Medical Imaging in Canada

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It should be noted that the analyses and conclusions in this report do not necessarily reflect those of the individual members of the Expert Group or the organizations with which they are affiliated.

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Highlights

The Services

What We Know

- Many different kinds of imaging are used in clinical practice today, from new equipment that is still in development to well-established technologies. Each has its strengths and weaknesses, although capabilities sometimes overlap. Common tests account for the bulk of operating expenditures on diagnostic imaging. For instance, X-ray and ultrasound services accounted for more than half (56%) of total spending on diagnostic imaging by Ontario hospitals in 2000–2001.
- In Canada and elsewhere, the use of several types of medical imaging has increased in the last decade. In 2001, about 7% of Canadians aged 15 or older—about the same proportion as were hospitalized overnight—reported having a non-emergency CT, MRI, or angiography in the past 12 months. In total, over 787,000 had a CT; 647,000 an MRI; and 220,400 an angiography.
- Some types of imaging are even more common. For example, 70% of Canadian women aged 50 to 69 reported having had a mammogram in the last two years in 2000-2001, up from 61% in 1996–1997.
- Like many technologies, the value of medical imaging depends on how it is used and its ability to improve the lives of patients and/or the practice of health care. In areas where evidence-based clinical practice guidelines exist, Canadian and international researchers have documented both underuse and overuse of medical imaging relative to the guidelines. Several recent federal and provincial reports on health care have called for action to address access to diagnostic services and to better understand the appropriate use of these technologies, now and in the future.
- A variety of public and private sources fund medical imaging services in Canada. Most funding comes through provincial/territorial governments, but the mix varies by technology and by jurisdiction. A 2003 survey found that provincial/territorial governments were the primary source of operating funds for 98% of hospital-based angiography suites; MRI, CT, and PET scanners; catheterization labs; and nuclear medicine cameras. They were also the main funder for about one-third of the machines housed in free-standing imaging facilities. Equipment in both settings may also have a variety of secondary sources of funding.
- Total spending on medical imaging in Canada has risen in recent years. For example, hospitals in British Columbia, Alberta, Ontario, and New Brunswick collectively spent about $1.3 billion on diagnostic imaging services in 2000, up 44% from 1996.

- Waiting for care remains an important issue for Canadians. For example, respondents to a November 2002 poll said that reducing wait times for diagnostic services, such as MRI and CT scans, should be the number one priority for new health care spending. Over half (55%) of Canadians aged 15 and over who had a non-emergency MRI, CT, or angiography in 2001 said that they waited less than a month for their test, but the 5% with the longest waits waited 26 weeks or more*. Sixteen percent of test recipients said that waiting affected their lives. Worry, anxiety, and stress were the most frequently reported effects.

What We Don't Know

- How many Canadians receive different types of medical imaging services each year? To what extent does the current use pattern of medical imaging match with evidence-based best practice? What combination of tests and rates of service would best meet the health care needs of different patient groups and communities?
- How much is spent, in total, on medical imaging services? How do services provided by free-standing and hospital-based imaging facilities differ? How do levels of public and private spending on imaging affect access, patient and provider satisfaction, patient outcomes, and overall health care costs?
- How do medical imaging services affect patient care, outcomes, and costs in particular circumstances compared to other types of imaging or to assessing/managing patients' conditions without imaging technology? What are the relative costs and benefits of using various types of imaging?

The Technologies

What We Know

- All provinces now have nuclear medicine cameras, angiography suites, CT scanners, and MRI machines, as well as other imaging technologies, such as X-ray and ultrasound services. Numbers of some imaging machines are increasing. For instance, between 1997 and 2003, the total number of MRI machines in Canada (including those in hospitals and free-standing imaging facilities) grew by 167%. The number of CTs grew by a third (33%) over the same period.
- The supply of medical imaging equipment varies across Canada. For example, as of January 2003, Ontario had the most CT scanners (95) in the country, but the fewest machines per million population (7.8). In contrast, the Yukon Territory's one CT gave it the highest number per capita (33.5). Variations also exist internationally. For instance, the per capita ratio of CT machines for Japan (data for 1999) was triple that of Korea (2001), the country with the next highest ratio; almost 9 times that of Canada (2001); and fifteen times that of England (2001).
- Nationally and internationally, data show that regions with more machines per person do not necessarily have higher scan rates. The supply of machines needs to be considered in the context of many other factors, including how imaging machines are used to provide care, their hours of operation and staffing, and the mix of other imaging services available.

* Interpret with caution due to high sampling variability.

- The extent to which imaging services are available outside of hospitals varies by imaging modality. For example, free-standing facilities in some parts of the country have provided X-ray and ultrasound services for many years. In some cases, the number of machines in free-standing imaging facilities is growing. As of January 2003, 9 CTs (about 3% of the total) and 27 MRIs (18%) were in this type of facility, up from an estimated 7 (about 2%) and 20 (15%) machines respectively in July 2001. In 2001, 98% of Canadians aged 15 and over who had a non-emergency angiography in the past year said that they received their test in a hospital or public clinic. That compares to 96% for CT scans and 92% for MRIs.

What We Don't Know

- What number and mix of imaging technologies at regional, provincial, and national levels would best meet current and future health care needs?
- At what point do imaging technologies require upgrading or replacement based on patient safety, quality of care, cost-effectiveness, cost implications, and/or other considerations? Based on this assessment, what proportion of today's machines will require significant capital investment in the next 1, 2, 5, 10 years, and beyond?
- How much in total is spent to purchase various types of medical imaging equipment? How does the public/private funding mix for capital and operating costs differ among technologies and across the country? Do these differences affect the mix of imaging services that Canadians receive, their access to care, overall spending, and the cost-effectiveness of imaging services?

The People

What We Know

- A diverse mix of health professionals is involved in medical imaging. For instance, there were over 14,700 medical radiation technologists (MRTs), 2,500 sonographers, 1,900 diagnostic radiology physicians, and 200 nuclear medicine physicians across Canada in 2001.
- Each profession tends to specialize in certain areas, although skills and roles are evolving over time and sometimes overlap. For instance, as imaging technologies progress and new applications are developed, radiologists are taking on a wider range of services (e.g. interventional radiology). At the same time, other physicians sometimes perform services also provided by radiologists. The roles of radiology technologists are also evolving. Just as there is no agreed national or international standard for how many MRI or CT machines we should have, deciding on the best number and mix of medical imaging professionals to serve a particular community is challenging.
- As baby boomers move towards retirement, the average age of Canadians is rising. That trend also holds for health professionals in general and imaging professionals in particular. For example, the average age of MRTs increased from 34 years in 1991 to 40 years in 2001. As well, the proportion of younger MRTs (under the age of 35) in the workforce is decreasing, from 47% in 1991 to 31% in 2001.
- The level of education required to work in medical imaging varies from profession to profession and has changed over time. For example, sonographers have traditionally taken one-year post-diploma programs, but some institutions now offer three-year entry-level diploma programs and four-year degree programs.

What We Don't Know

- How many and what mix of health professionals will be required in the future to meet the medical imaging needs of Canadians regionally, provincially, and nationally? How will changes to training requirements, scope of practice, and regulatory status for imaging professionals affect their supply, access to care, and patient and provider satisfaction?
- What impact will recently announced plans for spending on medical equipment have on training opportunities for imaging professionals and on the demand for their services?
- How will teleradiology and other digital imaging technologies affect the traditional dynamics of the medical imaging team, productivity, access to care, and patient satisfaction and outcomes?

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About This Report

In the past century, we have witnessed dramatic technological changes in the field of medicine, including in 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 miles away in a matter of minutes. Surgeries that once required several days of hospitalization are now being performed on an out-patient basis. And more sophisticated forms of medical imaging—such as the ability to generate functional images of almost any structure within the body—are becoming essential to the provision of general and specialized medical care and treatment.

Timely access to medical imaging technologies has become a key area of concern for Canadians. Respondents to a November 2002 Ipsos-Reid poll said that reducing wait times for diagnostic services such as MRI and CT scans should be the priority for new health care spending.* Within the last few years, two federal and several provincial health commission report reviews have also stressed that the availability of appropriate medical imaging services is of major importance.

Nevertheless, little is known about the actual use of these technologies in Canada. This report aims to start to fill this gap. It is meant to serve as a consolidated reference of what we know and don't know about medical imaging across Canada, helping to inform decisions as we move forward. We look in particular at the historical development of imaging technologies; the numbers of different kinds of machines in Canada and how they are used; and 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 where the information base is strongest. Many of the issues that we highlight, however, apply across the spectrum of imaging technologies.

The report is divided into six chapters:

Chapter 1: *Medical Imaging Technologies: The Past, Present, and Future* provides a brief history of the development of medical imaging technologies and describes selected types of technologies and their applications.

Chapter 2: *Medical Imaging in Practice* provides an overview of the available information on the use of imaging technologies in Canada today. Included in this chapter is information about scan rates and the costs of using these technologies.

* Mickleburgh R. (November 25, 2002). *Faster Care Tops Wish List in Health Care Poll.* News Release. www.globeandmail.com.

Chapter 3: *Imaging Technologies—Supply and Capital Costs* provides an overview of the available information on 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 capital costs associated with purchasing these technologies.

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

Chapter 5: *Current Issues in Medical Imaging* touches on some of the major issues related to how medical imaging technologies are used. It addresses topics such as our current understanding of when to use different technologies, how effective they are, and factors that affect Canadians' access to imaging services.

Chapter 6: *Medical Imaging in Canada: An Incomplete Picture* concludes the report with a discussion about the existing gaps of information surrounding these topics.

Where possible, the report includes national and international comparisons. It also includes a *Fast Facts* section. *Fast Facts* provides an expanded range of comparative data on medical imaging technologies across the country. Whenever the icon to the right appears beside the text, it indicates that related data can be found in the *Fast Facts* section at the back of the report.

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What's New in This Report

Medical Imaging in Canada draws on new data and analysis from CIHI, as well as research produced at provincial, 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 in 2003 and how these characteristics have changed over time.
- How MRIs, CTs, and other selected imaging services are funded.
- How many people have non-emergency MRI, CT, and angiography tests, the reason for their tests, and how scan rates in selected jurisdictions are changing.
- How selected imaging technologies are being used in various settings.
- The proportion of hospital spending on medical imaging services in selected provinces.
- The latest information on the age and distribution of medical imaging professionals in Canada.

For More Information

Highlights and the full text of *Medical Imaging in Canada* are available free of charge in both official languages on the CIHI Web site 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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There's More on the Web!

The print version of this report is only part of what you can find at our Web site (www.cihi.ca). On the day that *Medical Imaging in Canada* is released and in the weeks and months following, we will be adding much 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.
- Sign up to receive regular updates via email.
- Look at CIHI's annual reports; other special reports, such as *Canada's Health Care Providers*; and the regular series of reports on aspects of health spending, health human resources, health services, and population health.
- Learn about upcoming reports, including *Improving the Health of Canadians* (check out the Canadian Population Health Initiative at our Web address), and other special reports on topics such as maternal and infant health and health care.

1 Medical Imaging Technologies: The Past, Present, and Future

Just as microwaves have changed the way that we cook and telephones the way that we communicate, medical imaging has changed the practice of medicine. From their origins just over a century ago, a wide range of technologies can now be found in clinicians' toolboxes and more are being developed. Each has its strengths and weaknesses, although capabilities often overlap. A variety of factors may be considered when deciding which tool is best in a particular situation (for further details, see Chapter 5). This Chapter provides a brief overview of the development and application of some of the major imaging technologies, as well as glimpses into the future.

1

Lending a Hand
The first human radiograph (of Frau Roentgen's hand).

Source: Images courtesy of Dr. D. Worseley, UBC and VHHSC

From the Beginning: X-rays and Nuclear Medicine

On November 8, 1895, Wilhelm Conrad Roentgen was experimenting with a cathode-ray tube in a dark laboratory when he noticed a nearby screen begin to glow. He realized that the glow could only have been produced by more penetrating radiation than cathode rays.[1–5] By December, he released a preliminary report, accompanied by experimental radiographs and the first X-ray image—of his wife's hand.

In February 1896, a Montreal physician used X-rays to make a diagnosis for the first time in Canada. A young man had been shot in a brawl on Christmas Eve and several surgical explorations had failed to find the bullet. After a radiograph showed the bullet lodged between the tibia and fibula, it was successfully removed.[6,7] The film was subsequently used in court, perhaps the first use of radiography in jurisprudence.[6]

Radiology continued to progress rapidly throughout the century. For example, Pierre and Marie Curie made numerous discoveries, including isolating radium, and became double Nobel laureates. Their daughter, Irene Curie, and her husband Frederick Joliot went on to discover artificial radioactivity and to gain Nobel prizes. Another laureate, Ernest (later Lord) Rutherford, working at McGill University, discovered alpha and beta particles and

DID YOU KNOW?

Within weeks of Roentgen's announcement, newspapers, magazines, and professional journals around the world were providing explanations of the mysterious rays, along with detailed instructions on their production and use. News of the X-ray caused a public fervour, including fears about its use. In London, a firm began selling X-ray-proof underwear. In New York state, officials tried to pass legislation banning the use of X-rays in opera glasses.[8]

advanced our understanding of atomic structure as mostly space with tiny units of mass-energy in the nucleus and orbiting electrons.

The use of orally administered pharmaceutical contrast agents in the early 1900s allowed physicians to examine the alimentary tract for the first time. After much experimentation, an intravenous contrast agent was developed. These discoveries and others—such as Georg Von Hevesy's tracer principle which is fundamental to the use of radionuclides in medicine—facilitated the emergence of another clinical specialty after the Second World War: nuclear medicine.[9]

In 1946, a landmark event in the development of nuclear medicine took place—a patient suffering from cancer of the thyroid was treated with radioactive iodine. The treatment prevented the spread of the patient's cancer.[10] Subsequently, radioactive iodine was used to measure both the function of the thyroid and to diagnose thyroid disease.

2

Milestones in Radiology

Since the discovery of radiology technology in the late 1800s, there have been numerous developments both in Canada and in the world. A selection of events is shown below.

World Events	Year	Canadian Events
Professor Roentgen discovers X-rays	1895	
	1896	First clinical radiograph in Canada Alexander Graham Bell experiments with X-rays in Baddeck, Nova Scotia
First tracer work by Georg Von Hevesy	1911	Ernest Rutherford determines nuclear structure of atoms
First X-ray film (cellulose nitrate base) Coolidge tube discovered	1913	
Walter Dandy develops pneumo-encephalography	1918	
Egas Moniz performs first angiography	1927	
Catheterization done for first time by Forssmann in Germany	1929	
The first usable contrast media	1930	
	1937	Canadian Association of Radiologists formed
Tc-99m discovered	1938	
	1942	Canadian Association of Medical Radiation Technologists founded
Nuclear Magnetic Resonance (NMR) phenomenon discovered by Bloch and Purcell	1946	
First image intensifier	1948	
	1950	Canadian Association of Radiologists' Journal first published
First scintillation scanner developed by Benedict Cassen	1951	World's first cobalt-60 unit developed in Saskatoon
First clinical ultrasound of soft tissue	1952	
First automatic film processor manufactured	1956	
Gamma camera invented by Hal Anger	1958	
	1960	Shoe-fitting fluoroscopes abandoned in 1960s
Emission reconstruction tomography developed by David Kuhl	1962	
Hounsfield and Cormack develop computed tomography (CT)	1972	
Rare earth screens available	1973	First CT scanner at Montreal Neurological Institute (MNI)
First Human Positron Emission Tomography (PET) scan	1974	
	1975	MNI developed and installed Canada's first PET scanner
First clinical Magnetic Resonance Imaging (MRI) scans produced	1980	
	1982	First MRI installed in Canada
	1985	First clinical uses of MRI in Canada
First clinical Echo Planar MR Imaging (EPI) (of the brain)	1993	

Source: Compiled by ProMed Associates.

Radiography Today

Because bones absorb (attenuate) more of the X-rays passing through them than do the surrounding tissues, they are clearly visible on an X-ray film. It is not surprising, therefore, that X-rays were initially used to examine bones. The ability of other tissues in the body to absorb X-rays varies only slightly, making it difficult to distinguish between organs or to detect abnormalities within them.

Contrast material that is swallowed or injected enhances the visibility of certain tissues and organs by outlining them clearly on the film. For example, swallowed contrast material can be used to see the outline of the stomach or bowel.[11] Injected contrast material can show the outline of arteries or of the kidneys as it is excreted.

Fluoroscopy is used to examine the body using X-rays in real time. The image is projected on a screen, allowing the radiologist to see the tissues and to move the patient as needed to obtain different views. If the patient swallows a contrast material, for example, the way in which the esophagus moves the material down into the stomach will be visible. In the same way, angiography can reveal the arteries of the brain or the coronary arteries of a beating heart.

With these and other developments, today's applications of radiography go far beyond the standard X-ray machine. Examples include:

- **Mammography** uses low dose X-rays with high contrast, high-resolution film to create detailed images of the breast. While breast X-rays have been performed since the 1920s, modern mammography used to detect breast cancer emerged in the early 1970s.
- **Bone Mineral Densitometry** is a diagnostic test that measures the density of bones. The most commonly used test is dual energy X-ray absorptiometry (DXA), a low dose X-ray beam that scans the spine, hip, or both. This test is used in the diagnosis of osteoporosis and risk fracture assessment.
- **Angiography** is used to find and treat abnormalities in the blood vessels. Using fluoroscopy images to guide placement, a fine hollow catheter may be inserted into small blood vessels deep in the body. A contrast agent is injected to outline the blood vessel and reveal blockages or abnormalities in the blood supply to organs, such as may occur with cancer. The same catheter may then be used to introduce drugs or other treatments, such as balloons to expand the artery wall (angioplasty).
- **Cardiac Catheterization** is a form of angiography used in the cath lab to image the blood vessels in the heart, to examine the function of the heart, and often to dilate narrowed blood vessels that are not supplying adequate amounts of blood to heart muscles.

Although modern X-ray machines produce significantly less radiation than those of years ago, X-rays must still be used in a prudent manner because over-exposure can cause unnatural chemical reactions inside the body's cells. Experts recommend that women who are pregnant or breastfeeding, for example, should carefully weigh the benefits of radiography against the potential risk of exposing the fetus or infant to radiation.[12]

Beyond Diagnosis

In medicine, imaging technologies are most often used to diagnose health problems. But, in interventional radiology, physicians use imaging technologies (such as X-rays, CT and MRI scans, and ultrasound) to guide small instruments such as catheters or needles through blood vessels to treat disease. In general, interventional radiology procedures are designed to replace open surgical procedures, with a view to making them less risky and/or painful for patients. The American Medical Association officially recognized interventional radiology as a medical specialty in the mid-1990s.[13]

A Different Approach: Ultrasound

Around the time that nuclear medicine was born, another important technology was developing. Pierre Curie discovered the piezo-electric effect in crystals, a phenomenon that forms the basis for creating and measuring sound waves in ultrasounds.

Ultrasound technology—like echolocation by bats, dolphins, and whales—works by measuring the echoes of high-frequency sound waves. Ultrasound waves bounce off tissue in much the same way as marine sonar detects fish or explores the sea bottom. As a sound wave reaches a patient's tissues, part of the wave is reflected back and part continues. Waves that travel further into the body take longer to return; the intensity of a returning echo depends on the properties of the tissues encountered. Doppler ultrasound measures changes in echo frequency to calculate how fast an object is moving, thus permitting measurement of the velocity and direction of blood flow.

Ultrasound was first used experimentally as a possible diagnostic tool in medicine in the early 1940s. Karl Theodore Dussik, a neurologist/psychiatrist at the University of Vienna, located brain tumors and the cerebral ventricles by measuring the transmission of ultrasound waves through the skull, using a transducer on either side. George Ludwig, a physician at the Naval Research Institute in Bethesda, Maryland, was a pioneer in the late 1940s in using pulse-echo ultrasound for animal tissue diagnosis. He discovered that gallstones embedded in the muscles of animals could be detected using ultrasound.[14] (This followed a much earlier experiment by Sir William Osler, perhaps the most notable physician of his time, which failed to detect gallstones using X-rays.)

Today, ultrasound is well established. It is used in many fields of medicine, including obstetrics and gynecology, cardiology, urology, oncology, interventional radiology, and many others. Common applications include the diagnosis of gallstones, tumors of the liver or kidney, and the sex, position, and size of babies in the uterus. Emergency departments may also turn to ultrasound as a rapid imaging tool for diagnosis, particularly in trauma.

Until recently, ultrasound could only provide three-dimensional images. However, a fourth dimension—time—was recently added. This allows clinicians to see fetal motion, behaviour, and surface anatomy. Proponents suggest that 4D ultrasound may also have applications related to gynecology, breast cancer, prostate cancer, and other conditions.[15]

Harnessing Computer Power

Computers have revolutionized many aspects of our lives. Medical imaging is no exception. New digital technologies can substitute bits and bytes for traditional imaging films. In some cases, digital images may allow more latitude in exposure and some potential for image processing (e.g. edge enhancement).[16] Nevertheless, technology assessments do not always find a significant advantage over conventional approaches.[17]

The World of Digital Imaging

In a country as vast as Canada, providing access to quality care for everyone is a challenge. New technologies, collectively known as telehealth, are beginning to offer innovative ways of delivering health care services and information over small and large distances.

Conceived by Alexander Graham Bell who experimented with the telephone transmission of X-ray signals, teleradiology can now facilitate a range of imaging services.[18] For instance, X-rays and other diagnostic imaging can be transmitted electronically for interpretation by radiologists who live many kilometers from where the image was produced. These services (as well as regular radiology services) often make use of a new set of technologies—called Picture Archiving and Communication Systems or PACS—to store and exchange digital images.

Across the country, a number of small and large teleradiology projects are underway. Some connect health facilities across provincial, territorial, and even international boundaries, but not all telehealth connections cover large distances.

Many teleradiology technologies and projects are relatively new, but evaluations of early initiatives are emerging. Some results suggest significant promise. Others identify a number of technological, legal, organizational, clinical, and other challenges.

An international systematic review of studies of patient satisfaction with telemedicine indicated that under ideal circumstances, patients accept and are generally satisfied with the care that they received.[19] Likewise, a 2001 review found relatively convincing evidence for effectiveness of teleradiology, although the authors argued that evidence regarding the effectiveness of telemedicine is still limited.[20]

Closer to home, an evaluation was conducted of a teleradiology project in Nova Scotia. Over 24,500 routine and about 200 emergency cases were transmitted as part of this project as of May 1998. In a review of 87 emergency cases, referring physicians indicated that teleradiology changed patient management in 68 of those cases (78%). For example, for two in five cases, physicians were able to begin treatment sooner and one-quarter avoided patient transfer. In 12% of cases, admission to hospital was avoided.[21]

Computers have also made possible an alphabet soup of new imaging technologies—CT, MRI, SPECT, and PET to name just a few. These devices use high capacity computers to reconstruct sectional or other images from complex data sets. Most consist of a patient bed (couch) that slides into the central hole of a donut-shaped device (the gantry). The central hole may admit the head (small-aperture) or whole body (large-aperture). The gantry contains the imaging hardware. A console in the technologist area houses the computer and controls, and a physician console allows for the interpretation of images without disrupting ongoing tests.

Computed Tomography

Computed Tomography or CT, also known as Computer Assisted Tomography or CAT, was developed in the late 1960s and introduced in the early 1970s by Godfrey Hounsfield and Allan Cormack. It was the first imaging technology to allow for 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.

In present (third and fourth generation) machines, a fan beam of radiation sweeps through 360 degrees while detectors provide a digital readout of the amount of radiation and the degree to which it has been attenuated. From the linear attenuation in multiple projections, it is possible to reconstruct a sectional display of body structure according to electron density. Contrast material may be used with CT to outline certain tissues, as in conventional radiography.

There are far more electrons in bone than in organs such as the liver, which in turn are more electron-dense than fat. Because CT imaging can detect subtle variations in density—for example between that of liver tumors and liver tissue—radiologists can construct sectional structural maps that facilitate diagnosis of some health problems. CT examinations can also be used to plan and properly administer radiation treatments for tumors and to guide biopsies and other invasive procedures.

CT scanning technology continues to evolve. For example, the development of multi-detector, multi-slice helical scanning CTs makes it possible to obtain images over a broader area with good spatial resolution and in shorter times.[16,22]

Magnetic Resonance Imaging

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 radio-frequency 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.

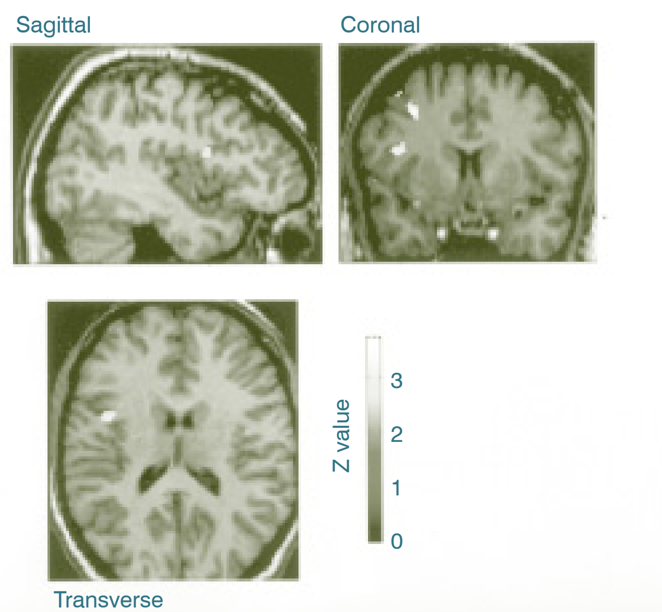
MRI can provide detailed images of all tissues except bone (where the protons are tightly bound and less susceptible to magnetic influence). Images are created using algorithms similar to those used in CT.[23] MRI techniques can be enhanced by injected agents such as gadolinium chelates, analogous to the contrast materials used in radiography.

MRI scans can be used to diagnose conditions such as multiple sclerosis and infections in the brain or spine; to visualize injuries; and to evaluate tumors, herniated discs, and masses in soft tissues. As with ultrasound, MRI does not use ionizing radiation. Drawbacks to the technology include the high cost of MRI equipment and the noise produced during a scan. Some patients cannot have an MRI, including those with pacemakers, those who have difficulty holding still for extended periods of time, and those susceptible to claustrophobia. For others, such as those who are larger, pregnant, or young, the gantry configuration may be hard to use. To accommodate these and other patient issues, some MRI machines are built in an open configuration (i.e. patients don't need to enter a gantry).

3

Visualizing the Way We Think

The bright areas in this MRI image show activity in the inferior frontal region of the brain of a subject who had been asked to think of words starting with a given letter of the alphabet.



Source: Image courtesy of Dr. Bruce Forster, UBC and VHHSC

A functional MRI (fMRI) has the potential to image chemical processes in the body. For example, the iron in the hemoglobin of blood cells influences the protons in the oxygenated hemoglobin of arterial blood differently than hemoglobin in venous blood. As a result, the relative blood flow to parts of the brain can be imaged in response to different perceptual or motor tasks.

Another type of MRI, called magnetic resonance spectroscopy (MRS), measures concentrations of metabolites to produce images of chemical processes, such as the adenosine phosphate pathway responsible for releasing much of the energy the body expends.[24] Likewise, magnetic resonance angiography (MRA) uses magnetic resonance technology to image arteries and veins. MRA techniques have improved over the last several years and in some cases MRA is now being used to detect and diagnose disorders of the blood vessels instead of conventional catheter angiography.

Positron Emission Tomography

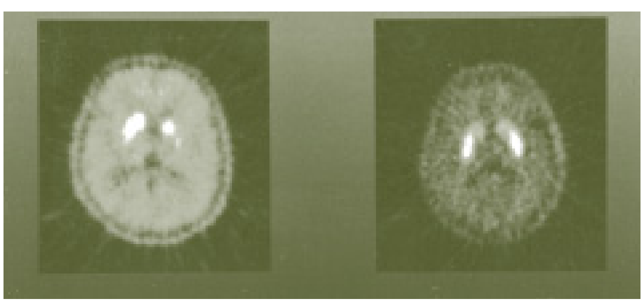
Positron Emission Tomography (PET) scanners create images by detecting subatomic particles emitted from a tracer radioactive substance injected into a patient. When the radionuclide decays, it emits positrons (positively charged electrons also called ß+ particles), which, when they collide with an electron, 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.

4

Brain Function and Parkinson's Disease

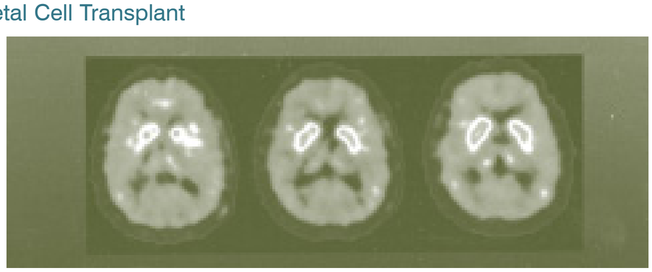
The top PET image shows the brain of a patient with Parkinson's disease: the first (using a fluorodopa tracer) reveals evidence of damage to pre-synaptic neurons while the second (using raclopride) shows compensatory up-regulation. The lower image is of serial scans with flurodopa in a patient with Parkinson's disease who had undergone fetal cell transplant.

Parkinsonian



^{18}F-Fluorodopa ^{11}C-Raclopride

Fetal Cell Transplant



Baseline   6 months   12 months

Source: Images courtesy of Dr. D. Worseley, UBC and VHHSC

In Canada, PET has primarily been used as a research tool. However, the technology is emerging as a clinical tool. For example, PET scans have been used to detect cancer, stage its extent, examine the effects of therapy, and study myocardial viability.[25] Evaluations of clinical applications are underway in some parts of the country.

The logistics of a PET scan can be complex. For example, a cyclotron is needed to produce the radionuclides used in PET scans. As the tracers have very short half-lives (from a few minutes to well over an hour), this usually means that PET scanners must be located in close proximity to a cyclotron.

A recent development involves combining anatomical and functional imaging (sometimes called fusion imaging) from CT and PET in the same display. Early evaluations of the combined imaging system in certain clinical settings, such as non-small-cell cancer, suggest that the images created by the integrated technology may provide better diagnostic information for some clinical conditions than either of the technologies on its own.[26]

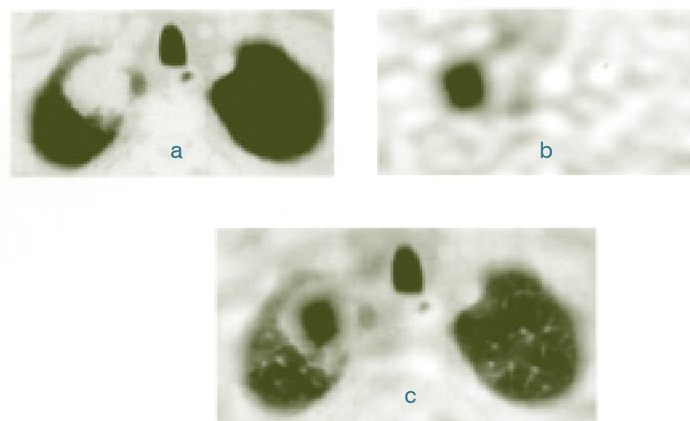
Single-Photon Emission Computed Tomography

Single-Photon Emission Computed Tomography (SPECT) measures the concentration of radionuclides introduced into a patient's body. One or more gamma camera heads are mounted on a gantry that circles the patient. Using computed algorithms, an image of tracer distribution in multiple organ sections can be created.

SPECT is an older technology than PET and tends to have more limited resolution and sensitivity than PET. Different radionuclides are used that emit a single photon, rather than a positron, as in PET. Nevertheless, some suggest that the availability of SPECT, particularly for imaging the brain and head, and other practical aspects of SPECT instrumentation can make this mode of emission tomography attractive.[24, 27]

5 Comparing CT and SPECT Visuals

Image (a) shows a SPECT image of a lung mass demonstrating the hypermetabolism of F-18 fluorodeoxyglucose. Image (b) shows a CT scan of the same site showing the 3 cm diameter mass. Image (c) shows composite anatomical (CT) and functional (SPECT) images of the mass (a lung carcinoma).



Source: Images courtesy of Dr. D. Worseley, UBC and VHHSC

6 How Imaging Modalities Compare

Robert Greenes and James Brinkley have compared selected imaging modalities with respect to several basic characteristics. For more details, please refer to the reference below.

Characteristic	Nuclear Medicine	Ultrasound	CT	MRI	Computed Radiology
Spatial resolution	Low	Moderate	Moderate	Low	High
Contrast resolution	Low	Low	High	High	Low
Temporal resolution	High	High	Moderate	Low	Low
Typical number of images per study	30	30 (plus dynamic series)	60	100	2
Radiation	Moderate	None	Moderate	None	Moderate
Cost	Moderate	Low	High	High	Moderate
Physiologic function	Yes	No	No	Yes	No
Portability	Yes	Yes	No*	No*	Some

Spatial resolution: A measure of the ability to distinguish among points that are close to each other.
Contrast resolution: A measure of the ability to distinguish among different levels of intensity.
Temporal resolution: The time between acquisition of each of a series of images. Limited by the time needed to produce each image.

*Some mobile MRIs and CTs exist.

Source: Adapted by CIHI from Greenes RA, Brinkley JF. (2001). Imaging Systems. In *Medical Informatics: Computer Applications in Health Care and Biomedicine 2nd Ed*. Shortliffe EH, Perreault LE Wiederhold G, Fagan LM. Eds. New York: Springer.

The Future

There is no crystal ball to predict the future of medical imaging technologies. Given the rapid changes in the last few decades, any projections must be made particularly cautiously.

That said, no one-size-fits-all technology appears to be on the horizon that would diagnose all diseases and support all types of interventional radiology. Plain film radiography, particularly of the chest, continues to be a large part of the work in radiological or imaging services, in both hospital and ambulatory care facilities. Use of several other technologies has also increased in recent years. A number—such as MRI, ultrasonography, and image-guided interventions, among others—have also become core radiological technologies.

New applications also continue to be explored for both diagnosis and treatment. A few of the many items in the research pipeline include:

- **Electrical Impedance Imaging:** This technique relies on the fact that different tissues absorb weak electrical currents differently. Reviews suggest that it has been slow to find clinical applications despite its relative simplicity and low cost.[28] However, sectional impedance imaging has now been proposed and a commercial device has been produced.[29] It aims to detect small breast cancers with a high degree of sensitivity and specificity, as a precursor to selecting patients for mammography or for diagnosis in younger women with dense breasts.
- **Optical Imaging:** Using light to image the interior of the body as distinct from its surface is not a new idea. Intense light was used to trans-illuminate the breast and peripheries years ago. Further development of trans-illuminate imaging has proven challenging because of issues in signal analysis, but research continues.[30]
- **Molecular Imaging:** This technique allows for the characterization and measurement of processes at the molecular and cellular level. It is being used experimentally to assess specific molecular targets for gene- and cell-based therapies. In the future it might be used to detect and characterize disease earlier as well as to assess treatment efficacy at the molecular level.[31]
- **Imaging Capsules:** A capsule–sized camera that can take colour video images as they pass through the digestive tract is now being tested. These M2A capsules are just one example of the rapidly developing technologies that offer new ways of looking inside the human body.

Which of these technologies, if any, will prevail? How will they fit within the imaging toolbox, within the parameters of our evolving health care system, and with changing provider and consumer expectations? Only time will tell.

For More Information

[1] Kevles BH. (1997). *Naked to the Bone: Medical Imaging in the Twentieth Century*. New Brunswick: Rutgers University Press.

[2] Eisenberg RL. (1992). Roentgen and the Discovery of X-rays. In Patterson AS, Gunter A, eds. *Radiology: An Illustrated History*. St. Louis: Mosby Year Book.

[3] Aldrich J. (1995). Röntgen and the discovery of X-rays. In Aldrich J, Lentle BC, eds. *A New Kind of Ray: The Radiological Sciences in Canada 1895-1995*. Montreal: The Canadian Association of Radiologists.

[4] Donizetti P. (1967). *Shadow and Substance: The Story of Medical Radiography*. Oxford: Pergamon Press.

[5] Grigg ERN. (1965). *The Trail of the Invisible Light*. Illinois: Thomas.

[6] Cohen M. (1995). Canada's first clinical X-ray. In Aldrich JE, Lentle BC, eds. *A New Kind of Ray: The Radiological Sciences in Canada 1895-1995*. Montreal: The Canadian Association of Radiologists.

[7] Cox J, Kirkpatrick RC. (1896). The new photography with report of a case in which a bullet was photographed in the leg. *Montreal Medical Journal*, 24, 661.

[8] Karolevitz RF. (1967). *Doctors of the Old West: A Pictoral History of Medicine on the Frontier*. Seattle: Superior Publishing Company.

[9] Eisenberg RL. (1992). Nuclear medicine. In Patterson AS, Gunter A, eds. *Radiology: An Illustrated History*. St. Louis: Mosby Year Book.

[10] Society of Nuclear Medicine. (2003). *The History of Nuclear Medicine*. www.snm.org/nuclear/history.html.

[11] Cannon WB. (1898). The movements of the stomach studied by means of the Roentgen ray. *American Journal of Physiology*, 1, 359.

[12] Health Canada. (2000). *X-ray Equipment in Medical Diagnosis Part A: Recommended Safety Procedures for Installation and Use*. Ottawa: Health Canada.

[13] Society of Interventional Radiology. (2003). *Interventional Radiology is 21st Century Medicine*. www.sirweb.org.

[14] Woo J. (2003). *A Short History of the Development of Ultrasound in Obstetrics and Gynecology*. www.ob-ultrasound.net/history.html.

[15] Industry Canada. (2002). *Life Sciences News Brief GE Medical Systems Unveils 4D Ultrasound Breakthrough in Canada*. http://strategis.ic.gc.ca/ssg/ph01536e.html.

[16] Freeman MT, Artz DS. (1997). Image processing in digital radiography. *Seminars in Roentgenology*, 32, 25-37.

[17] Ho C, Hailey D, Warburton R, MacGregor J, Pisano E, Joyce J. (2002). *Digital Mammography Versus Film-Screen Mammography: Technical, Clinical and Economic Assessments*. Ottawa: Canadian Coordinating Office for Health Technology Assessment.

[18] Aldrich J. (1995). Alexander Graham Bell. In Aldrich J, Lentle BC, eds. *A New Kind of Ray: The Radiological Sciences in Canada 1895-1995*. Montreal: The Canadian Association of Radiologists.

[19] Mair F, Whitten P. (2000). Systematic review of studies of patient satisfaction with telemedicine. *British Medical Journal*, 320, 1517-20.

[20] Roine R, Ohinmaa A, Hailey D. (2001). Assessing telemedicine: A systematic review of the literature. *Canadian Medical Association Journal*, 165(6), 765-771.

[21] Canadian Institute for Health Information. (2001). *Health Care in Canada 2001*. Ottawa: Canadian Institute for Health Information.

[22] Tsuchiya K, Katase S, Aoki C, Hachiya J. (2003). Application of multi-detector row helical scanning to postmyelographic CT. *European Radiology*, 13(6), 1438-1443.

[23] Balfe DM, Ehman RL. (1998). Research in CT and MRI imaging: 2000 and beyond. *Radiology*, 207, 561-566.

[24] Orrison WW Jr. (1996). 3M Mayneord Memorial Lecture: Functional Brain Imaging—An Overview. *British Journal of Radiology*, 69(822), 493-501.

[25] Coleman R, Wieler H. (2000). Current status of PET. In Wieler H, Coleman R, eds. *PET in Clinical Oncology.* Germany: Dietrich Steinkopff.

[26] Lardinois D, Weder W, Hany TF, Kamel EM, Korom S, Seifert B, von Schulthess GK, Steinert HC. (2003). Staging of non-small-cell lung cancer with integrated positron-emission tomography and computed tomography. *New England Journal of Medicine*, 348(25), 2500-2507.

[27] Kessler RM. (2003). Imaging methods for evaluating brain function in man. *Neurobiology of Aging*, 24 Suppl 1, S21-S35.

[28] Kotre CJ. (1997). Electrical impedance tomography. *British Journal of Radiology*, 70 Spec No, S200-S205.

[29] TransScan. (2002). *T-Scan™ 2000 ED: Advancing the Frontiers of Early Detection*. www.tscan.org/home/home.html.

[30] Hebden JC, Delpy DT. (1997). Diagnostic imaging with light. *British Journal of Radiology*, 70 Spec No, S206-S214.

[31] Allport JR, Weissleder R. (2001). In vivo imaging of gene and cell therapies. *Experimental Hematology*, 29(11), 1237-1246.

2 Medical Imaging in Practice

Throughout the ages, society's healers have developed a variety of approaches to diagnose and treat their patients' ills. Imaging technologies became part of the arsenal of tools used to find and fight disease in the last century. Today, clinicians use dozens of types of imaging, often as early diagnostic steps that may precede or preclude other health care services. Some technologies, such as X-ray machines, have been used for more than a century. Others, including MRI and PET scanners, are more recent, part of an increasingly sophisticated range of imaging technologies.

Although millions of Canadians receive imaging services each year, relatively little is known about how these technologies are used and how they affect patient care and outcomes. Pockets of information do, however, exist. This chapter of the report focuses on what we know about five of the many types of imaging used today–mammography, angiography, CT, MRI, and PET–and about the costs of imaging services.

About the Data: The Fine Print

- Statistics Canada's **Health Services Access Survey** (HSAS) is a supplement to the Canadian Community Health Survey (CCHS) 2000-2001. 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. Overall, 17,616 CCHS participants were included in the HSAS; 81% responded. All estimates from the HSAS presented in this chapter reflect *reported* use and may be different from estimates of the number of scans performed derived from administrative data.
- CIHI's **National Ambulatory Care Reporting System** (NACRS) captures summary information on ambulatory care. For 2001–2002, the database primarily captured information on emergency department care in Ontario (approximately 4.8 million emergency department visits). For this report, we examined the use of CT scans in this environment. Slightly more than 94,000 CT scans were reported. The CT scans were completed during the emergency department visit and could have been ordered for either the patient's main problem or other problem.
- 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 only directly comparable for selected jurisdictions. Imaging services paid for entirely through hospital global budgets or by individuals/third-party payers (e.g. Workers Compensation Boards) are not captured.
- 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, and PET scanners)* in Canadian hospitals and those in free-standing imaging facilities (sometimes also called 'non-hospital', 'community-based', and/or 'private' facilities) as of January 1, 2003. For more detailed information about this survey, please refer to Chapter 3.
- CIHI's **Management Information Systems Database** (CMDB) provides financial and statistical information (e.g. expenditures by functional area, workload measurements, outpatient visits) primarily on hospitals with some limited data on regional health authorities across Canada. Information is primarily obtained from provincial/territorial ministry of health databases. For some jurisdictions, however, data are collected from individual facilities/regional health authorities via survey. For this report we examined hospital operating expenses for selected types of medical imaging equipment.

For a more detailed description of these and other data sources, please visit CIHI's Web site at www.cihi.ca or Statistics Canada's Web site at www.statcan.ca.

* The survey also included lithotriptors, but results will be reported elsewhere.

Mammography: Looking for Breast Cancer

The National Cancer Institute of Canada estimates that there will be about 21,100 new cases of breast cancer and about 5,300 breast cancer deaths among Canadian women in 2003. This makes breast cancer the most commonly diagnosed form of cancer among women, although lung cancer is the leading cause of cancer deaths.[1]

In an effort to reduce the toll of breast cancer, thousands of women receive clinical breast exams, perform breast self-exams, and have screening mammograms each year. The body of knowledge about what works best for which women continues to evolve. Several groups have weighed this evidence and made recommendations about what women should do to prevent the disease.

7

Recommendations for Breast Cancer Screening

Recommendations for different types of breast cancer screening made by the American Cancer Society, the Canadian Cancer Society, the Canadian Task Force on Preventive Health Care, and the US Preventive Services Task Force.

Organization and Date Last Reviewed	Screening Mammography	Clinical Breast Exam	Breast Self-Exam
American Cancer Society (2002)	Yearly starting at age 40	Every 3 years, ages 20–39; yearly starting at age 40	Optional regular self-monitoring beginning at age 20
Canadian Cancer Society (2002)	Every 2 years, ages 50–69	Every 2 years for all women	Regular self-monitoring for all women
Canadian Task Force on Preventive Health Care (1994–2001)	Good evidence for screening every 1 to 2 years, ages 50–69 (1998) Evidence insufficient to recommend for or against for inclusion in the periodic health examination for women aged 40-49 at average risk of breast cancer (2001)	Good evidence for screening every 1 to 2 years, ages 50–69 (1998) The value of adding clinical breast examination to mammography is unclear for women aged 40-49 at average risk of breast cancer (2001)	Fair evidence to exclude from periodic health examination (2001)
US Preventive Services Task Force (2002)	Every 1 to 2 years starting at age 40 with or without clinical breast exam	Evidence insufficient to recommend for or against routine clinical breast exam alone	Evidence insufficient to recommend for or against

Source: Compiled by CIHI

Experts agree about what should be done in many—but not all—areas. For example, the Canadian and American Cancer Societies and the Canadian Task Force on Preventive Health Care all recommend a screening mammogram and a clinical breast exam at least every two years for women aged 50 to 69. However, experts disagree in a few areas, as table 7 shows. (For more information surrounding the on-going debate about mammography screening, please refer to CIHI's *Health Care in Canada 2002* report.)

8

Mammography Across Canada

Percentage of women aged 50 to 69 who reported having had a mammogram for routine screening or for any reason in the past two years in 2000-2001.

Note: (1) Any reason includes routine screening, family history of breast cancer, age, previously detected lump, follow-up of breast cancer treatment, on hormone replacement therapy, breast problem, or other reasons. (2) Data for Nunavut are suppressed due to extreme sampling variability.

* Interpret with caution due to sampling variability.

Source: Canadian Community Health Survey, Statistics Canada

Most women aged 50 to 69 do have regular mammograms, although some groups are more likely to have the test than others. In the 2000–2001 Canadian Community Health Survey, 70% of women aged 50 to 69 reported having a mammogram in the last two years; 52% of all women in this age group said that their mammogram was specifically for routine screening. Women were more likely to have had a recent mammogram if they had a regular doctor, higher incomes, and higher levels of education. The percentage of women who reported having a recent mammogram also varied across the country.

Coronary Angiography

Coronary angiography (or arteriography) provides images of blood vessels or chambers of the heart. It can be an important tool in detecting obstructions in coronary arteries and is often performed to determine the necessity of further interventions, such as angioplasty or bypass surgery.

Angiography is just one of many tests used to diagnose heart disease. As with other health conditions, a variety of tests may be used alone or in combination. The choice of which test(s) to use—and when—may depend on factors such as the patient's risk factors, health history, and current symptoms and situation; the availability of different tests and skilled professionals to conduct them and to interpret the results; and options for proceeding after test results are known.[2] Groups such as the American College of Radiology's Expert Panel on Cardiovascular Imaging have weighed the evidence and developed consensus-based ratings of the appropriateness of different tests for different clinical conditions (see Figure 9 for an example).[3]

9

Which Test?

Appropriateness ratings (1=least appropriate; 9=most appropriate) and related comments for radiological exam procedures that may be used for a patient with acute chest pain and suspected myocardial ischemia, as assigned by the American College of Radiology's Expert Panel on Cardiovascular Imaging in 1999.

Radiologic Exam Procedure	Appropriateness Rating	Comments
Chest film (X-ray)	9	Plain films are needed to exclude other causes for chest pain.
Coronary angiography	8	Necessary to define extent of stenosis. Usually done late in the work-up.
Transthoracic echocardiography (TTE)	7	Indicated as a screening test to evaluate cardiac function. Inexpensive and portable.
Left ventricular (LV) angiography	7	Indicated to define ventricular function as part of the ischemia evaluation.
Radionuclide myocardial perfusion scan	6	May be indicated to evaluate extent of ischemia. Usually done after initial screening tests suggest ischemia.
Radionuclide ventriculogram	6	May be indicated to evaluate cardiac function.
Infarct avid imaging	5	May be indicated in questionable cases to confirm infarction.
Transesophageal echocardiography (TEE)	4	May be indicated to evaluate cardiac function or to rule out aortic dissection.
Electron beam CT/multihead ultrafast CT with contrast	4	Probably not indicated except for quantitating ventricular function. Noncontrast images may be useful in screening for coronary calcification.
Magnetic resonance angiography (MRA)	4	
Conventional computed tomography (CT) with contrast	3	Little indication except for documenting other sources of chest pain.
Magnetic resonance imaging (MRI)	3	Little indication except for screening for possible aortic dissection. May have some applicability in evaluating cardiac function.
MR perfusion studies	2	Research studies show promise in evaluating infarction. Not extensively used clinically.
Positron emission tomography (PET)	2	See comments on MR perfusion studies.

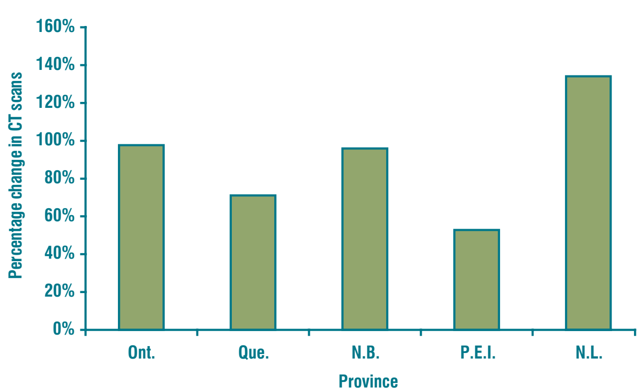
Note: Reproduced with permission from the Canadian Chapter of the American College of Radiology.

Source: American College of Radiology Expert Panel on Cardiovascular Imaging. (1999). *Acute Chest Pain—Suspected Myocardial Ischemia.* www.acr.org/dyna/?id=appcrit&pdf=0007-14_acute_chest_pain_susp_myocard_ischemia_ac.

10

Growth in the Number of CT Scans

The percentage change in publicly funded CT scans performed based on fee-for-service billings paid by selected provinces between 1994 and 2000.



Notes: (1) Comparing scan rates between provinces and/or countries is challenging for a variety of reasons. For example, where fee-for-service data exist, the billing codes used to designate a CT scan—and how scans are counted—sometimes differ, limiting the ability to compare between jurisdictions. Accordingly, only data on the percent change in the number of scans–rather than an actual scan rate per population–is presented here. (2) Data from Ontario, PEI, New Brunswick, and Newfoundland and Labrador are by fiscal year; Quebec data are by calendar year. (3) Data from Ontario, PEI, and Newfoundland and Labrador exclude scans performed for hospital inpatients (4) Interprovincial billings and scans done on hospital inpatients are included in New Brunswick data.

Sources: National Physician Database, CIHI (Ontario and PEI)
Eco-Santé, Ministère de la Santé et des Services sociaux (Québec)
Department of Health and Wellness, Government of New Brunswick
Department of Health and Community Services, Government of Newfoundland & Labrador

In the 2001 Health Services Access Survey (HSAS) by Statistics Canada, about 1%* of respondents aged 15 and older reported that they had had a non-emergency angiography within the last year. These respondents tended to be between the ages of 40-64; 52%* were women. Most (98%) said that their procedure was done in a hospital or public clinic.

CT Scans

Physicians use CT scans for diagnosing a wide and changing range of conditions, such as head injury, chest trauma, or musculoskeletal fractures. According to Statistics Canada data, about 787,300 Canadians aged 15 and older (3%) reported that they had had a non-emergency CT scan in 2001. The leading reason for these tests, accounting for almost 30% of scans, was neurological or brain disorders. About 33%* reported a mix of other reasons for their CT scans, and 37% did not specify the reason for their test. Most respondents (96%) stated that their CT scan was done in a hospital or public clinic.

Performing CTs In Ontario Emergency Departments

Radiology plays an important role in the emergency department (ED). Used appropriately, imaging can, for example, aid in identifying patients who may benefit from immediate intervention, monitoring, or early discharge.

Depending on a patient's condition and circumstances and other factors, different types of imaging (or, of course, no imaging) may be used. Some types of tests are relatively common–1.4 million X-rays were performed for patients in Ontario's EDs in 2001–2002. Others are used less often. For example, just over 94,000 CT scans were performed in the same period. Two-thirds of these tests (66%) were head scans; another 20% were of the abdomen. The number of women receiving CT scans was higher than the number of men for all age groups, except those aged 10 to 29. Patients 70 years of age or older received 28% of scans, although they accounted for only 13% of all ED visits.

The decision about whether to use a CT is not always clear. For example, there is some debate about which patients with minor head injury should be scanned.[7,8] Canadian researchers recently developed a decision rule to assist physicians with these choices.[7] They found that when the rule was used, physicians were significantly better able to predict whether a CT scan would find an important brain injury and whether patients needed neurosurgery than they could when relying on judgement alone.[9,10]

In Canada, researchers expect that use of this rule would stabilize or decrease CT use for patients with minor head injury.[10] A recent study suggested that Canadian CT use could fall by 17.8% (with the 'medium-risk' criteria designed to detect important brain injury) or by 44.5% (with the 'high-risk' criteria designed to detect patients who need neurological intervention). Researchers estimate that this could result in annual savings of about $3.5-$5.5 million to the Canadian health care system.[11] Researchers in other countries however, have questioned the generalizability of these Canadian rules.[12]

11

CT Scans in Ontario's Emergency Departments

The number of CT scans by body site in Ontario's emergency departments, 2001–2002.

Note: (1) Some emergency departments did not submit data to the National Ambulatory Care Reporting System for the 2001-2002 fiscal year and are therefore excluded from these counts. (2) "Other" includes CT scans not otherwise specified.

Source: National Ambulatory Care Reporting System, CIHI

* Interpret with caution due to sampling variability.

In Canada and elsewhere, both the number of CT machines and the number of CT scans has increased in recent years. For example, the number of publicly funded CT scans in Newfoundland and Labrador more than doubled between 1994 and 2000 and almost doubled in Ontario and New Brunswick. Other provinces, such as Quebec and PEI, also saw a growth in the number of CT scans during this period. Scan rates have also been rising in other parts of the world. Many other countries, including Australia,[4] the United States,[5] and England,[6] have also seen significant growth in CT scans in recent years.

12

Decision Rules for CT Scans

Key parameters from recent multicentre studies comparing the results of applying Canadian and US decision-rules for CT scans in patients with minor head injuries in a Canadian context.

Study Parameters	Canadian CT Head Rule	New Orleans Criteria
Population	Adult minor head injury patients with witnessed loss of consciousness, amnesia, or confusion and a Glasgow Coma Score of 13–15.	Adult minor head injury patients with witnessed loss of consciousness, amnesia, or confusion and a Glasgow Coma Score of 15.
# patients included in population	2,588	1,733
% patients requiring a CT scan using head rule	36% ('high risk' criteria) 62% ('medium risk' criteria)	88%
% patients requiring neurological intervention identified using head rule	100% ('high risk' criteria)	100%
% patients with important brain injuries identified using head rule	100% ('medium risk' criteria)	100%
% cases MDs underestimated the risk	7.1%	5.4%
% cases MDs uncomfortable in applying the rule	7.7%	11.5%

Notes: The Canadian CT head rule stratifies minor head injury patients into high-, medium- and low-risk categories based upon seven clinical criteria. The Glasgow Coma Score is a trauma scoring index ranging from 3 to 15 (3 being severe, 15 being minor) based on observation of patient eye, verbal, and motor responses.

Sources: Stiell IG, Clement C, Wells GA, Brison R, McKnight RD, Schull M, Rowe BH, Dreyer JA, Bandiera G, Lee J, MacPhail I, Lesiuk H. (2003). Multicenter prospective validation of the Canadian CT head rule. *Academic Emergency Medicine,* 10(5), 539.; Stiell IG, Clement C, Rowe BH, Brison R, Schull M, Wells GA, Greenberg G, Cass D, Holroyd B, Worthington JR, Reardon M, Eisenhauer M. (2003). Multicenter prospective validation of the New Orleans criteria for CT in minor head injury. *Academic Emergency Medicine,* 10(5), 477.

MRI Scans

The first MRI machine came to Canada in 1982,[13] but most scanners have been installed within the last five years. The number of tests performed and the range of health conditions for which MRI tests are used have also increased in recent years.

Across the country, about 647,000 Canadians aged 15 and over (3%) reported having had a non-emergency MRI scan in 2001. About 18%[†] were scans of joints and/or fractures, followed by tests for neurological or brain disorders (12%).[**†] As for CT scans, most patients (92%) received their MRI tests in hospitals or public clinics.

FF

[**] The reason for the MRI was unspecified in 37% of all cases.

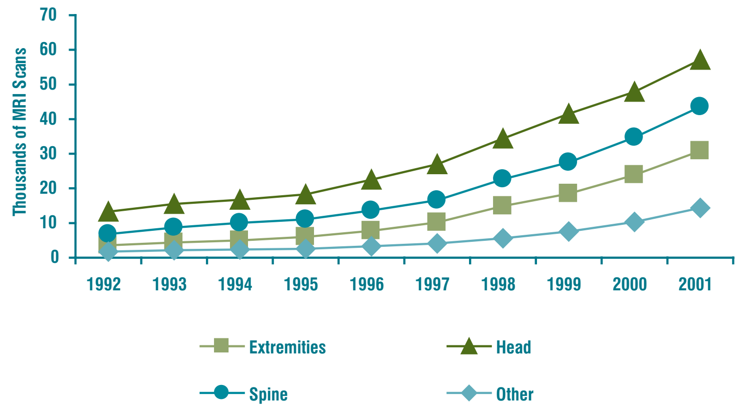
[†] Interpret with caution due to sampling variability.

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.[4,6] 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 1992 and 2001. Throughout this period, MRIs of the head were the most common type of test (they accounted for 39% of MRIs in 2001), but some rarer scans rose rapidly (eg: abdominal scans were up more than 1,100%).[14]

13

MRIs for What?

Thousands of outpatient MRI scans by body site per year in Ontario, 1992–2001.



Note: Other includes MRI scans for abdomen, pelvis, thorax, and neck.

Source: Iron K, Przybysz R, Laupacis A. (2003). *Access to MRI in Ontario: Addressing the Information Gap*. Toronto: Institute for Clinical Evaluative Sciences.

Data from other parts of the country are not directly comparable, partly because of differences in how MRI services are offered and reimbursed. Cautious comparisons do suggest that scan rates vary considerably across the country. But regions with higher rates don't necessarily have more MRI machines, and vice versa. For example, Ontario had more hospital-based machines per capita in 2001 than Manitoba, but reported fewer outpatient scans per capita. (Inpatient scan rate comparisons are not available)

Internationally, the same is true. For instance, England had more MRI machines per person in 2001 than Manitoba, but seems to have performed fewer scans per capita. Nationally and internationally, many factors may explain observed differences in scan rates including what types of scans are being performed, how many hours machines are operating (see Chapter 5), and how services are organized and delivered.

PET Scans

Positron emission tomography (PET) was introduced shortly after computed tomography (CT) in the early 1970s.[15] Unlike CT, which produces images of the patient's anatomy, PET is a type of nuclear medicine that measures biochemical processes in the body.

Across Canada, there were 14 PET scanners in January 2003, up from six in 1997. Most were located in hospitals or affiliated research centres, but one has recently been installed in a free-standing imaging facility in British Columbia and Ontario. Eleven of the 14 scanners installed as of January 2003 can accommodate full-body scanning; the others can only accommodate head scans.

While many imaging modalities are regularly used in clinical practice, PET remains largely a research tool in Canada.[16] In part, the high cost of equipment and the complexity of its use may have slowed its adoption in clinical settings, according to the literature.[17] For example, PET imaging studies use short-lived radioactive molecules (positron emitting tracers) to produce images, requiring access to a nearby cyclotron to generate the radioisotopes. Cyclotrons are particle accelerators that cost about $3-4 million plus annual maintenance and other costs.[17-19]

Will PET scans become part of the diagnostic toolbox in Canada? Several recent studies have assessed the appropriateness of its use for specific clinical applications.[19-21] All pointed to the need for further research (e.g. larger studies comparing PET with other imaging technologies and research on the cost-effectiveness of PET use in Canada). Nevertheless, the authors did suggest that:

- **Oncology:** PET scanning may be useful in the diagnosis and staging of lung cancer.[19-21]
- **Neurology:** A Quebec study found evidence to support the use of PET for identifying regions in the brain responsible for inducing epileptic seizures and in evaluating lesions following treatment of a recurrent brain tumor (mainly gliomas).[21] In contrast, an Ontario study did not find evidence to support the use of PET for diagnosing or for the symptomatic management of dementia.[19]
- **Cardiology:** A Quebec study found PET to have clinical utility in studying myocardial viability.[21] However, a study from Ontario found in that there was no convincing evidence of the clinical utility of PET for cardiac indications.[19]

The Cost of Imaging

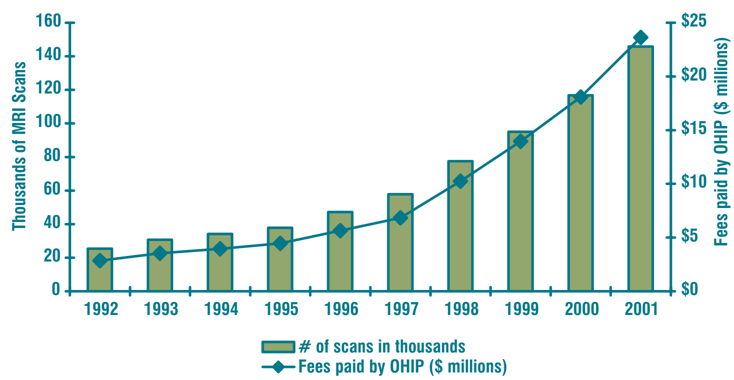
Canadians spend billions of dollars each year on imaging services. The professionals who operate and maintain the equipment must be paid; related parts and supplies must be purchased;‡ and overhead costs add up. In addition, physicians receive professional fees for performing and/or interpreting tests. There are also other costs.

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.

14

The Growing Use and Cost of MRIs in Ontario

The number of fee-for-service outpatient MRI scans and fees paid (in millions of dollars) by the Ontario Health Insurance Plan, 1992-2001.

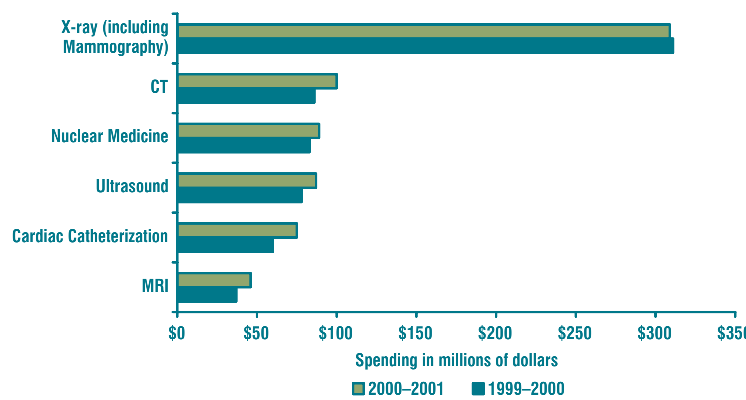


Source: Iron K, Przybysz R, Laupacis A. (2003). *Access to MRI in Ontario: Addressing the Information Gap*. Toronto: Institute for Clinical Evaluative Sciences.

15

Spending on Medical Imaging in Hospitals

Total hospital operating expenses for selected types of medical imaging equipment, Ontario, 1999–2000 and 2000–2001.



Source: Canadian MIS Database, CIHI

‡ Capital costs associated with medical imaging equipment are examined in Chapter 3.

Available snapshots include:

- Total spending on medical imaging in Canada has risen in recent years. For example, hospitals in British Columbia, Alberta, Ontario, and New Brunswick collectively spent about $1.3 billion (7%) on diagnostic imaging services in 2000.▫
- A recent Quebec Auditor General's report indicated that the province spent about $358 million on diagnostic imaging services in 1999-2000.[22]
- A recent Ontario study showed an eight-fold increase in the overall amount that the provincial health insurance plan paid for outpatient MRI scans between 1992 and 2001.[14]
- The Saskatchewan government estimates that MRI services alone cost more than $3.9 million in 1998-1999 or about $365 per scan, excluding maintenance contracts on new units.[23]
- In 2001, the British Columbia government estimated costs of about $20 million to operate its MRI scanners.[24]

Where the Money Comes From

A variety of public and private sources fund Canada's medical imaging operating costs. Most funding comes through provincial/territorial governments, but funding approaches vary by technology and by 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 'technical' component, covering all operating costs.

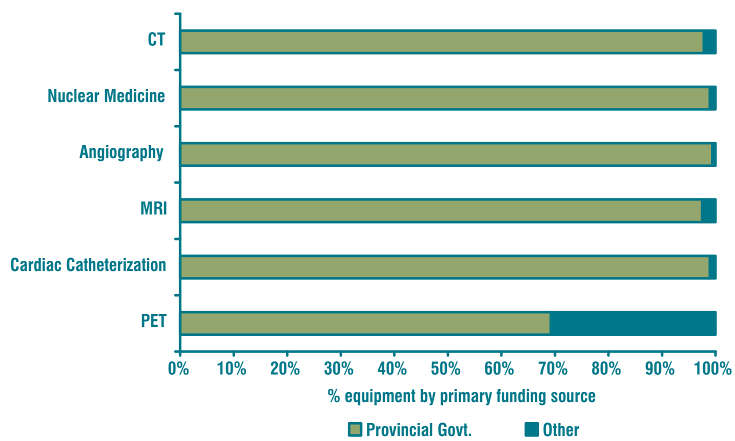
The 2003 National Survey of Selected Medical Imaging Equipment provides insight into the extent to which different payers fund medical imaging operating costs for MRI, CT, and PET scanners, nuclear medicine, catheterization labs, and angiography. For the vast majority of hospital-based equipment captured in the survey, funding for operating costs comes primarily from provincial/territorial governments (98%). This was also the primary funding source for about a third (32%) of the machines housed in free-standing imaging facilities.

Equipment in both settings may also have a variety of secondary sources of funding, not all of which were identified by every survey respondent. Examples include the federal government, Workers' Compensation Boards, research grants, private insurance companies, and out-of-pocket payments. See Chapter 5 for more information about issues related to funding for imaging services.

16

Paying to Operate Health Technologies

Percentage of equipment in **hospital** facilities by primary funding source of operating dollars for selected imaging technologies, 2002–2003.



Note: Other category includes funding not otherwise specified and Worker's Compensation Board payments

Source: National Survey of Selected Medical Imaging Equipment, CIHI

▫ Hospital spending in total dollars based on data from the following provinces: British Columbia, Alberta, Ontario, and New Brunswick. Comparable data from other provinces were not available.

Where the Dollars Go

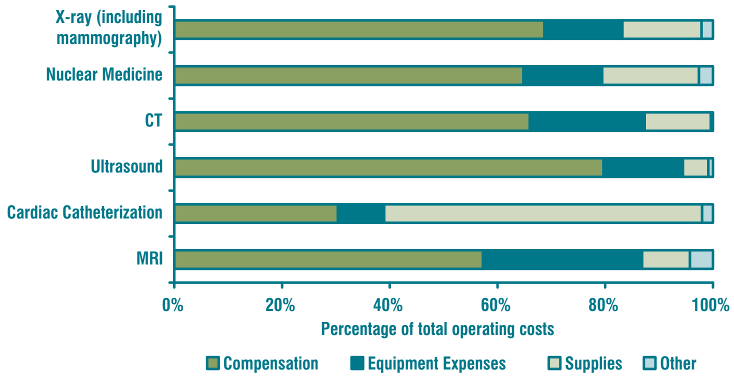
Medical imaging tests vary greatly in their complexity and the resources required to carry them out. In most hospitals, common tests account for the bulk of overall operating expenditures on diagnostic imaging. According to CIHI's Management Information Systems Database (CMDB), in 2000-2001 hospitals in Ontario spent about $309 million on X-rays— approximately three times as much as to other imaging technologies such as CT, ultrasound, cardiac catheterization, or nuclear medicine. Other services—such as MRIs—cost more per test, but fewer people receive them. Ontario hospitals, for example, spent about $46 million for MRI scans in 2000-2001.

Types of operating expenses also vary according to imaging modalities. For some services (e.g. MRI, CT, and ultrasound), salaries paid to health professionals account for more than half (57%, 66%, and 80% respectively) of total operating costs. For others, such as cardiac catheterizations, medical supplies used to perform the procedure make up the majority of spending (59%).

17

Where the Dollars Are Spent

The distribution of hospital operating expenses for selected types of medical imaging equipment, Ontario, 2000–2001.



Note: Other category includes sundries, referred out services, and building and grounds expenses.

Source: Canadian MIS Database, CIHI

Information Gaps:

What We Know

- Proportion of Canadians who reported receiving selected non-emergency medical imaging services in 2001.
- Number of selected medical imaging services provided over time for various jurisdictions.
- Number of medical imaging services in Ontario emergency departments and the demographic characteristics of those who received them.
- What hospitals in selected provinces spend to operate certain types of medical imaging equipment.
- How much physicians bill in fee-for-service payments for certain types of medical imaging procedures for selected provinces.
- The primary sources of operating funding used for selected types of imaging technology.

What We Don't Know

- Exactly how many Canadians receive different types of medical imaging services each year? How many scans are performed? What combination and rate of medical imaging services would best meet the health care needs of different patient groups and communities and what would the implications be for access to care, health care costs, and patient outcomes?
- How many Canadians receive medical imaging services that are not publicly funded? Where do they receive these services and for what purpose? What effect does this have on their health and health care, as well as on publicly funded services and costs?
- How much is spent in total to provide medical imaging services? How do levels of spending on imaging affect access to imaging and other types of care, patient and provider satisfaction, patient outcomes, and overall health care costs?
- What types of imaging services are payers other than provincial/territorial Ministries of Health purchasing? What are the motivations for these purchases? What effect do they have on patient and provider satisfaction, patient outcomes, and overall health care costs?

What's Happening

- In February 2003, Canada's First Ministers agreed to report to their citizens annually on enhancements to diagnostic and medical equipment and services using comparable indicators and to develop the necessary data infrastructure for these reports. Ministers were directed to consider a number of indicators, including volumes and wait time measures for MRIs and CTs.
- CIHI recently revised the diagnostic imaging workload measurement system in the Canadian MIS Guidelines to better capture the volumes and costs of medical imaging activities in hospitals and health regions.

For More Information

[1] National Cancer Institute of Canada. (2003). *Canadian Cancer Statistics 2003*. Toronto: National Cancer Institute of Canada.

[2] American Heart Association. (2002). *Tests to Diagnose Heart Disease*. www.americanheart.org/presenter.jhtml?identifier=4739.

[3] American College of Radiology. (1999). *Acute Chest Pain-Suspected Myocardial Ischemia*. www.acr.org/dyna?/id=appcrit&pdf=0007-14_acute_chest_pain_susp_myocard_ischemia_ac.

[4] Australian Health Insurance Commission. (2003). *Health Statistics: Diagnostic Imaging Services (Magnetic Resonance Imaging)*. www.hic.gov.au.

[5] International Marketing Ventures. (2002). *CT Sites Moving Quickly to Adopt Latest CT Multi-slice Technology and Applications*. www.imvlimited.com/mid/news_ctpr.html.

[6] Department of Health. (2002). *Total Number of Imaging and Radiodiagnostic Examinations or Tests, by Imaging Modality, England, 1995-96 to 2001-02*. www.doh.gov.uk/hospitalactivity/data_requests/imaging_and_radiodiagnostics/ts_imag.xls.

[7] Stiell IG, Wells GA, Vandemheen K, Clement C, Lesiuk H, Laupacis A, McNight RD, Verbeek R, Brison R, Cass D, Eisenhauer ME, Greenberg G, Worthington J. (2001). The Canadian CT head rule for patients with minor head injury. *Lancet*, 357(9266), 1391-1396.

[8] Oguz KK, Yousem DM, Deluca T, Herskovits EH, Beauchamp NJ. (2002). Effect of emergency department CT on neuroimaging case volume and positive scan rates. *Academic Radiology*, 9(9), 1018-1024.

[9] Stiell IG, Worthington J, Dreyer J, Vandemheen K, Clement C, De Maio V, Schull M, Reardon M, Morrison L, McKnight D, MacPhail I, Greenberg G, Eisenhauer M, Cass D, Brison R, Wells G. (2003). Comparison of the Canadian CT head rule to physician judgement. *Canadian Journal of Emergency Medicine*, 2(3), 49.

[10] Stiell IG, Clement C, Wells GA, Brison R, McKnight RD, Schull M, Rowe BH, Dreyer JA, Bandiera G, Lee J, MacPhail I, Lesiuk H. (2003). Multicenter prospective validation of the Canadian CT head rule. *Academic Emergency Medicine*, 10(5), 539.

[11] Coyle D, Stiell IG, Wells GA, Clement C. (2003). Economic evaluation of the potential impact of the Canadian CT head rule. *Academic Emergency Medicine*, 10(5), 554.

[12] Needham G, Currie DG. (2002). Canadian CT head rule for patients with minor head injury. *Clinical Radiology*, 57(2), 152-153.

[13] Rankin RN. (1999). Magnetic resonance imaging in Canada: Dissemination and funding. *Canadian Association of Radiologists Journal*, 50(2), 89-92.

[14] Iron K, Przybysz R, Laupacis A. (2003). *Access to MRI in Ontario: Addressing the Information Gap*. Toronto: Institute for Clinical Evaluative Sciences.

[15] Robert G, Milne R. (1999). Positron emission tomography: Establishing priorities for health technology assessment. *Health Technology Assessment*, 3(16), 1-54.

[16] Zeidenberg J. (2003). *Ontario's First Private-Sector PET Imaging Clinic Open for Business.* www.canhealth.com/may03.html#anchor58697.

[17] Adams EJ, Asua J, Conde Olasagasti JG, Erlichman M, Flynn K, Hurtado-Saracho I. (1999). *Positron Emission Tomography: Experience With PET and Synthesis of the Evidence*. Stockholm: International Network of Agencies for Health Technology Assessment.

[18] Minnesota Department of Health. (1999). *Positron Emission Tomography for Oncologic Applications*. www.health.state.mn.us/htac/pet.htm.

[19] Laupacis A. (2001). *Health Technology Assessment of Positron Emission Tomography: Executive Summary.* Toronto: Institute for Clinical Evaluative Sciences. www.ices.on.ca/PDFs/TechnicalReports/PET-ExSum.pdf.

[20] Benk V, Laupacis A, Paszat L, Hodgson D. (2003). *Health Technology Assessment of Positron Emission Tomography (PET) in Oncology: A Systematic Review.* Toronto: Institute for Clinical Evaluative Sciences. www.ices.on.ca/PDFs/TechnicalReports/PET_report_May2003.pdf.

[21] Dussault FP, Nguyen VH, Rachet F. (2001). *Positron Emission Tomography in Quebec*. Montreal: Agence d'évaluation des technologies et des modes d'intervention et santé (AÉTMIS).

[22] Auditor General of Quebec. (2001). *Report to the National Assembly for 2000–2001, Volume 1.* Quebec: Government of Quebec.

[23] Legislative Assembly of Saskatchewan. (2000). *No. 50 Votes and Proceedings: First Session - Twenty-Fourth Legislature*. www.legassembly.sk.ca/journals/Votes/24L1S/2401vp50.htm.

[24] Legislative Assembly of British Columbia. (2001). *Select Standing Committee on Health: Minutes and Hansard*. www.legis.gov.bc.ca/cmt/37thparl/session-2/aaf/hansard/a11024p.htm.

3 Imaging Technologies—Supply and Capital Costs

In Chapter 2, we looked at the changing utilization of medical imaging technologies in health care. Often, however, the focus seems to be more narrow—how many machines we have, as well as how that quantity compares over time and with other countries.

This chapter addresses these and related questions, but it's only part of the picture. The supply of machines needs to be considered in the context of many of the factors covered in this and other chapters of this report. For example, an important factor is how imaging machines are used to provide care (see Chapter 2). So is the number and mix of medical imaging professionals (see Chapter 4) and the context in which imaging technologies are used (see Chapter 5).

How Many are There?

Many different kinds of imaging machines are used in clinical practice today, from new equipment that is 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, such as X-ray and ultrasound.

CIHI's recent National Survey of Selected Medical Imaging Equipment tracked six types of imaging equipment.[▪] As of January 1, 2003, it counted:

- 594 nuclear medicine cameras,
- 326 CT scanners,
- 165 angiography suites,
- 147 MRI scanners,
- 94 catheterization laboratories, and
- 14 PET scanners.

These imaging technologies have been introduced into clinical practice at different times, and their diffusion rates vary. For example, the number of CT and MRI scanners has grown significantly since they were introduced (in 1973 and 1985 respectively). Since 1990, the number of CT scanners has grown by 65% whereas MRIs have grown by 674%. Overall, growth in the number of MRI scanners has outpaced that for CT machines since 1997.

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.[1–3]

[▪] The survey also counted lithotriptors, but results will be reported elsewhere.

About the National Survey of Selected Medical Imaging Equipment

Over a period of many years, the Canadian Coordinating Office for Health Technology Assessment (CCOHTA) conducted a survey on the number, distribution, and key characteristics of selected imaging technologies in Canadian hospitals. Following discussions with CCOHTA, CIHI undertook a similar survey in 2003. Basic information on the survey is provided below. For more information, see CIHI's Web site: www.cihi.ca.

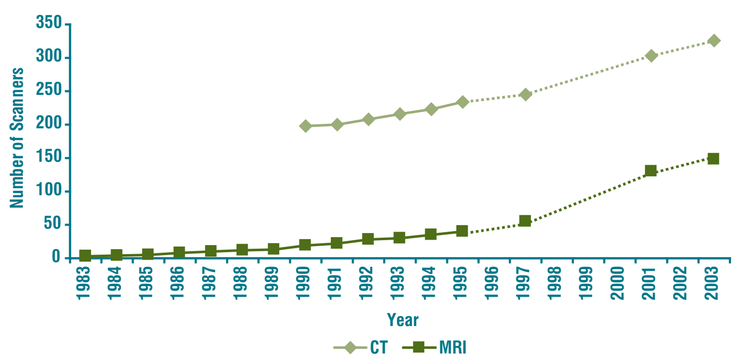
What's Included: The CIHI survey tracked data on machines installed in Canadian hospitals and those in free-standing imaging facilities (sometimes also called "non-hospital", "community-based", and/or "private" facilities) as of January 1, 2003. The imaging machines covered by the survey (angiography suites, catheterization labs, CT scanners, MRI scanners, nuclear medicine cameras, and PET scanners) were the same as those surveyed by CCOHTA in 2001.

The Survey Process: CIHI retained the services of ProMed Associates Ltd. to coordinate data collection. They contacted health regions and hospitals and relevant free-standing imaging facilities across Canada. Various medical and technical organizations and provincial/territorial ministries of health were asked to encourage participation in the survey. Most respondents completed the survey using a bilingual Web site. To maximize response rates, ProMed Associates Ltd. completed several rounds of follow-up with respondents.

18

Trends in MRI and CT Scanners in Canada

Numbers of magnetic resonance imaging (MRI) and computed tomography (CT) scanners in Canada between 1983 and 2003, including units in hospitals and in free-standing imaging facilities.



Notes: 1) 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. 2) CCOHTA inventories were not conducted annually. A dotted line is drawn between data points spanning two years or more.

Sources: OECD Health Data 2002, OECD (1983–1990)
National Inventory of Selected Imaging Equipment, Canadian Coordinating Office for HealthTechnology Assessment (1991–2001)
National Survey of Selected Medical Imaging Equipment, CIHI (2003)

Validating the Results: To ensure that the coverage was as complete as possible, responses were cross-checked against results from CCOHTA's 2001 survey, lists provided by medical imaging technology manufacturers, published lists of equipment (e.g. research reports and health directories), and data reported by hospitals and health regions to CIHI's Canadian MIS Database. Provincial/territorial ministries of health were also asked to validate overall equipment counts. In addition, ProMed Associates reviewed information submitted and contacted participants for follow-up where required. All equipment captured in the 2001 survey was captured in 2003. An additional 317 machines (31% more than in the 2001 survey) were also identified, including those located in free-standing imaging facilities (not captured in previous surveys).

The Supply of Imaging Technologies in Canada

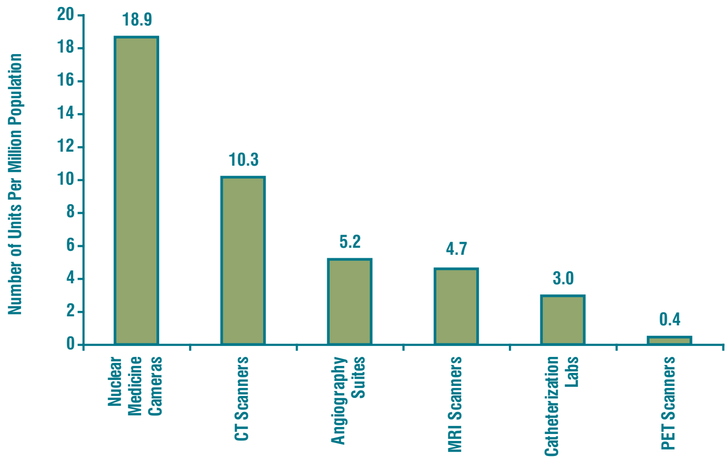
Most Canadians receive imaging services in the province or territory where they live, although some travel within their jurisdiction or to other parts of the country for care. All provinces now have nuclear medicine cameras, angiography suites, CT scanners, and MRI machines,▪ as well as other imaging technologies, such as X-ray and ultrasound services.

Rates of equipment per population do, however, vary across the country. For example, as of January 2003, Ontario, with the largest population in Canada, had the largest numbers of CT scanners (95). However, it had the fewest CT machines per million population (7.8). In contrast, with one CT scanner, the Yukon Territory has the largest per capita ratio (33.5). That said, more machines do not necessarily mean more scans (see Chapter 2).

19

Imaging Technologies in Canada in 2003

Number of units per million population of selected imaging technologies in Canadian hospitals and free-standing imaging facilities as of January 1, 2003.



Note: Of the 14 PET scanners in Canada, eleven can accommodate full body scans; three can only accommodate head scans.

Source: National Survey of Selected Medical Imaging Equipment, CIHI

20

Distribution of Imaging Technologies Across Canada in 2003

Numbers (#) and numbers of units per million population (rate) of selected imaging technologies in hospitals and free-standing imaging facilities by jurisdiction as of January 1, 2003.

Jurisdiction	Nuclear Medicine Cameras		CT Scanners		Angiography Suites		MRI Scanners		Catheterization Labs		PET Scanners	
	#	Rate	#	Rate	#	Rate	#	Rate	#	Rate	#	Rate
B.C.	61	14.7	44	10.6	20	4.8	18	4.3	11	2.6	2	0.5
Alta.	54	17.2	30	9.6	15	4.8	23	7.3	11	3.5	2	0.6
Sask.	14	13.9	10	9.9	4	4.0	3	3.0	4	4.0	–	–
Man.	16	13.9	14	12.2	3	2.6	3	2.6	4	3.5	–	–
Ont.	244	20.1	95	7.8	66	5.5	50	4.1	36	3.0	6	0.5
Que.	151	20.2	94	12.6	38	5.1	40	5.5	21	2.8	4	0.5
N.B.	18	23.8	9	11.9	9	11.9	5	6.6	2	2.6	–	–
N.S.	23	24.4	15	15.9	5	5.3	4	4.2	3	3.2	–	–
P.E.I.	2	14.2	2	14.2	1	7.1	–	–	–	–	–	–
N.L.	10	18.8	11	20.7	4	7.5	1	1.9	2	3.8	–	–
Nun.	–	–	–	–	–	–	–	–	–	–	–	–
N.W.T.	1	24.2	1	24.2	–	–	–	–	–	–	–	–
Y.T.	–	–	1	33.5	–	–	–	–	–	–	–	–
Canada	**594**	**18.9**	**326**	**10.3**	**165**	**5.2**	**147**	**4.7**	**94**	**3.0**	**14**	**0.4**

Note: Of the 14 PET scanners in Canada, eleven can accommodate full body scans, and three can only accommodate head scans.

Source: National Survey of Selected Medical Imaging Equipment, CIHI

▪ Prince Edward Island's new MRI machine was not counted in the national survey since it was installed in the spring of 2003.

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. As a result, some suggest that a high availability of CT services might reduce acquisition of MRIs.[4] Interestingly, Newfoundland and Labrador, the province with the highest per capita rate of CTs (20.7 per million population), also has the lowest rate of MRIs (1.9). On the other hand, Alberta has the most MRIs per capita (7.3 per million) but fewer CTs (9.6) than most jurisdictions.

Technology At Our Fingertips

With digital imaging comes the potential to acquire, review, distribute, and archive image information electronically. Picture Archiving and Communications Systems (PACS) are designed to undertake several of these functions. Evaluating the impact of these systems on cost, quality, and other outcomes is challenging, partly because the technology continues to evolve and has been implemented in different ways in different places.[5]

Canadian hospitals began implementing PACS systems many years ago, but comprehensive information about who is using what types of systems and how is not currently available. Implementation is, however, continuing. For example, six projects with PACS components have been moving forward under the Canada Health Infostructure Partnerships Program, including ones with Central BC and the Yukon, Manitoba Telehealth, Saskatchewan Telehealth, NORad (which includes nine Northeastern Ontario hospitals), NORTH Network, and Health Infostructure Atlantic (which includes New Brunswick, Newfoundland, Nova Scotia, and Prince Edward Island).[6]

21

Ratios of MRIs to CTs

Ratios of MRIs to CTs in hospitals and free-standing imaging facilities by jurisdiction as of January 1, 2003.

Jurisdiction	MRI:CT Ratio
B.C.	1:2.5
Alta.	1:1.3
Sask.	1:3.3
Man.	1:4.7
Ont.	1:1.9
Que.	1:2.3
N.B.	1:1.8
N.S.	1:3.8
P.E.I.	–
N.L.	1:10.9
Nun.	–
N.W.T.	–
Y.T.	–
Canada	**1:2.2**

Source: National Survey of Selected Medical Imaging Equipment, CIHI

The International Context

Internationally, the Organization for Economic Cooperation and Development (OECD) has reported large variations in the supply of medical imaging technologies among member countries. For instance, the per capita ratio of CT machines for Japan (data for 1999) was triple that of Korea (2001), the country with the next highest ratio; almost 9 times that of Canada (2001); and fifteen times that of England (2001).

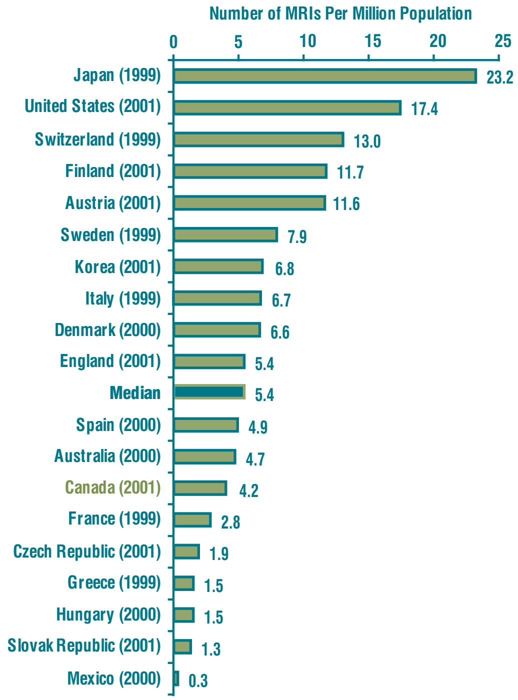
All OECD countries where data are available report more CTs and MRIs over time, but some have acquired the technologies at a faster rate than others. For example, throughout the 1990s, the number of MRIs per capita in Canada grew less quickly than Spain's and Australia's, but more quickly than those of the Czech Republic and Greece.

As is true in Canada, having more machines does not necessarily mean that more people receive imaging services. 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 per capita ratio of MRIs has been partly attributed to the market situation of the medical engineering industry, as well as sociocultural factors such as a bias towards new technologies.[7] 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 (see Chapter 5).

22

MRIs in OECD Countries

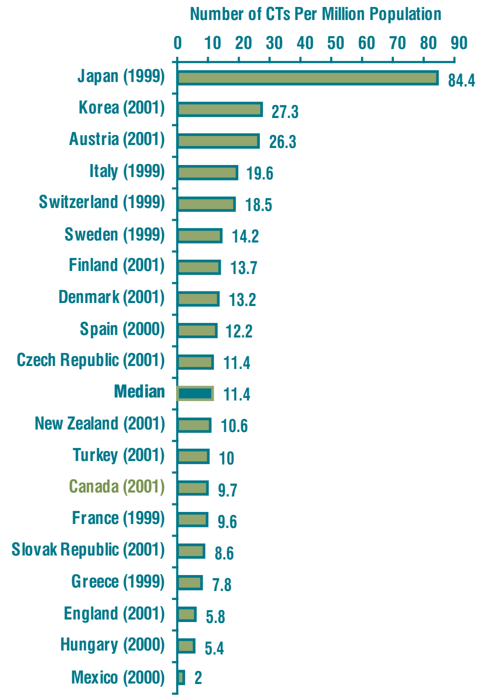
Number of magnetic resonance imaging (MRI) scanners per million population in selected OECD countries with a population of a million or more and the year for which rates were reported.



23

CTs in OECD Countries

Number of computed tomography (CT) scanners per million population in selected OECD countries with a population of a million or more and the year for which rates were reported.



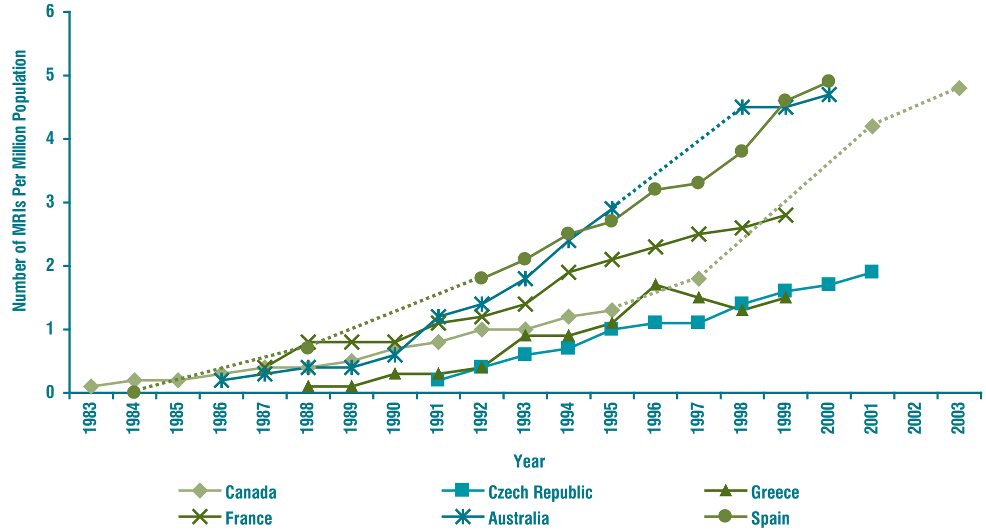
General Notes: 1) Countries for which only data prior to 1999 were available are not shown.
2) Mexico only counts scanners located in public institutions.
3) Units located both in hospitals and in free-standing imaging facilities are included for Canada. The number of MRI and CT scanners in free-standing imaging facilities was imputed for 2001 based on data collected in the 2003 National Survey of Selected Medical Imaging Equipment.
MRI Notes: 4) Australian numbers include only units approved for billing to Medicare.
5) Only units located in hospitals are counted in Japan.
6) Units located both in hospitals and non-hospital sites are included for the United States. "Mobile" MRI units are not included. IMV was used as the data source because it counts the number of MRIs, whereas OECD figures count the number of hospitals that report having at least one scanner.
CT Notes: 7) Greece and Hungary do not include CT scanners from military hospitals.
8) Japan only counts CT scanners in hospitals and general clinics.
9) CT scanners installed in the private sector are not counted in England.
10) OECD estimates for the United States refer to the number of hospitals that report having at least one scanner, rather than the total number of machines. Accordingly, they were not included.

Sources: OECD Health Data 2002, OECD
National Inventory of Selected Imaging Equipment
Canadian Coordinating Office for Health Technology Assessment (2001 data for Canada)
Information Services for the Health Care and Scientific Markets (IMV) (data for the United States)

24

MRI Trends

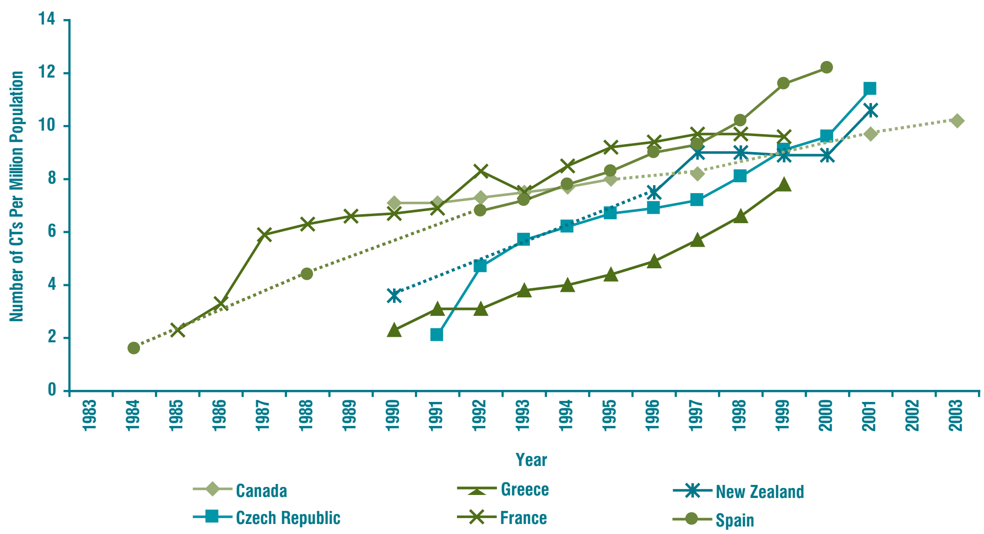
Trends in the number of magnetic resonance imaging (MRI) scanners per million population between 1983 and 2003 in selected OECD countries (Canada and the five countries whose most recent rates of scanners per million population were closest to Canada's in 2001).



25

CT Trends

Trends in the number of computed tomography (CT) scanners per million population between 1983 and 2003 in selected OECD countries (Canada and the five countries whose most recent rates of scanners per million population were closest to Canada's in 2001).



Notes: 1) Yearly 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.
2) Australian MRI numbers include only units approved for billing to Medicare.
3) England was not included because prior to 2000 data were collected for all of United Kingdom; therefore, data prior to 2000 are not comparable to 2001 data.
4) Units located both in hospitals and in free-standing imaging facilities are included for Canada for all years. The number of MRI and 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 2002, OECD
National Inventory of Selected Imaging Equipment
Canadian Coordinating Office for Health Technology Assessment (1991–2001 data for Canada)
National Survey of Selected Medical Imaging Equipment, CIHI (2003 data for Canada)

Where Imaging Technologies are Located

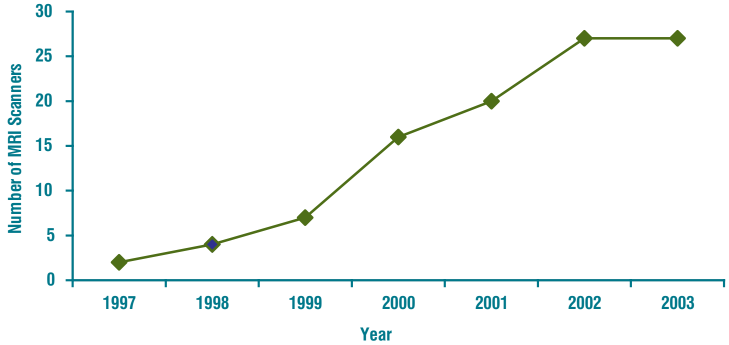
Hospitals typically offer a range of medical imaging services, but some types of imaging are also available elsewhere. For example, there is a well-established practice of free-standing facilities offering X-ray and ultrasound services.

The extent to which imaging services are available outside of hospitals varies by imaging modality. Services such as CT and MRI, for example, tend to be located in densely populated areas and are often found in teaching and large community hospitals. However, the number in free-standing (or non-hospital) imaging facilities is growing. As of January 2003, about 3% of CTs and 18% of MRIs were in this type of facility, up from an estimated 2% and 15%, respectively, in July 2001. This transition has not been without controversy, as Chapter 5 describes. (For locations of selected imaging modalities across Canada, please see Appendix A—Fast Facts).

26

MRI Scanners Outside of Hospital

Approximate number of magnetic resonance imaging (MRI) scanners in free-standing imaging facilities in Canada between 1997 and January 2003.



Note: The numbers of MRI scanners were imputed for years prior to 2003 based on data on year of installation reported in the 2003 survey.

Source: National Survey of Selected Medical Imaging Equipment, CIHI

Aging and Renewal of Medical Imaging Technologies

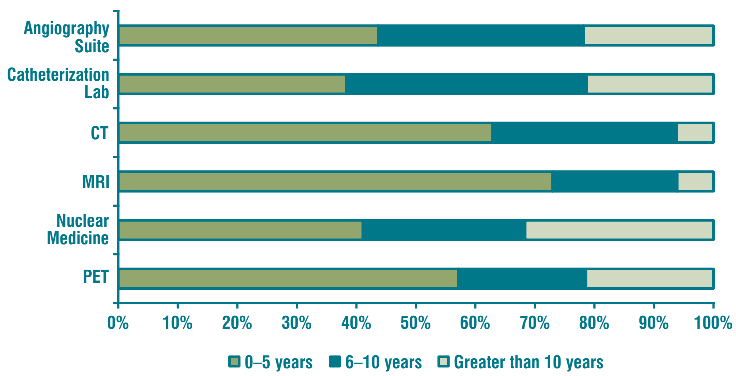
The age of Canada's imaging technologies varies by modality and across the country. For example, while about 38% of catheterization labs were under five years old at the beginning of 2003, 73% of MRIs were in this category.

Canada's MRI and CT machines also tend to be somewhat newer than those in many European countries. In 2001, the proportion of scanners that were installed in Canadian hospitals under five years old was higher than that in hospitals in selected European countries.

27

Age of Imaging Technologies in Canada in 2003

Percentage of units by years since installation for selected medical imaging technologies located in Canadian hospitals and free-standing imaging facilities as of January 1, 2003 (some machines were upgraded since installation).



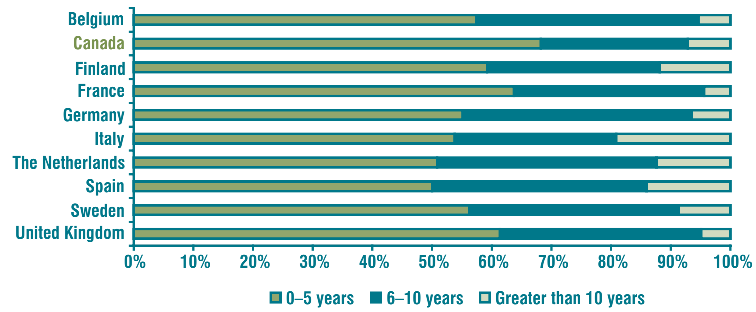
Source: National Survey of Selected Medical Imaging Equipment, CIHI

Like other equipment, medical imaging technologies do not last indefinitely, but there is no universally agreed standard about when equipment should be replaced or updated. For example, both the Canadian Association of Radiologists and the British Royal College of Radiologists estimate that an imaging machine's useful life varies between 6 years (e.g. for MRIs) and 10 years (e.g. for X-ray machines).[8, 9] On the other hand, the Quebec Ministry of Health and Social Services recently advised the Quebec Auditor General that maximum life spans of between 9 and 18 years respectively, were appropriate.[10]

28

Age of CTs and MRIs in Canadian and European Hospitals in 2001

Percentage of units by years since installation of CTs and MRIs located in Canadian and European hospitals in 2001.



Notes: Data for European countries represent data from four major companies which supply diagnostic imaging equipment to European hospitals. The study relies on data that do not cover 100% of the installed equipment, but the companies involved in the study represent a high share of the total installed base. The companies are: General Electric Systems Europe, France; Philips Medical Systems, The Netherlands; Siemens Medical Solutions, Germany; Toshiba Medical Systems, The Netherlands.

Sources: European Coordination Committee of the Radiological and Electromedical Industries. (2003). *Age Profile Medical Devices, Third Edition: The Need for Sustained Investment*. Frankfurt: COCIR; National Inventory of Selected Imaging Equipment, Canadian Coordinating Office for Health Technology Assessment (data for Canada)

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.[8] Furthermore, they suggest that it may be more difficult to obtain spare parts for older equipment; that there may be cost implications (i.e. maintenance fees) involved when updating older equipment; and that older machines 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.

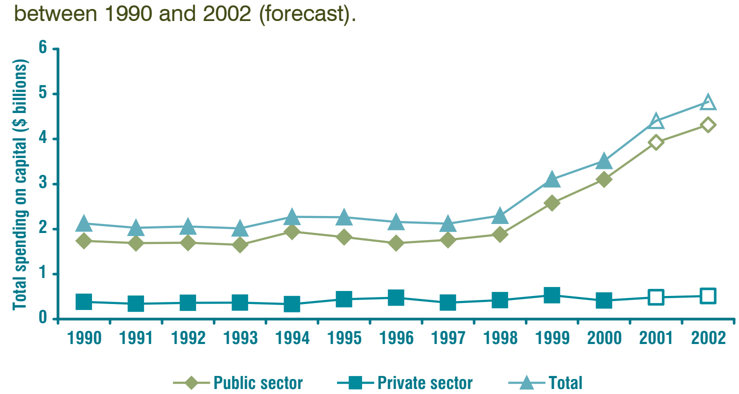
Buying and Replacing Equipment: Capital Costs

In 2002, Canada spent $4.8 billion on construction, machinery, and major equipment in the health sector.[11] Capital costs represented about 4.3% of total health spending (forecast). Most (89%) came through provincial/territorial governments; about 11% came from the private sector. Both sources of funds and levels of capital spending have fluctuated over time. After a comparatively lean period in the early to mid 1990s, spending has risen steadily in recent years.

29

Capital Spending Across Canada

Total capital spending in health care (expenditures on construction, machinery, and equipment of hospitals, clinics, first-aid stations, and residential care facilities) by public and private sector payers in Canada between 1990 and 2002 (forecast).



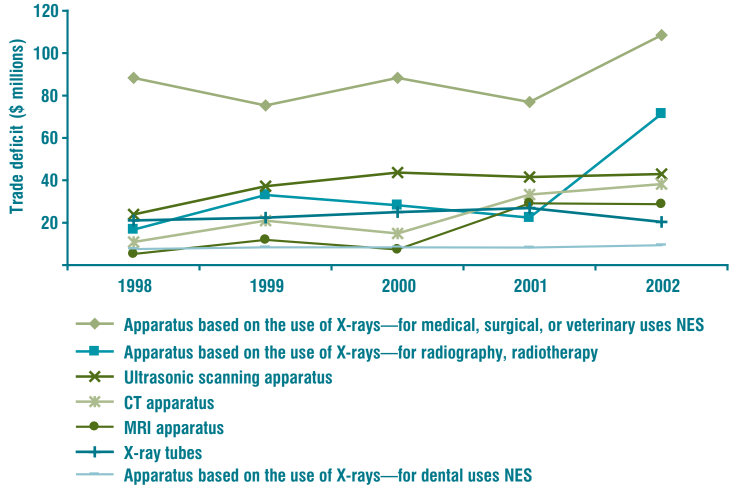
Note: Open symbols represent forecast figures.

Source: National Health Expenditure Database, CIHI

30

Net Imports of Imaging Equipment

Canada's trade deficit (total imports minus total exports) for selected imaging equipment and supplies in millions of Canadian dollars (not adjusted for inflation) between 1998 and 2002.



Source: Trade Data Online, Industry Canada based on data from Statistics Canada

Medical imaging equipment accounts for an important, but unknown, share of total capital spending. "Big ticket" technologies such as MRI and CT scanners have high initial costs compared to common technologies such as X-rays and ultrasounds. An MRI costs over $2 million (Cdn), whereas the average cost of a CT scanner is about $1 million according to the UK Audit Commission.[12] Viewed in another way, for the cost of one MRI, it would be possible to buy about five X-ray machines at about $340,000 each or 12 ultrasound machines at about $160,000 each. Of course, making these choices would affect which types of patients would benefit, operating costs, and many other factors. PET scanners are much more expensive: about $2.5 million to $4.6 million depending on whether a cyclotron is present.[13]

Canada's total spending on medical imaging equipment is a fraction of worldwide sales, which are estimated at $14.5 billion in 2002.[14] The majority of the devices used in Canada, as well as the parts to maintain them, come from outside the country. The bulk of our imports come from the United States, Germany, and Japan. The United States alone accounted for 57% of MRI, 50% of radiography and radiotherapy X-ray, 66% of ultrasound, and 53% of CT apparatus imports in 2002.[15]

Domestically, there were about 15 companies in the medical imaging/radio-therapy sector (including expenditures for equipment such as X-ray, ultrasound, MRI, nuclear medicine, etc.) in 2000, according to Statistics Canada's Medical Devices Industry Survey. Together, this sector had just over $115 million in net medical devices sales in 1999. Firms forecast that sales would grow to $194 million by 2002.[16]

Where the Money Comes From

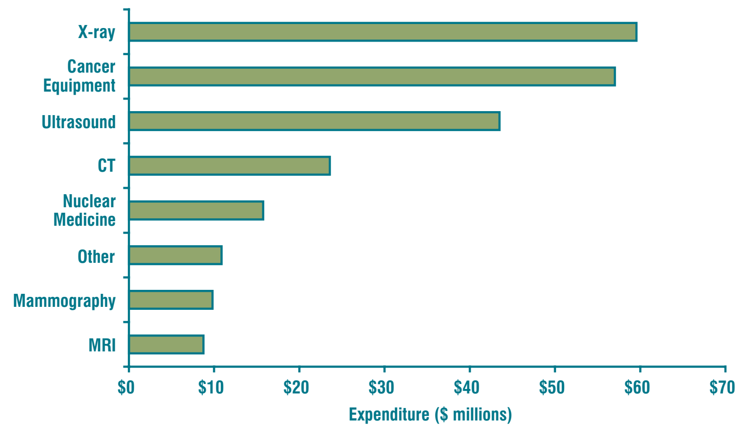
Funding to buy medical imaging equipment comes from many sources. Many provincial/territorial governments fund the purchase and replacement of non-major equipment through regular health region/hospital operating funds.[17] Funds for specific larger projects, on the other hand, may be allocated directly 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 then national inventory of MRI machines was provided by direct government grants.[18] Free-standing imaging facilities may also invest in or lease the equipment that they use. Part of what they charge for their services goes towards recovering capital costs.

In recent years, the federal government has also played a role in funding imaging and other equipment. In September 2000, it created a $1 billion Medical Equipment Fund to assist provinces and territories with purchasing and installing equipment. There has been some controversy regarding how and how quickly these funds were spent,[19] but the Romanow Commission and Kirby Committee both called for expanded investment in this area. Following the 2003 First Ministers Accord, the federal government announced a new $1.5 billion Diagnostic/Medical Equipment Fund. This fund is intended to support specialized staff training and equipment, and to improve access to publicly funded diagnostic services.[20]

31

Medical Equipment Fund Spending in Ontario

Selected diagnostic equipment purchases made by Ontario health care facilities using the funds from the Federal Medical Equipment Trust Fund for 2000/2001 and 2001/2002.



Notes: 1) Expenditure on the above medical equipment also includes dollars spent on accessories and upgrades.
2) The “Other” category includes other diagnostics and therapeutics such as bone densitometry, echocardiography, and ECG systems.

Source: *Federal Medical Trust Fund—Ontario’s Share Report For The 2000–01 and 2001–02 Fiscal Years*, Ontario Ministry of Health and Long-Term Care, March 2003, www.health.gov.on.ca/english/public/pub/ministry_reports/med_equip/med_equip.pdf.

Information Gaps:

What We Know

- How many MRIs, CTs, and other selected imaging technologies are installed in hospitals and free-standing imaging facilities across Canada and where they are located.
- How selected technology-to-population ratios in Canada compare with those in other OECD countries.
- Patterns of diffusion of MRI and CT scanners in Canada and in other OECD countries over time.
- The age range of different technologies in Canada and in some European countries.
- Total capital expenditures by the public and private sector for each province/territory and Canada.
- Total imports and exports of selected medical imaging equipment for Canada over time.

What We Don't Know

- What number and mix of imaging technologies at regional, provincial, and national levels would best meet health care needs?
- What factors should be taken into account in life-cycle planning for equipment? At what point do imaging technologies require upgrading or replacement based on patient safety, quality of care, cost-effectiveness, and other considerations?
- How much in total is spent to purchase various types of medical imaging equipment? How does the public/private funding mix for capital and operating costs differ among imaging technologies and across the country? Are there resulting implications concerning the mix of imaging services that Canadians receive, access to care, overall spending, and the cost effectiveness of imaging services?

What's Happening

- In September 2000, first ministers agreed on a vision, principles, and action plan for health system renewal; the First Ministers' Accord on Health Care Renewal followed in 2003. This accord sets out an action plan for reform, which includes establishing new investments to improve access to publicly funded diagnostic services.
- Commencing in 2004, first ministers agreed to report to their citizens on an annual basis on enhancements to diagnostic and medical equipment and services. This reporting is intended to inform Canadians on progress achieved and key outcomes.
- To track the nature, distribution, and use of medical imaging equipment, CIHI conducted a pan-Canadian survey of selected technologies in hospitals and in free-standing imaging facilities in 2003.
- The Canadian Association of Radiologists is conducting a survey about the distribution and implementation of PACS in Canada. The survey will examine the number of diagnostic imaging departments and clinics that have PACS, the percentage of work that is filmless, the provincial distribution of PACS, the number of diagnostic imaging departments and clinics that have plans to implement PACS within the next 3–5 years, and the level of support for PACS.

For More Information

1 Amendola M, Gafford J. (1988). *The Innovative Choice: An Economic Analysis of the Dynamics of Technology*. Oxford: Basil Blackwell Limited.

2 Dodgson M, Bessant J. (1996). *Effective Innovation Policy: A New Approach*. London: International Thompson Business Press.

3 Battista RN, Jacob R, Hedge MS. (1995). *Health Care Technology in Canada (with special reference to Quebec)*. Washington, DC: U.S. Government Printing Office. www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk1/1995/9562/956205.PDF.

4 Australian Health Technology Advisory Committee. (1997). *Review of Magnetic Resonance Imaging*. www.health.gov.au/haf/mri/mriahtac.pdf.

5 VA Research and Development. (1997). *Picture Archiving and Communication Systems: A Systematic Review of Published Studies of Diagnostic Accuracy, Radiology Work Processes, Outcomes of Care, and Cost*. www.va.gov/resdev/ps/pshsrd/pacs.pdf.

6 Personal communication. (2003). Office of Health and the Information Highway, Health Canada.

7 Hisashige A. (1994). The introduction and evaluation of MRI in Japan. *International Journal of Technology Assessment in Health Care*, 103, 392-405.

8 Canadian Association of Radiologists. (2000). *Special Ministerial Briefing - Outdated Radiology Equipment: A Diagnostic Crisis*. Montreal: Canadian Association of Radiologists.

9 European Coordination Committee of the Radiological and Electromedical Industries. (2003). *Age Profile Medical Devices, Third Edition: The Need for Sustained Investment*. Frankfurt: COCIR.

10 Le Vérificateur Général du Québec. (2001). *Rapport à l'Assemblée nationale pour l'année 2000-2001 (1) - Services d'imagerie médicale*. Québec : Gouvernement du Québec.

11 Canadian Institute for Health Information. (2002). *National Health Expenditures Trends 1975-2002*. Ottawa: CIHI.

12 The Audit Commission. (2002). *Radiology: Acute Hospital Portfolio*. Review of National Findings. London, United Kingdom: The Audit Commission. www.audit-commission.gov.uk/Products/AC-REPORT/AB95E11A-A6C1-4335-9482-618441DB347/Radiology_Full.pdf.

13 Agency for Health Services and Technology Assessment (AETMIS). (2001). *Positron Emission Tomography Fact Sheet*. www.aetmis.gouv.qc.ca/fr/publications/scientifiques/ imagerie_medicale/2001_03_ann_en.pdf.

14 Medtech Insight. (2002). *The World Wide Market for Diagnostic Imaging Equipment*. www.medtechinsight.com/Report1491.html.

15 Industry Canada. (2003). *Trade Data Online*. http://strategis.ic.gc.ca/sc_mrkti/tdst/engdoc/tr_homep.html.

16 Statistics Canada. (2001). *Medical Devices Industry Survey 2000*. Ottawa: Statistics Canada.

17 McKillop I, Pink GH, Johnson LM. (2001). *The Financial Management of Acute Care in Canada: A Review of Funding, Performance Monitoring, and Reporting Practices*. Ottawa: CIHI.

18 Rankin RN. (1999). Magnetic resonance imaging in Canada: Dissemination and funding. *Canadian Association of Radiologists Journal*, 50(2), 89-92.

19 Canadian Medical Association. (2002). *Wither the Medical Equipment Fund? Background Paper and Technical Notes*. www.cma.ca/cma/staticContent/HTML/N0/l2/advocacy/ news/2002/MedicalEquipmentFund.pdf.

20 Federal/Provincial/Territorial First Ministers. (2003). *First Minister's Accord on Health Renewal*. www.scics.gc.ca/pdf/800039004_e.pdf.

4 Medical Imaging Professionals

In the world of science fiction, many machines think for themselves, although like the superhuman android “Data” on Star Trek, they rarely have human feelings. In practice, even today’s most sophisticated imaging technologies are relatively inert machines. They 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 and don’t 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.[▪] 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, in which part of the country the facility is located, and on the procedure being performed. In addition to the patients themselves, 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 tests, read and interpret test 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 optimum performance of equipment; and service engineers who maintain and service equipment. Other professionals—such as dentists, chiropractors, and obstetrician/gynaecologists—may also use medical imaging equipment as part of the services that they offer to patients.

Medical Radiation Technologists (MRTs)

Canada’s 14,700-plus medical radiation technologists (MRTs) make up the bulk of the medical imaging workforce. They include radiological, nuclear medicine, radiation therapy,[❖] and magnetic resonance technologists.

Radiological technologists, **also called radiographers**, comprise about 80% (about 11,650) of all active MRTs. They often work in hospitals, or free-standing imaging facilities to produce diagnostic X-ray images of specified parts of the body, as well as conduct some therapeutic procedures. Radiological technologists may operate X-ray equipment including plain film radiography, mammography, angiography, fluoroscopy, and

[▪] Detailed role descriptions of physician specialists in imaging (www.rcpsc.medical.org), MRTs (www.camrt.ca), sonographers (www.csdms.com/pdf/scope.pdf), and medical physicists (www.medphys.ca) can be found at their respective websites.

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

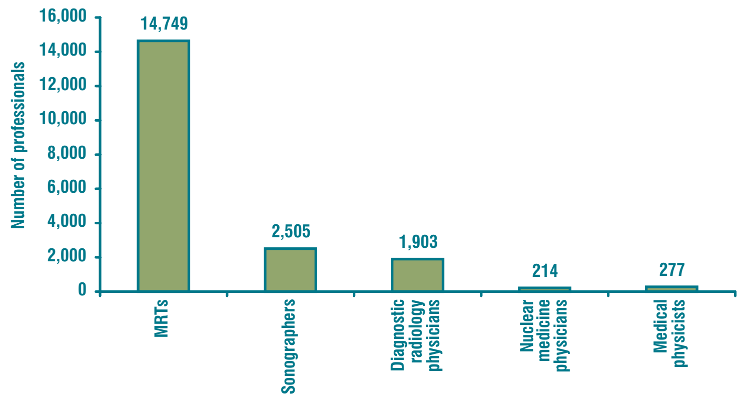
computed tomography (CT). A radiographer can further specialize in the area of magnetic resonance imaging (MRI).[1]

Nuclear medicine technologists (NMTs) comprise about 11% of all MRTs. These professionals also work primarily in hospitals and in free-standing imaging facilities. The approximately 1,600 NMTs across Canada 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 positron emission tomography (PET). Like radiological technicians, NMTs can also further specialize in the field of magnetic resonance.

32

Imaging Professionals

The number of selected medical imaging professionals in Canada, 2001.



Notes: MRT category includes radiological technologists, nuclear medicine technologists, and radiation therapists.
Physician 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 to 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/territorial physician data that categorize physicians on some other basis (e.g. functional specialty, payment specialty, or provisional licenses). Data for medical physicists include only those registered with the Canadian Organization of Medical Physicists.

Sources: 2001 Census of Canada, Statistics Canada (sonographer data). Southam Medical Database, CIHI (physician data). Health Personnel in Canada, CIHI (medical physicists and MRT data).

Sonographers

There were about 2,500 **sonographers** (also known as ultrasonographers) practicing across Canada in 2001. 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 areas or 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 provide imaging services. The Royal College of Physicians and Surgeons of Canada (RCPSC) recognizes 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 practice and/or refer patients for imaging tests.

Who Orders Tests

In Canada, many types of medical imaging require a referral by a physician. Who orders the test may vary depending on the type of test, policies/protocols in specific health regions or facilities, the reason the test is being ordered, the available range of medical specialties, the geographical location of the ordering physician and other factors. For example, a recent report[2] 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 distribution of MRI referrals varied depending on the kind of physician making the referral, the body site for which the MRI test 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 to GPs/FPs (14.8%). Likewise, referrals for scans in northern Ontario were more likely to come from GP/FPs (42% of scans) than those in southern Ontario (17%).

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Who Refers Patients for Tests?

Types of medical professionals who can refer patients for MRI or CT scans in each jurisdiction.

Jurisdiction	MRI	CT
B.C.	Specialist or GP	Specialist or GP
Alta.	Specialist usually, but may vary by regional health authority	Specialist or GP
Sask.	Specialist	Specialist usually, but in some areas GP
Man.	Specialist	Specialist or GP with level of urgency indicated
Ont.	Specialist or GP	Specialist or GP
Que.	Specialist or GP	Specialist or GP
N.B.	Specialist but in some circumstances GP upon radiologist consultation	Specialist usually; GP request with radiologist consultation
N.S.	Specialist	Specialist or, where absent or scarce, GP
P.E.I.	Referred out of province by attending physician*	Specialist or GP
N.L.	Specialist usually	Specialist except in rural board where GPs may refer
N.W.T.	Referred out of territory by specialist or GP	Specialist or GP
Nun.	Specialist or GP	Specialist or GP
Y.T.	GP in consultation with specialist	GP in consultation with specialist

*Newly installed MRI now means not all patients travel out of province.

Source: Information obtained from the Provincial/Territorial Ministries of Health as of 2001; updated 2003.

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 a test, quality control, and a number of clinical procedures. Canada's 1,900 diagnostic radiologists work both independently, as well as 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 (e.g. angioplasty).[4]

The Royal College 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 paediatric radiology. These subspecialties are accredited but not certified. That is, there is no certification examination.

Nuclear medicine physicians[■] (about 200 in Canada in 2001) 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 a university. In general, they are responsible for consulting with referring physicians on diagnoses and treatments, advising them on appropriate imaging procedures, and deciding if 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.

Trends in Supply

Just as there is no agreed national or international standard for how many MRI or CT machines 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 people who live there. Others relate to how health services are organized and delivered; how clinical knowledge, practice patterns, and technology evolve; health professionals' characteristics and how they work, 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, for every one diagnostic radiologist, there are 8 MRTs.

While numbers of professionals fluctuate from year to year, they have been relatively stable for MRTs, diagnostic radiologists, and medical physicists since 1997. As Chapter 3 showed, this period saw growth in some types of imaging equipment (e.g. MRI and CT). However, we do not know whether the use of more common imaging technologies, such as X-ray, rose or fell during this period.

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 United Kingdom's Royal College of Radiologists revealed that over 150 positions had remained unfilled for more than 2 years in 2000.[8] Similar data about vacancy rates are not available across Canada, but pockets of information[e.g. 9] do exist.

[■] Some radiologists also work in nuclear medicine.

The Supply of Imaging Professionals

Trends in the supply of selected medical imaging professionals per 100,000 Canadians.

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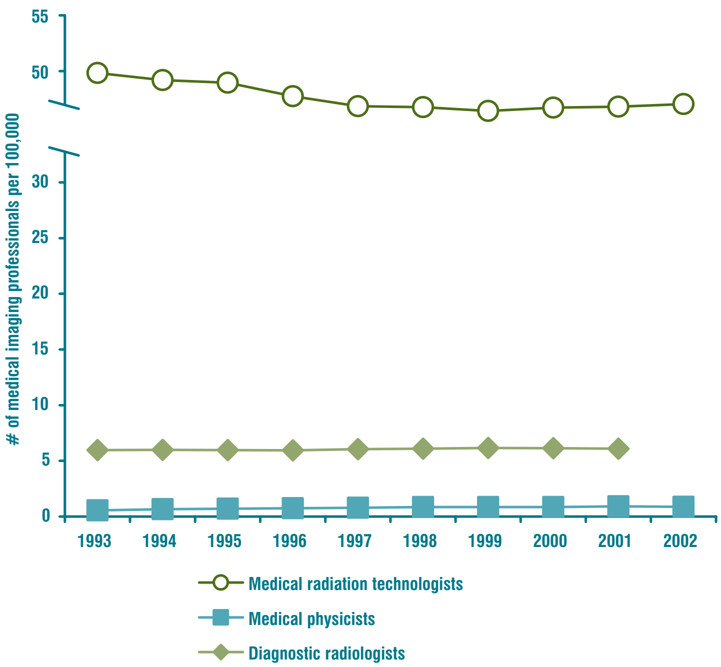


Notes: The data for MRTs only reflect those who are active members of the College of Medical Radiation Technologists of Ontario (Ontario data), l'Ordre des technologues en radiologie du Québec (Québec data), and the Canadian Association of Medical Radiation Technologists (data for other provinces).

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 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 to 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/territorial physician data that categorize physicians on some other basis (e.g. functional specialty, payment specialty, or provisional licenses).

Sources: Health Personnel in Canada, CIHI (medical physicists and MRTs). Southam Medical Database, CIHI (diagnostic radiology physicians).

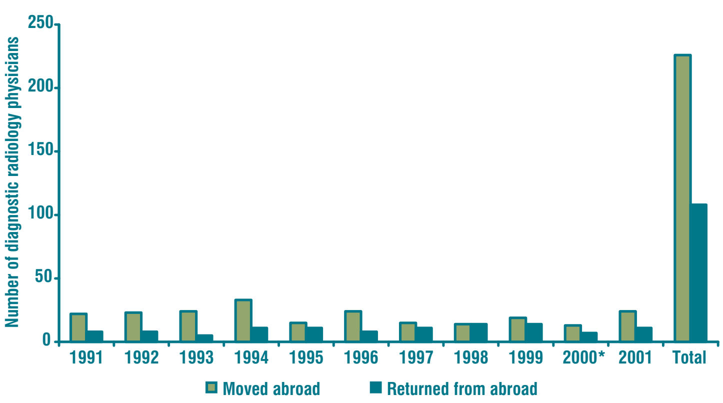
Moving Abroad

Overall, about 1% of active physician specialists in diagnostic radiology left Canada between 1991 and 2001, although about half returned within this period. The resulting total net loss of diagnostic radiology physicians was three-fifths of a percent of the total supply. This loss may have been offset by foreign-trained specialists who migrated to Canada and became licensed to practice for the first time, but the number of physician specialists in imaging who did so is not known.

Physician Migration

The total number of diagnostic radiology physicians who moved abroad between 1991 and 2001 and the number who returned during this time. (Does not include immigration of foreign physicians who have not previously practiced in Canada).

35



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 to 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/territorial physician data that categorize physicians on some other basis (e.g. functional specialty, payment specialty, or provisional license).

*Data from 2000 do not reflect annual updates from the Government of the Yukon and the College of Physicians and Surgeons of Alberta.

Source: Southam Medical Database, CIHI

Age and Aging

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

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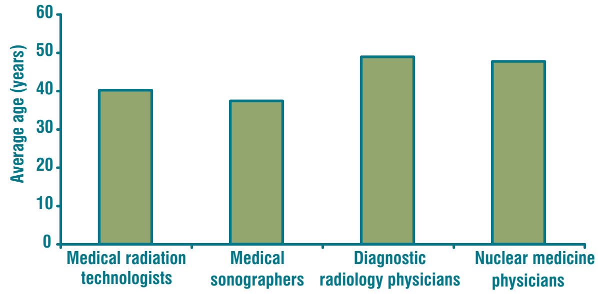
The Age of Imaging Professionals

The average age of selected medical imaging professionals in Canada, 2001.



Notes: Physician 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 to 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/territorial physician data that categorize physicians on some other basis (e.g. functional specialty, payment specialty, or provisional licenses).

Sources: Labour Force Survey, Statistics Canada (MRT and sonography data); Southam Medical Database, CIHI (physician data).

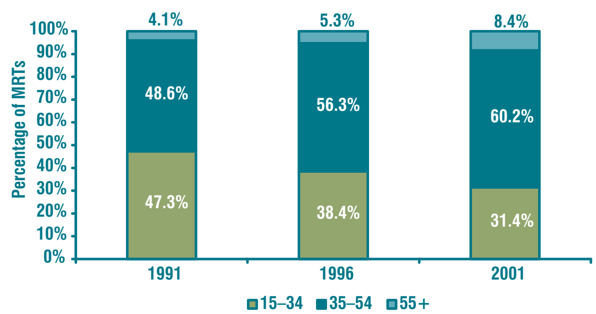
The Male/Female Mix

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 were women, compared to about 2 in 10 physician imaging specialists. 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]

37

Fewer Young MRTs

Percentage of MRTs in Canada by age group in 1991, 1996, and 2001.

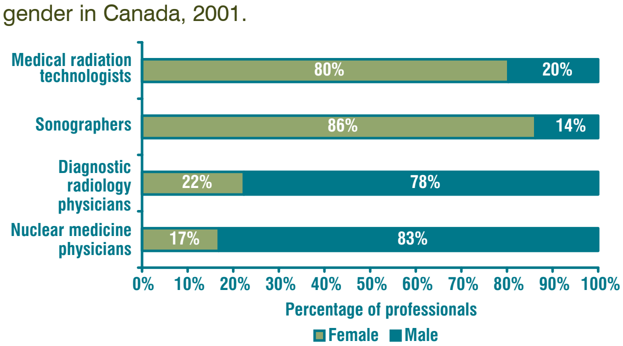


Source: 2001 Census of Canada, Statistics Canada.

38

The Gender Divide

Percentage of selected medical imaging professionals by gender in Canada, 2001.



Notes: Physician 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 to 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/territorial physician data that categorize physicians on some other basis (e.g. functional specialty, payment specialty, or provisional licenses).

Sources: 2001 Census of Canada, Statistics Canada (MRT and sonographer data). Southam Medical Database, CIHI (physician data).

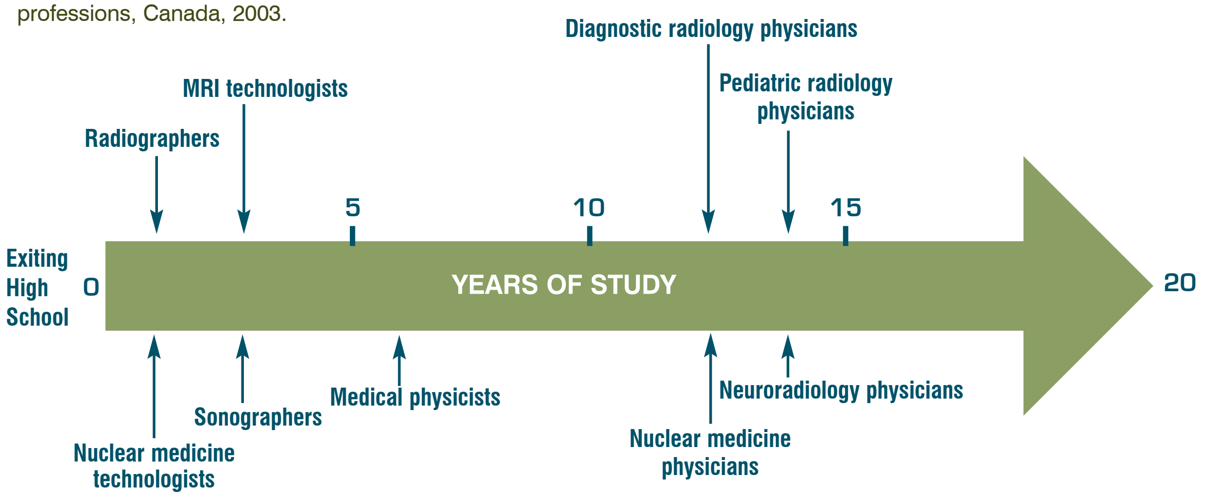
Learning to Image

The level of education required to work in medical imaging varies from profession to profession and has changed over time. For example, while it may take less than five years to become an MRT following high school graduation, physician specialists in nuclear medicine or diagnostic radiology may spend 12 years or more in training.

39

Training The Experts

Minimum typical duration of training after high school graduation for entry into selected medical imaging professions, Canada, 2003.



Sources: Certification Candidates Handbook, Canadian Association of Medical Radiation Technologists, 2002.
Royal College of Physicians and Surgeons, www.rcpsc.com.
Canadian Organization of Medical Physicists and Canadian College of Physicists in Medicine, www.medphys.ca.
Canadian Society of Diagnostic Medical Sonographers.

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 multi-disciplinary 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.

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). Degrees are not yet required for entry-to-practice, but, as of 2005, the Canadian Association of Medical Radiation Technologists has announced that it will no longer permit diploma graduates to write the certification exam or to register as members of the association. (Requirements for a university degree would not apply to those who graduated prior to 2005.) Internationally, it has been reported that some countries—United States, the United Kingdom, and Australia—all who 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:

- 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 sub-discipline. In response, some provinces are developing cross-training programs (e.g. 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 (e.g. 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 established a Maintenance of Certification program that commenced in 2001. Fellows must participate in this program to receive and renew their Fellowship and to use the College's designations.[13]

40

Medical Imaging Training Programs Across The Country

The distribution of training programs across Canada for selected medical imaging professions, 2003.

	Other medical imaging professions					Physician specialties			
	Diagnostic ultrasound (sonography)*	Magnetic resonance imaging technology*	Nuclear medicine technology*	Radiological technology*	Medical physics	Diagnostic radiology	Nuclear medicine	Pediatric radiology	Neuroradiology
B.C.	1	1	1	1	1	1	1		
Alta.	4	1	1	2	2	2	1		1
Sask.				1	1	1			
Man.		1		1	1	1	1		
Ont.	4	1	1	7	6	5	2	1	2
Que.			1	4	3	4	3	2	2
N.B.			1	3					
N.S.	1		1	1	1	1	1		1
P.E.I.				2					
N.L.	1			1		1			
Total	11	4	6	23	15	16	9	3	6

Notes: 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.

* Programs registered/accredited through the conjoint accreditation process managed by the Canadian Medical Association as of June 26, 2003.

Sources: Canadian Medical Association (list of medical imaging technology programs), www.cma.ca/accredit.
Royal College of Physicians and Surgeons of Canada, www.rcpsc.medical.org.
Canadian Organization of Medical Physicists, www.medphys.ca.

Training Physicians

Each year, dozens of new residents begin their specialist training. According to the Canadian Resident Matching Service, the number of training spaces for physician specialists in imaging fluctuates slightly from year to year. Between 1997 and 2001, there were 39–44 diagnostic radiology spaces and 2–5 nuclear medicine spaces annually. The former have been increasingly sought after. Sixty-one Canadian residency applicants listed diagnostic radiology as their first choice for specialty training in 2002, up from 44 in 1997. In contrast, not all nuclear medicine training spaces have been filled in recent years.

Each year, some international medical graduates (IMGs) also undertake residency training in Canada. Some are permanent residents or Canadian citizens. They accounted for 1–8% of total students exiting from diagnostic radiology programs each year between 1993 and 2002, according to the Canadian Post-MD Education Registry. In 2002, there were more (37%) IMGs with visas that exited diagnostic radiology programs in Canada, up from 17% in 1993.

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. For example:

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Who is Regulated Where?

Regulatory status for selected medical imaging professions by province, Canada, 2003.

	Medical radiation technologists*	Sonographers	Medical physicists	Diagnostic radiology physicians	Nuclear medicine physicians
B.C.	◆	⊗	⊗◗	✓	✓
Alta.	✓	◆◗	⊗◗	✓	✓
Sask.	✓	⊗	⊗	✓	✓
Man.	◆	⊗	⊗	✓	✓
Ont.	✓	◆◗	⊗	✓	✓
Que.	✓	✓	⊗◗	✓	✓
N.B.	✓	◆◗	⊗	✓	✓
N.S.	✓	⊗	⊗	✓	✓
P.E.I.	◆	⊗	⊗	✓	✓
N.L.	◆	⊗	⊗	✓	✓
Y.T.	⊗	⊗	⊗	✓	✓
N.W.T.	⊗	⊗	⊗	✓	✓
Nun.	⊗	⊗	⊗	✓	✓

* includes radiographers and nuclear medicine technologists

✓ Regulated

⊗ not regulated

◆ voluntary professional provincial associations

◗ profession 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/Territorial medical registration organizations.

- The Royal College of Physicians and Surgeons is the national certifying body for specialty and subspecialty physicians. They are also responsible for setting and maintaining standards for post-graduate medical education, as well as for promoting continuing education.
- In order to practice in Canada, MRTs must pass an examination set by the Canadian Association of Medical Radiation Technologists or its Quebec counterpart.
- Sonographers are only currently 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.[14]
- 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.

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 which describe various professional tasks and what it means to perform them at an acceptable level; establishing entry-level qualifications to practice; establishing a formal complaints and discipline procedure; assuming accountability for defining standards; ensuring appropriate qualifications to practice and qualifications for continuing competence in the profession; and setting policy related to disciplinary action for professional misconduct.[15]

Life at Work

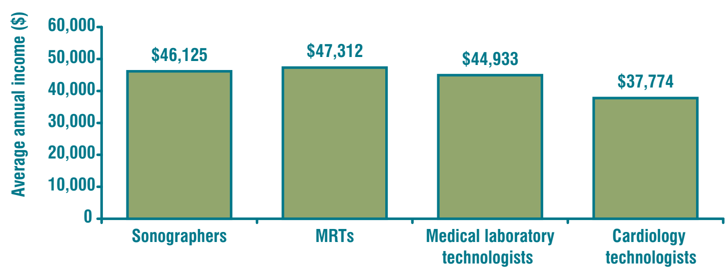
New research is beginning to explore the relationship between the worklife of health professionals and their recruitment and retention, job satisfaction, and health, as well as patient satisfaction, outcomes of care, and health care costs. Relatively little is known, however, about the working conditions,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

- 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. However, average incomes vary across the country. A 2001 environmental scan report commissioned by Health Canada[11] looking at human resources issues facing medical technologists suggested that wage disparities may cause unbalanced distribution of medical imaging professionals across the country, with higher income potential attracting more medical imaging professionals to provinces able to afford them. Recent news stories about MRT recruitment in some parts of the country have also led to questions about differences in compensation and working conditions between some hospitals and free-standing imaging facilities.
- In 2002, about 8 in 10 MRTs and sonographers worked full-time, about the same as in recent years. The Health Canada report[11] noted that some employers may find it more attractive to hire casual and part-time technologists because they do not have to pay for benefits for these workers. The authors also suggested that evening and weekend demands for diagnostic imaging services might be more easily alleviated with part-time/casual positions.

42

Income Comparisons

Average annual incomes of selected technical health professionals who worked full year, full-time, in 2000.



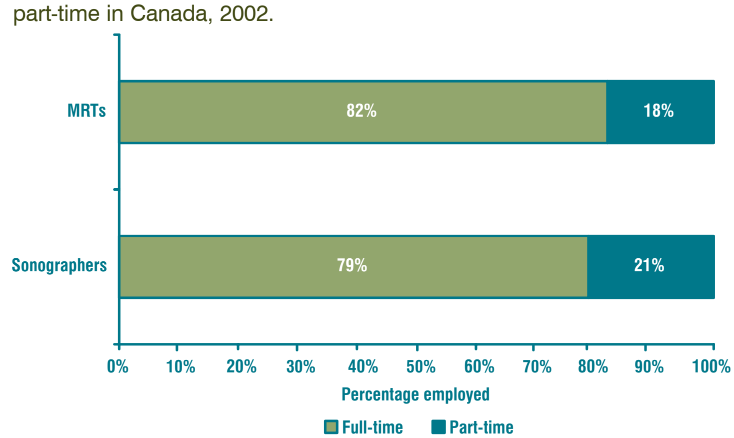
Note: Medical laboratory technologist category includes pathologists' assistants

Source: 2001 Census of Canada, Statistics Canada.

43

Type of Work

The percentage of MRTs and sonographers working full-time/part-time in Canada, 2002.



Source: Labour Force Survey, Statistics Canada.

- Information on job satisfaction, absenteeism, and other similar indicators is scarce for imaging professionals. Nevertheless, based on input received, the authors of the Health Canada report[11] concluded that low morale in the workplace was common among medical imaging technologists, possibly because of budget pressures and cutbacks, increased client flow, limited career opportunities, and greater volume of work leading to increased work-related stress and injury on the job. It was reported that these and other related issues may contribute to absenteeism and burnout.

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.[16] 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 on 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.[17]

In the early 1950s, increasing leukemia mortality rates among radiologists began to receive attention.[16] It was at this time that regular monitoring of radiation became routine.[18] 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.[19]

In Canada, a 2002 report[20] on occupational radiation exposure showed that imaging professionals tend to be well below the allowable annual dosage of occupational radiation (50 mSv).◈ Average annual doses were 0.07mSv for radiological technologists, 1.47 mSv for nuclear medicine technologists, 0.13 mSv for diagnostic radiologists, and 0.20 mSv for medical physicists.

◈ Radiation dose equivalent is expressed in Sievert (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.

Information Gaps:

What We Know

- Which imaging professions are regulated in different jurisdictions.
- Typical minimum length of training and the distribution of educational programs across Canada for physician specialists, MRTs, sonographers, and medical physicists.
- Changes in training requirements for MRTs, sonographers, and physician specialists.
- Number of post-MD training spaces offered in nuclear medicine and diagnostic radiology.
- How many active physician specialists in imaging, medical radiation technologists (MRTs), sonographers, and medical physicists there are in Canada and in each province and territory.
- Selected demographic characteristics for medical imaging professionals.
- Average earnings for MRTs and sonographers and how many work full-time versus part-time.
- Migration patterns of Canadian physician imaging specialists.
- Pockets of information on the worklife of MRTs, sonographers, and physician specialists.

What We Don't Know

- How many and what mix of health professionals will be required to meet the imaging needs of Canadians nationally, provincially, and regionally? How will changes to training requirements, scope of practice, and regulatory status for imaging professionals affect their supply, access to care, and patient and provider satisfaction?
- What impact will recently announced plans for spending on medical equipment have on the training opportunities for imaging professionals and on the demand for their services?
- How many MRTs, sonographers, and medical physicists are leaving Canada to practice abroad and/or returning to Canada? What impact does international and inter-provincial migration of imaging professionals have on their supply, training programs, and on Canadian's access to care?
- How will teleradiology and other digital imaging technologies affect the traditional dynamics of the medical imaging team, productivity, access to care, and patient satisfaction and outcomes?

What's Happening

- On March 31, 2003, the federal minister of health announced the scope and parameters of the new $1.5 billion Diagnostic and Medical Equipment Fund. The Fund is intended to support new investments in training staff as well as in purchasing and installing new medical and diagnostic equipment and upgrading older equipment. Also, commencing in 2004, first ministers have agreed to report on enhancements to diagnostic and medical equipment and services.
- The Canadian Institute for Health Information will soon be releasing updated health personnel data for years 1993 to 2002.

For More Information

[1] Health Human Resources Advisory Committee. (2001). *Profile of Select Allied Health Professions: Medical Imaging Workshop*. www.healthplanning.gov.bc.ca/strategic/pdf/pharmprofile.pdf.

[2] Iron K, Przybysz R, Laupacis A. (2003). *Access to MRI in Ontario: Addressing the Information Gap*. Toronto: Institute for Clinical Evaluative Sciences.

[3] Royal College of Physicians and Surgeons of Canada. (2003). *Objectives of Training and Special Training Requirements in Diagnostic Radiology*. http://www.rcpsc.medical.org/english/residency/certification/training/diarad_e.html.

[4] Millward SF, Holley ML. (2001). The current status of interventional radiology in Canada: Results of a survey by the Canadian Interventional Radiology Association. *Canadian Association of Radiologists Journal*, 52(2), 87-91.

[5] Royal College of Physicians and Surgeons of Canada. (2003). *Objectives of Training and Training Requirements in Nuclear Medicine*. www.rcpsc.medical.org/english/residency/certification/training/nucmed_e.html.

[6] Canadian Organization of Medical Physicists and the Canadian College of Physicists in Medicine. (2003). *What is Medical Physics?* www.medphys.ca/index.cfm.

[7] Jones DN. (2002). 2002 Australian Radiology Workforce Report. *Australasian Radiology*, 46, 231–248

[8] Royal College of Radiologists. (2002). *Clinical Radiology: A Workforce in Crisis*. http://www.rcr.ac.uk/upload/workforce1.pdf.

[9] Ontario Ministry of Health and Long-Term Care. (2003). *List of Areas Designated as Underserviced for Specialists July/August/September 2003*. http://www.health.gov.on.ca/english/providers/program/uap/listof_areas/specialist_ladau_7-9_03.pdf.

[10] Noseworthy T. (2001). *Diagnostic Supply Report: Newfoundland and Labrador 2000/2001*. www.nlhba.nf.ca/hr/documents/Diagnostic.pdf.

[11] Assessment Strategies. (2002). *An Environmental Scan of the Human Resource Issues Affecting Medical Laboratory Technologists and Medical Radiation Technologists 2001*. Ottawa: Health Canada. http://www.hcsc.gc.ca/hppb/healthcare/pdf/environment_scan.pdf.

[12] Personal communication. (2003). Office of the Executive Director, Canadian Society of Diagnostic Medical Sonographers.

[13] Royal College of Physicians and Surgeons of Canada. (2003). *Maintenance of Certification*. www.rcpsc.medical.org/english/maintenance/.

[14] Canadian Society of Diagnostic Medical Sonographers (CSDMS). (2003). *Provincial Regulation*. www.csdms.com/regulation.html.

[15] Casey JT. (1999). *Status Report and Analysis of Health Professional Regulations in Canada*. Prepared for the Federal/Provincial/Territorial Advisory Committee on Health Human Resources. Edmonton: Field Atkinson Perraton.

[16] Mabuchi K, and Yoshinaga S. (2002). Medical radiation exposure in occupational studies: Overview of occupational medical exposure. *Radiation Research*, 158, 803-4.

[17] Taylor LS. (1996) *What you need to know about radiation*. http://www.physics.isu.edu/radinf/lstintro.htm.

[18] National Radiological Protection Board. (2002). *eBulletin No.2: Current Issues in Radiation and Health*. www.nrpb.org/publication/bulletin/no2/report1_print.htm.

[19] Croft J, LeFaure C. (2003). *Overview of Medical Occupational Exposure Issues in the European Countries.* http://ean.cepn.asso.fr/pdf/program6/Session%20A/J_Croft.pdf.

[20] Health Canada. (2002). *2002 Report on Occupational Radiation Exposures in Canada*. Ottawa: Health Canada.

5 Current Issues in Medical Imaging

So far, we've focused on the history, utilization, and supply of medical imaging technologies, as well as the professionals involved in providing imaging services. We've touched on a few of the major issues in the field, including the rapid evolution of imaging technologies, but have not addressed many others. In an attempt to start to fill this gap, this chapter focuses on additional issues related to the dynamic development and application of the MITs and services, including:

- the appropriate use of imaging technologies;
- their impact on patient care, outcomes, and costs, as well as how they fit with other types of technologies;
- the changing roles of medical imaging professionals;
- the settings in which imaging services are provided; and
- wait times for different kinds of imaging.

The Right Tool for the Right Job

To scan or not to scan (and what and how to scan)–these decisions can have far-reaching consequences, both for patients and for the health care system. Medical imaging may be done for many reasons: screening patients at risk for a disease; reducing uncertainty about a diagnosis to reassure practitioners, patients, and caregivers; assisting with decisions about care choices; monitoring the effect of treatments and understanding prognoses; and/or guiding surgery or other interventions.[1,2]

Deciding 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. Examples of factors that may influence decisions include:

- **Technical efficacy**: how well an imaging technique represents the physical structure of the body site in question;
- **Diagnostic accuracy**: to what degree is test information likely to contribute to the determination of a correct diagnosis;
- **Comparative efficiency**: how much better (or worse) is the diagnostic information produced than that generated by other approaches;
- **Therapeutic impact**: to what extent is diagnostic information likely to affect care decisions; and
- **Health outcomes**: what are the expected effects—positive, neutral, or negative—of both diagnosis and treatment on morbidity and mortality outcomes.[3]

In addition, non-clinical and other factors may be considered.

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.[4]

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Typical Radiation Dose

Effective radiation doses that patients in the United Kingdom typically received from various medical imaging procedures during the 1990s, the number of chest X-rays required to generate a similar dose, and the length of time required to receive a similar dose from background radiation in the United Kingdom.

Diagnostic procedure	Typical effective dose (mSv)	Equivalent # of chest X-rays	Approx. equivalent period of natural background radiation in the UK
Limb & joint X-ray (except hip)	<0.01	<0.5	<1.5 days
Chest X-ray	0.02	1	3 days
Hip X-ray	0.3	15	7 weeks
Abdomen X-ray	1.0	50	6 months
Barium swallow	1.5	75	8 months
CT of the head	2.3	115	1 year
PET of the head (F-18 FDG)	5	250	2.3 years
Barium enema	7	350	3.2 years
CT of the chest	8	400	3.6 years
CT of the abdomen or pelvis	10	500	4.5 years

Source: European Commission Directorate-General for the Environment (Adapted by experts representing European radiology and nuclear medicine in conjunction with the UK Royal College of Radiologists). (2001). *Radiation Protection 118: Referral Guidelines for Imaging*. Luxembourg: Office for Official Publications of the European Communities.

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.[5] For others, careful consideration of potential benefits, costs, and risks is required. In some cases, the best option may be 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.[6]

Many have called for technology assessments, clinical practice guidelines, and other tools to summarize the latest evidence and assist clinicians, policy makers, and patients in making decisions about medical imaging technologies.[7,8] At the same time, some point out that this process can be challenging given the rapid evolution of technology and practice in the field.[9]

Nevertheless, groups have begun to develop and apply tools to assist with decisions. For example, Ottawa-based researchers have created a series of decision-rules for use in the emergency department. They cover X-rays for ankle[6] or knee[10] injuries; cervical spine radiography for alert and stable trauma patients;[11] and CT scans in patients with minor head injuries.[2] The rules suggest imaging in some cases, observation or other clinical processes in others. The researchers suggest that if Canadian hospitals were to apply these rules, they would substantially reduce the number of tests ordered, while still accurately identifying patients at higher risk who should be tested.[2,10,12]

The earliest decision-rules (the Ottawa Ankle Rules) are the best known. More than 69% of emergency physicians in the US, Canada, the UK, and France (but not Spain) were aware of them and more than 70% in Canada and the UK reported using the rules frequently. Awareness and use of the later decision rules for the knee was lower in all countries.[13]

"Recreational" Scanning?

Marketing imaging services to healthy people is controversial. Enchanted as some are with the fetal photo album or keepsake videos, for example, many oppose the use of ultrasound for non-medical purposes. The Canadian Association of Radiologists (CAR),[14] Health Canada[4], the US Food and Drug Administration (FDA),[15] the American Institute of Ultrasound in Medicine (AIUM),[16] and others have all expressed concerns about the relative risks and benefits of this practice. At the same time, these groups do support appropriate use of ultrasound as a clinical tool in the care of expectant mothers and their babies. Obstetricians often use ultrasounds to check the size, location, and number of fetuses in the womb, as well as other health-related factors such as birth defects, fetal movement, breathing, and heartbeat; a number of clinical practice guidelines have been developed in this area.[(e.g. 17)]

Similarly, "full-body" or "head-to-toe" CT scans for healthy individuals are being advertised in some parts of Canada. While proponents argue that these types of scans can detect markers for diseases such as lung cancer and certain types of heart disease in asymptomatic individuals, many experts dispute their merits.[18-23] They point to the lack of scientific evidence about the efficacy and risks of screening and the difficulties in providing full information to support informed consumer choices. Risks may include radiation exposure and false positive screening results, which could trigger significant follow-up care and its associated costs and risks.[24-26]

In March 2002, the Canadian Association of Radiologists concluded, "there is no conclusive evidence that CT scan screening of asymptomatic healthy individuals is of benefit to their health."[27] Internationally, organizations such as the U.S. Food and Drug Administration,[28] the United Kingdom's Department of Health[29] and the American College of Radiology[30] share their view that currently there is insufficient evidence that the benefit of whole-body screening outweighs its potential harm.

Effects on Care, Outcomes, and Costs

'First do no harm' is an enduring principle of medical care, but both ancient and modern texts also focus on how patients' lives can benefit from appropriate care. An understanding of the probability that a test result will affect patients' diagnoses, their care plans, and their outcomes can aid in deciding whether or not to test (and in evaluating the cost-effectiveness of a test). Yet establishing direct causal links between imaging results, care decisions, and outcomes may not be easy as many other factors may be involved. In addition, in certain cases our ability to diagnose health problems exceeds our ability to treat them.

Nevertheless, studies have begun to look at the effects of medical imaging. An early Manitoba study (November 1991 to October 1992) explored the impact of MRI scans on patient management and outcomes.[31] Researchers found that test results changed the referring physicians' provisional diagnosis in 42% of cases. Two-thirds of the time, the provisional diagnosis was ruled out by normal scan results; in the other cases, the consulting radiologist offered an alternative diagnosis. Overall, physicians reported altering patient management plans in just over half (54%) of all cases; in about a quarter (24%), they switched from lower to higher levels of intervention. Whether these results would still hold today is not clear, given the changes that have occurred in the number and use of MRIs over the last decade.

A number of other researchers have also studied what imaging technologies allow clinicians and patients to know and do. Sometimes results are clear, but often results are mixed. For example, while some studies have reported that CT scanning reduces unnecessary appendectomy rates,[32-35] others show no such effects.[36-39]

How and how often test results influence care plans and patient outcomes also affects the cost-effectiveness of medical imaging. So do the costs of tests and associated follow-up care for patients with positive and negative test results. As technology and operating costs, care patterns, and patient outcomes change over time, the balance of costs and benefits also shifts.

Many cost-effectiveness studies in medical imaging have focused on specific applications in particular care environments. Research results have been mixed, perhaps partly because the data required for a full assessment of costs and benefits have often not been available. Some studies suggest that new technologies save money overall, but many show that they increase costs.[40-42]

Complementary or Competing Technologies?

New breakthrough products get a lot of attention, but there are also ongoing changes in how both new and older technologies are used.[43] For example, X-rays are now used very differently than when introduced. Sometimes new applications or adaptations, such as mammography screening, are developed.[44] In other cases, emerging evidence suggests alternatives to imaging tests.

In some cases (or at least for some specific applications), new technologies replace old ones, but uses may also overlap. For example, imaging technologies, such as CTs and MRIs, have specific applications but can also sometimes be substituted one for another.[45] Imaging modalities may also be complementary. For instance, patients being evaluated for possible disease often first receive non-invasive tests (those that do not involve inserting objects or fluids into the body). If further information is required, they may then undergo more complex or invasive tests.

New or expanded applications for existing imaging equipment, as well as changes in field strength, speed and clarity of imaging, patient comfort and convenience, and evidence about the effectiveness of imaging modalities are examples of the technological factors that may play a role in changing the demand for–and consequently the use of–imaging technologies.[46,47] Non-technical factors such as clinician and patient knowledge about the capabilities and risks of different medical imaging technologies, patients' preferences regarding their health care, costs, and the availability of different technologies may also influence use.[3,48,49]

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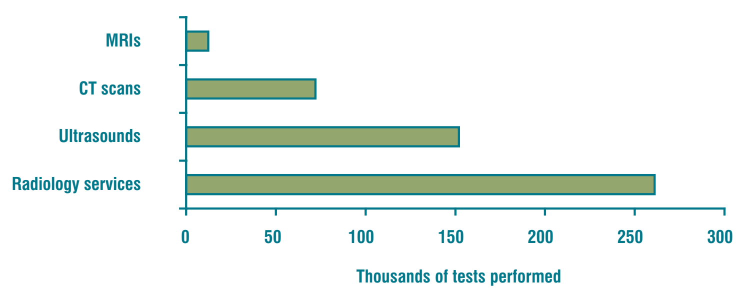
Common and Not-So-Common Tests

Number of imaging tests paid for by Saskatchewan Health in 2002–2003, according to the department's annual report (selected modalities).



Source: Saskatchewan Health. (2003). Annual Report 2002-2003. Regina: Saskatchewan Health. www.health.gov.sk.ca/mc_dp_skhlth_2002-03_ar.pdf

Changing Roles and Evolving Scopes of Practice

Over the last century, several different types of health professionals have become involved in medical imaging services. Some roles are distinct. Others are shared. “Scopes of practice” define the services that members of an occupation may provide and the methods that they use.[50] Each profession tends to specialize in certain areas, although skills and roles are evolving over time and sometimes overlap. For instance, as imaging technologies progress and new applications are developed, radiologists are taking on a wider range of services, such as the subspecialty of interventional radiology which is still relatively new.

At the same time, other physicians sometimes deliver services also provided by radiologists. For example, a survey in 2001 found that some interventional radiology functions (e.g. biopsies) were performed by other specialties.[51] Likewise, in a separate national survey, emergency physicians reported that they were usually the first to read radiographs during and after normal business hours, although most hospitals said that a majority of their emergency physicians did not have formal training in reading radiographs.[52] (Emergency physicians were also less likely than their radiologist colleagues to report that current emergency radiology services were excellent–29% versus 46%).

The roles of radiology technicians and technologists are also evolving. In Canada, basic education programs for medical radiation technologists (MRTs) are lengthening, as described in Chapter 4. The merits of increasing entry-to-practice requirements continue to be debated. Proponents point to new and more complex imaging technologies and techniques, changes in roles of the imaging team, and other factors. Others note the cost of extended training and are concerned about the ability to attract and retain personnel whose training is well matched with the work that they will be doing.[53]

Changes in roles are also happening in other countries. For example, the UK has developed a “red dot” system. Under this system, the radiological technologist studies each X-ray film or image and indicates the potential presence of an abnormality with a red dot. This assists radiologists by enabling them to focus on patients with abnormal findings, thus speeding the throughput of patients. Also, some radiological technologists perform intravenous injections and administer barium enemas.[54]

In the US, the American College of Radiologists (ACR) has defined the roles and responsibilities of a new advanced-level ‘radiology assistant’ position.[55] These professionals will interpret radiological examinations and transmit observations to the supervising radiologist. As well, radiology assistants will be responsible for obtaining consent for and injecting agents for diagnostic imaging purposes; obtaining clinical history from patients or medical records; assisting radiologists with invasive procedures; communicating reports of radiologists’ findings to referring physicians; and other tasks.

The Many Ways of Delivering Imaging Services

The words "private health care" evoke strong feelings for many Canadians–both for and against.[56] But they also mean different things to different people. In the context of medical imaging, the phrase may refer to:

- **Who paid to purchase the equipment?** Governments may pay for equipment publicly through direct grants, hospital/health region global budgets, and/or public research grants. Alternatively, its purchase may be funded privately through foundations, gifts, private capital, and private research grants.[57] For information on the purchase of capital equipment, see Chapter 3.
- **Who owns and operates it?** Many imaging facilities are located in not-for-profit hospitals, but there is also a well-established tradition in Canada of free-standing imaging facilities which may be for- or not-for-profit. In some cases, they are led by entrepreneurs (often the health professionals delivering the services) who need not answer to shareholders; in others, they are owned by corporate organizations that aim to provide returns on investment to their shareholders.[56,58]
- **Who pays for the delivery of imaging services?** Whether the facility is for-profit or not-for-profit, provincial/territorial health insurance programs, other public payers (e.g. workers' compensation boards or the federal government), and/or private individuals or their insurance plans may pay for imaging services. Who pays may depend on why the scan is required, what type of scan is needed, where the facility is located, and many other factors.

Free-standing imaging facilities range from specialized services such as dentistry, chiropractic, or mammography to broad-based imaging centres offering a wide range of tests. The mix of hospital-based and free-standing imaging facilities where patients receive services differs among imaging modalities. For example, 98% of Canadians who reported having had a non-emergency angiography in 2001 said that they received their test in a hospital or public clinic. The proportion was slightly lower for CT scans (96%) and for MRIs (92%).

The first MRI in a free-standing imaging facility opened in Calgary in 1993. Within a decade (by January 2003), there were 16 such facilities with MRIs across Canada and another nine with both MRI and CT services. Overall, about 18% of the country's MRI machines and about 3% of CTs were installed in free-standing imaging facilities at the beginning of 2003. That's up from about 15% and 2% respectively in mid-2001. However, as of January 2003, fewer than 5% of angiography, catheterization labs, and nuclear medicine cameras were located outside of hospitals.

According to the 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. In the vast majority of cases, the primary source of operating funding for hospital-based equipment was the provincial/territorial government. Additional secondary funding sources also existed. For example, some hospitals provide CT and MRI services funded by other payers in off-hours. In contrast, provincial/territorial governments were the primary source of operating funding for about a third (32%) of imaging equipment located in free-standing imaging facilities.

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Who Pays?

Percentage of selected types of medical imaging equipment installed in public hospitals and free-standing imaging facilities across Canada by primary source of operating funds and the total number of machines installed in each setting as of January 2003.

	Hospital-Based Equipment			Free-Standing Facilities		
Primary source of operating funds	**CT**	**MRI**	**Nuclear Medicine**	**CT**	**MRI**	**Nuclear Medicine**
Provincial Government	98%	98%	99%	-	15%	64%
Workers' Compensation Board	<1%	-	-	-	-	-
Private Health Insurance, Other Private Insurance, Out-Of-Pocket Payments	-	-	-	22%	19%	28%
Other Types of Funding	2%	2%	1%	78%	63%	8%
Total # Machines	**317**	**120**	**569**	**9**	**27**	**25**

Note: Figures may not add to 100% due to rounding error.

Source: National Survey of Selected Medical Imaging Equipment, CIHI

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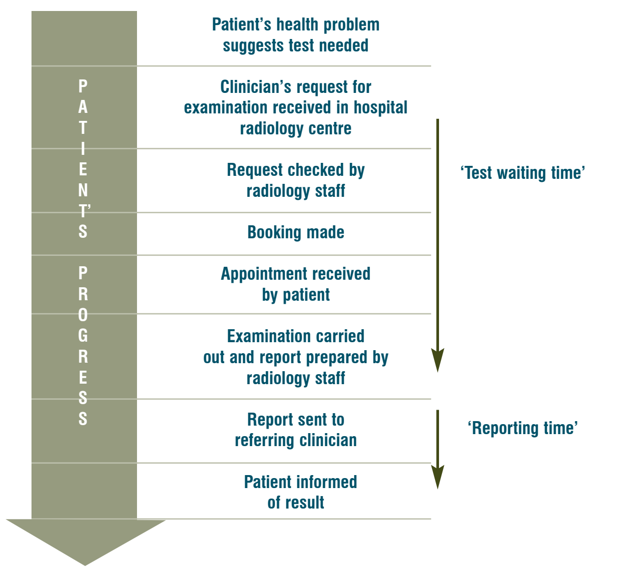
Waiting for Diagnostic Services

An example of the care path for patients waiting for diagnostic radiology services.



Adapted from: The Audit Commission. (2002). *Radiology: Acute Hospital Portfolio. Review of National Findings.* www.audit-commission.gov.uk/Products/AC-Report/AB95E11A-A6C1-4335-9482-9618441DB347/Radiology_Full.pdf

Waiting for Care

Waiting for care remains a key issue for Canadians, both for diagnostic tests and for other services.[59] Respondents to a November 2002 Ipsos-Reid poll said that reducing wait times for diagnostic services, such as MRI and CT scans, should be the number one priority for new health care spending.[60]

Comparable data about who is waiting for what, and for how long, are scarce but growing. One of the challenges is deciding how to define wait times, specifically, when waiting actually begins and ends.[61]

A recent Statistics Canada survey[62] describes the experiences of Canadians aged 15 and over who accessed non-emergency MRIs, CTs, or angiographies in 2001. About 1.7 million people (7% of those aged 15 and over) reported getting at least one of these services in the previous 12 months. Over half (55%) reported waiting less than a month for their test, but the 5%* with the longest waits waited 26 weeks or more for their test. Half waited longer than 3 weeks and half waited 3 weeks or less.

* Interpret with caution due to high sampling variability.

A quarter of those who had any of the three diagnostic tests felt that their wait time was unacceptable. These individuals were more likely to have had longer waits (median wait of 8.6* weeks instead of 2.0 weeks) and 10 times more likely to have reported that waiting had affected their lives (51% vs. 5%*), than those who said their wait time was acceptable. The most common consequences reported by the 16% of patients who said that waiting affected their lives were worry, anxiety, or stress (68% of those who said they were affected by waits).

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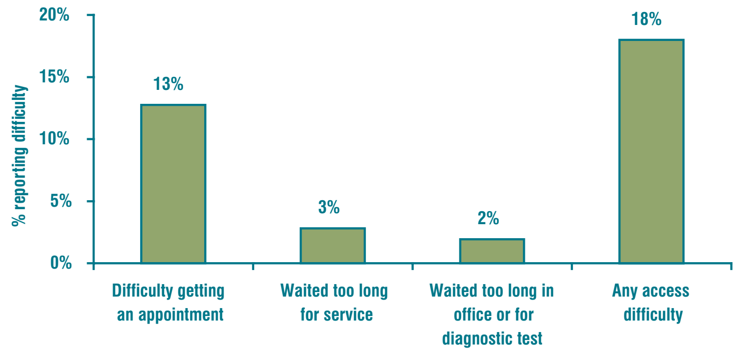
What Are the Difficulties?

Percent of Canadians aged 15 and over who had selected diagnostic services (non-emergency MRI, CT, or angiography) in the last year in 2001 who reported difficulties in accessing the test.



Source: Health Services Access Survey, Statistics Canada

Additional information from Canada and elsewhere are beginning to give us further insight into factors that affect wait times. Examples include:

- **What type of care you need:** For example, data from Alberta suggest that wait times for MRIs and CTs differ substantially.[63,64] Likewise, waits at the University Health Network in Toronto between January and March 2003 were shorter for elective angioplasty (median wait of 15 days) than for outpatient cardiac catheterization (22 days).[65]
- **Whose list you are on and where you are waiting:** There is no single nation-wide or often even province-wide wait list for medical imaging. Wait lists are typically managed at the regional, hospital, or clinic level. Where comparable data are collected, they often show wait time variations. For example, Alberta wait time data suggest that variations exist between the various MRI and CT facilities in the province.[63,64] Similarly, data from Quebec showed differences in wait times for ultrasound and CT across health regions and sometimes even within the same region.[66]
- **How urgently you need care:** The Western Canada Waiting List (WCWL) project[67] was launched to develop practical tools for prioritizing patients on scheduled waiting lists, including those waiting for MRIs. The project developed scoring tools based on literature reviews and input from clinical panels. Evaluations found that reliability was strongest for the general surgery and hip and knee criteria and weakest for the diagnostic MRI criteria. In spite of the challenges, some health regions are introducing prioritization tools. For example, Calgary has established priority guidelines for MRI and CT in an effort to optimize utilization of equipment and patient management. The guidelines suggest recommended maximum wait times based on whether a patient's condition is emergent, urgent, semi-urgent, or routine.[68,69]

* Interpret with caution due to high sampling variability.

- **How many hours imaging facilities operate:** Operating hours vary by type of imaging, by location and/or facility, by time of year, and other factors, such as the availability of trained professionals to operate the equipment and interpret results and maintenance/upgrading schedules.[70] A recent report by the Institute for Clinical Evaluative Sciences[1] showed that two of Ontario's 25 MRI centres in 2002 operated 24/7, two were open less than 12 hours a day and seven were not open on weekends (the hours of operation for the remaining centres were not reported). Likewise, reports from Quebec in 2001 and Nova Scotia more recently show variations in hours of operation between MRI centres.[66,71]

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Keeping Track of Waiting

There are many ongoing and new initiatives aimed at collecting data about wait times. The results of these studies are not always comparable partly because of variations in the methods and data sources used. The table below outlines some of the key differences between selected recent Canadian wait list studies.

	Jurisdiction/Study	Data Source	What is Measured	Time Period
Health Regions/Facilities	Publicly funded scans in Alberta published in Alberta Health and Wellness reports	Actual patient experience reported by Regional Health Authorities & Alberta Cancer Board	Volume and average wait times for publicly funded MRIs, CTs	Ongoing quarterly reporting
	Winnipeg Regional Health Authority's regular report for region and government	Actual patient experience reported by hospitals	Wait times (in weeks) for publicly funded scans; number of patients waiting; number of exams for CT, MRI, ultrasound, and bone densitometry	Ongoing monthly reporting
	Quebec Auditor General Report 2000–2001	Health regions and hospitals	Minimum and maximum days waiting for abdominal ultrasound and head CT (with infusion) among health regions in Quebec	20–24 November 2000
	Nova Scotia Capital Health Annual Report for 2001–2002	Free-standing imaging facilities and hospitals	Average wait times (in days) for mammography screening for women with no symptoms in a free-standing imaging facility; average wait times (in days) for MRI and bone densitometry screenings	August 2002
Patient survey	Health Services Access Survey, Statistics Canada	Patient reports on waits for non-emergency MRI, CT, and angiography received in the past 12 months.	From decision by doctor and individual to go ahead with a test, to the test (includes publicly and privately funded scans)	November–December 2001
Physician survey	Fraser Institute National Waiting List Survey	Survey of physician opinion on waits across 12 specialties and 10 provinces	Median of specialists' responses	Ongoing annual survey since 1995

Source: Compiled by CIHI

- **How care is delivered:** Practice patterns and patient preferences vary. Patients referred for imaging in some settings may be managed differently in others. For example, clinicians responding to proposed rules for CT scans for patients with minor head injuries felt that their use would lead to fewer scans in Canada and the United States but more in parts of the United Kingdom.[72] Because there is little systematic data on these variations, it is difficult to assess their effects on wait times (or on outcomes and costs).
- **How a wait is measured:** Inconsistencies in calculating wait times affect the ability to compare and determine acceptable waits. Additionally, wait lists may be inaccurate. For instance, audits of waiting lists in Canada and elsewhere often find that the same patient is on multiple lists, that not all listed patients still require the service, and other issues.[73]
- **Special factors related to individual patients or conditions:** A range of factors may play a role for different types of medical imaging. For example, critically ill patients may need to be stabilized before they have tests. In the case of elective tests, patients may wish to schedule the procedure to take work or family events into account.

Information Gaps:

What We Know

- Recommendations on the appropriate use of selected medical imaging technologies in certain clinical situations made by different groups.
- Number of free-standing imaging and hospital-based facilities for selected types of imaging technologies.
- Number of Canadians aged 15 and over who reported receiving selected non-emergency medical imaging services and whether or not they had difficulties in accessing these services.
- Some information on wait times for various imaging services and problems patients report experiencing while waiting for care.

What We Don't Know

- How do medical imaging services affect patient care, outcomes, and costs in particular circumstances, compared to other types of imaging or to assessing/managing patients' conditions without imaging technology? What are the relative costs and benefits of using various types of imaging?
- To what extent does the current pattern of use of medical imaging services match with evidence-based best practice? What factors contribute to any observed deviations? What impact do deviations have on patients and on the health care system?
- How does the private/public funding mix for capital and operating costs vary among technologies across the country? How do services provided by free-standing and hospital-based imaging facilities differ? What effect do these differences have on access to care, costs, wait times, and patient satisfaction and outcomes?

What's Happening

- In February 2003, Canada's first ministers pledged to report to their citizens annually on enhancements to diagnostic medical equipment and services, using comparable indicators, and to develop the necessary data infrastructure for these reports. In addition, wait times for CT and MRI were two of the indicators that they directed health ministers to consider for reporting. Some jurisdictions and individual facilities have already begun to report wait time data.
- At the same time, first ministers committed to accelerating technology assessment activities. Subsequently, the Canadian Coordinating Office for Health Technology Assessment received additional federal funding over five years. Federal, provincial, and territorial health ministers have also been directed to develop a comprehensive strategy for technology assessment by September 2004.
- The Western Canada Waiting List Project recently received new funding in support of on-going initiatives related to waiting list management, including exploring the development of accepted standards for wait times.

For More Information

[1] Iron K, Przybysz R, Laupacis A. (2003). *Access to MRI in Ontario: Addressing the Information Gap*. Toronto: Institute for Clinical Evaluative Sciences.

[2] Stiell IG, Wells GA, Vandemheen K, Clement C, Lesiuk H, Laupacis A, McKnight RD, Verbeek R, Brison R, Cass D, Eisenhauer ME, Greenberg G, Worthington J. (2001). The Canadian CT head rule for patients with minor head injury. *Lancet*, 357(9266), 1391-1396.

[3] Fryback DG, Thornbury JR. (1991). The efficacy of diagnostic imaging. *Medical Decision Making*, 11(2), 88-94.

[4] Health Canada. (2001). *Guidelines for the Safe Use of Diagnostic Ultrasound*. Ottawa: Health Canada.

[5] Wagner JL. (1981). *Case Study #2: The Feasibility of Economic Evaluation of Diagnostic Procedures: The Case of CT Scanning*. Washington: Office of Technology Assessment U.S. Congress. www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk3/1981/8132/813203.PDF.

[6] Stiell IG, McKnight RD, Greenberg GH, McDowell I, Nair RC, Wells GA, Johns C, Worthington JR. (1994). Implementation of the Ottawa ankle rules. *Journal of the American Medical Association*, 271(11), 827-832.

[7] Romanow RJ. (2002). *Building on Values: The Future of Health Care in Canada. (Final Report)*. Ottawa: Commission on the Future of Health Care in Canada. www.hc-sc.gc.ca/english/pdf/care/romanow_e.pdf.

[8] The Standing Senate Committee on Social Affairs, Science and Technology. (2002). *The Health of Canadians: The Federal Role (Final Report on the State of the Health Care System in Canada)*. Ottawa: Government of Canada. www.parl.gc.ca/37/2parlbus/commbus/senate/com_e/SOEI-E/repe/repoct02vol6-e.pdf.

[9] Hunink MGM, Krestin GP. (2002). Study design for concurrent development, assessment, and implementation of new diagnostic imaging technology. *Radiology*, 222, 604-614.

[10] Stiell IG, Wells GA, Hoag RH, Sivilotti ML, Cacciotti TF, Verbeek PR, Greenway KT, McDowell I, Cwinn AA, Greenberg GH, Nichol G, Michael JA. (1997). Implementation of the Ottawa Knee Rule for the use of radiography in acute knee injuries. *Journal of the American Medical Association*, 278(23), 2075-2079.

[11] Stiell IG, Wells GA, Vandemheen KL, Clement CM, Lesiuk H, De Maio VJ, Laupacis A, Schull M, McKnight RD, Verbeek R, Brison R, Cass D, Dreyer J, Eisenhauer MA, Greenberg GH, MacPhail I, Morrison L, Reardon M, Worthington J. (2001). The Canadian C-spine rule for radiography in alert and stable trauma patients. *Journal of the American Medical Association*, 286(15), 1841-1848.

[12] Bachmann LM, Kolb E, Koller MT, Steurer J, ter Riet G. (2003). Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: Systematic review. *British Medical Journal*, 326, 417-423.

[13] Graham ID, Stiell IG, Laupacis A, McAuley L, Howell M, Clancy M, Durieux P, Simon N, Emparanza JI, Aginaga JR, O'connor A, Wells G. (2001). Awareness and use of the Ottawa ankle and knee rules in 5 countries: Can publication alone be enough to change practice? *Annals of Emergency Medicine*, 37(3), 259-266.

[14] Canadian Association of Radiologists. (1996). *Position on the Use of Diagnostic Ultrasound for Non Medical Purposes.* www.umanitoba.ca/colleges/cps/Guidelines and Statements/1502.html.

[15] United States Food and Drug Administration. (2002). *Fetal Keepsake Videos*. www.fda.gov/cdrh/consumer/fetalvideos.html.

[16] American Institute of Ultrasound Medicine. (2003). *American Institute of Ultrasound Medicine Official Statements*. www.aium.org/patient/entertainment/statements/pdf.

[17] Health Services Utilization and Research Commission. (1996/2000). *Selective Prenatal Ultrasound Guidelines.* Saskatoon: HSURC.

[18] Lewis C. (2001). *Full-body CT Scans: What You Need to Know*. www.fda.gov/fdac/features/2001/601_ct.html.

[19] Canadian Coordinating Office for Health Technology Assessment. (2003). *Multi-Slice/Helical Computed Tomography for Lung Cancer Screening*. www.ccohta.ca/publications/pdf/ct_cetap_e.pdf.

[20] O'Rourke RA, Brundage BH, Froelicher VF, Greenland P, Grundy SM, Hachamovitch R, Pohost GM, Shaw LJ, Weintraub WS, Winters WL. (2000). American College of Cardiology/American Heart Association expert consensus document on electron-beam computed tomography for the diagnosis and prognosis of coronary artery disease. *Circulation*, 102, 126-140.

[21] O'Malley PG, Taylor AJ, Jackson JL, Doherty TM, Detrano RC. (2000). Prognostic value of coronary electron-beam computed tomography for coronary heart disease events in asymptomatic populations. *American Journal of Cardiology*, 85, 954-958.

[22] Keelan PC, Bielak LF, Ashai K, Jamjoum LS, Denktas AE, Rumberger JA, Sheedy II PF, Peyser PA, Schwartz RS. (2001). Long-term prognostic value of coronary calcification detected by electron-beam computed tomography in patients undergoing coronary angiography. *Circulation*, 104(4), 412-417.

[23] Bach PB, Kelley MJ, Tate RC, McCrory DC. (2003). Screening for lung cancer: A review of the current literature. *Chest*, 123(1 Suppl), 72S-82S.

[24] Canadian Coordinating Office for Health Technology Assessment. (2003). *Multislice/spiral computed tomography for screening for coronary artery disease*. www.ccohta.ca/publications/pdf/ct_scanning_ctap_e.pdf.

[25] Forster BB, Mayo JR. (2003). Rational computed tomography screening in 2003. *Canadian Association of Radiologists Journal*, 54(1), 14-17.

[26] Stolberg HO. (2003). Yuppie scans from head to toe: Unethical entrepreneurism. *Canadian Association of Radiologists Journal*, 54(1), 10-13.

[27] Canadian Association of Radiologists. (2002). *CT Screening: CAR Resolution No. MW02-16*. www.car.ca/politics/resolutions/ct.htm.

[28] U.S Food and Drug Administration. (2002). *Whole Body Scanning Using Computed Tomography (CT)*. www.fda.gov/cdrh/ct.2002.

[29] Allan PL, Williams JR. (2003). Full-body CT scans: Are they worth the cost and the radiation exposure? *Journal of the Royal College of Physicians of Edinburgh*, 33, 8-14.

[30] American College of Radiology. (2002). *ACR Statement on CT Screening Exams*. www.acr.org/departments/pub_rel/press_releases/total-bodyCT.html.

[31] Mustard CA, McClarty B, MacEwan D. (1996). Influence of magnetic resonance imaging on diagnosis and therapeutic intention. *Academic Radiology*, 3(7), 589-596.

[32] Walker S, Haun W, Clark J, McMillin K, Zeren F, Gilliland T. (2000). The value of limited computed tomography with rectal contrast in the diagnosis of acute appendicitis. *American Journal of Surgery*, 180, 450-455.

[33] Horton MD, Counter SF, Florence MG, Hart MJ. (2000). A prospective trial of computed tomography and ultrasonography for diagnosing appendicitis in the atypical patient. *American Journal of Surgery*, 179(5), 379-381.

[34] Wilson EB, Cole JC, Nipper ML, Cooney DR, Smith RW. (2001). Computed tomography and ultrasonography in the diagnosis of appendicitis: When are they indicated? *Archives of Surgery*, 136, 670-675.

[35] Stroman DL, Bayouth CV, Kuhn JA, Westmoreland M, Jones RC, Fisher TL, McCarty TM. (1999). The role of computed tomography in the diagnosis of acute appendicitis. *American Journal of Surgery*, 178, 485-489.

[36] Evans LV, Werdmann MJ, Degutis LC, D'Onofroi G. (2003). Impact of abdominal/pelvic computed tomography with and without oral contrast on emergency department patients undergoing appendectomy. *Academic Emergency Medicine*, 10, 501.

[37] Lee SL, Walsh AJ, Ho HS. (2001). Computed tomography and ultrasonography do not improve and may delay the diagnosis and treatment of acute appendicitis. *Archives of Surgery*, 136, 556-562.

[38] McDonald GP, Pendarvis DP, Wilmouth R, Daley BJ. (2001). Influence of preoperative computed tomography on patients undergoing appendectomy. *The American Surgeon*, 67, 1017-1021.

[39] Perez J, Barone JE, Wilbanks TO, Jorgensson D, Corvo PR. (2003). Liberal use of computed tomography scanning does not improve diagnostic accuracy in appendicitis. *American Journal of Surgery*, 185, 194-197.

[40] Szczepura AK, Fletcher J, Fitz-Patrick JD. (1991). Cost effectiveness of magnetic resonance imaging in the neurosciences. *British Medical Journal*, 303(6815), 1435-1439.

[41] Ebinger M, Rieber A, Leidl R. (2002). Cost-effectiveness of magnetic resonance imaging and enteroclysis in the diagnostic imaging of Crohn's disease. *International Journal of Technology Assessment in Health Care*, 18(3), 711-717.

[42] McMahon PM, Araki SS, Sandberg EA, Neumann PJ, Gazelle GS. (2003). Cost-effectiveness of PET in the diagnosis of Alzheimer disease. *Radiology*, (in press).

[43] Morgan S, Hurley J. (2002). *Discussion Paper No.14 for the Commission on the Future of Health Care in Canada: Influences on the "Health Care Technology Cost-Driver".* www.hc-sc.gc.ca/english/pdf/romanow/pdfs/14_Morgan_E.pdf.

[44] GE Medical Systems. (2003). *History of Mammography*. www.gemedicalsystems.com/rad/whc/mswhhis.html.

[45] Australian Health Technology Advisory Committee. (1997). *Review of Magnetic Resonance Imaging*. www.health.gov.au/haf/mri/mriahtac.pdf.

[46] Mitchell DG, Parker L, Sunshine JH, Levin DC. (2002). Body MR imaging and CT volume: Variations and trends based on an analysis of medicare and fee-for-service health insurance databases. *American Journal of Roentgenology*, 179(1), 27-31.

[47] Imaging Advisory Committee. (2001). *Magnetic Resonance Imaging: Report of Findings and Recommendations*. www.health.gov.ab.ca/public/document/MRIApril09_01.pdf.

[48] Medical Imaging Technology Roadmap Steering Committee. (2000). *Future Needs for Medical Imaging in Health Care: Report of Working Group 1: Medical Imaging Technology Roadmap*. Ottawa: Industry Canada.

[49] Livstone BJ, Parker L, Levin DC. (2002). Trends in the utilization of MR angiography and body MR imaging in the US Medicare population: 1993-1998. *Radiology*, 222(3), 615-618.

[50] Canadian Institute for Health Information. (2001). *Canada's Health Care Providers*. Ottawa: Canadian Institute for Health Information.

[51] Millward SF, Holley ML. (2001). The current status of interventional radiology in Canada: Results of a survey by the Canadian Interventional Radiology Association. *Canadian Association of Radiologists Journal*, 52(2), 87-91.

[52] Torreggiani WC, Nicolaou S, Harris AC. (2002). Emergency radiology in Canada: A national survey. *Canadian Association of Radiologists Journal*, 53(3), 160-167.

[53] Noseworthy T. (2001). *Diagnostic Supply Report Newfoundland and Labrador 2000/2001*. www.nlhba.nf.ca/hr/documents/Diagnostic.pdf.

[54] Expert Group on Radiography Grades. (2001). *Report of the Expert Group on Radiography Grades*. Dublin: Department of Health and Children. www.doh.ie/publications/radiog.html.

[55] American College of Radiologists. (2003). *ACR Approves Statement on Radiologist Assistant Functions*. www.acr.org/dyna/?doc=ra-rpa/ra_rpa_public_page.html.

56 Deber RB. (2002). *Discussion Paper No.17 of the Commission on the Future of Health Care in Canada: Delivering Health Care Services: Public, Not-For-Profit, or Private?* www.hc-sc.gc.ca/english/pdf/romanow/pdfs/17_Deber_E.pdf.

57 Rankin RN. (1999). Magnetic resonance imaging in Canada: Dissemination and funding. *Canadian Association of Radiologists Journal*, 50(2), 89-92.

58 Devereaux PJ, Choi PT, Lacchetti C, Weaver B, Schunemann HJ, Haines T, Lavis JN, Grant BJ, Haslam DR, Bhandari M, Sullivan T, Cook DJ, Walter SD, Meade M, Khan H, Bhatnagar N, Guyatt GH. (2002). A systematic review and meta-analysis of studies comparing mortality rates of private for-profit and private not-for-profit hospitals. *Canadian Medical Association Journal*, 166(11), 1399-1406.

59 Maxwell J, Jackson K, Legowski B, Rosell S, Yankelovich D, Forest P, Lozowchuck L. (2002). *Report on Citizens' Dialogue on the Future of Health Care in Canada. Prepared for the Commission on the Future of Health Care in Canada.* www.hc-sc.gc.ca/english/pdf/romanow/pdfs/Dialogue_E.pdf.

60 Ipsos-Reid. (2002). *Awaiting Romanow: Priorities for Healthcare Spending.* www.ipsos-reid.com/pdf/media/mr021124-1b.pdf.

61 Sanmartin C, Shortt SE, Barer ML, Sheps S, Lewis S, McDonald PW. (2000). Waiting for medical services in Canada: Lots of heat, but little light. *Canadian Medical Association Journal*, 162(9), 1305-1310.

62 Sanmartin C, Houle C, Berthelot J, White K. (2002). *Access to Health Care Services in Canada, 2001*. Ottawa: Minister of Industry. www.statcan.ca/english/freepub/82-575-XIE/82-575-XIE2002001.pdf.

63 Alberta Health and Wellness. (2003). *Computerized Tomography—Volumes and Wait List*. www.health.gov.ab.ca/system/funding/performance/CT.pdf.

64 Alberta Health and Wellness. (2003). *Magnetic Resonance Imaging—Volumes and Wait Times*. www.health.gov.ab.ca/system/funding/performance/MRI.pdf.

65 University Health Network. (2003). *Wait Times Currently Measured by UHN Program Groupings*. www.uhn.ca/uhn/corporate/oppm/site/docs/wait_times_june2003.pdf.

66 Auditor General of Quebec. (2001). *Report to the National Assembly for 2000–2001, Volume 1.* Quebec: Government of Quebec.

67 Western Canada Waiting List Project. (2001). *From Chaos to Order: Making Sense of Waiting Lists in Canada. (Final Report)*. www.wcwl.org/graphics/finalrpt.pdf.

68 Calgary Health Region. (2002). *Diagnostic Imaging Guidelines for Prioritization of MRI Studies*. www.calgaryhealthregion.ca/di/images/PrioritizationGuidelines_MR_v20020522_expanded.pdf.

69 Calgary Health Region. (2002). *Diagnostic Imaging Guidelines for Prioritization of CT Studies*. www.calgaryhealthregion.ca/di/images/PrioritizationGuidelines_CT_v20020522_expanded.pdf.

70 The Audit Commission. (2002). *Radiology: Acute Hospital Portfolio*. *Review of National Findings*. London, United Kingdom: The Audit Commission. www.audit-commission.gov.uk/Products/AC-REPORT/AB95E11A-A6C1-4335-9482-9618441DB347/Radiology_Full.pdf.

71 Arsenault D. (2003). *Guidelines Focus of MRI Review: Running Existing Machines Longer, Buying New Ones Among Options*. www.herald.ns.ca/stories/2003/05/16/f207.raw.html.

72 Needham G, Currie DG. (2002). Canadian CT head rule for patients with minor head injury. *Clinical Radiology*, 57(2), 152-153.

73 McDonald P, Shortt S, Sanmartin C, Barer M, Lewis S, Sheps S. (1998). *Waiting Lists and Waiting Times for Health Care in Canada: More Management!! More Money??* Ottawa: Health Canada.

6 Medical Imaging in Canada: An Incomplete Picture

Once a curiosity, medical imaging is now an indispensable part of modern medical care. It was only a little over a hundred years ago that X-rays were "discovered". Within a few months, physicians in many parts of the world were experimenting with them, and today a wide array of medical imaging technologies are used in the diagnosis—and sometimes treatment—of a range of health conditions. For example, a mother-to-be and her care provider can now see images of her unborn child through an ultrasound and check for fetal abnormalities. Physicians can make definitive diagnoses of broken bones with imaging technologies. And we can even obtain clear pictures of the workings of the brain.

As this report illustrates, use of medical imaging is increasing in Canada and other developed countries. For example, the use and purchase of various technologies—including CT and MRI scans—has grown steadily in recent years. At the same time, polls suggest that access to imaging remains a key priority for Canadians.

Like many technologies, the value of medical imaging depends on how it is used and its ability to improve the lives of patients and/or the practice of health care. Recent reports on health care (eg, Romanow/Kirby) have called for action both to address issues surrounding access to diagnostic services and to engage in research to better understand the appropriate use of these technologies, now and in the future.

As plans move ahead, it helps to understand where we are starting from. The information in this report is intended to summarize the current status of imaging in Canada to contribute to this process. This summary includes:

- a brief history of the development of imaging technologies;
- current data about how many imaging technologies there are in Canada and how they are used;
- information about the many health professionals who use these technologies; and
- a description of some of the issues surrounding their use.

This information, much of which was newly assembled or updated for this report, is important, but significant pieces of the puzzle are missing, rendering the picture incomplete. For example, we know how many CT and MRI scanners there are in Canada, where they are located, and how old they are, but little about how they are used. Nor do we know much about the relative opportunity costs of particular imaging technologies in relation to each other or to other types of care.

Only pockets of information exist about how scan rates compare across the country or around the world, why scans were done, to what extent people who needed scans did (or did not) receive them, and how long patients waited for tests. Even less is available about the resultant effects on patient care, costs, and outcomes, partly because understanding the impact of imaging on what patients and providers know and do is challenging. For instance, while imaging technologies have revolutionized cancer detection, some cancer mortality rates remain stubbornly resistant to therapeutic advances. And, while these technologies have the potential to avert many exploratory surgeries, others may result when something unusual shows up on a mammogram, CT scan, or X-ray.

As these examples illustrate, the “what we don’t know” sections of the report are compelling. Yet public, practitioner, and policy interest in medical imaging is strong. We hope that this report will help to inform debate and decisions about imaging today, as well as efforts to improve the information base available to support informed choices, five or even ten years from now.

Appendix A: Fast Facts

List of Data Tables and Figures

1

Number of MRI Scanners by Province/Territory, Canada, 1991 to 2003

	1991	1992	1993	1994	1995	1997	2000	2001	2003
B.C.	3	5	5	6	7	9	10	14	18
Alta.	2	5	5	6	6	6	13	23	23
Sask.	1	1	1	1	1	1	3	3	3
Man.	1	1	1	0	1	1	3	3	3
Ont.	10	11	11	12	12	23	42	44	50
Que.	4	4	5	8	10	12	n/a	35	40
N.B.	0	0	0	0	1	1	2	5	5
N.S.	1	1	1	1	1	1	2	2	4
P.E.I.	0	0	0	0	0	0	0	0	0
N.L.	0	0	1	1	1	1	1	1	1
Nun.	0	0	0	0	0	0	0	0	0
N.W.T.	0	0	0	0	0	0	0	0	0
Y.T.	0	0	0	0	0	0	0	0	0

Notes: 1) Surveys were not carried out in 1996, 1998, 1999 and 2002.
2) CCOHTA notes that Quebec data were incomplete for 2000; therefore, they are not included.
3) Units located both in hospitals and in 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 in the 2003 National Survey of Selected Medical Imaging Equipment.
4) 2003 data are as of January 2003. Some additional equipment has subsequently been installed.

Source: National Inventory of Selected Imaging Equipment, Canadian Coordinating Office for Health Technology Assessment (MRIs in hospitals, 1991–2001)
National Survey of Selected Medical Imaging Equipment, CIHI (2003)

2

Number of CT Scanners by Province/Territory, Canada, 1991 to 2003

	1991	1992	1993	1994	1995	1997	2001	2003
B.C.	23	23	23	24	25	28	38	44
Alta.	22	22	24	23	23	23	25	30
Sask.	5	6	6	6	6	7	9	10
Man.	8	8	9	10	10	10	13	14
Ont.	65	68	72	76	79	84	91	95
Que.	58	60	60	62	68	69	92	94
N.B.	6	7	7	7	7	8	9	9
N.S.	7	8	8	8	9	9	14	15
P.E.I.	1	1	1	1	1	1	2	2
N.L.	5	5	6	6	6	6	9	11
Nun.	0	0	0	0	0	0	0	0
N.W.T.	0	0	0	0	0	0	1	1
Y.T.	0	0	0	0	0	0	0	1

Notes: 1) Surveys were not carried out in 1996, 1998 to 2000, and 2002.
2) Units located both in hospitals and in free-standing imaging facilities are included for 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.
3) 2003 data are as of January 2003. Some additional equipment has subsequently been installed.

Source: National Inventory of Selected Imaging Equipment, Canadian Coordinating Office for Health Technology Assessment (CTs in hospitals, 1991–2001)
National Survey of Selected Medical Imaging Equipment, CIHI (2003)

Number of Nuclear Medicine Physicians by Province/Territory, Canada, 1993 to 2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
B.C.	15	21	21	20	19	21	22	22	22
Alta.	7	10	11	13	14	13	15	14	13
Sask.	5	3	3	4	3	3	3	3	3
Man.	8	8	7	7	8	8	8	8	6
Ont.	56	57	59	62	66	67	74	74	75
Que.	78	83	88	88	88	89	87	87	85
N.B.	2	2	3	3	3	3	3	3	3
N.S.	2	3	3	3	3	3	4	4	5
P.E.I.	0	0	0	0	0	0	0	0	0
N.L.	2	2	2	2	2	2	2	2	2
Y.T.	0	0	0	0	0	0	0	0	0
N.W.T.	0	0	0	0	0	0	0	0	0
Nun.							0	0	0
Canada	175	189	197	202	206	209	218	217	214

Notes: 1) Data exclude residents and physicians who are not licensed to provide clinical practice and have requested to the Business Information Group (formerly Southam Medical Group) that their data not be published.
2) Data as of December 31 of given year.
Includes physicians in clinical and/or non-clinical practice, including research, teaching or administration.
Specialty is based on most recent certified specialty, and data may differ from other sources of provincial/territorial physician data that categorize physicians on some other basis (e.g. functional specialty, payment specialty, or provisional licenses).
3) Caution must be exercised when comparing Northwest Territory data prior to 1999 with Northwest Territory data after 1998, since some of the change may be attributable to the creation of the Nunavut Territory.
4) 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.

Source: Southam Database, CIHI

3

Number of Diagnostic Radiologists by Province/Territory, Canada, 1993 to 2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
B.C.	228	224	229	233	242	236	234	236	230
Alta.	149	150	150	153	159	168	182	180	192
Sask.	45	48	50	50	51	50	49	51	45
Man.	60	57	62	62	65	63	64	63	60
Ont.	661	666	656	650	666	675	689	702	721
Que.	437	462	473	484	493	505	504	500	506
N.B.	38	41	41	43	43	44	44	46	42
N.S.	70	71	69	66	69	73	79	81	70
P.E.I.	4	5	5	4	6	6	6	6	6
N.L.	27	25	27	27	27	30	31	31	30
Y.T.	0	0	0	0	0	0	0	0	0
N.W.T.	2	1	1	1	2	2	2	2	1
Nun.							0	0	0
Canada	1,721	1,750	1,763	1,773	1,823	1,852	1,884	1,898	1,903

Notes: 1) Data exclude residents and physicians who are not licensed to provide clinical practice and have requested to the Business Information Group (formerly Southam Medical Group) that their data not be published.
2) Data as of December 31 of given year.
Includes physicians in clinical and/or non-clinical practice, including research, teaching or administration.
Specialty is based on most recent certified specialty, and data may differ from other sources of provincial/territorial physician data that categorize physicians on some other basis (e.g. functional specialty, payment specialty, or provisional licenses).
3) Caution must be exercised when comparing Northwest Territory data prior to 1999 with Northwest Territory data after 1998, since some of the change may be attributable to the creation of the Nunavut Territory.
4) 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.

Source: Southam Database, CIHI

4

Number of Members of Medical Radiation Technologists' Associations in the Discipline of Nuclear Medicine by Province/Territory of Residence, Canada, 1993 to 2002

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
B.C.	153	171	169	171	178	181	180	186	191	192
Alta.	125	126	124	120	117	125	121	140	142	151
Sask.	26	27	27	29	25	27	32	30	33	35
Man.	45	44	45	44	44	46	47	45	44	45
Ont.[1]	525[2]	577	572	593	593	604	604	615	638	647
Que.[3]	••	••	••	••	••	••	••	••	395	403
N.B.	26	29	32	34	36	36	38	42	43	47
N.S.	63	63	70	65	66	68	64	62	63	73
P.E.I.	3	3	3	2	3	4	5	5	5	6
N.L.	14	15	17	15	16	15	15	14	16	13
Terr.	••	••	••	••	••	••	••	••	••	••
Canada	980	1,055	1,059	1,073	1,078	1,106	1,106	1,139	1,570	1,612

5

Notes: ••Not available

Members qualifying in other disciplines are counted in other disciplines.

[1] Ontario data represent active registered members of the College of Medical Radiation Technolgists of Ontario.

[2] The 1993 data were generated by the Board of Radiological Technicians and include other members other than "active." Therefore, the data are not comparable with data after 1993.

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

Source: Health Personnel in Canada, CIHI

Number of Members of Medical Radiation Technologists' Associations in the Discipline of Radiological Technology by Province/Territory of Residence, Canada, 1993 to 2002

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
B.C.	1,258	1,292	1,298	1,315	1,350	1,337	1,319	1,352	1,316	1,290
Alta.	1,204	1,142	1,128	1,093	1,101	1,151	1,153	1,187	1,208	1,226
Sask.	351	368	360	355	356	356	356	369	377	369
Man.	548	567	580	570	537	543	530	526	509	511
Ont.[1]	4,594[2]	4,346	4,319	4,198	4,118	4,158	4,133	4,136	4,163	4,202
Que.[3]	••	••	••	••	••	••	••	••	2,991	2,999
N.B.	368	378	388	393	382	399	403	398	393	409
N.S.	457	446	432	414	428	411	405	399	383	391
P.E.I.	67	62	63	64	62	67	63	60	64	62
N.L.	239	240	245	235	236	235	234	237	249	251
Terr.	••	••	••	••	••	••	••	••	••	••
Canada	9,086	8,841	8,813	8,637	8,570	8,657	8,596	8,664	11,653	11,710

6

Notes: ••Not available

Members qualifying in other disciplines are counted in other disciplines.

[1] Ontario data represent active registered members of the College of Medical Radiation Technolgists of Ontario.

[2] The 1993 data were generated by the Board of Radiological Technicians and include other members other than "active." Therefore, the data are not comparable with data after 1993.

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

Source: Health Personnel in Canada, CIHI

7

Distribution of Imaging Technologies Across Canada in January 2003

	Nuclear Medicine Cameras			CT Scanners			Angiography Suites			MRI Scanners			Catheterization Labs			PET Scanners		
Jurisdiction	H	FS	Rate	H	FS	Rate	H	FS	Rate	H	FS	Rate	H	FS	Rate	H	FS	Rate
B.C.	61	-	14.7	43	1	10.6	20	-	4.8	14	4	4.3	11	-	2.6	1	1	0.5
Alta.	41	13	17.2	27	3	9.6	15	-	4.8	17	6	7.3	11	-	3.5	2	-	0.6
Sask.	14	-	13.9	10	-	9.9	4	-	4.0	3	-	3.0	4	-	4.0	-	-	-
Man.	16	-	13.9	14	-	12.2	3	-	2.6	3	-	2.6	4	-	3.5	-	-	-
Ont.	234	10	20.1	95	-	7.8	66	-	5.5	50	-	4.1	36	-	3.0	6	-	0.5
Que.	149	2	20.2	89	5	12.6	38	-	5.1	24	16	5.5	21	-	2.8	4	-	0.5
N.B.	18	-	23.8	9	-	11.9	9	-	11.9	5	-	6.6	2	-	2.6	-	-	-
N.S.	23	-	24.4	15	-	15.9	5	-	5.3	3	1	4.2	3	-	3.2	-	-	-
P.E.I.	2	-	14.2	2	-	14.2	1	-	7.1	-	-	-	-	-	-	-	-	-
N.L.	10	-	18.8	11	-	20.7	4	-	7.5	1	-	1.9	2	-	3.8	-	-	-
Nun.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N.W.T.	1	-	24.2	1	-	24.2	-	-	-	-	-	-	-	-	-	-	-	-
Y.T.	-	-	-	1	-	33.5	-	-	-	-	-	-	-	-	-	-	-	-
Canada	569	25	18.9	317	9	10.3	165	-	5.2	120	27	4.7	94	-	3.0	13	1	0.4

Note: Rate = Numbers of units per million population of selected imaging technologies in provincial and territorial hospitals and free-standing imaging facilities as of January 2003; H = Number of selected imaging technologies in hospitals; FS = Number of selected imaging technologies in free-standing imaging facilities.

Source: National Survey of Selected Medical Imaging Equipment, CIHI

8

Results from the Health Services Access Survey

Selected parameters for Canadians aged 15 and over who reported receiving a non-emergency angiography, CT, or MRI in 2001.

Parameter	Angiography[3]	CT[3]	MRI[3]
Approximate number age 15 and over who had a test[1]	220,000*	787,000	647,000
% of population age 15 and over who had a test	1%*	3%	3%
Age distribution of test recipients			
• % under 45 years	–	33%	40%*
• % age 45-64	52%*	41%	40%
• % age 65 and over	37%*	26%	19%*
% of test recipients who were male	48%*	50%	53%
Reason for test			
• Heart or stroke disease	77%	7%*	–
• Cancer	–	13%*	–
• Joints or fractures	–	13%*	18%*
• Neurological or brain disorders	–	29%	12%*
• Other/not specified	–	37%	46%
Place of test			
• Hospital/Public Clinic	98%	96%	92%
• Other[2]	2%	4%	8%
% who reported any difficulties in accessing the test	–	17%*	15%*

Notes: [1] Rounded to the nearest 1,000 persons.
[2] "Other" includes private clinics and other locations not specified.
[3] "–" means data are suppressed due to extreme sampling variability.
*Interpret with caution due to sampling variability.

Source: Health Services Access Survey, Statistics Canada

How Medical Imaging Equipment in Hospitals is Funded

Funding arrangements for selected medical imaging equipment operating costs flowing through ministries of health in each province and territory, 2003

Equipment	B.C.		Alta.		Sask.		Man.		Ont.		Que.*		N.B.		N.S.		P.E.I.		N.L.		Nun.*		N.W.T.*		Y.T.	
	FA	PF	FA	PF	FA	PF	FA	PF	FA	PF	FA	PF	FA	PF	FA	PF	FA	PF	FA	PF	FA	PF	FA	PF	FA	PF
MRI	● ▼	● ▼	●	● ■ ▼	●	●	●	■ ▼	● ▼	● ■	●	■	● ▼	■ ▼	● ▼	■ ▼	●	▼	● ▼	■ ▼	●	▼	●	▼	▼	▼
CT	● ▼	■ ▼	●	● ■	●	●	●	■ ▼	● ▼	■			● ▼	■ ▼	● ▼	■ ▼	●		● ▼	■ ▼					● ▼	▼
PET			● ▼	●										●											▼	▼
Angiography	● ▼	■ ▼	● ▼	■ ▼	●	■	●	■ ▼					● ▼	■ ▼	● ▼	■ ▼	●		● ▼	■ ▼					▼	▼
Cardiac Catherization	● ▼	■ ▼	● ▼	■ ▼	●	■	●	■	● ▼				● ▼	■ ▼	● ▼	■			● ▼	■ ▼					▼	▼
Nuclear Medicine Cameras	● ▼	■ ▼	● ▼	● ■ ▼	●	●	●	■					●	■	● ▼	■ ▼	●		● ▼	■ ▼					▼	▼
Ultrasound	● ▼	■ ▼	● ▼	● ■ ▼	● ■	● ■	●	■ ▼					● ▼	■ ▼	● ▼	■ ▼	●		● ▼	■ ▼					● ▼	■ ▼
X-ray	● ▼	■ ▼	● ▼	● ■ ▼	● ■	● ■	●	■ ▼					● ▼	■ ▼	● ▼	■ ▼	●		● ▼	■ ▼					● ▼	■ ▼

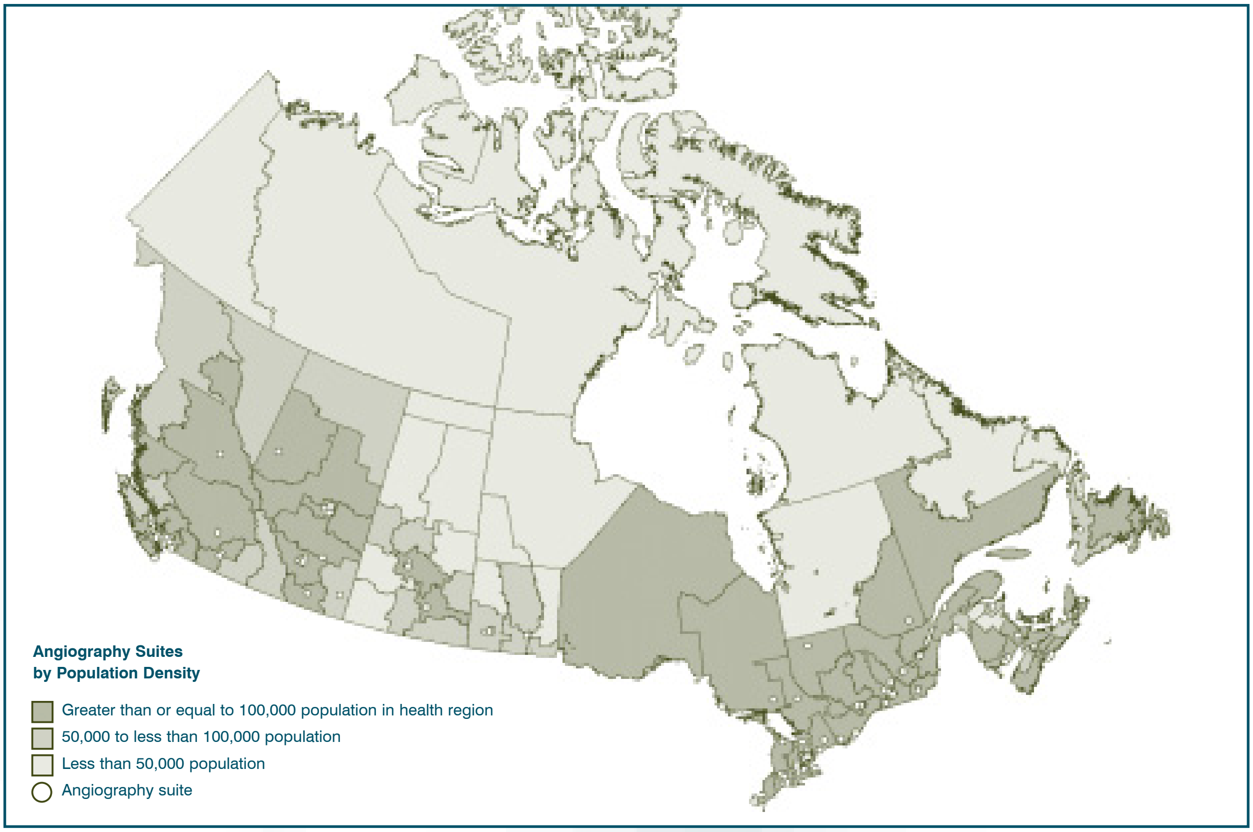
FA = Facility Fees
PF = Professional Fees

●/● = Regional/Hospital Global Budgets
■/■ = Included in FFS payments
▼/▼ = Interprovincial reciprocal billings

*At the time of publication funding arrangements for other technologies in these provinces/territories were unavailable. Data presented are as of 1999.

Source: Adapted from a 2001 Alberta Report entitled: *Magnetic Resonance Imaging Report of Findings and Recommendations* prepared by the Imaging Advisory Committee.

Angiography Suites in Hospitals Across Canada, 2003



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Source: National Survey of Selected Medical Imaging Equipment, CIHI, 2003

Catheterization Laboratories in Hospitals Across Canada, 2003

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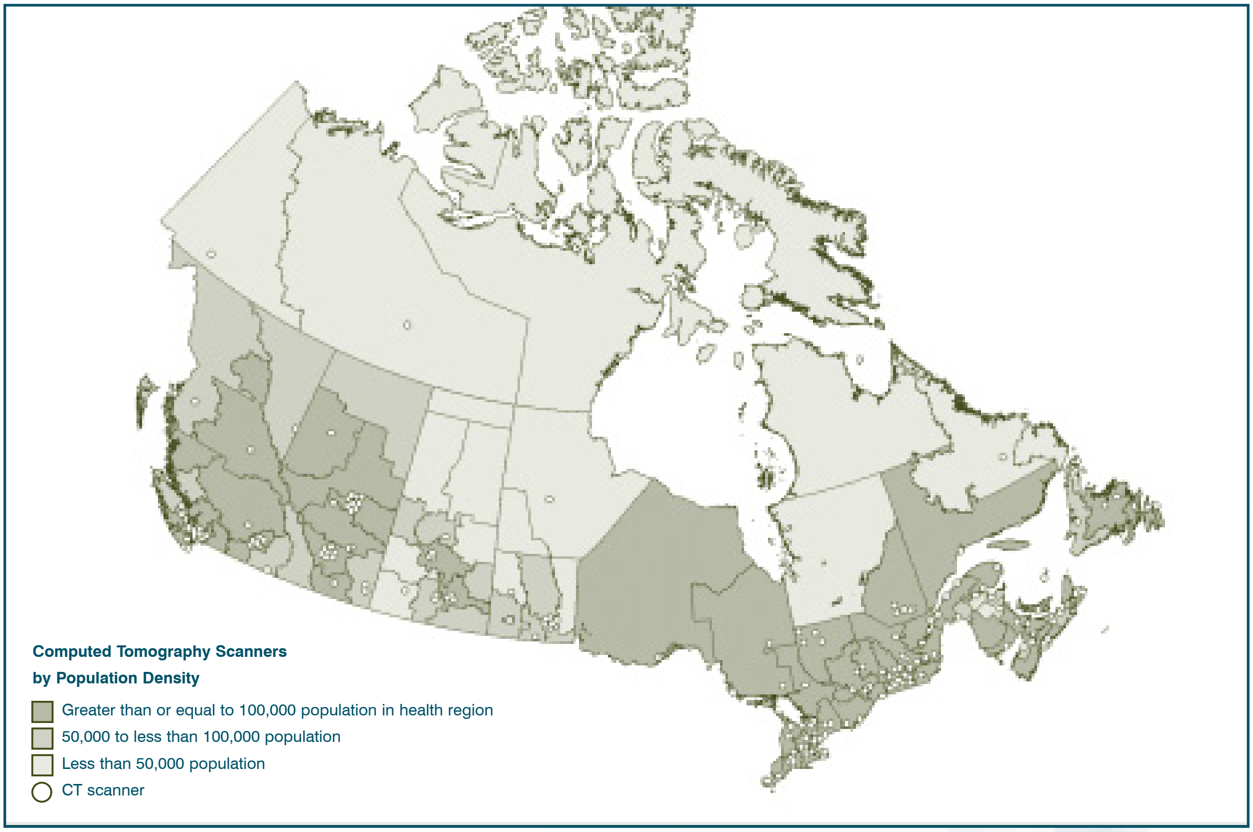
Source: National Survey of Selected Medical Imaging Equipment, CIHI, 2003

Computed Tomography (CT) Scanners in Hospitals Across Canada, 2003



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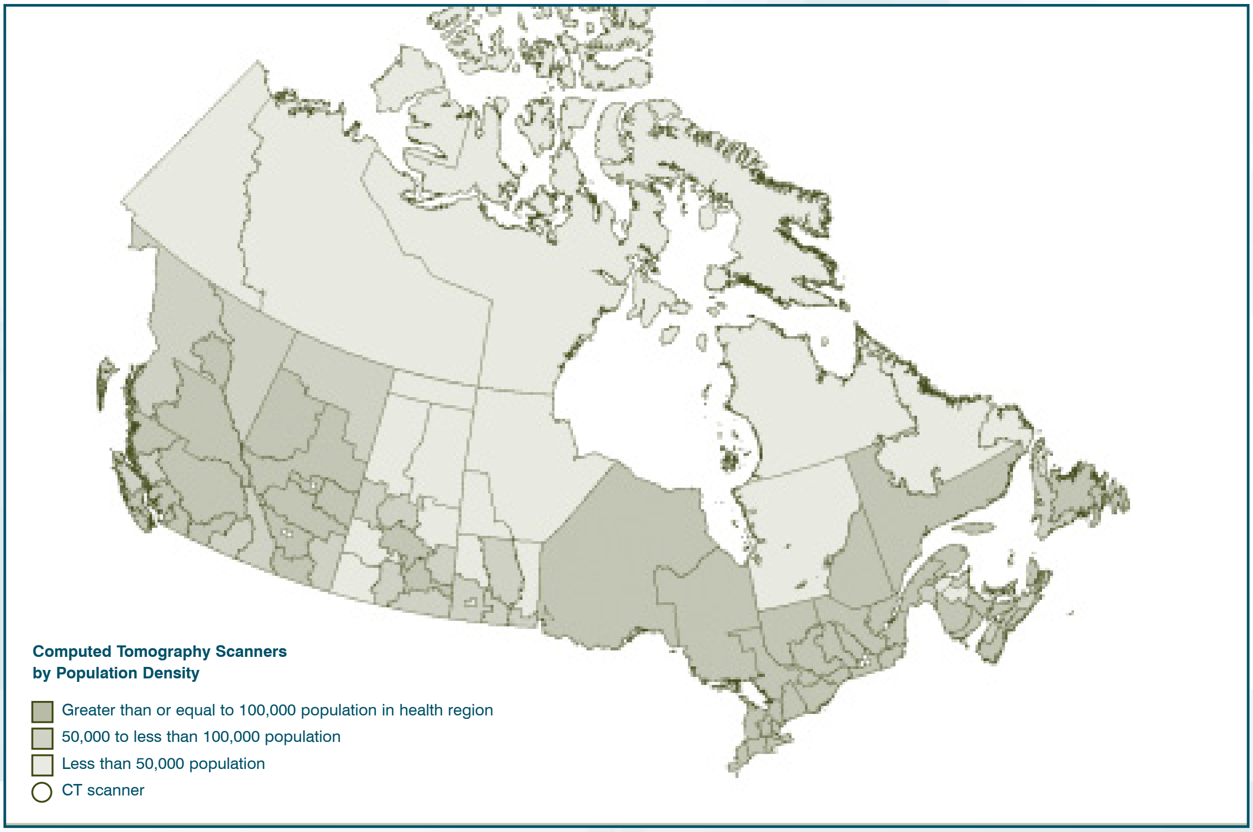
Source: National Survey of Selected Medical Imaging Equipment, CIHI, 2003

Computed Tomography (CT) Scanners in Free-Standing Imaging Facilities Across Canada, 2003



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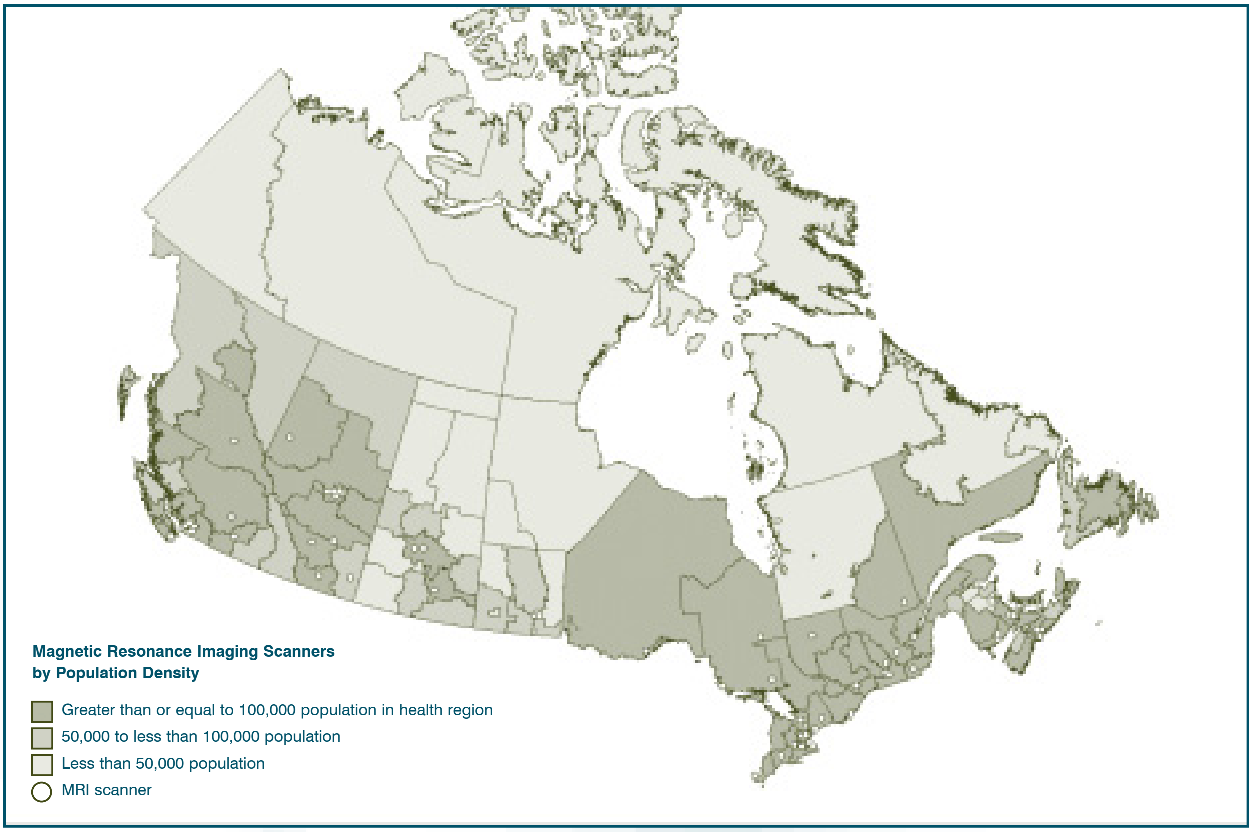
Source: National Survey of Selected Medical Imaging Equipment, CIHI, 2003

Magnetic Resonance Imaging (MRI) Scanners in Hospitals Across Canada, 2003



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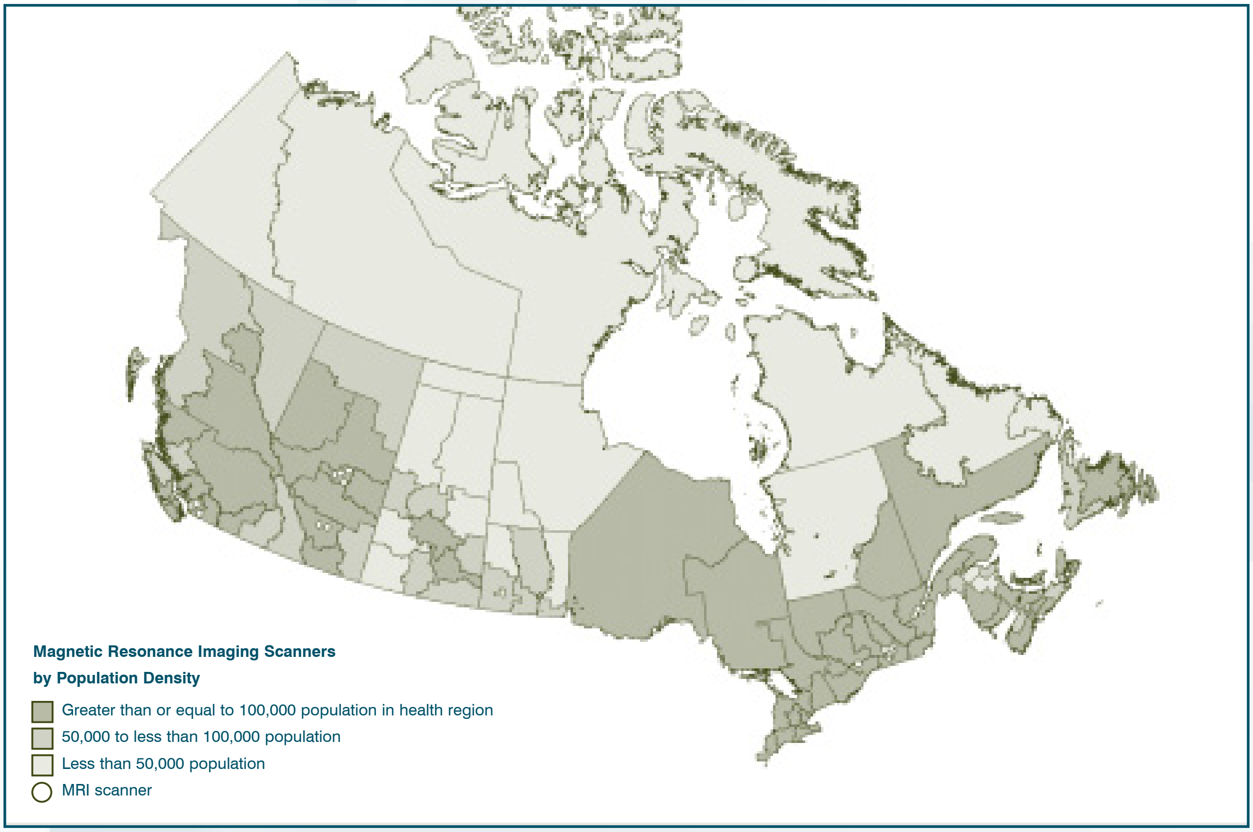
Magnetic Resonance Imaging (MRI) Scanners in Free-Standing Imaging Facilities Across Canada, 2003



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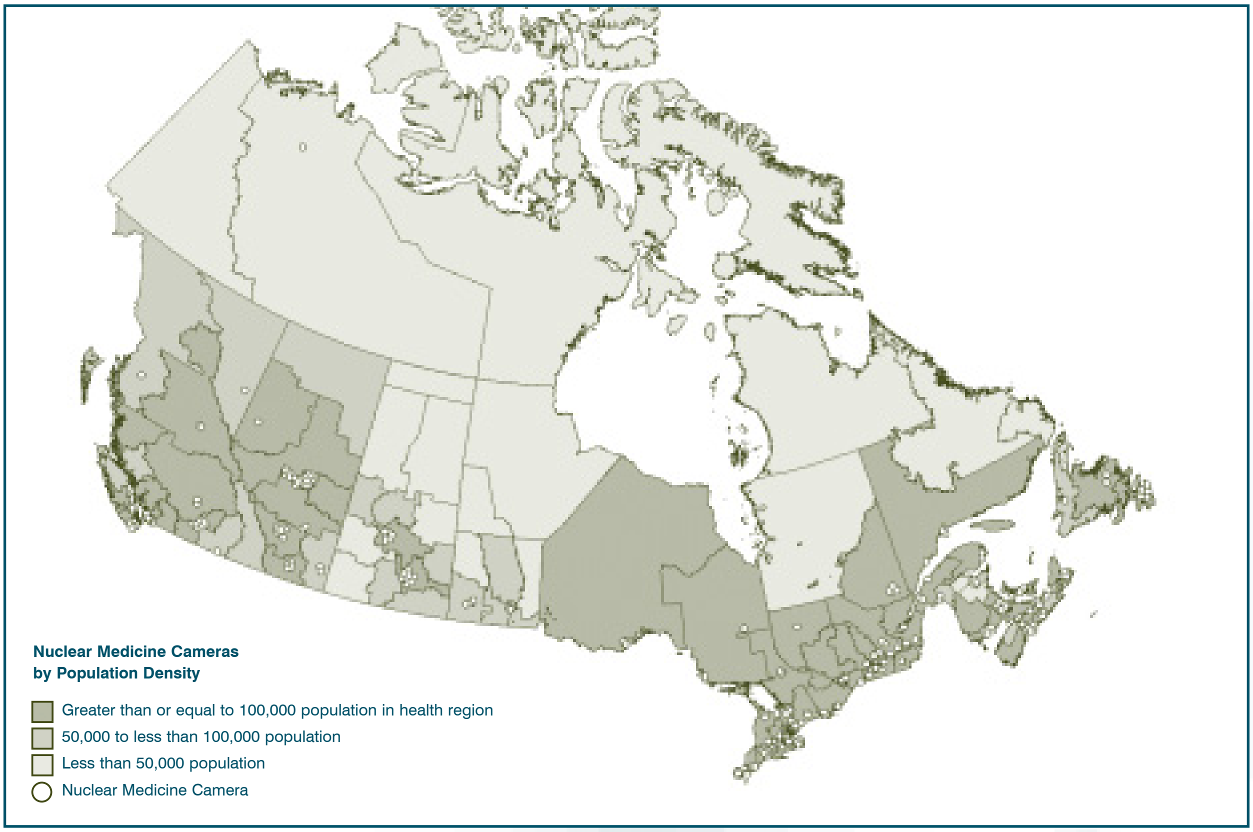
16 Nuclear Medicine Cameras in Hospitals Across Canada, 2003



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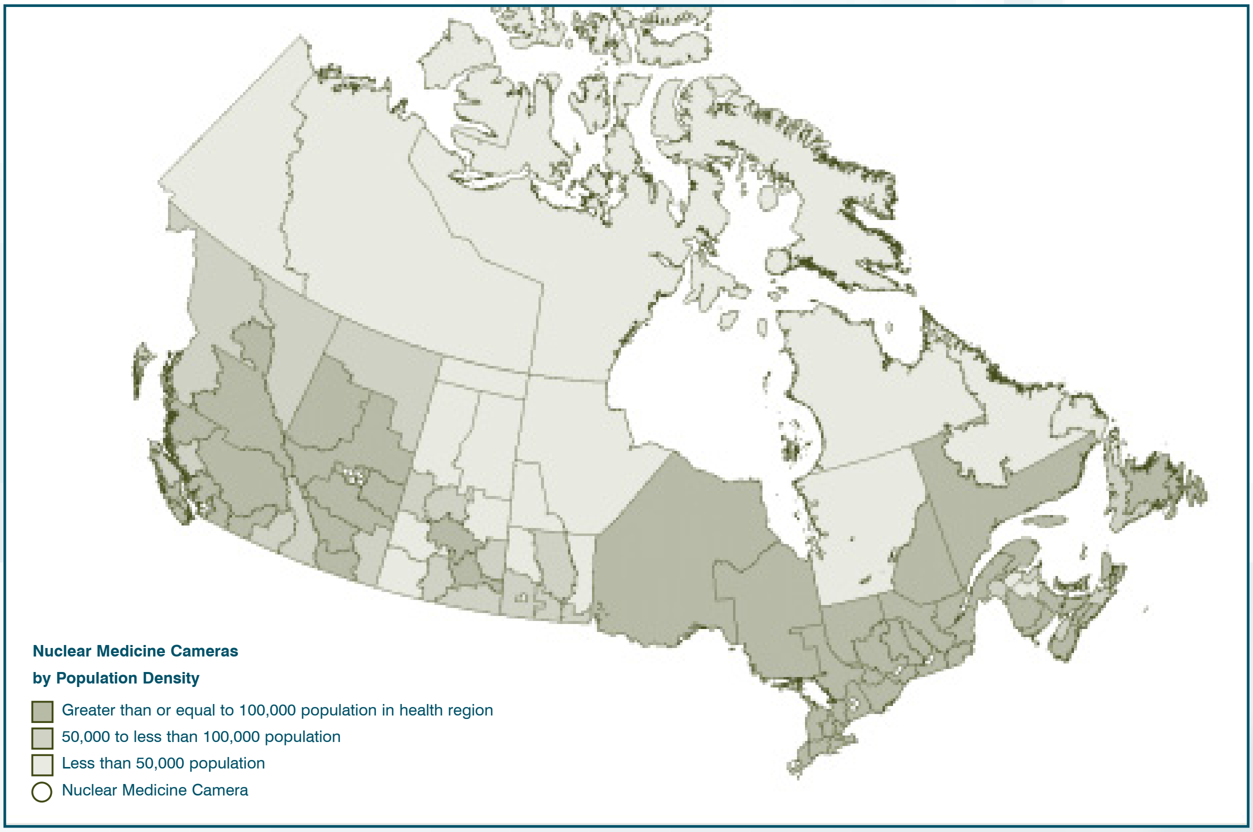
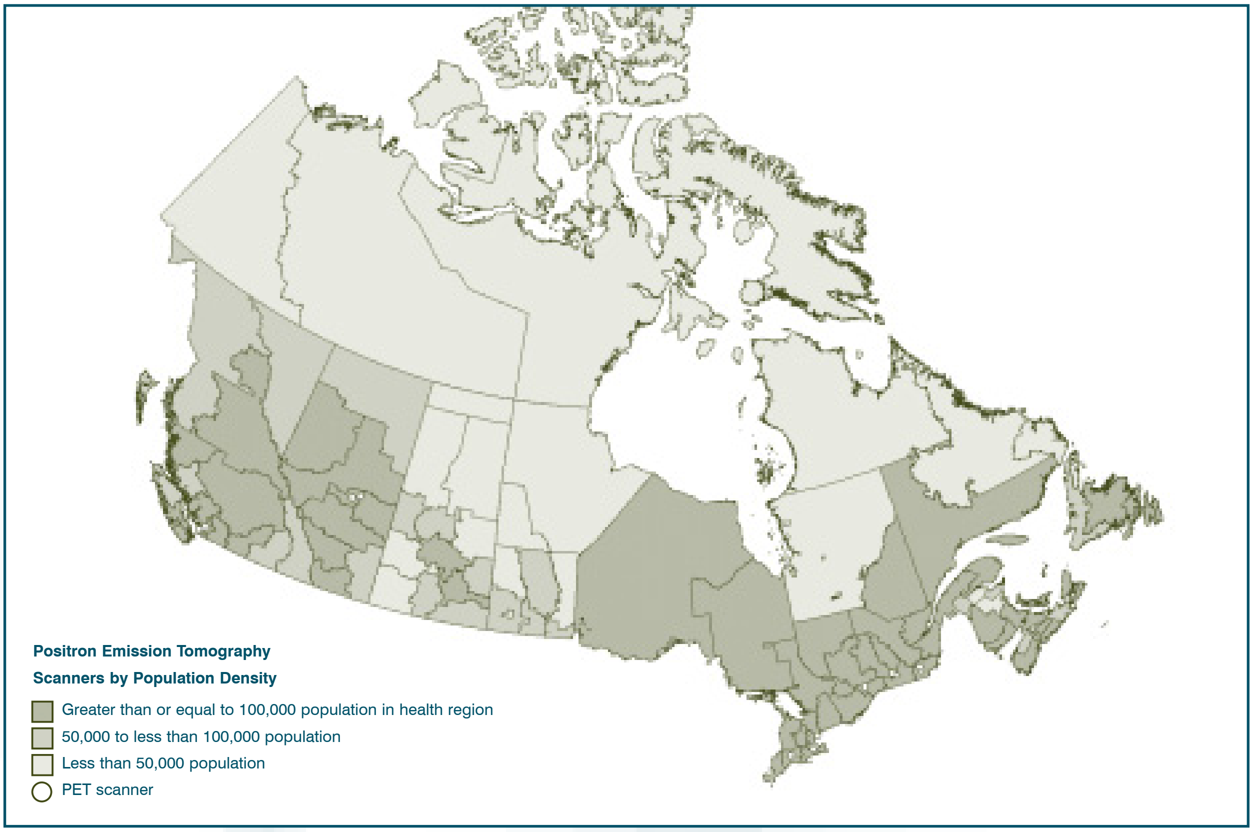
17 Nuclear Medicine Cameras in Free-Standing Imaging Facilities Across Canada, 2003



Source: National Survey of Selected Medical Imaging Equipment, CIHI, 2003

Positron Emission Tomography (PET) Scanners in Hospitals and in Free-Standing Imaging Facilities Across Canada, 2003



Source: National Survey of Selected Medical Imaging Equipment, CIHI, 2003

Appendix B: Glossary of Terms

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.

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

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, 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.

CAT: See Computed Tomography Scan

Computed Tomography Scan (CT) or Computed Assisted or Axial Tomography (CAT) Scan: A diagnostic technique that uses X-rays and computer technology to produce cross-sectional images (often called slices), both horizontally and vertically, of the body. 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.

CT: See Computed Tomography Scan

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.

Fluoroscopy: A study of moving body structures, similar to an 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.

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

Interventional Radiology: An area of specialty within the field of radiology which 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 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 (e.g. X-ray, ultrasound, CT scan, MRI).

MRI: See Magnetic Resonance Imaging

MRS: See Magnetic Resonance spectroscopy

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.

PACS: See Picture Archiving and Communications System

PET: See Positron Emission Tomography

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, ultra violet (UV), and micro waves 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 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.

REM: See Roentgen Equivalent Man

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 only be used 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 rotates around the patient and takes pictures from many angles, which a computer then uses to form a tomographic (cross-sectional) image.

Sonography: See Ultrasound Imaging

SPECT: See Single Photon Emission Computed Tomography

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, or 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.

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