.C.	***▶	×	×▶	✓	✓
Y.T.	×	×	×	✓	✓
N.W.T	×	×	×	✓	✓
Nun.	×	×	×	✓	✓

Notes

† Includes radiographers/radiological technologists, nuclear medicine technologists, magnetic resonance technologists and radiation therapists.

Legend:

- ✓ Regulated.
- ×
- ◆ Voluntary professional provincial associations.
- ▶ Profession seeking self-regulation.
- * Mandatory membership with the Canadian Association of Medical Radiation Technologists (CAMRT), which requires certification by CAMRT. Membership in CAMRT is possible only for members of the provincial association and, therefore, medical radiation technologists are also members of their provincial association.
- ** All medical radiation technologists covered by provincial union contracts must have membership with the Canadian Association of Medical Radiation Technologists (CAMRT), which requires certification by CAMRT. Membership in CAMRT is possible only for members of the provincial association and, therefore, medical radiation technologists are also members of their provincial association.
- ***▶ All medical radiation technologists employed in publicly funded facilities must have membership with the Canadian Association of Medical Radiation Technologists (CAMRT), which requires certification by CAMRT. Membership in CAMRT is possible only for members of the provincial association and, therefore, medical radiation technologists are also members of their provincial association. The profession is seeking self-regulation.

Sources

Canadian Association of Medical Radiation Technologists (CAMRT) and provincial associations; Canadian Association of Registered Diagnostic Ultrasound Professionals (CARDUP); Canadian Organization of Medical Physicists (COMP)/Canadian College of Physicists in Medicine (CCPM); provincial or territorial medical registration organizations.

What Is Self-Regulation?

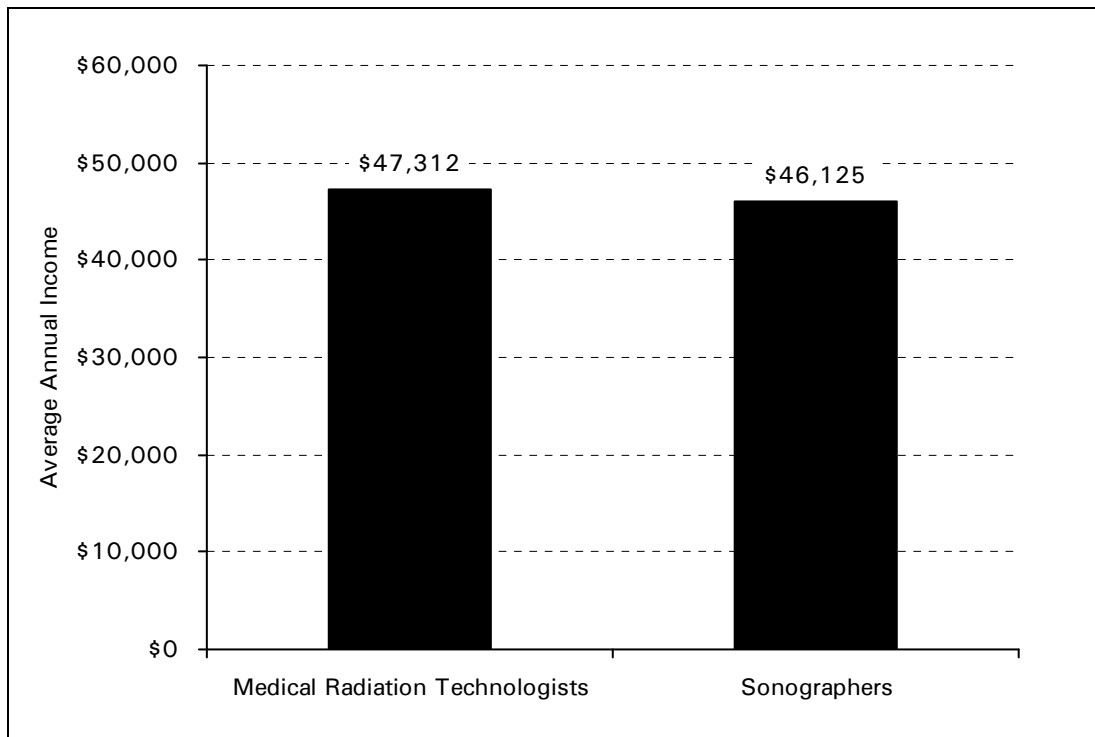
With self-regulation, members of a profession are accountable to the public through a regulatory college or a professional organization. This generally includes setting standards of practice that describe various professional tasks and what it means to perform them at an acceptable level; establishing entry-level qualifications to practise; establishing a formal complaints and discipline procedure; assuming accountability for defining standards; ensuring appropriate qualifications to practise and qualifications for continuing competence in the profession; and setting policy related to disciplinary action for professional misconduct.¹⁶

Life at Work

New research is beginning to explore the relationship between the work life of health professionals and their recruitment and retention, job satisfaction and health, as well as patient satisfaction, outcomes of care and health care costs. Relatively little is known, however, about the working conditions, health and work life of Canada's medical imaging professionals. Nonetheless, some information does exist, including the following:

- According to the 2001 census, full-time MRTs and sonographers who worked for the full year earned, on average, just over \$47,000 and \$46,000, respectively, in 2000 (Figure 70). However, average incomes vary across jurisdictions.

Figure 70 Average Annual Incomes of Medical Radiation Technologists and Sonographers Who Worked Full Year, Full Time, Canada, 2000

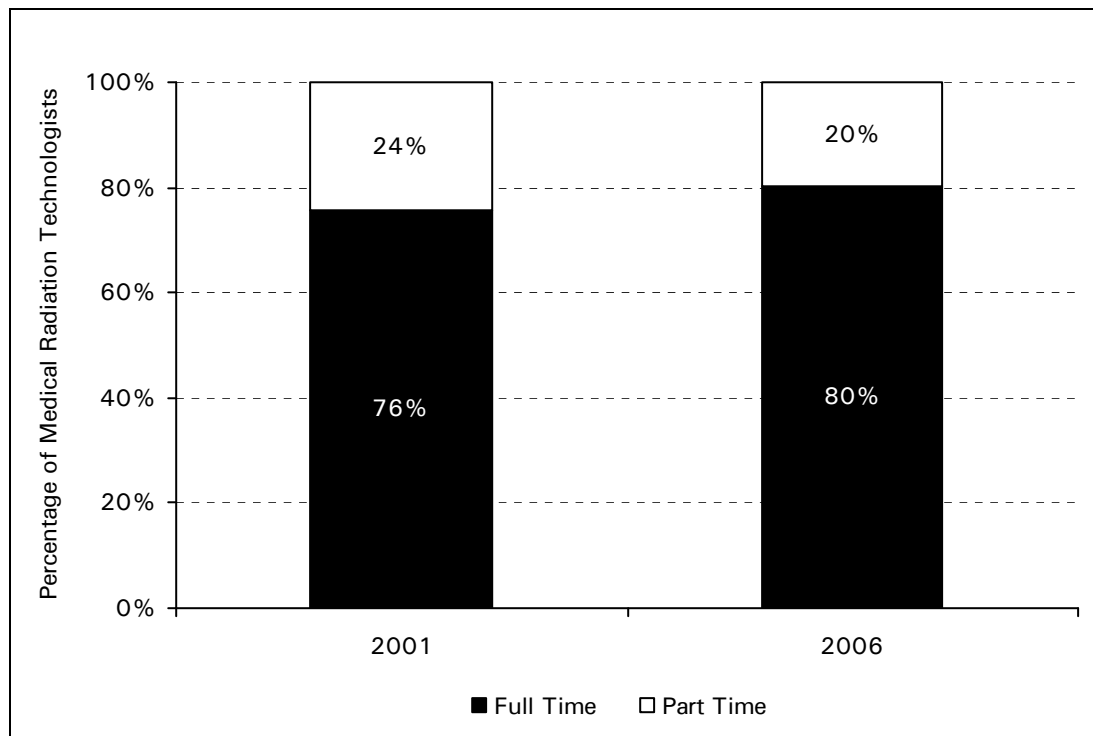


Source

Census of Canada 2001, Statistics Canada.

- From Figure 71 we see that in 2006, 80% of MRTs worked full time, a slight increase from 2001 (76%).

Figure 71 The Percentage of Medical Radiation Technologists Working Full Time/Part Time, Canada, 2001 and 2006



Note

Percentage estimates should be used with caution due to small size of survey sample.

Source

Labour Force Survey, Statistics Canada.

Risk at Work?

Radiologists and radiation technologists were among the first occupational groups to use and be exposed to radiation. In 1902, soon after X-rays were discovered, cases of skin cancer were prevalent among radiologists.¹⁷ Concern about occupational exposure to radiation prompted radiologists around the world to form the First International Congress of Radiology in 1925. The first task was to develop a standard method and unit by which to measure radiation. The second was to set up a committee and program to address protection against radiation. In 1928, a new quantity and unit (named after Roentgen, inventor of the X-ray) to measure X-ray radiation was developed, but no agreement was reached about what level of exposure was reasonably safe. The Roentgen remained in use until 1953 when two more units were added—the rad and the rem.¹⁸

In the early 1950s, increasing leukemia mortality rates among radiologists began to receive attention.¹⁷ It was at this time that regular monitoring of radiation became routine.¹⁹ Since then, there have been significant improvements in radiological protection and technology. At the same time, however, new cutting-edge technologies create new challenges in understanding and managing occupational hazards related to radiation exposure.²⁰

In Canada, a 2006 report²¹ on occupational radiation exposure showed that imaging professionals tend to be well below the allowable annual dosage of occupational radiation (50 mSv).^{iv} Average annual doses were 0.10 mSv for radiological technologists, 1.97 mSv for nuclear medicine technologists, 0.19 mSv for diagnostic radiologists and 0.06 mSv for medical physicists.

However, any X-Ray, no matter the intensity, can have an effect on living tissues. Similarly, any type of electromagnetic radiation has the potential for harm, including those produced by MRI or sonogram units.

iv. Radiation dose equivalent is expressed in sieverts (Sv), or millisieverts (mSv; 1/1000 of a sievert). These terms stand for the dose of radiation to living tissue, and take into account both the absorbed dose and type of radiation.

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Appendix A

Fast Facts

Medical Imaging in Canada, 2007

Appendix A—Fast Facts

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Table A.1 Number of MRI Scanners, by Province/Territory, Canada, 1991 to 2007

	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Nun.	Can.
1991	0	0	1	0	4	10	1	1	2	3	0	0		22
1992	0	0	1	0	4	11	1	1	5	5	0	0		28
1993	1	0	1	0	5	11	1	1	5	5	0	0		30
1994	1	0	1	0	8	12	0	1	6	6	0	0		35
1995	1	0	1	1	10	12	1	1	6	7	0	0		40
1996	--	--	--	--	--	--	--	--	--	--	--	--		--
1997	1	0	1	1	12	23	1	1	6	9	0	0		55
1998	--	--	--	--	--	--	--	--	--	--	--	--		--
1999	--	--	--	--	--	--	--	--	--	--	--	--		--
2000	1	0	2	2	--	42	3	3	13	10	0	0	0	76
2001	1	0	2	5	35	44	3	3	23	14	0	0	0	130
2002	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2003	1	0	4	5	38	53 ^R	3	3	23 ^R	19 ^R	0	0	0	149
2004	1	1	4	5	41 ^R	56 ^R	3 ^R	3	23 ^R	20 ^R	0	0	0	157
2005	1	1	5	5	52 ^R	63 ^R	6	3	25	24 ^R	0	0	0	185
2006	2	1	5	5	58 ^R	67 ^R	8	4	26	25	0	0	0	201
2007	3	1	6	5	67	72	8	4	27	28	0	0	0	222

Notes

-- Not available.

R Data are revised.

a) Surveys were not carried out in 1996, 1998, 1999 and 2002.

b) CCOHTA notes that Quebec data were incomplete for 2000; therefore, they are not included.

c) Units located in both hospitals and free-standing imaging facilities are included for Canada for all years. The number of MRI scanners in free-standing imaging facilities was imputed for years prior to 2003 based on data collected on the year of installation in the 2003 National Survey of Selected Medical Imaging Equipment.

d) Some MRI scanners were captured for the first time in the National Survey of Selected Medical Imaging Equipment two or more years after they were installed. Historical revisions were made for these scanners. Because of the delay between the time a scanner is installed and when it becomes operational, such scanners are counted as installed and operational two years after their indicated year of installation. For example, a scanner reported for the first time in the 2007 survey as installed in 2004 is counted as installed and operational as of January 1, 2006 (but not as of January 1, 2005).

e) 2007 data are as of January 1. Some additional equipment has subsequently been installed.

f) The number of scanners in Ontario and British Columbia in 2006 and 2007 is an estimation.

Sources

National Inventory of Selected Imaging Equipment, Canadian Coordinating Office for Health Technology Assessment (MRIs in hospitals, 1991 to 2001); National Survey of Selected Medical Imaging Equipment, 2003 to 2007, Canadian Institute for Health Information, supplemented by information from provincial ministries of health.

Table A.2 Number of CT Scanners, by Province/Territory, Canada, 1991 to 2007

	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Nun.	Can.
1991	5	1	7	6	58	65	8	5	22	23	0	0		200
1992	5	1	8	7	60	68	8	6	22	23	0	0		208
1993	6	1	8	7	60	72	9	6	24	23	0	0		216
1994	6	1	8	7	62	76	10	6	23	24	0	0		223
1995	6	1	9	7	68	79	10	6	23	25	0	0		234
1996	--	--	--	--	--	--	--	--	--	--	--	--		--
1997	6	1	9	8	69	84	10	7	23	28	0	0		245
1998	--	--	--	--	--	--	--	--	--	--	--	--		--
1999	--	--	--	--	--	--	--	--	--	--	--	--		--
2000	--	--	--	--	--	--	--	--	--	--	--	--		--
2001	9	2	14	9	92	91	13	9	25	38	0	1	0	303
2002	--	--	--	--	--	--	--	--	--	--	--	--		--
2003	10	2	15	9	94 ^R	95 ^R	14	10 ^R	30	44	1	1	0	325
2004	10	3	15	10 ^R	99 ^R	100 ^R	17	11 ^R	30	44	1	1	0	341
2005	10	3	15	12 ^R	111 ^R	113 ^R	17	13	31 ^R	46	1	1	0	373
2006	10	2	16 ^R	14 ^R	112 ^R	122 ^R	18	15	34	47	1	1	0	392
2007	11	2	16	15	119	130	19	15	41	49	1	1	0	419

Notes

-- Not available.

R Data are revised.

a) Surveys were not carried out in 1996, 1998 to 2000, and 2002.

b) Units located in both hospitals and free-standing imaging facilities are included for Canada for all years. The number of CT scanners in free-standing imaging facilities was imputed for years prior to 2003 based on data collected on the year of installation in the 2003 National Survey of Selected Medical Imaging Equipment.

c) Some CT scanners were captured for the first time in the National Survey of Selected Medical Imaging Equipment two or more years after they were installed. Historical revisions were made for these scanners. Because of the delay between the time a scanner is installed and when it becomes operational, such scanners are counted as installed and operational two years after their indicated year of installation. For example, a scanner reported for the first time in the 2007 survey as installed in 2004 is counted as installed and operational as of January 1, 2006 (but not as of January 1, 2005).

d) 2007 data are as of January 1. Some additional equipment has subsequently been installed.

e) The number of scanners in Ontario and British Columbia in 2006 and 2007 is an estimation.

Sources

National Inventory of Selected Imaging Equipment, Canadian Coordinating Office for Health Technology Assessment (CTs in hospitals, 1991 to 2001); National Survey of Selected Medical Imaging Equipment, 2003 to 2007, Canadian Institute for Health Information, supplemented by information from provincial ministries of health.

Table A.3 Number of Nuclear Medicine Physicians, by Province/Territory, Canada, 1993 to 2006

	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Nun.	Can.
1993	2	0	2	2	78	56	8	5	7	15	0	0		175
1994	2	0	3	2	83	57	8	3	10	21	0	0		189
1995	2	0	3	3	88	59	7	3	11	21	0	0		197
1996	2	0	3	3	88	62	7	4	13	20	0	0		202
1997	2	0	3	3	88	66	8	3	14	19	0	0		206
1998	2	0	3	3	89	67	8	3	13	21	0	0		209
1999	2	0	4	3	87	74	8	3	15	22	0	0	0	218
2000	2	0	4	3	87	74	8	3	14	22	0	0	0	217
2001	2	0	5	3	85	75	6	3	13	22	0	0	0	214
2002	2	0	6	3	84	71	7	3	15	21	0	0	0	212
2003	2	0	6	3	84	73	7	3	15	20	0	0	0	213
2004	3	0	5	3	87	71	7	4	16	22	0	0	0	218
2005	3	0	6	3	85	72	7	4	17	21	0	0	0	218
2006	3	0	5	3	90	69	8	4	18	21	0	0	0	221

Notes

- Data exclude residents and physicians who are not licensed to provide clinical practice and have requested of the Business Information Group (formerly Southam Medical Group) that their data not be published.
- Data as of December 31 of a given year include physicians in clinical and/or non-clinical practice, including research, teaching or administration. Specialty is based on most recent certification with the Royal College of Physicians and Surgeons of Canada or the Collège des médecins du Québec. Results may differ from other sources of provincial and territorial physician data that categorize physicians on some other basis (for example, functional specialty, payment specialty or provisional licences). For example, the Newfoundland Medical Board includes provisionally licensed, non-certified specialists in its specialist physician counts. The provisional licence information for these physicians is not available in the Scott's Medical Database and these physicians are, therefore, excluded from the diagnostic radiology and nuclear medicine physician counts presented in this report.
- Caution must be exercised when comparing Northwest Territories data prior to 1999 with Northwest Territories data after 1998, since some of the change may be attributable to the creation of the new territory of Nunavut.
- Yukon Territory and Alberta data in 2000 (and subsequently the Canada total) do not reflect the annual update from the Government of the Yukon or the College of Physicians and Surgeons of Alberta, respectively.
- Ontario data in 2002 do not reflect 4 of 12 monthly updates (September to December 2002) from the College of Physicians and Surgeons of Ontario.
- Nuclear medicine physicians include certificants of the Royal College of Physicians and Surgeons of Canada and the Collège des médecins du Québec.

Source

Scott's Medical Database, Canadian Institute for Health Information.

Table A.4 Number of Diagnostic Radiologists, by Province/Territory, Canada, 1993 to 2006

	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Nun.	Can.
1993	27	4	70	38	437	661	60	45	149	228	0	2		1,721
1994	25	5	71	41	462	666	57	48	150	224	0	1		1,750
1995	27	5	69	41	473	656	62	50	150	229	0	1		1,763
1996	27	4	66	43	484	650	62	50	153	233	0	1		1,773
1997	27	6	69	43	493	666	65	51	159	242	0	2		1,823
1998	30	6	73	44	505	675	63	50	168	236	0	2		1,852
1999	31	6	79	44	504	689	64	49	182	234	0	2	0	1,884
2000	31	6	81	46	500	702	63	51	180	236	0	2	0	1,898
2001	30	6	70	42	506	721	60	45	192	230	0	1	0	1,903
2002	31	4	70	41	495	733	57	45	205	231	0	1	0	1,913
2003	32	5	70	41	486	726	56	41	214	235	0	0	0	1,906
2004	30	6	69	48	507	746	58	45	224	234	0	0	0	1,967
2005	43	6	73	47	521	747	59	63	219	231	0	0	0	2,009
2006	46	7	71	47	522	754	58	61	227	241	0	0	0	2,034

Notes

- Data exclude residents and physicians who are not licensed to provide clinical practice and have requested of the Business Information Group (formerly Southam Medical Group) that their data not be published.
- Data as of December 31 of a given year include physicians in clinical and/or non-clinical practice, including research, teaching or administration. Specialty is based on most recent certification with the Royal College of Physicians and Surgeons of Canada or the Collège des médecins du Québec. Results may differ from other sources of provincial and territorial physician data that categorize physicians on some other basis (for example, functional specialty, payment specialty or provisional licences). For example, the Newfoundland Medical Board includes provisionally licensed, non-certified specialists in its specialist physician counts. The provisional licence information for these physicians is not available in the Scott's Medical Database and these physicians are, therefore, excluded from the diagnostic radiology and nuclear medicine physician counts presented in this report.
- Caution must be exercised when comparing Northwest Territories data prior to 1999 with Northwest Territories data after 1998, since some of the change may be attributable to the creation of the new territory of Nunavut.
- Yukon and Alberta data in 2000 (and subsequently the Canada total) do not reflect the annual update from the Government of the Yukon or the College of Physicians and Surgeons of Alberta, respectively.
- Ontario data in 2002 do not reflect 4 of 12 monthly updates (September to December 2002) from the College of Physicians and Surgeons of Ontario.

Source

Scott's Medical Database, Canadian Institute for Health Information.

Table A.5 Number of Members of Medical Radiation Technologists' Associations in the Discipline of Nuclear Medicine, by Province/Territory, Canada, 1993 to 2006

	N.L.	P.E.I.	N.S.	N.B.	Que. *	Ont. †	Man.	Sask.	Alta.	B.C.	Terr.	Can.
1993	14	3	63	26	--	525 [‡]	45	26	125	153	--	980
1994	15	3	63	29	--	577	44	27	126	171	--	1,055
1995	17	3	70	32	--	572	45	27	124	169	--	1,059
1996	15	2	65	34	--	593	44	29	120	171	--	1,073
1997	16	3	66	36	--	593	44	25	117	178	--	1,078
1998	15	4	68	36	--	604	46	27	125	181	--	1,106
1999	15	5	64	38	--	604	47	32	121	180	--	1,106
2000	14	5	62	42	--	615	45	30	140	186	--	1,139
2001	16	5	63	43	395	638	44	33	142	191	--	1,570
2002	13	6	73	47	403	647	45	35	151	192	--	1,612
2003	17	4	75	48	419	655	44	40	197	207	--	1,706
2004	17	5	75	53	424	663	44	38	224	209	--	1,752
2005	16	4	73	56	448	678	45	34	192	206	--	1,752
2006	15	3	71	55	460	693	42	36	193	212	1	1,781

Notes

-- Not available.

* Quebec data represent active registered members of the Ordre des technologues en radiologie du Québec.

† Ontario data represent active registered members of the College of Medical Radiation Technologists of Ontario.

‡ The 1993 data were generated by the Board of Radiological Technicians and include members other than "active"; therefore, the data are not comparable with data from after 1993.

Members qualifying in other disciplines are counted in other disciplines.

Source

Health Personnel Database, Canadian Institute for Health Information.

Table A.6 Number of Members of Medical Radiation Technologists' Associations in the Discipline of Radiological Technology, by Province/Territory, Canada, 1993 to 2006

	N.L.	P.E.I.	N.S.	N.B.	Que.*	Ont.†	Man.	Sask.	Alta.	B.C.	Terr.	Can.
1993	239	67	457	368	--	4,594‡	548	351	1,204	1,258	--	9,086
1994	240	62	446	378	--	4,346	567	368	1,142	1,292	--	8,841
1995	245	63	432	388	--	4,319	580	360	1,128	1,298	--	8,813
1996	235	64	414	393	--	4,198	570	355	1,093	1,315	--	8,637
1997	236	62	428	382	--	4,118	537	356	1,101	1,350	--	8,570
1998	235	67	411	399	--	4,158	543	356	1,151	1,337	--	8,657
1999	234	63	405	403	--	4,133	530	356	1,153	1,319	--	8,596
2000	237	60	399	398	--	4,136	526	369	1,187	1,352	--	8,664
2001	249	64	383	393	2,991	4,163	509	377	1,208	1,316	--	11,653
2002	251	62	391	409	2,999	4,202	511	369	1,226	1,290	--	11,710
2003	265	65	408	396	3,130	4,167	511	395	1,354	1,361	--	12,052
2004	263	71	408	415	3,201	4,155	537	376	1,410	1,393	--	12,229
2005	261	62	404	422	3,261	4,252	518	370	1,382	1,446	--	12,378
2006	263	57	403	387	3,342	4,336	501	359	1,229	1,352	26	12,255

Notes

-- Not available.

* Quebec data represent active registered members of the Ordre des technologues en radiologie du Québec.

† Ontario data represent active registered members of the College of Medical Radiation Technologists of Ontario.

‡ The 1993 data were generated by the Board of Radiological Technicians and include members other than "active"; therefore, the data are not comparable with data from after 1993.

Members qualifying in other disciplines are counted in other disciplines.

Source

Health Personnel Database, Canadian Institute for Health Information.

Table A.7 Distribution of Imaging Technologies for Hospitals and Free-Standing Imaging Facilities, by Survey Year, by Province/Territory, Canada

Modality		N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Nun.	Can.
As of January 1, 2003															
Nuclear Medicine Cameras	H	10	2	23	20	150	241	16	14	41	61	0	0	0	578
	FS	0	0	0	0	2	10	0	0	14	0	0	0	0	26
CT Scanners	H	10	2	15	9	89	95	14	10	27	43	1	1	0	316
	FS	0	0	0	0	5	0	0	0	3	1	0	0	0	9
Angiography Suites	H	3	1	5	10	38	66	3	4	15	20	0	0	0	165
	FS	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MRI Scanners	H	1	0	3	5	24	53	3	3	17	14	0	0	0	123
	FS	0	0	1	0	14	0	0	0	6	5	0	0	0	26
Catheterization Labs	H	2	0	3	2	23	38	4	4	11	11	0	0	0	98
	FS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PET Scanners	H	0	0	0	0	4	5	0	0	2	1	0	0	0	12
	FS	0	0	0	0	0	0	0	0	1	0	0	0	0	1
PET/CT Scanners	H	0	0	0	0	0	1	0	0	0	0	0	0	0	1
	FS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As of January 1, 2004															
Nuclear Medicine Cameras	H	10	2	23	18	151	246	15	14	42	64	0	0	0	585
	FS	0	0	0	0	2	12	0	0	14	0	0	0	0	28
CT Scanners	H	10	3	15	10	94	100	17	10	27	43	1	1	0	331
	FS	0	0	0	0	5	0	0	1	3	1	0	0	0	10
Angiography Suites	H	3	1	6	8	41	71	3	5	14	20	0	0	0	172
	FS	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MRI Scanners	H	1	1	3	5	27	56	3	3	17	16	0	0	0	132
	FS	0	0	1	0	14	0	0	0	6	4	0	0	0	25
Catheterization Labs	H	2	0	5	2	23	42	4	4	11	12	0	0	0	105
	FS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PET Scanners	H	0	0	0	0	4	5	0	0	2	1	0	0	0	12
	FS	0	0	0	0	0	1	0	0	1	0	0	0	0	2
PET/CT Scanners	H	0	0	0	0	0	2	0	0	1	0	0	0	0	3
	FS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As of January 1, 2005															
Nuclear Medicine Cameras	H	10	2	23	18	154	245	15	14	42	64	0	0	0	587
	FS	0	0	0	0	2	18	0	0	17	0	0	0	0	37
CT Scanners	H	10	3	15	12	104	110	17	13	28	44	1	1	0	358
	FS	0	0	0	0	7	3	0	0	3	2	0	0	0	15
Angiography Suites	H	3	0	6	8	41	74	4	5	14	21	0	0	0	176
	FS	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MRI Scanners	H	1	1	4	5	36	61	6	3	19	17	0	0	0	153
	FS	0	0	1	0	16	2	0	0	6	7	0	0	0	32
Catheterization Labs	H	2	0	5	2	27	44	4	4	11	12	0	0	0	111
	FS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PET Scanners	H	0	0	0	0	3	5	0	0	2	1	0	0	0	11
	FS	0	0	0	0	0	1	0	0	0	1	0	0	0	2
PET/CT Scanners	H	0	0	0	0	1	3	0	0	1	0	0	0	0	5
	FS	0	0	0	0	1	0	0	0	0	0	0	0	0	1

Table A.7 Distribution of Imaging Technologies for Hospitals and Free-Standing Imaging Facilities, by Survey Year, by Province/Territory, Canada (cont'd)

Modality		N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Nun.	Can.
As of January 1, 2006															
Nuclear Medicine Cameras	H	10	2	23	17	151	241	16	13	42	63	0	0	0	578
	FS	0	0	0	0	2	18	0	0	17	0	0	0	0	37
CT Scanners	H	10	2	16	14	103	118	18	15	31	45	1	1	0	374
	FS	0	0	0	0	9	4	0	0	3	2	0	0	0	18
Angiography Suites	H	3	0	6	8	41	73	5	4	14	21	0	0	0	175
	FS	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MRI Scanners	H	2	1	4	5	42	62	7	4	20	18	0	0	0	165
	FS	0	0	1	0	16	5	1	0	6	7	0	0	0	36
Catheterization Labs	H	2	0	5	3	26	46	4	4	12	12	0	0	0	114
	FS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PET Scanners	H	0	0	0	0	3	5	1	0	2	1	0	0	0	12
	FS	0	0	0	0	1	1	0	0	0	1	0	0	0	3
PET/CT Scanners	H	0	0	0	0	3	5	0	0	2	1	0	0	0	11
	FS	0	0	0	0	1	0	0	0	0	0	0	0	0	1
SPECT/CT Scanners	H	0	0	0	1	5	--	0	2	0	1	0	0	0	9
	FS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As of January 1, 2007															
Nuclear Medicine Cameras	H	11	2	23	17	149	231	16	13	40	62	0	0	0	564
	FS	0	0	0	0	3	19	0	0	17	0	0	0	0	39
CT Scanners	H	11	2	16	15	107	126	19	15	38	47	1	1	0	398
	FS	0	0	0	0	12	4	0	0	3	2	0	0	0	21
Angiography Suites	H	3	0	5	9	42	73	5	5	15	21	0	0	0	178
	FS	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MRI Scanners	H	3	1	5	5	48	67	7	4	21	20	0	0	0	181
	FS	0	0	1	0	19	5	1	0	6	9	0	0	0	41
Catheterization Labs	H	2	0	5	3	26	50	5	4	11	12	0	0	0	118
	FS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PET Scanners	H	0	0	0	0	3	4	1	0	1	1	0	0	0	10
	FS	0	0	0	0	1	1	0	0	0	1	0	0	0	3
PET/CT Scanners	H	0	0	0	1	5	7	0	0	2	1	0	0	0	16
	FS	0	0	0	0	2	0	0	0	0	0	0	0	0	2
SPECT/CT Scanners	H	0	0	0	1	9	19*	0	3	0	3	0	0	0	35*
	FS	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes

-- Not available.

* Ontario data are as of July 31, 2008. Since no data on SPECT/CT scanners were reported for Ontario in the 2007 survey, the number of SPECT/CT scanners confirmed by the Ontario Ministry of Health and Long-Term Care as installed and operational in Ontario hospitals as of July 31, 2008, is included here, instead.

H Number of selected imaging technologies in hospitals.

FS Number of selected imaging technologies in free-standing imaging facilities.

a) PET/CT scanners were identified separately from PET and CT scanners for the first time in the 2006 survey. The numbers of PET/CT scanners were imputed for 2003, 2004 and 2005 based on the year of installation indicated in the 2006 survey.

b) Data on SPECT/CT scanners were first collected in the 2006 survey.

c) Some devices were captured for the first time in the National Survey of Selected Medical Imaging Equipment of 2004, 2005, 2006 and 2007 two or more years after they were installed. Historical revisions were made for these devices. Because of the delay between the time a device is installed and when it becomes operational, such devices are counted as installed and operational two years after their indicated year of installation. For example, a device reported for the first time in the 2007 survey as installed in 2004 is counted as installed and operational as of January 1, 2006 (but not as of January 1, 2005).

d) Data are as of January 1, 2007. Some additional equipment has subsequently been installed.

e) The number of scanners in Ontario and British Columbia in 2006 and 2007 is an estimation.

Source

National Survey of Selected Medical Imaging Equipment, 2003 to 2007, Canadian Institute for Health Information, supplemented by information on scanners from provincial ministries of health.

Table A.8 Results From the Health Services Access Surveys, 2001, 2003 and 2005

Selected parameters for Canadians aged 15 and over who reported receiving a non-emergency angiography, CT or MRI in the previous 12 months.

Parameter	Angiography			CT			MRI		
	2001	2003	2005	2001	2003	2005	2001	2003	2005
Approximate number aged 15+ who had a test [†]	220,000*	242,000	226,000	787,000	962,000	1,116,404	647,000	892,000	1,012,092
Population aged 15+ who had a test	0.9%*	0.9%	0.9%	3.1%	3.7%	4.3%	2.6%	3.4%	3.9%
Age distribution of test recipients									
Under 45 years	--	26%*	15%*	33%	38%	34%	40%*	37%	42%
Age 45–64	52%*	32%	54%	41%	36%	37%	40%	48%	42%
Age 65+	37%*	42%	32%	26%	26%	29%	19%*	15%	16%
Test recipients who were male	8%*	54%	60%	50%	45%	42%	53%	48%	51%
Reason for test									
Heart disease or stroke	77%	66%	63%	7%*	7%*	7%*	--	9%*	7%*
Cancer	--	--	--	13%*	9%	11%	--	6%*	4%*
Joints or fractures	--	--	--	13%*	16%	16%	18%*	35%	35%
Neurological or brain disorders	--	--	--	29%	19%	18%	12%*	14%	19%
Other/not specified	--	28%*	30%*	37%	48%	48%	46%	35%	35%
Place of test									
Hospital/public clinic	98%	83%	96%	96%	96%	96%	92%	90%	89%
Other [‡]	2%	17%*	--	4%	4%*	4%*	8%	9%	11%*
Percent who reported any difficulties in accessing the test	--	--	--	17%*	14%	10%	15%*	21%	16%

Notes

-- Data are suppressed due to extreme sampling variability.

* Interpret with caution due to high sampling variability.

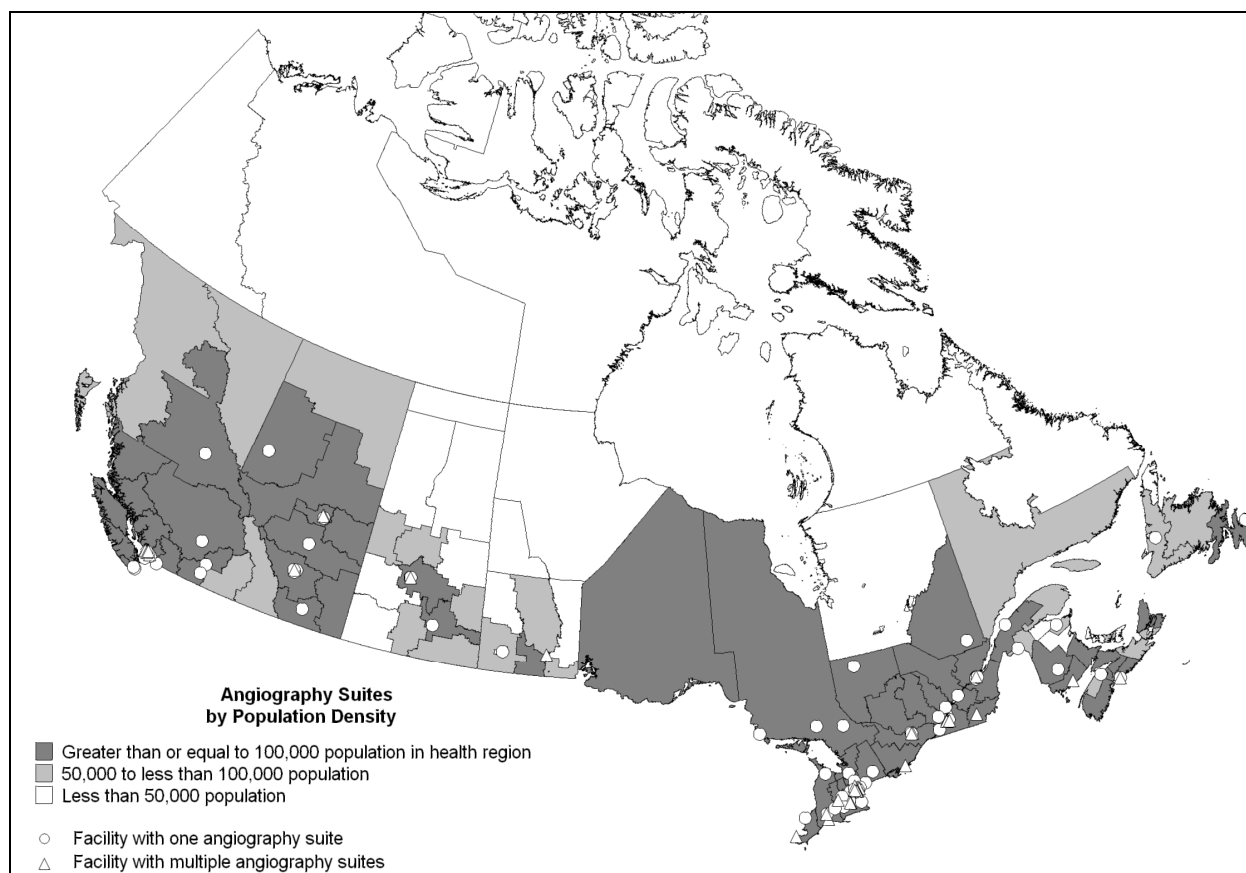
† Rounded to the nearest 1,000 persons.

‡ "Other" includes private clinics and other locations not specified.

Sources

Health Services Access Surveys 2001, 2003 and 2005, Statistics Canada.

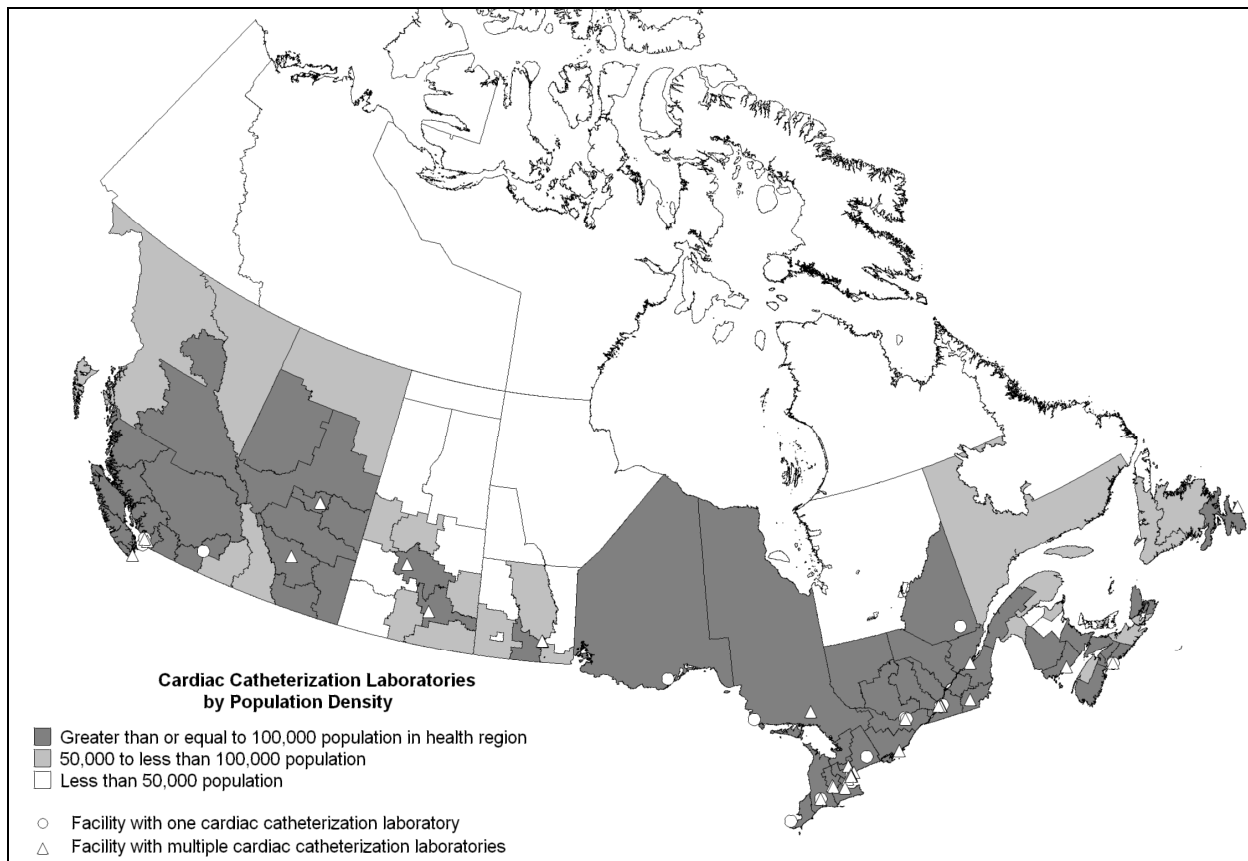
Figure A.1 Angiography Suites in Hospitals and Free-Standing Facilities Across Canada, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

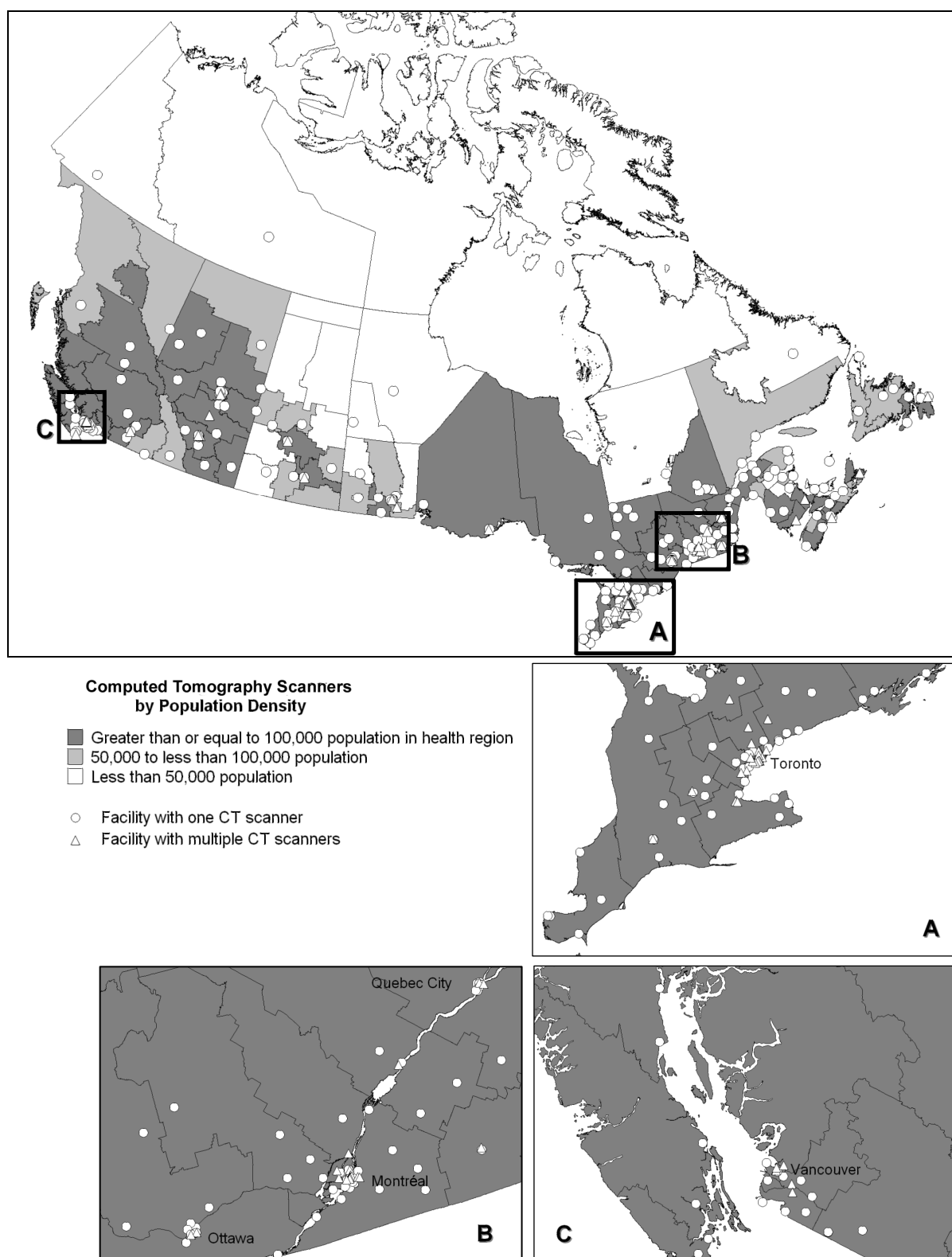
Figure A.2 Cardiac Catheterization Laboratories in Hospitals and Free-Standing Facilities Across Canada, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

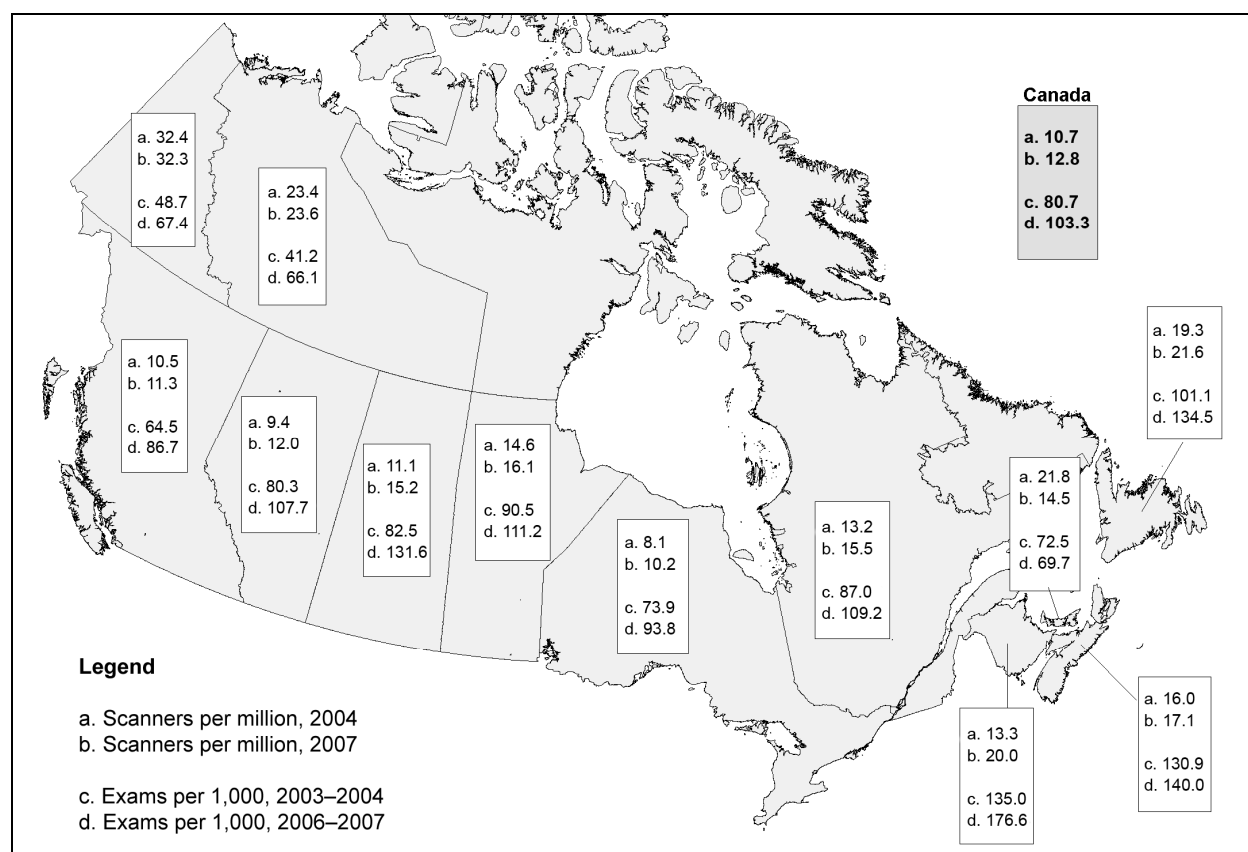
Figure A.3 CT Scanners in Hospitals and Free-Standing Facilities Across Canada, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure A.4 CT Scanners per Million Provincial Population and Exams per 1,000 Provincial Population, 2004 and 2007



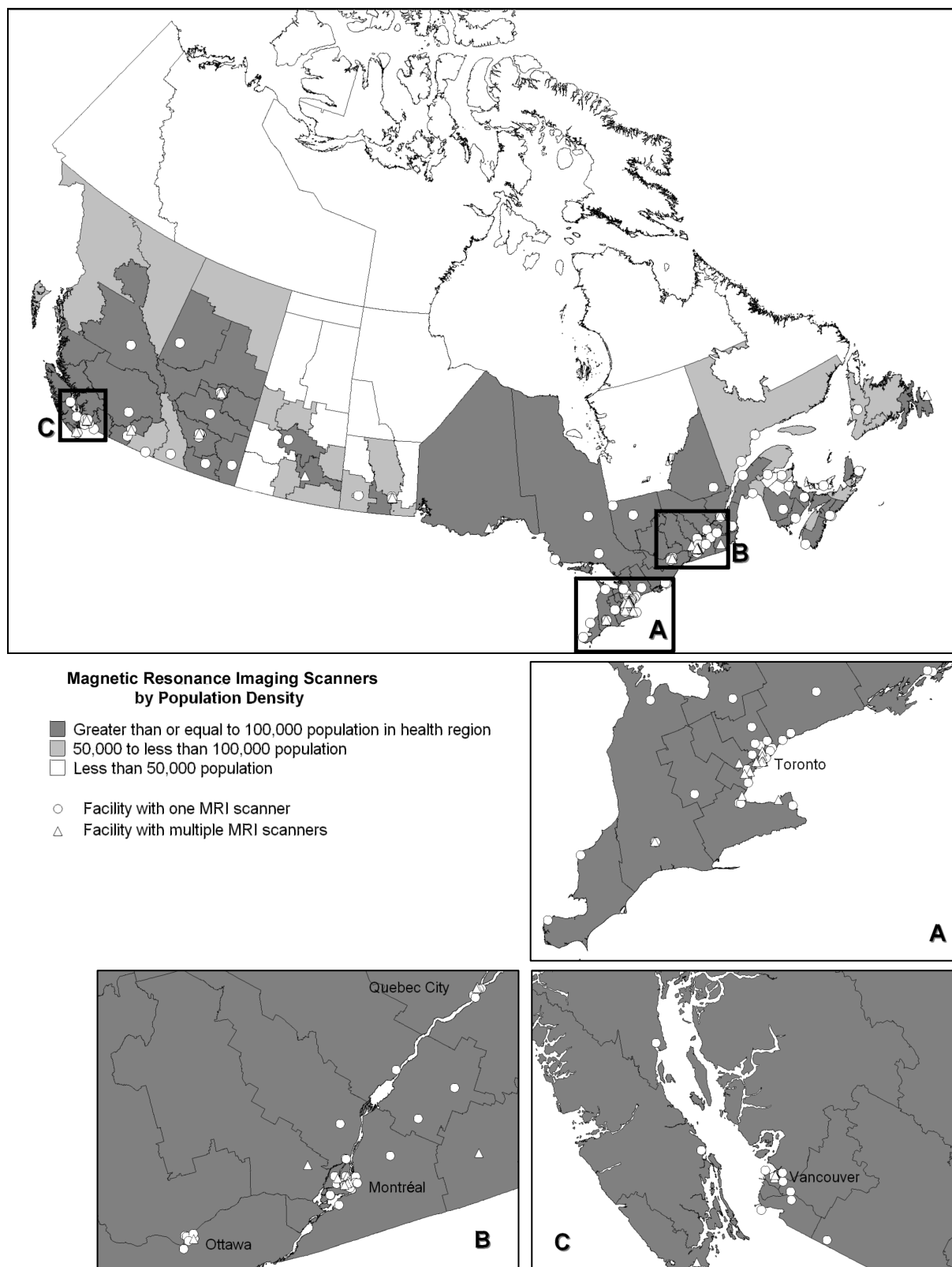
Notes

- a) Scanners per million population comprise all scanners installed and operational as reported in Table A.7, including those used exclusively or mainly for research.
- b) Exams per 1,000 population comprise only exams done by scanners used exclusively or mainly for clinical purposes (that is, 50% of the time or more) as reported in Table 5 of Chapter 3. Exams done by scanners used exclusively or mainly for research are excluded.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

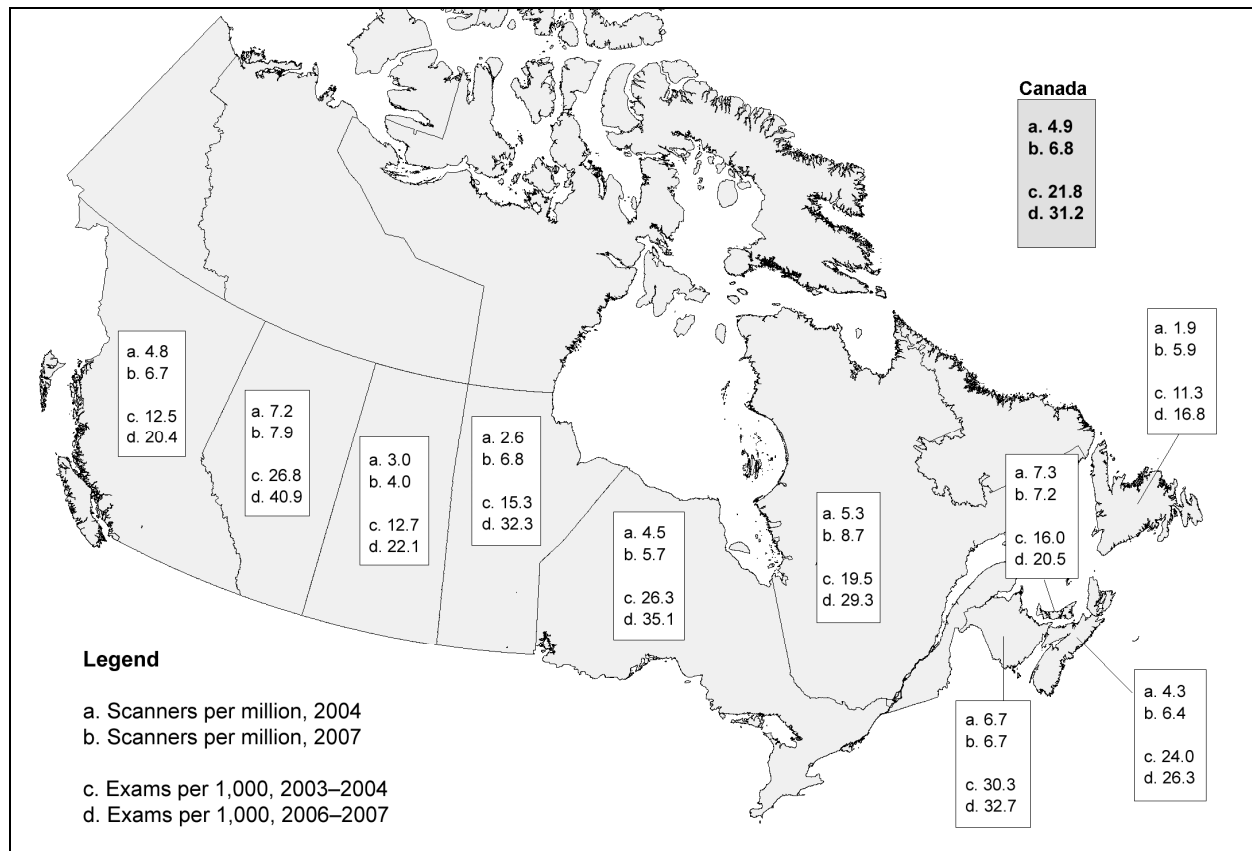
Figure A.5 MRI Scanners in Hospitals and Free-Standing Facilities Across Canada, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure A.6 MRI Scanners per Million Provincial Population and Exams per 1,000 Provincial Population, 2004 and 2007



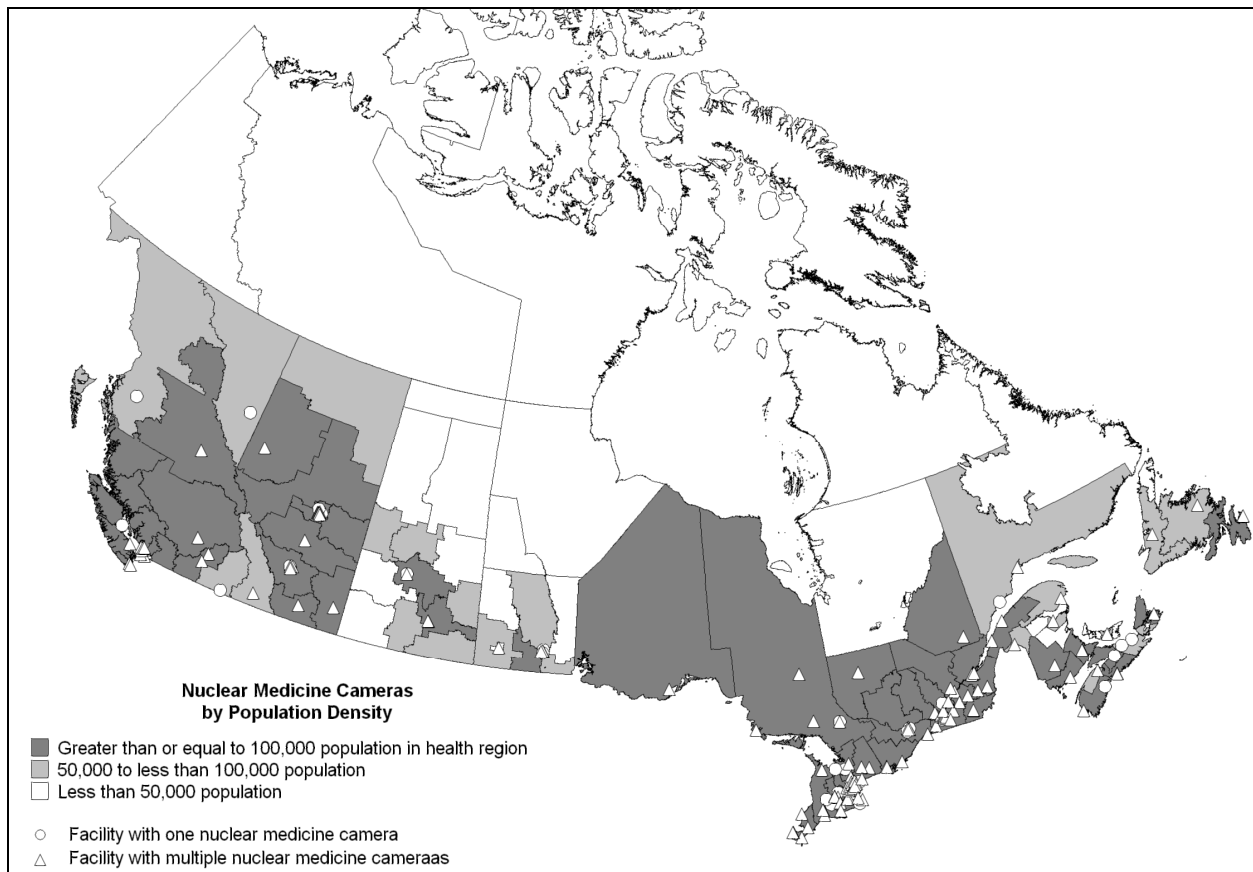
Notes

- a) Scanners per million population comprise all scanners installed and operational as reported in Table A.7, including those used exclusively or mainly for research.
- b) Exams per 1,000 population comprise only exams done by scanners used exclusively or mainly for clinical purposes (that is, 50% of the time or more) as reported in Table 5 of Chapter 3. Exams done by scanners used exclusively or mainly for research are excluded.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

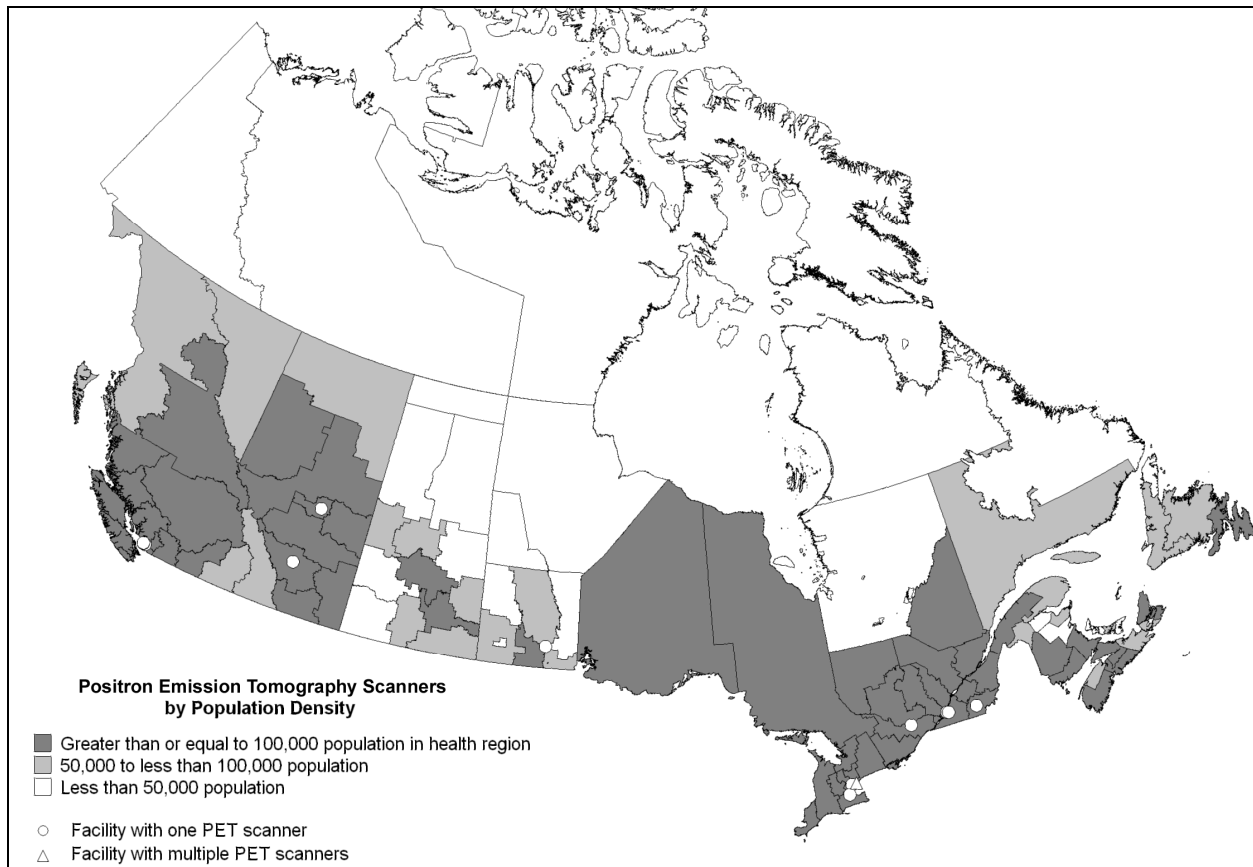
Figure A.7 Nuclear Medicine Cameras in Hospitals and Free-Standing Facilities Across Canada, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

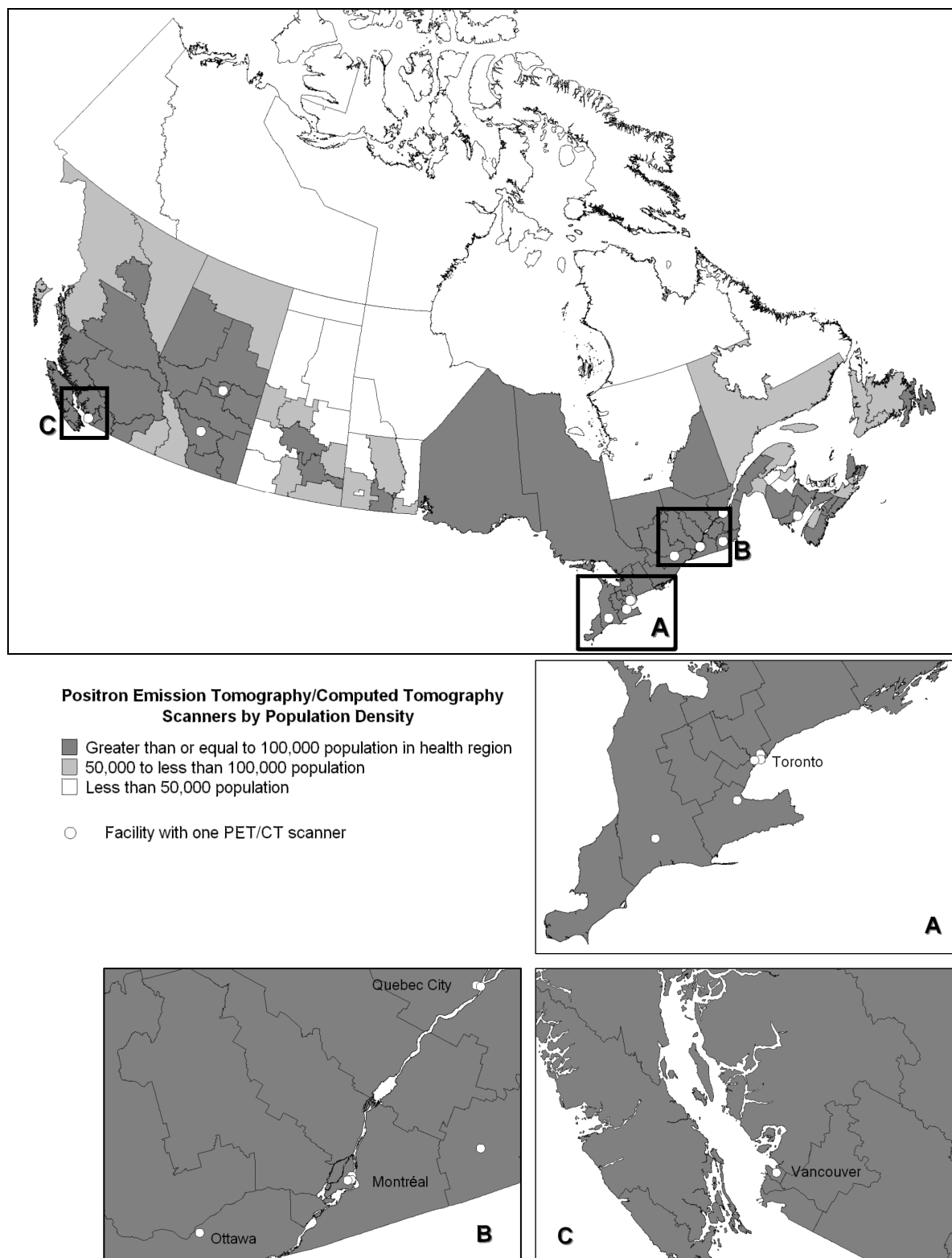
Figure A.8 PET Scanners in Hospitals and Free-Standing Imaging Facilities Across Canada, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

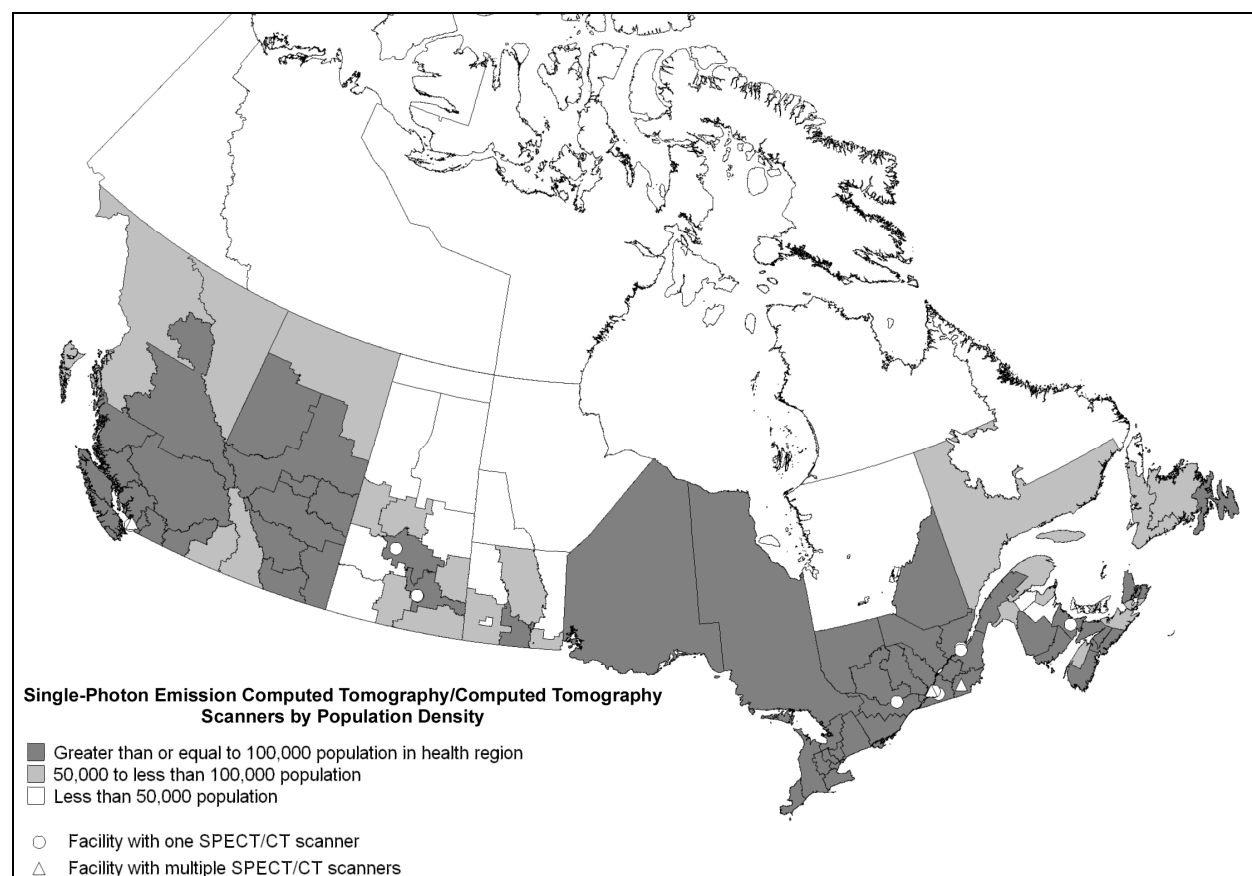
Figure A.9 PET/CT Scanners in Hospitals and Free-Standing Imaging Facilities Across Canada, 2007



Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Figure A.10 SPECT/CT Scanners in Hospitals and Free-Standing Imaging Facilities Across Canada, 2007



Note

No data on SPECT/CT scanners were reported for Ontario in the 2007 survey. The 19 SPECT/CT scanners confirmed by the Ontario Ministry of Health and Long-Term Care as installed and operational in Ontario hospitals as of July 31, 2008, are not shown here as their names and locations were not available.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information.

Appendix B

Methodological Notes

Appendix B—Methodological Notes

Introduction

The Canadian Institute for Health Information (CIHI) aims to provide accurate and timely data and information to help shape Canada's health policies, improve health, strengthen our health care system and assist leaders in the health sector and Canadians to make informed decisions. As part of this goal, in 2003, CIHI undertook an annual national survey of selected high-technology medical imaging equipment. The National Survey of Selected Medical Imaging Equipment is intended to monitor changes in the national inventory of select modalities of medical imaging and treatment equipment so as to inform Canadians about the distribution and use of these technologies.

The CIHI survey is based on a similar survey and process that was last conducted by the Canadian Coordinating Office for Health Technology Assessment (CCOHTA) in June 2001 (CCOHTA was renamed the Canadian Agency for Drugs and Technologies in Health in April 2006). CIHI first ran the survey in 2003 and released a report that included the results in September 2003. Both CIHI and CCOHTA have worked together to build upon the database and ensure a smooth transition. As was done for the 2001 CCOHTA survey, CIHI retained the services of ProMed Associates Ltd., a diagnostic imaging consulting firm headquartered in Vancouver, to coordinate the data collection for 2003, 2004, 2005, 2006 and 2007.

This section of the report is intended to provide important information that will help users of the National Survey of Selected Medical Imaging Equipment data to judge the extent to which the data may be used for their particular needs. Users who require information beyond what is provided here are encouraged to contact the National Health Expenditure Database section of CIHI, by phone at 613-241-7860, by fax at 613-241-8120 or by email at nhex@cihi.ca.

Concepts and Definitions

Population

The 2007 National Survey of Selected Medical Imaging Equipment collected data from all identifiable health care facilities (public and private) in each province and territory in Canada that had one or more of seven specific types of equipment included in the scope of the original 2003 survey. The types of medical imaging equipment that were included in the scope of the original survey were magnetic resonance imaging (MRI) scanners, computed tomography (CT) scanners, positron emission tomography (PET) scanners, angiography suites, catheterization laboratories and nuclear medicine cameras. A seventh type of equipment, lithotripters (therapeutic devices), was also included in the scope of the original survey. In the 2006 and 2007 surveys, data were also collected on two types of fusion technology: positron emission tomography combined with computed tomography (PET/CT) and single-photon emission computed tomography combined with computed tomography (SPECT/CT). In the 2006 and 2007 surveys, information was also requested on bone mineral densitometers (previously listed under nuclear medicine). This additional information was requested from those facilities with at least one of the seven types of equipment in the scope of the original 2003 survey.

The 2007 survey was carried out between April 17, 2007, and June 30, 2007, with follow-up to mid-October 2007. Participants were asked to identify the technologies, described above, that were installed and operational prior to January 1, 2007.

Variables and Concepts

The following data elements collected in the 2007 survey were consistent with the data elements requested in the 2003 survey and surveys of subsequent years:

- Name of province or territory;
- Health region;
- Hospital (facility);
- The number of units (to establish current distribution);
- Type of equipment (only equipment operational as of January 1, 2007, could be included in the survey);
- Classification data (identified individual data elements for each type of technology, see listing below);
- Source of operating funding/revenue from April 1, 2006, to March 31, 2007 (sources of funding and the percentage distribution of those sources);
- Year installed (to determine age);
- Was this the initial year of service;
- Original equipment manufacturer (OEM);
- Site address and postal code for each piece of equipment; and
- Confidential contact information for further follow-up.

In the 2004 survey, participants were asked to respond to several additional questions. The following data elements collected in the 2007 survey were consistent with the data elements requested in the 2004 survey and surveys of subsequent years:

- 1) The average weekly hours the equipment was in use;
- 2) The percentage of time that the equipment was in use for clinical purposes only;
- 3) Whether film was used to record exams, or whether images were stored on electronic media (film, electronic or both);
- 4) Whether images acquired with this equipment were routed to a picture archive and communications system (PACS);
- 5) Whether PACS images were accessible in strategic areas of the hospital (that is, care areas/clinics);
- 6) Whether key images that were stored were available on a departmental image viewing system; and

- 7) Number of examinationsⁱ in a fiscal year (asked of CT, MRI in all years and of PET/CT and SPECT/CT since the 2006 survey; not asked of other types of equipment).

In the 2007 survey, the additional questions asked for each of the 10 specific types of technology involved the following:

Angiography suites:

- i) Select applications: general angio/cardiac angio/neurological angio;
- ii) Main purpose: diagnostic/interventions/both; and
- iii) Type: single plane/bi-plane.

Bone densitometer (separate from nuclear medicine since the 2006 survey; also includes equipment measuring bone density without the need to administer radioactive contrast material to the patient):

- i) Type: peripheral/axial.

Cardiac angiography—catheterization laboratory:

- i) Configuration: single plane/bi-plane;
- ii) Dynamic study recording: conventional (cine)/digital (electronic);
- iii) Main purpose: diagnostic/interventions/both; and
- iv) Dedicated to physiologic procedures (device implant and cardiac electrical conduction evaluation studies): yes/no.

Computed tomography (CT):

- i) Scanning mode: spiral/non-spiral;
- ii) Multidetectors: identify level of CT technology (that is, 4-slice, 16-slice or enter 0 if no multidetectors);
- iii) Capable of fluoroscopy: yes/no;
- iv) Mobile CT: the names of the sites that shared the unit (or no if the installation is fixed);
- v) Applications: diagnostic/interventions/both;
- vi) Whether the CT is also used for some treatment simulations; and
- vii) For the fiscal year beginning April 1, 2006, and ending March 31, 2007, the total number of CT examinations performed at the facility/site.

i. The definition of an examination is from the *Standards for Management Information Systems in Canadian Health Service Organizations* (MIS Standards). Examinations are defined as a technical investigation using an imaging modality to study one body structure, system or anatomical area that yields one or more views for diagnostic and/or therapeutic purposes. Exceptions include routinely ordered multiple body structures that by common practice or protocol are counted as one exam.

Fusion technology—positron emission tomography combined with computed tomography (PET/CT)—(included since the 2006 survey):

- i) Scanning mode: spiral/non-spiral;
- ii) Multidetectors: identify level of CT technology (that is, 4-slice, 16-slice or enter 1 if only a single slice);
- iii) CT capable of fluoroscopy: yes/no;
- iv) Mobile PET/CT: the names of the sites that shared the unit (or no if the installation is fixed);
- v) Applications: diagnostic/interventions/both;
- vi) Whether the CT is also used for some treatment simulations;
- vii) PET imaging scope: head only/full body;
- viii) Type of practice: dedicated to research/dedicated to clinical purposes/both;
- ix) Does the facility operate a cyclotron? yes/no; and
- x) For the fiscal year beginning April 1, 2006, and ending March 31, 2007, the total number of PET/CT examinations performed at the facility/site.

Fusion technology—single-photon emission computed tomography combined with computed tomography (SPECT/CT)—(included since the 2006 survey):

- i) Scanning mode: spiral/non-spiral;
- ii) Multidetectors: identify level of CT technology (that is, 4-slice, 16-slice or enter 1 if only a single slice);
- iii) CT capable of fluoroscopy: yes/no;
- iv) Mobile SPECT/CT: the names of the sites that shared the unit (or no if the installation is fixed);
- v) Applications: diagnostic/interventions/both;
- vi) Whether the CT is also used for some treatment simulations;
- vii) SPECT/CT number of scanning heads (detectors): single head/dual head/triple head; and
- viii) For the fiscal year beginning April 1, 2006, and ending March 31, 2007, the total number of SPECT/CT examinations performed at the facility/site.

Lithotripsy:

- i) Shockwave generation technology: electromagnetic/electrohydraulic/piezoelectric; and
- ii) Imaging source: X-ray/ultrasound/both.

Magnetic resonance imaging (MRI):

- i) Field strength (Tesla);
- ii) Configuration: closed bore/open bore;

- iii) Mobile MRI: If mobile, the names of the sites that shared the unit (or no if the installation is fixed); and
- iv) For the fiscal year beginning April 1, 2006, and ending March 31, 2007, the total number of MRI examinations performed at the facility/site.

Nuclear medicine—gamma cameras (gamma and SPECT):

- i) Number of scanning heads (detectors): single head/dual head/triple head.

Positron emission tomography (PET):

- i) Imaging scope: head only/full body;
- ii) Type of practice: dedicated to research/dedicated to clinical purposes/both; and
- iii) Does the facility operate a cyclotron? yes/no.

Definitions

Angiogram: An X-ray of a blood vessel that has been injected with a contrast agent.

Angiography: A technique that enables blood vessels to show up on X-rays. A dense contrast agent (X-ray dye) is injected into the blood vessel, and an X-ray is taken. This outlines the blood vessel, revealing blockages or other abnormalities.

Angioplasty: The use of a small balloon on the tip of a catheter inserted into a blood vessel to open up an area of blockage inside the vessel.

Bone density: A diagnostic test that measures the amount of mineral in bones. The most commonly used test is dual-energy X-ray absorptiometry (DXA), a low-dose X-ray beam that scans the spine or the hip, or both.

Cardiac catheterization: A form of coronary angiography used to image the blood vessels in the heart, to examine the function of the heart and to dilate narrowed blood vessels that are not supplying adequate amounts of blood to heart muscles.

Computed tomography (CT) scan or computed assisted or axial tomography (CAT) scan:

A diagnostic technique that uses X-rays and computer technology to produce cross-sectional images of the body (often called slices), both horizontally and vertically. A CT scan can show detailed images of various parts of the body, including the bones, muscles, fat and organs. They are more detailed than general X-rays.

Contrast media: A radiopaque substance used during an X-ray exam (or some other exams) to provide visual contrast in the pictures of different tissues and organs. This substance can be given orally or intravenously (by injection).

Contrast resolution: The ability of an imaging method to distinguish one tissue from another, or diseased from normal tissue.

Coronary angiography: A diagnostic technique used to image coronary arteries. A catheter is used to inject the arteries with a contrast agent (X-ray dye) and an X-ray is taken.

Digital Imaging and Communications in Medicine (DICOM): An industry-recognized standard that dictates what digital image information is shared between two or more devices, as well as how that information is shared. DICOM limitations may restrict the ease of interfacing devices or the type of information that can be exchanged.

Doppler ultrasound: Measures change in echo frequency to calculate how fast an object is moving, thus permitting measurement of the velocity and direction of blood flow.

Evaluation of cancer diagnostic tests: Four indices are used to assess the sensitivity, specificity and accuracy of a diagnostic test. Administering the test to one group of persons who have the cancer and to another group who do not, and then comparing the results, can assess the sensitivity and specificity of a diagnostic test.

True positive: Those who tested positive and have cancer.

True negative: Those who tested negative and do not have cancer.

False positive: Those who tested positive but do not have the cancer.

False negative: Those who tested negative but in fact have the cancer.

Sensitivity: The division of the number of true positives by the total number of patients who have the cancer.

Specificity: The number of true negatives divided by the number of patients who do not have the cancer.

Accuracy: The sum of true positives and true negatives divided by the total number of the patients tested.

Exam: A defined technical investigation using an imaging modality to study one body structure, system or anatomical area that yields one or more views for diagnostic and/or therapeutic purpose. Exceptions include routinely ordered multiple body structures that by common practice or protocol are counted as one exam.

Fluoroscopy: A study of moving body structures, a sort of X-ray "movie." A continuous X-ray beam is passed through the body part being examined, and is transmitted to a TV-like monitor so that the body part and its motion can be seen in detail.

Free-standing imaging facility: Ranges from specialized services run privately by physicians, radiologists, dentists and chiropractors, to mammography programs and broad-based imaging centres offering a wide range of tests.

Gamma camera: A device used in nuclear medicine to scan patients who have been injected with small amounts of radioactive materials.

Health Level-7 (HL7): A standard that was developed to allow the transfer of text data between different information systems in health care.

Hospital: An institution where patients are accommodated on the basis of medical need and are provided with continuing medical care and supporting diagnostic and therapeutic services. Hospitals are licensed or approved as hospitals by a provincial or territorial government, or are operated by the government of Canada, and include those providing acute care, extended and chronic care, rehabilitation and convalescent care and psychiatric care.

Hospital information system (HIS): An information system used to manage patient information, including reports, schedules, text data and billing.

Interventional radiology: An area of specialty within the field of radiology that uses various radiology techniques (such as X-ray, CT scans, MRI scans and ultrasounds) to place wires, tubes or other instruments inside a patient to diagnose or treat an array of conditions.

Ionizing radiation: Produces charged particles (ions) in matter. The particles are produced by unstable atoms, which have an excess of energy or mass or both, and are said to be radioactive. Radiation is the emission of this excess energy or mass needed to reach stability.

Lithotripsy: The crushing of a stone in the renal pelvis, ureter or bladder by mechanical force or sound waves.

Magnetic resonance imaging (MRI): A diagnostic technology that uses a large magnet, radio waves and a computer to scan a patient's body and produce two- or three-dimensional images of tissues and organs.

Magnetic resonance spectroscopy (MRS): A type of MRI that measures concentrations of metabolites to produce images of chemical processes.

Mammography: Uses low-dose X-ray with high-contrast, high-resolution film to create detailed images of the breast.

Modality: A treatment or method of examination (for example, X-ray, ultrasound, CT scan, MRI).

Non-emergency diagnostic test: A booked or planned diagnostic test provided on an outpatient or inpatient basis. Does not refer to tests provided through admission to the hospital emergency room as a result of, for example, an accident or life-threatening situation.

Nuclear medicine: A medical specialty where organ function and structure are examined by administering small amounts of radioactive contrast materials to the patient and taking scans with a gamma camera or other device for the purpose of diagnosing and treating disease.

Operating expense: Operating expenses include compensation of medical imaging staff, supplies, equipment, sundry, referred-out services and traceable supplies and other expenses. Operating expenses do not include the capital cost of purchasing major equipment, such as medical imaging equipment.

Picture archiving and communications system (PACS): A system that acquires, transmits, stores, retrieves and displays digital images and related patient information from a variety of imaging sources and communicates the information over a network.

Positron emission tomography (PET): A non-invasive diagnostic technology that measures the metabolic activity of cells.

RAD: See *radiation absorbed dose*.

Radiation: The emission and flow of energy in the form of high-speed particles and electromagnetic waves. For example, visible light and radio, television, ultraviolet (UV) and microwaves are made up of electromagnetic waves.

Radiation absorbed dose (RAD): A unit that measures radiation in terms of the absorbed dose. For radiological procedures it is equivalent to the Roentgen equivalent man (REM), and the two units are used interchangeably.

Radiograph: A photographic image produced on a radiosensitive surface by radiation other than visible light (especially by X-rays or gamma rays).

Radiography: The process of making a radiograph.

Radiology: The scientific discipline of medical imaging using ionizing radiation, radionuclides, nuclear magnetic resonance and ultrasound for the diagnosis and treatment of disease.

Radiology information system (RIS): An information system used to schedule radiological procedures, generate reports of clinical findings and bill.

Roentgen equivalent man (REM): A unit used to derive a quantity called “equivalent dose,” which relates the absorbed dose in human tissue to the effective biological damage of the radiation.

Radiopharmaceutical (tracer or radionuclides): Basic radioactively tagged compound necessary to produce a nuclear medicine image.

Roentgen (R): A unit used to measure a quantity called “exposure” and which can be used only to describe an amount of gamma and X-rays, and only in air. This unit measures the ionizations of the molecules in a mass of air.

Single-photon emission computed tomography (SPECT): A type of nuclear medicine. It measures the concentration of radionuclides introduced into a patient’s body. One or more gamma cameras rotate around the patient and take pictures from many angles; a computer then uses the pictures to form a tomographic (cross-sectional) image.

Spatial resolution: The ability of an imaging method to resolve anatomic detail.

Teleradiology: Teleradiology is a means of electronically transmitting radiographic patient images and consultative text from one location to another.

Temporal resolution: The ability of an imaging method to reflect changing physiological events such as cardiac motion, disease remission or progression as a function of time.

Tomography: A method whereby a three-dimensional image of the internal structures of the human body is produced.

Ultrasound imaging (sonography): Uses high-frequency sound waves to make pictures of the body organs. Echoes from the sound waves are recorded and displayed as a real-time, visual image.

X-ray (radiograph): A small amount of radiation (electromagnetic waves) directed toward a specific part of the body to produce an image on a film on the other side of the body. Radiologists study the X-ray images to detect and diagnose disease or injury. Common X-ray methods and procedures include fluoroscopy, mammography and angiography.

Major Data Limitations

The survey, which includes publicly and privately funded facilities and their equipment, relied on the participation of diagnostic imaging medical heads and managers as primary sources of information to ensure that accurate data were collected across Canada. Secondary sources were also employed in order to verify data submitted by primary data providers and to identify sites where these technologies may be located, but that were unidentifiable through primary sources.

The survey also relies on the consistency of the approach with previous surveys, including consistent data elements, question types and process management, to ensure comparability of the information over time. However, as with previous surveys, there was no mandatory requirement for sites to participate. It was only through continued encouragement that many sites participated in the survey.

The information obtained from the survey will provide users with a “snapshot” of selected imaging technologies in Canada. The survey did not include any questions on general radiology equipment, ultrasound and therapeutic equipment (except for lithotriptors), and included only a few questions on radiology information systems (RIS) and picture archiving and communication systems (PACS) and other information technology. For this reason, it cannot be considered a complete data source for all medical imaging equipment in Canada.

Private facilities were hesitant, in general, to participate in the survey process, and were often willing to identify “private or other” as a source of funding, but were generally unwilling to identify specific sources of funding. Overall, responses to the funding questions were limited, since some participants did not identify more than one source of funding. For 2007, respondents did not report any sources of funding for 256 machines (15.3%). See Table 4 of Chapter 2 for the number of CT scanners, MRI scanners and nuclear medicine cameras for which sources of funds were reported, and number of such devices installed and operational.

Each time the survey is conducted, it offers an opportunity to update information that was captured in previous years. However, there were areas of perceived potential underreporting. For instance, new or merged facilities since the 2006 survey needed to be identified

through the primary and secondary sources, and extensive research was undertaken and completed to locate these changes in the frame. Contact lists also needed constant updating due to shifting roles, new personnel and changing organizational structures at the provincial or territorial, regional, hospital and clinic levels.

The information from the survey is limited by the quality of participants' responses, since it is generally based on their first-hand knowledge of the technologies. The voluntary nature of the participation in the survey also means that some medical imaging equipment may not be captured, as some facilities declined to participate or were unable to complete the survey. Furthermore, there is no known comprehensive baseline study or report in the literature to validate the survey information, other than the existing 2001 CCOHTA and the 2003 to 2006 CIHI survey results.

Some provincial issues, such as changes in the number of health regions or changes in names, may also have affected the 2007 survey results. For instance, the number of health regions in Ontario increased from 7 to 14. The number of health regions in Newfoundland and Labrador decreased from eight to four. In Alberta, the Mistahia Region had its name changed to Peace County Health Region. Occasionally, there was some confusion among participants regarding the current name of their own health region. Also, some regional or hospital contacts changed due to changes in health regions, internal organizational changes, re-assignments of responsibilities, etc.

The electronic survey questionnaire was posted on ProMed Associates Ltd.'s website. The questionnaire was designed to change automatically, depending on the type of modality the respondent was entering. For instance, if a respondent was entering information on a CT scanner, there would be four more questions than there would be for an angiography suite. As a result, some respondents seemed to be confused by the addition or change in questions when entering more than one type of technology. However, where required, participants were contacted by ProMed representatives for follow-up or clarification of the data they had provided.

Collection and Non-Response

The following notes briefly describe some of the major technical points associated with the compilation of the 2007 National Survey of Selected Medical Imaging Equipment and report. Additional information can be obtained by contacting the National Health Expenditure Database section, by phone at 613-241-7860, by fax at 613-241-8120 or by email at nhex@cihi.ca.

General Methods

Based on experience with previous surveys, a primary process and a secondary process for collecting data were developed; these processes were performed concurrently.

The primary process began with the distribution of introductory and instructional information to chief executive officers (CEOs) of every health region and hospital in Canada. The list was created from administrative information gathered from CIHI and ProMed Associates Ltd. and other sources, as well as research to identify all potential locations of medical imaging equipment. CEOs continued the process by distributing the information to the heads or managers of medical imaging and nuclear medicine departments in their organizations. An enhanced website was developed that allowed participants to register online and complete the information from their respective sites. The package that the heads and managers of medical imaging and nuclear medicine departments received included introductory and instructional information that was distributed by the consultants on CIHI letterhead (an overview of CIHI's mandate, a description of the project, the timetable, instructions for online registration and data entry or modification, verification and how to produce a printout of their information for their records). Both public and private facilities were contacted, per the agreed-upon scope of work.

The secondary process included contacting medical imaging-related organizations, such as the Canadian Association of Radiologists (CAR), l'Association des radiologistes du Québec (ARQ) and the Canadian Association of Nuclear Medicine (CANM), in order to secure their assistance, where possible, to identify potential locations of these technologies, regardless of whether they were identified previously or not. In addition, original equipment manufacturers, such as Siemens, General Electric, Philips and Toshiba, were contacted for the same purpose.

For those unable to access the website, alternative methods were offered in order to help facilitate participation. All participants were advised that their data would remain online in the database and that, with the proper authorization, staff from within their organization could access this information for various planning purposes.

Every question in the survey was identified as mandatory, except for the questions related to funding. These questions were answered globally for each organization, and were again asked for each piece of equipment. Participants had to provide a response to all questions before they were able to move ahead to the next piece of equipment. Clear and concise instructions in both official languages were provided to participants in written form and online (on the website) as part of the process to ensure the same level of understanding among respondents. The 2007 survey defaulted to the language that each participant's

computer was set to. Participants also had the option to move freely between both official languages. Where necessary, support was provided to the respondents in real time or online throughout the survey process.

Manual download of the online database was completed on a daily basis. Where required, participants were contacted for follow-up information and/or clarification on the data that they had provided. Where it was felt that the data were incomplete or possibly inaccurate, participants were contacted to verify their information.

When participants finished their data entry, they were taken to a main review page, where they could continue to enter new equipment or end the survey. Unlike the 2003 survey, when each participant was asked (as part of the online survey process) to review the information he or she had provided, verify that it was complete and accurate, then to move on to the next equipment entry, the review process was continual in the 2007 survey (as in the 2004 to 2006 surveys) and took place as each piece was entered.

During the course of the 2007 survey, ProMed Associates Ltd. received, along with any updates, validation of the 2006 data from the Government of the Yukon and the governments of Newfoundland and Labrador, Quebec, Manitoba, Saskatchewan, Alberta and B.C. The number of devices reported in the 2007 survey increased relative to the 2006 survey for eight types of equipment, but decreased for nuclear medicine cameras and PET scanners.

- Angiography suites increased by 2.3%.
- Bone densitometers increased by 15.7%.
- Catheterization laboratories increased by 3.5%.
- CT scanners increased by 6.0%.
- PET/CT scanners increased by 27.3%.
- SPECT/CT scanners increased by 133.3%.
- Lithotripsy units increased by 18.8%.
- MRI scanners increased by 6.5%.
- Nuclear medicine cameras decreased by 2.0%.
- PET scanners decreased by 6.7%.

Coverage

CEOs for all health regions and hospitals were sent a copy of the cover letter and instructional information for distribution to medical heads and to managers of radiology and nuclear medicine departments. Identified key executives of private clinics were contacted directly. Within days of these mail-outs, each CEO's office was contacted to confirm receipt of the information and to encourage immediate distribution of the information to medical directors and managers of radiology and nuclear medicine who may have MRI, CT, PET, angiography, catheterization labs, nuclear medicine and lithotripter technology (which fell under the scope of this national survey). The corporate office was asked to identify a primary survey contact and an alternate contact (if there wasn't one already identified) to facilitate survey participation.

Using the 2001 to 2006 data files as an initial list of reference sites with these technologies, data entries in the 2007 survey were monitored to ensure that there was only one respondent for each health region, hospital or clinic. When duplication was suspected, based on registry information or if a significant change in technology numbers from the previous survey was detected, participants were contacted to verify their responses.

In the 2007 survey, 534 facilities were identified as having the selected types of equipment that fell under the scope of the national survey. Of these, 513 facilities (96.1%) submitted their data. There were five hospitals and 16 private facilities that were unable to complete the survey or declined to participate, although they had reported in previous surveys. The number of imaging devices in these non-reporting facilities and their characteristics were imputed in 2007 based on information collected in previous surveys. The number of imaging devices so imputed accounted for 3.2% of all imaging devices for the selected types of imaging equipment. The imaging devices in the 21 facilities were assumed to have remained the same as in the latest year for which the data were provided, but the information may no longer be accurate. The 21 facilities that were unable to complete the 2007 survey or declined to participate are listed in Table B.1, along with the imaging devices reported in previous surveys and their year of installation. Most of the non-reporting facilities are in Quebec (14) and Alberta (4). New Brunswick, Ontario and B.C. each have one facility that did not report.

Table B.1 Facilities That Were Unable to Complete the 2007 Survey or Declined to Participate, But That Reported in Previous Surveys

Province	Site Name	City	Technology	Year of Installation
New Brunswick	Hôpital régional d'Edmundston	Edmundston	Angiography	1991
	Hôpital régional d'Edmundston	Edmundston	Nuclear Medicine Camera	1993
	Hôpital régional d'Edmundston	Edmundston	Computed Tomography	1991
	Hôpital régional d'Edmundston	Edmundston	Nuclear Medicine Camera	1993
	Hôpital régional d'Edmundston	Edmundston	Magnetic Resonance Imaging	1999
	Hôpital régional d'Edmundston	Edmundston	Bone Densitometer	1999
Quebec	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Angiography	1995
	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Nuclear Medicine Camera	1995
	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Nuclear Medicine Camera	1996
	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Nuclear Medicine Camera	2001
	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Nuclear Medicine Camera	2001
	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Magnetic Resonance Imaging	1999
	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Computed Tomography	2003
	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Nuclear Medicine Camera	1998
	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Nuclear Medicine Camera	1998
	Centre hospitalier régional de Trois-Rivières	Trois-Rivières	Computed Tomography	1999
	Radiologie JTB	Montréal	Computed Tomography	2001
	Léger et Associés, radiologistes	Montréal	Magnetic Resonance Imaging	1996
	IRM Québec, Centre médical Mailloux	Quebec City	Computed Tomography	2002
	IRM Québec, Centre médical Mailloux	Quebec City	Magnetic Resonance Imaging	1998
	IRM Québec, Centre médical Mailloux	Quebec City	Magnetic Resonance Imaging	2002
	Ottawa Valley MRI	Hull	Magnetic Resonance Imaging	2001
	Radiologie Laennec Inc. — Site Beaumont	Montréal	Computed Tomography	1998
	Radiologie Laennec Inc. — Site Beaumont	Montréal	Magnetic Resonance Imaging	1997
	Radiologie Laennec Inc. — Site Desjardins	Montréal	Magnetic Resonance Imaging	2000
	McGill University Health Centre — Montréal Neurological Hospital	Montréal	Angiography	1987
	McGill University Health Centre — Montréal Neurological Hospital	Montréal	Magnetic Resonance Imaging	1985
	McGill University Health Centre — Montréal Neurological Hospital	Montréal	Computed Tomography	1997
	McGill University Health Centre — Montréal Neurological Hospital	Montréal	Magnetic Resonance Imaging	2002
	Royal Victoria Hospital of the McGill University Health Centre	Montréal	Angiography	1992
	Royal Victoria Hospital of the McGill University Health Centre	Montréal	Computed Tomography	1996
	Royal Victoria Hospital of the McGill University Health Centre	Montréal	Computed Tomography	2003
	Royal Victoria Hospital of the McGill University Health Centre	Montréal	Magnetic Resonance Imaging	2006
	Royal Victoria Hospital of the McGill University Health Centre	Montréal	Lithotripsy/Lithotripsy	1988
	Centre de radiologie West-Island Inc.	Pointe Claire	Magnetic Resonance Imaging	2002
	Tomo Concorde Inc.	Laval	Magnetic Resonance Imaging	1997
	Tomo Concorde Inc.	Laval	Magnetic Resonance Imaging	2000
	Tomo Concorde Inc.	Laval	Computed Tomography	1998
	Radiologie St-Denis	Montréal	Computed Tomography	1999
	Radiologie Montérégie	Longueuil	Magnetic Resonance Imaging	2001
	Radiologie Montérégie	Longueuil	Computed Tomography	2001
	Le Centre radiologique Clarke Inc.	Montréal	Magnetic Resonance Imaging	2002
Ontario	Superior Imaging	Thunder Bay	Computed Tomography	2004
Alberta	Insight Medical Imaging, 136 Athabasca Avenue	Sherwood Park	Nuclear Medicine Camera	2004
	Insight Medical Imaging, 15309 Castledowns Road	Edmonton	Nuclear Medicine Camera	1997
	Insight Medical Imaging, 200 Meadowlark Health Centre	Edmonton	Nuclear Medicine Camera	2000
	Insight Medical Imaging, 200 Meadowlark Health Centre	Edmonton	Nuclear Medicine Camera	2002
	Insight Medical Imaging, 200 Meadowlark Health Centre	Edmonton	Nuclear Medicine Camera	2005
	Insight Medical Imaging, 200 Meadowlark Health Centre	Edmonton	Magnetic Resonance Imaging	2000
	Insight Medical Imaging, 200 Meadowlark Health Centre	Edmonton	Computed Tomography	2003
	Mayfair Diagnostics	Calgary	Computed Tomography	2002
British Columbia	Mayfair Diagnostics	Calgary	Magnetic Resonance Imaging	1999
	Fraser Valley Cancer Centre	Surrey	Computed Tomography	1996

Some hospitals and free-standing facilities with scanners (CT, MRI, PET, PET/CT and SPECT/CT) potentially installed and operational as of January 1, 2007, were contacted for the first time during the 2007 survey, but declined to participate. Additional hospitals and free-standing facilities with scanners potentially installed and operational as of January 1, 2007, were identified by CIHI outside of the survey process (that is, were not contacted during the 2007 survey).

After the 2007 survey was completed, the provincial and territorial ministries of health were asked by CIHI to validate the 2007 survey data, as well as the 2006 survey data, on the number scanners (CT, MRI, PET, PET/CT and SPECT/CT) and the year that they became operational. The list of scanners sent to the provincial and territorial ministries of health for validation also included scanners identified as potentially installed and operational. Eight provinces and the Yukon provided a complete validation of the list of scanners in hospitals. However, the hospital data for the Northwest Territories were not validated, and there was only a preliminary or partial validation of the data for Ontario and B.C. Since the provincial ministries of health were generally unable to validate the list of scanners in free-standing imaging facilities, the facilities with scanners potentially installed and operational as of January 1, 2007, were contacted directly by CIHI.

Table B.2 shows, following the validation, scanners confirmed as installed and operational as of January 1, 2007, in Quebec, Ontario, Manitoba, Alberta and B.C., but for which no data were collected in the 2007 survey. Since, generally, no information on their technological characteristics or number of exams was collected in the validation process, these scanners are not included in the tables and graphs of the present report, except for the tables and graphs on the number of devices and their age (or year when they became operational) and on the field strength of MRI scanners for which information was collected in the validation. Table B.3 shows the percentage of imaging devices for which technological characteristics were reported, including the scanners in Table B.2.

Table B.2 Scanners Confirmed as Installed and Operational as of January 1, 2007, But for Which no Data Were Collected in the 2007 Survey

Province	Site Name	City	Technology
Quebec	Centre de santé Cloutier-Du Rivage	Trois-Rivières	Computed Tomography
	Centre de santé de Chibougamau	Chibougamau	Computed Tomography
	Centre de santé du Granit	Lac-Mégantic	Computed Tomography
	Centre hospitalier d'Amqui	Amqui	Computed Tomography
	CSSS du Lac-Témiscamingue	Ville-Marie	Computed Tomography
	Hôpital d'Argenteuil	Lachute	Computed Tomography
	Hôtel-Dieu de Montmagny	Montmagny	Computed Tomography
	Hôtel-Dieu de Saint-Jérôme	Saint-Jérôme	Computed Tomography
	Imagerie médicale de la Capitale	Quebec City	Computed Tomography
	Léger et Associés	Montréal	Computed Tomography
	Centre hospitalier Honoré-Mercier	Saint-Hyacinthe	Magnetic Resonance Imaging
	Centre hospitalier régional de Sept-Iles	Sept-îles	Magnetic Resonance Imaging
	Centre IRM du sein Ville-Marie	Montréal	Magnetic Resonance Imaging
	Imagerie des pionniers	Lachenaie	Magnetic Resonance Imaging
	IRM/MRI Plus	Gatineau	Magnetic Resonance Imaging
	IRM St-Joseph	Gatineau	Magnetic Resonance Imaging
	IRM Trois-Rivières	Trois-Rivières	Magnetic Resonance Imaging
	Résonance Magnétique Saint-Louis	Quebec City	Magnetic Resonance Imaging
	Hôtel-Dieu de Quebec	Quebec City	Positron Emission Tomography
	Centre d'imagerie médicale RésoScan	Greenfield Park	PET/CT (fusion technology)
	CHUM Notre-Dame	Montréal	PET/CT (fusion technology)
	Imagerie médicale de la Capitale	Quebec City	PET/CT (fusion technology)
	CHUL	Quebec City	SPECT/CT (fusion technology)
	CHUS—Hôpital Fleurimont	Fleurimont	SPECT/CT (fus. tech.)—2 scanners
	CSSS du Haut-Richelieu et Rouville	Saint-Jean-sur-Richelieu	SPECT/CT (fusion technology)
	Hôpital Charles-LeMoyne	Greenfield Park	SPECT/CT (fusion technology)
	Hôpital de Gatineau	Gatineau	SPECT/CT (fusion technology)
	Hôpital Jean-Talon	Montréal	SPECT/CT (fus. tech.)—2 scanners
	Hôpital de l'Enfant-Jésus	Quebec City	SPECT/CT (fusion technology)
Ontario	Kingston MRI	Kingston	Magnetic Resonance Imaging
	KMH Centre (Kitchener)	Kitchener	Magnetic Resonance Imaging
	KMH Centre (Richmond Hill/Vaughan)	Richmond Hill/Vaughan	Magnetic Resonance Imaging
Manitoba	CancerCare Manitoba	Winnipeg	Computed Tomography
Alberta	Alberta Hospital Edmonton	Edmonton	Computed Tomography
	St. Mary's Hospital (East Central)	Camrose	Computed Tomography
British Columbia	Urgent Care (False Creek Surgical Centre)	Vancouver	Magnetic Resonance Imaging

Note

Excludes SPECT/CT scanners confirmed by the Ontario Ministry of Health and Long-Term Care as installed and operational in Ontario hospitals as of July 31, 2008.

Table B.3 Percentage of Imaging Devices for Which Technological Characteristics Were Reported, by Province/Territory, Canada, as of January 1, 2007

Jurisdiction	Nuclear Medicine Cameras Number of Heads			MRI Scanners Field Strength (Tesla)			CT Scanners Number of Slices		
	Free-Standing			Free-Standing			Free-Standing		
	Hospitals	Facilities	Total	Hospitals	Facilities	Total	Hospitals	Facilities	Total
N.L.	100.0	-	100.0	100.0	-	100.0	81.8	-	81.8
P.E.I.	100.0	-	100.0	100.0	-	100.0	100.0	-	100.0
N.S.	100.0	-	100.0	100.0	100.0	100.0	87.5	-	87.5
N.B.	100.0	-	100.0	100.0	-	100.0	93.3	-	93.3
Que.	100.0	100.0	100.0	100.0	100.0	100.0	75.7	75.0	75.6
Ont.	99.1	100.0	99.2	100.0	40.0	95.8	97.6	50.0	96.2
Man.	100.0	-	100.0	100.0	100.0	100.0	100.0	-	100.0
Sask.	100.0	-	100.0	100.0	-	100.0	100.0	-	100.0
Alta.	100.0	100.0	100.0	100.0	100.0	100.0	92.1	100.0	92.7
B.C.	100.0	-	100.0	100.0	100.0	100.0	93.6	100.0	93.9
Y.T.	-	-	-	-	-	-	100.0	-	100.0
N.W.T.	-	-	-	-	-	-	100.0	-	100.0
Nun.	-	-	-	-	-	-	-	-	-
Canada	99.7	100.0	99.7	100.0	92.7	98.7	90.0	76.2	89.3
Jurisdiction	Angiography Suites Configuragion (Single Plane or Bi-Plane)			Catheterization Labs Configuragion (Single Plane or Bi-Plane)			PET Scanners Imaging Scope (Head Only or Full body)		
	Free-Standing			Free-Standing			Free-Standing		
	Hospitals	Facilities	Total	Hospitals	Facilities	Total	Hospitals	Facilities	Total
N.L.	100.0	-	100.0	100.0	-	100.0	-	-	-
P.E.I.	-	-	-	-	-	-	-	-	-
N.S.	100.0	-	100.0	100.0	-	100.0	-	-	-
N.B.	100.0	-	100.0	100.0	-	100.0	-	-	-
Que.	100.0	-	100.0	100.0	-	100.0	100.0	100.0	100.0
Ont.	100.0	100.0	100.0	100.0	-	100.0	100.0	-	100.0
Man.	100.0	-	100.0	100.0	-	100.0	100.0	-	100.0
Sask.	100.0	-	100.0	100.0	-	100.0	-	-	-
Alta.	100.0	-	100.0	100.0	-	100.0	100.0	-	100.0
B.C.	100.0	-	100.0	100.0	-	100.0	100.0	100.0	100.0
Y.T.	-	-	-	-	-	-	-	-	-
N.W.T.	-	-	-	-	-	-	-	-	-
Nun.	-	-	-	-	-	-	-	-	-
Canada	100.0	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0
Jurisdiction	PET/CT Scanners Imaging Scope (Head Only or Full body)			SPECT/CT Scanners Number of Heads					
	Free-Standing			Free-Standing					
	Hospitals	Facilities	Total	Hospitals	Facilities	Total			
N.L.	-	-	-	-	-	-			
P.E.I.	-	-	-	-	-	-			
N.S.	-	-	-	-	-	-			
N.B.	100.0	-	100.0	100.0	-	100.0			
Que.	40.0	50.0	42.9	0	-	0			
Ont.	100.0	-	100.0	-	-	-			
Man.	-	-	-	-	-	-			
Sask.	-	-	-	100.0	-	100.0			
Alta.	100.0	-	100.0	-	-	-			
B.C.	100.0	-	100.0	100.0	-	100.0			
Y.T.	-	-	-	-	-	-			
N.W.T.	-	-	-	-	-	-			
Nun.	-	-	-	-	-	-			
Canada	81.3	50.0	77.8	43.75	-	43.8			

Notes

- a) Includes imaging devices in non-reporting facilities whose characteristics were imputed in 2007 based on information collected in previous surveys.
- b) Excludes SPECT/CT scanners confirmed by the Ontario Ministry of Health and Long-Term Care as installed and operational in Ontario hospitals as of July 31, 2008.

Source

National Survey of Selected Medical Imaging Equipment, Canadian Institute for Health Information, 2007, supplemented by information on scanners from provincial ministries of health.

Calculation Methods

Calculation of Population Rates

Equipment per million population was calculated using the number of units divided by the most recent (January 1) total population estimate in millions.

MRI and CT exams per 1,000 population were calculated using the number of units divided by the most recent (October 1) total population estimate in thousands.

Calculation of Hospital Operating Expenses

Hospital operating expense (MIS Financial Secondary Accounts 3*, 4*, 5*, 6*, 7*, 8*, 9*) is the sum of compensation, supplies, sundry, equipment, referred-out services and building and grounds.

Treatment of Mobile MRI and CT Units

Mobile units are treated as one machine, whether or not they are shared by more than one organization or facility. Mobile units are associated with the site where, in the opinion of the survey respondent, the unit is located most of the time. When calculating the number of MRI or CT exams per 1,000 health region population, the shared mobile units are included in every region that uses them.

Methods of Imputation for CT and MRI Exams

In Chapter 3, exams of CT scanners for which exams were not reported in the 2007 survey were imputed according to the method below:

Option A: If exams are reported in 2006 for the CT scanner, but not in 2007, use the 2006 figure as a proxy for 2007.

Option B: If exams are not reported in 2006 or in 2007, do the following:

1. Within the jurisdiction, compute the average number of exams for scanners for which exams are reported with the following distinctions: hospital versus clinic, first year of operation (1-year-old scanners) versus not first year of operation and one- or two-slice scanners versus more than two slices.
2. Apply this average to each scanner that does not report exams with the same above characteristics (for example, scanner in hospital, not first year of operation, more than two slices).
3. When, for a jurisdiction, exams are not reported for any scanner with the given characteristics, apply the Canadian average for scanners with the same characteristics.
4. When exams are not reported for any scanner with the given characteristics at the Canada level, an imputation is done on a case-per-case basis. The adjustment factor that will be generally used is based on the fact that hospitals generally do 4.4 times more CT exams per scanner than clinics.
5. Always exclude scanners with less than 50% clinical use or installed but not in operation.

In Chapter 3, exams of MRI scanners for which exams were not reported in the 2007 survey were imputed according to the method below:

Option A: If exams are reported in 2006 for the MRI scanner, but not in 2007, use the 2006 figure as a proxy for 2007.

Option B: If exams are not reported in 2006 or in 2007, do the following:

1. Within the jurisdiction, compute the average number of exams per hour for scanners for which exams are reported with the following distinctions: hospital versus clinic, first year of operation (1-year old scanners) versus not first year of operation, scanners with 1.5 Tesla or less versus scanners with more than 1.5 Tesla.
2. Apply this average to each scanner that does not report exams with the same above characteristics (for example, scanner in hospital, not first year of operation, more than 1.5 Tesla).
3. When, for a jurisdiction, exams are not reported for any scanner with the given characteristics, apply the Canadian average for scanners with the same characteristics.
4. When exams are not reported for any scanner with the given characteristics at the Canada level, an imputation is done on a case-per-case basis. The adjustment factor that will generally be used is based on the fact that hospitals generally do 2.4 times more MRI exams per scanner than clinics.
5. Always exclude scanners with less than 50% clinical use or installed but not in operation.

Major Changes From Previous Years

Most notable changes in the quality of the information are noted as follows:

- Data were provided directly from primary sources (in all cases).
- Secondary sources, such as the Canadian Association of Medical Radiation Technologists (CAMRT), l'Association des radiologistes du Québec (ARQ), the Canadian Association of Nuclear Medicine (CANM), Health Canada, Toshiba, General Electric (GE) and Siemens, helped to identify potential locations of existing technology.

Revision History

Some medical imaging devices were captured for the first time in the National Survey of Selected Medical Imaging Equipment of 2004, 2005, 2006 and 2007 two or more years after they were installed. Historical revisions were made in the present report for these devices. Because of the delay between the time an imaging device is installed and when it becomes operational, such devices are counted as installed and operational two years after their indicated year of installation. For example, a device reported for the first time in the 2007 survey as installed in 2004 is counted in the report as installed and operational as of January 1, 2006 (but not as of January 1, 2005). Table B.4 shows the revisions to the count of equipment for 2003 to 2006, based on the above rule.

Table B.4 Revisions to Medical Imaging Equipment Inventory, by Modality, 2003 to 2006

Modality	2003	2004	2005	2006
Angiography Suites	2	2	4	1
Catheterization Laboratories	3	2	6	2
Computed Tomography	-6	-5	13	14
Fusion Technology—PET/CT	0	0	-1	0
Fusion Technology—SPECT/CT	0	0	0	6
Magnetic Resonance Imaging	3	0	8	5
Nuclear Medicine—Gamma Camera	-9	4	6	-3
Nuclear Medicine—SPECT	-13	16	17	5
Positron Emission Tomography	0	0	1	0

Sources of Data

- CIHI's **National Survey of Selected Medical Imaging Equipment** provides information on the number, distribution and key characteristics of selected imaging technologies (angiography suites, catheterization labs, CT scanners, MRI scanners, nuclear medicine cameras, PET scanners and lithotripters) in Canadian hospitals and those in free-standing imaging facilities (sometimes also called "non-hospital," "community-based" and/or "private" facilities).
- CIHI's **Canadian MIS Database** (CMDB) provides financial and statistical information (for example, expenditures by functional area, workload measurement, outpatient visits) primarily on hospitals with some limited data on regional health authorities across Canada. Information is primarily obtained from provincial ministry of health databases. For the territories, however, data are collected from individual facilities/regional health authorities via the survey. For this report, we examined hospital operating expenses and diagnostic imaging exams for selected types of medical imaging equipment.
- Statistics Canada's **Health Services Access Survey** (HSAS) is a supplement to the Canadian Community Health Surveys (CCHS) of 2000–2001, 2003 and 2005. It captures national information on how Canadians 15 years of age and older use health care services and perceive barriers to care. The survey includes information on the use of three diagnostic services (MRI, CT and angiography) in non-emergency situations. All estimates from the HSAS reflect *self-reported* use and may be different from estimates of the number of medical imaging examinations performed derived from administrative data.
- CIHI's **National Ambulatory Care Reporting System** (NACRS) captures summary information on ambulatory care. The database primarily captures information on emergency department care in Ontario. For this report, we examined the use of CT scans in this environment. The CT scans were completed during the emergency department visit and could have been ordered for either the patient's main problem or other problems.
- CIHI's **National Physician Database** (NPDB) provides information about the socio-demographic characteristics of Canadian physicians and their fee-for-service activity levels. Since fee codes and payment methods for imaging services vary across the country, billing data on the use of medical imaging services are directly comparable only for selected jurisdictions. Imaging services paid for entirely through hospital global budgets or by individuals/third-party payers (for example, workers' compensation boards) are not captured.

