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ENVIRONMENTAL SCAN

Diagnostic Imaging of Ischemic Stroke in the Emergency Department Setting: Implementation Considerations

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Authors: Michael Raj, Charlotte Wells, Melissa Severn

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Context

Stroke is the third leading cause of death and the main cause of adult disability in Canada.[1] The average patient irretrievably loses 1.9 million brain cells each minute that stroke is untreated.[1] To halt the *progression* of irreversible brain tissue damage, swift treatment is required. The goal of neuroimaging is to improve the outcome of stroke by quickly making the correct diagnosis and enabling immediate treatment. Since patients cannot be treated until they are imaged, the rapid acquisition and interpretation of imaging studies is critical for improved outcomes.[2]

There are four main types of stroke: ischemic, hemorrhagic, covert, and transient ischemic attack.[3] The most common is ischemic,[3] accounting for approximately 80% of acute strokes.[4] To appropriately manage acute stroke, the purpose of the first imaging procedure performed in patients with suspected stroke is to distinguish between hemorrhagic and ischemic stroke.[4] Imaging can also contribute to efficiencies in stroke systems of care by assisting physicians in making decisions regarding the transfer of patients with acute ischemic stroke from primary stroke centres to centres capable of performing endovascular procedures.[5]

Non-contrast computed tomography (CT) is the most widely used first-line imaging modality for the diagnosis of suspected acute stroke.[6] The test rules out hemorrhage and other conditions that mimic stroke.[7] However, there are many other imaging modalities that can be used to investigate acute stroke.

Other factors that determine optimal use of imaging modalities include availability of skilled technicians and specialist physicians, access, physician preferences, and costs.[8] Geographical dispersion is also a barrier to the successful outcome of timely diagnoses of ischemic stroke.[9,10] There is uncertainty as to which implementation strategies for optimal imaging have been used in the Canadian emergency care setting, and which have been the most successful

Objectives

The objective of this Environmental Scan is to identify and summarize information regarding the implementation considerations for diagnostic imaging of acute ischemic stroke in the Canadian emergency care setting. The following questions are addressed:

1. What are the current diagnostic imaging modalities used for ischemic stroke diagnosis in the emergency setting in Canadian jurisdictions?

2. What types of ischemic stroke imaging modalities are accessible in Canadian jurisdictions across urban, rural, and remote health care settings?

3. What are the main challenges and enablers of diagnosing ischemic stroke in the emergency setting in Canadian jurisdictions?

Methods

Approach

To understand implementation issues associated with diagnosing ischemic stroke in Canadian emergency care settings, a dual-stage, sequential research protocol was followed. The two stages were consultation with targeted key stakeholders (informants) and a review of the published and grey literature. Findings from the literature search were used to supplement the information retrieved during the consultations.

Data Collection

Stage 1: Consultations

Consultations were conducted with targeted key informants identified through the clinician networks managed by the CADTH Implementation Support and Knowledge Mobilization team or referred through other informants during consultations. These key informants were consulted in order to provide a general overview of policy, practice and implementation issues related to imaging modalities in diagnosing ischemic stroke in Canadian emergency care settings as well as to identify relevant literature. To guide the consultations, a semi-structured interview guide was developed (Appendix 2). Interview questions were developed based on research questions and were related to the general approach to diagnosing ischemic stroke in the emergency department, challenges and supports to diagnosing of ischemic stroke, implementing strategies, gaps in the literature.

Consultations took place between August and November 2017 and consent to publish comments and names were obtained from key informants.

Stakeholder feedback was solicited by posting a draft version of the report on CADTH's website and by emails to subscribers of CADTH's mailing lists. Key informants involved in the consultations were also asked to provide feedback.

Stage 2: Literature Search

Search Methods

The literature search was performed by an information specialist, using a peer-reviewed search strategy.

Implementation-related information was identified by searching the following bibliographic databases: MEDLINE (1946–) with In-Process records and daily updates; Embase (1974–) through Ovid; CINAHL (1981–) through EBSCO; and PubMed. The search strategy is comprised of both controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. The main search concepts were stroke, diagnostic imaging, Canada, and key terms for implementation issues. No methodological filters were applied to limit retrieval by study design. Retrieval was limited to documents published since January 1, 2007. Results were limited to English- and French-language publications.

Grey literature (literature that is not commercially published) was identified by searching the Grey Matters checklist (https://www.cadth.ca/grey-matters), which includes the websites of health technology assessment agencies, clinical guideline repositories, systematic review repositories, economics-related resources, public perspective groups, and professional associations. Google and other Internet search engines were used to search for additional Web-based materials.

Selection Criteria

English- or French-language reports that described implementation and context issues, including barriers (or challenges) and facilitators (or enablers) associated with diagnosis and imaging of ischemic stroke in the emergency department (ED) were eligible for inclusion.

Screening and Selecting Articles for Inclusion and Data Extraction

Citations arising from the literature searches were screened independently by one reviewer for information related to implementation issues in Canada. From each potentially relevant article, one reviewer extracted the bibliographic details (i.e., the authors, the year of publication, and the country of origin), and data, which was organized under the INTEGRATE-HTA framework.[11] The information from the identified literature supplemented the information provided by the consultations, and attempted to address potential information gaps.

Descriptive analysis and synthesis

Responses from consultations were used to address Questions 1 and 3. Data from CADTH's Canadian Medical Imaging Inventory report (2017)[12] were used to address Question 2 (Appendix 3). All research questions were supplemented with information obtained through the literature search. Additionally, stakeholder feedback will be used to supplement information received from the consultations and literature search.

Information from consultations and findings from the literature were sorted into categories based on the domains identified by the Context and Implementation of Complex Interventions (CICI) framework from INTEGRATE-HTA.[11] This assisted in identifying themes related to the strategies used to improve timely access to the diagnosis of ischemic stroke in the Canadian emergency setting.

The framework helps to examine the influence of context and implementation issues as modifiers in an HTA, and factors enabling or limiting intervention uptake.

The concept of context within the framework is considered to be a set of characteristics or circumstances that interact, influence, modify, facilitate, or constrain the intervention and its implementation. Implementation, for the purposes of the framework, is considered to be an actively planned and deliberately initiated effort with the intention of bringing a given object into policy and/or practice.[11]

Using this framework, the domains of context, *socio-economic, socio-cultural, setting, political, legal, geographical, ethical*, and *epidemiological*, were used to guide the categorization of information on challenges and enablers of diagnosing ischemic stroke in the emergency setting in Canadian jurisdictions. The four domains of implementation, *provider, organization and structure, policy,* and *funding*, as well as the additional domain of *patient* were used to further guide the categorization of identified strategies, barriers, or supports as they relate to the implementation of diagnostic strategies across the various levels of health care service delivery.

Findings

Consultations

Nine key stakeholders were interviewed for the purposes of this Environmental Scan (Appendix 1: Stakeholder Consultations). This included three physicians (two ED physicians and one stroke neurologist); four health system administrators including provincial Ministry of Health representatives tasked with management or coordination of stroke services for their jurisdiction; one paramedic with considerable involvement with stroke services in his province; and one researcher representing a national special interest group in the stroke community. After stakeholder feedback, three additional consultations were conducted, bringing the total number of consultations to 12.

Efforts were made to contact stakeholders in other Canadian jurisdictions. Through these consultations, there was representation for the following provinces: British Columbia (BC), Alberta, Saskatchewan, Ontario, Nova Scotia (NS), and Prince Edward Island (PEI). While all stakeholders represented were based in urban environments, all were knowledgeable in issues relating to the rural and remote setting as related to stroke care and/or they served populations in these settings as well.

Literature Search

The literature search yielded 410 citations, of which 18 studies were determined to be eligible to address the research question. Twelve articles were published in Canada,[8-10,13-21] three in the US,[22-24] one in Switzerland,[25] and one was an international collaboration from both the US and Canada.[26] Additionally, a CADTH Rapid Response report was published, which was not specific to the Canadian context.[27] Three articles focused on imaging or best practice recommendations,[10,20,24] three articles focused on telestroke,[13,18,20] three articles focused on access to stroke care,[8,9,26] and one article focused on stroke education in emergency medical residency programs.[21] The remaining articles pertained to quality of stroke care, experiences with portable CT scanners, stroke protocols, field recognition and accuracy of stroke diagnoses, and other related neuroimaging articles.[14-17,22,23,25,27]

Findings below are presented by research question.

What are the current diagnostic imaging modalities used for ischemic stroke diagnosis in the emergency setting in Canadian jurisdictions?

Non-contrast computed tomography (NCCT) is considered by many to be useful in its ability to address imaging requirements for stroke assessment.[6] Other imaging modalities are also used, including CT angiography (CTA), multiphase CTA, CT perfusion (CTP), multimodal MRI, MR perfusion (MRP), MR angiography (MRA), and ultrasound. MRI may also be used, although less frequently and contingent on availability, suitability and time.[25] Some imaging modalities are prerequisites to selection of patients for certain treatments, such as vascular imaging for endovascular treatment (EVT).[24] The Canadian Stroke Best Practice Recommendations recommend that all patients presenting to the ED within treatment time window receive CT scanning and vascular imaging with CTA (with or without CTP).[10]

CT is the imaging modality available in most hospitals on a round-the-clock basis and is usually the first-line modality in hospitals.[6,25] While CT is more widely available, MRI can provide additional information compared with CT, and is more sensitive to small infarctions. [25] However,

MRI may not be suitable for all patients as some patients are contraindicated for MRI scanning (e.g., are claustrophobic, have pacemakers, or have metal in the body); thus, CT scanning is recommended for these patients.[27]

The choice of CT or MRI imaging is based on available infrastructure and staff, logistics, and expertise of the stroke team.[25] It also may depend on physician preferences, and logistical factors could include whether advanced imaging, especially MRI, can be performed quickly on a 24/7 basis.[24] Other factors that may impact the choice of modality are described below. However, CT is the most widely used imaging modality[6] and is thus the preferred choice compared with MRI, due to the logistical issues associated with the latter (e.g., availability in the acute setting [from zero to six hours from onset of stroke to imaging], feasibility and availability for individuals with metallic implants or with monitors or ventilators, cost, and motion artifact compromising image quality).[24]

Access to imaging modalities can enable timely stroke diagnosis. The consultations conducted with informants working in either urban, rural, or remote settings or with knowledge of the imaging capabilities across jurisdictions, indicated that CT is the primary diagnostic imaging strategy used to diagnose ischemic stroke across all consulted Canadian jurisdictions. Dr. Ken Butcher, from the University of Alberta, stated that in his urban facility, all patients undergo urgent CT, irrespective of time from onset, and that in the past eight years, CTA has become standard of care. He also added that after the publication of the DAWN (2018)[28] and DEFUSE-3 (2018)[29] clinical trials, CTP is more routinely used in his centre to select patients for EVT (Dr. Ken Butcher, Canada Research Chair in Cerebrovascular Disease, Heart and Stroke Foundation Professor of Stroke Medicine, Division of Neurology, University of Alberta, AB: personal communication, 2018 May 22). Although most of these modalities are available in urban, acute care centres, rural facilities tend to have on-site access to CT and ultrasound and some may also have CTA capabilities. Dr. Dar Dowlatshahi identified a remote centre located in Iqaluit with access to both CT and CTA, in which the images are read remotely (Dr. Dar Dowlatshahi, Associate Professor, University of Ottawa, Department of Medicine Clinician-Scientist Chair, Scientist, Ottawa Hospital Research Institute, Scientific Director, Ottawa Stroke Program Stroke, Neurologist, Ottawa Hospital, personal communication: 2018 May 11).

Lack of access to imaging modalities can be a barrier to timely stroke diagnosis. The consultations also highlighted that remote health care facilities generally do not have these services available and will send patients to the nearest, most appropriate site that can offer access to these modalities. Further information regarding the accessibility and availability of imaging modalities across Canada and in various Canadian jurisdictions is outlined in the question that follows next.

What types of ischemic stroke imaging modalities are accessible in Canadian jurisdictions across urban, rural, and remote health care settings?

CT imaging is the most common and widely used imaging modality for stroke in Canada.[6] MRI is also used in the diagnosis of stroke; however, less frequently than CT scanning.[6] Single-photon emission computed tomography and positron emission tomography (PET) scanners are also used in neurology to visualize brain physiology.[30] PET is considered gold standard for measuring brain physiology, but is not generally used in the acute stroke setting as it is not considered practical, due to the long interval between probe injection and imaging, the relatively smaller number of PET scanners available 24/7, and difficulties for the stroke patient to remain still during imaging.[31,32]

To determine what stroke imaging modalities are accessible in Canadian jurisdictions in a variety of health care settings, data from the 2017 Canadian Medical Imaging Inventory were used.[12] The CADTH CMII report provides an update on the availability and use of specialist imaging equipment across the country. Data are provided from a Web-based survey of private or public health care settings that operate medical imaging equipment, supplemented by provincial data validators. The most recent survey was completed in 2017.

As of 2017, data from the CMII survey indicated that there are 561 CT scanners and 366 MRI scanners in Canada.[12]

The majority of CT scanners are located in Ontario (32.7%) and Quebec (29.1%), with the least number of CT scanners available in Nunavut, Northwest Territories (NT), and Yukon. Each province has access to at least one CT scanner. Per one million people, Ontario has 13.0 CT scanners, and Nunavut, NT and Yukon have 26.5, 22.7, and 26.4 respectively. The highest number of CT scanners per million residents is in Newfoundland and Labrador, at 30.3.[12]

The majority of MRI scanners are also located in Ontario (33.1%), and there are 8.5 MRI scanners per million people in Ontario. However, there are no MRI scanners in NT or Nunavut. Per one million residents, Yukon has the highest number of MRIs, at 26.5.[12]

Rural, Remote, and Urban Health Care Settings

The 2017 CMII survey also collected information on the setting in which the health care facility is located — this was self-reported as "urban," "rural," or "remote."[12]The 39.9% of sites represented in this part of the survey amounted to 46.5% of imaging units available in Canada.[12]

Urban settings contained the majority of stroke imaging modalities, ranging from 75.4% of CT scanners to 85.5% of MRI scanners. Rural settings contained 23.1% of CT scanners and 14.5% of MRI scanners. [12] There are four CT scanners available in remote regions in Canada. [12] Table 3 provides additional details regarding urban, rural, and remote settings and the imaging modalities available. [12]

What are the main challenges and enablers of diagnosing ischemic stroke in the emergency setting in Canadian jurisdictions?

Geography and Setting

The INTEGRATE-HTA domain of *geography* refers to the broader physical environment, landscapes, and resources available at a given location. Issues of geography can refer to infrastructure (e.g., transportation), access to health care, and geographical isolation.[11] The *setting* domain according to INTEGRATE-HTA encompasses the immediate physical and organizational environment in which an intervention is delivered. Issues of setting can refer to region, country (e.g., urban and rural), or type of facility.[11]

Several articles reviewed pointed to the challenge in accessing care as posed by Canada's vast geography, varying size of regions and provinces, and the larger proportion of rural and remote communities.[10,12-14,33] These issues, coupled with Canada's challenging landscapes and climate, can limit the speed of access to hospital in time for treatment, even with fast door-to-treatment times.[9,14] One of the biggest factors in delays of prompt neuroimaging is the arrival to the hospital from a setting other than home, and the presentation to rural hospitals versus urban hospitals (even if neuroimaging is available at rural locations).[17] The distance between the patient and the hospital contributes to non-timely diagnosis.[9] In rural areas, the distance makes accessing emergency medical services (EMS) difficult for urgent conditions, including stroke.[9]

In widely dispersed regions with long distances between a more comprehensive stroke centre and a regional (rural) stroke centre with fewer capabilities, diversion of patients to comprehensive centres has the potential to substantially improve outcomes.[15] Dr. Eddy Lang indicated that in more remote locations of Alberta, patients who meet certain key symptoms of stroke, such as speech disorder, extremity weakness, or lack of consciousness, are usually flown out of the community by air ambulance (Dr. Eddy Lang, Alberta Health Services, Calgary, AB: personal communication, 2017 Aug 8). Lori Latta, a project manager supporting stroke initiatives for the Saskatchewan Ministry of Health, indicated that in Saskatchewan the use of air ambulances to transport patients from remote (northern) areas is fairly common given its geography, although the volume of stroke patients from those regions is typically low (Lori Latta, Project Manager, Clinical Pathways Ministry of Health, Saskatchewan: personal communication, 2017 Nov 17).

A Canadian study found access to specialized services varied greatly across Canada. In general, rural communities in Canada tend to have limited access to advanced neuroimaging or stroke specialists, and small hospitals may have minimal or no access to diagnostic services.[9,16]The vastness of regions in larger provinces with a large proportion of rural areas also contributes to untimely diagnosis. [12] Additionally, even with access to imaging at rural hospitals, individuals presenting with symptoms to rural hospitals were less likely to receive timely neuroimaging when compared with urban hospitals.[17] One possible explanation for this, according to Dr. Patrice Lindsay is that regional centres in Canadian rural settings tend to experience longer wait times because the ED is also the trauma centre and cardiac centre, and there is no local option of a specialized stroke centre (Dr. Patrice Lindsay, Director, Stroke, Heart & Stroke (National), Ottawa, Ontario: personal communication, 2017 Sep 12).

Access to Diagnostic Services and Imaging

According to Dr. Devin Harris there is a gap in access to CT in rural and remote areas in BC (Dr. Devin R. Harris, Medical Advisor, Stroke Services BC: personal communication, 2017 Aug 22). Furthermore, current clinical practice guidelines state that CT tests must be performed when ischemic stroke is suspected, though this technology is not always available in rural or remote EDs.[27] Because of this, Dr. Devin Harris added, patients in BC being transported by EMS often need to bypass their local centre to get to one that has the technology (Dr. Devin R. Harris: personal communication, 2017 Aug 22). Dr. Eddy Lang furthered this by noting that, while some rural facilities in Alberta may have a CT scanner, stroke patients may still require a transfer to a regional centre where CTA is available (Dr. Eddy Lang: personal communication, 2017 Aug 8). On the contrary, Dr. Ken Butcher explained that CT scanners are widely available in Alberta, and all CT scanners can perform CTA (with the exception of one in Wainwright), where a portable CereTom is utilized. This scanner can also perform an intracranial (not extracranial) CTA, but this requires an intravenous injector that has not been purchased at the site) (Dr. Ken Butcher: personal communication, 2018 May 22). CTA is available in most high volume EDs.[34] Dr. Ken Butcher added that although CT is frequently available, MRI is restricted to mostly urban settings, and this creates a geographical gap in availability of diagnostic imaging services (Dr. Ken Butcher: personal communication, 2018 May 22).

Generally, people living in rural and remote locations also have challenges accessing EMS for urgent conditions including stroke.[9] The time taken to transport patients is higher, and distance highly influences whether a patient is taken to a stroke centre or not.[14] According to Carolyn MacPhail, smaller provinces such as PEI may face similar issues as rural communities in that they lack access to certain technologies, procedures, and specialists that other provinces might have, even in the urban setting (Carolyn MacPhail, Chronic Disease Prevention and Management Manager, Health PEI, Prince Edward Island: personal communication, 2017 Sep 27). Conversely,

Dr. Michael Hill believes that access to diagnostic imaging in the form of CT scanners is an enabler for best practice in Canada, as he believes that more than 90% of the population has access to these devices within a 60 minute drive (Dr. Michael Hill: personal communication, 2018 May 11) In Ontario, Dr. Dar Dowlatshahi stated that in urban settings, most centres have access to CT and CTA scanning and use a combination of the two to allow for timely thrombolysis and EVT (Dr. Dar Dowlatshahi: personal communication, 2018 May 11)

Access to Stroke Specialists

In urban centres, stroke specialists are often available in hospitals; however, they are usually not immediately available in rural centres.[18] Dr. Dar Dowlatshahi stated that centres that do not have access to stroke specialists face many challenges to timely diagnosis (Dr. Dar Dowlatshahi: personal communication, 2018 May 11). The specialized expertise required to provide advanced stroke care is generally limited to larger communities and urban areas, and patients living outside these boundaries in the past did not have access to this care.[9] Moreover, Dr. Stephen Phillips stated the low population density in Nova Scotia's rural settings means hospitals do not manage many stroke patients, and clinicians are therefore less familiar with recognizing stroke symptoms and signs (Dr. Stephen Phillips, Professor of Medicine (Neurology), Dalhousie University, Nova Scotia; Stroke Neurologist, Halifax Infirmary, Nova Scotia: personal communication, 2017 Sep 27). According to Dr. Devin Harris, rural paramedics in BC may not have as much stroke experience as their urban counterparts, travel times take longer and management within the ED is dependent on local expertise and imaging capabilities (Dr. Devin R. Harris: personal communication, 2017 Aug 22).

Dr. Stephen Phillips in NS noted that while there have been improvements in remote settings, facilities in urban settings generally have in-house radiologists and 24/7 access to CT scanning and technicians (Dr. Stephen Phillips: personal communication, 2017 Sep 27). Dr. Devin Harris added that urban facilities in BC will also offer neurology services and stroke teams including stroke neurologists and nurses (Dr. Devin R. Harris: personal communication, 2017 Aug 22). Conversely, rural areas may not have a CT scanner staffed at all times and technologists therefore need to be called in during off-hours, which may cause further delays in getting a patient scanned. This situation becomes especially problematic in smaller communities where the expense of a standard CT scanner with the requirement of specialized technicians may not be feasible.[19] Moreover, Dr. Stephen Phillips and Lori Latta both noted that in hospitals serving large rural areas, pressure on limited radiology resources means that radiologists may not be available to read a CT image in a timely manner (Dr. Stephen Phillips: personal communication, 2017 Sep 27, Lori Latta: personal communication, 2017 Nov 17). Pam Ramsay indicated that in BC, this challenge has been mitigated through the creation of Tiers of Service for Stroke. These tiers of service support decisions regarding bypassing of rural and remote patients to a higher level of care (Pam Ramsay, Provincial Director, Stroke Services BC, Provincial Health Services Authority, British Columbia: personal communication, 2017 Aug 30). Dr. Dar Dowlatshahi added that the challenge of limited access to specialists can also be mitigated with the use of telestroke, as detailed below (Dr. Dar Dowlatshahi: personal communication, 2018 May 11).

While access to CT imaging can be a significant barrier for some areas, one study demonstrated that a portable CT scanner can be used successfully in the evaluation of patients in remote regions who do not have timely access to stroke experts or do not have conventional imaging with CT scans available.[19] Another strategy identified in the literature is the use of mobile stroke units, which are ambulances equipped with point-of-care blood tests and CT imaging, and they are staffed with specially trained nurses, paramedics, and physicians.[20] The results from several studies in a meta-analysis demonstrated that the time from symptom onset to treatment with

intravenous thrombolytic drugs is significantly shorter for patients arriving at hospital by mobile stroke unit compared with patients arriving by ambulance.[20] Unfortunately, these mobile stroke units are only currently practical in urban settings.[20]

Telestroke

Telestroke is the use of telecommunication technologies, such as video conferencing and mobile apps to deliver stroke care to patients without direct access to specialized services.[20] Most telestroke systems operate on a "spoke-and-hub" model — in which there is one hub (a primary care centre), and multiple "spokes" (tertiary care centres) that are connected to the primary care centre. The use of telestroke systems enables improved communication and networking to increase access to stroke expertise, regardless of the physical location of the patient, which can be of benefit to individuals living in more rural or remote areas.[20] Dr. Ken Butcher explained that in Alberta, there are established primary stroke centres (all rural hospitals with CT scanning capabilities) that are supported by the telestroke system. A central line connects primary stroke centres with an urban stroke specialist for phone and video consultation, and treatment is administered at the primary stroke centre (Dr. Ken Butcher: personal communication, 2018 May 22). Dr. Dar Dowlatshahi also added that Ontario in particular has a highly successful telestroke network with 30 primary stroke centres capable of performing CT and CTA, and on-call stroke physicians for the province who can review imaging results and order transfers to comprehensive stroke centres (Dr. Dar Dowlatshahi: personal communication, 2018 May 11). He additionally mentioned the expansion of telestroke networks in the Maritime Provinces (Dr. Dar Dowlatshahi: personal communication, 2018 May 11).

Improvements in the speed, capacity, quality, and availability of telestroke technology have enabled the delivery of cross-continuum services and has aided in bridging the gaps in access in many communities.[20,35] The expansion of this technology has also increased its efficiency, with process times improving due to better communications, engagement, and experience.[35] Greater efficiencies in telestroke have also been attributed to the development of mobile stroke units, as mentioned above, and better communication, engagement and experience.[20]

One challenge is that telestroke delivery of care still requires the treating centre to complete a CT scan immediately, which is not always feasible due to several issues including the availability of skilled technicians.[19] A further challenge to the use of this technology identified by Pam Ramsay was that when a rural or remote community hospital is consulting with a comprehensive stroke centre to determine if a patient is eligible for transfer for endovascular treatment, there may be delays in transmission/availability of CT imaging (multiphase CTA). This imposes undue delay (Pam Ramsay: personal communication, 2017 Aug 30).

Political

The *political* domain focuses on the distribution of power, assets and interests within a population, as well as the range of organizations involved, their interests and the formal and informal rules that govern interactions between them.[11]

Dr. Stephen Phillips noted that one of the defining characteristics of stroke care is that it cuts across many areas of the health care system including EMS, radiology, neuroradiology, neurology nursing, and the ED, as well as internal medicine, neurology, and neurosurgery (Dr. Stephen Phillips: personal communication, 2017 Sep 27). This can make it challenging to determine who is ultimately responsible and who the decision-maker is, not only for patient care but also for the system organization (Dr. Stephen Phillips: personal communication, 2017 Sep 27).

Ethical

The *ethical* domain refers to the concepts of morality, which encompasses beliefs, standards of conduct, and principles that guide the behaviour of individuals and institutions.[11]

With regard to emergency response, there is an ethical dilemma sometimes posed for rural and remote communities. More specifically, when one in-service ambulance is occupied transporting a patient to a comprehensive stroke centre, if there are only a small number of ambulances in a region, this could compromise care for other citizens in that jurisdiction.[15] Pam Ramsay echoed this notion stating that in BC as part of the Tiers of Service model and stroke bypass protocols, the decision may be to bypass a community facility with limited stroke expertise or imaging capability to go to a higher level of care facility. In smaller communities, this may result in an ambulance leaving a community that may only have a limited number of ambulances services in the community (Pam Ramsay: personal communication, 2017 Aug 30). This is compounded in the winter season with variable road conditions. Given this, it is critical that there be partnership with emergency health services in planning for stroke transport (Pam Ramsay: personal communication, 2017 Aug 30).

Domains of Implementation

Provider

This implementation domain focuses on the characteristics of the individuals adopting and delivering the intervention. This domain includes the personal attributes, knowledge, skills, emotions, motivations, intentions, and goals of health care providers.[11] The literature review and consultations pointed toward a few key areas when considering the role of providers with respect to implementation: training and education, guidelines and buy-in, and physician collaboration.

Training and Education

The largest barrier to stroke training for Canadian physicians, according to Dr. Devin Harris, is the limited time within emergency medicine residency programs devoted to stroke (Dr. Devin R. Harris: personal communication, 2017 Aug 22). In one Canadian survey, 1% of lecture time was devoted to the topics of stroke and transient ischemic attack within the emergency medicine residency programs, despite neurologic emergencies being 5% of all presenting complaints to ERs.[21] The majority of teaching around stroke and transient ischemic attack is primarily academic, in the form of limited lectures and oral examinations.[21]

Dr. Stephen Phillips pointed to the fact that internists are generally responsible for conducting stroke assessments in regions and facilities in NS without neurologists, yet internal medicine residents get relatively little training in neurology (Dr. Stephen Phillips: personal communication, 2017 Sep 27). Dr. Devin Harris remarked that remote outposts in BC may be particularly challenged because they have limited stroke expertise and diagnostic capability. In addition, pre-hospital care is often provided through caregivers (Dr. Devin R. Harris: personal communication, 2017 Aug 22). Dr. Michael Hill echoed this sentiment, stating that there is a general lack of expertise in neurology and gaps in knowledge pertaining to image interpretation (Dr. Michael Hill: personal communication, 2018 May 11).

One way to mitigate this, according to Dr. Patrice Lindsay, is through in-hospital training, regional stroke training, and best practice webinars so that stroke education can be provided not only to physicians but also nurses, rehabilitation experts, technologists, and other staff who are part of the stroke continuum (Dr. Patrice Lindsay: personal communication, 2017 Sep 12). Dr. Patrice

Lindsay added that this emphasizes the imperative need to develop strong regional stroke systems of care including the use of technology such as telestroke to support assessment, diagnosis, and management decision-making in rural regions (Dr. Patrice Lindsay: personal communication, 2017 Sep 12). Dr. Dar Dowlatshahi cited education for physicians in recently published evidence regarding stroke imaging, diagnosis, and treatment, as well as remote management using telestroke, as important in improving and implementing stroke care within the country (Dr. Dar Dowlatshahi: personal communication, 2018 May 11).

Guidelines and Buy-In

Clinical practice guidelines can pose a particular challenge to optimizing diagnostic strategies. One Saskatoon hospital participated in the Endovascular Treatment for Small Core and Anterior Circulation Proximal Occlusion with Emphasis on Minimizing CT to Recanalization Times (ESCAPE) trial[36] (a trial regarding endovascular thrombectomy and thrombolysis treatment), and required improvements to comply with timelines for the trial and with the Canadian Best Practice Guidelines for stroke care.[37] By following this ESCAPE protocol, Canadian stroke guidelines, and adapting the Calgary Hurry Acute Stroke Treatment and Evaluation (HASTE) program (which includes factors such as increasing ambulance bypass windows to 12 hours, using the FAST (Face, Arms, Speech, Time) stroke assessment, and EMS pre-notification) [38] door-to-CT times were improved to 21 minutes to 40 minutes between 2012 and 2014.[39] Dr. Patrice Lindsay added that some specialists may not always follow guidelines completely due to the emergent nature of the situation, available resources and local protocols or restrictions, such as not making CTA the routine first-line imaging modality (and performing NCCT only) (Dr. Patrice Lindsay: personal communication, 2017 Sep 12). Dr. Michael Hill agreed that one of the major problems with stroke imaging is that many physicians simply do not image potential stroke patients in the ED and disagreed that it is the lack of imaging modalities or resourcing (Dr. Michael Hill: personal communication, 2018 May 11). In contrast, Dr. Dar Dowlatshahi indicated that there is recent scientific literature demonstrating the efficacy of EVT as a treatment for acute stroke, which has also been a driver in the increasing uptake of CT and CTA imaging. He also indicated that in Ontario, it is rare to be refused a CTA in a rural referral centre in the context of telestroke, as it is necessary for EVT (Dr. Dar Dowlatshahi: personal communication, 2018 May 11).

Buy-in was cited by many of the informants as a common barrier with respect to providers. Dr. Patrice Lindsay and Dr. Stephen Phillips were of the opinion that, regardless of practice guidelines or department policy, some physicians are more committed to and engaged in stroke care than others. (Dr. Patrice Lindsay: personal communication, 2017 Sep 12, Dr. Stephen Phillips: personal communication, 2017 Sep 27). Carolyn MacPhail pointed to the importance of family physicians and nurse practitioners also needing to buy-into the value of having a stroke unit, although the majority of persons with stroke spend at least part of their stay on the provincial stroke unit and some family physicians in PEI do not yet utilize established protocols (Carolyn MacPhail: personal communication, 2017 Sep 27).

Dr. Stephen Phillips added that there are still physicians in Canada who are not supportive of tPA (tissue plasminogen activator, a treatment for stroke), which slows down buy-in for stroke care improvements (Dr. Stephen Phillips: personal communication, 2017 Sep 27). This is in spite of recommendations from the Canadian Association of Emergency Physicians that support the use of thrombolytic treatment with recombinant tPA within three hours of symptom onset.[40] In NS, efforts to enhance stroke care are continuing more than a decade after the provincial government committed dedicated funding to it. An enabler identified by both Dr. Devin Harris and Lori Latta was the use of physician champions to implement protocols and promote guideline uptake in both BC and Saskatchewan (Dr. Devin R. Harris: personal communication, 2017 Aug 22, Lori Latta: personal communication, 2017 Nov 17). For Carolyn MacPhail this included

bringing together physician groups including ED physicians and radiology peers about the use of protocols and benefits of CTA, for example (Carolyn MacPhail: personal communication, 2017 Sep 27). Dr. Devin Phillips added that in each health district in NS, they appointed and provided some salary support for a lead stroke physician — family physician or internist — who took responsibility for helping build the local stroke program, and this turned out to be a key component of their implementation success (Dr. Stephen Phillips: personal communication, 2017 Sep 27).

Physician Collaboration

There was general agreement among those interviewed that collaboration between physicians across radiology, neurology, and EDs was key to a successful stroke program. Both Dr. Eddy Lang and Dr. Patrice Lindsay highlighted the importance of these specialties coming together to find a common approach and working toward better integration in order to provide the best care possible (Dr. Eddy Lang: personal communication, 2017 Aug 8, Dr. Patrice Lindsay: personal communication, 2017 Sep 12). There was agreement between Jeremy Measham in PEI and Dr. Eddy Lang in Alberta that there is room for improvement in communication between ED physicians, neurologists, and radiologists and understanding who is ultimately the decision-maker for the stroke patient presenting to the ED (Jeremy Measham, Special Projects Coordinator, Island EMS, Prince Edward Island: personal communication, 2017 Sep 26; Dr. Eddy Lang: personal communication, 2017 Aug 8).

Patient

The additional patient domain was also considered, which combines socio-cultural, socio-economic, and epidemiological components of the context domains of the INTEGRATE-HTA framework.

Stroke often renders patients incapable of seeking help themselves, leaving bystanders or family members responsible for contacting emergency services.[17] Approximately two-thirds of patients seeking acute care for stroke in Canada arrive at a hospital by an ambulance transport.[10] Paramedic transfer is considered safer and allows for the paramedics to triage the patient to an appropriate hospital for care.[10] The greatest proportion of patients who received timely neuroimaging were those who presented to the ED within 30 to 60 minutes after symptom onset.[17] Timely door-to-imaging times are important as it allows for swift treatment and improved outcomes.[2]

Stroke does not uniformly engender a sense of urgency because it does not usually cause pain and many people do not know how to recognize stroke in another person and to seek help.[14] As such, people need to be aware of the signs of stroke and contact EMS without delay to maximize eligibility for these time-sensitive treatments.[9] Dr. Devin Harris emphasized the need for patient and family awareness as to the signs and symptoms of stroke which can be difficult to recognize, leading to people arriving too late to the ED. Stroke may present with significant neurological deficits and, at other times, with headaches or vision problems, so awareness is key (Dr. Devin R. Harris: personal communication, 2017 Aug 22). Dr. Ken Butcher echoed this sentiment, stating that both patient and physician recognition of stroke symptoms and the unawareness that it is a treatable condition are some of the main challenges to timely diagnosis (Dr. Ken Butcher: personal communication, 2018 May 22). Pam Ramsay and Dr. Patrice Lindsay both referenced the Heart and Stroke Foundation of Canada's FAST (Face, Arms, Speech, Time) campaign as being an enabler to patient education (Pam Ramsay: personal communication, 2017 Aug 30, Dr. Patrice Lindsay: personal communication, 2017 Sep 12).[41] Dr. Patrice Lindsay noted that Canadian patients today are much more informed when it comes to their health and

their families are more aware about when and how to act when faced with a potential stroke, although there is still much work to be done (Dr. Patrice Lindsay: personal communication, 2017 Sep 12).

Organization and Structure

This domain comprises the organizational policies, guidelines, and practices as well as culture and climate that reside within an organization and on different levels such as the organization as a whole, units, and teams through which an intervention is delivered. Therefore, constructs such as team dynamics, leadership, supervision and guidance are also part of this domain.[11]

The literature review and consultations highlighted the following organization and structure aspects that could enable or act as a barrier to implementation: pre-arrival notification and bypass, coordination of care, and culture.

Pre-arrival Notification and Bypass

Among patients with acute ischemic stroke, transport by EMS has been associated with earlier arrival and faster ED evaluations — these benefits stem, at least in part, from pre-arrival activation of stroke teams because of hospital pre-notification by EMS and bypass protocols.[22]

Pre-arrival notification to hospital has been found to be extremely beneficial in PEI as described by Jeremy Measham (Jeremy Measham: personal communication, 2017 Sep 26). Typical intake protocols for when patients present to the ED, in his opinion, simply cause delays and lengthen the door-to-CT time. Instead, the ED nurse manager and physician in PEI will be notified by EMS of the incoming stroke patient and will meet the patient at the doors of ED and quickly triage and decide if they should go to CT rather than finding a bed in the ED to wait in. These patients will thereby bypass the ED and be taken directly to the CT scanner accompanied by the paramedic and then the ED physician or stroke specialist will see the patient later in the ED to decide on next steps (Jeremy Measham: personal communication, 2017 Sep 26).

Guideline-recommended pre-hospital practices have been demonstrated to improve the efficiency of in-hospital care for stroke patients.[23] One study suggests that hospital pre-notification is associated with improved stroke response as measured by door-to-evaluation times and the rate and speed of tPA delivery.[23] Another study found that EMS-recognized strokes had faster door-to-CT times and transportation by EMS is an important predictor of improved in-hospital stroke response and use of tPA for patients with acute ischemic stroke.[22] Findings from the North Carolina Stroke Care Collaborative showed that arrival by EMS (versus private transport) was associated with faster access to brain imaging and faster interpretation of these images.[9]

According to Dr. Patrice Lindsay, organizational relationships and partnerships with EMS are key enablers with a common understanding that paramedics are not merely transporters, but are experts trained to recognize the signs of stroke and take appropriate actions (Dr. Patrice Lindsay: personal communication, 2017 Sep 12). Dr. Stephen Phillips and Pam Ramsay added that because paramedics are at the front lines, they are instrumental in operationalizing bypass protocols as demonstrated in both NS and BC respectively (Dr. Stephen Phillips: personal communication, 2017 Sep 27, Pam Ramsay: personal communication, 2017 Aug 30).

Jeremy Measham described how stroke system stakeholders in the province of PEI have developed a diversion policy to divert stroke patients in ambulance from minor hospitals that do not have CT to sites that have these technologies. Because the island's EMS is centralized, if an

ambulance is moved away from one community, another will be moved to fill the gap (Jeremy Measham: personal communication, 2017 Sep 26).

Coordination of Care

Although an ideal system might see all patients receiving care at specialized stroke centres, this may be difficult to achieve in large, geographically diverse jurisdictions.[8] Coordinated systems of stroke care have been established in many provinces that include bypass protocols for paramedics and the use of telestroke modalities to access specialists at large urban centres for consultation and to support intravenous tPA administration.[10] Dr. Devin Harris added that urban hospitals in BC tend to have in place structured protocols, guidelines, imaging equipment, and overall access to endovascular therapy and stroke units, which rural facilities typically do not (Dr. Devin R. Harris: personal communication, 2017 Aug 22).

The overall coordination of stroke care is a challenge identified by Lori Latta (Lori Latta: personal communication, 2017 Nov 17). Nurse coordination or stroke team coordination, is vital to raising the profile of stroke and ensuring that standardized order sets for care and administration of treatments are adhered to (Lori Latta: personal communication, 2017 Nov 17).

Culture

From a cultural perspective, Dr. Devin Harris believes that there has been a paradigm shift within the medical community when it comes to stroke, stating "At one time, we did not think that stroke was treatable and preventable. Now we know it is treatable and preventable and this changes our approach to how we deal with patients. There is still room for improvement" (Dr. Devin R. Harris: personal communication, 2017 Aug 22). Dr. Eddy Lang added that, "It was only a decade ago that most urban hospitals were operating their imaging machines for fixed hours, but now we are seeing an evolution in thinking to recognize that neurology emergencies can happen at any hour of the day and so imaging needs to be available 24/7" (Dr. Eddy Lang: personal communication, 2017 Aug 8). Dr. Michael Hill agrees with this approach, stating that we must "adapt our practice of care to the biology of the disease," as it is impossible to adapt the biology of the disease to our health care systems. He believes this includes same-day imaging for stroke patients at minimum (Dr. Michael Hill, Professor, Department of Clinical Neuroscience, Hotchkiss Brain Institute, Cumming School of Medicine, University of Calgary, Calgary, AB: personal communication, 2018 May 11). Dr. Ken Butcher agreed with this view, and although he admitted that it has been challenging to get 24-hour access to CT and CTA scanning, he stated that this was much better in Alberta when compared with other areas of Canada (Dr. Ken Butcher: personal communication, 2018 May 22).

Funding

The domain of *funding* relates to short-term or long-term funding mechanisms by governmental, non-governmental, private sector, and philanthropic organizations used to implement an intervention.[11]

Dr. Devin Harris highlighted that stroke is a continuum disorder, so the funding needed for it in his province of BC does not usually align with the necessary silos (ED, radiology, neurology, etc.) which generally have different reporting structures (Dr. Devin R. Harris: personal communication, 2017 Aug 22). With shrinking budgets and hospitals often required to curb spending, finding additional funds available for stroke services and costly imaging technologies is challenging (Dr. Devin R. Harris: personal communication, 2017 Aug 22). One study reviewed found that patients in the US used significantly more imaging resources than patients in Canada, where capacity is restricted by centralized provincial budgets.[26]

Pam Ramsay noted that capital investments are always a challenge in the acute care setting, adding that we must be mindful of the capabilities of CT scanners in small communities in BC and that some may be in need of upgrading (Pam Ramsay: personal communication, 2017 Aug 30). Pam Ramsay and Jeremy Measham in PEI both stated that operational investments (human resources) are another barrier with the need for staff available to respond to stroke cases 24/7, including specialist physicians and imaging technicians (Pam Ramsay: personal communication, 2017 Aug 30, Jeremy Measham: personal communication, 2017 Sep 26).

One article reviewed noted that a limitation in addressing stroke patients is that 24-hour CT scanning may not be possible at all acute sites due to lack of resources, and that patient transfers to larger centres can result in precious time loss and may not always be possible for patients with unstable conditions.[19] Dr. Ken Butcher agrees that although there is an larger upfront cost to increased scanning volumes in the rural setting, these costs are offset by the decrease in patient transfers and improved patient outcomes (Dr. Ken Butcher: personal communication, 2018 May 22).

This becomes an especially important consideration in smaller communities where the expense of a standard CT scanner with the requirement of specialized technicians may not be feasible.[19] Dr. Devin Harris and Dr. Patrice Lindsay echoed this opinion and added that funding for personnel to operate diagnostic imaging equipment (CT scanners) 24 hours a day, seven days a week is a challenge for many Canadian facilities including those in urban settings (Dr. Patrice Lindsay: personal communication, 2017 Sep 12, Dr. Devin R. Harris: personal communication, 2017 Aug 22).

In some jurisdictions another challenge exists where some people avoid calling EMS because of the fees associated with the ambulance. From Carolyn MacPhail's perspective, some people in PEI believe that they can get themselves faster to hospital than EMS and without the associated cost (Carolyn MacPhail: personal communication, 2017 Sep 27).[42] Given the importance of minimizing the door-to-treatment time for patients with suspected stroke, it is important that people understand the specialized training EMS personnel have in responding to stroke patients and not merely as ambulance transport. Moreover, stroke protocols are put in place to ensure that treatment occurs in the right place and in a timely manner (Carolyn MacPhail: personal communication, 2017 Sep 27).

Policy

According to INTEGRATE-HTA, the *policy* domain comprises policy measures and processes of government, public, private, or other organizations directly concerning or indirectly influencing the implementation of an intervention.[11]

There is much agreement in the literature and among most interviewed that one of the biggest aspects to enable the management of ischemic stroke is the use of standardized protocols in both urban and rural/remote settings. One article underscored that effective and standardized imaging protocols are necessary for clinical decision-making.[25] In BC, Dr. Devin Harris reports that a key enabler for his facility has been the use of standardized stroke protocols (Dr. Devin R. Harris: personal communication, 2017 Aug 22).

Dr. Patrice Lindsay added that protocols facilitate the process for paramedics in more urban settings as they are often trained and can identify the signs of stroke (Dr. Patrice Lindsay: personal communication, 2017 Sep 12). Pam Ramsay in BC added that a policy around bypass is also necessary, particularly when a decision needs to be made regarding air versus ground

transport of stroke patients (Pam Ramsay: personal communication, 2017 Aug 30). Bypass involves emergency services bypassing a facility to send a patient to a higher tier centre with better equipped stroke treatment capabilities. This type of system coordination requires that hospitals work with EMS which, according to Trish Helm-Neima, they are doing in PEI (Trish Helm-Neima, Provincial Stroke Coordinator, Health PEI, Prince Edward Island: personal communication, 2017 Sep 27). One article emphasized that coordinated systems of care and ambulance bypass agreements must continue to evolve to ensure maximal access to hyper acute stroke services.[9]

In BC, an example of a policy that potentiated a barrier to implementing "best practice stroke care" was described by Pam Ramsay (Pam Ramsay: personal communication, 2017 Aug 30). In an effort to reduce wait times and backlogs in the ED, patients were being transferred out of the ED into the first available hospital bed (in-patient) as quickly as possible. Although patient focused, this might mean that a patient with a stroke could be transferred to a bed other than the most appropriate stroke unit bed. Efforts are required to harmonize competing policies/ guidelines (Pam Ramsay: personal communication, 2017 Aug 30).

One key policy change that is expected to drive change in the stroke system is the mandating to collect key data elements in a jurisdiction. Pam Ramsay noted that in BC all health authorities are now recording stroke information in the discharge abstract database to measure time-to-CT and transfer time-to-stroke unit for example (Pam Ramsay: personal communication, 2017 Aug 30).

Socio-economic, Socio-cultural, Legal, and Epidemiological

The consultations and literature search together did not yield any articles that addressed the INTEGRATE-HTA domains of *socio-economic, socio-cultural, legal,* and *epidemiological*. All other domains are described with respect to challenges and enablers of implementation.

Limitations

The findings of this Environmental Scan aim to present an overview of examples and current information regarding the diagnostic imaging for ischemic stroke in the ED setting and are not intended to provide a comprehensive review of the topic. The results are based on a limited, non-systematic literature search and consultations with nine stakeholders. While there was representation from BC, Alberta, Saskatchewan, Ontario, NS, and PEI, not all jurisdictions responded to our request for an interview and some informants were only able to speak on behalf of a single site or organization and not the jurisdiction's health care system as a whole. Moreover, opinions and perspectives provided as part of the targeted stakeholder consultations may not be representative of the views of all stakeholders across Canadian jurisdictions.

The literature search did not identify studies pertaining to many aspects of issues relating to implementation or the INTEGRATE-HTA framework. There was a lack of information regarding the epidemiology, socio-economic status, political, policy, socio-cultural, and legal domains of INTEGRATE-HTA.

There were also limitations in the data used from the CMII database. The setting of "urban," "rural," or "remote" were self-reported by the individual who filled out the survey and were not guided by a specific definition of these settings. This means that the categorization by setting may be inconsistent between respondents. Additionally, 39.9% of respondents reported on the setting of their site; thus, some information may not have been captured in the survey, and therefore not reported.

Conclusion

The Environmental Scan included a review of the literature and targeted consultations with stakeholders from BC, Alberta, Saskatchewan, Ontario, NS, and PEI and included both health care professionals and health system administrators.

The current diagnostic imaging modalities available in Canada include CT, MRI, and ultrasound. CT is considered by many to be optimal in its ability to address imaging requirements for stroke assessment and is the primary modality used across Canadian jurisdictions in diagnosing ischemic stroke in the ED setting. MRI, although less widely available, is more sensitive to small infarctions and can provide additional information for the physician. Practical considerations that may influence imaging modality selection include availability of imaging equipment, the proximity of imaging equipment to the ED, the length of imaging times, patient factors (such as contraindications to some imaging modalities), physician preferences, logistical considerations, and the availability of an expert to perform and interpret the imaging. The 2017 CMII database[12] provided information regarding the number of imaging modalities available in Canada — Ontario and Quebec have the most units available for all imaging modalities compared with other Canadian provinces and territories, but do not have the highest number of units per one million residents.[12]

In urban, rural, and remote settings, access to imaging and diagnostic tools is variable, which can create disparities in stroke care. Canada's vast geography and sizable populations in rural and remote communities has an impact on the ability to diagnose and treat stroke patients in a timely manner. The CMII database[12] provided some information regarding the distribution of imaging modalities across rural, remote, and urban regions — CT scanning is the most widely available imaging technique in Canadian jurisdictions, and the only imaging modality available in remote regions. Urban regions contain the majority of imaging modalities, including 75.4% of CT scanners, and 85.5% of MRI scanners.

There are many barriers and aspects that enable the timely diagnosis of acute ischemic stroke in the Canadian context. Barriers include a lack of patient education on the symptoms of stroke, difficult travel through large geographical regions with unpredictable weather conditions, and a lack of stroke services in some hospitals (for example, a lack of a specialized stroke specialists). Additionally, when removing ambulance or EMS services from a community to accommodate longer transportation times for bypass services, there is a potential ethical issue, as the use of these ambulances is now limited for other emergencies. Providers of care to stroke patients in the acute care setting also do not receive as much education or training regarding neurologic emergencies when compared with other acute emergencies and therefore may be less equipped to handle stroke emergencies.

Getting stroke patients swiftly to the necessary imaging is critical, and any impediment to a timely diagnosis can impact patient outcomes. As such, standardized protocols and bypass policies are important. Key elements, including jurisdictional policies, collaboration among providers, and coordination with EMS have been found to enable implementation of stroke strategies. Telestroke systems are also a potential asset in the timely diagnosis and treatment of stroke. Appropriate funding, education and training of clinicians, and public awareness of the signs and symptoms of stroke can also impact implementation success.

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Appendix 1: Stakeholder Consultations

The following stakeholders were consulted for this Environmental Scan. Permission was granted by all interviewees to publish their comments in this report.

Province/Territory	Key Informant
Alberta	**Dr. Eddy Lang** Academic Department Head and Professor, Department of Emergency Medicine, University of Calgary Clinical Department Head, Emergency Medicine, Alberta Health Services (Calgary Zone) Senior Researcher, Alberta Health Services
	Dr. Michael Hill Professor, Department of Clinical Neuroscience Hotchkiss Brain Institute Cumming School of Medicine, University of Calgary
	Dr. Ken Butcher Canada Research Chair in Cerebrovascular Disease Heart and Stroke Foundation Professor of Stroke Medicine Division of Neurology University of Alberta
British Columbia	**Dr. Devin R. Harris** Medical Advisor, Stroke Services BC
	Ms. Pam Ramsay Provincial Director, Stroke Services BC Provincial Health Services Authority
Nova Scotia	**Dr. Stephen Phillips** Professor of Medicine (Neurology), Dalhousie University Stroke Neurologist, Halifax Infirmary
Prince Edward Island	**Ms. Trish Helm-Neima** Provincial Stroke Coordinator Health PEI
	Ms. Carolyn MacPhail Chronic Disease Prevention and Management Manager Health PEI
	Mr. Jeremy Measham Special Projects Coordinator Island EMS
Saskatchewan	**Ms. Lori Latta** Project Manager, Clinical Pathways Ministry of Health
Ontario	**Dr. Dar Dowlatshahi** Associate Professor, University of Ottawa Department of Medicine Clinician-Scientist Chair Scientist, Ottawa Hospital Research Institute Scientific Director, Ottawa Stroke Program Stroke Neurologist, Ottawa Hospital
National (Ottawa, Ontario)	**Dr. Patrice Lindsay** Director, Stroke Heart and Stroke Foundation of Canada

Appendix 2: ConsulAppendix 1: Stakeholder Consultationstation Questions

The following questions were posed to key informants as part of the stakeholder consultation:

1. In your experience, how are the current diagnostic strategies for ischemic stroke in the emergency setting different for urban, rural, and remote locations across Canada?
   a) What are the strategies for urban areas?
   b) What are the strategies for rural areas?
   c) And remote areas?
2. Generally, what types of imaging procedures are available in your jurisdiction or settings to diagnose ischemic stroke?
   a) What are the gaps in availability?
3. What do you consider to be the main challenges to the timely diagnosis of ischemic stroke in the Canadian emergency setting?
4. What is in place now that enables best practice as it relates to ischemic stroke diagnosis?
5. Is there anything else relating to implementation issues that we should consider?
6. Are there any studies regarding implementation issues that we should be aware of?
7. Are there any other experts you suggest we consult with for this project?

Appendix 3: 2017 Canadian Medical Imaging Inventory Data[12]

Table 1: Number of CT and MRI Imaging Modalities per Province

Number of Imaging Modalities per Province		
Province/Territory	Number of Units (Number of Sites with Units)	
	CT	**MRI**
British Columbia	66[a] (47)	46[a] (42)
Alberta	56 (41)	41 (29)
Saskatchewan	15 (13)	10 (7)
Manitoba	23 (16)	12 (7)
Ontario	184 (105)	121 (74)
Quebec	163[a] (97)	107[a] (75)
New Brunswick	15 (11)	11 (9)
Prince Edward Island	2 (2)	1 (1)
Nova Scotia	18 (14)	12 (11)
Newfoundland and Labrador	16 (14)	5 (5)
Yukon	1 (1)	1 (1)
Northwest Territories	1 (1)	0 (0)
Nunavut	1 (1)	0 (0)
Canada	561 (363)	366 (261)

CT = computed tomography.

[a] Total includes private units.

Note: Private units are not always used in the ED setting.

Source: Canadian Medical Imaging Inventory, 2017.[12]

Table 2: Number of CT and MRI Imaging Modalities per One Million Residents

Number of Imaging Modalities per One Million Residents		
Province/Territory	Units per One Million Residents	
	CT	MRI
British Columbia	13.8	9.6
Alberta	13.1	9.6
Saskatchewan	12.9	8.6
Manitoba	17.3	9.0
Ontario	13.0	8.5
Quebec	19.5	12.8
New Brunswick	19.8	14.5
Prince Edward Island	13.4	6.7
Nova Scotia	18.9	12.6
Newfoundland and Labrador	30.3	9.5
Yukon	26.5	26.5
Northwest Territories	22.7	0
Nunavut	26.7	0

CT = computed tomography.

Source: Canadian Medical Imaging Inventory, 2017. [12]

Table 3: Number of Imaging Modalities in Urban, Rural, and Remote Settings

Setting	Number of Units		Percentage of Units (%)	
	CT	MRI	CT	MRI
Urban	196	136	75.4	85.5
Rural	60	23	23.1	14.5
Remote	4	0	1.5	0.0
Total	260	159	100	100

CT = computed tomography.

Source: Canadian Medical Imaging Inventory, 2017.[12]