CADTH

The Canadian Medical Imaging Inventory, 2015

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[Authors]

[Preamble: to be added]

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ABBREVIATIONS

CIHI	Canadian Institute of Health Information
CT	computed tomography
MRI	magnetic resonance imaging
PACS	picture archiving and communication system
PET	positron emission tomography
PET-CT	positron emission tomography-computed tomography
PET-MRI	positron emission tomography-magnetic resonance imaging
SPECT	single-photon emission computed tomography
SPECT-CT	single-photon emission computed tomography-(X-ray) computed tomography

INTRODUCTION

In Canada, medical imaging (MI) is a vital service within our healthcare system, providing the basis for diagnosis, staging, and monitoring in a variety of diseases and conditions. Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Single-photon Emission Tomography (SPECT), and Positron Emission Tomography (PET), have become commonplace in medical imaging departments across Canada. In recent years, hybrid technologies such as SPECT-CT, PET-CT, and PET-MRI have further expanded the MI repertoire. Other recent innovations include techniques that provide higher quality imaging, lower radiation doses, faster examinations, and greater integration of imaging with procedures, enabling targeted interventions and delivery of therapy.

As imaging modalities advance, decision-makers and clinicians face complex choices about which MI technologies to employ. Each offers unique characteristics, advantages, and disadvantages. Furthermore, advancement and implementation occurs with the context of a finite healthcare budget and limited availability of clinical and technical expertise. Conversely, overuse of imaging studies has been highlighted by Choosing Wisely Canada[1,2] and is associated with risks beyond cost such as unnecessary exposure to radiation, unnecessary treatment, and inconvenience to patients.

Given these considerations, it is critical that there is current information regarding the status of MI equipment in Canada. In 2001, CADTH (then the Canadian Coordinating Office for Health Technology Assessment) conducted its first inventory of diagnostic imaging equipment in Canada. From 2003 to 2012 the Canadian Institute of Health Information continued to collect data on the inventory and use of diagnostic imaging equipment.[3-5] In 2015 CADTH resumed work on the inventory to meet the ongoing need. This report summarizes the findings of the 2015 iteration.

Data were collected on six modalities: CT, MRI, SPECT, PET-CT, PET-MRI, and SPECT-CT. Brief introductions to each of these modalities follow. These six were given priority over several modalities captured in previous iterations of the survey (angiography units, cardiac catheterization units, bone densitometers and lithotripters).[3-5] We limited the scope because of feasibility in our initial cycle, and because feedback indicated that the six modalities potentially have the greatest current impact on healthcare.

In addition, we captured data on infrastructure requirements of particular current concern: use and access to a picture archiving and communications system (PACS) for each of the six modalities, and source of isotopes for PET and its hybrid modalities.

Modalities of interest

Computed Tomography (CT)

Computed Tomography employs X-rays as a source of ionizing radiation, sensitive radiation detectors, and computerized analysis to create cross sectional images of the body including of the head, heart, lungs, cardiovascular system, musculoskeletal system, abdomen, pelvis, and spine.[6] Specialties which routinely employ CT include neurology, cardiology, oncology, internal medicine, orthopedics, and emergency trauma care.

The main advantages of CT are its speed, allowing rapid imaging and diagnosis in urgent situations, and its ability to visualize fine details in bone, lungs, and other organs.[6] However, CT

involves exposure to ionizing radiation, which means that it is contraindicated in pregnancy, and the risk-benefit of its use in young children and repeat use must be carefully assessed.[6]

Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging (MRI) uses powerful electromagnets, radiofrequency waves, and computers to produce cross sectional images of the body including of the head, neck, cardiovascular system, breast, abdomen, pelvis, musculoskeletal system, and spine.[7] Specialties that commonly employ MRI include neurology, gastroenterology, cardiology, oncology, internal medicine, orthopedics, and emergency services.[7]

MRI does not employ ionizing radiation, and therefore may be preferred where CT and MRI would provide comparable information, for example when examining children.[7] MRI provides high sensitivity and soft tissue details, allowing for visualization of anatomy and pathologies which lends to early diagnosis, staging and re-staging, identification of treatment response, and detection of recurrence in various cancers.

A disadvantage of MRI is the exams take up to 45 minutes, and patients must be able to remain motionless within a narrow enclosure. MRI may not be suitable for patients with claustrophobia, those who cannot lie flat for prolonged periods, or those who are extremely obese. [7-9] The powerful electromagnet fields and radiofrequencies used in MRI are incompatible with many commonly implantable electronic medical devices, such as deep brain stimulators, cochlear implants, and some pacemakers, all of which may malfunction, heat up, or be displaced within the body[9,10]. All patients undergoing an MRI exam must be screened beforehand to identify any potential contraindicated devices. [9,10]

Nuclear Medicine

Nuclear Medicine imaging uses an injection, ingestion, or inhalation of radioactive materials such as radioisotopes and/or radiopharmaceuticals, and sensitive radiation detection cameras and computers to create three dimensional images of the functional, physiological, and metabolic activity within the body.[11] The ability to obtain functional information is a primary advantage of this modality.[11]

Nuclear medicine exams identify and evaluate a variety of pathologies including cancers, heart disease, gastrointestinal, endocrine, and neurological disorders. Single Photon Emission Computed Tomography (SPECT) and Positon Emission Technology (PET) are examples of nuclear medicine modalities commonly used in Canada.

Single–photon emission tomography (SPECT)

Single-photon emission computed tomography (SPECT) uses radioisotope injections and sensitive radiation detection cameras and computers to detect and visualize areas of increased radioisotope uptake within the body, creating three dimensional images of areas of interest such as brain, bone, and heart. The physiologic and metabolic information obtained which provides potential for early diagnosis and evaluates a patient's response to interventions.

Medical specialties that commonly use SPECT imaging include oncology, neurology, cardiology, internal medicine, and orthopedics.

Positron Emission Tomography (PET)

Positron Emission Tomography (PET) uses radioactive sugar solution injections, sensitive radiation detector cameras, and powerful computers to detect and visualize areas of increased metabolism, such as tumors. It creates three dimensional images of regions of interest such as brain, bone, and heart.[12]

The main advantage of PET is the ability to measure and evaluate body and organ functions such as blood flow, oxygen usage, sugar metabolism, and physiologic information. These advantages allow for early diagnosis, staging and re-staging, identifying a patient's response to treatment, and detection of recurrence in various cancers.

Medical specialties that commonly use PET imaging include oncology, neurology, cardiology, and internal medicine.

Disadvantages of Nuclear Imaging Modalities

Exams can be long, with some taking several hours or days to complete. They involve radiation exposure. Although the risk must be offset by the potential diagnostic benefit, the effect is cumulative. Nuclear medicine scans have lower resolution than other imaging modalities, so a second modality is used to see anatomic detail.[13]

Another concern for SPECT and SPECT-CT are recent global shortages of medical radioisotopes, compounded by the pending decommissioning of Canada's specialized nuclear reactor.[14] Given the short supply of radioactive materials, the cost associated with obtaining and transporting the materials is an ongoing concern.[11]

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

Hybrid imaging combines two or more imaging modalities to take advantage of the characteristics of each. Therefore, hybrid imaging can simultaneously provide high anatomic detail and metabolic and/or physiological function, enabling more accurate diagnosis, better care pathways, refined treatment regimes, and improved patient outcomes.[11]

SPECT-CT

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

The disadvantages of SPECT-CT are those of the component modalities, both of which involve exposure to ionizing radiation.[15]

PET-CT

PET-CT combines the modalities of PET and CT, creating three dimensional images of the body part of interest such as brain, bone, and lung, among others. Both scans are performed in tandem or in sequence during a single session, and the images are computationally aligned. PET-CT is commonly used in oncology to demonstrate, diagnose, and stage various cancers such as lung, gastrointestinal, colorectal, breast, and thyroid cancer. Additionally, hybrid PET-

CT is commonly employed to diagnose neurological, cardiovascular, infectious, and inflammatory pathologies.[11]

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

The disadvantages of PET-CT are those of the component modalities, both of which involve exposure to ionizing radiation.[11,16,17]

PET-MRI

PET-MRI combines PET with MRI[18], permitting high sensitivity metabolic imaging with high resolution of soft tissue detail, enabling visualization of anatomy and pathologies not commonly attainable with other modalities. The two scans are performed in tandem or in sequence; the images are then computationally aligned. PET-MRI is the newest combination to reach clinical use, but has use in oncology, neurology, cardiology, internal medicine and orthopedics. In particular, in oncology, PET-MRI might facilitate early diagnosis, staging and re-staging, identification of a patient's response to treatment, and detection of recurrence in various cancers. [19,20]

PET-MRI requires injection of radioactive isotope tracers, so does require the same risk-benefit considerations as other nuclear medicine imaging modalities for women of reproductive age and on children [9,10]. Since the CT component is replaced by MRI, X-ray exposure is avoided, however the potential hazards of magnetic fields and radiofrequency waves remain.[9,10]

Picture Archiving and Communications System

PACS is an electronic web-based system used to digitally manage images including transmission, filing, storage, distribution, and retrieval of medical images. PACS systems, combined with other web-based telehealth technologies, allow timely access to medical images and specialists. PACS has replaced film and film library systems.

Access to images outside medical imaging departments by referring and consulting physicians is important for efficient patient care, particularly so in a country like Canada, with its size and dispersed population. We therefore asked respondents to indicate whether they stored images on PACS, and about the extent of access to PACS within their jurisdiction.

OBJECTIVES

The purpose of this pan-Canadian inventory is document current practices and developments related to the purchasing, distribution, operation and use of select medical imaging modalities at public and private Canadian healthcare facilities. The specific overall objectives of the project are:

1. To determine the number of selected devices in Canada

2. To provide accurate and timely data on the supply, distribution and use of selected imaging devices in Canada

3. To improve current understanding of the functional characteristics of medical imaging equipment in Canada

4. To monitor trends and developments in medical imaging equipment use across Canada

5. To inform medical imaging-related strategic planning on a national, provincial or territorial basis

METHODS

This section presents an abbreviated description of the methods used for the survey and analysis. For more complete information, please see the project website at [link to come].

Data were primarily collected via a web-based survey on the CADTH website. Both English and French versions were offered. Potential respondents were contacted by email. To access the survey, all participants were asked to register a profile on the CADTH website to ensure their response was linked to a unique registration profile.

Most respondents were pre-identified using a database of previous participants provided by CIHI. These contacts were updated to account for changes due to position turnover, retirement, and restructuring. Potential respondents included individuals working in private or public healthcare settings that operate medical imaging equipment. Occupations included executive (e.g., president of a private facility, hospital administrator), and leadership positions (e.g., chief technologist, manager or director of diagnostic imaging, site coordinator). Some respondents were identified through CADTH liaison officers, external stakeholders, and participant referrals.

In addition, private contacts were identified for Ontario through a provincial database of independent health facilities, and for Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, and Quebec using a combination of CIHI data and searching on 'FindPrivateClinics.ca'.

Passive methods of recruitment included promotion of the renewed survey on the CADTH website and social media including Twitter and LinkedIn. It is unclear whether any participants were identified through these channels.

The survey opened on September 16, 2015 and data collection closed on January 4, 2016. These dates account for two extensions; a public extension until November 17, 2015 during which up to three email-based reminders were sent, and an informal extension until January 4, 2016 during which non-responders were contacted directly by researchers, through CADTH liaison officers, or through survey validators. To accommodate participants who found the web-based survey inaccessible, data were received by Excel, email, or phone. Implied consent was assumed for participants that completed the survey using alternative methods.

There was one amendment to the survey during the period of data collection, primarily to ensure that use data was captured across all units at a site rather than only units installed after 2012. Respondents who entered information prior to this amendment were contacted individually and asked to complete the additional questions, while CADTH researchers migrated the previously entered data.

We asked each respondent for information about themselves (or the contact person for the site), and the site or sites they were responding for. For each the six modalities (PET and PET-CT, CT, MRI, PET-MRI, SPECT-CT, and SPECT), we asked about the availability and number of units, decommissioning activities and plans to install new units, total number of examinations, overall hours of utilization, overall percentage of time devoted to various uses, whether units are used for treatment planning purposes, and whether hybrid units as used for singular applications (e.g., whether the CT component of PET-CT machine is used as standalone CT), operation of cyclotrons, source of isotope supply for PET technologies. We also asked for details of individual units installed after January 2, 2012, including make and model information, year of installation, and technical specifications (including device mobility), to update data already collected by CIHI to the end of 2011. For the sites themselves, we asked about the availability of the use of picture archiving and communication systems (PACS). For the

purposes of the survey the following definitions were used for examinations, hospital, and free standing facility:

- **Imaging examination**: An exam is defined as a medical imaging session using an imaging modality to study one (or more than one) body structures, systems or anatomical areas that yield one or more views for diagnostic and/or therapeutic purposes.
- **Hospital:** An institution where patients 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. Included are those providing acute care.
- **Free standing facility:** Ranges from specialized services run privately by physicians, radiologists, dentists, chiropractors or mammography programs to broad-based imaging centres offering a wide range of tests.

Upon survey closure on November 17, 2016, we sent summary statistics of the number of units per modality in each jurisdiction to pre-identified regional validators. Validators assessed the summaries for accuracy and provided corrections and information for non-responders. Validators were also asked to encourage non-responders in their regions to participate in the survey by the extended deadline. In addition, we conducted a grey literature search for press releases, annual reports, and other publicly available information for non-responding facilities. This data was used to assess accuracy and to fill data gaps. Lastly, identified stakeholders and survey respondents were given the opportunity to review a draft report during a stakeholder feedback process. The report underwent two rounds of internal review and a formal peer review process prior to publication.

DATA ANALYSIS

CIHI kindly provided the survey data current until January 2012. This included unit counts for CT, MRI, Nuclear Medicine Cameras (SPECT and gamma), and PET. As well, CIHI makes available a subset of the variables collected through a web interface at QuickStats,[4] updated with sites and data confirmed or collected after the final analysis of the 2012 survey. Manual comparison of the CIHI and QuickStats datasets identified units in QuickStats that were not represented in CIHI, and the available data for these were merged.

Our original intention was to merge the CMII and CIHI datasets for the entire analysis. Following the necessary update of the survey to ensure we captured aggregated current use data for all units at a site, we modified that strategy to use the most updated information at each stage, as shown in Table 1.

Population data for Canada and the provinces, and cartographic shape files plotting maps were obtained from Statistic Canada.[21] International data for the number of CT and MRI units and exams were obtained from the Organization for Economic Development (OECD) website.[22-25]

TABLE 1 USE OF DATASETS IN ANALYSES

Data Summaries	Data Sources: CMII Survey Results	CIHI 2012 Data	Validation Data	Grey Literature	Statistics Canada	International Data[b]
Summaries of site characteristics.	•					
Summaries of modality availability, number of units	•		•	•		
Summary of planned installations, and planned decommissioning	•					
Summary of units at sites that had data in the 2012 CIHI survey, but did not respond to the CMII data[a]	•	•				
Maps of machine locations	•		•	•		
Summaries of exams in one fiscal year, summaries of average hours per week and hours per day of operation, summaries of proportions of types of use.	•					
Summaries of units per site and units per population.	•		•	•	•	
Comparisons of inventory with international availability for CT and MRI.	•		•	•		•
Age of units, current and decommissioned	•	•	•	•		

[a] CIHI 2012, compared with CMII 2015 to eliminate sites with updated data available.
[b] International data from the OECD.[22-25]

We present the data using descriptive summaries and graphs of site-level and province-level findings. We use counts for discrete data such as the number of sites with a given modality, or the number of units at a site. We use summary statistics such as mean (average), median or range between minimum and maximum values, for continuous data such as the number of exams. The median value is the one that lies at the midpoint if all the values are arranged in order, and may represent the data better if there are a few very high or very low values. Where we asked respondents to choose between two or more responses (e.g., Yes/No), we report the numbers and/or percentages who selected each response.

Stacked bar charts were used to display number of units and PACS access information, number of exams and hours of operation, dot plots were used to display number of exams, the distribution of modalities were presented using geocoded data presented on maps, and proportions for type of use was presented using side by side box plots

The survey also included space to invite respondents to give additional detail. We extracted information from those regarding decommissioning activities and operation of mobile units.

We imputed values for a limited number of missing values, where we had not obtained a response to our queries. In particular, we imputed the number of units as 0 when the respondent had indicated that the site did not have the modality. If the questions regarding planned installations or decommissioning were left blank, we assumed the answer was no. If the completed use categories added up to 100%, then the missing values were assumed to be 0%. Out of range values for the number of hours of operation per week (>168 hours) or per day (>24 hours) were set to missing. For the comparison with international data only, we used the median number of exams from the sites that reported exams to infer the total number of exams for the sites that did not report exams.

RESULTS

RESPONSE RATE FOR THE 2015 UPDATE

The number and reach of contacts varied between provinces or territories, as shown in Table 2. In addition, our direct contacts were encouraged to forward the information to other potential respondents and survey announcements and calls for response were sent out on social media; thus we do not have an exact figure for the number of eligible potential respondents we reached. We received 222 responses to the web survey, having initially sent the survey to 332 contacts, as shown in Table 2. Provincial validators supplied information about availability of modalities at sites and number of units for a further 100 sites, respondents for 8, a CADTH Environmental Scan of PET use in Canada[26] for 17, and grey literature for 8.[27-35]

TABLE 2 SUMMARY OF CONTACT STRUCTURE AND RESPONSE RATE FOR ALL PROVINCES

	Contact structure	Number of surveys sent	Number of responses	Response rate (%)
Alberta	Provincial contact – one contact	25	34	
British Columbia	Facility contact	70	38	54.3
Manitoba	Facility contact	16	16	100
New Brunswick	Facility contact	10	7	70
Newfoundland and Labrador	Facility contact, plus provincial contact	13	6	100
Northwest Territories			1	
Nova Scotia	Provincial contact – one contact	15	15	100
Ontario	Facility contact	98	59	60.2
Prince Edward Island	Facility contact	2	2	100
Quebec	Facility contact	72	38	52.8
Saskatchewan	Regional contact – three contacts	11		
Yukon			1	

CHARACTERISTICS OF FACILITIES RESPONDING TO THE 2015 UPDATE

Of the 239 sites that provided information on facility type, 155 (64.9%) were identified as hospitals, 42 (17.6%) as tertiary care centres, 17 (7.1%) as community hospitals, and 25 (10.5%) as free standing facilities. We do not have information on facility type for the remaining 135 sites, predominately those that were added during our supplementary data search, or from validator counts. Most of the 250 sites who reported on funding sources were publicly funded, 226 (90.4%), with a minority that were either privately funded, 16 (6.4%), or received both public and private funding, 8 (3.2%). Summaries of type of facility by province and funding by province are presented in Appendix A, Table 11 and Table 12.

CHARACTERISTICS OF FACILITIES THAT DID NOT RESPOND TO THE 2015 UPDATE

One hundred and twenty-six (126) sites were represented in the CIHI 2012 dataset but did not respond to the CMII 2015 survey, and were not included in validator responses. Ninety-eight sites were reported as Private Practice and 28 were public facilities associated with a health region.

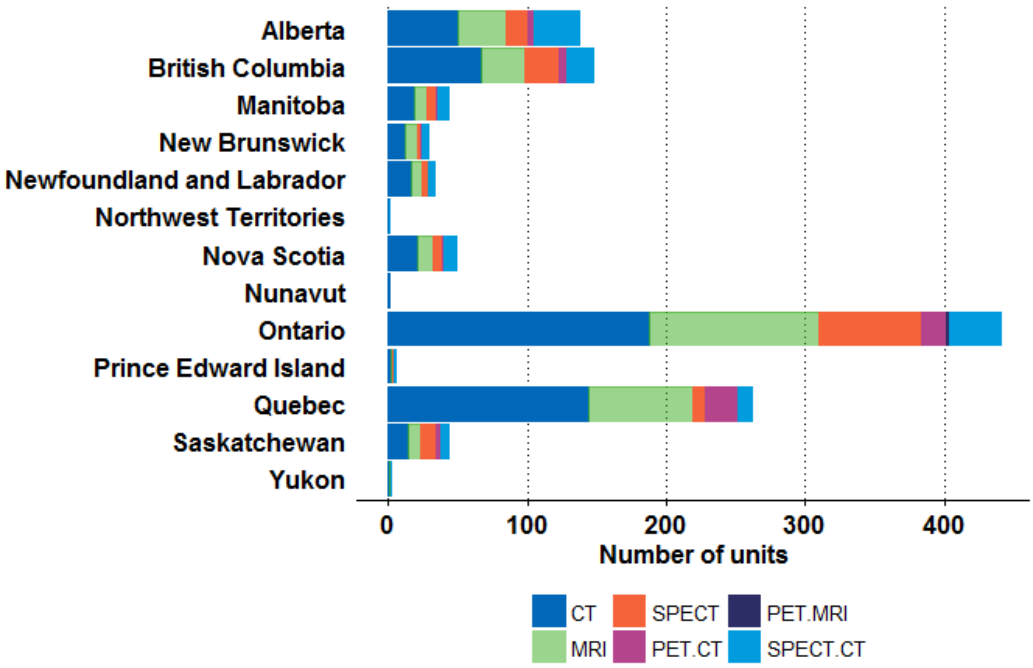
OVERALL INVENTORY OF MEDICAL IMAGING EQUIPMENT IN CANADA

In this section, we briefly describe the overall reported inventory of machines and use in terms of total number of exams for the six imaging modalities of interest across all provinces and territories. Subsequent sections present in greater detail the inventory and use for CT, MRI, SPECT, PET-CT, PET-MRI, and SPECT-CT, respectively.

Total Unit Counts

Figure 1 and Table 3 show the overall provincial and territorial inventory of all six modalities. Table 3 shows the total number of units per jurisdiction as well as the number of sites that have that modality available. Ontario and Quebec had the highest number of units identified for all modalities. All the provinces and territories reported at least one CT unit. The Northwest Territories, the Yukon, and Nunavut reported a single CT unit each. All provinces and territories, reported at least one MRI unit, with the exception of Nunavut and the Northwest Territories. Ten provinces or territories reported at least one SPECT and at least one SPECT-CT unit; the Northwest Territories, Yukon and Nunavut were the exceptions. Eight provinces reported at least one PET or PET-CT unit, Alberta, British Columbia, Manitoba, New Brunswick, Ontario, Quebec, and Saskatchewan. Two PET-MRI units were reported, both in Ontario.

FIGURE 1 OVERALL PROVINCIAL OR TERRITORIAL INVENTORY OF CT, MRI, SPECT, PET-CT, PET-MRI, AND SPECT-CT



Data derived from question: "If respondents indicated that they had operational units but failed to respond regarding the specific number of units, validator counts were included if available."

TABLE 3 OVERALL PROVINCIAL OR TERRITORIAL INVENTORY AND AVAILABILITY OF CT, MRI, SPECT, PET-CT, PET-MRI, AND SPECT-CT

	Number of units[b,c] (Number of sites with units)[a,c]					
Province	**CT**	**MRI**	**SPECT**	**PET-CT**	**PET-MRI**	**SPECT-CT**
Alberta	50 (36)	35 (24)	16 (11)	4 (3)	0	32 (16)
British Columbia	67 (46)	31 (27)	25 (10)	5 (3)	0	19 (13)
Manitoba	19 (15)	9 (4)	7 (4)	1	0	7 (4)
New Brunswick	12 (7)	9 (8)	2 (2)	2 (2)	0	4 (4)
Newfoundland and Labrador	17 (14)	7 (6)	5 (3)	0	0	4 (3)
Northwest Territories	1	0	0	0	0	0
Nova Scotia	21 (16)	11 (10)	7 (4)	1	0	9 (8)
Nunavut	1	0	0	0	0	0
Ontario	188 (115)	122 (72)	73 (40)	18 (12)	2 (2)	37 (29)
Prince Edward Island	2 (2)	1	1	0	0	1 (1)
Quebec	144[d]	75[d]	9[d] (5)	23 (20)	0	10[d] (5)
Saskatchewan	14 (11)	9 (6)	12 (2)	3 (3)	0	5 (1)
Yukon	1 (1)	1	0	0	0	0
Canada	442 (300) 537[e]	271 (187) 310[e]	157 (82)	57 (45)	2 (2)	128 (84)

[a] Data derived from question: "Do you have a [modality] machine(s) in your hospital/facility?" Each 'yes' counts as one.

[b] Data derived from question: "If so, how many [modality] do you have?" For sites without survey information, validators' indication of availability and counts were included, if available.

[c] Counts also include supplementary data supplied by validators.

[d] The validator reviewing the Quebec survey data supplied aggregated totals for units at public facilities: CT 144 units, MRI 75 units, PET or PET-CT 16 units, and SPECT or SPECT-CT 154 units. The survey identified 50 CT units at 35 sites, and 36 MRI units at 28 sites.

[e] Including additional data from Quebec.

Units at Non-Responding Sites

The aggregated CIHI dataset contains an additional an additional 83 CT units, 72 MRI units, 117 SPECT units, 4 PET-CT units, and 16 SPECT-CT units, at sites that did not respond to the survey, and were not reported by validators (with the exception of Quebec; Appendix B, Table 14). For those sites for which we have only validator data for CT and MRI (British Columbia and Ontario), we calculated 44 additional SPECT CTs and 10 additional CTs. Given that we are uncertain of the current status of these units, we have not included them in the summaries, but they provide an upper bound for unit counts.

Growth in Inventory over 2012-2015

Within the facilities that responded to our survey, there was an overall increase in the number of units of all modalities. These facilities reported installing 112 CT units, 64 MRI units, 33 SPECT units, 19 PET-CT units, and 42 SPECT-CT units since January 2, 2012 (Appendix A, Table 13). During the same period facilities, reported the decommissioning of 44 CT units, 18 MRI units, 26 SPECT units, 3 PET-CT units, and 2 SPECT-CT units.

Number of Units by Provincial or Territorial Population

Overall, Canada has 14.98 CT units, 8.65 MRI units, 4.38 SPECT units, 1.59 PET or PET-CT units, 0.06 PET-MRI units, and 3.57 SPECT-CT units per million people. Provincial and territorial trends are discussed within the sections for each modality, and Canadian data are compared with international data in the Discussion. Table 4 shows the number of units reported per million people for all the provinces or territories and for Canada as a whole.

TABLE 4 CT, MRI, SPECT, PET-CT, PET-MRI, AND SPECT-CT UNITS BY PROVINCIAL OR TERRITORIAL POPULATION

	Number of units[a] per million population[b]					
Province	**CT**	**MRI**	**SPECT**	**PET-CT**	**PET-MRI**	**SPECT-CT**
Alberta	11.91	8.34	3.81	0.95	0.00	7.63
British Columbia	14.31	6.62	5.34	1.07	0.00	4.06
Manitoba	14.69	6.96	5.41	0.77	0.00	5.41
New Brunswick	15.92	11.94	2.65	2.65	0.00	5.31
Newfoundland and Labrador	32.21	13.26	9.47	0.00	0.00	7.58
Northwest Territories	22.68	0.00	0.00	0.00	0.00	0.00
Nova Scotia	22.27	11.66	7.42	1.06	0.00	9.54
Nunavut	27.10	0.00	0.00	0.00	0.00	0.00
Ontario	13.63	8.85	5.29	1.31	0.15	2.68
Prince Edward Island	13.66	6.83	6.83	0.00	0.00	6.83
Quebec	17.43	9.08	1.09	18.64	0.00	1.21
Saskatchewan	12.35	7.94	10.59	2.65	0.00	4.41
Yukon	26.74	26.74	0.00	0.00	0.00	0.00
Canada	14.98	8.65	4.38	1.59	0.06	3.57

[a] Data derived from question: "If so, how many [modality] do you have?", if sites did not provide survey information, validators' indication of availability and counts were included, if available.

[b] The Population as of July 1, 2015.[21]

Number of Units by Facility Type

Table 5 gives an overall summary of the number of units of each modality by self-reported facility type, for those sites with available data. Sites that did not report a facility type are not included in the table (135 sites). Appendix A, Table 11 shows the number of sites by facility type and province. Most responding sites identified as hospitals (64.9%), with the remaining sites identifying as community hospitals (17.6%), tertiary care centres (7.1%), or free standing facilities (10.5%).

TABLE 5 CT, MRI, SPECT, PET OR PET-CT, PET-MRI, AND SPECT-CT UNITS BY FACILITY TYPE

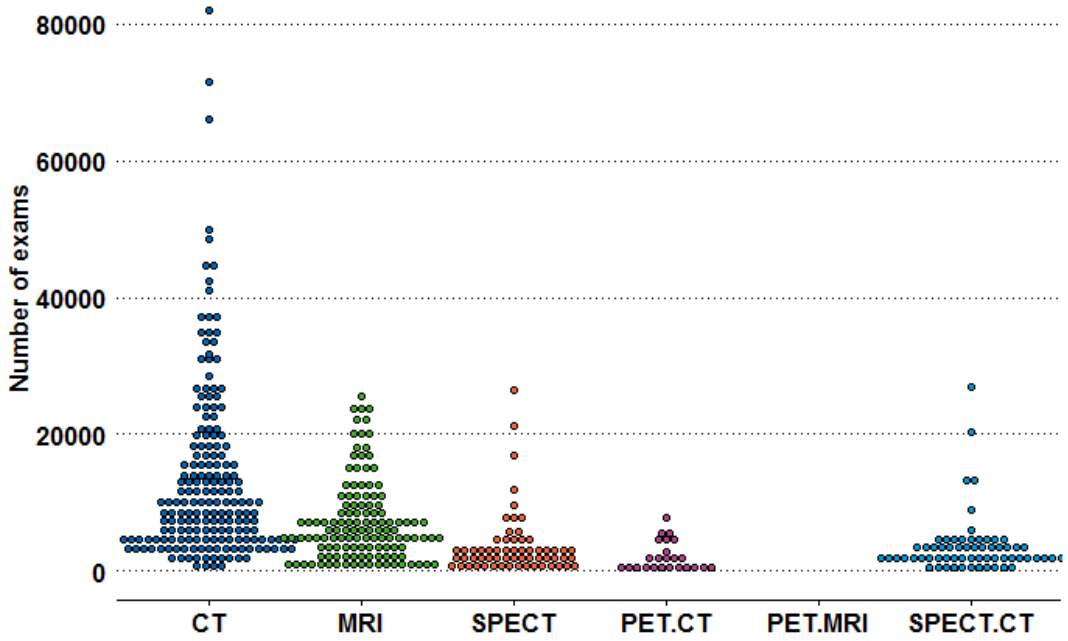
	Number of units[a]				
Facility Type[b,c]	**CT**	**MRI**	**SPECT**	**PET-CT**	**SPECT-CT**
Hospital	205	133	83	26	88
Community Hospital	49	19	24	0	15
Tertiary Care	27	18	22	5	11
Free Standing	8	14	12	5	6
All	289	184	141	36	120

[a] Data derived from question: "If yes, how many [modality] do you have?"
[b] Data derived from question: "What type of facility is this?"
[c] Sites that did not report a facility type are omitted from counts.

Overall Number of Examinations

Figure 2 shows the examinations reported for all modalities across Canada, for the most recent fiscal year for each site. The data is presented as a combined total count of exams independent of number of units at a site or number of units per population. PET-MRI is an emerging modality and there are no units currently in routine clinical use. The data are not normally distributed, and are influenced by the number of units as well as the volume at sites. Total examinations, examinations per number of units, and examinations per provincial population are discussed in the summaries of findings for individual modalities.

FIGURE 2 TOTAL NUMBER OF EXAMS PER SITE FOR EACH MODALITY



Data derived from question: "For all [modality] units, how many examinations are conducted in a fiscal year?" Each dot represents the total exams for one site.

The figure above does not account for the number of units at a site. Most sites carry out fewer than 20,000 CT exams per year, 10,000 MRI exams per year, 5,000 SPECT or SPECT CT exams per year, or 2,000 PET-CT exams per year. For all modalities, there are a few outliers.

COMPUTED TOMOGRAPHY (CT)

Number and Location of CT Units

Three hundred (300) sites in 13 provinces or territories have one or more CT units (Table 6). There were up to 8 units per site, for a total of 537 units (including 96 sites reported in aggregate for Quebec). Ontario had the highest number of CT units, followed by Quebec, and then British Columbia. The Northwest Territories, Nunavut, and the Yukon have one unit each.

TABLE 6 SUMMARY OF AVAILABILITY AND STATUS OF CT UNITS BY PROVINCE

Province	Sites with units[a]	Number of units[b]	Sites planning to install[c]	Sites that decommissioned since 2012[d]	Units per million population[e]
Alberta	36	50	8	11	11.91
British Columbia	46	67	7	6	14.31
Manitoba	15	19	1	3	14.69
New Brunswick	7	12	6	2	15.92
Newfoundland and Labrador	14	17	0	3	32.21
Northwest Territories	1	1	0	0	22.68
Nova Scotia	16	21	3	3	22.27
Nunavut	1	1	0	0	27.10
Ontario	115	188	22	12	13.63
Prince Edward Island	2	2	1	0	13.66
Quebec	35	144[f]	12	3	17.43[f]
Saskatchewan	11	14	5	1	12.35
Yukon	1	1	0	0	26.74
Canada	300	537[g]	65	44	14.98[g]

[a] Data derived from question: "Do you have a CT machine(s) in your hospital/facility?" Each 'yes' counts as one.

[b] Data derived from question: "If so, how many CTs do you have?" For sites without survey information, validators' indication of availability and counts were included, if available.

[c] Data derived from question: "Do you have plans to install a new additional CT machine in the next two years?" Each 'yes' counts as one.

[d] Data derived from question: "Have you decommissioned a CT since January 2, 2012?" Each 'yes' counts as one.

[e] The population as of July 1, 2015.

[f] Fifty units were reported for 35 sites in the survey. The Validator supplied an aggregated total of 144 CT units, without specifying sites. This figure was used to calculate the units per population.

[g] Including aggregated data from Quebec.

A hundred and twelve (112) new CT units were installed between 2012 and 2015. Forty-four sites decommissioned one or more CT units (most decommissioned one) since the last survey

in 2012, and 65 sites reported planned installation of one or more CT units in the two years after this survey (Table 6). Our survey did not discriminate between replacement and new installations; therefore it is unclear whether planned installations are to be new machines, replacements, or upgrades. The respondent for one site added in a comment that the planned installations were replacements for decommissioned units, and two more sites indicated plans to replace current units. One site indicated that their machine had been upgraded.

The provinces or territories with the highest number of machines per million people are Newfoundland and Labrador, the Yukon, and Nunavut, whereas Alberta, Saskatchewan, and Ontario all have a relatively low number of units per million people. This does not account for geographical distribution. CT also represents the highest number of units per population of all six modalities.

Geographical Distribution of CT Units

Figure 3 shows the present geographical distribution of CT units across Canada mapped to the level of settlement (city or town), with a circle size (area) proportional to the number of units.

FIGURE 3 DISTRIBUTION OF CT UNITS ACROSS CANADA

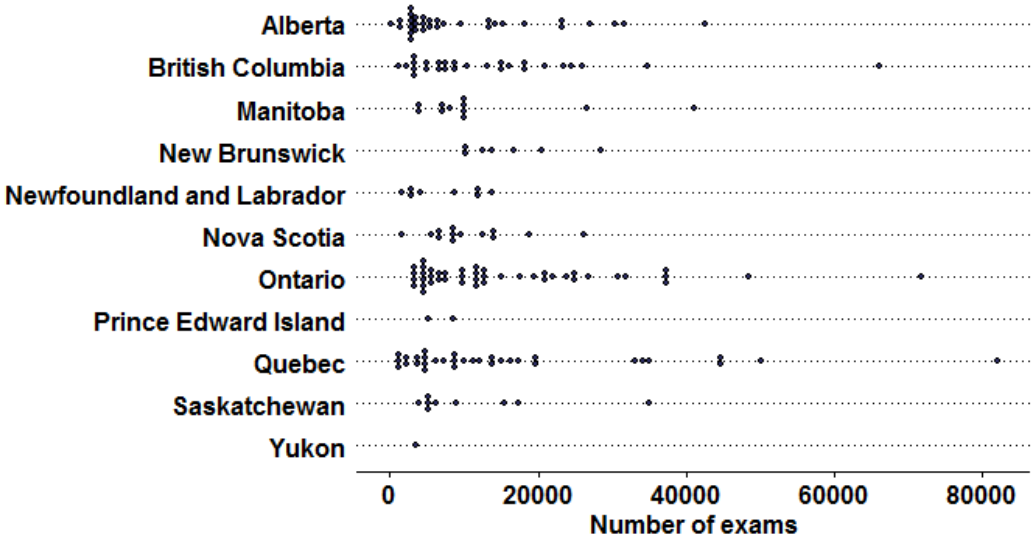
Data derived from question: "If yes, how many CTs do you have?" Counts for all sites within a city/town were aggregated, and symbol area is proportional to the number of units. For sites without survey information, validators' indication of availability and counts were included, if available.

Patterns of CT Use: Number of Examinations in a Fiscal Year

Across Canada, 187 sites reported an overall total of 2,533,751 CT examinations per year, where each site reported for its last fiscal year. The number of exams at an individual site ranged widely, from 133 exams to 81,943, although most sites recorded fewer than 20,000 exams a year (Figure 2 and Figure 4).

Figure 4 shows the individual site data by province, and the detailed summary statistics across all provinces or territories are provided in Appendix C, Table 15.

FIGURE 4 CT EXAMINATIONS BY PROVINCE OR TERRITORY OVER THE LATEST FISCAL YEAR



Data derived from question: "For all CT units, how many examinations were conducted in the last fiscal year?" Each dot represents the figure from one site.

No exam data were reported for the Northwest Territories and Nunavut. New Brunswick, Ontario, and Quebec had the highest median number of exams per site, while the Yukon and Alberta had the lowest. These figures are influenced by the number of units at each site (Appendix D, Table 18).

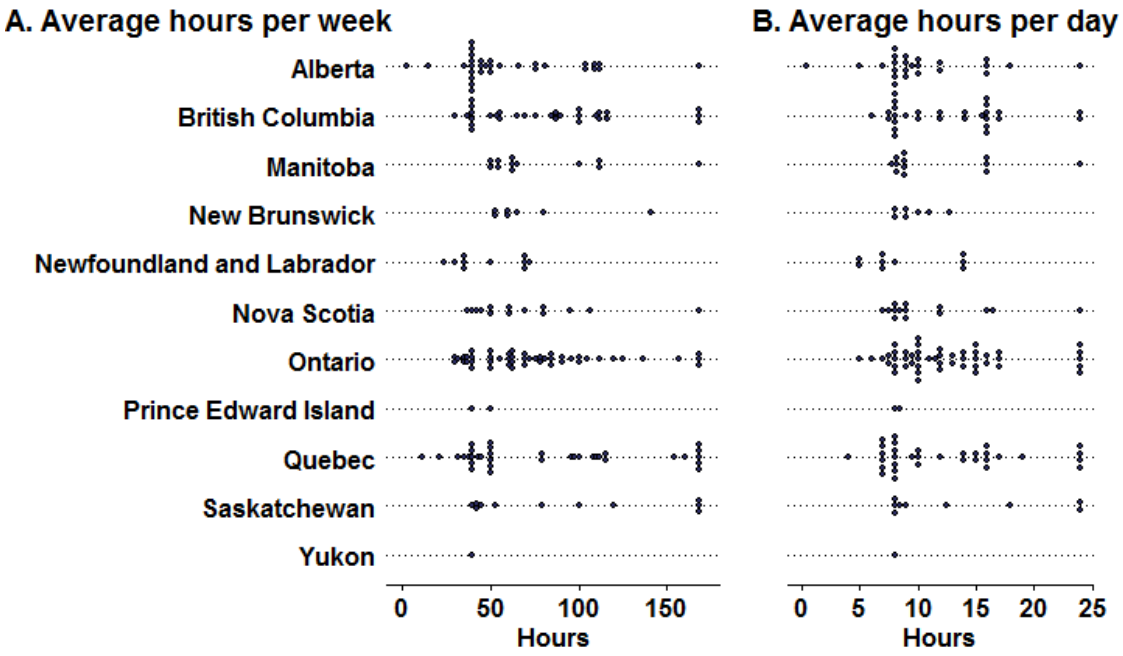
When we adjusted for the population of each province, Nova Scotia, New Brunswick, and Newfoundland and Labrador had the highest median number of exams per 1,000 people, while Ontario and Quebec had the lowest (Appendix D, Table 19).

Patterns of CT Use: Typical Hours of Operation in a Week and Day, and Weekend Use

Two hundred and one (201) sites provided information on the hours of CT use in a typical week and 178 sites provided information on a typical day. Sites were asked for a single estimate of average use over all their units. The median estimate was 63 hours per week and 10 hours per day.

Hours per week and hours per day are shown by province in Figure 5, and detailed summary statistics are presented in Appendix C, Table 16 and Table 17.

FIGURE 5 AVERAGE HOURS OF OPERATION OF CT UNITS IN A TYPICAL WEEK AND IN A TYPICAL DAY



A. Data derived from question: "In an average week (168 hours) how many hours are the CT units in use, averaged across all units?"

B. Data derived from question: "On a regular workday, how many hours per day are the CT units in use, averaged across all units?"

British Columbia and Saskatchewan had the highest average hours per week, and Newfoundland and Labrador and the Yukon had the lowest (Appendix C, Table 16). British Columbia, Ontario and Quebec have the longest reported working days (Appendix C, Table 17). Newfoundland and Labrador had the lowest hours per day. Sites varied in whether they calculated the average hours per day over all calendar days, or only days of operation. As the summary statistics suggest, most sites who responded to these questions operated on the weekend.

Patterns of CT use: Types of Use

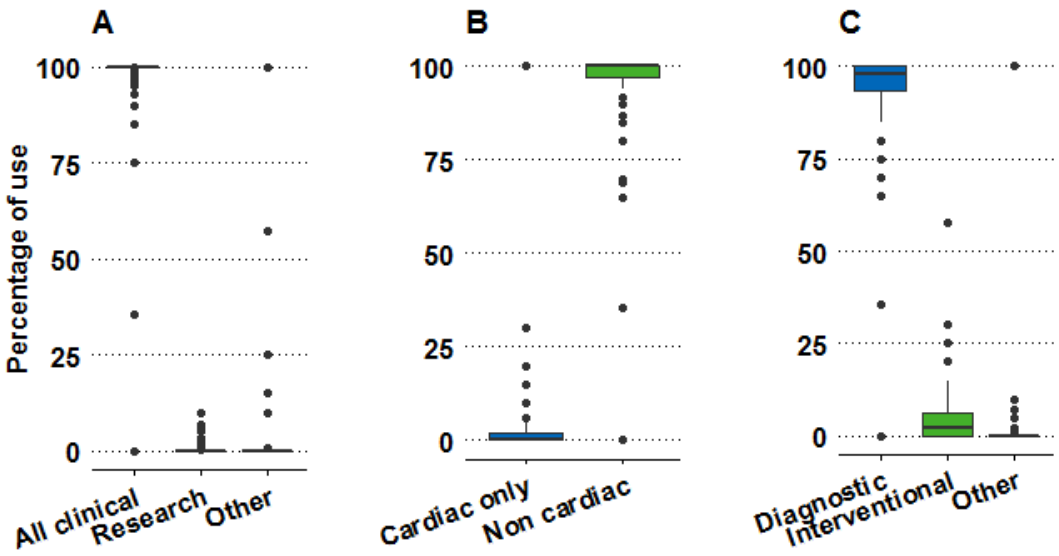
One hundred and ninety-one (191) sites provided information on the typical type of use across all their CT units. Sites were asked to give a breakdown of the percentage of use for all their units across two separate groups of categories: Indication and Procedure. Indication was subdivided as clinical (further subdivided into cardiac only and non-cardiac), research, or other. Procedure was subdivided as diagnostic, interventional, or other.

For indication, most use was clinical. Where clinical use was divided, most use was non-cardiac, with the remainder devoted to cardiac use. Research use accounted for a very small proportion. Sites did not indicate what 'other' use represented.

For procedure, most use was diagnostic, with the remainder devoted to interventional use or other purposes. Some sites identified intervention in comments as intra-operative or biopsy. Sites did not indicate what 'other' use represented.

Boxplots for average percentage of use across Canada is shown in Figure 6. Indication is shown on the left (A, B) and procedure on the right (C).

FIGURE 6 OVERALL PROPORTION OF TYPE OF USE OF CT UNITS



A, B. Indication. Data derived from question: "Based on your practice in the last fiscal year what % of time is this CT used for: Cardiac only/Non-cardiac/Research/Other?" All clinical was calculated by adding Cardiac only and non-cardiac.

C. Procedure. Data derived from question: "Based on your practice in the last fiscal year what percentage of clinical time is this CT used for: Diagnostic/Interventional/Other?"

Of the small number of sites (17) who responded to a question about whether any of their CT units were used in treatment planning, 41.2% answered yes.

MAGNETIC RESONANCE IMAGING (MRI)

Number and Location of MRI Units

One hundred and eighty-seven (187) sites in 11 provinces or territories have one or MRI units. There were up to 5 units per site, to a total of 310 units (including an additional 39 sites reported in aggregate by the Quebec validator; Table 7). Four of these were mobile units shared between up to four sites each (see below). Ontario and Quebec reported the highest number of units. Prince Edward Island and Yukon had one MRI each, and the Northwest Territories and Nunavut had none.

TABLE 7 SUMMARY OF AVAILABILITY AND STATUS OF MRI UNITS BY PROVINCE

Province	Sites with unit(s)[a]	Number of units[b]	Sites planning to install[c]	Sites that decommissioned since 2012[d]	Units per million population[e]
Alberta	24	35	4	5	8.34
British Columbia	27	31	6	1	6.62
Manitoba	4	9	3	1	6.96
New Brunswick	8	9	0	3	11.94
Newfoundland and Labrador	6	7	0	0	13.26
Northwest Territories	0	0	0	0	0.00
Nova Scotia	10	11	0	0	11.66
Nunavut	0	0	0	0	0.00
Ontario	72	122	12	5	8.85
Prince Edward Island	1	1	0	0	6.83
Quebec	28	75[f]	7	3	9.08[f]
Saskatchewan	6	9	1	0	7.94
Yukon	1	1	0	0	26.74
Canada	184	310[g]	33	18	8.65[g]

[a] Data derived from question: "Do you have a MRI machine(s) in your hospital/facility?" Each 'yes' counts as one.

[b] Data derived from question: "If so, how many MRIs do you have?" For sites without survey information, validators' indication of availability and counts were included, if available.

[c] Do you have plans to install a new additional MRI machine in the next two years? Each 'yes' counts as one.

[d] Have you decommissioned a MRI since January 2, 2012? Each 'yes' counts as one.

[e] The population as of July 1, 2015.

[f] Thirty-six units were reported for 28 sites in the survey. The Validator reviewing the Quebec survey data supplied an aggregated total of 75 MRI units for Quebec. This was used to calculate the units per population.

[g] Including aggregated data from Quebec.

Sixty-four (64) new MRI units were installed between 2012 and 2015. Eighteen (18) sites decommissioned an MRI unit since the last survey in 2012, and 33 sites plan the installation of one or more MRI units in the next two years after this survey (Table 7). Our survey did not discriminate between replacement and new installations; therefore, it is unclear whether planned installations are to be new machines, replacements, or upgrades. The respondent for

one site identified the planned installations as replacements for equipment that had been or was to be decommissioned.

The number of MRI units per population is highest in the Yukon, New Brunswick and Nova Scotia, and relatively lower in Prince Edward Island, Manitoba, and British Columbia, again not accounting for geographical spread. MRI has the second highest per population number of units compared to the other modalities.

GEOGRAPHICAL DISTRIBUTION OF MRI

Figure 7 shows the geographical distribution of MRI across Canada mapped to the level of settlement (city or town), with a circle proportional to the number of units.

FIGURE 7 DISTRIBUTION OF MRI UNITS ACROSS CANADA

Data derived from question: “If yes, how many MRIs do you have?” Counts for all sites within a city/town were aggregated, and symbol area is proportional to the number of units. For sites without survey information, validators’ indication of availability and counts were included, if available.

Mobile MRI

Survey respondents reported four mobile MRI units, two in British Columbia, and one each in Alberta and New Brunswick. In British Columbia, one unit is shared between three facilities in the Okanagan Valley. The other mobile MRI in British Columbia is shared between four facilities on Vancouver Island. The machine in New Brunswick is housed at Upper River Valley Hospital in Waterville, although it is not clear which sites share the unit. The machine in Alberta is shared between four facilities all located outside of Edmonton in Central Alberta.

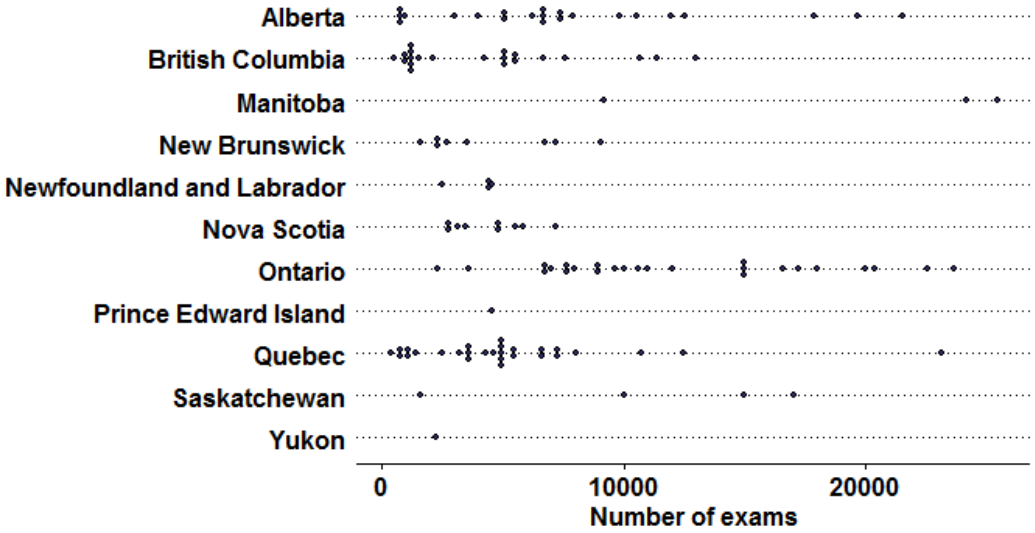
Based on press-releases, one MRI machine that was formerly operational as a mobile device in Lloydminster, Alberta is now operating as a fixed machine. As well, in 2013, a mobile machine in British Columbia was used as a temporary replacement for a damaged permanent machine.

Patterns of MRI Use: Number of Examinations in a Fiscal Year

Across Canada, 126 sites reported a total of 917,517 MRI examinations per year, where each site reported for its last fiscal year. The number of exams at an individual site varied from 370 to 25,440, with most sites reporting fewer than 10,000 exams per year (Figure 2 and Figure 8).

Figure 8 shows the individual data by provinces or territories, and the summary statistics across all provinces or territories are provided in Appendix C, Table 15.

FIGURE 8 MRI EXAMINATIONS BY PROVINCE OVER THE LATEST FISCAL YEAR



Data derived from question: "For all MRI units, how many examinations were conducted in the last fiscal year?" Each dot represents the figure from one site.

Manitoba, Ontario, and Saskatchewan had the highest median number of exams per site, while New Brunswick and Yukon had the lowest. As previously noted, these totals are influenced by the number of units at each site (Appendix D, Table 18).

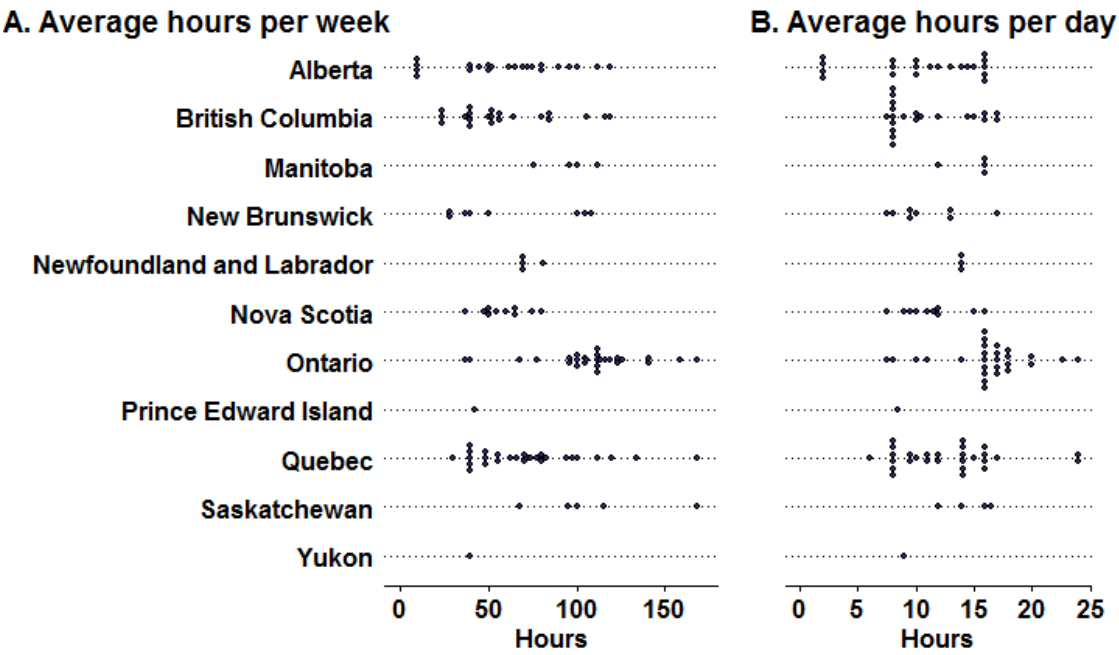
When we adjusted for the population of each province, sites in the Yukon, New Brunswick, and Manitoba had the highest median number of exams per 1,000 people, and British Columbia and Quebec had the lowest (Appendix D, Table 19).

Patterns of MRI Use: Typical Hours of Operation in a Week and Day, and Weekend Use

One hundred and thirty three (133) sites provided information on the hours of use averaged across all their MRI units in a typical week and/or in a typical day. Sites were asked for a single estimate of average use over all their units. The median estimate was 72 hours per week and 13 hours per day.

Hours per day and hours per week are shown by province in Figure 9, and detailed summary statistics are presented in Appendix C, Table 16 and Table 17.

FIGURE 9 AVERAGE HOURS OF OPERATION OF MRI UNITS IN A TYPICAL WEEK AND IN A TYPICAL DAY



A. Data derived from question: "In an average week (168 hours) how many hours are the MRI units in use, averaged across all units?"

B. Data derived from question: "On a regular workday, how many hours per day are the MRI units in use, averaged across all units?"

Patterns of MRI Use: Types of Use

One hundred and twenty-eight (128) sites provided information on the typical type of use across all their MRI units. Use was assigned to two sets of categories: Indication and Procedure. Indication was subdivided as clinical, research, or other. Procedure was subdivided as diagnostic, interventional, or other.

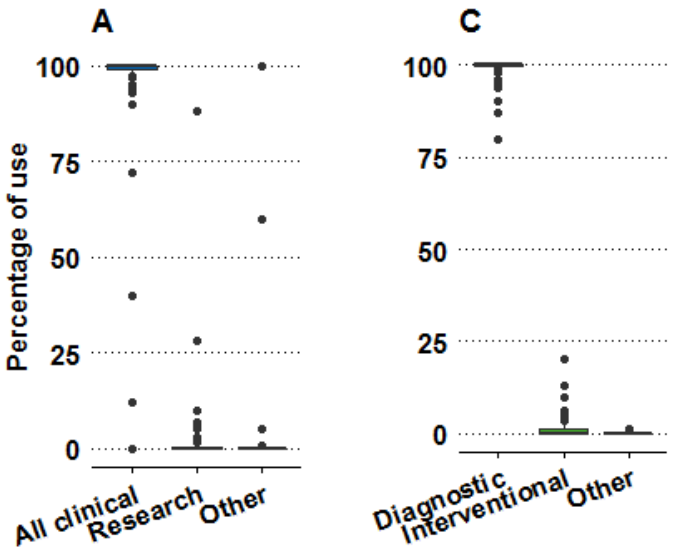
For indication, most use was clinical, while research and other uses together accounted for less than 5% on average. Survey respondents who selected other did not identify what 'other' use represented.

For procedure, most use for MRI was diagnostic, with an average of 2% for interventional or other use. Survey respondents who selected other did not identify what 'other' use represented.

A summary of use is shown in

Figure 10. Indication is shown on the left (A) and procedure on the right (B).

750 **FIGURE 10 OVERALL PROPORTION OF TYPE OF USE OF MRI UNITS**



751

752 A. Indication: Data derived from question: “Based on your practice in the last fiscal year what % of time is this CT used for:
753 Cardiac/Research/Other?”

754 B. Procedure: Data derived from question: “Based on your practice in the last fiscal year what percentage of clinical time is this CT
755 used for: Diagnostic/Interventional/Other?”

756

757

SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY (SPECT)

Number and Location of SPECT Units

Eighty (82) sites in 11 provinces or territories reported having SPECT available. There were between 1 and 9 units per site, for a total of 157 units (Table 8). Ontario has the highest number of SPECT units, followed by British Columbia. Newfoundland and Labrador have one unit each, and the Northwest Territories, Nunavut, and the Yukon have none.

TABLE 8 SUMMARY OF AVAILABILITY AND STATUS OF SPECT UNITS BY PROVINCE

Province	Sites with units[a]	Number of units[b]	Sites planning to install[c]	Sites that decommissioned since 2012[d]	Units per million population[e]
Alberta	11	16	1	4	3.81
British Columbia	10	25	1	3	5.34
Manitoba	4	7	0	1	5.41
New Brunswick	2	2	0	2	2.65
Newfoundland and Labrador	3	5	1	1	9.47
Northwest Territories	0	0	0	0	0.00
Nova Scotia	4	7	0	4	7.42
Nunavut	0	0	0	0	0.00
Ontario	40	73	7	9	5.29
Prince Edward Island	1	1	0	0	6.83
Quebec	5	9[f]	0	1	1.09
Saskatchewan	2	12	0	1	10.59
Yukon	0	0	0	0	0.00
Canada	82	157	10	26	4.38

[a] Data derived from question: "Do you have a SPECT machine(s) in your hospital/facility?" Each 'yes' counts as one.

[b] Data derived from question: "If so, how many SPECTs do you have?" For sites without survey information, validators' indication of availability and counts were included, if available.

[c] Do you have plans to install a new additional SPECT machine in the next two years? Each 'yes' counts as one.

[d] Have you decommissioned a SPECT since January 2, 2012? Each 'yes' counts as one.

[e] The population as of July 1, 2015.

[f] Survey respondents reported 9 units at 5 sites. The validator reviewing the Quebec survey data supplied combined totals for units at public facilities: SPECT or SPECT-CT, 54 units, estimating that the distribution was approximately equal. These data were not used in the calculation of units per population.

Thirty-three (33) new SPECT units were installed between 2012 and 2015. Twenty-six (26) sites have decommissioned one or more SPECT units since the last survey in 2012, and 10 sites plan the installation of one or more SPECTs in the next two years (Table 8). Our questions did not discriminate between replacement and new installations; therefore, it is unclear whether all planned installations are to be new machines, replacement, or upgrades. The respondent for one site identified the two planned installations as replacements for decommissioned equipment.

The number of SPECT units per population is highest in Saskatchewan, Newfoundland and Labrador, and Nova Scotia and lowest in New Brunswick and Quebec. This does not account for geographical spread.

Mobile SPECT

One site in Ontario reported that they have two mobile SPECT units, but indicated that both were serving its site alone as fixed units.

Geographical Distribution of SPECT

Figure 11 shows the present geographical distribution of SPECT across Canada mapped to the level of settlement (city or town), with a circle diameter proportional to the number of units.

FIGURE 11 DISTRIBUTION OF SPECT ACROSS CANADA

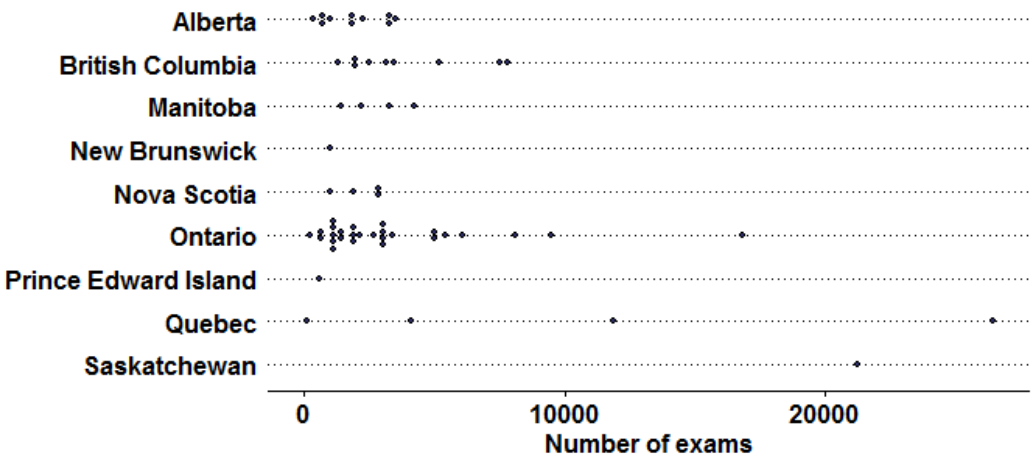
Data derived from question: "If yes, how many SPECTs do you have?Data derived from question: " For sites without survey information, validators' indication of availability and counts were included, if available. Counts for all sites within a city/town were aggregated, and symbol area is proportional to the number of units.

Patterns of SPECT Use: Number of Examinations in a Fiscal Year

Sixty-one sites reported a total of 229,502 SPECT examinations per year, where each site reported for its last fiscal year. The number of exams at an individual site varied widely, from 91 to 26,425 exams, but most sites performed fewer than 5,000 exams (Figure 2 and Figure 12).

Figure 12 shows the individual site data by province or territory, and the summary statistics across all provinces or territories are given in Appendix C, Table 15.

FIGURE 12 SPECT EXAMINATIONS BY PROVINCE OVER THE LATEST FISCAL YEAR



Data derived from question: "For all SPECT units, how many examinations were conducted in the last fiscal year?" Each dot represents the figure from one site.

Quebec and the single unit reported for Saskatchewan had the highest median number of examinations, and Prince Edward Island and New Brunswick the lowest. As previously noted, these totals are influenced by the number of units at each site (Appendix D, Table 18).

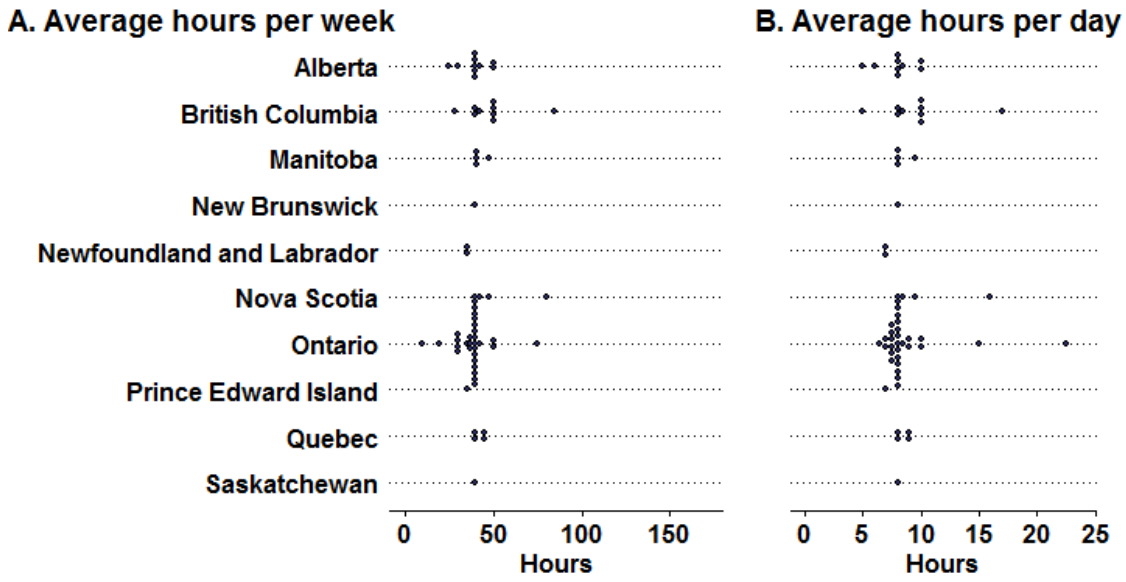
When we adjusted for the population of each province sites in Nova Scotia and Saskatchewan had the highest median exams per 1,000 people, with Saskatchewan almost double the figure for Nova Scotia. Prince Edward Island, New Brunswick, and Alberta had the lowest median number of examinations per site. No use data were available for Newfoundland (Appendix D, Table 19).

Patterns of SPECT Use: Typical Hours of Operation in a Week and Day, and Weekend Use

Sixty-five (65) sites provided information on the hours of use averaged across all their SPECT units in a typical week and 64 provided information for use in a typical day. Sites were asked for a single estimate of average use over all their units. The median estimate was 40 hours per day and 8 hours per week.

Hours per week and hours per day are shown for all sites by province in Figure 13, and detailed summary statistics are presented in Appendix C, Table 16 and Table 17.

FIGURE 13 AVERAGE HOURS OF OPERATION OF SPECT UNITS IN A TYPICAL WEEK AND IN A TYPICAL DAY



A. Hours per week: Data derived from question: "In an average week (168 hours) how many hours are the SPECT units in use, averaged across all units?"
B. Hours per day: Data derived from question: "On a regular workday, how many hours per day are the SPECT units in use, averaged across all units?"

Most sites in all provinces operated a 40 or 50 hour week and 8 or 10 hour day. We note that sites varied in whether they calculated the average hours per day over all working days, or only days of operation. Few SPECT units operated at the weekend, 6/73 (8.2%).

Patterns of SPECT Use: Types of Use

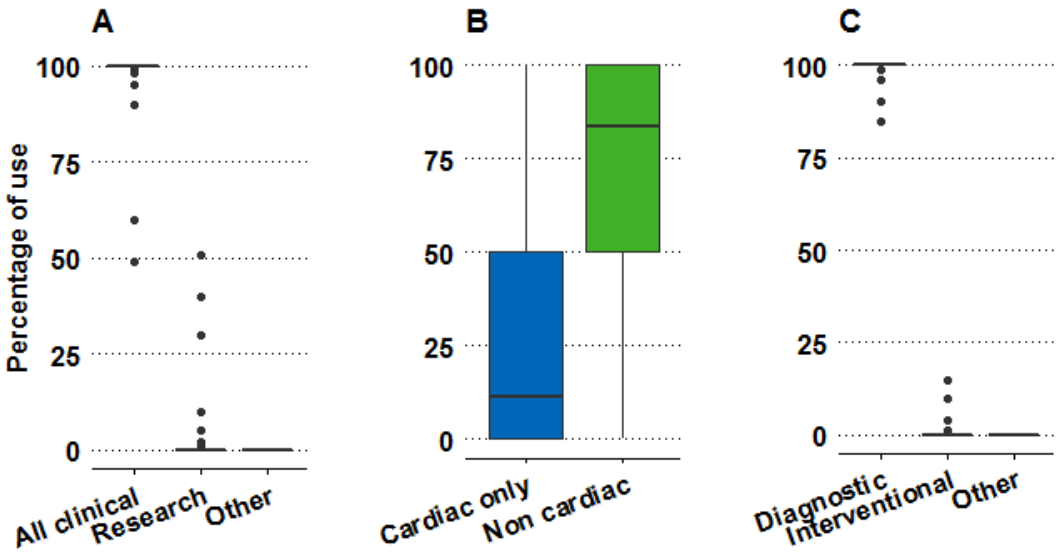
Sixty-four sites (64) provided at least partial information on the typical type of use across all their CT units. Use was assigned to two categories: Indication and Procedure. Indication was subdivided as clinical (further subdivided into cardiac only and non-cardiac), research, or other. Procedure was subdivided as diagnostic, interventional, or other.

For indication, most use was clinical. Where clinical use was subdivided, most use was non-cardiac, and the minority cardiac, although the proportion of cardiac use (around 30%) was higher than for the other modalities. This is likely due to the representation of dedicated cardiac SPECT units. Research and other use accounted for less than 3%, on average.

For procedure, most use was diagnostic, with less than 1% on average devoted to interventional use. No sites reported other uses for SPECT.

A summary of use is shown in Figure 14. Indication is shown on the left (A, B) and procedure on the right (C).

FIGURE 14 OVERALL PROPORTION OF TYPE OF USE OF SPECT UNITS



A, B. Indication: Data derived from question: "Based on your practice in the last fiscal year what % of time is this SPECT used for: Cardiac only/Non-cardiac/Research/Other?" All clinical was calculated by adding Cardiac only and non-cardiac.
C. Procedure: Data derived from question: "Based on your practice in the last fiscal year what percentage of clinical time is this SPECT used for: Diagnostic/Interventional/Other?"

Of the small number of sites (11) who responded to a question about whether any of their SPECT units were used in treatment planning, 1 (9%) answered yes.

POSITRON EMISSION TOMOGRAPHY (PET) OR POSITRON EMISSION TOMOGRAPHY-COMPUTED TOMOGRAPHY (PET-CT)

Number and Location of PET or PET-CT Units

Forty-five (45) sites in 8 provinces have one or more PET or PET-CT units. There were up to three units per site, for a total of 57 units (Table 9). Quebec and Ontario had the highest number of units. Manitoba and Nova Scotia reported one unit each. Newfoundland, Prince Edward Island, and the three territories did not report any PET-CT units within their regions, although Newfoundland anticipates having a new unit operational in St Johns in 2016.[26]

TABLE 9 SUMMARY OF AVAILABILITY AND STATUS OF PET-CT UNITS BY PROVINCE

Province	Sites with units[a]	Number of units[b]	Sites planning to install[c]	Sites that decommissioned since 2012[d]	Units per million population[e]
Alberta	3	4	0	1	0.95
British Columbia	3	5	2	0	1.07
Manitoba	1	1	1	0	0.77
New Brunswick	2	2	0	0	2.65
Newfoundland and Labrador	0	0	1	0	0.00
Northwest Territories	0	0	0	0	0.00
Nova Scotia	1	1	0	0	1.06
Nunavut	0	0	0	0	0.00
Ontario	12	18	2	2	1.31
Prince Edward Island	0	0	0	0	0.00
Quebec	20	23	5	0	1.21
Saskatchewan	3	3	0	0	2.65
Yukon	0	0	0	0	0.00
Canada	45	57	11	3	1.59

[a] Data derived from question: "Do you have a PET-CT machine(s) in your hospital/facility?" Each 'yes' counts as one.
[b] Data derived from question: "If so, how many PET-CTs do you have?" For sites without survey information, validators' indication of availability and counts were included, if available.
[c] Do you have plans to install a new additional PET-CT machine in the next two years? Each 'yes' counts as one.
[d] Have you decommissioned a PET-CT since January 2, 2012? Each 'yes' counts as one.
[e] The population as of July 1, 2015.

Nineteen new PET-CT units were installed between 2012 and 2015. Three sites decommissioned one or more PET or PET-CT unit since the last survey in 2012, and 11 sites reported planned installation of one or more PET-CTs in the next two years (Table 9). Our survey did not discriminate between replacement and new installations; therefore, it is unclear whether planned installations are to be new machines, replacements or upgrades.

Geographical Distribution of PET-CT

Figure 15 shows the present geographical distribution of PET-CT across Canada mapped to the level of settlement (city or town), with a circle diameter proportional to the number of units.

FIGURE 15 DISTRIBUTION OF PET-CT ACROSS CANADA

Question: Data derived from question: "If yes, how many PET-CTs do you have?" For sites without survey information, validators' indication of availability and counts were included, if available. Counts for all sites within a city/town were aggregated, and symbol area is proportional to the number of units.

Quebec, New Brunswick, and Saskatchewan have the highest number of machines per population. Alberta, Nova Scotia, and Manitoba have the lowest number per population, not accounting for geographical spread.

Mobile PET-CT

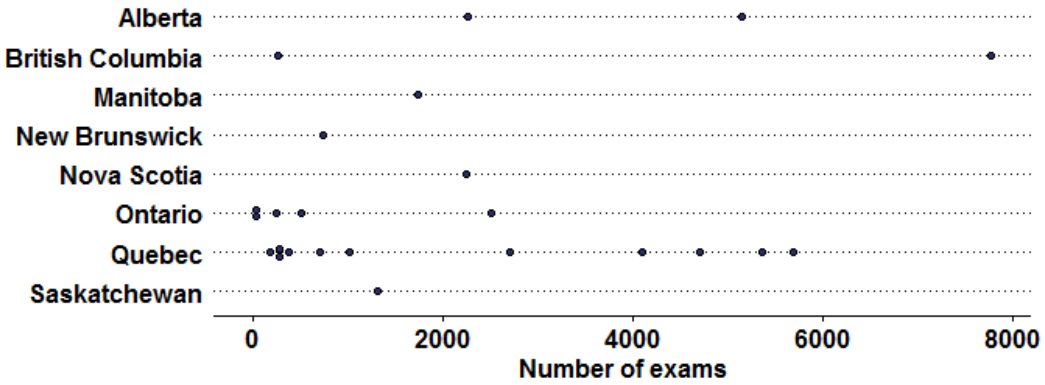
Two sites, one in Ontario and one in Saskatchewan, reported having a mobile PET-CT, however the one in Ontario was fixed. Neither site indicated which facilities the machine is shared with.

Patterns of PET-CT Use: Number of Examinations in a Fiscal Year

Twenty-four (24) sites across Canada reported a total of 50,163 PET-CT examinations per year, where each site reported for its last fiscal year. The number of exams per site ranged from 25 to 7,775, with most sites reporting less than 2,500 per year.

Figure 16 shows the individual site data by province, and the summary statistics across all provinces or territories are provided in Appendix C, Table 15.

FIGURE 16 PET-CT EXAMINATIONS BY PROVINCE OVER THE LATEST FISCAL YEAR



Data derived from question: "For all PET-CT units, how many examinations were conducted in the last fiscal year?" Each dot represents the figure from one site.

British Columbia and Alberta had the highest median exams per site, and Ontario and New Brunswick had the lowest. As previously noted, these totals are influenced by the number of units counted, as well as by volume (Appendix D, Table 18).

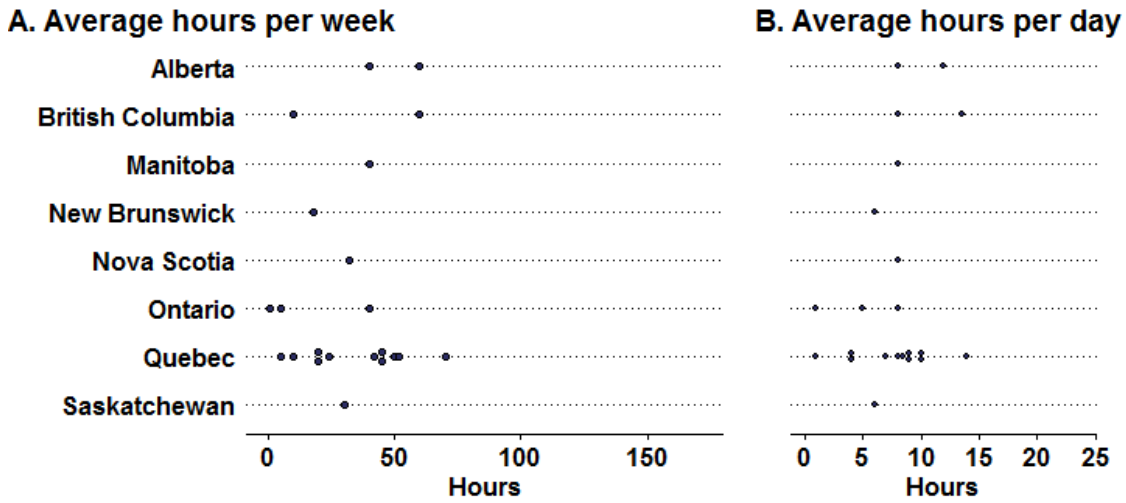
When we adjusted for the population of each province, Quebec and Nova Scotia had the highest number of exams per 1,000 people, and Ontario and New Brunswick had the lowest (Appendix D, Table 19).

Patterns of PET-CT Use: Typical Hours of Operation in a Week and Day, and Weekend Use

Twenty-two (22) sites provided information on the hours of use averaged across all their PET-CT units in a typical week and/or in a typical day. Sites were asked for a single estimate of average use over all their units. The median estimate was 36 hours per week and 8 hours per day.

Hours per week and hours per day are shown by province in Figure 17, and detailed summary statistics are presented in Appendix C, Table 16 and Table 17.

FIGURE 17 AVERAGE HOURS OF OPERATION OF PET-CT UNITS IN A TYPICAL WEEK AND IN A TYPICAL DAY



A. Average hours per week: Data derived from question: "In an average week (168 hours) how many hours are the PET-CT units in use, averaged across all units?"

B. Average hours per day: Data derived from question: "On a regular workday, how many hours per day are the PET-CT units in use, averaged across all units?"

Patterns of PET-CT use: Types of use

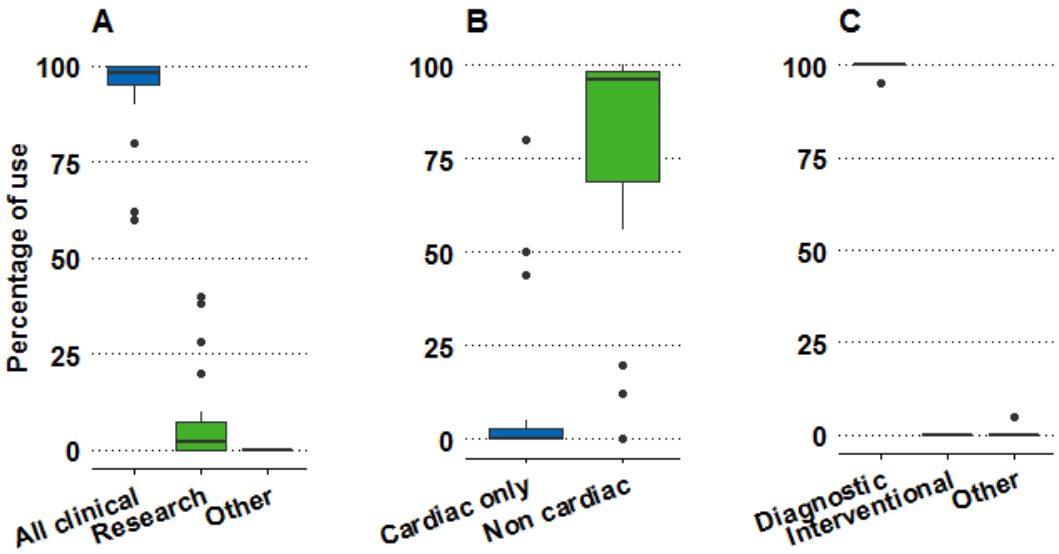
Twenty-four sites provided at least partial information on the typical type of use across all their PET-CT units. Use was assigned to two sets of categories: Indication and Procedure. Indication was subdivided as clinical (further subdivided into cardiac only and non-cardiac use), research, or other. Procedure was subdivided as second category subdivided as diagnostic, interventional, or other.

For indication, most use was clinical. Of this majority, over three quarters of use was non-cardiac, with the remainder devoted to cardiac use. Research use accounted for less than 10% on average, and none of the sites indicated any 'other' use.

For procedure, use was almost exclusively diagnostic (>99% on average), with no interventional use reported. Less than 1% of use was 'other', which was not specified.

A summary of use is shown in Figure 18. Indication is shown on the left (A, B) and procedure on the right (C).

FIGURE 18 SUMMARY (BOXPLOT) OF PROPORTION OF TYPE OF USE OF PET-CT UNITS



A, B. Indication: Data derived from question: "Based on your practice in the last fiscal year what % of time is this CT used for: Cardiac only/Non-cardiac/Research/Other?" All clinical was calculated by adding Cardiac only and non-cardiac.

C. Procedure: Data derived from question: "Based on your practice in the last fiscal year what percentage of clinical time is this CT used for: Diagnostic/Interventional/Other?"

Of the small number of sites who responded to a question about whether any of their PET-CT units were used in treatment planning, 6/13 (46.2%) answered yes, and 5/12 (41.7%) reported that they operated the stand-alone CT component.

POSITRON EMISSION TOMOGRAPHY-MRI (PET-MRI)

Number and Location of PET-MRI Units

We identified two sites with PET-MRI installations, both of which were in Ontario (Figure 19). Neither of which were in clinical operation as of the survey data collection period, and there are no data on use available.

Planned Installations for PET-MRI Units

Two sites, one in Manitoba and one in Quebec, indicated on the survey that they plan to install a PET-MRI in the next two years. In addition, based on press-releases, data collected during a 2015 CADTH Environmental Scan on PET, PET-CT, and PET-MRI in Canada,[26] and a focused internet search, we identified a further four facilities with concrete plans or intentions to install a PET-MRI unit in the near future, one in British Columbia, one in Alberta, and two in Ontario.[26]

FIGURE 19 DISTRIBUTION OF PET-MRI UNITS ACROSS CANADA

Data derived from question: "If yes, how many PET-CTs do you have?" For sites without survey information, validators' indication of availability and counts were included, if available. Counts for all sites within a city/town were aggregated, and symbol area is proportional to the number of units.

SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY-COMPUTED TOMOGRAPHY (SPECT-CT)

Number and Location of SPECT-CT Units

Eighty-two (82) sites in 10 provinces or territories reported having SPECT-CT available. There were up to 5 units per site, for a total of 128 units (Table 10). Ontario has the highest number of units, followed by Alberta and British Columbia. Prince Edward Island and Saskatchewan reported one unit each. The three territories did not report any units.

TABLE 10 SUMMARY OF AVAILABILITY AND STATUS OF SPECT-CT UNITS BY PROVINCE

Province	Sites with units[a]	Number of units[b]	Sites planning to install[c]	Sites that decommissioned since 2012[d]	Units per million population[e]
Alberta	16	32	5	2	7.63
British Columbia	13	19	4	0	4.06
Manitoba	4	7	3	0	5.41
New Brunswick	4	4	2	0	5.31
Newfoundland and Labrador	3	4	0	0	7.58
Northwest Territories	0	0	0	0	0.00
Nova Scotia	8	9	1	0	9.54
Nunavut	0	0	0	0	0.00
Ontario	29	37	9	0	2.68
Prince Edward Island	1	1	1	0	6.83
Quebec	5	10[f]	3	0	1.21
Saskatchewan	1	5	0	0	4.41
Yukon	0	0	0	0	0.00
Canada	84	128	28	2	3.57

[a] Data derived from question: "Do you have a SPECT-CT machine(s) in your hospital/facility?" Each 'yes' counts as one.
[b] Data derived from question: "If so, how many SPECT-CTs do you have?" For sites without survey information, validators' indication of availability and counts were included, if available.
[c] Do you have plans to install a new additional SPECT-CT machine in the next two years? Each 'yes' counts as one.
[d] Have you decommissioned a SPECT-CT since January 2, 2012? Each 'yes' counts as one.
[e] The population as of July 1, 2015.
[f] Survey respondents reported 10 units at 5 sites. The validator reviewing the Quebec survey data supplied combined totals for units at public facilities: SPECT or SPECT-CT, 54 units, estimating that the distribution was approximately equal. These data were not used in the calculation of units per population.

Forty-two (42) new SPECT-CT units were installed between 2012 and 2015. Two sites reported that they decommissioned a SPEC-CT since the last survey in 2012, and 28 sites planned the installation of one or more SPECT-CTs in the next two years. Our questions did not discriminate between replacement and new installations; therefore, it is unclear whether planned installations are to be new machines, replacements or upgrades.

The provinces with the highest number of units per million people are Nova Scotia, Alberta, Prince Edward Island, and Nova Scotia, and those with the lowest are Ontario, and Quebec. This does not account for geographical distribution.

Mobile SPECT-CT

One site in British Columbia reported that it has a mobile SPECT-CT unit, but that it is fixed in place.

Geographical Distribution of SPECT-CT

Figure 20 shows the present geographical distribution of SPECT-CT across Canada mapped to the level of settlement (city or town), with a circle diameter proportional to the number of units.

FIGURE 20 DISTRIBUTION OF SPECT-CT ACROSS CANADA

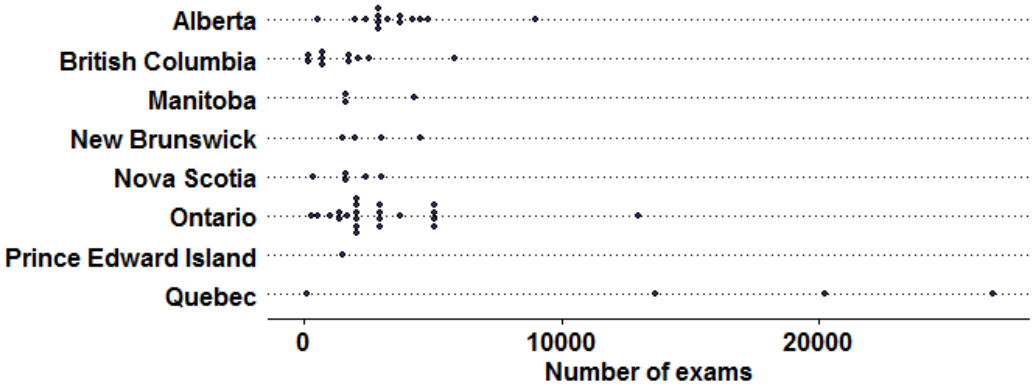
Data derived from question: “If yes, how many SPECT-CTs do you have?” For sites without survey information, validators’ indication of availability and counts were included, if available. Counts for all sites within a city/town were aggregated, and symbol area is proportional to the number of units.

Patterns of SPECT-CT Use: Number of Examinations in the Last Fiscal Year

Sixty-three (63) sites across Canada reported a total of 222,827 SPECT-CT examinations per year, where each site reported for its last fiscal year. The median number of examinations per site varied widely, from 77 to 26,795, but most sites recorded less than 5,000 examinations per year.

Figure 21 shows the individual site data by province, and summary statistics across all provinces or territories are provided in Appendix C, Table 15.

FIGURE 21 SPECT-CT EXAMINATIONS BY PROVINCE OVER THE LATEST FISCAL YEAR



Data derived from question: "For all SPECT-CT units, how many examinations were conducted in the last fiscal year?" Each dot represents the figure from one site.

Quebec has the highest median exams per site, followed by Alberta and New Brunswick. British Columbia, Prince Edward Island, and Manitoba recorded the lowest.

As previously noted, these totals are influenced by the number of units counted, as well as by volume (Appendix D, Table 18).

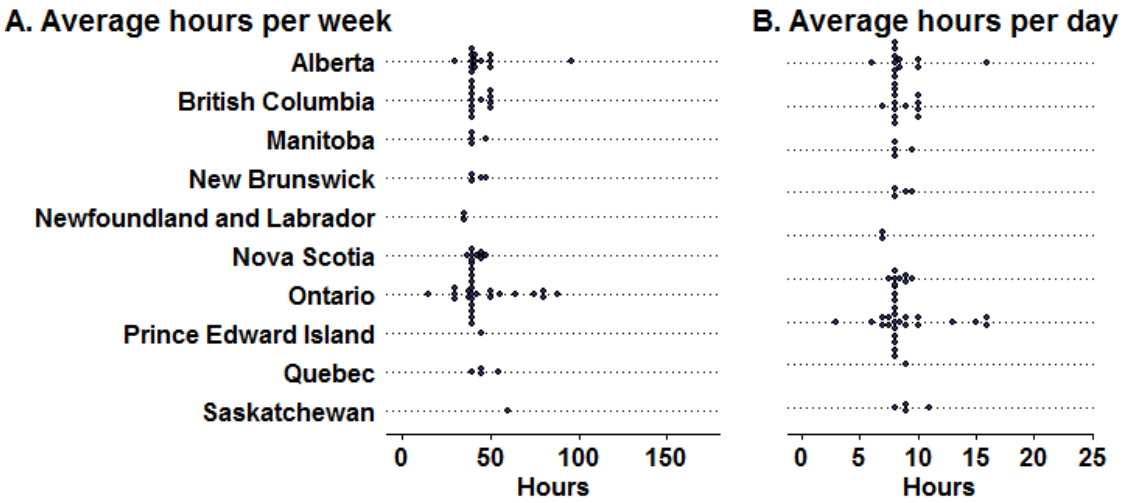
When we adjusted for the population of each province, Quebec and New Brunswick have the highest and Manitoba and Nova Scotia the lowest (Appendix D, Table 19).

Patterns of SPECT-CT Use: Typical Hours of Operation in a Week and Day, and Weekend Use

Seventy-six (76) sites provided information on the hours of use averaged across all their SPECT units in a typical week and 74 provided information for use in a typical day. Sites were asked for a single estimate of average use over all their units. The median estimate was 40 hours per week and 8 hours per day.

These data are shown by province in Figure 22, and detailed summary statistics are presented in Appendix C, Table 16 and Table 17.

FIGURE 22 AVERAGE HOURS OF OPERATION OF SPECT-CT UNITS IN A TYPICAL WEEK AND IN A TYPICAL DAY



A. Data derived from question: "In an average week (168 hours) how many hours are the SPECT-CT units in use, averaged across all units?"

B. Data derived from question: "On a regular workday, how many hours per day are the SPECT-CT units in use, averaged across all units?"

Most sites in all provinces operated a 40 or 50 hour week and 8 or 10 hour day. Based on comparisons of weekly and daily hours, there was variation in whether sites averaged over all calendar days, or only days of operation. Ten of 73 sites (13.7%) reported weekend operation.

Patterns of SPECT-CT Use: Types of Use

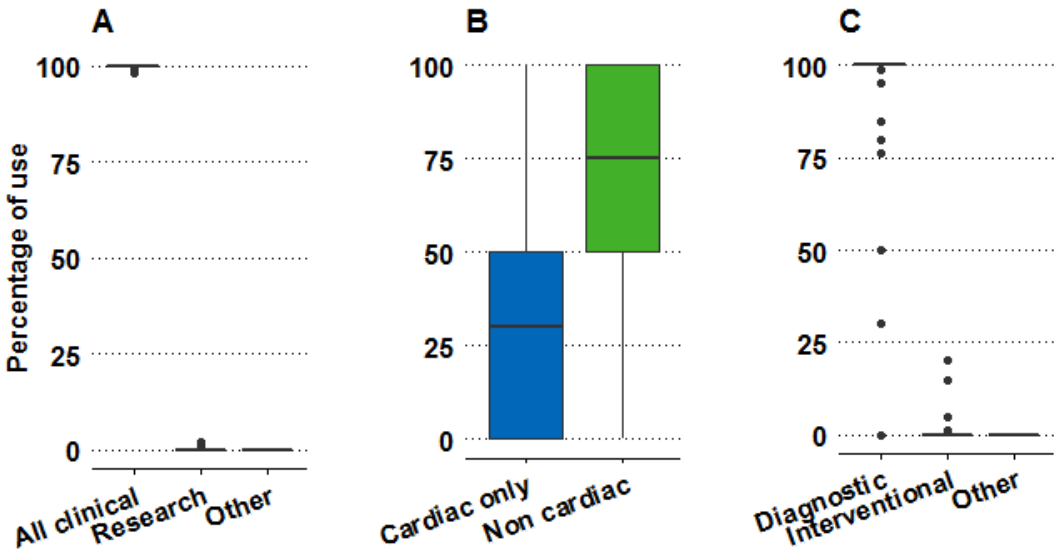
Sixty-eight sites provided at least partial information on the typical type of use across all their CT units. Use was assigned to two sets of categories: Indication and Procedure. Indication was subdivided as clinical (further subdivided into cardiac only and non-cardiac), research, or other. Procedure was subdivided as diagnostic, interventional, or other.

For indication, most use was clinical. Of clinical use, two thirds on average was non-cardiac, and one third was cardiac only. Most sites reported no research use, and none reported other uses.

For procedure, most use was diagnostic, with the remainder (<5%) devoted to interventional use. No sites reported other uses for SPECT-CT.

A summary of use is shown in Figure 23. Indication is shown on the left (A, B) and procedure on the right (C).

FIGURE 23 OVERALL PROPORTION OF TYPE OF USE OF SPECT-CT UNITS



A,B. Indication. Data derived from question: "Based on your practice in the last fiscal year what % of time is this CT used for: Cardiac only/Non-cardiac/Research/Other?" All clinical was calculated by adding Cardiac only and non-cardiac.

C. Procedure. Data derived from question: "Based on your practice in the last fiscal year what percentage of clinical time is this CT used for: Diagnostic/Interventional/Other?"

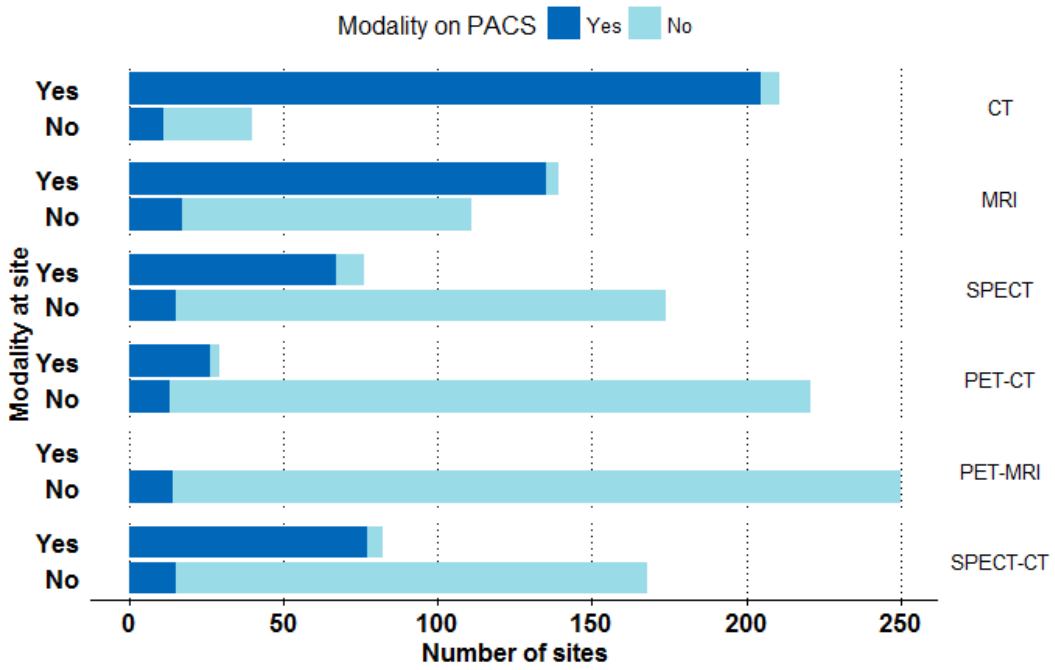
Of the small number of sites (10) who responded to a question about whether any of their SPECT-CT units were used in treatment planning, 10.0% answered yes. Four of 12 reported that they operated the stand-alone CT component.

PICTURE ARCHIVING COMMUNICATION SYSTEM (PACS)

Modalities Available on PACS

Data regarding access to images on PACS based on operation of modalities are shown in Figure 24. For all modalities excluding PET-MRI, most sites that had operational units installed stored those images on PACS. There are no data on PACS use for the two sites that have PET-MRI. Across all modalities, including PET-MRI, a small minority of sites without the modality on site could access images through PACS.

FIGURE 24 OVERALL ACCESS TO IMAGES THROUGH PACS COMPARED WITH AVAILABILITY OF MODALITIES AT SITES

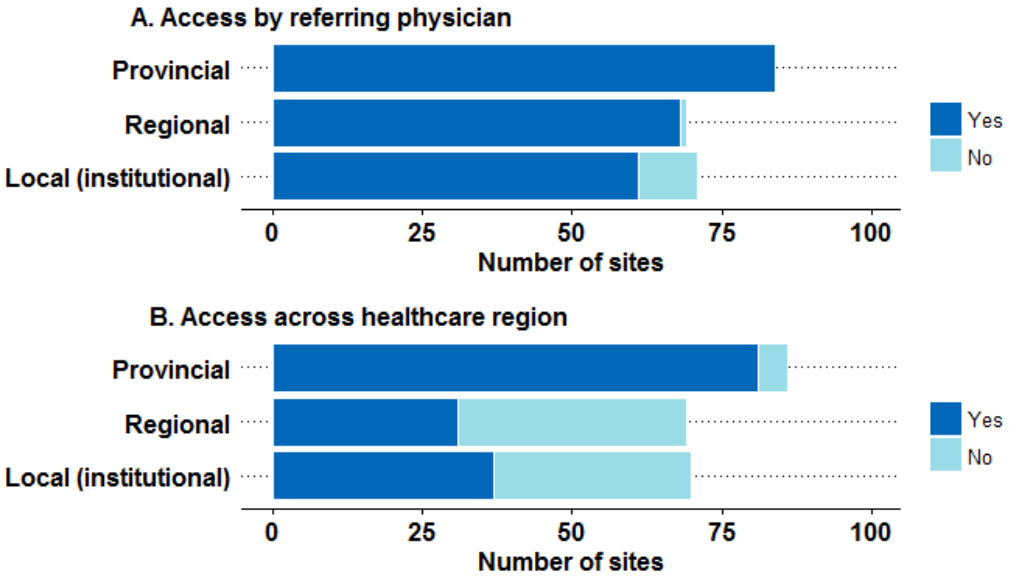


Data derived from question: "Are medical images stored on a Picture Archive and Communication System (PACS)?"
Data derived from question: "If yes, which imaging modalities are stored on PACS systems? PET-CT or PET / CT / MRI/PET-MRI / SPECT-CT / SPECT"

PACS Coverage

Two hundred and forty-three (243) sites reported the coverage of their PACS network: 31.3% local, 28.8% regional, and 39.9% provincial. PACS images were available to referring physicians outside of the imaging department at the majority 213/224 (95.1%) of sites. Routine access throughout the sites provincial health care system, without the need to manually push images from any particular location/modality, was also available at the majority 149/225 (66.2%) of sites. Figure 25 shows the results of cross-tabulation of these three variables, indicating that sites with PACS extending over the province offered the greatest access. We did not, however, identify sites as members of specific PACS networks.

FIGURE 25 EXTENT OF ACCESS TO IMAGES THROUGH PACS COMPARED WITH PACS COVERAGE



Left column in A and B): Data derived from question: "Is your PACS Local (institutional)/Regional/Provincial?"

A. Data derived from question: "Do referring physicians have access to PACS images in areas of the hospital outside of Diagnostic Imaging, e.g., hospital clinics, the OR, case rounds, meeting rooms, etc?"

B. Data derived from question: "Are PACS images routinely accessible throughout your provincial health care system without the need to manually push images from any particular location/modality?"

MEDICAL ISOTOPE SUPPLY

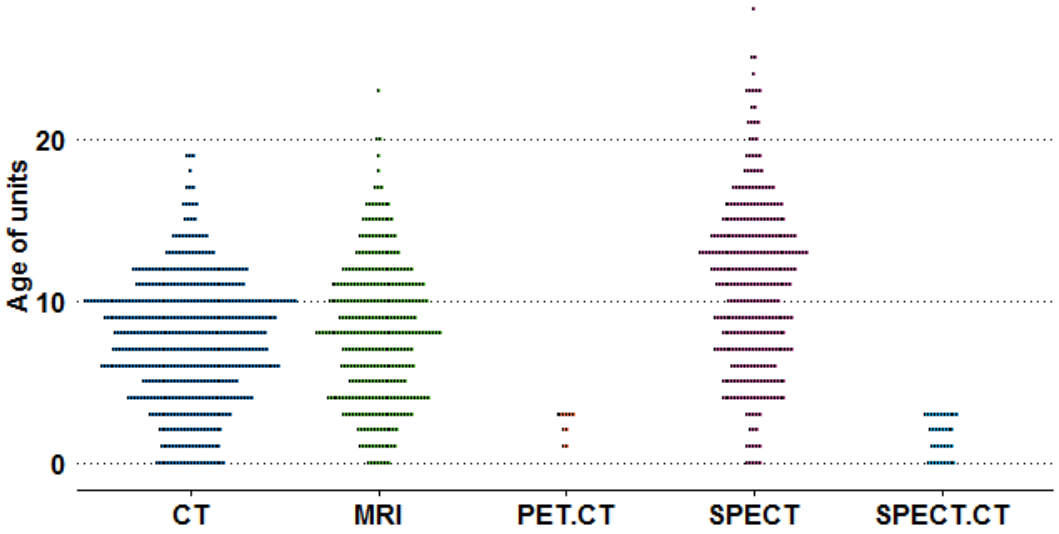
Given the concerns about isotope supply in Canada, we asked sites reporting a PET or PET-CT whether they had access to a cyclotron, and if not, where they obtained their isotopes. Of the 24 sites who responded, six had access to a cyclotron, in Alberta, British Columbia, Manitoba, Nova Scotia, Ontario, and Quebec. The Canadian Nuclear Safety Commission website identified total of 10 PET cyclotrons in Canada.[36] Three of the four cyclotrons not identified by the survey are in Ontario and the fourth in Quebec.[36] The 2015 CADTH Environmental Scan identified three additional cyclotrons expected to become operational in 2016 or later, one in Ontario, one in Saskatchewan, and one in Newfoundland and Labrador.[26]

Eighteen sites without a cyclotron obtained isotopes elsewhere, the majority from commercial suppliers, 11/18 (61.1%). The remainder obtained isotopes from other sites with cyclotrons (4/18) or did not indicate a source (3/18).

AGE OF IMAGING EQUIPMENT IN CANADA

We estimated the age of imaging equipment for 537 active units in the combined CMII 2015 and CIHI 2012 datasets, based on reported installation and decommissioning dates. The average age of CT units is 7.5 years, MRI 8.1 years, SPECT 11.0 years, PET-CT 2.4 years, and SPECT-CT, 1.6 years. The age distribution is plotted in Figure 26 and the detailed summaries by province appear in Appendix E.

FIGURE 26 AGE OF MEDICAL IMAGING EQUIPMENT IN CANADA



Provinces with fewer units tended to lie at the extremes, which was not surprising, given that a single unit due to be replaced, or newly replaced, would have greater influence on summary values (Appendix E, Table 20).

We used data collected on units decommissioned since 2012 in the CMII survey to identify units in the CIHI dataset that were no longer in use. In a number of cases, particularly for SPECT, we could not match years of installation with enough confidence to warrant their removal. Therefore these summaries may include some units that have been decommissioned. In addition, we are missing dates of installation for units identified by validators and during the grey literature search. Depending on the balance between newer and older units, we may be over- or under-estimating mean ages.

CANADIAN DATA VERSUS INTERNATIONAL DATA

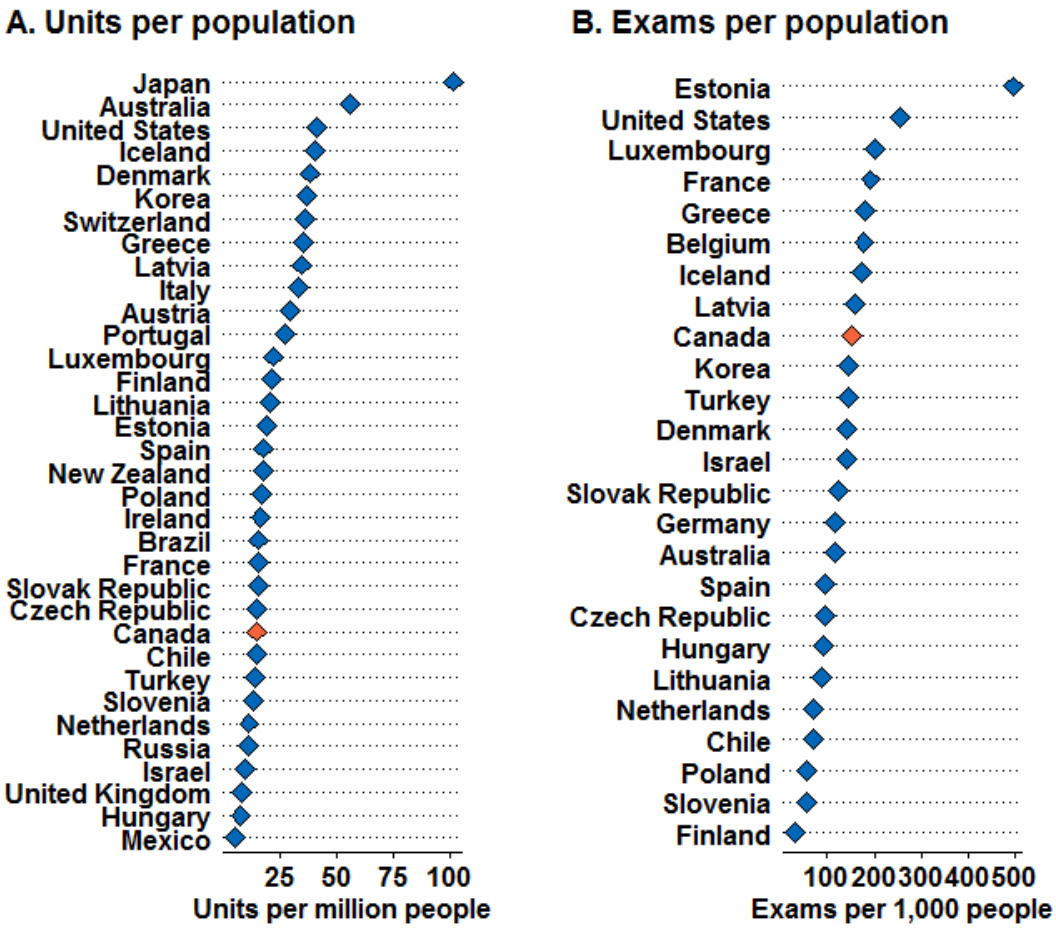
The availability of machine count and use data allowed comparison of the Canadian data we collected to international data from the Organization for Economic Co-operation and Development (OECD),[22-25] which included 33 other countries of varying levels of development. The last observation carried forward method was used for all countries to impute 2015 values. Some countries had data as recent as 2014.

Computed Tomography

Based on our survey results, including data from validators and grey literature, Canada ranks below approximately half of the countries with data collected by OECD in terms of number of Computed Tomography devices per million people,[24] slightly higher than the number of units recorded in Canada in 2013 (Figure 27)

As only a subset of sites reported examination data in our survey, we used the median number of exams from the sites that provided data to impute the missing totals (Figure 27). Canada placed halfway in the field of other countries,[22] with slightly more exams than reported in 2013. The variations are likely to reflect variations in practice as well as variations in accessibility.

FIGURE 27 COMPARISON OF CANADIAN AND INTERNATIONAL DATA FOR COMPUTED TOMOGRAPHY



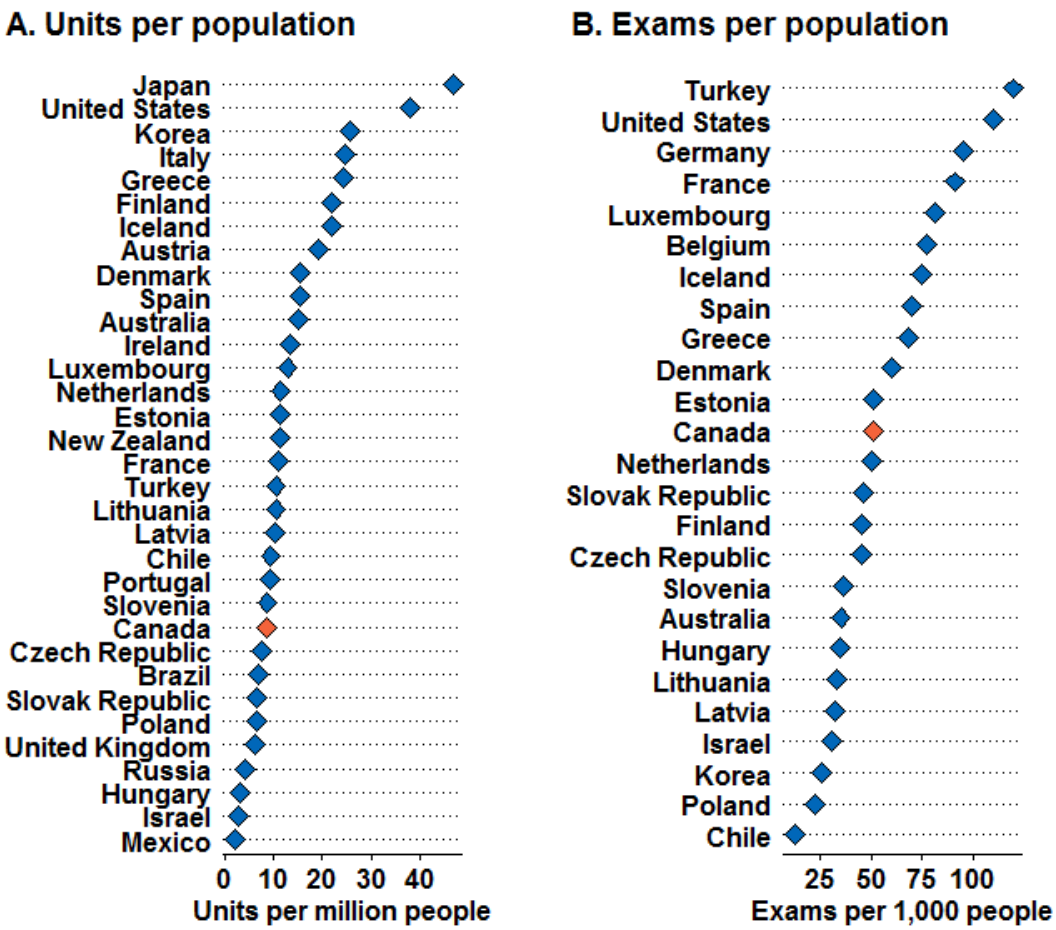
Canadian data from CMII 2015 survey (orange) is compared with most recently collected international data (2011-2014). The total exams for Canada in 2015 was calculated by imputing the median number of exams per site for all sites without data and adding the total number of exams for sites that provided data.

Magnetic Resonance Imaging

Canada is just above the bottom third of countries with data collected by OECD in terms of number of Magnetic Resonance Imaging devices per million people, slightly higher than what was observed in 2013 (Figure 28).[25]

As only a subset of sites reported examination data in our survey, we used the median number of exams from the sites that provided data to impute the missing totals. Canada placed below approximately half of the other countries (Figure 28)[23] with a slightly lower quantity of MRI exams than what was observed in 2013.

FIGURE 28 COMPARISON OF CANADIAN AND INTERNATIONAL DATA FOR MAGNETIC RESONANCE IMAGING



Canadian data from CMII 2015 survey (orange) is compared with most recently collected international data (2011-2014).
The total exams for Canada in 2015 was calculated by imputing the median number of exams per site for all sites without data and adding the total number of exams for sites that provided data.

DISCUSSION

OVERALL FINDINGS

These survey results are based on responses from a pan-Canadian sample of primarily publicly funded hospitals, community hospitals, and tertiary care centres, with a minority of free-standing facilities, some of which receive private or a combination of public and private funding.

Type of Facility

Most units identified are installed within publicly funded hospitals or tertiary care centres. The number and importance of free standing clinics to the health care system may vary across provinces, with some provinces using referral to free standing clinics to manage wait times. Our response rate from free standing facilities was low, and in future cycles we aim to increase representation.

Modalities

CT is the most widespread modality in Canada, with the highest volume of use (based on number of exams and hours of use), followed by MRI. Except for SPECT, they are the longest established of the modalities surveyed, as well as those with the widest indications. All provinces have one or more units of CT, MRI, SPECT, and SPECT-CT. CT is now operating in all territories, and MRI in the Yukon; the other modalities are not. PET-MRI is the newest modality, with two units installed in Ontario, but several other sites have installations planned or in progress.

Variation in Number of Exams and Hours of Use

For all modalities, there is substantial variation in number of exams and hours of use (per week or day) across jurisdictions, and within jurisdictions. Some of this variation may be explained by the availability of units, and technical and clinical expertise to operate them. In addition, we used a single definition of examination that does not incorporate duration and complexity. Determinants of use that could be at play and that may be of interest to investigate include over-screening and the age of units (older units may see lighter use). Further, patient demographics and socioeconomic status may contribute to use patterns,[37] as well as proportion of care provided by specialists versus primary care physicians.[38]

Variation in Type of Use Across Modalities

While clear patterns emerged in regards to the primary applications of each modality, there was variation. CT and MRI were used almost exclusively for non-cardiac clinical purposes, and for diagnostic rather than interventional purposes. Some respondents indicated that interventional purposes included biopsy, and intra-operative imaging. SPECT and SPECT-CT are used for both cardiac and non-cardiac clinical purposes, though primary non-cardiac use is more common, and primarily for diagnostic purposes. As we collected data for overall use for all units, we did not systematically identify older SPECT and SPECT-CTs that were exclusively for cardiac use, but of the units installed since 2012, five SPECTs and two SPECT-CTs were for dedicated cardiac use. PET-CT had more research use than the other modalities, possibly because it is a newer modality and methods are still being developed. PET-MRI at present is exclusively used for research.

Research use may be under reported, as we gave priority to clinical imaging in our selection of contacts. Comments in the survey indicated that, where respondents had to answer for large or multiple sites, they preferentially reported units in clinical use. In large centres, research facilities for medical imaging may be separate from clinical imaging departments. There may be other uses that are captured but not identified such as animal research studies or veterinary imaging, as respondents did not indicate what they meant by 'other' when this option was selected.

Lifecycle and age of diagnostic imaging equipment

The data on decommissioning, recent, and planned installations for CT and MRI suggests that facilities are both installing new units and replacing older units. This could reflect the higher use patterns observed as life expectancy is lower for frequently used machines.[39] Our survey did not discriminate between replacements, new installations and upgrades. Given the trend in technology for frequent upgrades and replacements it is likely that these actions may represent at least some of the planned installations.

The average age of a CT unit nationally is 7.5 years, of an MRI unit 8.1 years, and of a SPECT unit, 11 years. The average for each of the hybrid modalities is <3 years. For those units already decommissioned, the average age at decommissioning of a CT unit was 9.4 years, of an MRI unit 11.7 years and of a SPECT unit 13.7 years. This calculation, however, included only those units that have been reported as decommissioned, and that had dates of installation and decommissioning available. The Canadian Association for Radiologists' 2013 Lifecycle Guidance Report suggests that all modalities listed in this report have a life expectancy of approximately 8 to 12 years.[39] It suggests that certain factors including demand, technology evolution, history of use, changes in safety consideration, and availability of parts and services are important to consider in the update, replacement and procurement of new technologies. While these items may be considered it is unclear what their influence is on current decommissioning activities. Recently, CADTH released for feedback a draft Environmental Scan on Diagnostic Imaging Equipment Replacement and Upgrade in Canada.

Emergence of hybrid PET Modalities

PET imaging has been entirely superseded by its hybrid forms, particularly PET-CT, which offers both the functional imaging of PET and the high anatomical resolution of CT. The data for SPECT and SPECT-CT also suggests a pattern of succession, with replacement of some older SPECT units by SPECT-CT. PET-MRI, which offers high anatomical resolution without the radiation dose associated with CT scanning, is in the early stage of diffusion. However, due to potential applications in oncology, neuropsychiatric conditions (e.g., Alzheimer's disease) and mental illness, adoption and increased use is anticipated.[40] PET/MRI may provide greater clinical utility than PET/CT or MRI alone.[40,41] Due to potential barriers such as cost, technical challenges[18,20,42] associated with implementation, projected wait times, contraindications (e.g., pacemakers), limited highly-qualified personnel,[20] and uncertainty with respect to which hybrid PET modality (i.e. CT or MRI) provides optimal clinical utility,[43] the speed of adoption is unclear.[41]

PACS Accessibility

Most facilities with imaging installed stored PACS images for those modalities. A minority of sites without units installed had access PACS images for those modalities. We do not know what forms of storage are used where PACS are not used, and how the images are shared with referring physicians and consultants.

Respondents in free text comments noted difficulty transferring images between PACS systems, especially between private and public facilities. This is of concern particularly when patients are being treated within the public healthcare system, but are undergoing imaging at private clinics, as may occur due to long wait times at public facilities. There may be barriers to accessing images in a timely manner, which could have an influence on the quality of care provided.

JURISDICTIONAL DIFFERENCES

Urban versus rural and remote coverage

Overall, larger provinces including Alberta, British Columbia, Ontario, and Quebec have the greatest quantity of machines, followed by Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, and Saskatchewan, which have a relatively moderate number of machines. Provinces or territories with relatively low machine counts include the northern territories, and Prince Edward Island.

Some of these differences may be explained by provincial or territorial population size as the number of modalities per million people is more equitable than the total machine counts per population. This, however does not account for population distribution in the respective provinces or territories, and suggests that access in the rural and remote areas of Canada is substantially less than in the urban areas. For instance, the territories have the highest number of CT units per million people, yet each territory has a single unit supplying a large geographical area, requiring patients to travel or be transferred significant distances. This incurs treatment delays, extra costs, and limits the value of CT in emergencies and for frail patients.

Some rural areas are serviced by mobile units, but based on the survey responses many of those units may be fixed or operating at a single location, with the general exception of mobile MRI units. Issues related to logistics, transportation, and operation of mobile machines may hinder their use. It is unclear whether use of these technologies has changed over time.

Medical imaging machines are clustered around major urban centres and within provinces and territories with larger populations, perhaps owing to already established physical infrastructure and the presence of staff with clinical and technical expertise. Some of the smaller and less populated provinces or territories lack within-jurisdiction access to most modalities, and access may depend on cross-jurisdictional partnerships, patients' abilities and willingness to travel, and integrated telemedicine services. It is important to explore how effectively these partnerships fulfil the need in provinces or territories without certain modalities installed. We have not investigated further the contrast between rural and remote and urban access suggested in our findings, but plan to do so.

Funding Structures

One aspect of medical imaging practice that the survey did not address was potential differencing in funding structures across jurisdictions, specifically, private-public partnerships and cost-sharing across jurisdictions. Based on some comments provided by survey respondents, there may be cross-jurisdictional care of patients, as well as referral of wait list patients to private clinics. In both of these scenarios it is not clear whether private or public funds are used to cover the costs of imaging and care. Regulatory frameworks in place to govern operation of private facilities may also differ across jurisdictions and may influence the number and utilization of clinics.

Highly-Trained Personnel

The availability of highly trained personnel may also contribute to some of the variation observed across sites. Presence of an academic training centre, research facilities, and large healthcare facilities that provide employment opportunities may be necessary to attract clinicians and technicians. Centres in rural or remote regions may face challenges in attracting and retaining highly-trained professionals, or in providing training and continuing education for existing staff. As telemedicine and mobile technologies evolve there may be opportunity to provide improved access through the combination of these innovations. Telehealth, including access to images generated remotely, is already an aspect of some areas of clinical practice including stroke management.[44] Further, there is limited evidence that it may be cost-effective to set up imaging services in rural and remote areas.[45,46]

CANADIAN DATA VERSUS INTERNATIONAL DATA

Compared to 33 other countries of different levels of development around the world, as recorded by the OECD, Canada currently ranks in the lower 50% in terms of number of CT units per million people. This is up from 2013, when Canada ranked within the bottom third. A similar pattern is observed for MRI. Canada ranked in the upper 50% for number of CT exams and around the middle for number of MRI exams, with the total increasing slightly from 2013 for CT, and decreasing slightly for MRI.

The observed decrease in number of MRI exams is unexpected, given the emerging concerns about exposure to radiation from medical imaging; we expected an increased number of exams. Our estimated number of exams is based on imputation of missing exam information, and it is possible that the sites used to impute the missing data tended to be lower throughput. In addition, the survey data on private sites are limited.

No data were publicly available on the other modalities of interest; therefore, the Canada's status compared to other countries is unclear in these cases. In the future it would be interesting to compare Canada's adoption of emerging technologies (e.g., PET-MRI) against other countries, especially as clinical applications and use increase.

STRENGTHS

The data collected for this report represents the first survey of medical imaging equipment in Canada since the last survey by CIHI in 2012. As such, this survey meets a need that is especially relevant in the current environment of proliferating use of medical imaging, and emergent technologies and clinical applications.

To address non-responses, extensive efforts were made to obtain high-level data from provincial or territorial validators, through review of press-releases, news articles and other grey literature sources, and through consideration of 2012 CIHI data for facilities that had no other sources of data. Through these efforts we believe an accurate characterization of the medical imaging landscape in Canada has been achieved.

This version of the survey also captured data on technical specifications, allowing further insight into associations not just of modality, but specific type of modality with patterns of use; this information will be reported in future updates.

LIMITATIONS

Selection of imaging modalities

Six modalities are included in this inventory; therefore, the report does not provide information about the availability of other imaging modalities operated within Canada (for example, X-ray, ultrasound, gamma cameras, angiography, and lithotripsy). In addition, these exclusions may limit understanding of the relationship between modalities (for example, stepwise imaging processes) and the ability to consider funding allocation for diagnostic imaging across all modalities. We will review inclusion for future iterations of the survey as needs and technologies evolve.

Private versus Public Coverage

As participation in the survey was not mandatory, and a definitive up-to-date list of facilities using medical imaging equipment in Canada was lacking, we cannot ensure that all facilities were contacted or are represented. In particular, there was a notable difference in the number of responses between publicly and privately funded facilities. Publicly funded facilities were more readily identified and for which data were held a multiple administrative levels, and private facilities. Not all provinces have a publicly available repository of private imaging facilities.

Variable Response Rates Across Jurisdictions

The response rate for Quebec, Ontario and British Columbia were lower than the other provinces or territories. This could be explained by several factors. These provinces have relatively large populations and, thus, quantity of facilities, increasing the likelihood of non-response. The workload at some facilities may also be relatively high, and, as such, some facilities may not have had the resources available to complete the survey. In addition, the Quebec health care system was undergoing administrative restructuring at the time of the survey, with the extra work and transition of responsibilities involved.

Correction for Non-Response

We have not completed an assessment of non-responders, so it is unclear at this time whether the responders and non-responders differ. Imputation was used in a few instances of partial non-response where data could be inferred from other responses. It is unclear how overall non-response rates influenced outcome variables.

Variable Instrument Coverage

The quality and completeness of the data collected appears to be relatively high for CT and MRI compared to the other modalities. Both are established and have seen longstanding use. For the established nuclear medicine modalities (SPECT and SPECT-CT in particular) several respondents referred us to separate clinical divisions, and it is possible our survey failed to reach the appropriate people in other institutions during the period it was open. It is also possible that some units are housed within cardiology departments or cancer care facilities associated with major hospitals. In these cases some survey responses may have failed to capture specific data.

Reliability

Responses rely on the personal knowledge of the individual contacts. Level of insight and accuracy of estimates may vary substantially and contribute to variability in the quality and

completeness of reporting. Recall bias cannot be avoided as we were unable to assess whether all information was visually verified and based on real data, or whether questions were answered from memory. Further, respondent fatigue could have contributed to poor responses for difficult questions such as those regarding the number of examinations, or hours of utilization, particularly if real-time data was not recorded at the facilities.

Inconsistency in Data Sources

Most of our data derives from formal survey responses. The data collected from provincial or territorial validators, the CADTH Environmental Scan on PET use, and grey literature sources is in most cases limited to modality and location. As a result, aggregate data presentations are often based on a subsample of the study population and generalizability may be limited.

Variable Interpretation of Questions

Standard definitions for facility type were not provided within the survey; therefore the difference between the various categories, particularly community hospital and hospital, may have been unclear. This may have resulted in some overlap across categories. Based on comparisons of weekly and daily hours, there was variation in whether sites averaged over all calendar days, or only days of operation. If the former, the hours of operation would be underestimated.

FUTURE DIRECTIONS AND NEXT STEPS

As Canada moves towards health technology management, rather than the current focus of assessment of emergent technologies, it may be beneficial to encourage the mandatory reporting of diagnostic imaging statistics. Other countries have instituted data reporting requirements linked to reimbursement and accreditation. The feasibility and appropriateness of such measures is unclear, but mandatory reporting would ensure an accurate representation of all healthcare facilities providing medical imaging.

Policy, Research, and Clinical Practice Questions

Several questions have emerged from consideration of the current medical imaging context in Canada.

- How is patient radiation safety monitored, and what measures are in place (e.g., training, implementation of guidelines) to ensure patient safety?

- What is the total annual expenditure for the various modalities, and further, what is the cost-effectiveness of medical imaging technologies (taking into account wait times, clinical pathways, and clinical utility)?

- What are the clinical indications for each specific imaging modality and is there a stepwise clinical imaging approach for individual health conditions (i.e., when is one or a combination of modalities more appropriate?).

- What are the quality assurance and safety measures required for each modality and how are they enforced?

- What is the regulatory framework in place to support private-public partnerships, specifically in terms of eligibility for private imaging (e.g., length of waitlist) and proportion of public

funding provided?

- Can abnormally high utilization at some facilities be linked to over-screening?
- What factors explain abnormally low use? Can it be attributed to machine age, lack of highly-trained personnel, population density, or improper applications?
- How is legislation regarding diagnostic imaging different across jurisdictions and does that influence the way devices are distributed and utilized?

Conclusions and Implications of Findings

In the absence of any change in practice, the growth and aging of the Canadian population implies increased demand for diagnostic imaging services.[37] This trend is paralleled by innovations in medical imaging that meet clinical need but are costly to install and maintain. Information on which technologies are being purchased and how they are being used is valuable in the context of limited budgets, and in the interest of optimal clinical practice.

This report presents data on the number of units, their distribution, and their volume and type of use across Canada for six medical imaging modalities, as informed through a comprehensive survey and data collection process. It also discusses changes over time and Canada's status compared to other countries. Future updates of this inventory will present information on technical features of machines, as well as further information on trends and developments in medical imaging equipment use. The application of this evidence to inform medical imaging-related strategic planning across Canada will be monitored closely.

The survey results provide insight into the current context of medical imaging across Canada. It raises relevant questions related to how medical imaging is monitored and regulated, how it is optimally used, how funding structures are organized and what the most cost-effective practices are, as well as issues of equitable access to imaging and care provided by highly-trained personnel. CADTH plans ongoing exploration of some of these issues.

Data collection for the next iteration of the survey will occur in the summer/fall of 2017, and the update will be published in 2018.

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APPENDICES

Appendix A DETAILS OF FACILITIES RESPONDING TO THE CMII 2015 UPDATE

TABLE 11 SUMMARY OF TYPE OF FACILITY INCLUDED IN THE CMII 2015 UPDATE

	Number of sites[a,b]			
Province	**Hospital[c]**	**Community Hospital[c]**	**Tertiary Care[c]**	**Free Standing[c]**
Alberta	31	2	1	3
British Columbia	26	4	4	6
Manitoba	4	9	0	0
New Brunswick	8	0	0	0
Newfoundland and Labrador	4	0	0	0
Nova Scotia	7	4	3	2
Ontario	32	23	4	4
Prince Edward Island	2	0	0	0
Quebec	33	0	3	8
Saskatchewan	7	0	2	2
Yukon	1	0	0	0
All	155	42	17	25

[a] Data derived from question: "If yes, how many [modality] do you have?" For sites without survey information, validators' indication of availability and counts were included, if available.

[b] Sites that did not provide the information are not included in this table

[c] Data derived from question: "What type of facility is this?"

TABLE 12 SUMMARY OF SOURCE OF FUNDING FOR SITES INCLUDED IN THE CMII 2015 UPDATE

	Number of units		
Province	**Publicly [a]**	**Privately [a]**	**Both [a]**
Alberta	35	0	2
British Columbia	34	6	0
Manitoba	13	0	0
New Brunswick	8	0	0
Newfoundland and Labrador	13	0	0
Northwest Territories	1	0	0
Nova Scotia	15	0	0
Ontario	59	3	2
Prince Edward Island	2	0	0
Quebec	36	6	2
Saskatchewan	10	1	1
Yukon	0	0	1
Canada	226	16	8

[a] Data derived from question: "How is this facility funded?"

TABLE 13 SUMMARY OF NEW UNITS ADDED BETWEEN 2012 AND 2015

	Number of units				
Province or territory	**CT**	**MRI**	**SPECT**	**PET-CT**	**SPECT-CT**
Alberta	18	14	2	3	7
British Columbia	18	9	6	2	7
Manitoba	7	1	1	0	1
New Brunswick	3	7	0	1	2
Newfoundland and Labrador	1	0	0	0	0
Nova Scotia	9	4	1	0	4
Ontario	30	9	20	5	15
Quebec	18	15	2	6	3
Saskatchewan	4	3	1	2	2
Yukon	1	1	0	0	0
Canada	112	64	33	19	42

Appendix B SITES AND MACHINES REPORTED IN THE CIHI 2012 SURVEY BUT NOT UPDATED IN THE CMII 2015 SURVEY

TABLE 14 MACHINES REPORTED IN THE CIHI 2012 SURVEY BUT NOT UPDATED IN THE CMII 2015 SURVEY

	Number of units (Number of sites with modality available)				
Province	**CT**	**MRI**	**Nuclear Medicine Cameras (Gamma and SPECT)**	**PET-CT**	**SPECT-CT**
Alberta	4 (3)	10 (7)	22 (14)	0	3 (3)
British Columbia	10 (8)	19 (17)	3 (1)	1	4 (2)
Manitoba	2 (1)	0	1	0	0
New Brunswick	8 (2)	5 (5)	1	0	1
Newfoundland and Labrador	1	0	0	0	0
Ontario	28 (19)	16 (10)	72 (45)	0	3 (2)
Quebec[a]	28 (27)	22 (19)	18 (12)	3 (3)	5 (5)
Saskatchewan	2 (2)	0	0	0	0
Canada	83 (67)	72 (58)	122 (74)	4 (4)	18 (13)
Without Quebec	59	51			

[a] The Validator reviewing the Quebec survey data supplied aggregated unit totals for public facilities: CT 144 units, MRI 75 units, PET or PET-CT 16 units, and SPECT or SPECT-CT 154 units.

Appendix C SUMMARIES OF USE DATA

TABLE 15 SUMMARY OF NUMBER OF EXAMS IN THE MOST RECENT FISCAL YEAR FOR ALL MODALITIES ACROSS ALL PROVINCES

		Number of exams [a,c]				
		CT	MRI	SPECT	PET-CT	SPECT-CT
Alberta	n [b]	32	22	10	2	14
	median	5279.5	6644.5	1808	3710.5	3097.5
	min-max	(133-42476)	(663-21507)	(320-3500)	(2268-5153)	(550-9000)
British Columbia	n [b]	27	21	9	2	10
	median	9005	4200	3162	4014.5	1211
	min-max	(1239-66000)	(462-13000)	(1300-7800)	(254-7775)	(77-5830)
Manitoba	n [b]	11	3	4	1	3
	median	9612	24144	2743	1741	1646
	min-max	(3800-41052)	(9180-25440)	(1439-4215)		(1528-4276)
New Brunswick	n [b]	7	8	1	1	4
	median	13770	3103	1000	729	2500
	min-max	(10000-28504)	(1604-9041)			(1500-4500)
Newfoundland and Labrador	n [b]	8	4			
	median	6431.5	4404.5			
	min-max	(1561-13817)	(2480-4550)			
Nova Scotia	n [b]	13	9	4	1	5
	median	8893	4782	2302	2241	1688
	min-max	(1576-26236)	(2637-7175)	(992-2993)		(320-2993)
Ontario	n [b]	44	25	27	5	22
	median	11744	10574	2101	250	2060.5
	min-max	(2850-71647)	(2325-23674)	(200-16804)	(25-2500)	(250-13000)
Prince Edward Island	n [b]	2	1	1		1
	median	6788	4567	600		1519
	min-max	(5093-8483)				
Quebec	n [b]	33	28	4	11	4
	median	10000	4916.5	7977.5	1014	16963
	min-max	(900-81943)	(370-23138)	(91-26425)	(172-5696)	(91-26795)
Saskatchewan	n [b]	9	4	1	1	
	median	6217	12500	21255	1315	
	min-max	(3877-35000)	(1600-17061)			
Yukon	n [b]	1	1			
	median	3500	2200			
	min-max					

[a] For all [modality], how many examinations are conducted in a fiscal year?

[b] Number of sites contributing responses

[c] -- indicates data not available, either because province does not have modality, or no sites reported examination data

TABLE 16 SUMMARY OF AVERAGE HOURS PER WEEK OF USE FOR ALL MODALITIES ACROSS ALL PROVINCES

		Average hours per week [a,c]				
		CT	**MRI**	**SPECT**	**PET-CT**	**SPECT-CT**
Alberta	n [b]	31	22	10	2	14
	median	47.5	63.5	40	50	42
	min-max	(2.5-168)	(10-119)	(25-50)	(40-60)	(30-96)
British Columbia	n [b]	30	21	9	2	12
	median	80.5	52	50	35	40
	min-max	(30-168)	(24-119)	(28-85)	(10-60)	(39-50)
Manitoba	n [b]	12	4	4	1	4
	median	63	98	40.6	40	40
	min-max	(50-168)	(76-112)	(40-47.5)		(40-47.5)
New Brunswick	n [b]	7	8	1	1	4
	median	60	45	40	18	42.5
	min-max	(52.5-141)	(28.5-108)			(40-47.5)
Newfoundland and Labrador	n [b]	10	4	2		2
	median	42.5	70	35		35
	min-max	(24-72)	(70-81)	(35-35)		(35-35)
Nova Scotia	n [b]	14	10	4	1	8
	median	60.5	57.5	45	32	41.2
	min-max	(37.5-168)	(37.5-80)	(40-80)		(37.5-47.5)
Ontario	n [b]	48	27	29	3	26
	median	70	112	40	5	40
	min-max	(30-168)	(37.5-168)	(10-75)	(1-40)	(15-88)
Prince Edward Island	n [b]	2	1	1		1
	median	45.2	42.5	35		45
	min-max	(40-50.5)				
Quebec	n [b]	35	28	4	11	4
	median	50	70.4	42.5	42	45
	min-max	(12-168)	(30-168)	(40-45)	(5-70)	(40-55)
Saskatchewan	n [b]	11	5	1	1	1
	median	79	100	40	30	60
	min-max	(40-168)	(68-168)			
Yukon	n [b]	1	1			
	median	40	40			
	min-max					

[a] Data derived from question: "In an average week (168 hours) how many hours are the [modality] units in use, averaged across all units?"

[b] Number of sites contributing responses

[c] -- indicates data not available, either because province does not have modality, or no sites reported examination data

1634 **TABLE 17 AVERAGE HOURS PER DAY OF USE FOR ALL MODALITIES ACROSS ALL PROVINCES**

		Average hours per day [a,c]				
		CT	**MRI**	**PET-CT**	**SPECT**	**SPECT-CT**
Alberta	n [b]	24	21	9	2	13
	median	9	11.2	8	10	8
	min-max	(0.5-24)	(2-16)	(5-10)	(8-12)	(6-16)
British Columbia	n [b]	28	21	9	2	12
	median	12	9	10	10.8	8
	min-max	(6-24)	(7.5-17)	(5-17)	(8-13.5)	(7-10)
Manitoba	n [b]	12	4	4	1	4
	median	9	16	8.1	8	8
	min-max	(7.75-24)	(12-16)	(8-9.5)		(8-9.5)
New Brunswick	n [b]	7	8	1	1	4
	median	9	9.8	8	6	8.5
	min-max	(8-12.75)	(7.5-17)			(8-9.5)
Newfoundland and Labrador	n [b]	9	3	2		2
	median	7	14	7		7
	min-max	(5-14)	(14-14)	(7-7)		(7-7)
Nova Scotia	n [b]	14	10	4	1	8
	median	9	11.2	9	8	8.2
	min-max	(7-24)	(7.5-16)	(8-16)		(7.5-9.5)
Ontario	n [b]	48	27	29	3	26
	median	11.8	16	8	5	8
	min-max	(5-24)	(7.5-24)	(6.5-22.5)	(1-8)	(3-16)
Prince Edward Island	n [b]	2	1	1		1
	median	8.2	8.5	7		9
	min-max	(8-8.5)				
Quebec	n [b]	33	28	4	11	4
	median	10	13	8.5	8.4	9
	min-max	(4-24)	(6-24)	(8-9)	(1-14)	(8-11)
Saskatchewan	n [b]	9	4	1	1	
	median	9	15	8	6	
	min-max	(8-24)	(12-16.5)			
Yukon	n [b]	1	1			
	median	8	9			
	min-max					

1635 [a] Data derived from question: "In an average day how many hours are the [modality] units in use, averaged across all units?"
1636 [b] Number of sites contributing responses
1637 [c] -- indicates data not available, either because province does not have modality, or no sites reported examination data

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Appendix D SUMMARIES OF PER POPULATION DATA FOR CANADA

TABLE 18 TOTAL EXAMS PER UNIT, BY MODALITY AND PROVINCE

	Examinations per unit[a,c]				
Province	**CT**	**MRI**	**SPECT**	**PET-CT**	**SPECT-CT**
Alberta	6728.68	4942.20	1157.62	1855.25	1556.91
British Columbia	5584.54	2958.74	1393.88	1605.80	856.74
Manitoba	7200.42	6529.33	1591.43	1741.00	1064.29
New Brunswick	9356.17	3927.44	500.00	364.50	2750.00
Newfoundland and Labrador	3398.76	2262.71	--	--	--
Nova Scotia	6731.62	3652.09	1227.00	2241.00	991.78
Ontario	3782.32	2492.31	1247.64	183.33	1811.38
Prince Edward Island	6788.00	4567.00	600.00	--	1519.00
Quebec	3782.44	1976.08	4719.00	1103.78	6081.20
Saskatchewan	7293.14	4851.22	1771.25	438.33	--
Yukon	3500.00	2200.00	--	--	--

[a] Data derived from question: "For all [modality], how many examinations are conducted in a fiscal year?"
[c] -- indicates data not available, either because province does not have modality, or no sites reported examination data

TABLE 19 TOTAL EXAMS PER 1,000 PEOPLE, BY MODALITY AND PROVINCE

	Exams[a,b] per 1,000 people[c]				
Province	**CT**	**MRI**	**SPECT**	**PET-CT**	**SPECT-CT**
Alberta	80.17	41.22	4.41	1.77	11.87
British Columbia	79.90	19.59	7.44	1.71	3.48
Manitoba	105.77	45.43	8.61	1.35	5.76
New Brunswick	148.92	46.89	1.33	0.97	14.59
Newfoundland and Labrador	109.47	30.01	--	--	--
Nova Scotia	149.91	42.60	9.11	2.38	9.47
Ontario	51.56	22.05	6.60	0.24	4.86
Prince Edward Island	92.73	31.20	4.10	--	10.38
Quebec	65.91	17.93	5.14	3.07	7.36
Saskatchewan	90.07	38.52	18.75	1.16	NA
Yukon	93.58	58.82	--	--	--
Canada	70.67	25.59	6.40	1.40	6.22

[a] Data derived from question: "For all [modality], how many examinations are conducted in a fiscal year?"
[b] -- indicates data not available, either because province does not have modality, or no sites reported examination data
[c] Population as of July 1, 2015.[21]

Appendix E AGE OF MEDICAL IMAGING EQUIPMENT

TABLE 20 AGE OF MEDICAL IMAGING EQUIPMENT

		CT	MRI	SPECT	PET-CT	SPECT-CT
Alberta	n [b]	56	48	35	2	7
	median	6.1	7.1	9.1	3	1.9
	min-max	(0-16)	(0-16)	(1-19)	(3-3)	(0-3)
British Columbia	n [b]	80	51	33		6
	median	6.9	8.1	10.2		1
	min-max	(0-18)	(1-17)	(-1-23)		(0-3)
Manitoba	n [b]	22	8	10		
	median	7.5	8.1	10.4		1
	min-max	(0-14)	(2-12)	(0-16)		0
New Brunswick	n [b]	18	15	2		2
	median	7.3	8.2	17	1	2.5
	min-max	(0-11)	(1-16)	(17-17)	3	(2-3)
Newfoundland and Labrador	n [b]	14	5	7		
	median	6.4	7	10.9		
	min-max	(4-10)	(4-10)	(5-15)		
Northwest Territories	n [b]	1				
	median	10				
	min-max					
Nova Scotia	n [b]	21	12	9		4
	median	5.7	6.8	12.4		0.5
	min-max	(0-14)	(1-11)	(7-21)		(0-2)
Ontario	n [b]	180	109	149	3	12
	median	8	8.6	11	2.7	2.1
	min-max	(0-19)	(0-20)	(0-28)	(2-3)	(1-3)
Prince Edward Island	n [b]	2	1	1		
	median	10.5	12	17		
	min-max	(10-11)				
Quebec	n [b]	124	87	97	3	2
	median	8.4	8.8	11.5	1.7	2
	min-max	(0-19)	(0-23)	(3-25)	(1-3)	(1-3)
Saskatchewan	n [b]	19	9	7	1	1
	median	6.9	4.4	11.4	2	1
	min-max	(0-12)	(-1-10)	(2-17)		
Yukon	n [b]	2	1			
	median	4.5	0			
	min-max	(3-6)				