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CADTH

Authors: Alison Sinclair, Teo Quay, Lisa Pyke, Andra Morrison

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Reviewers

External Reviewers

This document was externally reviewed by content experts, and the following individuals granted permission to be cited.

Sandor Demeter, MD, FRCPC
Section Head Nuclear Medicine
Health Sciences Centre
Winnipeg, Manitoba, Canada

Eric Turcotte, MD, FRCPC
Spécialiste en médecine nucléaire, Centre intégré universitaire de santé et de services sociaux de l'Estrie
Chef clinique du Centre d'imagerie moléculaire de Sherbrooke
Clinicien-chercheur, Axe Imagerie, Centre de recherche du CHUS
Professeur agrégé, Département de médecine nucléaire et de radiobiologie, Université de Sherbrooke
Sherbrooke, Quebec, Canada

Content Experts

The CMII survey questions and/or draft report were reviewed by the following organizations:

Canadian Association of Medical Radiation Technologists
Canadian Association of Nuclear Medicine
Canadian Association of Radiologists
Canadian Care Network of Ontario
Canadian Interventional Radiology Association
Canadian Organization of Medical Physicists
Canadian Society of Cardiovascular Nuclear and CT Imaging.

Authorship

Alison Sinclair contributed to survey development, review, and revision; contributed to data review and cleaning; tabulated and analyzed data; led the writing of the report; and revised the report based on reviewers' comments.

Teo Quay contributed to survey development, review, and revision; contributed to data review; contributed to contact with respondents, tracking, and entry of data revisions; and contributed to the writing, review, and revision of the report.

Andra Morrison, as project lead, led survey development, review, and revision; contributed to data review and cleaning; managed contact with respondents; and contributed to the review and revision of the report.

Lisa Pyke contributed to survey development, review, and revision; contributed to contact with respondents; and contributed to the writing, review, and revision of the report.

All authors approved the final draft report.

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Abbreviations

CIHI	Canadian Institute for Health Information
CMII	Canadian Medical Imaging Inventory
CT	computed tomography
MRI	magnetic resonance imaging
OECD	Organization for Economic Cooperation and Development
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

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Executive Summary

We conducted a survey of imaging providers in Canada so that we could provide an updated status of the holdings and use of specialist medical imaging in Canada. The Canadian Institute for Health Information (CIHI) collected data on medical imaging technologies in Canada up to mid-2012, at which time collection was decommissioned. CADTH has now taken on this task and will continue to maintain the inventory and publish a report of the findings every two years.

Methods

We collected information on six modalities using a Web-based survey, supplemented with information from data validators, report reviewers, and literature searches. The modalities were:

- Computed tomography (CT)
- Magnetic resonance imaging (MRI)
- Single-photon emission computed tomography (SPECT)
- Positron emission tomography–computed tomography (PET-CT)
- Positron emission tomography–magnetic resonance imaging (PET-MRI)
- Single-photon emission computed tomography–computed tomography (SPECT-CT).

The survey opened on September 16, 2015, and data collection formally closed on November 17, 2015. Informally, data were collected and updated until January 4, 2016. High-level data were reviewed by pre-identified regional and provincial validators, who supplied corrections and supplementary data. Identified stakeholders and survey respondents were given the opportunity to review the report during the stakeholder feedback process.

Results

We received 222 responses, having contacted 332 potential respondents directly, and reached an undetermined number through referrals and social media. We obtained availability and unit counts for a total of 374 individual sites from a combination of survey respondents, validators, reviewers, and grey literature searches. Nearly 90% of the sites were public facilities. We therefore included units from CIHI data from private sites — data current as of 2012 — in our final counts.

Computed Tomography

- We identified a total of 538 CT units in Canada. All provinces or territories had at least one unit. Ontario and Quebec had the most units, followed by British Columbia (BC) and Alberta. The three Northern Territories had one unit each. Since January 1, 2012, more than twice as many CT units were added as were decommissioned, suggesting a net growth.
- From examination data reported for approximately half of the CT units, we estimated that a total of 5.28 million CT examinations were performed in the most recent fiscal year in Canada. This is equivalent to 147.0 exams per 1,000 people.
- CT units operate for a median of 63 hours per week, and 10 hours per day. Most operate at weekends. CT is used mostly for clinical and diagnostic purposes, with a small proportion dedicated to research or interventional purposes.
- When the number of CT units per population for Canada is compared with other countries reported to the Organization for Economic Co-operation and Development (OECD), Canada appears in the lower half. For the number of exams per population, Canada appears in the upper half.

Magnetic Resonance Imaging

- We identified a total of 340 MRI units in Canada. All provinces and one territory had at least one unit. Ontario and Quebec had the most units, followed by BC and Alberta. Yukon has a single unit. Since January 1, 2012, three times as many MRIs were installed than were decommissioned, suggesting a net growth.
- From examination data reported for approximately half of the MRI units, we estimated that a total of 1.95 million MRI examinations were performed in the most recent fiscal year in Canada. This is equivalent to 54.0 exams per 1,000 people.
- MRI units operate for a median of 72.2 hours per week, and 13.5 hours per day. Most operate at weekends. MRI is used mostly for clinical and diagnostic purposes, with a small proportion dedicated to research (< 5%) or interventional (< 1%) purposes.
- When the number of MRI units per population for Canada is compared with other countries reported to the OECD, Canada appears in the lower half. For the number of exams per population, Canada appears around the midpoint.

Single-Photon Emission Computed Tomography

- We identified a total of 264 SPECT units in Canada. All 10 provinces had at least one unit. Ontario and Quebec had the most units, followed by BC and Alberta. Slightly more SPECT units were installed than were decommissioned since January 1, 2012, suggesting flattening growth.
- From examination data reported for approximately half of the SPECT units, we estimated that a total of 0.76 million SPECT examinations were performed in the most recent fiscal year in Canada. This is equivalent to 21.0 exams per 1,000 people.
- SPECT units operate for a median of 40 hours per week and eight hours per day. A minority operate at weekends. SPECT is used mostly for clinical and diagnostic purposes, with a small proportion dedicated to research or interventional purposes. SPECT is used for cardiac examinations comparatively more than the other modalities.

Positron Emission Tomography–Computed Tomography or Positron Emission Tomography

- We identified a total of 47 PET or hybrid PET-CT units in Canada, almost all of which were PET-CT. Eight provinces had at least one unit, with Ontario and Quebec having the most. Since January 1, 2012, 19 new units were installed and three were decommissioned, suggesting marked growth.
- From examination data reported for approximately half of the PET-CT units, we estimated that a total of 77,000 PET-CT examinations were performed in the most recent fiscal year in Canada. This is equivalent to 2.0 exams per 1,000 people.
- PET-CT units operate for a median of 40 hours per week, and eight hours per day. PET-CT is used mostly for clinical and diagnostic purposes, with a larger proportion dedicated to research than for CT or MRI.
- A quarter of sites had access to a cyclotron for generating radioisotopes. Two-thirds of the sites without access to a cyclotron obtained radioisotopes from commercial sources.

Positron Emission Tomography–Magnetic Resonance Imaging

- The hybrid modality of PET-MRI is the newest specialist imaging modality. We identified two units currently operating for clinical research purposes, both in Ontario, and five sites with plans to install PET-MRI in the near future.
- As the PET-MRI has yet to enter clinical use, we do not have any examination or use data.

Single-Photon Emission Computed Tomography–Computed Tomography

- We identified a total of 214 SPECT-CT units in Canada. All 10 provinces had at least one unit. Ontario and Quebec had the most units, followed by BC and Alberta. Since January 1, 2012, 41 units were installed, compared with two decommissioned, suggesting marked growth, some of which is probably from replacement of SPECT units by SPECT-CT.
- From examination data reported for approximately half of the SPECT-CT units, we estimated that a total of 0.72 million SPECT-CT examinations were performed in the most recent fiscal year in Canada. This is equivalent to 20.0 exams per 1,000 people.
- SPECT-CT units operate for a median of 40 hours per week and eight hours per day. A minority operate at weekends. SPECT is used mostly for clinical and diagnostic purposes, with a small proportion dedicated to research or interventional purposes. SPECT-CT is used for cardiac examinations comparatively more than the other modalities (median 22.5%).

Picture Archiving Communications System

- One-third (31.4%) of sites had access to a local or institutional picture archiving communications system (PACS) network, 28.4% had access to a regional network, and four in 10 (40.3%) had access to a provincial network.
- Almost all sites gave access to PACS images outside the imaging department, and two-thirds gave access to other sites within the provincial health care system.
- Almost all sites with CT, MRI, SPECT, PET-CT, or SPECT-CT stored and accessed images for these modalities on PACS. A minority of sites without each of these modalities could also access images. We do not have information about PET-MRI.

Limitations

- For feasibility, this iteration of the survey was restricted to six specialist imaging modalities and does not include others that are more common and widespread (e.g., X-ray and ultrasound).
- As we do not have a definitive list of facilities holding equipment, and the survey was voluntary, we cannot ensure that all facilities or departments holding modalities were contacted or responded.
- Response rates varied across jurisdictions, with lower responses from larger provinces.

Introduction

Medical imaging is a vital service within the Canadian health care system, providing the basis for diagnosis, staging, and monitoring of a variety of diseases and conditions. Computed tomography (CT), magnetic resonance imaging (MRI), and nuclear medical imaging, including single-photon emission computed tomography (SPECT) and positron emission tomography (PET), have become commonplace in medical imaging and nuclear medicine departments across Canada. In recent years, hybrid technologies such as SPECT-CT, PET-CT, and PET-MRI have further expanded the imaging repertoire. Other recent innovations include techniques that provide higher-quality imaging, lower radiation doses, and faster examinations.[1,2]

As imaging modalities advance, decision-makers and clinicians face complex choices about which medical imaging technologies to acquire and use. Each offers unique characteristics, advantages, and disadvantages. Advancement and implementation occurs within the context of a finite health care budget and limited availability of clinical and technical expertise. Conversely, the need for appropriate use of imaging studies has been highlighted by Choosing Wisely Canada[3,4] and Canada Safe Imaging.[5] Overuse is associated with unnecessary exposure to radiation, inconvenience to patients due to travel and appointment scheduling, and risks of further investigation and treatment arising from false positive or incidental findings.

Given these considerations, it is critical that there is current information regarding the status of medical imaging equipment in Canada. In 2001, CADTH (then the Canadian Coordinating Office for Health Technology Assessment [CCOHTA]) conducted its first inventory of diagnostic imaging equipment in Canada. From 2003 to 2012, the Canadian Institute for Health Information continued to collect data on the inventory and use of diagnostic imaging equipment.[6-8] In 2015, CADTH resumed work on the inventory to meet the ongoing need. This report summarizes the findings of the 2015 inventory.

For this iteration, we collected data on six modalities: CT, MRI, SPECT, PET or PET-CT (which has superseded PET), PET-MRI, and SPECT-CT. These six received priority over several modalities captured in previous iterations of the survey (angiography units, cardiac catheterization units, bone densitometers and lithotripsy imaging),[6-8] and over the widely used modalities of X-ray and ultrasound imaging. We limited the scope to ensure feasibility for our initial cycle of the inventory, and were guided by stakeholder interest in the complex modalities. We also captured data on infrastructure requirements of 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 employs X-rays as a source of ionizing radiation, sensitive radiation detectors, and computerized analysis to create cross-sectional images of the body, including the head, heart, lungs, cardiovascular system, musculoskeletal system, abdomen, pelvis, and spine.[9] Specialties that routinely employ CT include neurology, cardiology, oncology, internal medicine, orthopedics, and emergency trauma care.

The main advantages of CT are its speed, which enables rapid imaging and diagnosis in urgent situations, and its ability to visualize fine details in bone, lungs, and other organs.[9] However, CT involves exposure to ionizing radiation, which means that the risks and benefits of its use during pregnancy, in young children, and when repeated scans are involved must be carefully assessed.[9-11]

Magnetic Resonance Imaging

MRI uses powerful electromagnetic and radiofrequency fields and computation to produce cross-sectional images of the body, including of the head, neck, cardiovascular system, breast, abdomen, pelvis, musculoskeletal system, and spine.[12] Specialties that commonly employ MRI include neurology, gastroenterology, cardiology, oncology, internal medicine, orthopedics, and emergency services.[12]

Because MRI does not use ionizing radiation, it may be preferred over CT if both modalities would provide comparable information — when imaging children, for example.[12] MRI provides high sensitivity and soft-tissue details, especially in the abdomen and pelvis, allowing for visualization of anatomy and pathologies. In oncology, this assists early diagnosis, staging and re-staging, identification of treatment response, and detection of recurrence in various cancers.[12]

A disadvantage of MRI is that the exams can take up to an hour or more, and patients must be able to remain motionless within a narrow enclosure. It may not be suitable for patients with claustrophobia, those who cannot lie flat for prolonged periods, or those who are obese.[12-14] The strong magnetic fields and radiofrequencies used in MRI are incompatible with many common implantable medical devices, such as deep-brain stimulators, cochlear implants, and pacemakers.[14,15] All patients undergoing an MRI exam must be screened beforehand to identify any potentially contraindicated devices, and to check for metallic foreign bodies in their eyes.[14,15]

Nuclear Medicine Modalities

Single-Photon Emission Computed Tomography

In nuclear medicine imaging, trace amounts of radiopharmaceuticals are administered to patients intravenously, or by injection (e.g., subcutaneous or intradermal), ingestion, or inhalation to visualize areas of radioisotope uptake within the body. Depending on the radiopharmaceutical administered, the function (i.e., physiology) of almost any organ system can be observed.[16] Nuclear medicine gamma cameras detect the gamma rays emanating from the radioisotope, and form flat images; most cameras are also capable of cross-sectional imaging (SPECT).

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

Positron Emission Tomography

Patients undergoing a PET scan first receive an injection of a sugar or other metabolic tracer labelled with a positron-emitting radioisotope. Sensitive radiation detector cameras and powerful computers then detect and visualize areas of increased metabolism, such as tumours. It creates three-dimensional images of regions of interest such as the brain, bones, and heart.[17]

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

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

Disadvantages of Nuclear Imaging Modalities

A SPECT exam may involve scanning over hours to days, although the duration of the imaging may be similar to an MRI. Nuclear medicine also involves exposure to ionizing radiation, which means that the risks and benefits of its use during pregnancy, in young children, and for repeat use must be carefully assessed. Nuclear medicine produces lower-resolution scans than other imaging modalities.

Another concern for SPECT is global shortages of medical radioisotopes, compounded by the pending decommissioning of Canada's specialized nuclear reactor.[18] The cost associated with obtaining and transporting the materials is an ongoing concern.[16]

Hybrid Medical Imaging Technologies

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.[16]

SPECT-CT

SPECT-CT combines SPECT and CT to create three-dimensional images of the body part of interest, such as the brain, bones, and heart. Its main advantage is that it couples metabolic and physiological information with the resolution of CT. During a hybrid SPECT-CT, both scans are performed in sequence; the images are then computationally aligned with each other to show anatomic and functional detail, and to correct for attenuation of the SPECT signal. 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,[19] and concerns about availability of radioisotopes.

PET-CT

PET-CT combines the modalities of PET and CT, creating three-dimensional images of the body part of interest, such as the brain, bones, and lungs. Both scans are performed in sequence during a single session, and the images are computationally aligned.[20] PET-CT is commonly used in oncology to diagnose and stage various cancers, such as lung, gastrointestinal, colorectal, breast, and thyroid cancer. Additionally, PET-CT is commonly

employed to diagnose neurological, cardiovascular, infectious, and inflammatory pathologies, and the CT component is used to detect coronary artery calcification, a marker of coronary atherosclerosis.[16]

The main advantage of PET-CT is the ability to produce metabolic information with precise anatomic detail from multi-slice, high-resolution CT images, to the extent that PET-CT has replaced stand-alone PET in Canada. Medical specialties that commonly use 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.[16,21,22] The radioisotopes used in PET-CT have a half-life measured in hours, so imaging depends on availability and proximity of a cyclotron and transportation.

PET-MRI

PET-MRI combines PET with MRI,[23] 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 and the images are then computationally aligned. PET-MRI is the newest combination to reach clinical use, and has applications in oncology, neurology, cardiology, internal medicine, and orthopedics.[24,25]

PET-MRI requires injection of radioisotope tracers, and therefore involves the same risk-benefit assessment as other nuclear medicine imaging modalities for women of reproductive age and children.[14,15] As the CT component is replaced by MRI, X-ray exposure is avoided, but the potential hazards of magnetic fields remain.[14,15] The radioisotopes have a short half-life, requiring proximity to a cyclotron. The units and their infrastructure requirements are extremely expensive.

Picture Archiving and Communications System

PACS refers to an electronic system used to digitally manage, transmit, file, store, distribute, and retrieve medical images. It is networked and frequently Web-based. Combined with other Web-based telehealth technologies, PACS allows 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 in a country like Canada, with its size and dispersed population.

Objectives

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

- To determine the number of selected medical imaging units in Canada
- To provide accurate and timely data on the supply, distribution, and use of selected medical imaging units in Canada
- To improve current understanding of the technical characteristics of medical imaging equipment in Canada

- To monitor trends and developments in medical imaging equipment use across Canada
- 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 www.cadth.ca/medicalimaging.

We collected data primarily via a Web-based survey on the CADTH website (the English-language survey is reported in Appendix A). Both English and French versions were offered. Potential respondents were contacted by email. To access the survey, all participants were asked to register and create a profile on the CADTH website to ensure their response was linked to a unique registration profile.

We pre-identified most respondents using a database of previous participants. These contacts were updated to account for changes due to position turnover, retirement, and restructuring. Potential respondents included individuals working in private or public health care 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 historical 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 incorporate 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 researchers contacted non-responders directly through CADTH liaison officers or survey validators. We also accepted data by phone or in Excel spreadsheets or emails on request to facilitate survey response.

One amendment was made to the survey during the period of data collection, primarily to ensure that use data were captured across all units at a site rather than only at units installed after January 1, 2012. We contacted respondents who entered information prior to this amendment individually and asked them to complete the additional questions, while CADTH researchers transferred the previously entered data to the amended survey.

We asked each respondent for information about their position and details of the site or sites for which they were responding. For each of 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 in a fiscal year, average hours of use in a typical week and in a typical day, overall percentage of time devoted to various uses, whether units are used for treatment-planning purposes, whether hybrid units were used for singular applications (e.g., whether the CT component of a PET-CT unit is used as stand-alone CT), and the source of isotopes for PET technologies. We also asked for details on individual units installed after January 1, 2012, including make and model information, year of installation, and technical specifications (including device mobility), to update historical data to the end of 2011. For the sites themselves, we asked about the availability, use of PACS, and the extent of access to images on PACS within their jurisdiction (institutional and/or local, regional, or provincial). Survey respondents were asked to consent to the use of the information by CADTH. Implied consent was assumed for participants who completed the survey using alternative methods.

Upon survey closure on November 17, 2015, we sent summary statistics of the number of units per modality in each jurisdiction to pre-identified validators. Depending upon the jurisdiction, validators reviewed data for entire provinces, or for one or more health regions within a province. Validators assessed the summaries for accuracy and provided corrections and information on 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. These data were used to assess accuracy and 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

We obtained data from the Canadian Institute for Health Information (CIHI), current up to January 1, 2012. This included unit counts for CT, MRI, nuclear medicine cameras (SPECT and gamma cameras), and PET. CIHI makes most of its data available through a Web interface, QuickStats,[7] updated with sites and data confirmed or collected after the final analysis of the 2012 survey.

Our original intention was to merge the Canadian Medical Imaging Inventory (CMII) and CIHI data for the entire analysis. Following the necessary update of the survey to ensure we captured data for current use of 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 for maps, were obtained from Statistics Canada.[26] International data for the number of CT and MRI units and exams were obtained from the Organization for Economic Cooperation and Development (OECD) website.[27-30]

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. The median is the value that lies at the midpoint if all the values are arranged in ascending or descending order, and may represent the data better if there are a few very high or very low values. The number of exams was treated as continuous. Where we asked respondents to choose between two or more responses (e.g., Yes/No), we report the numbers and/or percentages of those who selected each response.

Table 1: Use of Datasets in Analyses

Data Summaries	Data Sources					
	CMII Survey	CIHI 2012	Validators/ Stakeholders	Grey Literature Search	Statistics Canada	International Data[a]
Summaries of site characteristics	•					
Summaries of modality availability, number of units	•		•	•		
Summary of planned installations, and planned decommissioning	•		•			
Summary of units at private sites that had data in the 2012 CIHI survey, but did not respond to the CMII data[b]	•	•	•			
Maps of unit 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	•		•	•		•

CIHI = Canadian Institute for Health Information; CMII = Canadian Medical Imaging Inventory; CT = computed tomography; MRI = magnetic resonance imaging.

[a] International data from the Organization for Economic Cooperation and Development.[27-30]

[b] CIHI data compared with CMII 2015 to eliminate sites with updated data available.

Stacked bar charts were used to display number of units and PACS access information; the distribution of modalities were presented using geocoded data presented on maps; and box plots and dot plots present use information.

The survey also included a text field to invite respondents to provide additional detail. We extracted information from those regarding decommissioning activities and operation of mobile units.

We imputed data for a limited number of missing values if we had not obtained a response to our queries. In particular, 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%, 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.

We aggregated counts or estimates for machines at publicly funded sites for all provinces. For private sites in Alberta, British Columbia (SPECT and SPECT-CT), Ontario, and Quebec, we reviewed the CIHI data for additional private and free-standing units that were current as of January 1, 2012, and added these to the totals.

Not all sites reported examination data. We estimated the total examinations per fiscal year for provinces and territories from the available data, by a proportional scaling of exams per unit for those units that had available exam data. The total examinations for Canada was calculated by summation of totals.

Results

Response Rate for the 2015 Update

The number of contacts varied among provinces and territories, depending on whether contacts were responding for their local institution, health region, or jurisdiction. We encouraged our direct contacts to forward the information to other potential respondents. In addition, 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 the survey reached. We received 222 responses to the Web survey, having initially sent the survey directly to 332 contacts. Validators supplied information about availability and number of units for a further 132 site/modality combinations, reviewers of the completed document for 14, a CADTH Environmental Scan of PET use in Canada[31] for 14, respondents for two, and grey literature for eight.[32-40]

Characteristics of Facilities Responding to the 2015 Update

Availability and count data were captured for a total of 374 individual sites, plus those reported in aggregate. Of the 242 sites that provided information on facility type, we identified 159 (65.7%) as hospitals, 40 (16.5%) as tertiary care centres, 16 (6.6%) as community hospitals, and 27 (11.2%) as free-standing facilities. Facility type was not directly reported for the remaining 132 sites, predominately those that were added during our supplementary data search or from validator counts. Of these 132 sites, 116 (87.8%) were public and 16 (12.2%) were private. Of the 246 sites that reported on funding sources, 222 (90.2%) were publicly funded, with a minority that were either privately funded, 16 (6.5%), or received both public and private funding, 8 (3.3%). Summaries of type of facility by province or territory and funding by province or territory are presented in Appendix B, Table 15 and Table 16.

Overall Inventory of Medical Imaging Equipment in Canada

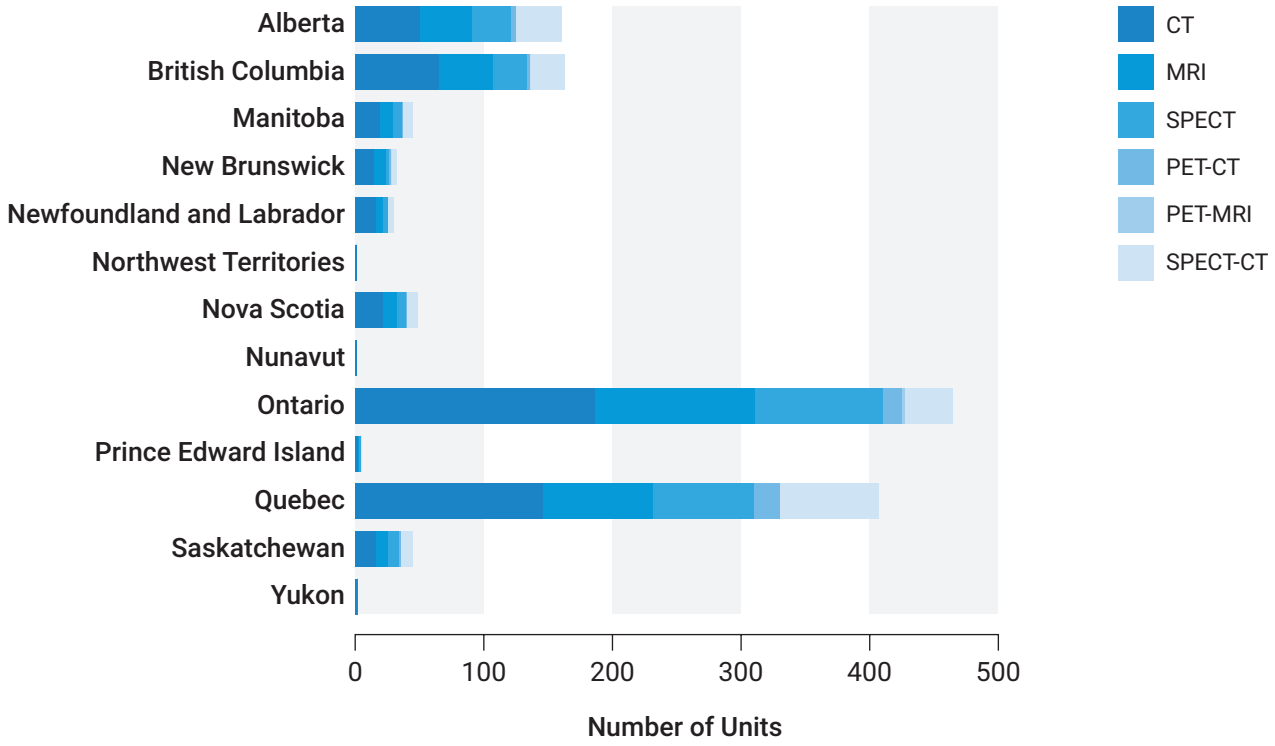
In this section, we briefly describe the overall reported inventory of units and use in terms of total number of exams for the six imaging modalities of interest across all provinces and territories. Subsequent sections present in greater detail the inventory and use for CT, MRI, SPECT, PET or PET-CT,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

Total Unit Counts

Figure 1 and Table 2 show the overall provincial and territorial inventory of all six modalities. The survey identified 531 CT units, 320 MRI units, 216 SPECT units, 47 PET or PET-CT units, two PET-MRI units, and 211 SPECT-CT units. CIHI data added seven CT units, 20 MRI units, 48 SPECT units, and three SPECT-CT units from private sites in Alberta, Ontario, and Quebec that did not appear in the 2015 inventory; we assumed that these units had not been decommissioned without replacement since 2012.

Table 2 shows the total number of units per jurisdiction as well as the number of sites that have that modality available, based on survey responses, validator and stakeholder counts, and additional units identified in the CIHI survey at free-standing facilities. Ontario and Quebec had the highest number of units identified for all modalities. All the provinces and territories reported at least one CT unit, with the Northwest Territories, Yukon, and Nunavut reporting 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, Nova Scotia, 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 or PET-CT, PET-MRI, and SPECT-CT



CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photon emission computed tomography.

Note: Data were derived from the 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.

Table 2: Overall Provincial or Territorial Inventory and Availability of CT, MRI, SPECT, PET or PET-CT, PET-MRI, and SPECT-CT

	Number of Units[a,b] (Number of Sites With Units)[c,b]					
Province	CT	MRI	SPECT	PET or PET-CT	PET-MRI	SPECT-CT
Alberta	50 (36)	41 (24)	30 (25)	4 (3)	0	35 (19)
British Columbia	65 (47)	42 (36)	26 (16)	3 (2)	0	27 (16)
Manitoba	19 (15)	10 (6)	7 (5)	1	0	8 (5)
New Brunswick	14 (10)	10 (9)	2 (2)	2 (2)	0	4 (4)
Newfoundland and Labrador	16 (14)	5 (5)	4 (2)	0	0	5 (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	186 (114)	125 (75)	99 (69)	15 (11)	2 (2)	38 (28)
Prince Edward Island	2 (2)	1	1	0	0	1 (1)
Quebec	146[d]	85[d]	79[e]	20 (20)	0	77[e]
Saskatchewan	16 (13)	9 (6)	9[f] (2)	1 (1)	0	10[f] (3[f])
Yukon	1 (1)	1	0	0	0	0
Canada	538 (305)	340 (216)	264 (130)	47 (39)	2 (2)	214 (91)

CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photon emission computed tomography.

[a] 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.

[b] Counts include supplementary data supplied by validators.

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

[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, with an estimated 50:50 split.

[e] Estimated. The Quebec validator estimated a 50:50 split between SPECT and SPECT-CT. Two additional private units were identified.

[f] Three units at 1 site were reported as SPECT, but were identified as SPECT-CT (CT with attenuation correction) late in this writing.

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 108 CT units, 63 MRI units, 33 SPECT units, 19 PET-CT units, and 41 SPECT-CT units since January 2, 2012 (Appendix B, Table 17). None of the responding facilities reported installing a PET-MRI, and the information on PET-MRI came from a 2015 CADTH Environmental Scan.[31] During the same period, facilities reported the decommissioning of 46 CT units, 19 MRI units, 28 SPECT units, three PET-CT units, and two SPECT-CT units. We did not include a question about decommissioning for PET-MRI, as it is a new modality.

Number of Units by Provincial or Territorial Population

Per million people, Canada has 15.01 CT units, 9.48 MRI units, 7.36 SPECT units, 1.31 PET or PET-CT units, 0.06 PET-MRI units, and 5.97 SPECT-CT units. Provincial and territorial trends are discussed within the sections for each modality, and we compare Canadian data with international data in the Discussion. Table 3 shows the number of units reported per million people for all the provinces or territories and for Canada as a whole.

Table 3: CT, MRI, SPECT, PET or PET-CT, PET-MRI, and SPECT-CT Units by Provincial or Territorial Population

Province or Territory	Population (Million)[b]	Number of Units[a] per Million Population[b]					
		CT	MRI	SPECT	PET or PET-CT	PET-MRI	SPECT-CT
Alberta	4.197	11.91	9.77	7.15	0.95	0.00	8.34
British Columbia	4.683	13.88	8.97	5.55	0.64	0.00	5.77
Manitoba	1.293	14.69	7.73	5.41	0.77	0.00	6.19
New Brunswick	0.754	18.57	13.26	2.65	2.65	0.00	5.31
Newfoundland and Labrador	0.528	30.31	9.47	7.58	0.00	0.00	9.47
Northwest Territories	0.044	22.68	0.00	0.00	0.00	0.00	0.00
Nova Scotia	0.943	22.27	11.66	7.42	1.06	0.00	9.54
Nunavut	0.037	27.10	0.00	0.00	0.00	0.00	0.00
Ontario	13.792	13.49	9.06	7.18	1.09	0.15	2.76
Prince Edward Island	0.146	13.66	6.83	6.83	0.00	0.00	6.83
Quebec	8.264	17.67	10.29	9.56	2.42	0.00	9.32
Saskatchewan	1.134	14.11	7.94	7.94	0.88	0.00	8.82
Yukon	0.037	26.74	26.74	0.00	0.00	0.00	0.00
Canada	35.85	15.01	9.48	7.36	1.31	0.06	5.97

CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photon emission computed tomography.

[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.[26]

Table 4: Reported and Imputed Examinations per Fiscal Year for All Modalities Across Canada

	CT	MRI	SPECT	PET-CT	SPECT-CT
Total exams reported,[a] and number of units[b]	(n = 263)	(n = 169)	(n = 108)	(n = 27)	(n = 104)
	2,471,903	912,737	226,503	50,138	223,845
Total exams imputed[c]	(n = 538)	(n = 340)	(n = 260)	(n = 47)	(n = 199)
	5,278,341	1,952,060	761,279	76,824	724,017
Exams per 1,000 people[d]	147.0	54.0	21.0	2.0	20.0

CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photon emission computed tomography.

[a] Data derived from question: "For all CTs, how many examinations are conducted in a fiscal year?"

[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] Where no provincial exam data were available, these provinces were omitted from the calculation.

[d] The population as of July 1, 2015 (see Table 3).[26]

Overall Number of Examinations

Table 4 shows the total examinations reported for all modalities across Canada for the most recent fiscal year for each site, and the total examinations imputed, based on the total unit count. CT is the most heavily used modality, followed by MRI. Use of SPECT and SPECT-CT is approximately equivalent, and PET or PET-CT is least used. PET-MRI is an emerging modality and there are no units currently in routine clinical use. Total examinations, examinations per number of units, and examinations per provincial population are discussed in the summaries of findings for individual modalities.

Table 5: Summary of Availability and Status of CT Units Across Canada

Province or Territory	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	12	11.91
British Columbia	47	65	7	7	13.88
Manitoba	15	19	1	4	14.69
New Brunswick	10	14	5	2	18.57
Newfoundland and Labrador	14	16	0	3	30.31
Northwest Territories	1	1	0	0	22.68
Nova Scotia	16	21	2	3	22.27
Nunavut	1	1	0	0	27.10
Ontario	114	186	20	11	13.49
Prince Edward Island	2	2	1	0	13.66
Quebec	36[f]	144[f]	12	3	17.67
Saskatchewan	13	16	5	1	14.11
Yukon	1	1	0	0	26.74
Canada	305	538	61	46	15.01

CT = computed tomography.

[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 (see Table 3).[26]

[f] Fifty units were reported for 35 sites in the survey. The validator supplied an aggregated total of 144 CT units, without specifying sites.

Computed Tomography

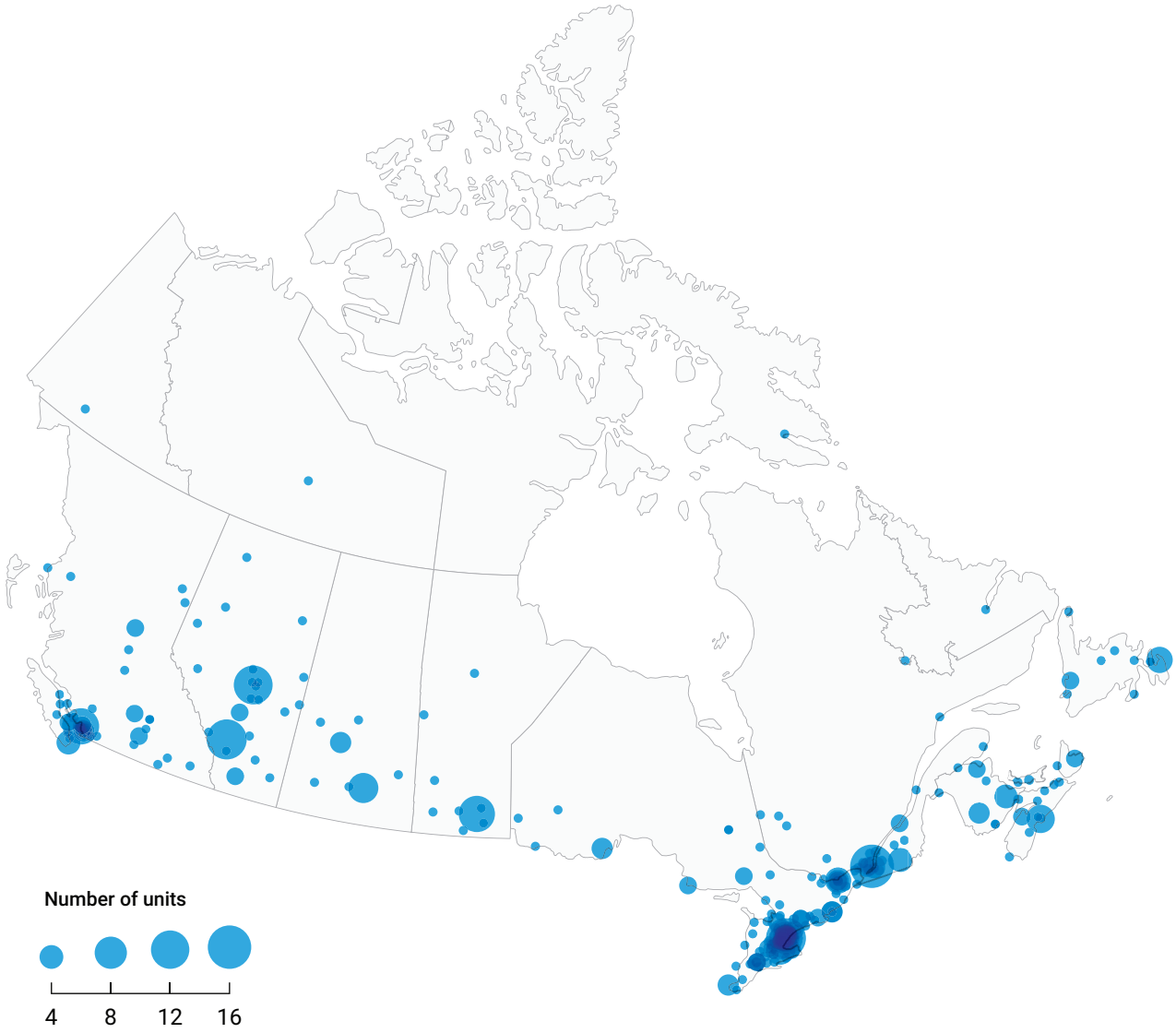
Number and Location of CT Units

We identified 305 sites in 13 provinces or territories with one or more CT units (Table 5). This does not include the public sites with units reported in aggregate for Quebec. There were up to eight units per site, for a total of 538 units. Ontario had the highest number of CT units, followed by Quebec and then British Columbia. The Northwest Territories, Nunavut, and Yukon have one unit each.

A total of 108 new CT units were installed between 2012 and 2015 (Appendix B, Table 17). Forty-six sites decommissioned one or more CT units (most decommissioned one) since the last survey in 2012, and 61 sites reported planned installation of one or more CT units in the next two years (Table 5). Because our survey did not discriminate between replacement and new installations, it is unclear whether planned installations are to be new units, 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 unit had been upgraded.

Newfoundland and Labrador, Nunavut, and Yukon had the highest number of units per million people, while Alberta, Ontario, and Prince Edward Island all had a relatively low number of units per million people. These are provincial averages and do not reflect geographic distribution of the units with respect to the people within the regions. CT also represents the highest number of units per population of all six modalities.

Figure 2: Distribution of Computed Tomography Units across Canada



CT = computed tomography.

Notes: Data derived from question: "If yes, how many 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. Units that were supplied in aggregate, without location information, are not represented on the map. This applies in particular to Quebec.

Geographical Distribution of CT Units

Figure 2 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.

Table 6: Reported and Imputed Total Examinations per Fiscal Year for CT

Province or Territory	Units With Records[a]	Recorded Exams[b]	Exams per Unit	Total Units	Total Imputed	Population (1,000)[c]	Exams per 1,000 People
Alberta	44	336,434	7,646	50	382,300	4,196.5	91.1
British Columbia	38	370,964	9,762	65	634,530	4,683.1	135.5
Manitoba	15	136,808	9,121	19	173,299	1,293.4	134.0
New Brunswick	12	112,274	9,356	14	130,984	753.9	173.7
Newfoundland and Labrador	8	57,779	7,222	16	115,552	527.8	218.9
Nova Scotia	17	127,333	7,490	21	157,290	943.0	166.8
Ontario	66	663,947	10,060	186	1,871,160	13,792.1	135.7
Prince Edward Island	2	13,576	6,788	2	13,576	146.4	92.7
Quebec	48	544,672	11,347	146	1,656,662	8,263.6	200.5
Saskatchewan	12	104,616	8,718	16	139,488	1,133.6	123.0
Yukon	1	3,500	3,500	1	3,500	37.4	93.6
Canada	263	2,471,903	9,399	538[d]	5,278,341	35,851.8	147.0

CT = computed tomography.

[a] 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.

[b] Data derived from question: "For all CTs, how many examinations are conducted in a fiscal year?"

[c] The population as of July 1, 2015 (see Table 3).[26]

[d] No provincial exam data were available for Nunavut and the Northwest Territories (one unit each).

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

Across Canada, an overall total of 2,471,903 examinations per year were reported for 263 CT units, where each site reported for its last fiscal year. The average number of exams per unit was 9,399. From this, we imputed an overall estimate of 5,278,341 exams for all inventoried CT units.

Table 6 shows the recorded and imputed total number of exams by province, and the number of exams per 1,000 people.

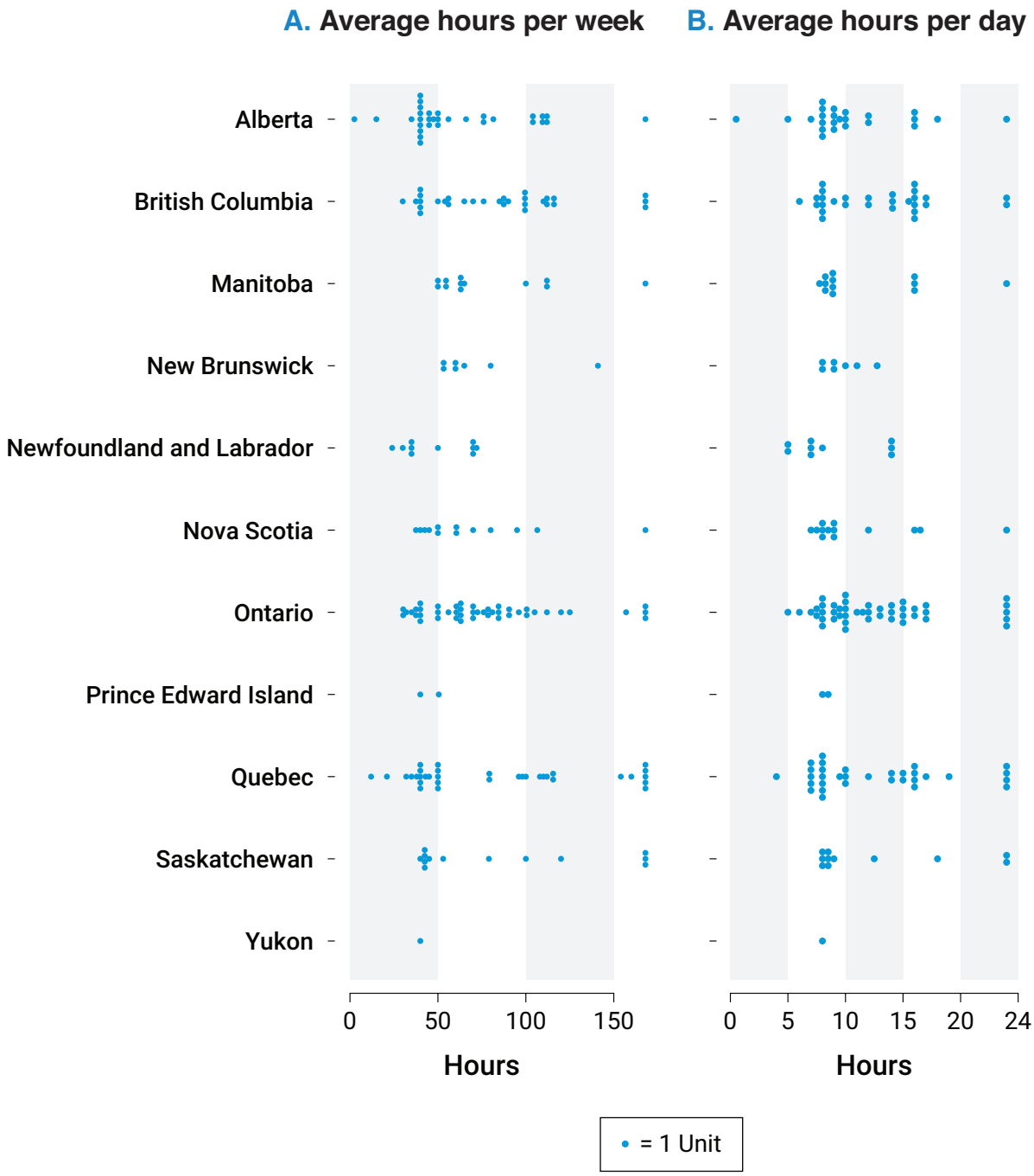
Ontario, Quebec, and British Columbia had the highest (imputed) total number of exams, and Newfoundland and Labrador, Prince Edward Island, and Yukon the lowest. No exam data were reported for the Northwest Territories and Nunavut.

When we adjusted for the population of each province, Newfoundland and Labrador, Quebec, and New Brunswick had the highest total exams per 1,000 people, while Prince Edward Island, Saskatchewan, and Alberta had the lowest.

The imputed totals must be interpreted with caution, as we assumed that sites with missing data conduct a similar number of exams as sites with data and that we have identified all units within a province. The totals and per-population values for Ontario, Quebec, and Newfoundland and Labrador are likely to be the most uncertain, as these calculations involved the greatest imputation.

The reported examination data, without imputation, are summarized by province or territory in Appendix C, Table 18.

Figure 3: Average Hours of Operation of CT Units in a Typical Week and in a Typical Day

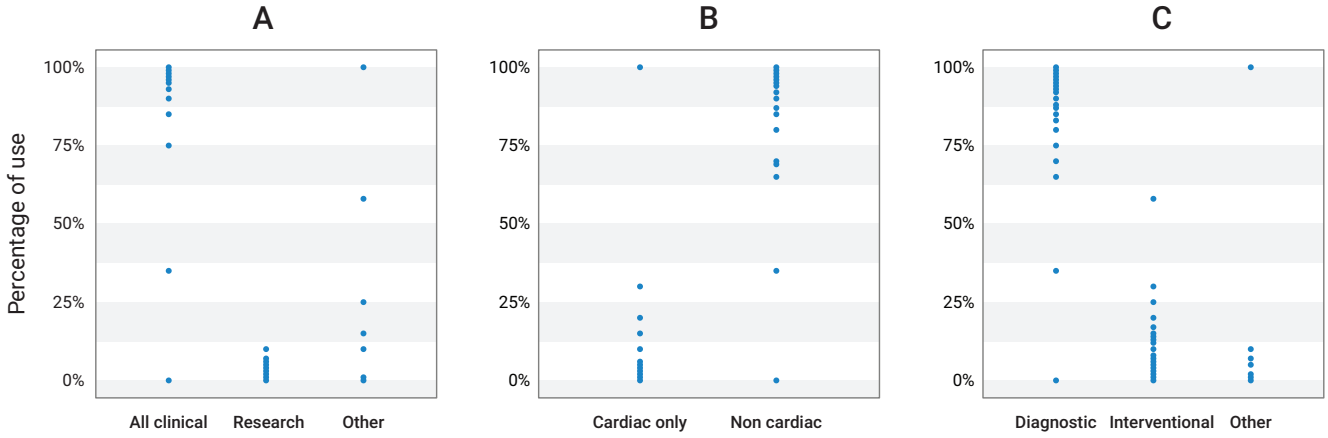


CT= computed tomography.

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?"

Figure 4: Overall Proportion of Type of Use of CT Units



CT= computed tomography.

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

B: Breakdown of All clinical use. The All clinical use represented in A is further subdivided into 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?"

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

We collected information on the hours of CT use in a typical week from 198 sites and information on a typical day from 184 sites. 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 or territory in Figure 3, and detailed summary statistics are presented in Appendix C, Table 19 and Table 20.

British Columbia, Quebec, and Saskatchewan had the highest average hours per week, and Prince Edward Island and Yukon had the lowest (Appendix C, Table 19). British Columbia and Ontario had the longest reported working days (Appendix C, Table 20). Yukon and Prince Edward Island had the shortest reporting working days. 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 that responded to these questions (144/197, 73.1%) operated on the weekend.

Patterns of CT Use: Types of Use

We received information from 186 sites 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, with a very small proportion of research use. Where clinical use was divided, most use was non-cardiac. 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.

Table 7: Summary of Availability and Status of MRI Units Across Canada

Province or Territory	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	41	4	5	9.77
British Columbia	36	42	6	1	8.97
Manitoba	6	10	3	1	7.73
New Brunswick	9	10	0	3	13.26
Newfoundland and Labrador	5	5	0	0	9.47
Northwest Territories	0	0	0	0	0.00
Nova Scotia	10	10	0	0	11.66
Nunavut	0	0	0	0	0.00
Ontario	75	125	13	5	9.06
Prince Edward Island	1	1	0	0	6.83
Quebec	28[f]	85[f]	7	3	10.29
Saskatchewan	6	9	2	1	7.94
Yukon	1	1	0	0	26.74
Canada	216	340	35	19	9.48

MRI = magnetic resonance imaging.

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

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

[e] The population as of July 1, 2015 (see Table 3).

[f] Thirty-six units were reported for 28 sites in the survey. The validator supplied an aggregated total of 75 MRI units for Quebec, without specifying sites.

Boxplots for average percentage of use across Canada are shown in Figure 4. Indication is shown on the left (A, B) and procedure on the right (C).

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

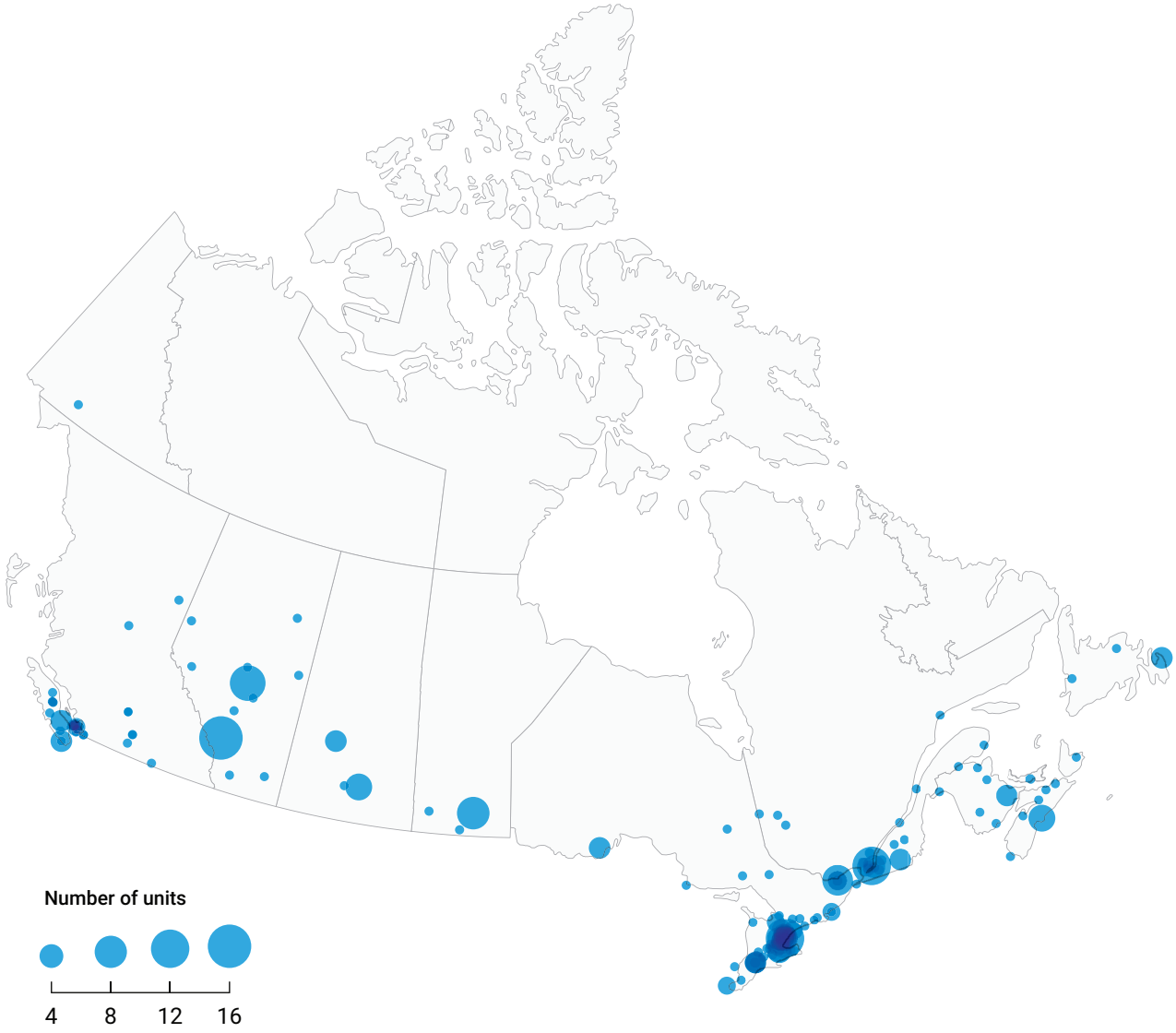
Magnetic Resonance Imaging

Number and Location of MRI Units

A total of 216 sites in 11 provinces or territories have one or more MRI units (Table 7). This does not include the public sites with units reported in aggregate for Quebec. There were up to five units per site, to a total of 340 units. Six of these were mobile units shared by up to five 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.

Sixty-three new MRI units were installed between 2012 and 2015 (Appendix B, Table 17). Nineteen sites decommissioned an MRI unit since the last survey in 2012, and 35 sites plan the installation of one or more MRI units in the next two years after this survey (Table 7). Because our survey did not discriminate between replacement and new installations, it is unclear whether planned installations are to be new units, replacements, or upgrades. The respondent for one site identified the planned installations as replacements for equipment that had been or was to be decommissioned.

Figure 5: Distribution of MRI Units Across Canada



MRI = magnetic resonance imaging.

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

The number of MRI units per population is highest in Newfoundland and Labrador, Nunavut, and Yukon, and relatively lower in Prince Edward Island, Manitoba, and Alberta. These are provincial averages and do not reflect geographic distribution of the units with respect to the people within the regions. The number of MRI units was the second highest per population compared with the other modalities.

Geographical Distribution of MRI

Figure 5 shows the geographical distribution of MRI units across Canada mapped to the level of settlement (city or town), with a circle proportional to the number of units.

Table 8: Reported and Imputed Total Examinations per Fiscal Year for MRI

Province or Territory	Units With Records[a]	Recorded Exams[b]	Exams per Unit	Total Units	Total Imputed	Population (1,000)[c]	Exams per 1,000 People
Alberta	30	172,977	5,766	41	236,406	4,196.5	56.3
British Columbia	25	91,721	3,669	42	154,098	4,683.1	32.9
Manitoba	8	58,764	7,346	10	73,460	1,293.4	56.8
New Brunswick	8	33,047	4,131	10	41,310	753.9	54.8
Newfoundland and Labrador	3	13,359	4,453	5	22,265	527.8	42.2
Nova Scotia	10	40,173	4,017	11	44,187	943.0	46.9
Ontario	39	304,062	7,796	125	974,500	13,792.1	70.7
Prince Edward Island	1	4,567	4,567	1	4,567	146.4	31.2
Quebec	36	148,206	4,117	85	349,945	8,263.6	42.3
Saskatchewan	8	43,661	5,458	9	49,122	1,133.6	43.3
Yukon	1	2,200	2,200	1	2,200	37.4	58.8
Canada	169	912,737	5,401	340	1,952,060	35,851.8	54.0

MRI = magnetic resonance imaging.

[a] 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.

[b] Data derived from question: "For all MRIs, how many examinations are conducted in a fiscal year?"

[c] The population as of July 1, 2015 (see Table 3).[26]

Note: Counts for all sites within a city/town were aggregated, and the symbol area is proportional to the number of units. Units that were supplied in aggregate, without location information, are not represented on the map. This applies in particular to Quebec.

Mobile MRI

Survey respondents reported five mobile MRI units: two in British Columbia and one each in Alberta, New Brunswick, and Quebec. An additional unit in Quebec was noted in review. In British Columbia, one mobile unit is shared by three facilities in the Okanagan Valley and another is shared by four facilities on Vancouver Island. The unit in New Brunswick is shared between Upper River Valley Hospital in Waterville and Campbellton Regional Hospital. The unit in Alberta is shared by four facilities, all outside of Edmonton in Central Alberta. One unit in Quebec is shared by five facilities, all in the administrative region of Gaspésie–Îles-de-la-Madeleine, while the other is shared by three facilities in Abitibi-Témiscamingue.

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

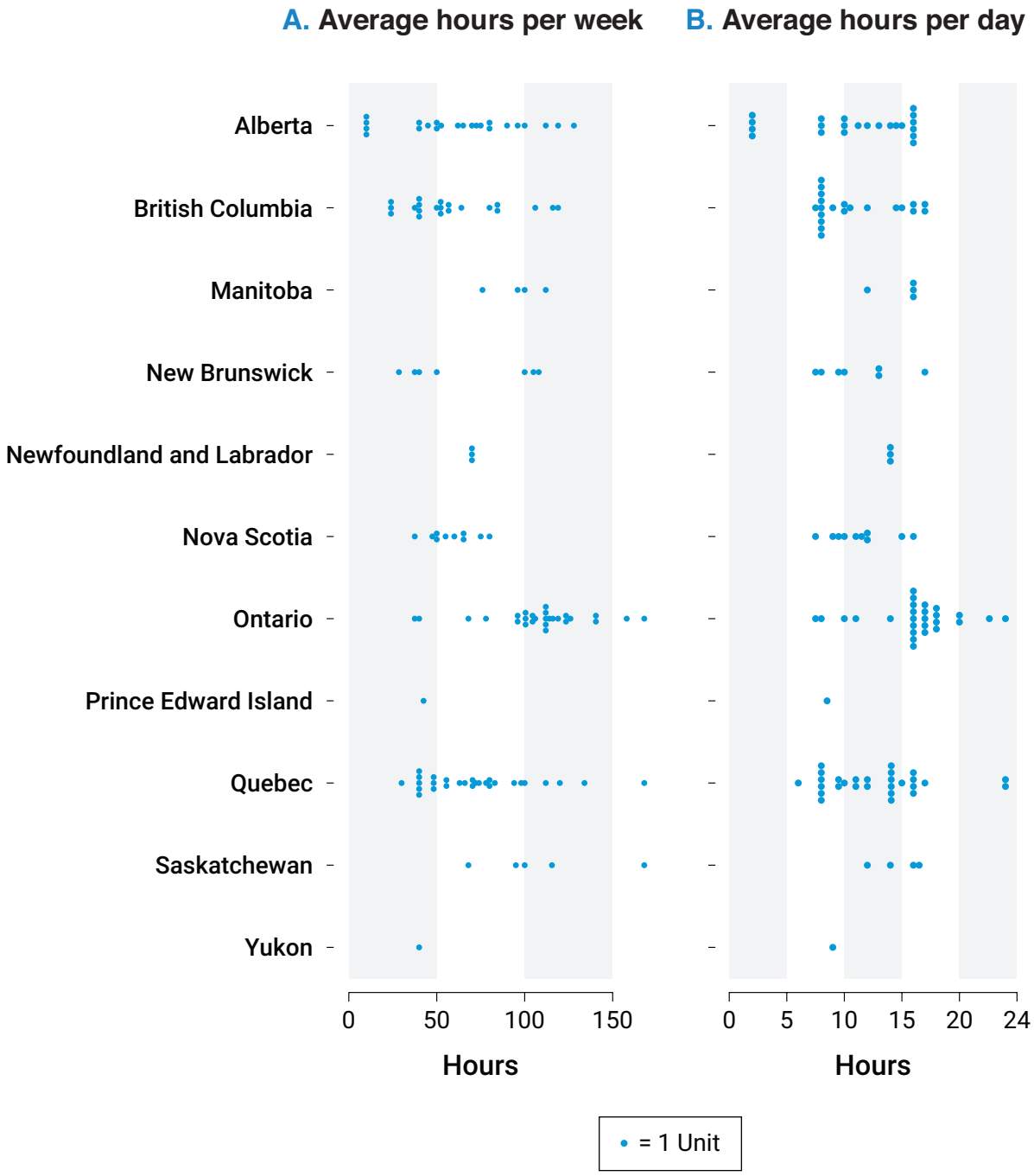
Patterns of MRI Use: Number of Examinations in a Fiscal Year

Across Canada, an overall total of 912,737 examinations per year were reported for 169 MRI units, where each site reported for its last fiscal year. The average number of exams per unit was 5,401. From this, we imputed an overall estimate of 5,278,341 exams for all inventoried MRI units. Table 8 shows the recorded and imputed total number of exams by province, and the number of exams per 1,000 people.

Ontario, Quebec, and Alberta had the highest (imputed) total number of exams, and Yukon and Prince Edward Island the lowest.

When we adjusted for the population of each province, Ontario, Yukon and Manitoba had the highest total exams per 1,000 people, while Prince Edward Island and British Columbia had the lowest.

Figure 6: Average Hours of Operation of MRI Units in a Typical Week and in a Typical Day

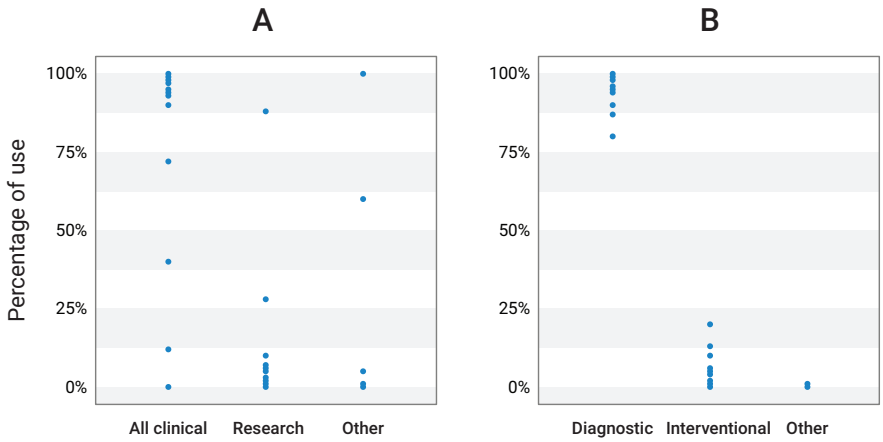


MRI = magnetic resonance imaging.

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?"

Figure 7: Overall Proportion of Type of Use of MRI Units



MRI = magnetic resonance imaging.

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

B. 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?"

The imputed totals must be interpreted with caution, as they assume that sites with missing data conduct a similar number of exams as sites with data and that we have identified all units within a province. The totals and per-population values for Ontario, Quebec, and British Columbia are likely to be the most uncertain, as these calculations involved the greatest imputation.

The reported examination data, without imputation, is summarized by province or territory in Appendix C, Table 18.

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

A total of 130 sites provided information on the hours of use averaged across all their MRI units in a typical week, and 128 sites provided hours of use in a typical day. Sites were asked for a single estimate of average use over all their units. The median estimate was 72.2 hours per week and 13.5 hours per day.

Hours per day and hours per week are shown by province or territory in Figure 6, and detailed summary statistics are presented in Appendix C, Table 19 and Table 20.

Saskatchewan, Ontario, and Manitoba had the highest average hours per week, and Prince Edward Island and Yukon had the lowest (Appendix C, Table 19). Manitoba, Ontario, and Saskatchewan had the longest reported working days (Appendix C, Table 20). Yukon and Prince Edward Island had the shortest reported working days. Sites varied in whether they calculated the average hours per day over all calendar days, or only days of operation. About half the sites that responded to these questions (69/134, 51.5%) operated on the weekend.

Patterns of MRI Use: Types of Use

One hundred and twenty-seven sites provided information on the typical type of use across all 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.

Table 9: Summary of Availability and Status of SPECT Units Across Canada

Province or Territory	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	25	30	1	4	7.15
British Columbia	16	26	2	5	5.55
Manitoba	5	7	0	1	5.41
New Brunswick	2	2	0	2	2.65
Newfoundland and Labrador	2	4	1	1	7.58
Northwest Territories	0	0	0	0	0.00
Nova Scotia	4	7	0	4	7.42
Nunavut	0	0	0	0	0.00
Ontario	69	99	7	9	7.18
Prince Edward Island	1	1	0	0	6.83
Quebec	7[f]	79[f,g]	0	1	9.56
Saskatchewan	2	12[h]	0	1	7.94
Yukon	0	0	0	0	0.00
Canada	130	264	11	28	7.36

SPECT = single-photon emission computed tomography.

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

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

[e] The population as of July 1, 2015 (see Table 3).[26]

[f] Survey respondents reported 9 units at 5 sites.

[g] Estimated. The Quebec validator estimated a 50:50 split between SPECT and SPECT-CT. Two additional private units were identified.

[h] Three units included as SPECT were identified as SPECT-CT (CT with attenuation correction) during in report review.

For procedure, most use for MRI was diagnostic, with an average of 1% 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 7. Indication is shown on the left (A) and procedure on the right (B).

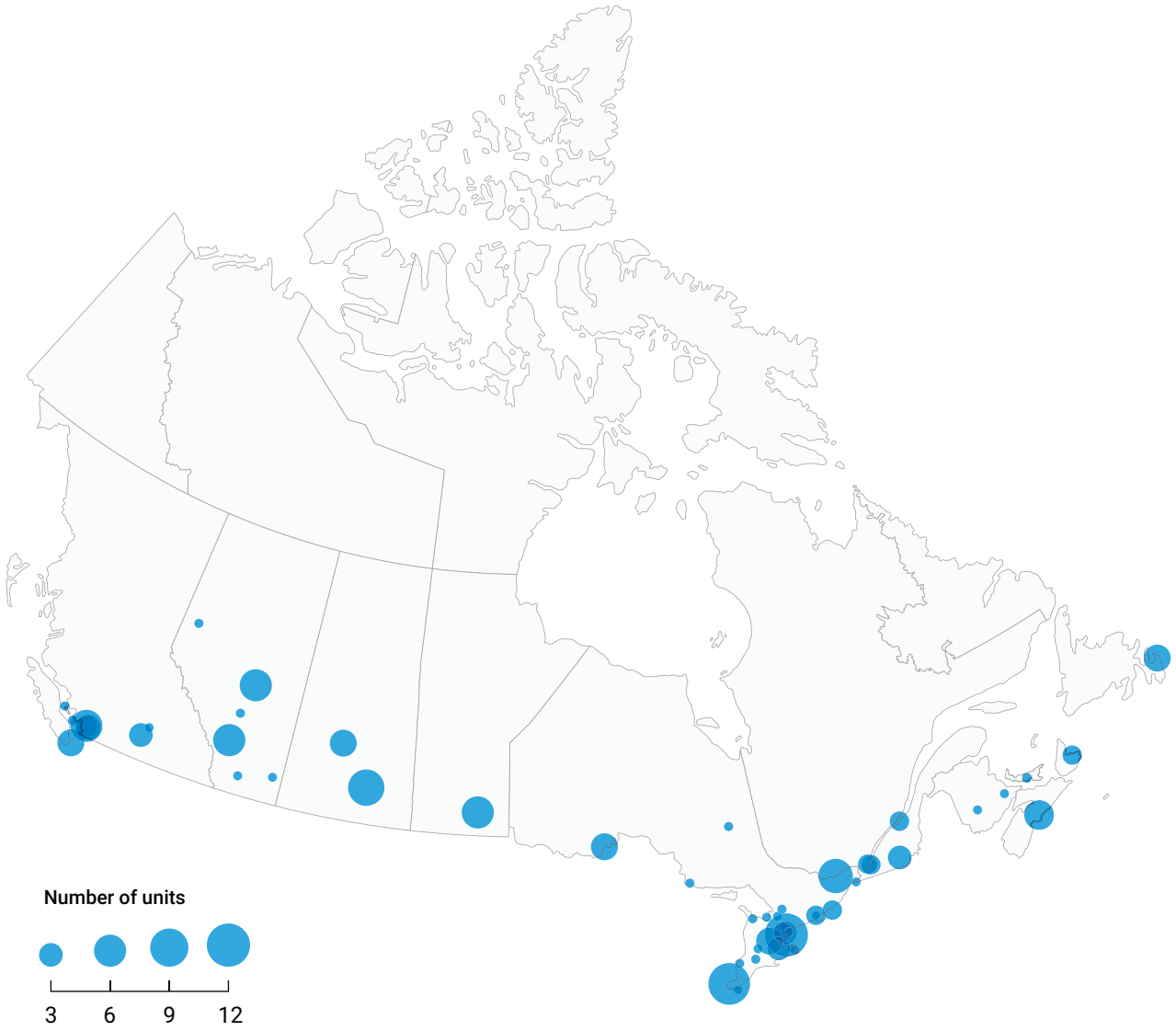
Single-Photon Emission Computed Tomography

Number and Location of SPECT Units

A total of 130 sites in 10 provinces reported having SPECT available (Table 9). The total does not include the public sites with units reported in aggregate for Quebec, but both site and machine counts include private sites that were represented in the CIHI data but did not supply an update for Alberta, Ontario, and Quebec. There were between one and nine units per site, for a total of 264 units. For Quebec, the contribution of public sites is represented by an estimate, as the validator provided aggregated SPECT plus SPECT-CT. Ontario has the highest number of SPECT units, followed by Quebec and Newfoundland and Labrador with one unit each. The Northwest Territories, Nunavut, and Yukon have none.

Thirty-three new SPECT units were installed between 2012 and 2015 (Appendix B, Table 17). Twenty-eight sites have decommissioned one or more SPECT units since the last survey in 2012, and 11 sites reported plans to install one or more SPECTs in the next

Figure 8: Distribution of SPECT Units Across Canada



SPECT = single-photon emission computed tomography.

Notes: Data derived from question: "If yes, how many SPECTs 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. Units that were supplied in aggregate, without location information, are not represented on the map. This applies in particular to Quebec.

two years (Table 9). Because our questions did not discriminate between replacement and new installations, it is unclear whether all planned installations are to be new units, replacements, or upgrades. The respondent for one site identified the two planned installations as replacements for decommissioned equipment.

For the provinces with SPECT units, the number of units per population is highest in Quebec, Saskatchewan, and Newfoundland and Labrador and lowest in New Brunswick, Manitoba and British Columbia. These are provincial averages and do not reflect geographic distribution of the units with respect to the people within the regions.

Table 10: Reported and Imputed Total Examinations per Fiscal Year for SPECT

Province or Territory	Units With Records[a]	Recorded Exams[b]	Exams per Unit	Total Units	Total Imputed	Population (1,000)[c]	Exams per 1,000 People
Alberta	13	18,522	1,425	30	42,750	4,196.5	10.2
British Columbia	15	34,847	2,323	26	60,398	4,683.1	12.9
Manitoba	6	11,140	1,857	7	12,999	1,293.4	10.1
New Brunswick	2	1,000	500	2	1,000	753.9	1.3
Nova Scotia	7	8,589	1,227	7	8,589	943.0	9.1
Ontario	52	88,079	1,694	99	167,706	13,792.1	12.2
Prince Edward Island	1	600	600	1	600	146.4	4.1
Quebec	8	42,471	5,309	79	419,411	8,263.6	50.8
Saskatchewan	4	21,255	5,314	9	47,826	1,133.6	42.2
Canada	108	226,503	2,097	264[d]	761,279	35,851.8	21.0

SPECT = single-photon emission computed tomography.

[a] 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.

[b] Data derived from question: "For all [modality], how many examinations are conducted in a fiscal year?"

[c] The population as of July 1, 2015 (see Table 3).[26]

[d] No provincial exam data were available for Newfoundland and Labrador (4 units).

Mobile SPECT

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

Geographical Distribution of SPECT

Figure 8 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.

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

Across Canada, an overall total of 226,503 SPECT examinations per year were reported for 108 units, where each site reported on its last fiscal year. The average number of exams per unit was 2,097. From this, we imputed an overall estimate of 761,279 exams for all inventoried units.

Table 10 shows the recorded and imputed total number of exams by province, and the number of exams per 1,000 people.

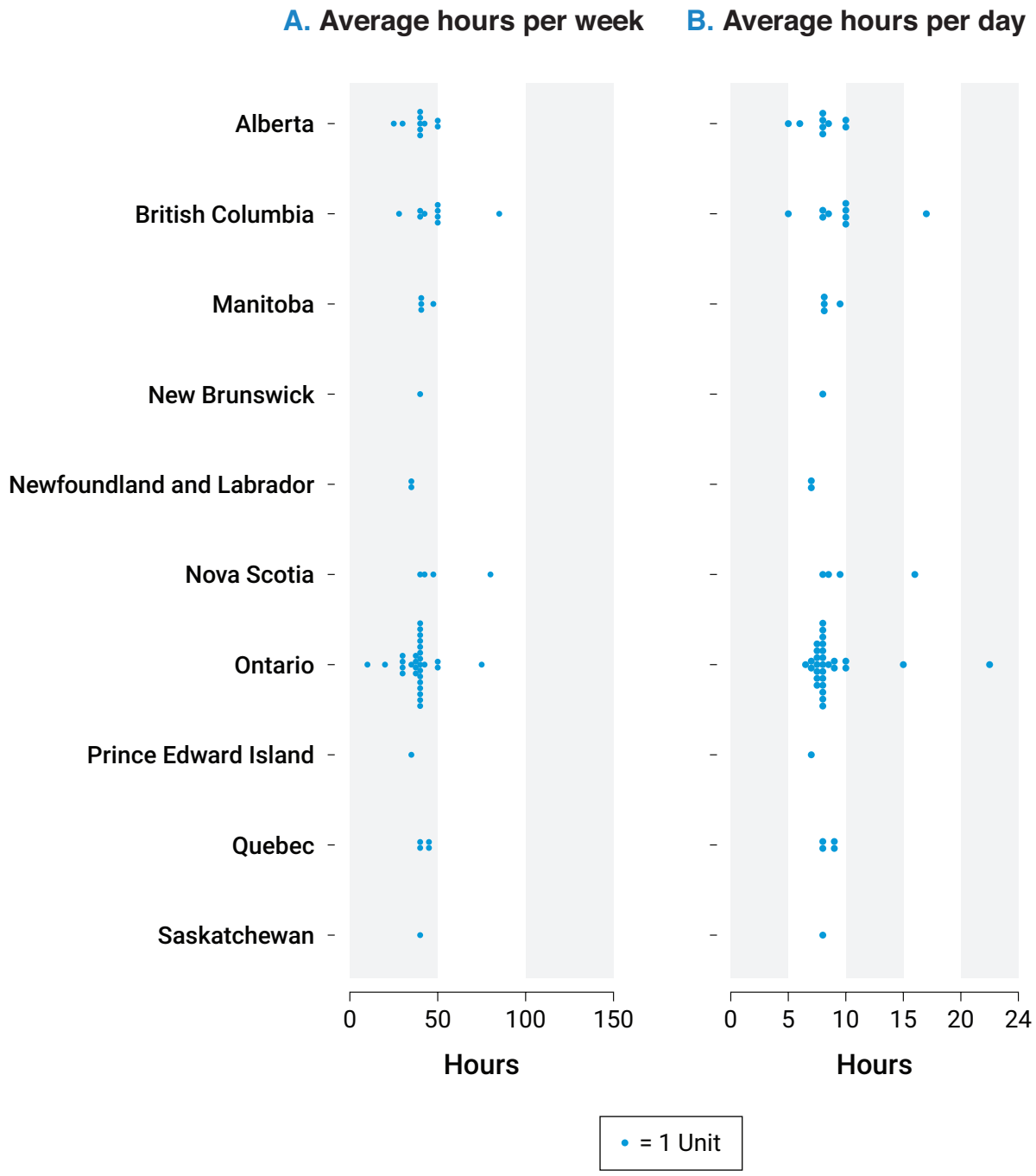
Quebec and Ontario had the highest (imputed) total number of exams and New Brunswick and Prince Edward Island the lowest.

When we adjusted for the population of each province, Quebec and Saskatchewan had the highest (imputed) exams per 1,000 people, while New Brunswick and Prince Edward Island had the lowest.

The imputed totals must be interpreted with caution, as we assumed that sites with missing data conduct a similar number of exams as sites with data and that we have identified all units within a province. The totals and per-population values for Quebec in particular are the most uncertain, as these calculations involved the greatest imputation.

The reported examination data, without imputation, are summarized by province or territory in Appendix C, Table 18.

Figure 9: Average Hours of Operation of SPECT Units in a Typical Week and in a Typical Day

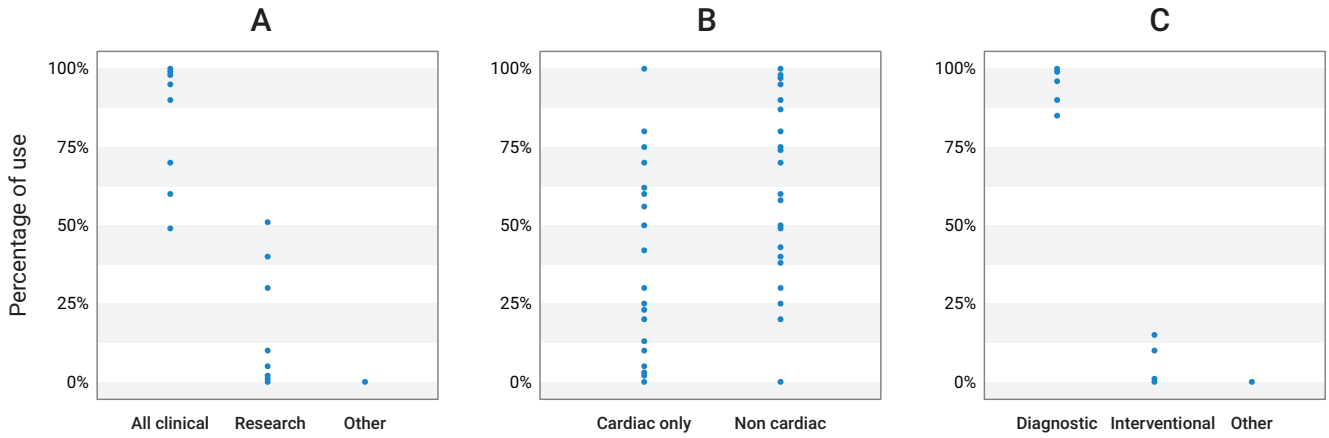


SPECT = single-photon emission computed tomography.

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?"

Figure 10: Overall Proportion of Type of Use of SPECT Units



SPECT = single-photon emission computed tomography.

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

B: Breakdown of All clinical use. The All clinical use represented in A is further subdivided into 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?"

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

Sixty-six sites provided information on the hours of use averaged across all their SPECT units in a typical week and 65 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 eight hours per day.

Hours per week and hours per day are shown for all sites by province in Figure 9, and detailed summary statistics are presented in Appendix C, Table 19 and Table 20.

Most sites in all provinces operated a 40- or 50-hour week and eight- 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 (6/71, 8.5%) operated during the weekend.

Patterns of SPECT Use: Types of Use

Sixty-four sites provided at least partial information on the typical type of use across all their SPECT 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 (approximately 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 10. Indication is shown on the left (A, B) and procedure on the right (C).

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

Table 11: Summary of Availability and Status of PET-CT Units Across Canada

Province or Territory	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	2	3	2	0	0.64
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	11	15	1	2	1.09
Prince Edward Island	0	0	0	0	0.00
Quebec	20	20	5	0	2.42
Saskatchewan	1	1	0	0	0.88
Yukon	0	0	0	0	0.00
Canada	39	47	10	3	1.31

CT = computed tomography; PET = positron emission tomography.

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

[b] Data derived from question: "If so, how many PET-CTs or PETs 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 PET-CT or PET machine in the next two years?" Each "yes" counts as one.

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

[e] The population as of July 1, 2015 (see Table 3).[26]

Positron Emission Tomography–Computed Tomography or Positron Emission Tomography

Number and Location of PET-CT or PET Units

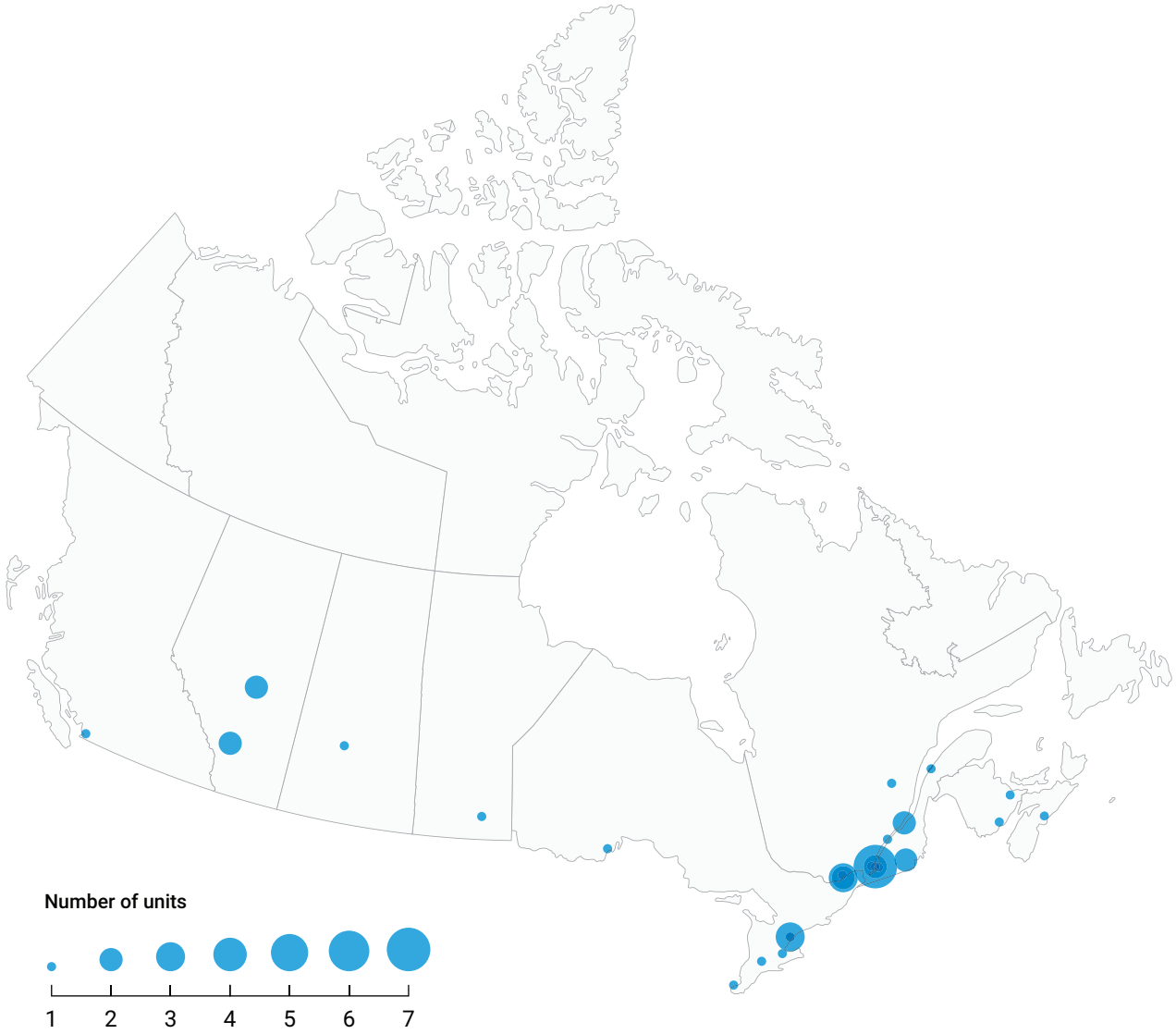
Thirty-nine sites in eight provinces have one or more PET-CT or PET units. There were up to two units per site, for a total of 47 units (Table 11). Although we asked about PET-CT or PET, findings of a recent CADTH Environmental Scan[31] suggest these units are almost exclusively PET-CT, as stand-alone PET has not been available in Canada for the past decade. Hereafter this category will be referred to as PET-CT, except when quoting from the survey. 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 that a new unit will be operational in St. John's in 2016.[31]

Nineteen new PET-CT units were installed between 2012 and 2015 (Appendix B, Table 17). Three sites decommissioned one or more PET-CT or PET units since the last survey in 2012, and 10 sites reported planned installation of one or more PET-CTs in the next two years (Table 11). Because our survey did not discriminate between replacement and new installations, it is unclear whether planned installations are to be new units, replacements or upgrades.

Geographical Distribution of PET-CT

Figure 11 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 11: Distribution of PET-CT Across Canada



CT = computed tomography; PET = positron emission tomography.

Notes: 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 and New Brunswick have the highest number of units per population. British Columbia and Manitoba have the lowest number per population, of those provinces or territories that had units. These are provincial averages and do not reflect geographic distribution of the units with respect to the people within the regions.

Mobile PET-CT

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

Table 12: Reported and Imputed Total Examinations per Fiscal Year for PET-CT

Province or Territory	Units With Records[a]	Recorded Exams[b]	Exams per Unit	Total Units	Total Imputed	Population (1,000)[c]	Exams per 1,000 People
Alberta	3	7,421	2,474	4	9,896	4,196.5	2.4
British Columbia	3	8,029	2,676	3	8,028	4,683.1	1.7
Manitoba	1	1,741	1,741	1	1,741	1,293.4	1.3
New Brunswick	1	729	729	2	1,458	753.9	1.9
Nova Scotia	1	2,241	2,241	1	2,241	943.0	2.4
Ontario	5	3,275	655	15	9,825	13,792.1	0.7
Quebec	12	25,387	2,116	20	42,320	8,263.6	5.1
Saskatchewan	1	1,315	1,315	1	1,315	1,133.6	1.2
Canada	27	50,138	1,857	47	76,824	35,851.8	2.0

CT = computed tomography; PET = positron emission tomography.

[a] 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.

[b] Data derived from question: "For all [modality], how many examinations are conducted in a fiscal year?"

[c] The population as of July 1, 2015 (see Table 3).[26]

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

Across Canada, an overall total of 50,138 examinations per year was reported for 27 PET-CT units, where each site reported for its last fiscal year. The average number of exams per unit was 1,857. From this, we imputed an overall estimate of 76,824 exams for all inventoried CT units. Table 12 shows the recorded and imputed total number of exams by province, and the number of exams per 1,000 people.

Quebec, British Columbia, and Ontario had the highest (imputed) total number of exams, and Saskatchewan and New Brunswick the lowest.

When we adjusted for the population of each province, Quebec, Nova Scotia, and Alberta had the highest total exams per 1,000 people, and Ontario and Saskatchewan had the lowest.

The imputed totals must be interpreted with caution, as we assumed that sites with missing data conduct a similar number of exams as sites with data and that we have identified all units within a province. This applies particularly to Ontario and Quebec.

The reported examination data, without imputation, is summarized by province or territory in Appendix C, Table 18.

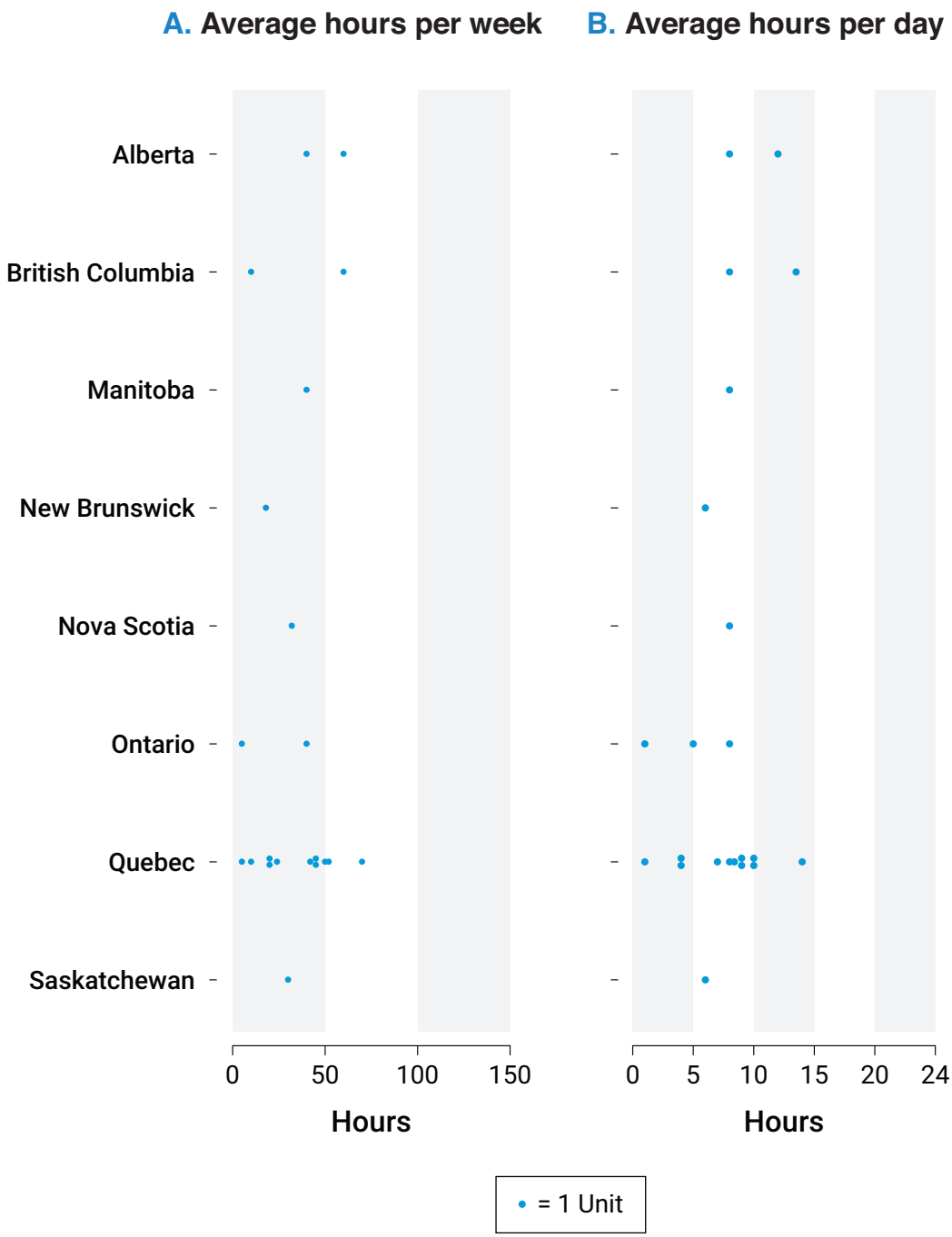
Patterns of PET-CT Use: Typical Hours of Operation in a Week and Day

Twenty-one sites provided information on the hours of use averaged across all their PET-CT units in a typical week and 22 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 40 hours per week and eight hours per day.

Hours per week and hours per day are shown by province in Figure 12, and detailed summary statistics are presented in Appendix C, Table 19 and Table 20.

Alberta and Manitoba had the highest number of hours per week and New Brunswick and Ontario had the lowest, whereas Alberta and British Columbia had the highest hours per day and Ontario, New Brunswick, and Saskatchewan had the lowest. Two of 40 sites (5%) operated PET-CT on the weekend.

Figure 12: Average Hours of Operation of PET-CT Units in a Typical Week and in a Typical Day

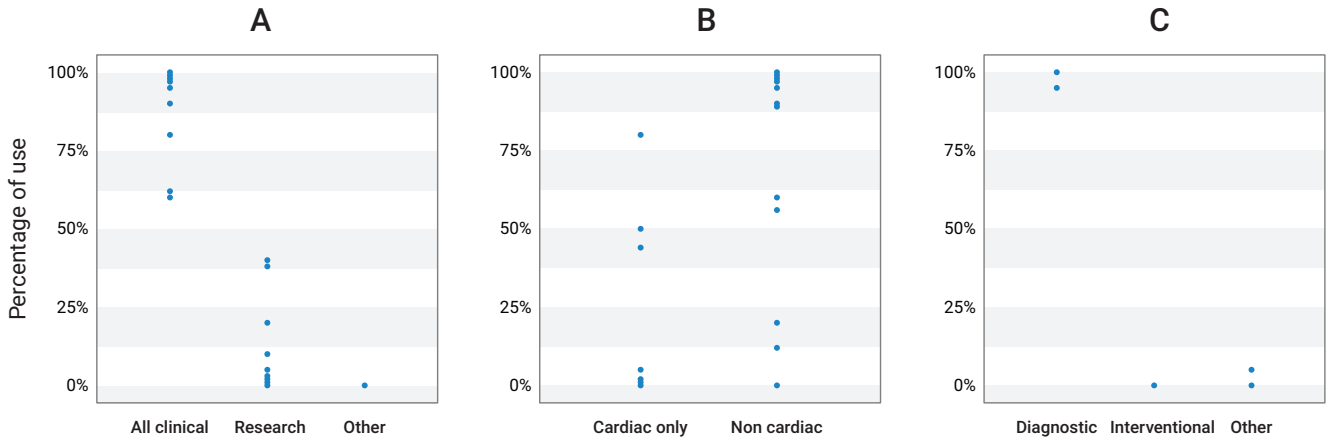


CT = computed tomography; PET = positron emission tomography.

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?"

Figure 13: Summary (Box Plot) of Proportion of Type of Use of PET-CT Units



CT = computed tomography; PET = positron emission tomography.

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

B: Breakdown of All clinical use. The All clinical use represented in A is further subdivided into 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 PET-CT used for: Diagnostic/Interventional/Other?"

Patterns of PET-CT Use: Types of Use

Twenty-two sites provided 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 diagnostic, interventional, or other.

For indication, most use was clinical. Of this majority, more than 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 13. Indication is shown on the left (A, B) and procedure on the right (C).

Of the small number of sites that 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–Magnetic Resonance Imaging

Number and Location of PET-MRI Units

We identified two sites with PET-MRI installations, both in Ontario (Figure 14). Neither unit was in clinical operation as of the survey data collection period, and there are no data on use available.

Planned Installations for PET-MRI Units

Respondents for 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

Figure 14: Distribution of PET-MRI Units Across Canada

MRI = magnetic resonance imaging; PET = positron emission tomography.

Notes: 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.

releases, data collected during a 2015 CADTH Environmental Scan on PET, PET-CT, and PET-MRI in Canada,[31] and a focused Internet search, we identified a further five facilities with concrete plans or intentions to install a PET-MRI unit in the near future: one in British Columbia, one in Alberta, and three in Ontario.[31]

Table 13: Summary of Availability and Status of SPECT-CT Units Across Canada

Province or Territory	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	19	35	5	2	8.34
British Columbia	16	27	4	0	5.77
Manitoba	5	8	3	0	6.19
New Brunswick	4	4	2	0	5.31
Newfoundland and Labrador	3	5	1	0	9.47
Northwest Territories	0	0	0	0	0.00
Nova Scotia	8	9	1	0	9.54
Nunavut	0	0	0	0	0.00
Ontario	28	38	9	0	2.76
Prince Edward Island	1	1	1	0	6.83
Quebec	5[f]	77[f,g]	3	0	9.32
Saskatchewan	3	7[h]	0	0	8.82
Yukon	0	0	0	0	0.00
Canada	91	214	29	2	5.97

CT = computed tomography; SPECT = single-photo emission computed tomography.

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

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

[e] The population as of July 1, 2015 (see Table 3).

f Survey respondents reported 10 units at 5 sites.

[g] Estimated. The Quebec validator estimated a 50:50 split between SPECT and SPECT-CT.

[h] Three units included as SPECT were identified as SPECT-CT (CT with attenuation correction) at an additional site during report review.

Single-Photon Emission Computed Tomography–Computed Tomography

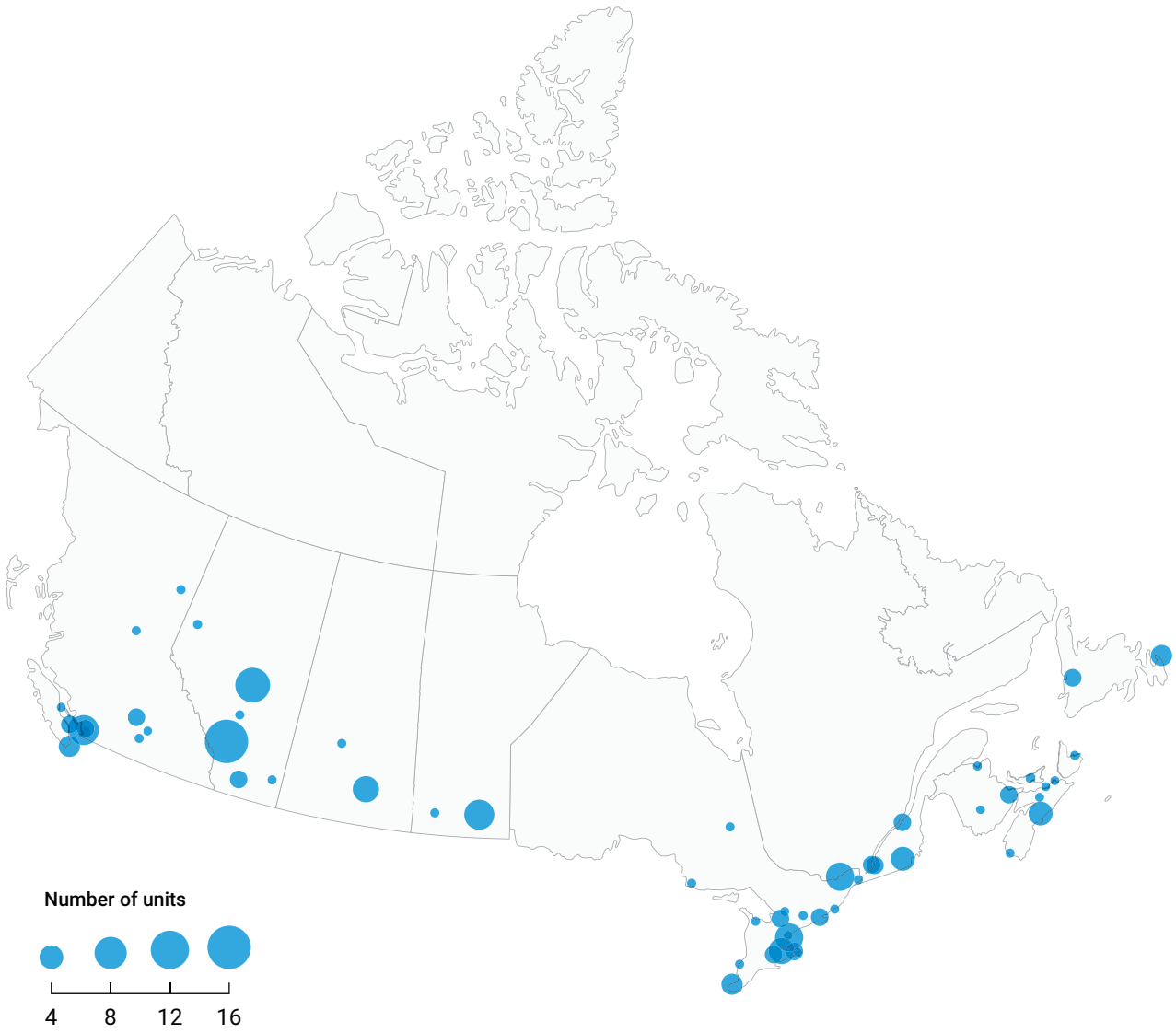
Number and Location of SPECT-CT Units

Ninety-one sites in 10 provinces reported operating SPECT-CT units. There were up to five units per site, for a total of 214 units (Table 13). For Quebec, the contribution of public sites is represented by an estimate, as the validator provided aggregated SPECT plus SPECT-CT. Quebec and Ontario have the highest number of units, followed by Ontario and Alberta. Prince Edward Island and Saskatchewan reported one unit each. The three territories did not report any units.

Forty-one new SPECT-CT units were installed between 2012 and 2015 (Appendix B, Table 17). Two sites reported decommissioning a SPEC-CT unit since the last survey in 2012, and 29 sites planned the installation of one or more SPECT-CTs in the next two years. Because our questions did not discriminate between replacement and new installations, it is unclear whether planned installations are to be new units, replacements, or upgrades.

The provinces with the highest number of units per million people are Newfoundland and Labrador, Nova Scotia and Quebec, and those with the lowest are Ontario and New Brunswick. These are provincial averages and do not reflect geographic distribution of the units with respect to the people within the regions.

Figure 15: Distribution of SPECT-CT Across Canada



CT = computed tomography; SPECT = single-photo emission computed tomography.

Notes: Data derived from question: "If yes, how many SPEC-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. Units that were supplied in aggregate, without location information, are not represented on the map. This applies in particular to Quebec.

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 15 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.

Table 14: Reported and Imputed Total Examinations per Fiscal Year for SPECT-CT

Province or Territory	Units With Records[a]	Recorded Exams[b]	Exams per Unit	Total Units	Total Imputed	Population (1,000)[c]	Exams per 1,000 People
Alberta	27	49,821	1,845	35	64,575	4,196.5	15.4
British Columbia	17	16,278	958	27	25,866	4,683.1	5.5
Manitoba	6	7,450	1,242	8	9,936	1,293.4	7.7
New Brunswick	4	11,000	2,750	4	11,000	753.9	14.6
Nova Scotia	8	8,926	1,116	9	10,044	943.0	10.7
Ontario	32	68,039	2,126	38	80,788	13,792.1	5.9
Prince Edward Island	1	1,519	1,519	1	1,519	146.4	10.4
Quebec	9	60,812	6,757	77	520,289	8,263.6	63.0
Canada	104	223,845	2,152	199[d]	724,017	35,851.8	20.0

CT = computed tomography; SPECT = single-photo emission computed tomography.

[a] 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.

[b] Data derived from question: "For all [modality], how many examinations are conducted in a fiscal year?"

[c] The population as of July 1, 2015 (see Table 3).[26]

[d] No provincial exam data were available for Newfoundland (5 units) or Saskatchewan (7 units). Data for 3 units in Saskatchewan were reported as for SPECT.

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

Across Canada, an overall total of 223,845 examinations per year were reported for 104 SPECT-CT units, where each site reported for its last fiscal year. The average number of exams per unit was 2,152. From this, we imputed an overall estimate of 724,017 exams for all inventoried SPECT-CT units. Table 14 shows the recorded and imputed total number of exams by province, and the number of exams per 1,000 people.

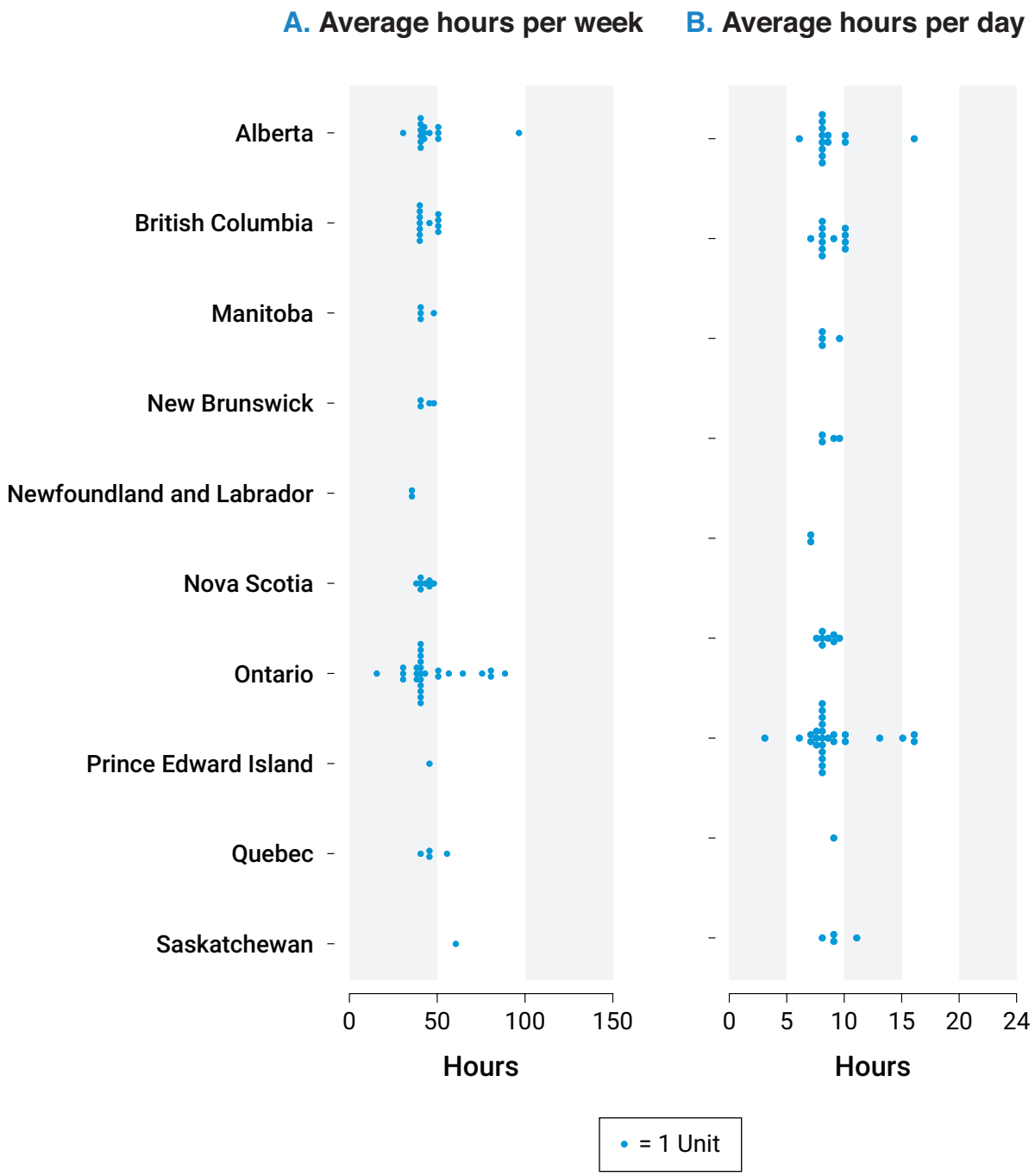
Quebec, Ontario, and British Columbia had the highest (imputed) total number of exams, and Prince Edward Island and New Brunswick the lowest. No exam data were reported for the Northwest Territories and Nunavut.

When we adjusted for the population of each province, Quebec and Alberta had the highest total exams per 1,000 people, while Ontario and British Columbia had the lowest.

The imputed totals must be interpreted with caution, as we assumed that sites with missing data conduct a similar number of exams as sites with data and that we have identified all units within a province. The totals and per-population values for Quebec in particular are the most uncertain, as these calculations involved the greatest imputation. If they represent high-volume sites, then the resulting total will be substantially overestimated.

The reported examination data, without imputation, are summarized by province or territory in Appendix C, Table 18.

Figure 16: Average Hours of Operation of SPECT-CT Units in a Typical Week and in a Typical Day

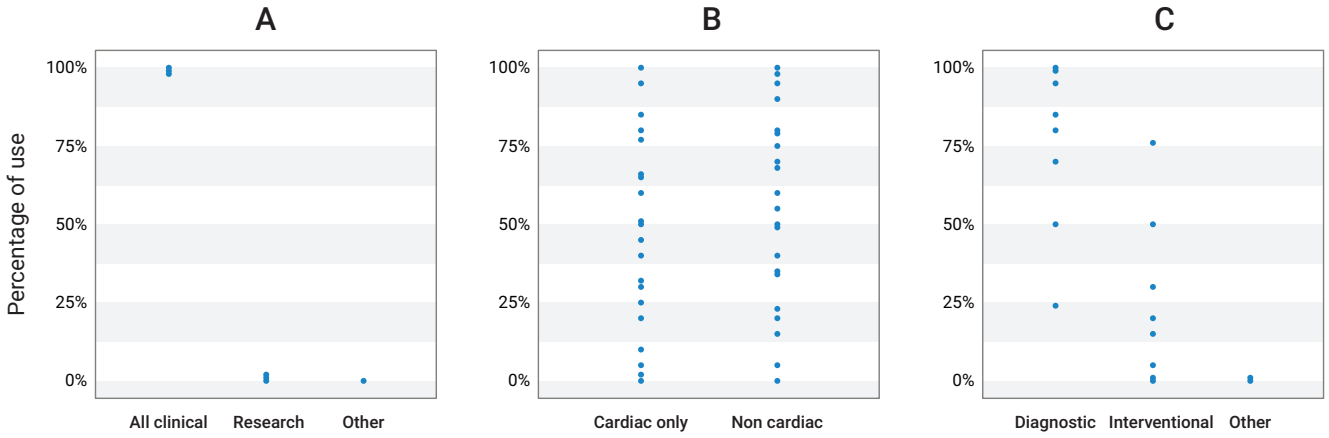


CT = computed tomography; SPECT = single-photo emission computed tomography.

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?"

Figure 17: Overall Proportion of Type of Use of SPECT-CT Units



CT = computed tomography; SPECT = single-photo emission computed tomography.

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

B: Breakdown of All clinical use. The All clinical use represented in A is further subdivided into 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 SPEC-CT used for: Diagnostic/Interventional/Other?"

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

Seventy-eight sites provided information on the hours of use averaged across all their SPECT units in a typical week and 76 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 eight hours per day.

These data are shown by province in Figure 16, and detailed summary statistics are presented in Appendix C, Table 19 and Table 20.

Most sites in all provinces operated a 40- or 50-hour week and eight- 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 76 sites (13.2%) reported weekend operation.

Patterns of SPECT-CT Use: Types of Use

Seventy-two sites provided at least partial information on the typical type of use across all their SPECT-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.

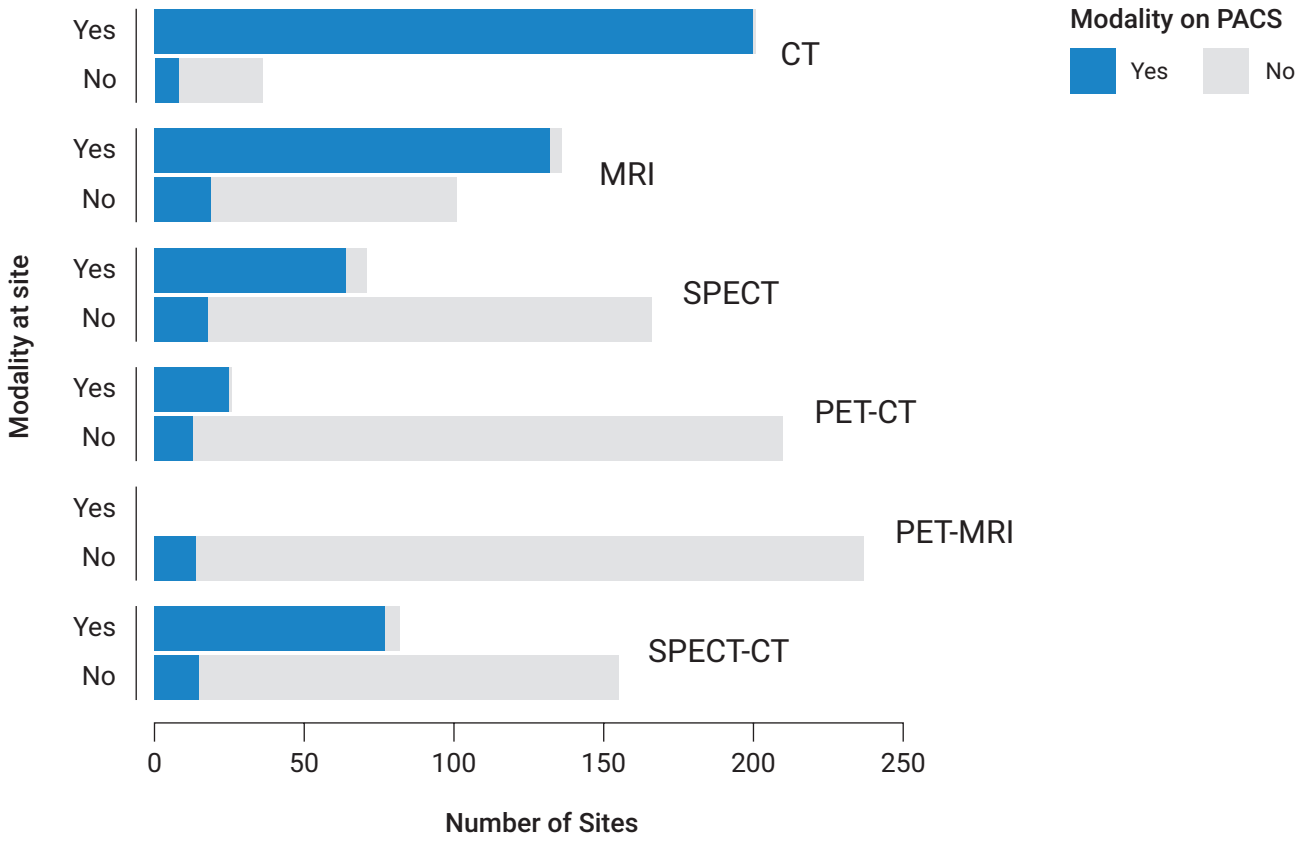
For indication, most use was clinical. Of clinical use, two-thirds on average was non-cardiac, and one-third was cardiac only. Most sites reported no research use, and none reported "other" uses.

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 17. Indication is shown on the left (A, B) and procedure on the right (C).

Of the 12 sites that responded to a question about whether any of their SPECT-CT units were used in treatment planning, 2 (16.7%) answered yes. Four of 12 reported operating the CT component in stand-alone mode, without using the SPECT component.

Figure 18: Overall Access to Images Through PACS Compared With Availability of Modalities at Sites



CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photo emission computed tomography; PACS = picture archiving communications system.

Notes: 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."

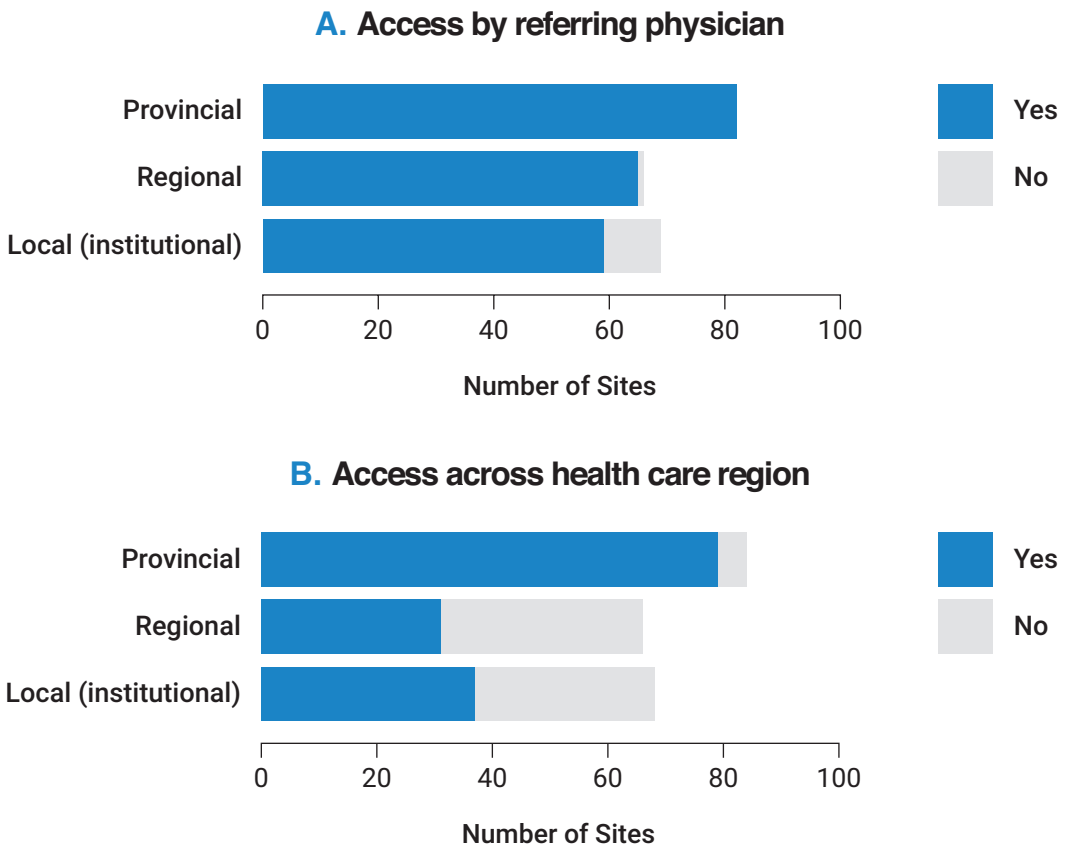
Picture Archiving Communication System

Modalities Available on PACS

Of the 239 respondents who answered the question on availability of PACS at their sites, 237 (99.2%) had access to PACS. We also asked which type of images the PACS system stored at each site. For most sites, the modalities available on PACS corresponded to those available on the site. Only a minority of sites had access through PACS to images obtained from elsewhere in the network using modalities that they did not have at their sites. There are no data on PACS use for the two sites with PET-MRI.

Figure 18 shows the relationship between the availability of each of the six modalities and the availability of images for that modality. For each modality, the number of sites with and without the modality is shown by the side-by-side bars (upper bar indicates Yes, lower No), and the availability of the modality on PACS within each group by the shading (dark indicates Yes).

Figure 19: Extent of Access to Images Through PACS Compared With PACS Coverage



PACS = picture archiving communications system.

Notes: 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?"

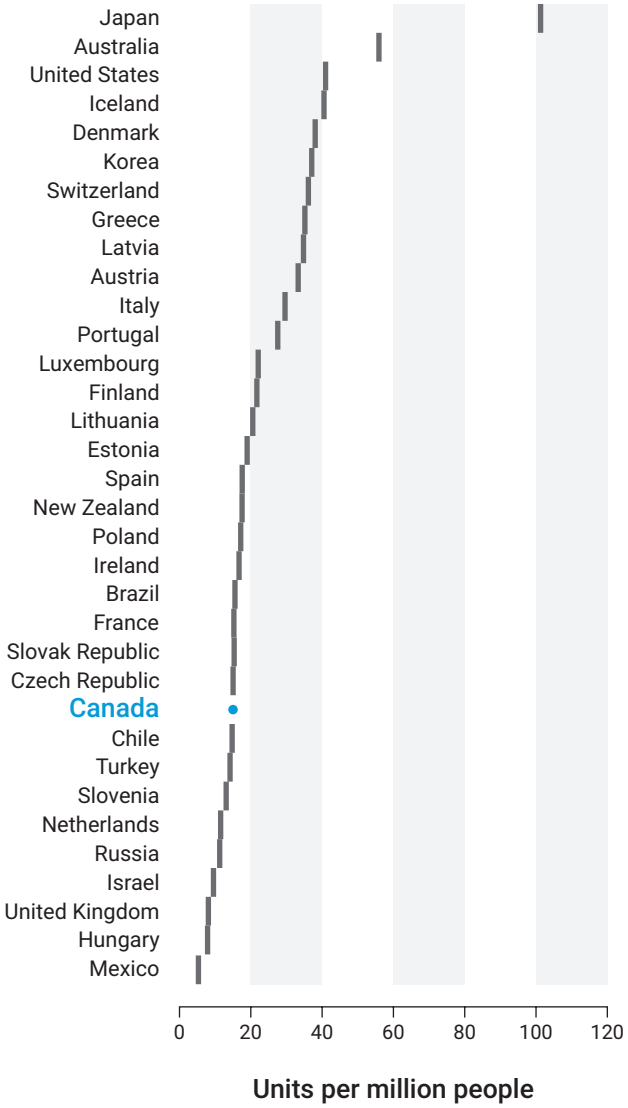
B: Data derived from question: "Are PACS images routinely accessible throughout your provincial health care system without the need to manually push images from any particular location/modality?"

PACS Coverage

A total of 236 sites reported the coverage of their PACS network: 74 sites (31.4%) had local and/or institutional coverage, 67 sites (28.4%) had regional coverage, and 95 sites (40.3%) had provincial coverage. PACS images were available to referring physicians outside of the imaging department at the majority 206/217 (94.9%) of sites. Routine access throughout the sites' provincial health care system, without the need to manually push images from any particular location and/or modality, was also available at most sites: 147/218 (67.4%).

Figure 19 shows the results of cross-tabulation of these three variables, indicating that sites with PACS extending over the province or territory offered the greatest access. We did not, however, identify sites as members of specific PACS networks.

Figure 20: Comparison of Canadian and International Data for CT: Total Units per Million People



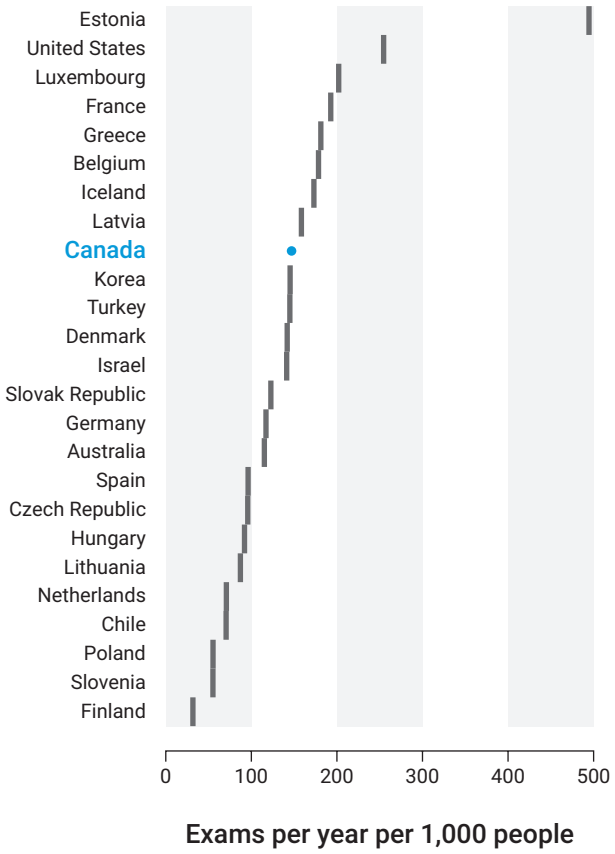
CT = computed tomography.

Note: Canadian data from the Canadian Medical Imaging Inventory 2015 survey (blue) are compared with latest data from each of the comparator countries, up to 2014.

Isotope Supply for PET Hybrid Modalities

We asked respondents at sites with a PET or PET-CT unit whether they had access to a cyclotron, and if not, where they obtained isotopes. Of the 24 sites that responded, six had access to a cyclotron, in Alberta, British Columbia, Manitoba, Nova Scotia, Ontario, and Quebec. The Canadian Nuclear Safety Commission website identified a total of 10 PET cyclotrons in Canada.[41] Three of the four cyclotrons not identified by the survey are in Ontario and the fourth is in Quebec.[41] The 2015 CADTH Environmental Scan identified three additional cyclotrons expected to become operational in 2016 or later, one each in Ontario, Saskatchewan, and Newfoundland and Labrador.[31]

Figure 21: Comparison of Canadian and International Data for CT: Total Exams (Imputed) per Million People



CT = computed tomography.

Notes: Canadian data from the Canadian Medical Imaging Inventory 2015 survey (blue) are compared with latest data from each of the comparator countries, up to 2014. The total exams for Canada in 2015 were calculated by imputation from the available data and the total number of units recorded.

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).

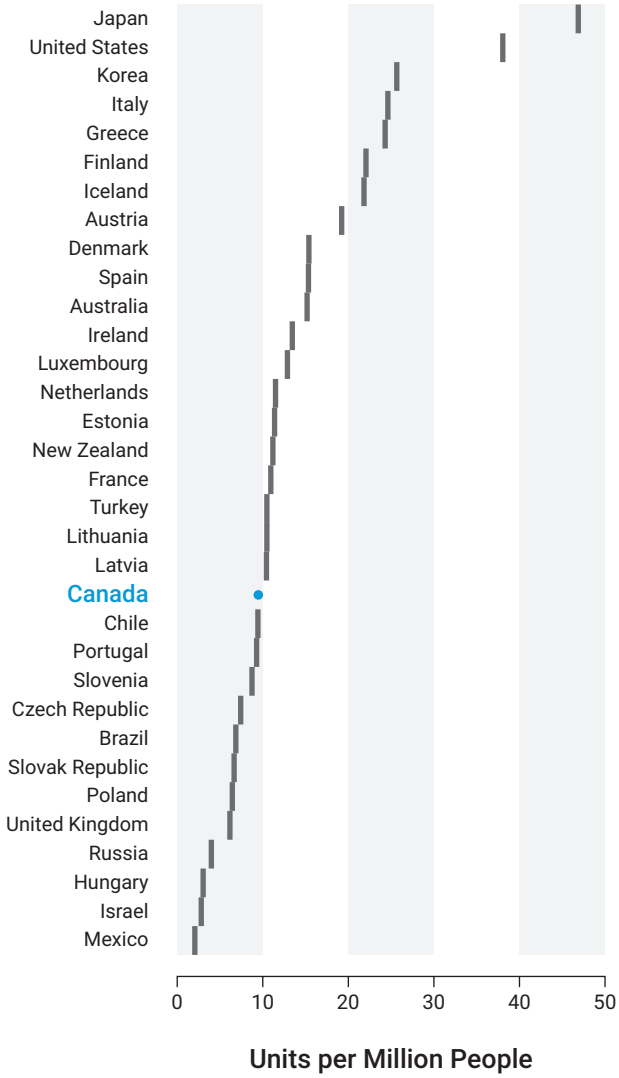
Canadian Data Versus International Data

The availability of unit count and use data allowed comparison of the Canadian data we collected to international data from the OECD.[27-30] We used the last observation carried forward method for all countries to impute values for comparison. Some countries had data as recent as 2014.

Computed Tomography

Based on our survey results, and including data from validators and grey literature, Canada appears below approximately half of the countries with data collected by the OECD in terms of number of CT devices per million people (Figure 20),[29] slightly higher than the number of units recorded in Canada in 2013. Comparator data are the latest reported for each country, up to 2014.

Figure 22: Comparison of Canadian and International Data for MRI: Total Units per Million People



MRI = magnetic resonance imaging.

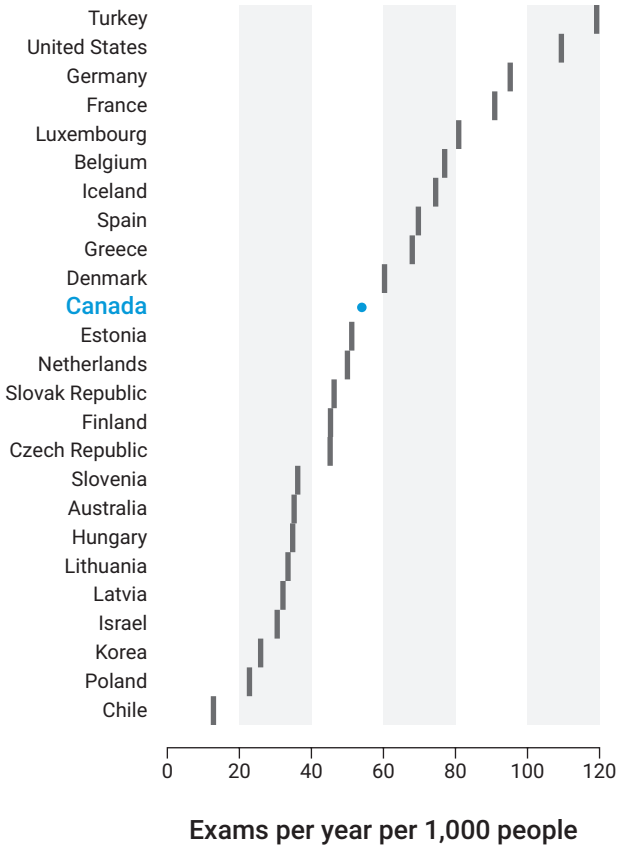
Note: Canadian data from the Canadian Medical Imaging Inventory 2015 survey (blue) are compared with most recently collected international data (2011-2014).

As only a subset of sites reported examination data in our survey, we used the total exams per unit at sites that provided data to estimate the missing totals (Figure 21). Comparator data are the latest reported for each country, up to 2014. Canada appears in the upper half of the countries that reported exam data,[27] with more exams than reported in 2013. The variations between countries are likely to reflect variations in practice as well as variations in accessibility.

Magnetic Resonance Imaging

Based on our survey results, including data from validators and grey literature, Canada ranks below approximately half of the countries with data collected by the OECD in terms of number of MRI units per million people,[30] slightly higher than the number of units recorded in Canada in 2013 (Figure 22). Comparator data are the latest reported for each country, up to 2014.

Figure 23: Comparison of Canadian and International Data for MRI: Exams per Fiscal Year per 1,000 People



MRI = magnetic resonance imaging.

Notes: Canadian data from the Canadian Medical Imaging Inventory 2015 survey (blue) are compared with latest data from each of the comparator countries, up to 2014. The total exams for Canada in 2015 were calculated by imputation from the available data and the total number of units recorded.

As only a subset of sites reported examination data in our survey, we used the total number of exams from the sites that provided data to impute the missing totals. Canada appears in the upper half of countries reporting exam data (Figure 23),[28] with an increase over the number of exams from 2013. The variations between countries are likely to reflect variations in practice as well as variations in accessibility.

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 and Number of Units

CT is the most widespread modality in Canada, with the highest number of units and 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, and also have 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 is in Yukon. PET-MRI is the newest modality, with two units installed in Ontario, but several other sites have installations planned or in progress. We were interested in assessing the age of units currently in use, but discrepancies between the unit counts for number of sites and the combined technical information for the CADTH survey and the CIHI data suggested the need to confirm the status of specific older units before doing so, to ensure an accurate estimate.

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, and possibly the age of units (with older units seeing lighter use). 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 regional variations in guidelines for imaging, and in adherence to guidelines. Further, patient demographics and socioeconomic status may contribute to use patterns,[42] as well as proportion of care provided by specialists versus primary care physicians.[43]

Variation in Type of Use Across Modalities

While clear patterns emerged with regard 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, although 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-CT units that were exclusively used for cardiac examinations, but of the units installed since 2012, five SPECT units and two SPECT-CT units were dedicated to cardiac use. PET-CT saw 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 underreported, 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.

Life Cycle of Diagnostic Imaging Equipment

The data on decommissioning, recent, and planned installations for CT and MRI suggest 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 units.[44] 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.

Emergence of Hybrid 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 suggest 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 clinical use and diffusion. Due to potential applications in oncology, neuropsychiatric conditions (e.g., Alzheimer disease) and mental illness, increased use is anticipated.[45] PET-MRI may provide greater clinical utility than PET-CT or MRI alone for these indications.[45,46] Due to potential barriers such as cost, technical challenges associated with implementation,[23,25,47] projected wait times, contraindications (e.g., pacemakers), limited highly qualified personnel,[25] and uncertainty with respect to which hybrid PET modality (i.e., CT or MRI) provides optimal clinical utility,[48] the speed of adoption is unpredicable.[46]

PACS Accessibility

Most facilities with imaging modality units at the site also stored PACS images for those modalities, while a minority of sites without units available had access to PACS images for those modalities. We do not know what forms of storage are used where PACS is 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 health care 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 for interpretation or comparison, which could have an influence on the quality of care provided.

Jurisdictional Differences

The Influence of Geography

The survey was restricted to specialist medical imaging, which tends to cluster around major urban centres and within provinces and territories with larger populations. Larger provinces, including Alberta, British Columbia, Ontario, and Quebec, have the greatest quantity of units, followed by Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, and Saskatchewan, which have a relatively moderate number of units. Jurisdictions with relatively low unit counts include the northern territories and Prince Edward Island.

The number of units per million people is more similar than the total unit counts per population across provinces, but these ratios do not account for population distribution in the respective provinces or territories. For example, each northern territory has a single CT unit that services a large geographical area, requiring patients who need specialist imaging to travel significant distances.

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 fulfill the need in provinces or territories without certain modalities installed.

Funding Structures

One aspect of medical imaging practice that the survey did not address was potential differences 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 health care facilities that provide employment opportunities may be necessary to attract clinicians, technologists, and technicians. Centres 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.[49] Further, there is limited evidence that it may be cost-effective to set up imaging services in rural settings[50,51] or remote areas.[50]

Canadian Data Versus International Data

Compared with other countries of different levels of development around the world, as recorded by the OECD, Canada currently appears 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 appears in the upper 50% for number of CT exams and MRI exams, with an increase in both since 2013.

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 have lower throughput. In addition, the survey data on private sites are limited.

No OECD data were publicly available on the other modalities of interest; therefore, Canada's status compared with 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 represent 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

For reasons of feasibility, this iteration of the survey was restricted to six specialist imaging modalities, and does not provide information about the availability of others that are more common and widespread (for example, X-ray and ultrasound) or that were included in previous survey iterations (gamma cameras and angiography). These exclusions bias the coverage strongly toward urban areas, and do not depict the options available outside these regions. In addition, these exclusions may limit understanding of the relationship between modalities within the health care system, 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, with more responses from publicly funded facilities. Publicly funded facilities were more readily identified than private facilities, as their data tend to be held at multiple administrative levels. Not all provinces have a publicly available repository of private imaging facilities.

Variable Response Rates Across Jurisdictions

Larger provinces, which have a greater number of facilities and health care regions, tended to have lower survey response rates.

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 with 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. 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 not have captured 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 may have affected the responses for difficult questions, such as those regarding the number of examinations or hours of utilization, particularly if real-time data were not recorded at the facilities.

Inconsistency in Data Sources

Most of our data are derived from formal survey responses. The data collected from provincial or territorial validators, the CADTH Environmental Scan on PET use,[31] and grey literature sources are limited in most cases 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 toward health technology management, rather than the current focus of assessment of emergent technologies, it may be beneficial to encourage the mandatory reporting of medical 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 health care 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 wait-list) and proportion of public funding provided?
- Can abnormally high utilization at some facilities be linked to overuse?
- What factors explain abnormally low use? Can it be attributed to unit age, lack of highly trained personnel, population density, or improper applications?
- How does legislation regarding diagnostic imaging differ across jurisdictions and does that influence the way devices are distributed and used?

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 medical imaging services.[42] 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, where they are being installed, and how they are being used is valuable in the context of limited budgets, and in the interest of health technology management.

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 with other countries. Future updates of this inventory will present information on technical features of units, 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. They raise 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 and fall of 2017, and the update will be published in 2018.

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Appendix A: The Canadian Medical Imaging Inventory 2015 Survey (Revised)

Page 1

Survey responder name

Survey responder title

Email

Phone

Name of facility or facilities for which you are reporting on:

What type of facility is this?

-Select-

Address

Alternate address

City

Province/territory

- Select -

How is this facility funded?

If both, please provide details

Page 2

Are medical images stored on a picture archiving communication system (PACS)?

If yes, which imaging modalities are stored on a PACS? (Select one or more)

Comments

Is your PACS:

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.)?

Are PACS images routinely accessible throughout your provincial health care system without the need to manually push images from any particular location/modality?

If no, please provide details

Page 3

Do you have PET/CT or PET machines in your hospital/facility?

If yes, how many PET/CT or PET machines do you have?

Do you have plans to install a new/additional PET/CT unit in the next two years?

For all PET/CT or PET units, how many examinations were conducted in the last fiscal year?

Have you decommissioned a PET/CT or PET since January 2, 2012?

If yes, what year was the PET/CT or PET decommissioned?

What year was the decommissioned PET/CT or PET originally installed?

What was the make of the decommissioned PET/CT or PET unit?

In an average week (168 hours), how many hours are the PET/CT or PET units in use, averaged across all units (please express the total in numbers)?

On a regular workday, how many hours per day are the PET/CT or PET units in use, averaged across all units (please express the total in numbers)?

Do any PET/CT or PET units operate on the weekend?

Based on your practice in the last fiscal year, what percentage of time are the PET/CT or PET units used for: (The total percentage, expressed as a number, must add up to 100.)

- non-cardiac clinical purposes
- dedicated cardiac purposes, only
- research purposes
- other (specify)

Comments:

Based on your practice in the last fiscal year, what percentage of clinical time are the PET/CT units used for: (The total percentage, expressed as a number, must add up to 100.)

- diagnostic purposes
- interventional purposes
- other (specify)

Comments:

Are the PET/CT or PET units also used for treatment-planning purposes in radiation therapy (i.e., PET/CT images are transferred for direct use in RT-planning platforms)?

Do you use the CT component of any PET/CT unit as a stand-alone CT unit for clinical CT examinations (i.e., to provide extra CT capacity)?

If yes, is this done:

Does your facility operate a cyclotron for the PET/CT or PET units?

If yes, please describe the make and model of the cyclotron, if it is single or dual beam, and the energy level or energy level range (MeV).

If no, where do you receive your PET/CT or PET isotope supply from?

Additional comments:

For each new PET/CT unit, (installed after January 2, 2012) please answer the following:

What is the make of the PET/CT unit?

If other is selected, please comment:

What is the model of the PET/CT unit?

What year did the PET/CT unit become operational?

What is the imaging scope of the PET/CT unit?

How many slices does the CT component of the PET/CT unit have?

If other is selected, please comment

Is the PET/CT unit mobile? Please include the names of the sites that share the PET/CT unit (or number if the installation is fixed):

Does the PET/CT unit have CT dose management controls?

Does the PET/CT unit incorporate image reconstruction techniques for dose reduction?

Does the PET/CT unit record patient CT radiation dose (e.g., as a save screen on PACS)?

Additional comments:

Page 4

Do you have a CT machine(s) in your hospital/facility?

If yes, how many CT machines do you have?

Do you have plans to install a new/additional CT unit in the next two years?

For all CT units, how many examinations were conducted in the last fiscal year?

Have you decommissioned a CT since January 2, 2012?

If yes, what year was the CT decommissioned?

What year was the decommissioned CT originally installed?

What was the make of the decommissioned CT unit?

If you have decommissioned additional CT units please add information below (year decommissioned, year uninstalled and make for each).

In an average week (168 hours), how many hours are the CT units in use, averaged across all units (please express the total in numbers)?

On a regular workday, how many hours per day are the CT units in use, averaged across all units (please express the total in numbers)?

Do any CT units operate on the weekend?

Based on your practice in the last fiscal year, what percentage of time are the CT units used for: (The total percentage, expressed as a number, must add up to 100.)

- non-cardiac clinical purposes
- dedicated cardiac purposes, only
- research purposes
- other (specify)

Comments:

Based on your practice in the last fiscal year, what percentage of clinical time are the CT units used for: (The total percentage, expressed as a number, must add up to 100.)

- diagnostic purposes
- interventional purposes
- other (specify)

Comments:

Are the CT units also used for treatment-planning purposes in radiation therapy (i.e., CT images are transferred for direct use in radiation therapy planning platforms)?

Additional comments:

For each new CT unit, (installed after January 2, 2012) please answer the following:

What is the make of the CT unit?

If other is selected, please comment

What is the model of the CT unit?

What year did the CT unit become operational?

How many multi-detectors does the CT unit have (how many slices)?

If other is selected, please comment

Does the CT unit have a dual energy option?

Does the CT unit have a dual target option?

Does the CT unit have CT dose management controls?

Does the CT unit incorporate image reconstruction techniques for dose reduction?

Does the CT unit record patient radiation dose by exam (e.g., as a save screen on PACS)?

Is the CT unit mobile? Please include the names of the sites that share the CT unit (or number if the installation is fixed):

Additional comments:

Page 5

Do you have MRI machine(s) in your hospital/facility?

If yes, how many MRI machines do you have?

Do you have plans to install a new/additional MRI machine in the next two years?

For all MRI machines, how many examinations were conducted in the last fiscal year?

Have you decommissioned a MRI since January 2, 2012?

If yes, what year was the MRI decommissioned?

What year was the decommissioned MRI originally installed?

What was the make of the decommissioned MRI unit?

If you have decommissioned additional MRI units please add information below (year decommissioned, year uninstalled and make for each).

In an average week (168 hours), how many hours are the MRI units in use, averaged across all units (please express the total in numbers)?

On a regular workday, how many hours per day are the MRI units in use, averaged across all units (please express the total in numbers)?

Do any MRI units operate on the weekend?

Based on your practice in the last fiscal year, what percentage of time are the MRI units used for: (The total percentage, expressed as a number, must add up to 100.)

- clinical purposes
- research purposes
- other (specify)

Comments:

Based on your practice in the last fiscal year, what percentage of clinical time are the MRI units used for: (The total percentage, expressed as a number, must add up to 100.)

- diagnostic purposes

- interventional purposes
- other (specify)

Comments:

Additional comments:

For each new MRI unit, (installed after January 2, 2012) please answer the following:

What is the make of the MRI unit?

If other is selected, please comment

What is the model of the MRI unit?

What year did the MRI unit become operational?

What is the field strength (Tesla) of the MRI unit?

If other is selected, please comment

What is the configuration of the MRI unit?

Is the MRI unit mobile? Please include the names of the sites that share the MRI unit (or number if the installation is fixed):

Additional comments:

Page 6

Do you have PET/MRI machine(s) in your hospital/facility?

If yes, how many PET/MRI machines do you have?

Do you have plans to install a new/additional PET/MRI unit in the next two years?

For all PET/MRI units, how many examinations were conducted in the last fiscal year?

In an average week (168 hours), how many hours are the PET/MRI units in use, averaged across all units (please express the total in numbers)?

On a regular workday, how many hours per day are the PET/MRI units in use, averaged across all units (please express the total in numbers)?

Do any PET/MRI units operate on the weekend?

Based on your practice in the last fiscal year, what percentage of time are the PET/MRI units used for: (The total percentage, expressed as a number, must add up to 100.)

- clinical purposes
- research purposes
- other (specify)

Comments:

Based on your practice in the last fiscal year, what percentage of time are the PET/MRI units used for: (The total percentage, expressed as a number, must add up to 100.)

- diagnostic purposes
- interventional purposes
- other (specify)

Comments:

Are the PET/MRI units also used for treatment-planning purposes in radiation therapy (i.e., PET/MRI images are transferred for direct

use in RT-planning platforms)?

Do you use the MRI component of your PET/MRI unit as a stand-alone MRI unit for clinical MRI examinations (i.e., to provide extra MRI capacity)?

Additional comments:

For each new PET/MRI unit, (installed after January 2, 2012) please answer the following:

What is the make of the PET/MRI unit?

If other is selected, please comment

What is the model of this PET/MRI unit?

What year did this this PET/MRI unit become operational?

What is the field strength (Tesla) of this PET/MRI unit?

If other is selected, please comment

Additional comments:

Page 7

Do you have SPECT/CT machine(s) in your hospital/facility?

If yes, how many SPECT/CT machines do you have?

Do you have plans to install a new/additional SPECT/CT unit in the next two years?

For all SPECT/CT units, how many examinations were conducted in the last fiscal year?

Have you decommissioned a SPECT/CT since January 2, 2012?

If yes, what year was the SPECT/CT decommissioned?

What year was the decommissioned SPECT/CT originally installed?

What was the make of the decommissioned SPECT/CT?

On an average week (168 hours) how many hours are the SPECT/CT units in use, averaged across all units (please express the total in numbers)?

On a regular workday, how many hours per day are the SPECT/CT units in use, averaged across all units (please express the total in numbers)?

Do any SPECT/CT units operate on the weekend?

Based on your practice in the last fiscal year, what percentage of time are the SPECT/CT units used for: (The total percentage, expressed as a number, must add up to 100.)

- non-cardiac clinical purposes
- dedicated cardiac purposes, only
- research purposes
- other (specify)

Comments:

Based on your practice in the last fiscal year, what percentage of clinical time are the SPECT/CT units used for: (The total percentage, expressed as a number, must add up to 100.)

- diagnostic purposes
- interventional purposes

- other (specify)

Comments:

Are the SPECT/CT units also used for treatment-planning purposes in radiation therapy?

Do you use the CT component of any SPECT/CT unit as a stand-alone CT unit for clinical CT examinations (i.e., to provide extra CT capacity)?

Additional comments:

For each new SPECT/CT unit, (installed after January 2, 2012) please answer the following:

What is the make of the SPECT/CT unit?

If other is selected, please comment

What is the model of the SPECT/CT unit?

What year did the SPECT/CT unit become operational?

Is this a dedicated cardiac SPECT/CT unit?

How many multi-detectors does the SPECT/CT unit have (how many slices)?

If other is selected, please comment

How many detectors heads does the SPEC/CT unit have?

What type of view does the SPECT/CT unit have?

What type of software is used for the SPEC/CT unit?

Does the SPECT/CT unit have dose management controls?

Does the SPECT/CT unit incorporate image reconstruction techniques for dose reduction?

Does the SPECT/CT unit record patient radiation dose by exam (e.g., as a save screen on PACS)?

Is the SPECT/CT unit mobile? Please include the names of the sites that share the SPECT/CT unit (or number if the installation is fixed):

Additional comments:

Page 8

Do you have a SPECT machine(s) in your hospital/facility?

If yes, how many SPECT machines do you have?

Do you have plans to install a new/additional SPECT machine in the next two years?

For all SPECT machines, how many examinations are conducted in a fiscal year?

Have you decommissioned a SPECT since January 2, 2012?

If yes, what year was the SPECT decommissioned?

What year was the decommissioned SPECT originally installed?

What was the make of the decommissioned SPECT?

If you have decommissioned additional SPECT units please add information below (year decommissioned, year uninstalled and make for each).

In an average week (168 hours) how many hours are the SPECT units in use, averaged across all units (please express the total in numbers)?

On a regular workday, how many hours per day are the SPECT units in use (please express the total in numbers)?

Do any SPECT units operate on the weekend?

Based on your practice in the last fiscal year, what percentage of time are the SPECT units used for: (The total percentage, expressed as a number, must add up to 100.)

- diagnostic purposes
- interventional purposes
- other (specify)

Comments:

Based on your practice in the last fiscal year, what percentage of time are the SPECT units used for: (The total percentage, expressed as a number, must add up to 100.)

- non-cardiac clinical purposes
- research purposes
- dedicated cardiac purposes, only
- other (specify)

Comments:

Are the SPECT units also used for treatment-planning purposes in radiation therapy (i.e., SPECT images are transferred for direct use in RT-planning platforms)?

Additional comments:

For each new SPECT unit, (installed after January 2, 2012) please answer the following:

What is the make of this SPECT?

What is the model of the SPECT unit?

What year did the SPECT unit become operational?

How many detectors heads does the SPECT unit have?

What type of view does the SPECT unit have?

What type of software is used for the SPECT unit?

Is this a dedicated cardiac SPECT unit?

Is the SPECT unit mobile? Please include the names of the sites that share the SPECT unit (or number if the installation is fixed):

Additional comments:

Page 9

Any additional comments

Disclaimer page

Agree to Terms

Appendix B: Details of Facilities Responding to the Canadian Medical Imaging Inventory 2015 Update

Table 15: Summary of Type of Facility Included in the CMII 2015 Update

	Number of Sites[a,b]			
Province or Territory	Hospital[c]	Community Hospital[c]	Tertiary Care[c]	Free- Standing[c]
Alberta	31	2	1	3
British Columbia	27	3	3	6
Manitoba	4	9	0	0
New Brunswick	7	0	0	0
Newfoundland and Labrador	9	0	0	2
Nova Scotia	7	3	3	2
Ontario	30	23	4	4
Prince Edward Island	2	0	0	0
Quebec	32	0	3	8
Saskatchewan	9	0	2	2
Yukon	1	0	0	0
All	159	40	16	27

CMII = Canadian Medical Imaging Inventory

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

[b] The 132 sites that did not provide the information in the summary are not included in this table. Of these sites, we identified 16 as free-standing.

[c] Data derived from question: "What type of facility is this?" The four categories are mutually exclusive.

Table 16: Summary of Source of Funding for Sites Included in the CMII 2015 Update

	Number of Units		
Province or Territory	Publicly[a]	Privately[a]	Both[a]
Alberta	35	0	2
British Columbia	33	6	0
Manitoba	13	0	0
New Brunswick	7	0	0
Newfoundland and Labrador	13	0	0
Northwest Territories	1	0	0
Nova Scotia	14	0	0
Ontario	57	3	2
Prince Edward Island	2	0	0
Quebec	35	6	2
Saskatchewan	12	1	1
Yukon	0	0	1
Canada	222	16	8

CMII = Canadian Medical Imaging Inventory.

[a] Data derived from question: "How is this facility funded?" Sites with these data missing are not included.

Table 17: Summary of New Units and Replacement 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	0	1	0	0	0
Canada	108	63	33	19	41

CT= computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photon emission computed tomography.

Appendix C: Summaries of Use Data

Table 18: Summary of Number of Exams Reported for the Most Recent Fiscal Year for All Modalities Across All Provinces or Territories

		Number of Exams				
		CT	MRI	SPECT	PET-CT	SPECT-CT
Alberta	n[a]	32	22	10	2	14
	median	5,279.5	6,644.5	1,808	3,710.5	3,097.5
	min-max	(133-42,476)	(663-21,507)	(320-3,500)	(2,268-5,153)	(550-9,000)
British Columbia	n[a]	26	21	9	2	10
	median	9,692	4,200	3,162	4,014.5	1,211
	min-max	(1,239-66,000)	(462-13,000)	(1,300-7,800)	(254-7,775)	(77-5,830)
Manitoba	n[a]	11	3	4	1	3
	median	9,612	24,144	2,743	1,741	1,646
	min-max	(3,800-41,052)	(9,180-25,440)	(1,439-4,215)		(1,528-4,276)
New Brunswick	n[a]	7	7	1	1	4
	median	13,770	3,510	1,000	729	2,500
	min-max	(10,000-28,504)	(1,604-9,041)			(1,500-4,500)
Newfoundland and Labrador	n[a]	8	3			
	median	6,431.5	4,530			
	min-max	(1,561-13,817)	(4,279-4,550)			
Nova Scotia	n[a]	12	9	4	1	5
	median	8,677	4,782	2,302	2,241	1,688
	min-max	(1576-26236)	(2637-7175)	(992-2,993)		(320-2,993)
Ontario	n[a]	41	25	26	4	23
	median	11,800	10,574	2,050.2	375	2,021
	min-max	(2,850-71,647)	(2,325-23,674)	(200-16,804)	(25-2,500)	(250-13,000)
Prince Edward Island	n[a]	2	1	1		1
	median	6,788	4,567	600		1,519
	min-max	(50,93-8,483)				
Quebec	n[a]	33	28	4	11	4
	median	10,000	4,916.5	7,977.5	1,014	16,963
	min-max	(900-81,943)	(370-23,138)	(91-26,425)	(172-5,696)	(91-26,795)
Saskatchewan	n[a]	11	4	1[b]	1	
	median	5,491	12,500	21,255	1,315	
	min-max	(1,179-35,000)	(1,600-17,061)			
Yukon	n[a]	1	1			
	median	3,500	2,200			
	min-max					

CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photon emission computed tomography.

Notes: Data derived from question: "For all [modality], how many examinations are conducted in a fiscal year?" Empty cell indicates data not available, either because province or territory does not have modality, or no sites reported examination data. Exam totals are as reported; no imputation was performed.

[a] Number of sites contributing responses.

[b] Exam data for 3 SPECT-CT (SPECT with CT attenuation correction) units at 1 site were reported under SPECT.

Table 19: Summary of Average Hours per Week of Use for All Modalities Across Canada

		Average Hours per Week				
		CT	MRI	SPECT	PET-CT	SPECT-CT
Alberta	n[a]	31	23	10	2	15
	median	47.5	65	40	50	42
	min-max	(2.5-168)	(10-128)	(25-50)	(40-60)	(30-96)
British Columbia	n[a]	30	21	9	2	12
	median	85.9	52	50	35	40
	min-max	(30-168)	(24-119)	(28-85)	(10-60)	(39-50)
Manitoba	n[a]	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[a]	7	7	1	1	4
	median	60	50	40	18	42.5
	min-max	(52.5-141)	(28.5-108)			(40-47.5)
Newfoundland and Labrador	n[a]	10	3	2		2
	median	42.5	70	35		35
	min-max	(24-72)	(70-70)	(35-35)		(35-35)
Nova Scotia	n[a]	13	10	4	1	8
	median	60	57.5	45	32	41.2
	min-max	(37.5-168)	(37.5-80)	(40-80)		(37.5-47.5)
Ontario	n[a]	45	27	30	2	27
	median	70	112	40	22.5	40
	min-max	(30-168)	(37.5-168)	(10-75)	(5-40)	(15-88)
Prince Edward Island	n[a]	2	1	1		1
	median	45.2	42.5	35		45
	min-max	(40-50.5)				
Quebec	na	34	28	4	11	4
	median	64.2	70.4	42.5	42	45
	min-max	(12-168)	(30-168)	(40-45)	(5-70)	(40-55)
Saskatchewan	n[a]	13	5	1	1	1
	median	53	100	40	30	60
	min-max	(40-168)	(68-168)			
Yukon	n[a]	1	1			
	median	40	40			
	min-max					

CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photon emission computed tomography.

Notes: Data derived from question: "In an average week (168 hours), how many hours are the [modality] units in use, averaged across all units?" Empty cell indicates data not available, either because province or territory does not have modality, or no sites reported examination data.

[a] Number of sites contributing responses.

Table 20: Average Hours per Day of Use for All Modalities Across Canada

		Average Hours per Day				
		CT	MRI	SPECT	PET-CT	SPECT-CT
Alberta	n[a]	24	22	9	2	14
	median	9	11.6	8	10	8
	min-max	(0.5-24)	(2-16)	(5-10)	(8-12)	(6-16)
British Columbia	n[a]	28	21	9	2	12
	median	13	9	10	10.8	8
	min-max	(6-24)	(7.5-17)	(5-17)	(8-13.5)	(7-10)
Manitoba	na	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	na	7	7	1	1	4
	median	9	10	8	6	8.5
	min-max	(8-12.75)	(7.5-17)			(8-9.5)
Newfoundland and Labrador	n[a]	9	3	2		2
	median	7	14	7		7
	min-max	(5-14)	(14-14)	(7-7)		(7-7)
Nova Scotia	n[a]	13	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[a]	45	27	30	3	27
	median	11.5	16	8	5	8
	min-max	(5-24)	(7.5-24)	(6.5-22.5)	(1-8)	(3-16)
Prince Edward Island	na	2	1	1		1
	median	8.2	8.5	7		9
	min-max	(8-8.5)				
Quebec	n[a]	32	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[a]	11	4	1	1	
	median	8.5	15	8	6	
	min-max	(8-24)	(12-16.5)			
Yukon	n[a]	1	1			
	median	8	9			
	min-max					

CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photon emission computed tomography.

Notes: Data derived from question: "In an average day, how many hours are the [modality] units in use, averaged across all units?" Empty cell indicates data not available, either because province or territory does not have modality, or no sites reported examination data

[a] Number of sites contributing responses.