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How Good is Canada's Medical Technology Inventory?

Main Conclusions

- Canada lags many other developed nations in the size of its medical technology inventory.
- The age and sophistication of medical technology determine the quality of available services. Outdated and unsophisticated equipment is qualitatively much different from relatively new and highly sophisticated medical equipment.
- Canada has far too many older, outdated, and possibly unreliable medical technologies currently in operation, and too few newer technologies. The situation is particularly alarming for bone densitometers, angiography suites, lithotripsy units, and cardiac catheterization labs.
- The medical technology inventory in Canada's free-standing facilities is generally newer (with the notable exception of bone densitometers and MRI) than in hospitals. Nevertheless, both Canada's hospitals and its free-standing facilities could be replacing older equipment more aggressively, which would benefit both patients and health care providers.
- Canada's inventory of medical technologies is less sophisticated than might be considered optimal. For example, many of Canada's CT scanners are unable to provide the clinical benefits and more comfortable and less invasive screening services offered by newer, more advanced models. Further, much of Canada's inventory cannot digitally archive and communicate images.
- These findings are particularly alarming given that the federal government transferred $3 billion to the provinces in an effort to improve the availability of medical technology in Canada between 2000 and 2004, and that Canada maintains one of the developed world's most expensive universal-access health care systems.

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Introduction

Medical technologies are an important component of medical care and can provide significant benefits to patients. Medical technologies can advance the identification and treatment of disease, provide more comfortable treatment regimes and reduce pain, offer new treatment options where none previously existed, and provide a safer environment for both patients and providers. Put simply, advanced and sophisticated medical technologies improve health outcomes and the quality of life for patients fortunate enough to have access to them.

Numerous reports and studies have shown that Canada lags many other developed nations in the size of its medical technology inventories (see, for example, OECD, 2008; and Esmail and Wrona, 2008). Notably, this is occurring in spite of $3 billion in targeted federal transfers to Canada's provincial governments, and in spite of the fact that Canada maintains one of the developed world's most expensive universal-access health insurance programs (Esmail and Wrona, 2008; Esmail and Walker, 2007). The lack of access to advanced medical technologies can seriously affect the comfort of patients undergoing treatment, the success of the treatment, and patient longevity and quality of life following treatment (Esmail and Wrona, 2008).

Apart from the size of medical technology inventories, their age and sophistication are also important because they determine the quality of available services. Relative to their newer counterparts, older medical technologies are generally less reliable and need more maintenance, may provide a lower quality output or be less accurate, may be less safe for patients and operators, and may expose patients to greater risk. Newer, more sophisticated medical technologies can allow for shorter examination or operation times, higher quality output, and can provide additional services.

Esmail and Wrona (2008) analyzed the Canadian Institute for Health Information's [CIHI] *National Survey of Selected Medical Imaging Equipment* in order to determine the age and sophistication of medical technologies in Canada. This Alert updates that analysis using the latest edition of the CIHI survey (2008a). The survey data, available on the CIHI website (www.cihi.ca), provides the location, age, and select specifications of:

- 398 CT scanners in hospitals and 21 CT scanners in free-standing facilities,[1]
- 10 PET scanners and 16 PET/CT scanners in hospitals, and 2 PET/CT scanners and 3 PET scanners in free-standing facilities,
- 187 MRI machines in hospitals and 38 MRI machines in free-standing facilities,[2]
- 350 SPECT scanners and 16 SPECT/CT scanners[3] in hospitals and 27 SPECT scanners in free-standing facilities,
- 214 gamma cameras in hospitals and 12 gamma cameras in free-standing facilities,
- 19 lithotriptors/lithotripsy units in hospitals,
- 178 angiography suites in hospitals and 1 in a free-standing facility,
- 118 cardiac catheterization labs in hospitals, and
- 106 bone densitometers in hospitals and 19 in free-standing facilities.[4]

The inventory of Canada's medical technologies is compared to guidelines published by Ontario's Expert Panel on MRI and CT, by the Canadian Association of Radiologists, and by the European Coordination Committee of the Radiological and Electromedical Industries. The comparisons indicate whether or not Canada's current, limited inventory of medical technologies is up to date and relatively sophisticated. The comparisons give some insight into the investment in new technology and the replacement of older, outdated equipment by Canada's health care system.

The analyses below treat medical equipment located in hospitals separately from equipment in free-standing facilities; it is important to separate these two classifications because in-hospital technologies are generally available to patients through taxpayer-funded health care programs, while equipment in free-standing facilities is not always available through these channels.

Age of equipment

The age of medical equipment is important for a number of reasons. Older and outdated equipment has a higher risk of failing or breaking down, which may disrupt imaging services (CAR, 2000). Further, it may be increasingly difficult to obtain spare parts for older equipment. Older machines can also produce poorer quality images (CAR,

Box 1: Descriptions of select medical technologies examined in this Alert

CT (Computerized Axial Tomography)—CT is a painless x-ray test in which a computer generates cross-sectional views of a patient's anatomy. It can identify normal and abnormal structures, and it can be used to guide procedures. 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.

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

PET (Positron Emission Tomography)— a highly specialized imaging technique that uses short-lived radioactive substances. This technique produces three-dimensional colored images. Unlike CT and MRI, which look at anatomy or body form, PET studies metabolic activity or body function. PET scanning has been used primarily to evaluate problems of the heart and nervous system and to demonstrate the spread of cancer.

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 for the purpose of diagnosing and treating disease.

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

SPECT (Single Photon Emission Computed Tomography)—a nuclear medicine procedure in which a gamma camera rotates around the patient to produce images from many angles, which a computer then uses to form a tomographic (cross-sectional) image.

PET/CT and SPECT/CT—These newer fusion technologies combine functional and anatomical imaging from SPECT or PET and CT in the same display.

Lithotriptor—a machine that is used to shatter kidney stones and gallstones by physical or other means, such as with shock waves.

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.

Cardiac catheterization—a form of coronary angiography used to take an image of 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.

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

PACS (Picture Archiving and Communications Systems)—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.

Sources: CIHI, 2008b; Webster's *New World Medical Dictionary*, 3rd ed.

2000). Ultimately, older equipment might be considered less reliable and less clinically useful than newer equipment.

Various organizations have developed standards for evaluating the age of medical equipment. Guidelines from two such organizations are considered in the analysis of Canada's technology inventory below: those published by the European Coordination Committee of the Radiological and Electromedical Industries and those published by the Canadian Association of Radiologists.

European Coordination Committee of the Radiological and Electromedical Industries

The rules published by the European Coordination Committee of the Radiological and Electromedical Industries (ECCREI) for the evaluation of medical equipment can be found in a report by Ontario's Expert Panel on MRI and CT (Keller, 2005). The guidelines divide the age of equipment into 3 categories. As table 1 shows, equipment up to 5 years old is considered to reflect the current state of technology, and the rules state that at least 60 percent of the installed equipment should fall within this category. Equipment 6 to 10 years old is still fit for use, but replacement strategies must be developed for it; the ECCREI rules state that not more than 30 percent of the installed equipment base should be in this category. Technologies older than 10 years are considered to be no longer "state-of-the art," and the ECCREI rules state that it is

Table 1: Rules from the European Coordination Committee of the Radiological and Electromedical Industries for evaluating medical equipment

Age	Rules
Up to 5 years old	• Reflects current state of technology • Offers economic and reasonable upgrade measures • At least 60% of the installed equipment base should be younger than 5 years
6-10 years old	• Still fit for use but requires replacement strategies to be developed • Not more than 30% of the installed equipment base should be between 6 and 10 years old
Older than 10 years	• No longer state-of-the-art technology • Not more than 10% of the installed base can be tolerated to be older than 10 years • Replacement is essential

Source: European Coordination Committee of the Radiological and Electromedical Industries in Keller, 2005: 38.

essential that this equipment be replaced. Not more than 10 percent of the installed equipment should be older than 10 years.

A careful examination of the age of Canada's medical technologies, using these standards to stratify technologies into three distinct groups (current state of technology; still fit for use but should be replaced soon; and no longer "state-of-the-art") is shown in tables 2a and 2b (hospital-based technologies) and 3 (clinic-based technologies). The tables lead to the inevitable conclusion that far too many of Canada's medical technologies are outdated and in need of replacement. Further, a sizable proportion of the inventory should be replaced in the next few years.

Consider that while the ECCREI guidelines state that not more than 10 percent of the installed inventory should be more than 10 years old, nearly 21 percent of hospital-based bone densitometers, nearly 29 percent of hospital-based SPECT units, more than 34 percent of hospital-based gamma cameras, nearly 32 percent of hospital-based lithotriptors, more than 24 percent of hospital-based angiography suites, and 28 percent of hospital-based cardiac catheterization labs were more than 10 years old at the start of 2007 (see tables 2a and 2b).[5]

Equally importantly, Canada's hospital-based inventories of bone densitometers, MRI machines, SPECT units, gamma cameras, lithotriptors, angiography suites, and cardiac catheterization labs have all failed to reach the ECCREI's 60 percent threshold for newer machines (0-5 years old).

Canada's clinics generally seem to outperform Canada's hospitals under the ECCREI guidelines. Specifically, compared with Canada's hospitals, a smaller proportion of the inventories of all types of medical technologies in Canada's clinics was over 10 years old. In fact, hospitals outperformed clinics only in relation to the proportion of bone densitometers between 0 and 5 years of age in (40.6 percent in hospitals, 26.3 percent in clinics). That noted, an analysis of the clinic-based inventory finds a sizable collection of relatively old gamma cameras (16.7 percent over 10 years old), and ageing bone denistometers (73.7 percent between 6 and 10 years old) (see table 3). Further, clinics failed to reach the ECCREI's 60 percent threshold for newer machines in their inventories of bone densitometers, MRI machines, and SPECT units (see table 3).

Canadian Association of Radiologists

Another set of guidelines for the appropriate age of medical technologies comes from the Canadian Association of Radiologists (CAR). Their recommended lifecycle guidelines for select technologies can be found in *The Province-wide Diagnostic Imaging Review and Framework for Strategic Planning* report for the Saskatchewan Department of Heath (ProMed Associates Ltd., 2004). Table 4 lists these guidelines and provides a slightly different set of standards by defining the maximum life expectancy of machines. As the report notes, "When machines exceed their maximum life expectancy, concerns arise related to equipment age, availability of parts, utilization capabilities, upgrade ability, clinical relevance, operational reliability and

Table 2a: The age of Canada's hospital-based medical technology inventories, relative to the rules from the European Coordination Committee of the Radiological and Electromedical Industries, January 1, 2007

	ECCREI rules	Hospital-based inventories					
		Bone density	CT	SPECT/CT	PET/CT	PET	All PET capable
Number of units	N/A	106	398	16	16	10	26
0-5 years old	At least 60% of the installed equipment base should be younger than 5 years	40.6%	66.3%	100.0%	100.0%	60.0%	84.6%
6-10 years old	Not more than 30% of the installed equipment base should be between 6 and 10 years old	38.7%	26.9%	0.0%	0.0%	0.0%	0.0%
> 10 years old	Not more than 10% of the installed base can be tolerated to be older than 10 years	20.8%	6.8%	0.0%	0.0%	40.0%	15.4%
Age of oldest machine(s) (years)	N/A	17	16	5	5	16	16

Sources: Keller, 2005: 38; CIHI, 2008a; calculations by author.

Table 2b: The age of Canada's hospital-based medical technology inventories, relative to the rules from the European Coordination Committee of the Radiological and Electromedical Industries, January 1, 2007

	ECCREI rules	Hospital-based inventories					
		MRI	SPECT	Gamma cameras	Litho-triptors	Angio. suites	Cardiac cath. labs
Number of units	N/A	187	350	214	19	178	118
0-5 years old	At least 60% of the installed equipment base should be younger than 5 years	54.5%	33.7%	38.3%	36.8%	40.4%	43.2%
6-10 years old	Not more than 30% of the installed equipment base should be between 6 and 10 years old	37.4%	37.7%	27.6%	31.6%	35.4%	28.8%
> 10 years old	Not more than 10% of the installed base can be tolerated to be older than 10 years	8.0%	28.6%	34.1%	31.6%	24.2%	28.0%
Age of oldest machine(s) (years)	N/A	22	25	26	21	45	19

Sources: Keller, 2005: 38; CIHI, 2008a; calculations by author.

Table 3: The age of Canada's free-standing facility-based medical technology inventories, relative to the rules from the European Coordination Committee of the Radiological and Electromedical Industries, January 1, 2007

	ECCREI rules	Free-standing facility-based inventories							
		Bone density	CT	PET/CT	PET	MRI	SPECT	Gamma cameras	Angio. suites
Number of units	N/A	19	21	2	3	38	27	12	1
0-5 years old	At least 60% of the installed equipment base should be younger than 5 years	26.3%	71.4%	100.0%	66.7%	57.9%	44.4%	75.0%	0.0%
6-10 years old	Not more than 30% of the installed equipment base should be between 6 and 10 years old	73.7%	28.6%	0.0%	33.3%	42.1%	48.1%	8.3%	0.0%
> 10 years old	Not more than 10% of the installed base can be tolerated to be older than 10 years	0.0%	0.0%	0.0%	0.0%	0.0%	7.4%	16.7%	100.0%
Age of oldest machine(s) (years)	N/A	10	9	1	7	10	17	21	12

Source: Keller, 2005: 38; CIHI, 2008a; calculations by author.

performance, safety, redundancy, serviceability, and increased operational costs" (ProMed Associates Ltd., 2004: 72).

Put succinctly, machines past their lifecycle guideline can be unreliable and can have limited clinical relevance.

Canadians should be particularly concerned then that more than 48 percent of hospital-based bone densitometers,[8] nearly 12 percent of hospital-based CT scanners, nearly 30 percent of hospital-based MRI machines, nearly 29 percent of hospital-based SPECT scanners, more than 34 percent of hospital-based gamma cameras, more than 42 percent of hospital-based lithotriptors, nearly 46 percent of hospital-based angiography suites, and nearly 42 percent of hospital-based cardiac catheterization labs were beyond their life expectancy at the start of 2007 (see table 5).

Not only has much of the equipment exceeded its life expectancy, but in some cases, a sizable additional proportion is nearing its lifecycle guideline. One notable example is Canada's hospital-based inventory of MRI machines, where another 29 MRI machines (16 percent of the inventory) were six years old at the start of 2007. Similarly, 7.6 percent of cardiac catheterization labs had reached their life expectancy at the beginning of 2007, as had 11.3 percent of hospital-based bone densitometers.

Across all of Canada's hospital-based technologies for which data is available from CIHI (except PET scanners), 29.0 percent (464 of

Table 4: The 2001 Canadian Association of Radiologists' lifecycle guidelines for selected technologies

Equipment	Years After which Equipment is Regarded as Outdated
General Radiography Unit	5-10
General Radiography Mobile	5-10
General Radiography Tomography	5-10
Fluoroscopic R/F	5-10
Mobile Fluoroscopic C-Arms	5-10
Angiographic Suites	7
Cardiac Catheterization Labs	7
CT	8
MRI	6
Ultrasound	6
Nuclear Medicine (including SPECT and Gamma Cameras[1])	10
Bone Density	6
Urology	10
Mammography	5-7
Lithotriptor	7

[1] At the time these guidelines were published, Nuclear Medicine included SPECT and Gamma Cameras but not PET (Esmail and Wrona, 2008).
Source: ProMed Associates Ltd., 2004: 72.

1,602 units) was beyond its CAR lifecycle guideline at the beginning of 2007. This means that about 3 out of every 10 units were due to be replaced at the start of 2007.

Free-standing facilities fared somewhat better than hospitals for some technologies, but worse for others, according to the CAR standards. Specifically, more than 68 percent of clinic-based bone densitometers, nearly 10 percent of clinic-based CT scanners, nearly 37 percent of clinic-based MRI scanners, more than 7 percent of clinic-based SPECT scanners, and nearly 17 percent of clinic-based gamma cameras were past their CAR lifecycle guideline at the start of 2007 (see table 6).

Advanced age of some medical technologies

Perhaps most startling is the advanced age of some medical technologies still in use in Canada. As shown in tables 2a, 2b, and 3 as well as tables 5 and 6, at the start of 2007 some of Canada's medical technologies had been in service well over two decades; some machines even longer than that. For example, in early 2007, Canada's oldest angiography suite, which had started operating in the early 1960s, was 45 years old. This compares to the ECCREI standard that machines over a decade old are no longer state-of-the-art and should be replaced, and to the lifecycle guidelines from the Canadian Association of Radiologists that range from 6 to 10 years.

Clearly, Canada is currently operating far too many older, outdated, and possibly unreliable medical technologies. The situation is particularly alarming for bone densitometers, angiography suites, lithotripsy units, and cardiac catheterization labs. The medical technology inventory in Canada's free-standing facilities is generally newer (with the notable exceptions of bone densitometers and MRI), suggesting that these facilities are better at updating their equipment. Nevertheless, Canada's hospitals and free-standing facilities could clearly be doing much more to replace older equipment.

Other surveys

These findings also apply to medical technologies beyond the nine considered here. For example, Pommerville et al. (2004), in a report discussing the findings of two Canada-wide surveys conducted by the Canadian Urological Association in 2003, discovered that older urology equipment was all too common in Canada's hospitals. According to their survey results, 26.2 percent of respondents[9] reported the cystoscopy tables at their centres were over 15 years old, and 22.8 percent of respondents reported their cystoscopes[10] were over 15 years old. Pomerville et al. (2004) concluded that these data

Table 5: The age of Canada's hospital-based medical technology inventories, relative to CAR guidelines, January 1, 2007

	Bone density	CT	SPECT/ CT	PET/CT	MRI	SPECT	Gamma cameras	Litho- triptors	Angio. suites	Cardiac cath. labs
Number of units	106	398	16	16	187	350	214	19	178	118
CAR Lifecycle Guideline	6 years	8 years	8 years (CT)	8 years (CT)	6 years	10 years	10 years	7 years	7 years	7 years
Percent beyond guideline	48.1%	11.6%	0.0%	0.0%	29.9%	28.6%	34.1%	42.1%	45.5%	41.5%
Age of oldest machine(s) (years)	17	16	5	5	22	25	26	21	45	19

Sources: ProMed Associates Ltd., 2004: 72; CIHI, 2008a; calculations by author.

Table 6: The age of Canada's free-standing facility-based medical technology inventories, relative to CAR guidelines, January 1, 2007

	Bone density	CT	PET/CT	MRI	SPECT	Gamma cameras	Angio. suites
Number of units	19	21	2	38	27	12	1
CAR Lifecycle Guideline	6 years	8 years	8 years (CT)	6 years	10 years	10 years	7 years
Percent beyond guideline	68.4%	9.5%	0.0%	36.8%	7.4%	16.7%	100.0%
Age of oldest machine(s) (years)	10	9	1	10	17	21	12

Sources: ProMed Associates Ltd., 2004: 72; CIHI, 2008a; calculations by author.

"suggest an important deficit in the updating of some of the basic tools for urology practice" (p. 2295).

A survey conducted by the Canadian Association of Radiologists in 2000 on the age of medical technologies found that 50.3 percent of Canada's diagnostic imaging units had exceeded their useful life as of September 2000 (CAR, 2000). Further, just one third of the equipment offered any potential for future upgrades. The report broke down its findings on the prevalence of outdated technology and reported that the following proportion of units were outdated: 63 percent of general X-ray equipment, 50 percent of mobile X-ray units, 63 percent of fluoroscopy x-ray equipment, 50 percent of angiography x-ray equipment, 53 percent of ultrasound equipment, 32 percent of mammography units, 34 percent of nuclear medicine equipment, 39 percent of CT scanners, and 30 percent of MRI units (CAR, 2000).

A 2004 province-wide review of diagnostic imaging for the Saskatchewan Department of Health also reported a high prevalence of older and outdated diagnostic imaging technologies (ProMed Associates Ltd., 2004). The report found that 55 percent of the 380 imaging devices in public facilities were over 10 years old. The average age of imaging devices in Saskatchewan's public facilities was 12.0 years, though some imaging units were well over 25 years old (ProMed Associates Ltd., 2004).

The unavoidable truth regarding the state of Canada's medical technology inventories is that there are far too many old and outdated machines being used to diagnose and treat the ailments of Canadians, which should be considered a failure of the Canadian health care model.

Sophistication of equipment

The age of the equipment is not the only measure by which to judge the quality of Canada's current limited inventory of medical technologies. Equipment sophistication is also important; newer, more sophisticated machines can produce faster, higher quality scans than older equipment. Newer machines can also provide more services than older, less sophisticated devices, which can improve the patient experience and, potentially, improve diagnosis and results.

The Canadian Institute for Health Information's (CIHI) *National Survey of Selected Medical Imaging Equipment* (2008a) provides select specifications for some of Canada's medical technologies. These specifications can be compared with recommendations for the sophistication of medical technologies published by Ontario's Expert Panel on MRI and CT (Keller, 2005). Such a comparison finds that Canadians are, in many cases, receiving diagnosis and treatment from equipment that might be sub-standard at delivering the latest advancements in care along with the most comfortable and highest quality services.

CT scanners

The sophistication of CT scanners[11] is partly determined by whether the scanners are "spiral" or "non-spiral" in design. Older, non-spiral CT scanners require that patients be moved through the scanner incrementally (the scanner takes an image or "slice" of data, stops rotation/image acquisition, moves the patient forward a distance equal to a slice of data, and then restarts rotation to take the next slice of data). Newer, spiral CT scanners allow the patient to be moved continuously as the CT scanner rotates and captures data. The result is that images are acquired more rapidly, artefacts due to movement are reduced (and thus the scans are sharper and better quality), and image resolution is increased (CIHI, 2005).

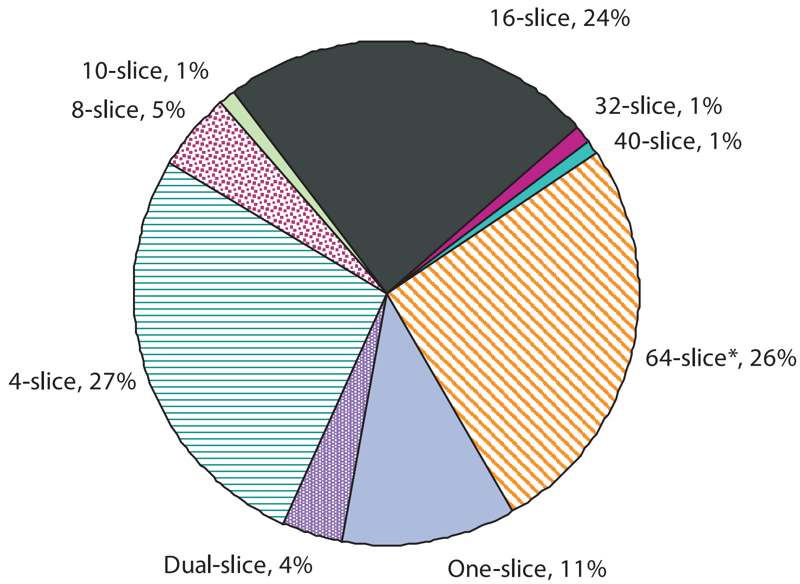
The unavoidable truth regarding the state of Canada's medical technology inventories is that there are far too many old and outdated machines being used to diagnose and treat the ailments of Canadians, which should be considered a failure of the Canadian health care model.

At the start of 2007, 9.5 percent of Canada's hospital-based inventory of CT scanners was older, non-spiral machines, and 6.3 percent of Canada's hospital-based PET/CT scanners was the older type.[12] Clearly, while the large majority of Canada's hospital-based CT scanners were spiral units, the inventory of non-spiral units in Canada's hospitals was not insignificant.

Canada's free-standing facility-based scanners fared worse by this measure. At the start of 2007, 19.0 percent of these CT scanners were the older, non-spiral design, though the 2 free-standing facility-based PET/CT scanners were spiral machines.

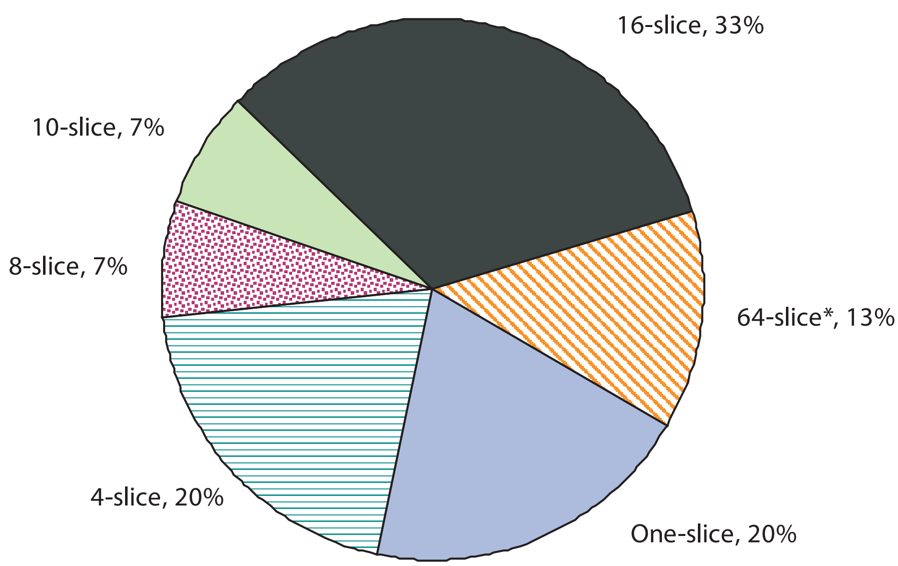
Among spiral scanners (90.5 percent of hospital-based scanners, 81 percent of free-standing facility-based CT scanners, and 93.8 percent of hospital-based PET/CT scanners), CT scanners can be further divided into "single-slice" or newer generation "multi-detector" or "multi-slice" units. The newer units allow multiple image slices to be taken simultaneously, making them faster (so more patients can be scanned in a given time frame), and allowing them greater detection capacity (CIHI, 2005; Keller, 2005). According to CIHI, the clinical advantages of multi-detector units include more efficient use of contrast media, replacement of more invasive procedures, and better spatial resolution. Multi-slice CT scanners can also be used for paediatrics, geriatrics, bariatrics (a field of

Figure 1: Inventory of hospital-based multi-slice CT scanners in Canada, by number of slices, January 1, 2007



*Minimum standard for CT scanners in Ontario according to Ontario's Expert Panel on MRI and CT (Keller, 2005).
Note: Data reported for 359 CT scanners
Source: CIHI, 2008b.

Figure 2: Inventory of clinic-based multi-slice CT scanners in Canada, by number of slices, January 1, 2007



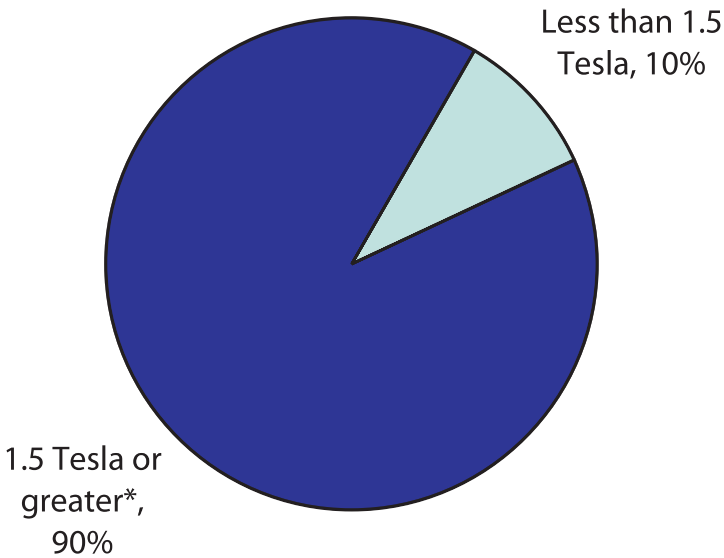
*Minimum standard for CT scanners in Ontario according to Ontario's Expert Panel on MRI and CT (Keller, 2005).
Note: Data reported for 15 CT scanners
Source: CIHI, 2008b.

medicine dealing with obesity), and cardiology (CIHI, 2005: 20).[13]

Among multi-slice CT scanners, there are also newer, more advanced machines. Specifically, multi-slice CT machines can range from older, slower, dual-slice units to the latest and most advanced 64-slice units. Next-generation 256-slice units are already being tested and likely will be available soon. Importantly, innovative and non-invasive diagnostic procedures such as CT colonoscopy and CT coronary angiography can only by performed with the newer and quicker multi-slice scanners (Keller, 2005). Advanced, multi-slice CT scanners enable arteries to be imaged, allowing patients to avoid invasive catheter angiography, which in turn results in less blood contamination and fewer of the complications that can arise from the insertion of medical tools and implements into arteries. The newer, faster machines are also better for children (minimizing or eliminating sedation altogether), allow for quicker treatment due to reduced imaging time, and reduce the doses of x-rays patients face (Zeidenberg, 2005). Importantly, Ontario's Expert Panel on MRI and CT believes that all CT centers should at least be capable of performing angiographies and brain perfusion studies, both of which require more advanced multi-slice machines, and that 64-slice should be the minimum standard for CT scanners in Ontario (Keller, 2005: 36).

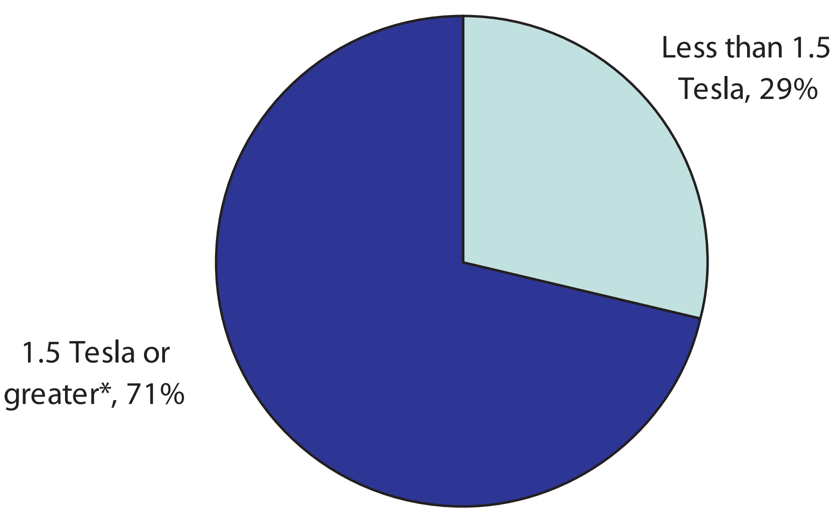
CIHI's research document *Medical Imaging in Canada 2007* (CIHI, 2008b), notes that of the 359 hospital based CT scanners for which the number of slices was reported in the survey, 11 percent were one-slice

Figure 3: Inventory of hospital-based MRI scanners in Canada, by magnetic field strength, January 1, 2007



*Minimum standard for MRI scanners in Ontario according to Ontario's Expert Panel on MRI and CT (Keller, 2005).
Source: CIHI, 2008a; calculations by author.

Figure 4: Inventory of clinic-based MRI scanners in Canada, by magnetic field strength, January 1, 2007



*Minimum standard for MRI scanners in Ontario according to Ontario's Expert Panel on MRI and CT (Keller, 2005).
Note: Information was not reported for an additional 3 MRI scanners in free-standing facilities.
Source: CIHI, 2008a; calculations by author.

units, 4 percent were older and slower dual-slice scanners, 27 percent were 4-slice scanners, 5 percent were 8-slice scanners, 1 percent were 10-slice scanners, 24 percent were 16-slice scanners, 1 percent were 32-slice and 40-slice scanners each, and 26 percent were 64-slice scanners (CIHI, 2008b) (see figure 1). In other words, about three-quarters of Canada's hospital-based CT scanners fell short of the standard set by Ontario's Expert Panel on MRI and CT.

Compared to the hospital-based inventory, Canada's free-standing facility-based scanners were less likely to be the advanced 64-slice variety. Specifically, of the 15 scanners for which the number of slices was reported in the survey, 20 percent were one-slice units, 20 percent were 4-slice scanners, 7 percent were 8-slice scanners, 7 percent were 10-slice scanners, 33 percent were 16-slice scanners, and 13 percent were 64-slice scanners (CIHI, 2008b) (see figure 2). Overall, only two of the 15 clinic-based CT scanners for which the number of slices was reported reached the 64-slice level of sophistication that Ontario's Expert Panel on MRI and CT judged to be the minimum standard for Ontario.

While 64-slice CT scanning services are available to some Canadians, many CT scanners in Canada are unable to provide the clinical benefits and more comfortable screening services offered by their more advanced counterparts. Specifically, among the 359 hospital-based CT scanners for which information on the number of slices is available from CIHI, only 26 percent met the 64-slice standard set by Ontario's

Expert Panel on MRI and CT. In free-standing facilities, only 13 percent of 15 machines for which information was reported met the standard.

MRI scanners

The sophistication of Canada's MRI inventory is initially determined by whether the machines are of "open-bore" or "closed-bore" design. A conventional, or closed-bore MRI machine uses a cylindrical magnet in which a patient lies still while an image is taken. The tunnel that houses the patient can be uncomfortable, especially for those who are claustrophobic (CIHI, 2005). In fact, because of patient reactions to claustrophobia, up to 10 percent of MRI examinations are cut short (Harriman et al., 1999). Conversely, wider and shorter open-bore MRI units do not enclose the patient inside a tunnel or casing; some of the latest open-bore units are open on all sides around the patient (CIHI, 2005). Open-bore MRI units not only make it easier to examine claustrophobic patients, but also increase access to MRIs for children, who often cannot remain still in the closed units, and obese individuals, who may be too big or heavy to fit into the tunnel of a conventional MRI.

CIHI data suggest that Canadians do not have easy access to open- bore MRI units. At the beginning of 2007, only 4 (2 percent) of Canada's 187 hospital-based MRI scanners were open bore units. Canada's free-standing facility-based MRI units measured up a little better: 5 (13 percent) of the 38 units were open-bore machines. (Information was not reported for an additional 3 MRI units in free-standing facilities.)

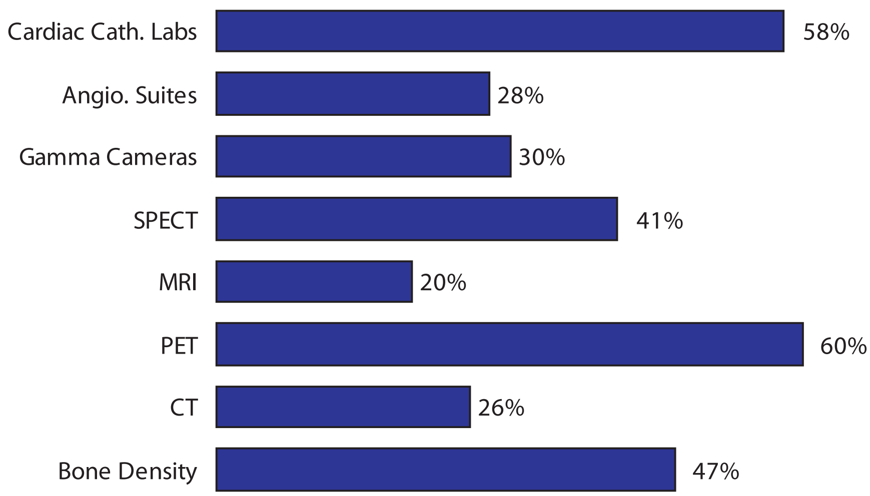
Field strength is a second measure of the sophistication of Canada's MRI scanners. Generally, higher magnetic field strengths (measured in tesla), allow better quality images to be acquired faster (CIHI, 2005). Further, MRI machines with higher field strengths are capable of performing newer tasks, such as functional imaging, angiography, and molecular imaging, as well as spectroscopy (providing information on tissue biochemistry) (CIHI, 2005).[14]

Picture Archiving and Communications Systems (PACS) enable the digital storage, management, and distribution of images, which reduces or eliminates the need to physically store films, and reduces the handling of the films that are stored. An obvious benefit of PACS is that images can be viewed on demand from anywhere in the facility, or even in the world, once access to the image server is secure.

Ontario's Expert Panel on MRI and CT recommends that MRI machines in Ontario should have at least a 1.5 tesla magnet and be capable of performing perfusion studies[15] and angiography (Keller, 2005: 36). At the beginning of 2007, Canada's hospital-based MRI machines performed relatively well by this standard: 90 percent of scanner units had a field strength of 1.5 tesla or more (see figure 3). Canada's free-standing facility-based MRI units fared worse than the hospital-based inventory on this measure: 71 percent (27) of the 38 MRI units for which data were available had a field strength of 1.5 tesla or higher (see figure 4). (Information was not reported for an additional 3 MRI units in free-standing facilities.) In sum, 10 percent of Canada's hospital-based MRI scanners and 29 percent of Canada's clinic-based MRI scanners for which data were available fell short of the field strength recommendation of 1.5 tesla by Ontario's Expert Panel on MRI and CT.

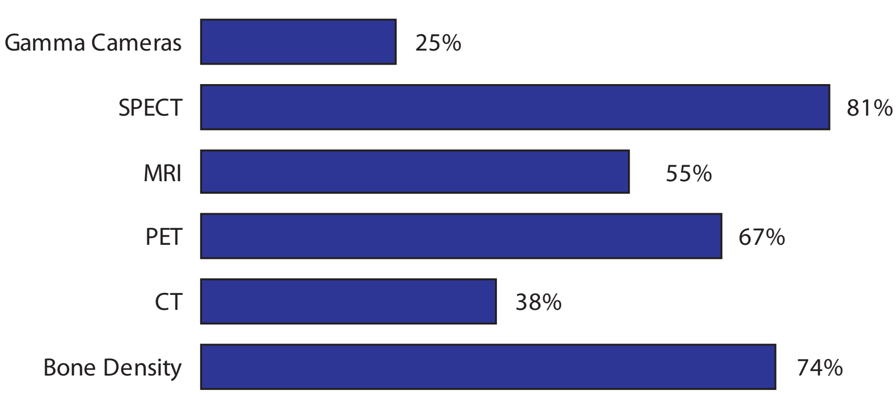
It should be noted that an MRI's performance is determined by more than field strength. According to CIHI (2005), "current technology" (ie., design adaptations) have reduced some of the performance differences in the lower versus the higher field strength machines. However, in Canada, the hospital- based closed-bore MRI units with field strengths

Figure 5: Percent of hospital-based inventory operating without PACS at January 1, 2007



Source: CIHI, 2008a; calculations by author.

Figure 6: Percent of free-standing facility-based inventory operating without PACS at January 1, 2007



Source: CIHI, 2008a; calculations by author.

below 1.5 tesla are nearly 9.5 years old on average, while the free-standing facility-based closed-bore units are 6.2 years old on average, which suggests that many of the lower field-strength machines in Canada are not likely to be benefiting from these advances in design.

PACS

The use of Picture Archiving and Communications Systems (PACS) can serve as another measure of the sophistication of diagnostic technologies. PACS enables the digital storage, management, and distribution of images, which reduces or eliminates the need to physically store films, and reduces the handling of the films that are stored. An obvious benefit of PACS is that images can be viewed on demand from anywhere in the facility, or even in the world, once access to the image server is secure.

CIHI (2005) lists a number of efficiency gains that are possible when an institution implements PACS. According to *Medical Imaging in Canada 2005*, facilities that have switched to viewing images digitally have reduced their diagnostic turnaround times markedly, increased the use of their diagnostic equipment, simplified the processes by which images are handled and assessed, and reduced the number of staff associated with a given exam (CIHI, 2005). Furthermore, CIHI notes that another benefit of PACS is a reduction in the number of lost films (2005: 35).

With PACS, teleradiology (the viewing of images away from the location where the image was taken) is greatly simplified and is available at reduced cost as a result of on-demand digital access. Remote digital access allows radiologists in other time zones to provide interpretations of scans taken at odd hours, which allows local physicians to rest and work a more regular schedule, while patients benefit from a quicker turnaround time for their diagnostics (Wachter, 2006a and 2006b). For example, because of time-zone differences, a CT scan taken in the middle of the night in Toronto or Vancouver can be read by a radiologist in Europe or Asia (during their day) while the radiologists in Toronto or Vancouver are asleep.[16] An additional benefit for payers is a potential reduction in costs resulting from broader competition in interpretation services and a potential reduction in labour costs, transportation costs, and late-night/on-call/overtime costs. Similarly, if the scan is to be interpreted or reinterpreted in Canada, it can be done from the radiologist's home or office, thereby saving a trip to the hospital or facility, or the cost of having the physical images rushed to the interpreting physician. PACS can also reduce duplication of scans, consolidate the expertise of radiologists, and facilitate the transfer of patients from one institution to another by potentially simplifying and speeding up the transfer of diagnostic images (Keller, 2005). In addition, PACS can help accelerate the delivery of diagnoses and services to patients in remote communities by electronically connecting them and their care provider(s) with a radiologist or other physician with the required knowledge or expertise in another community, province, or even country.

Ontario's Expert Panel on MRI and CT has recommended that all hospitals providing MRI and/or CT scans have a PACS that is capable of sharing information across a standard platform (Keller, 2005: 28). According to CIHI (2008a), however, while much of Canada's inventory of medical technologies is operating with a PACS in place, some is also operating without. Specifically, among hospital-based technologies, 47 percent of bone densitometers, 26 percent of CT scanners, 60 percent of PET scanners, 20 percent of MRI machines, 41 percent of SPECT units, 30 percent of gamma cameras, 28 percent of angiography suites, and 58 percent of cardiac catheterization labs were operating without PACS (see figure 5).

Among free-standing facility-based technologies, 74 percent of bone densitometers, 38 percent of CT scanners, 67 percent of PET scanners, 55 percent of MRI machines (information was not reported for an additional 3 MRI units in free-standing facilities), 81 percent of SPECT units, and 25 percent of gamma cameras were operating without PACS (see figure 6). Canada's sole clinic-based angiography suite was operating without PACS (CIHI, 2008a).

CIHI further reports that 20 percent of all PET/CT scanners and 29 percent of all SPECT/CT scanners were operating without PACS (CIHI, 2008b).

Conclusion

CIHI's data on medical technology inventories reveals that Canada has far too many older, outdated, and possibly unreliable medical technologies currently in operation, and too few newer technologies. Canada's inventory of medical technologies is also often less sophisticated than might be considered optimal, meaning that Canadians frequently do not have access to the latest advances in medicine or the highest quality diagnostic services available even from the current limited inventory of technologies. Canada's health care system often fails to provide the quality of technology specified by the Canadian Association of Radiologists, the European Coordination Committee of the Radiological and Electromedical Industries, and by Ontario's Expert Panel on MRI and CT. These failures of the Canadian approach to health care policy are particularly alarming in light of the fact that Canada maintains one of the developed world's most expensive universal access health care systems (Esmail and Walker, 2007). Canada's health care system could be doing much more than it now is to replace older equipment. Doing so would clearly benefit both patients and health care providers.

Canada's inventory of medical technologies is also often less sophisticated than might be considered optimal, meaning that Canadians frequently do not have access to the latest advances in medicine or the highest quality diagnostic services available even from the current limited inventory of technologies.

Notes

1 According to CIHI, hospitals are defined as "[a]n institution where patients are accommodated on the basis of medical need and are provided with continuing medical care and supporting diagnostic and therapeutic services. Hospitals are licensed or approved as hospitals by a provincial/territorial government, or are operated by the Government of Canada and include those providing acute care, extended and chronic care, rehabilitation and convalescent care, psychiatric care" (CIHI, 2008a).

On the other hand, free-standing facilities "[r]ange from specialized services run privately by physicians, radiologists, dentists, chiropractors, or mammography programs to broad-based imaging centres offering a wide range of tests" (CIHI, 2008a).

2 Out of a total of 41 MRI scanners for which location information is provided in CIHI (2008a), age and select specifications are not available for 3.

3 Data for SPECT/CT scanners in Ontario were not available from CIHI (2008a). According to CIHI (2008b), the Ontario Ministry of Health and Long-Term Care reported 19 SPECT/CT scanners installed and operational in Ontario hospitals at July 31, 2008.

4 According to CIHI (2008b), the count of bone densitometers may be incomplete. Importantly, the bone densitometers included in CIHI (2008a) do not include units in hospitals and free-standing facilities which may have had these machines but were not contacted for the survey because of a lack of the other types of medical imaging equipment detailed above.

5 All data from the CIHI survey are as of January 1, 2007.

8 All findings relating to bone densitometers should be interpreted with caution. According to CIHI (2008b), the count of bone densitometers in CIHI (2008a) may be incomplete. Importantly, the bone densitometers included in CIHI (2008a) do not include units in hospitals and free-standing facilities which may have had these machines but were not contacted for the survey because of a lack of the other types of medical imaging equipment detailed above.

9 Survey respondents were academic and hospital leaders who were also members of the Canadian Urological Association.

10 A cystoscope is a thin telescope that is passed into the bladder via the urethra. It allows a doctor to examine and perform procedures on the inside of the bladder. See, for example, <http://www.qe2foundation.com/en/home/howyourgifthelps/currentneeds/default.aspx#CystoscopyTable>

11 The discussion here looks only at CT and PET/CT scanners as CIHI did not publish comparable information on SPECT/CT machines.

12 11 hospital-based CT scanners and 3 hospital-based PET/CT scanners were reported as multi-slice but were not reported as either spiral nor non-spiral. They are counted as spiral machines here.

The sole hospital-based PET/CT scanner reported to be a non-spiral machine was also reported to be a multi-slice machine.

13 At the start of 2007, only one of Canada's 360 hospital-based spiral CT scanners was not a multi-slice unit (note that the number of slices was reported for only 359 scanners in CIHI, 2008b). On the other hand, all of Canada's free-standing facility-based spiral CT scanners were reported to be multi-slice units, as was one of the scanners reported as non-spiral. The same was the case for Canada's hospital-based spiral PET/CT machines (all multi-slice, one non-spiral machine reported as multi-slice). Canada's two free-standing facility-based PET/CT scanners were also multi-slice units. One potential downside to the newer generation units is the higher doses of radiation to which patients are exposed during their scan, though manufacturers are making progress on this front (CIHI, 2005; CIHI, 2008b).

14 Over time, the field strength of MRI units has generally increased from 0.5 tesla and below in the 1980s, to 1.5 tesla in the mid- to late-1980s. To some extent, this trend was reversed internationally in the 1990s when a number of countries opted for machines with lower field strengths, even though MRI units of up to 2 tesla were available. In more recent years, field strengths of 3 tesla have been introduced in clinical applications. In the past, open-bore MRI units often had lower field strengths than conventional MRI units, but this discrepancy has diminished significantly as newer, high-field MRI units are available with field strengths of 1.5 tesla.

15 Perfusion is the degree of blood flow to the area of interest (Duke Clinical Research Institute website: <www.dcri.duke.edu>.)

16 This example is based on the one employed by Wachter (2006b) in a presentation discussing patients in Bangor, Maine, receiving CT scans that are interpreted by radiologists in Bangalore, India.

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