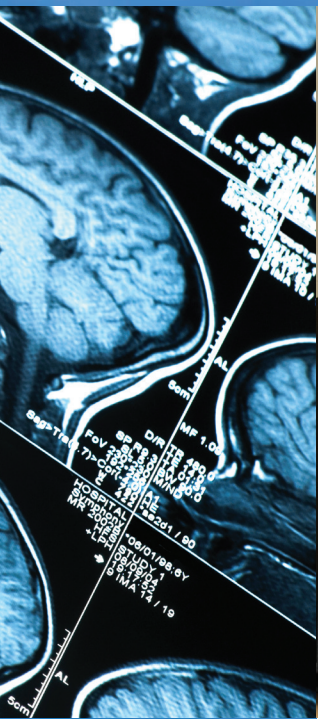


Expanding Telestroke in Canada



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Canadian Stroke Network Mission: *To reduce the impact of stroke on Canadians through collaborations that create valuable new knowledge in stroke; to ensure the best knowledge is applied; and to build Canadian capacity in stroke.*

Executive Summary

Introduction

Across Canada there is widespread agreement on what Best Practice Care for stroke looks like, yet the majority of Canadians do not receive it. The *Canadian Best Practice Recommendations for Stroke Care* conclude that telestroke should be used to give more Canadians access to emergency rtPA, whose use is otherwise usually restricted to patients in tertiary care centres. Telestroke can also play an important role throughout the stroke care continuum, increasing access to secondary prevention and rehabilitation, and incorporate specialists where needed in each step from critical care to long-term follow-up. At each step in the continuum, telestroke increases the use of effective care earlier, reducing both initial brain damage and the resulting long-term disability resulting from stroke.

In Canada, two provinces have widespread telestroke services for hyper-acute care (Alberta and Ontario), and one has pilot telestroke sites (British Columbia). Alberta also uses telestroke extensively in stroke prevention, and Saskatchewan is completing a pilot of telestroke-supported rehabilitation. The goal of this project was to identify the best approach to expanding the availability of rtPA treatment for acute stroke. Supported by literature review, environmental scan, interviews with stroke leaders and telestroke site visits, three options were assessed for feasibility, challenges, barriers, costs and benefits:

1. Expand regional/provincial telestroke operations, initiate telestroke in provinces and territories that do not currently offer it, and/ or establish interprovincial telestroke consultation.
2. Establish a national telestroke system.
3. Provide training for emergency room physicians safely to administer rtPA without the need for a telestroke neurology consult

Benefits of telestroke

Telestroke has proven very successful in increasing access to rtPA, both internationally and in Canada. Ontario, for instance, achieved an rtPA rate of over 30%, compared to Canada's average of 8%. Telestroke is both cost-effective and desired by patients. Overall benefits of telestroke include:

- More ischemic strokes are prevented, and more are treated to reduce subsequent brain damage
- Patients have better health outcomes, plus lower health care and long-term social support costs
- Patient satisfaction with the healthcare system is increased
- Regional inequities in access to and standards of care are reduced
- Improved clinical collaboration and processes, and better deployment of human resources

Key telestroke success factors in Canada

Interviews and site visits with a range of Canadian stroke policy and service leaders suggests that many of the key drivers of telestroke success and failure in Canada are different from the US, due both to our publicly-funded health care model and to our provincially-organized systems of health care:

1. **Provincial system of stroke care:** The most resounding message from informants was that telestroke for rtPA should not be advocated or adopted as a “stand alone” service, but should be introduced as a component of an integrated provincial system of stroke care. Telestroke is part of the change process, not an intervention which can be undertaken by itself, and depends on systemic approaches including

designated sites of stroke care, and province-wide bypass protocols to get people to them. Telestroke should support the continuum - prevention and rehabilitation, as well as hyper-acute care.

2. **Central leadership/ coordination:** Informants emphasized the importance of provincial leadership, in both establishing a provincial stroke system, and in making telestroke implementation within it possible. Provincial leadership is essential to have sufficient authority to make, negotiate and influence province-wide change and infrastructure development, as well as to achieve efficiencies of scale.
3. **Engaged care providers:** The difference between telestroke sites that excelled and those that struggled was inevitably a determined site champion. Champions must be well-supported and helped to build an effective site team. Engagement must involve all affected providers in a long-term and ongoing process, and address key concerns such as rtPA safety and neurologist workload.
4. **Effective support for the front-lines:** The new telestroke site needs ongoing support to help it change the way stroke care is conceived and delivered, connect the key players into a stroke team, and develop processes that ensure everyone knows what they must do, and can make it happen extremely quickly. Substantive clinical practice changes are usually required. Technical training needs to address issues such as low case volume and high physician turnover.
5. **Strong relationships:** Informants consistently placed overwhelming importance on building relationships and trust among telestroke participants, as critical to successful change management, and key to engaging front lines. rtPA involves a difficult decision, and just one part of care; participants need confidence in their partners and in the care provided throughout the continuum.
6. **Coordinated infrastructure and systems:** Basic infrastructure requirements include two-way videoconferencing (easily achieved); widespread broadband and CT scanners (widely and increasingly available); a call referral management service (can be more challenging for emergency applications); 24/7 CT coverage, 24/7 on-call neurologists, facilitative privacy law, and province-wide, immediate-access, interoperable image storage such as PACS (all significant challenges in most jurisdictions).
7. **Funding, with emphasis on the front-end:** Alberta and Ontario telestroke services built on large-scale investments in stroke systems, as well as in health, telehealth, and information/ telecommunications infrastructure. While these are not telestroke costs per se, they are essential prerequisites to effective telestroke, and are therefore seen as cost barriers to implementing telestroke: funds are more likely to be available for the technology itself than for the front-end systems organization. Telestroke is so dependent on, and embedded in, systems change and broader infrastructure that it is extremely difficult to identify a meaningful cost of developing a telestroke service as a distinct intervention.

The lessons learned from the varying governance structures among Ontario, Alberta and BC telestroke highlight the value of: strong provincial leadership; integration of telestroke with broader stroke system organization; and having strong and functionally-independent telehealth. Piloting telestroke may seem like a lower-risk investment, but in practice a non-system-wide approach creates significant challenges.

Issues around medical accountability, liability, credentialing and licensing have been major barriers in the USA, but were not of great concern to our Canadian informants, likely because of our public health care, combined with a strong Canadian preference to avoid the “drip and ship” approach wherever possible.

Current telestroke services in Canada

Although acute care is a priority in every provincial stroke strategy, telestroke is only widely available in two provinces. Key reasons for its low implementation seem to include:

- Telestroke is seen as too expensive, if creating a provincial system of stroke care is seen as a prerequisite to building telestroke services
- Telestroke has been equated with rtPA; lingering emergency physician concerns about rtPA mean rtPA is not a priority, so neither is telestroke
- Hyper-acute telestroke services have been promoted in isolation from the continuum of stroke care, where stroke leaders want integrated approaches for stroke and telestroke
- The main costs of telestroke do not accrue in the same place as its major benefits
- Proactive provincial leadership is essential for telestroke success

Some provinces and regions have pursued alternate approaches to telestroke in order to increase access to rtPA. Nova Scotia, in particular, has focused on increasing the capacity of regional hospitals to make independent rtPA decisions, without external neurology consult, but with a range of systemic supports and back-up systems which make this approach effective for its geography and infrastructure. Most of Canada, however, is planning or developing telestroke services, and most provinces would welcome assistance in furthering their telestroke development.

Although endorsing the view that the ideal implementation of telestroke is within an organized system of comprehensive stroke care, we argue that if the ideal is unattainable, then “stand-alone” telestroke is better than no telestroke. The “best” must not be allowed to be the enemy of the “good”. Telestroke implementation should be flexible, nimble, opportunistic, and responsive to local need and feasibility.

Recommendations

Recommendation 1: Expand telestroke across Canada

The research literature provides sound evidence that hyperacute telestroke for thrombolysis saves lives, reduces disability, and is highly cost-effective. In almost every province, support for expanding telestroke to improve access to best practice stroke care was strong. Telestroke is seen as a critical component of a quality system of stroke care, with an important role to play throughout the continuum of care. Even where a comprehensive stroke care system is unaffordable, telestroke for rtPA is better than no rtPA.

Our unequivocal recommendation is thus to expand telestroke services across the country.

Recommendation 2: Use a regional support model

The next question is then whether to pursue a single, cohesive national telestroke service model, or rather to work with each region individually to expand telestroke efforts piece by piece across the country. In making our recommendation, we looked at the key success factors which have been identified for telestroke, and considered the ability of each model to best help those success factors flourish. From the wise advice we received from across the country, we conclude that the core of *truly effective* telestroke is:

⇒ Active provincial leadership, provided through an organized system of stroke care

⇒ Key champions and engagement on the front-lines

We believe these core attributes are best served by enabling strong provincial and local leadership, with peer support and knowledge exchange, an approach informants saw as highly desirable and beneficial.

We therefore recommend that the expansion of telestroke services should be supported on a region-by-region basis across Canada, not as a single national telestroke initiative.

Recommendation 3: Provide timely telestroke support

Across Canada there are experienced telestroke sites, champions and leaders, as well as emerging telestroke services, eager to participate in national discussion and exchange with their peers. Canada has developed considerable expertise in stroke quality assessment, through the stroke audit, ICES, and Accreditation Canada. There are a number of key forums and networks which are connecting people and supporting exchange, including the Canadian Stroke Network and the Canadian Stroke Congress. These forums and networks should be leveraged to provide timely support to regions and provinces as they assess and implement telestroke. Examples of the support provided could include:

- A. Creating a repository of telestroke-relevant documents
- B. Sharing information between provinces about telestroke activities across the country
- C. Connecting people interested in telestroke for the purposes of knowledge exchange using existing forums such as the Canadian Stroke Congress
- D. Evaluating and comparing telestroke models and alternatives and applicability in various jurisdictions
- E. Identifying and assessing lessons learned, defining best practices, and setting standards for telestroke services
- F. Providing strategic advice on the implementation of telestroke provided by those with telestroke experience

We therefore recommend that existing stroke organizations and networking forums be leveraged to provide timely support and coordination for regions and provinces as they implement telestroke.

Introduction

The goal of this project was to identify the best way to expand the availability of thrombolysis (rtPA) treatment for hyperacute stroke, and to identify the steps and requirements to implement that approach. Secondary consideration was to be given to other aspects of specialized stroke care. Three options were assessed, in terms of their feasibility, challenges, costs, and benefits:

1. Expand regional/provincial telestroke operations, initiate telestroke in provinces and territories that do not currently offer it, and/or establish interprovincial telestroke consultation
2. Establish a national telestroke system
3. Provide training for emergency room physicians safely to administer rtPA without the need for a stroke neurology consult.

In addition to a literature review and environmental scan, we interviewed stroke leaders in both policy and services from all provinces. We also made site visits to explore two Canadian telestroke models in depth: the first in Alberta (Edmonton, Camrose, and Westlock) and the second in Ontario (Toronto). Quotations and descriptions throughout this document not otherwise referenced were obtained from key informants through these confidential interviews and discussions (see Appendix A for key informants).

The problem

If you are over 50, you have a one in six chance of suffering a stroke. Every year, approximately 50,000 strokes and “ministrokes” (or transient ischemic attacks - TIAs) are treated in Canadian hospitals. Stroke has the longest acute care length of stay of any disease and the highest alternate level of care days.¹ Stroke incidence rises sharply with age, so as the proportion of elderly Canadians increases, so will the incidence of strokes, exacerbated by increasing rates of obesity, diabetes, physical inactivity and high-salt diets, all of which are major risk factors. The long-term health care, social, and economic costs of stroke are currently estimated at \$3.6 billion annually in Canada (1); much of this cost is avoidable.

There is widespread agreement on what Best Practice Care for stroke looks like, yet the majority of Canadians do not receive it. Two innovations drastically reduce the burden of stroke, particularly when used together: thrombolysis, and integrated stroke units. Thrombolysis is the infusion of a “clot-busting” drug, recombinant tissue plasminogen activator (rtPA) into patients suffering acute stroke. rtPA can reduce the brain damage caused by stroke. Less brain damage means fewer deaths, lower morbidity, less long-term disability, and reduced health care costs. However, only about 8% of eligible stroke patients in Canada are treated with rtPA and most brain damage due to a stroke is not treated at all (2).

Furthermore, despite clear evidence that telestroke increases access to rtPA, only two provinces have implemented comprehensive telestroke services, and most have none at all. As rtPA becomes widely available in a few provinces, inequities in access to Best Practice Stroke Care across Canada are growing.

¹ A patient is designated “alternate level of care” when occupying a bed in a clinical service that provides a higher level of care than is necessary - e.g. a stroke patient in an acute care bed who should be in a rehabilitation facility – and indicates inefficiency in the health care system.

Overview of stroke and best practice stroke care

Eighty percent (80%) of strokes are caused by a clot which blocks the blood supply to part of the brain (ischemic stroke); the remainder result from bleeding into or around the brain due to a ruptured artery (hemorrhagic stroke). Since the late 1990s, it has been possible to treat acute ischemic stroke with rtPA. However, rtPA must be administered within 4.5 hours after the stroke to be effective², and the sooner the better: for every minute that the clot blocks blood flow, two million more brain cells die. Dissolving the clot and restoring blood flow as soon as possible after the stroke reduces the brain damage, improves recovery, and reduces long-term disability – thus the mantra, “Time is Brain”. Those who receive rtPA within an hour of a stroke have a one in two chance of complete recovery. Those who receive it towards the end of the 4.5 hour window have only a one in 18 chance of full recovery, but rtPA will still reduce the brain damage caused by the stroke and preserve more functionality (overview drawn from (2)).

Unfortunately, rtPA is a two-edged sword: while it can be a “miracle drug” for those with ischemic stroke, it is dangerous for patients with a hemorrhagic stroke, or some conditions that mimic a stroke. Before rtPA can be administered safely, a CT or MRI scan³ of the brain must be done and interpreted by a specialist to confirm that the patient has an ischemic stroke and that rtPA can be safely given.

Whether patients receive rtPA or not, their chances of survival and functional recovery are improved if they receive hospital care in a specialized stroke unit. Here, they are expertly assessed to determine the severity of stroke and their early rehabilitation needs, they receive drugs to reduce the risk of further stroke, and rehabilitation therapy can be started as early as possible. After leaving hospital, people with stroke continue to need specialized care and rehabilitation services, including counselling and education that will reduce their risk of another stroke (secondary prevention). As the majority of people with stroke will eventually return home, it is important that their families and caregivers receive information, education, emotional support, and access to community support services.

What is the role of telestroke in optimal stroke care?

“Far fewer Canadians should die or be disabled from stroke when we know how to prevent, treat and enhance recovery. The knowledge exists – we need to use it.” – CSN

Whether or not a stroke patient receives rtPA depends largely on where they live. The need for specialist assessment of the patient and their CT scan before taking the decision to administer rtPA has generally meant that only patients whose nearest hospital happens to be a *comprehensive stroke centre* (usually a tertiary care centre, with specialized stroke resources and neurologists available 24/7 hours a day) have access to rtPA: this is a major reason why rtPA rates are so low. For example, an Australian study found the rtPA rate was 2% state-wide, but 10% for those living close to a stroke unit (3).

The *Canadian Best Practice Recommendations for Stroke Care* (2) conclude that telestroke should be used to give more Canadians access to rtPA: telestroke provides an *intermediate stroke centre* (a hospital with CT and clinicians trained to deal with many aspects of stroke care) with the same ability as a comprehensive stroke centre to assess stroke and safely administer rtPA. With telestroke, a hospital can connect to a remote neurologist, who can access CT scans and examine the patient via video-link, to advise the local emergency room (ER) physician in taking the decision whether to administer rtPA.

² Recent evidence (Ref 52) suggests this should be revised to 6h.

³ In this report, we refer to CT scanning but MRI imaging can also be used to identify stroke; however, as MRIs are far less commonly available, the literature and our key informants refer almost exclusively to CT scanning.

The evidence in favour of telestroke as a way to increase thrombolysis rates is overwhelming. For example, compared to the 8% rtPA administration figure in Canada overall, rtPA rates average about 25% across a range of telestroke services internationally, and have reached more than 31% in Ontario. (4).

Beyond hyper-acute care, telestroke enables patients to access a range of specialists during critical care; rehabilitation; community-based care and support services; primary and secondary prevention clinics; and long-term follow-up and check-ups. At each step in the continuum, telestroke amplifies the benefits of earlier best-practice care, and reduces both the initial brain damage and resulting long-term disability.

How does telestroke work?

Steps in a typical telestroke consultation (modified from Ontario Telehealth Network procedure)

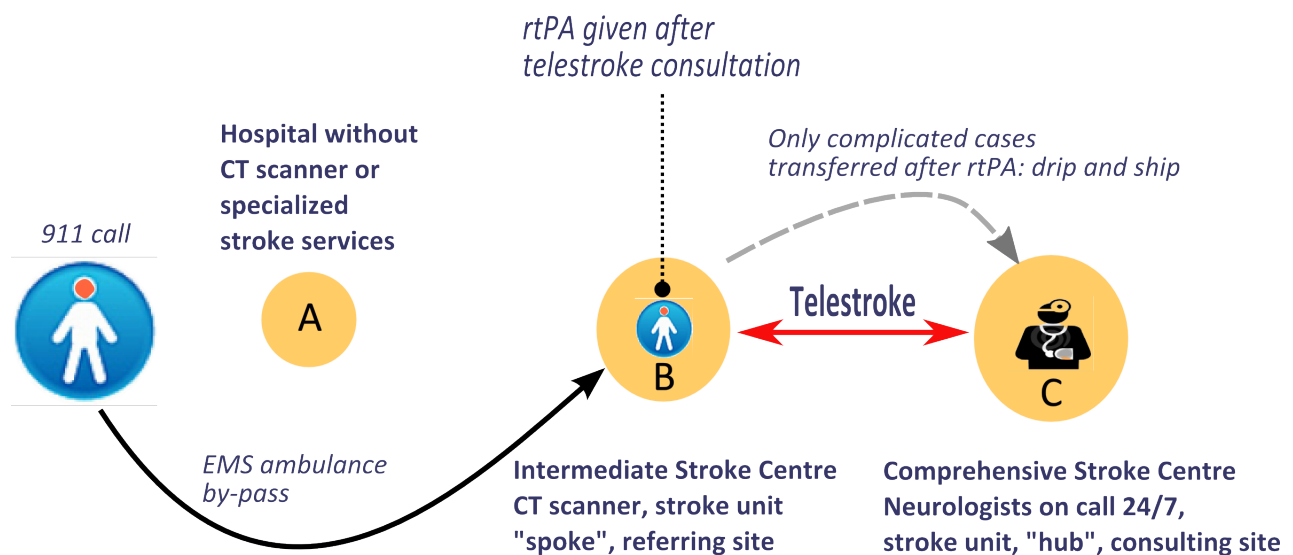
- Patient, family, or bystanders call 911. Emergency Medical Services (EMS) personnel identify a “hot stroke”, and transport patient to the nearest telestroke site (B in Fig.1), bypassing other facilities (A) that lack specialized stroke resources. En route, EMS alerts the ER, which activates an acute stroke protocol.
- Emergency room (ER) physician identifies patient as a candidate for rtPA and orders immediate CT
- ER contacts telestroke neurologist on call at the comprehensive stroke centre (C) (may also alert before)
- Neurologist and ER physician have preliminary discussion of the case
- The patient is brought to a video conferencing system (or vice-versa)
- The neurologist (at office, hospital, or home) reviews CT images transmitted from the telestroke site and connects for videoconference examination of patient’s signs and symptoms.
- Neurologist discusses acute treatment options with the referring ER physician, patient and family members
- ER physician, with neurology recommendations, decides whether to administer rtPA: if yes, patient is closely monitored for 1-2 hours, then moved to an intensive care bed. In case of complications, patient can be transported by ambulance to the comprehensive stroke centre, a process known as “drip and ship”.
- Neurologist follows up with telestroke site on patient status after 24h.
- When stable, patient is transferred from intensive care at the telestroke site to an associated rehabilitation centre, long-term care facility, or home (same day to several weeks, depending on severity).
- Patient receives counseling and follow-up to reduce chances of a subsequent stroke (secondary prevention), and further out-patient rehabilitation as required.

The first telestroke service began in 2001 at the Massachusetts General Hospital and the first commercial service, “Specialists on Call” was established in 2003, currently handling around 1000 consultations per month (5): telestroke is not an experimental or unproven approach. A recent American study (6) showed that both neurologists and ER physicians had a positive view of telestroke and its ability to reduce geographic disparity in stroke care.

In Canada, two provinces have widespread telestroke services for hyperacute care (Alberta and Ontario), and one has pilot telestroke sites (British Columbia). Alberta also uses telestroke extensively in stroke prevention, and Saskatchewan is completing a pilot of telestroke-supported rehabilitation. Four provinces are developing plans to pilot telestroke; some are potentially near implementation (Manitoba, New Brunswick), while others are in earlier planning stages (Newfoundland, Quebec). The remaining provinces (Nova Scotia and PEI, as well as Saskatchewan) are using alternative approaches to enhancing rtPA access, but Saskatchewan may have emerging interest in telestroke.

Telestroke services are generally organized on a “hub and spoke” model, where the “hub”, or consulting hospital, is a comprehensive stroke centre with stroke neurologists on call 24/7, usually a major urban tertiary-care hospital (“C” in Figure 1). The “spokes”, or referring centres, are usually intermediate stroke centres: mid-sized or regional hospitals large enough to have CT, and preferably also the capacity to provide specialized post-acute care for stroke patients (“B” in Figure 1). In Canada, our extensive geography drives our telestroke models: most provinces have a small number of neurologists, usually concentrated in just a couple of centres. Alberta, in consequence, has a hub-and-spoke model, with two hubs (Edmonton and Calgary) serving the North and South of the province respectively. Ontario, in contrast, has many larger cities and hospitals, and neurologists are distributed throughout the province. It therefore uses a “network” model, where referring centres are connected to a neurologist-on-call who may be located in any of the 5 consulting centres across the province. In Ontario, a hospital may be either a referring or a consulting site at different times, depending on where the on-call telestroke neurologist is located. BC currently has two mini-networks, each with one hub serving two spokes. However, BC also has neurologists distributed through a number of urban centres, and has might use a network model when telestroke is expanded across the province.

Figure 1: Simple Telestroke Schematic



There is considerable variability even within the hub and spoke structure. At one extreme, bilateral arrangements exist, with just one hub and one spoke: some US services, on the other hand, support up to 43 community hospitals from a single hub (7). Edmonton, Canada’s largest hub, has seven neurologists taking telestroke call to support eleven spokes, and appears to be near capacity.

What are the benefits of using telestroke?

More ischemic strokes are prevented. 22% of TIAs are followed by a major stroke, heart attack or death within one year, but secondary prevention can reduce the risk of severe stroke after TIA by up to 80% (8). While only 22% of Canadian hospitals are currently affiliated with a stroke prevention clinic (9), telestroke could provide access to prevention services for all Canadians, irrespective of location. The northern Alberta program, for example, provides about 400 stroke prevention clinic visits annually via telestroke from three hub sites to 52 spoke sites. Despite the aging population, Alberta’s prevention efforts from 2004/05 to 2008/09 resulted in a 12.8% decline in the numbers of acute stroke patients arriving at ERs and reduced the annual direct acute care cost of stroke by \$22M (10).

More ischemic strokes are treated with thrombolytics, more quickly. Through telestroke, operating in an organized system of stroke care, almost all Canadian patients could be taken directly to a hospital which is able to provide timely rtPA administration. Alberta and Ontario now have nearly comprehensive access to rtPA (95%+ of the population), demonstrating that Canadian geography need not be a barrier to treatment. In Ontario, for example, “In 2008/09, tPA was administered to 27% of those presenting within 2.5 hours of stroke onset, as compared to 14% in 2004/05 and 9.5% in 2002/03. Thrombolysis rates were 42% at regional stroke centres and 32% at district stroke centres” (11). Some telestroke sites now report “door to needle” times of only 40 minutes, as compared to the Canadian norm – for the 8% who get rtPA at all – of 72 minutes (1).

Patients have better health outcomes. BC recently noted that even though “stroke is a highly preventable and treatable disease,” 36% of BC stroke patients die within a year, and “the majority of stroke victims who survive their attack remain affected by neurological disabilities over the long term, and this fact underlies the important economic burden of stroke.” (12). However, by implementing a comprehensive stroke strategy which includes telestroke to increase access to tPA, Alberta experienced a 27% reduction in 30-day mortality for ischemic stroke between 2004/05 and 2008/09 (10).

Patients have lower acute care costs. Stroke patients usually require complex and lengthy care: 640,000 days in acute care in Canadian hospitals, and 4.5 million days in residential care facilities every year. Health-care costs for patients in just the first six months post-stroke are over \$2.5 billion a year. The average acute care stay in 2008-09 was 18 days, but sites in Alberta found this halved – some even reduced as low as four days – after introducing telestroke and integrated stroke care. Furthermore, Alberta has found that “building local capacity to manage and investigate stroke patients with telestroke support has contributed to a 29% reduction in overall transfers to [Edmonton] from 2004/05 to 2007/08”, a number which has continued to grow with the expansion of telestroke. Camrose, for instance, now keeps 95% of the stroke patients it used to ship to Edmonton for more expensive tertiary care. While Canada does not yet have any cost-effectiveness studies, evidence strongly suggest that telestroke avoids significant costs, compared to stroke treatment without telestroke. For example, Nelson et al (13) found that the incremental cost of telestroke over a person's lifetime was less than \$2500 per quality-adjusted life year (QALY):⁴ in other words, it is extraordinarily cost-effective compared to other common medical procedures and therapies, even looking only at acute care costs.

Broader healthcare costs are avoided. Nationally, an increase in rtPA rates from the 2010 average of 7.4% to a mere 10% was estimated to avoid annual direct costs of \$13.6M, due to 4,351 fewer acute care days, 43,902 fewer residential care days, and a further \$5.2M in indirect costs (1). In fact, telestroke has the potential to increase the rtPA rate well beyond 10%: in the northern Alberta network, the rate exceeds 20%, and it is over 30% in Ontario, suggesting that with widespread introduction of telestroke, Canada could achieve cost savings of three times this estimate – over \$55M per year.

Patients have lower long-term health and social support costs. Stroke is the leading cause of adult disability, affecting over 300,000 Canadians, including 7.1% of those aged 65-74. 60% of stroke survivors report needing help with daily living and 80% are restricted in their daily activities. Telestroke provides increased access to post-stroke care, rehabilitation, and community services that both

⁴ The threshold for an acceptable cost-effective procedure is usually regarded as \$50,000/QALY.

speed up and increase functional recovery (14). Less care does not save money; in fact, the BC Stroke Action Plan, for example, warns that “Without an immediate resource investment the benefits of the demonstrated cost avoidance will not be realized and costs of providing sub-optimal care will continue to grow at an increasingly rapid rate.” (12). Every neuron saved is also a dollar saved.

Patient satisfaction with the healthcare system is increased. Patient satisfaction with telestroke for hyperacute and prevention services is high (up to 97%) (15) (16), not only because rtPA seems like a “miracle cure”, but also because it keeps the patient closer to home and family, eliminates the physical stress of long transfers, the psychological distress of separation, and reduces family travel costs. Before the opening of Alberta’s newest telestroke site, the flight from High Level to Edmonton Alberta would cost the patient, and likely an accompanying family member, \$1,000 each to attend every follow-up appointment with the neurologist (raising the question of how many actually went). Now, patients can enrol in a post-stroke telerehabilitation program at home, where they perform as well or better than an in-patient control group, and report greater satisfaction with the program (17). Telestroke also allows rural patients to participate in clinical trials from which they are generally excluded (18).

“Patients really appreciate telestroke. Some people think the real value is tPA, but most don’t receive tPA – there is a lot of value just in having the consultation done early, so the family knows what’s happened, have reassurance that you’ve done it all, and know there’s a plan.” *Informant*

Regional inequities in access to and standards of care are reduced. Telestroke enables emergency care providers to make good care decisions even when they have limited experience with stroke. It both requires and enables the development of standards and consistent practice, and helps reduce variations among sites as well as individual providers; as one informant noted: “Before telestroke, we did bits of rtPA willy-nilly, if there was a cowboy kind of physician on that day.” Ensuring telestroke – the proven, cheap, and demonstrated standard of care – is available will eliminate providers’ vulnerability to legal challenge, and provinces’ vulnerability to charges of exposing Canadian stroke patients to avoidable risk of suffering and death, which could be argued to be a violation of their rights to life and security of the person under Section 7 of the Canadian Charter of Rights and Freedoms (51).

Improved clinical collaboration and processes. Informants report other benefits at least as important as access to rtPA: “The telestroke project brought standards, built a team: if we stopped rtPA now, we still would have gained a lot. It undid some gate-keeping barriers, created a chain of command that allowed things to happen quickly; there is more awareness of what to do with a stroke patient now. The neurologist is increasingly consulted, so the non-rtPA patients also benefit. The order sets are now in a place where everyone knows. Improved communications within the team is one of those legacies that will remain. Technology was a bit of a ruse to get people to talk and establish better processes.” acts as a continuing education process that allows referring site care providers to increase their expertise

Optimum deployment of limited number of neurologists. The small number of neurologists in Canada is a growing concern. Telestroke ensures that neurologists are involved in critical decision-making for all stroke patients, while reducing their involvement with routine care. Instead, only the most complex cases are transported to comprehensive stroke centres, making more appropriate use of the neurologists’ specialized knowledge and experience (19). With the removal of geographic restrictions and routine work, fewer neurologists can deal with more, and more dispersed, patients.

A platform for other emergency telehealth procedures. Telestroke systems create capacity for other emergency telehealth consultations, such as for a head trauma, burns, or mental health crises.

Telestroke – Key success factors

Telestroke is being used increasingly around the world, including Europe as well as Brazil, Thailand, and the Azores. The majority of the research literature, however, is based on US experiences, where telestroke is usually led by a single tertiary care institution seeking to improve care, and also to expand its revenue by providing services and expertise to smaller institutions. In the early days, academic innovators provided the service ‘off the sides of their desks’ with little emphasis on how it was paid for; now, telestroke has become a health technology product, marketed like any other. The major success factors/ implementation barriers identified in the literature accordingly reflect that technology innovation model.

Key telestroke success factors in the USA <i>extracted from the literature</i>	<ol style="list-style-type: none">1. Developing, marketing, selling and supporting the service, including addressing emergency physician concerns about rtPA2. Addressing physician billing and reimbursement, loss of neurologist income3. Resolving licensing, credentialing, and liability issues4. Ensuring the many insurers are willing to pay for telestroke services5. Ensuring telestroke doesn't require excessive time in the ER
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Interviews and site visits with Canadian stroke policy and service leaders show that the key drivers of telestroke success and failure in Canada are different from the US, due both to our publicly-funded health care model and to our provincially-organized systems of health care.⁵ In both provinces with and without, telestroke is usually seen as a process to help deliver a provincial strategy aimed at comprehensive access to best practice care. Telestroke, therefore, is not so much a discrete technological innovation as part of a system-wide change management process, and its success in Canada, in consequence, is most dependent on those factors essential to effective health system change management.

Key telestroke success factors in Canada <i>from key informant interviews</i>	<ol style="list-style-type: none">1. Provincial system of stroke care2. Central leadership/ coordination3. Engaged care providers4. Effective support for the front-lines5. Strong relationships6. Coordinated infrastructure and systems7. Some funding, with emphasis on the front-end
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1. Provincial systems of stroke care

Informants were adamant that telestroke should not be adopted as a “stand alone” service, but should be introduced as a component of an integrated provincial system of stroke care. This view was almost universal, whether the province had implemented telestroke *after* the creation of a provincial stroke system (Ontario); *during* the creation a provincial stroke system (Alberta); or *in the absence* of a provincial stroke system (BC). In other words, telestroke is

“First you must establish the sites of best practice care, and only then can you connect them with telestroke.” *(informant)*

⁵ Appendix C lists some of the major differences between telestroke in the US and Canada.

part of the change process, not an intervention which should be undertaken by itself: “You need a stroke services delivery model at the provincial level, then telehealth can be incorporated as a way to improve access to services.”

Need to address the larger continuum of care

Informants reacted negatively to the concept of telestroke focused on rtPA alone – “Telestroke is not just about rtPA!” – was a message we heard repeatedly. In fact, it was made clear to us that the perceived synonymy between telestroke and rtPA has been detrimental to its adoption. Informants differentiated between a simple hyper-acute telestroke site, whose role starts and ends with the administration of rtPA, and an intermediate stroke centre, able to provide quality care to all stroke patients – not just those rtPA-eligible – as well as the necessary post-rtPA care to ensure that the value of the rtPA is realized. Transferring patients to a tertiary centre for the rest of their care post-rtPA – the “drip and ship” model commonly used in the USA – may not be entirely avoidable, but it was rejected as a standard of care by almost all informants.

“If we push telestroke in every possible site, it’s not best practice. We should look at consolidating care to those centres.” *(informant)*

An intermediate stroke centre ideally includes a stroke unit and appropriate tele-connections to neurology specialists, rehabilitation and community services. Its standard practices include, for example, a simple swallowing test which virtually eliminate the risk of pneumonia, a common post-stroke complication: 50% of Canadian stroke patients are not so assessed. Its moves its patients on to rehabilitation services, unlike 63% of all moderate to severe stroke cases. Informants found that the drip-and-ship model doesn’t engage telestroke site providers. In contrast, when telestroke sites keep their stroke patients, the dramatic benefits of rtPA can be a powerful catalyst to strengthen the stroke team and improve the hospital’s stroke care across the continuum.

“If the patient crashes, there has to be a Plan B.” *(informant)*

Telestroke’s success also depends on participants trusting the system to provide the right advice to guide difficult choices about their patients: from EMS to ER, administrators to neurologists, all need certainty about their role and responsibilities for the patient, from the patient’s first contact with the ambulance service, to what happens after rtPA, and in the longer-term. When telestroke is introduced in isolation, these definitions tend to remain unclear, and there is no system in which to trust.

Finally, many informants recommended starting telestroke with secondary prevention, and only moving on to hyper-acute care when the site was fully engaged, ready, and well-practiced with the technology. In northern Alberta, for example, “Our program goes beyond acute stroke – in fact, telestroke for prevention was in place before thrombolysis at most sites, and rehab is now almost everywhere.”

Lessons learned in designating sites of care

For telestroke to improve access to care broadly (and not just in isolated hospitals) – it needs to be built into a system of designated sites of care, to which access is created through EMS bypass protocols. Provincial priorities and circumstances determine the criteria by which telestroke sites are assessed for feasibility and desirability. Alberta, for example, identified an optimal set of sites early in its provincial strategy, and then launched sites starting with the most willing and the most needed. OTN came into being as the merger of three independent pilot projects, and built on their existing, locally-driven, networks. Many provinces, such as BC and Quebec, have focused telestroke pilots or planning on larger-volume (sub)urban hospitals, given their volume of patients and already-available expertise and

infrastructure. Others, particularly Manitoba, have placed priority on the most remote communities, which have the minimum services. “In Manitoba, 15% of the population are in really small clusters and remote locations, where a centre might only see 12 strokes a year. We’re focusing on the most Northern first, then we aim to have the whole telestroke model in place for all major centres.”

In identifying first telestroke sites, Canadian experience suggests that mid-sized, less centrally-located sites may good starting places: small enough to want telestroke, large enough to acquire and retain expertise, and to take on the added role without detriment to their ability to provide other services. Furthermore, Canadian experience suggests that telestroke may be more able to deal with Canada’s dispersed geography than either the literature or healthcare planners anticipate.

Coherent selection of telestroke and acute stroke care sites

In the early days of Canadian telestroke, telestroke site selection tended to be opportunistic, establishing services where existing infrastructure and site eagerness coincided. Later expansions have become increasingly strategic, to address specific gaps in access or the continuum of care.

The BC experience highlights some of the challenges of setting up telestroke prior to the establishment of a provincial stroke system. A 2010 BC Stroke Strategy report concluded that the lack of a provincially-organized stroke system had limited the impact of its five years of investment in stroke services. A crucial continuing gap is the lack of site designations with bypass protocols; notes one informant: “they go where they go, and that’s where we treat them.” In consequence, only 4% of BC’s hospitalized ischemic stroke patients receive rtPA, and there is no system to ensure even those get appropriate follow-on care: “You can’t have it so that someone gets rtPA (at the hospital) where they arrive, but stays there and doesn’t get best practice care over the following weeks.” BC informants thus see completing the provincial system of site designations and associated bypass protocols as a critical prerequisite to expanding BC telestroke beyond its two initial pilots.

In another scenario without a connected system of stroke care and telestroke designations, a patient may bypass the nearest non-rtPA-enabled hospital, receive thrombolysis at a telestroke hospital and then, after a short period of observation, be shipped not to the nearest stroke centre, but instead be “repatriated” to the hospital that was originally bypassed, and which does not offer specialized stroke care. This “drip and slip” (our phrase) may occur when telestroke sites are selected through a separate decision-making process from other elements of the stroke strategy. Ontario, for example, is now seeking to create greater convergence between its telestroke services (led by OTN) and its broader stroke strategy (now led by the Ontario Stroke Network, OSN). “We’re moving from an opportunistic approach, to how do we best provide *both* telestroke and stroke unit care across the province,” to ensure that the potential of Ontario’s exemplary rtPA rates is realized by commensurate best-practice post-thrombolysis care.

In another example, Alberta’s most recently-launched telestroke site was explicitly chosen to plug a hole in the provincial access map: “In choosing High Level as a primary stroke centre, it was about the geographic location, not the population density or stroke volume.” Alberta may now be as close to comprehensive access as geography allows: 95% of residents, if they contact EMS, can be taken to a rtPA-enabled facility within 45 minutes (using ground and/or air transport).

Benefits and challenges of large urban telestroke sites

Although telehealth is often thought of as a rural service, it can in fact serve the greatest number of patients if implemented in large conurbations such as the GTA in Ontario, the Montreal area, and the

lower mainland in BC. Since “time is brain”, it’s worth saving a 50 minute ambulance trip from, say, Ajax to downtown Toronto, by having telestroke facilities in Ajax: the population served is about six times that of a telestroke site like Camrose in Alberta.

However, larger hospitals are not always the easiest places to start developing telestroke services. For example, BC prioritized fast launch of telestroke, and therefore selected pilot sites which seemed “almost ready,” needing just a bit of extra support to enable effective rtPA administration. These sites were large urban hospitals, close to and having existing relationships with tertiary centres, with stroke services already in place, CT scanners available, and sometimes also neurologists (though not necessarily stroke neurologists or 24/7 coverage), plus a high volume of strokes which would justify learning the new approach. However, an unforeseen corollary of a site being “almost ready” was that many participants did not see any need for telestroke: “They don’t see themselves as rural and remote, and needing telehealth for specialized service – they can just send patients by ambulance (to the tertiary centre).” Consulting neurologists may equally see the extra travel time as worth it to get the patients to a comprehensive stroke centre. Engaging providers in larger hospitals can thus be unexpectedly difficult when “the sites weren’t asking us for it,” and supposed ‘easy-launch’ sites may not be.

MacGyvers of the rural and remote

In contrast to urban hospitals, informants have found that small and remote sites are usually the most interested in telestroke, and less resistant to change: “I found when I lived up North that people were motivated to make change; in the South, they’re more hesitant, more careful.” Unfortunately, though, “the communities that need telestroke the most don’t have the resources to do it.”

Small remote sites lack the volume of stroke patients, and have very limited staff and high turnover, especially among physicians. The set-up costs of telestroke are small, but the operational costs substantial for the budget of a small hospital, particularly since many costs don’t scale down beyond a certain point. “There are a lot of other operating funds required to make it viable, there’s a whole bundle of services and people you need in place. The cost adds up quickly. We have a remote community, very isolated, which would make an ideal site – but it doesn’t have a CT technician who can work 24/7.” Furthermore, “you’re dealing with training that isn’t used very often – when people aren’t used to using the system, there are huge challenges when the need arises. In concept, telestroke for remote sites is great. In practice, difficult.”

Many informants, as well as the literature, therefore suggest that very small hospitals should probably not become telestroke sites. Some noted that a high volume of strokes is essential to provide effective telestroke: “We do over 200 rtPA cases per year, but for a small site, 25 would be a lot. Then each physician only sees the odd case and doesn’t acquire familiarity, so it’s really important to have site selection which ensures a reasonable volume.”

And yet - Alberta has successfully developed telestroke in sites which fall far below size recommendations elsewhere: Westlock, for instance, has about 5 rtPA cases in a year. In addition, these small hospitals are now devoting significant resources to all aspects of stroke, not just to hyper-acute. One lesson learned is that a

small, eager site may, despite its lack of resources and infrastructure, be more successful than a larger well-resourced (sub)urban centre that sees little need to change its current practices. Having an engaged,

“You have to make do with what you’ve got. We don’t have a respiratory technologist, but we deal well with respiratory patients – we all work well together. In an average day, one of our nurses might deliver baby, get called in to do a stroke in the ER, consult with the nurse trainees... we’re MacGyvers.” *(informant)*

willing site should perhaps trump almost all other considerations, especially in the selection of first sites, where experience is limited and impact of failure on subsequent uptake and broader implementation may be large.

Case study: Telestroke in Camrose

Informants from across Canada mentioned St. Mary's, a 76-bed hospital in Camrose, Alberta (population 15,000) as a model of telestroke success. Before becoming a telestroke site, stroke patients would be transferred to Edmonton; now, 95% receive quality stroke care in Camrose.

"We've been very successful because every department is involved." The moment EMS calls, everyone starts to get ready, so that by the time the patient arrives, the CT technician "is standing at the ER door with the lab technician too, sometimes drawing blood as we put the patient on the table." Door to CT time? Under 1 minute. Best rtPA time to date is 34 minutes. But Camrose staff found that "Once you see what you've done for them, then you realize, 'we can't stop with rtPA!'" Determined to be a true primary stroke centre, St. Mary's has transformed itself.

"Our inpatient unit has reduced length of stay tremendously: it's not just one area or person, it's a huge team approach." St. Mary's has created process, protocols, and teams determined to get everything done better and faster – diagnostics, swallow tests, ultrasound, speech pathology, education, dietician, access to rehabilitation. Telestroke applications are widely used to support prevention services, follow-up with neurologists, and in-patient rehabilitation.

All this has been achieved with no new money, no extra staff: "We haven't added new or different people, but all have had to take on huge new roles, it involved much retraining." The result? Satisfied patients getting better and more comprehensive care, closer to home, and at a lower cost. "Post-tPA patients now go home in 4 days – it used to be on average 17 days. We've saved \$2.1M by instituting the stroke program, just because of the shorter stays."

EMS role and bypass protocols

With designating sites of care comes creating protocols that ensure strokes are identified and patients get to the right site quickly: EMS therefore play an essential role in telestroke. EMS transport protocols must identify where a patient picked up anywhere in the province will be taken, and how (ambulance, air), in order to ensure that most people in the province have a defined route by which they will be taken to a rtPA-capable hospital as quickly as possible, within 2 hours of calling 911. Ambulance personnel must be trained and able to recognize acute stroke, to know when to activate the stroke protocol.

Creating province-wide bypass protocols was relatively easy in Alberta compared to other provinces, as Alberta was in the process of consolidating all EMS services into a single, provincially-run provider with highly-trained personnel. Negotiating with a single EMS provider simplified implementation of the protocols and associated training, though it did reduce the ability to build local relationships. Unlike most provinces, all Albertan EMS providers were trained to a consistent high level which included stroke assessment, so implementing the telestroke protocols required only refresher training on using the specified stroke scales (20).

Several informants noted that EMS contributed significantly to Alberta's telestroke success: providers were very enthusiastic and constantly looking for ways to make the process work better and faster – for

example, notifying the ER that a “hot stroke” was on its way, or bypassing ER triage and taking patients directly to CT. “They eliminate much time by taking on these extra jobs; they’ve been instrumental in reducing our time to treat.” With experience, EMS personnel can become proactive, and make increasingly complex judgements for individual cases, considering not just which centre is nearest, but its capacity, current case load, and other considerations which ensure that the patient gets the fastest treatment - which might not always mean going to the closest centre.

Developing comprehensive bypass protocols can be considerably more challenging in other provinces, however. In Ontario, for example, ambulance service is a joint responsibility of approximately 50 municipal providers and the Ministry of Health, which provides 50% of the funding and maintains standards; each telestroke site has had to negotiate its own sets of bypass protocols. Some informants suggested there remain areas where such protocols are not yet in effect. Newfoundland and Labrador has 911 service only available in metropolitan areas, and relies on a combination of hospital-based and private EMS companies whose personnel mostly are not trained to the level where they could do a stroke assessment and select patients to bypass. In Saskatchewan, stroke patients tend to be transported by private vehicle rather than ambulance, which renders bypass protocols irrelevant; informants suggest costly ambulance changes, in addition to the distances involved, deter effective stroke care (21).

While bypass protocols are essential to the provincial system, individual hospitals may not welcome a major – and often unfunded – increase in patients who need complex care. “We’re a long way from doing bypass protocols, because then you have to tell a particular ER that they will get more patients than they bargained for.” On the other hand, after experiencing the benefits of rapid access to rtPA, providing best practice care can become addictive: when one small telestroke site was become overburdened, staff were told to redirect patients to a distant site “but we refused – it’s too far for them to go.”

“There are no bypass protocols, so some patients are kept in these sites, at their peril.” *(informant)*

Bypass protocols are an important component of an organized system of stroke care, not just telestroke. Even within a single city, EMS needs to bypass those hospitals that do not administer rtPA, and go straight to those which do. In Toronto, for example, implementing city-wide bypass protocols has resulted in a 4-fold increase in patients treated in rtPA (22). Bypass protocols also are becoming increasingly recognized as important in other areas of health care. One province, for example, is building its stroke protocols on an existing trauma model, while another has found that the stroke protocols are “driving the next phase of cardiac care, that is, using bypass and improved assessment within EMS.”

Can telestroke be provided as a stand-alone service?

Having identified the development of a system of stroke care as a prerequisite to telestroke, some telestroke efforts across Canada seem to have become paralyzed by the scale of this challenge. Must a provincially-organized system of stroke care truly come first? Thrombolytic telestroke services can of course be established without being part of a comprehensive system of stroke care: this is how telestroke has generally been done in the USA. An individual hospital can link with a comprehensive stroke centre in order to administer rtPA safely; the patient is usually then transferred to the tertiary site (“drip and ship”). This approach will increase the use of rtPA at a particular site and allow patients to benefit.

Stand-alone telestroke may be less effective and more costly, and provide access to better care only for a few. Nonetheless, while our informants emphasize the importance of ultimately aiming to

“Just say yes to things! Do what you can – if you can’t have 24 hours, do 16 – it’s still way better than not doing anything at all.” *(Key Informant)*

“do it right”, they are equally clear that **any telestroke is better than no telestroke at all**. Imperfect solutions – such as part-time availability or local access only (e.g. without bypass) – are difficult and less-than optimal, but they still save lives, even if not as many as they could. And they open the door to expanding telestroke services, dissolving barriers as providers and patients experience telestroke benefits.

2. Central leadership/ coordination

“Our advantage was the Alberta provincial stroke strategy. It was phenomenal: a centralized coordination group that brought everyone together to build a common goal, standards, pillars. It kept the focus on the ultimate goal: the delivery of whatever that patient needed, in their own community as much as possible. *(informant)*”

In the US system of private health care providers, a single hub or health care company usually drives a telestroke network. In Canada, however, provinces fund and set the rules for health care, and informants emphasized the importance of provincial leadership, not just in establishing a provincial stroke system, but in making the implementation of telestroke within it possible. Provincial leadership is necessary both to have sufficient authority to make change, and to match patient needs to collective system capacity.

A central body charged to deliver provincial strategy can ensure that investments in systems and equipment are made to maximize consistency and compatibility, and reduce variation by institution or region. It can make the connections between stroke priorities and broader health initiatives, for example, investments in province-wide image storage systems, telehealth or EMS. The province remains an important draw for influential champions, can ensure appropriate funding, coordinate the various pieces, and undertake consistent evaluation to support the eventual integration of pilot telestroke services and funding into long-term stroke care objectives, budgets and practices.

A province-wide approach is often necessary to achieve the needed volumes of patients and specialists, and match them to a supply of accessible facilities, regardless of where they are located. Telestroke crosses institutional and regional boundaries, and therefore needs leadership at a level higher than these borders. Where regional boundaries are hard to cross, telestroke can catalyze change: “Getting patients across the boundary wall between the health authorities has been very difficult – we call it the Berlin Wall of health care. So tPA is part of it, but the changes to the system to get access to tertiary care is big.”

Many of the systems involved in telestroke are province-wide, and need provincial authority to change: for example, negotiating province-wide agreements with EMS, or changing physician remuneration practices, billing codes, licensing standards, or credentialing rules. Effective telestroke builds on a number of critical healthcare platforms, mostly provincially-driven, including image storage systems (e.g. PACS), electronic medical records, and call-centres for patient tracking, directing and referrals.

More sharing of technology platforms and systems makes telestroke implementation easier, cheaper, and more effective: “It would have been great to have one common platform or way of doing things – to have the same expectation from one geographic location to another, the same service levels, same equipment – these really do drive a higher end-user experience and improve the quality – and the cost.” Provinces have the authority and the leverage to build in consistency from the start: “Alberta is unique because we are mostly with one [PACS] vendor. When it was first introduced, if you went with the one vendor AHS suggested, you got extra funding from the province; it was helpful to create consistency.” Existing Canadian telestroke networks are now putting a lot of effort and resources into replacing or improving the compatibility of systems and equipment originally bought piecemeal, site by site. A central approach is

also important for planning for technology maintenance and improvement, as well as site expansion, (i.e. using telestroke to support new care activities), as well as new site development.

Efficiency and patient safety require consistency in standards and protocols at all telestroke sites. It also makes no sense for each site to reinvent telestroke, rather than implement a common process: “if each region has to do it alone, it won’t happen.” A central body can identify the roles, skills, process and needs common to all sites. Sites should be trained by a central group that can create, share, and support common processes and protocols. Each site needs help to adapt and individualize these to their specific logistics, needs and capacities, while maintaining the required level of standardization and compatibility.

“It’s important to have good provincial structure, so we’re not all left in the pool, floundering. We could feel the support right away. Everyone I called would answer.” (*informant*)

Finally, telestroke is most efficient and effective when sites communicate: the province plays an important role in connecting sites so they can mentor and learn from each other. It can also monitor performance and best practices – locally and internationally – and have the mandate to make system-wide changes.

“You need some provincial body that can help to coordinate and has a mandate and accountability for change. But you must focus on the fact that it’s the region that has to change.” (*informant*)

3. Engaged care providers

As with all innovations in healthcare, frontline champions make change happen: “Central coordination ensures you don’t keep reinventing the wheel; but the need, and the resources to do it, come from the grassroots.” Informants have experienced telestroke sites that excelled, and sites that struggled, and the difference was always in having a determined champion on site. Until such a person has been engaged, a referral site may have the telestroke equipment, but it won’t use it: “Telestroke was seen as just one more thing the big city is making us do.” While potential sites need to be *identified* through a central process, telestroke cannot be successfully imposed from outside, but rather must be drawn from within.

A corollary is that the process must be driven by *clinical need*, rather than by technology: once a site recognizes that telestroke responds to its clinical needs, the staff are engaged. “They have to believe this will improve the health of their patients. If they have no vision for that, it will go nowhere.” A good first telestroke experience can be powerful: “We were lucky: our first patient had a successful telestroke consult, was tPA eligible and recovered well - which provided immediate validity to our technology. He walked out of the hospital, it was a real good news story. This worked wonders.”

Reluctant sites and rtPA

“Everyone was so obsessed with the technology, that’s all they would talk about. But really, all they have to be able to work is a remote control. What I want is physician education: fly me out a guy from Ontario – an emergency physician who’s doing it - to host a dinner, talk to our emergency physicians about how, what.” (*informant*)

In informants’ experience, engaging ER physicians is the biggest challenge. If they do not believe rtPA is safe or effective, they will not see any point in telestroke, which has become equated with rtPA. If unconvinced of the benefits of rtPA, few are willing to take on its risks. Unfortunately, the Canadian Association of Emergency Physicians (CAEP)

continues to maintain its decade-old policy against the normal use of rtPA, despite international agreement that the case for efficacy and safety of rtPA in hyper-acute stroke has been now been unequivocally made, and contrary to the Canadian Best Practices Recommendations for stroke care. As generalists, ER physicians depend primarily on their own professional guidelines rather than specialist literature, with the result that informants all across Canada consistently found the CAEP policy cited as the primary reason not to implement telestroke.

People, not paper, is the key to providing access to the kinds of information that enables change. Informants have found the most important step in engaging sites, especially where physician resistance to rtPA is strong, is peer-to-peer knowledge exchange, through discussion between participating clinical colleagues, starting long before telestroke implementation. These discussions allow physician site leaders to review and assess the evidence with peers, and draw their own conclusions about what is best for the patients in their care: “Some were reticent to begin, because they thought it was all a push for rtPA, but the soft sell, the evidence, and ongoing collaboration, have turned the tide.”

Consulting neurologists have been essential telestroke champions, playing a key role in visiting, mentoring, and supporting their colleagues in referring sites, and building trust and confidence. Neurologists can help prospective primary stroke centres assess the demand for the service, and understand their current practices and patient transfer protocols. Successful Canadian telestroke services have been driven by passionate neurologists who dedicated enormous energy into travelling to new referring sites, addressing concerns, and achieving buy-in. As one neurologist described the process: “We let them know the impact of stroke on the individual and their community. We gave them hard numbers. When they understood what it means to treat within the window (for rtPA), and that they could do something effective.... then we didn’t find hard resistance. Once they started doing it, they were on board, even at the really small centres. Initial resistance stems from fear of the unknown. Once they crossed that barrier of fear, it was much easier.”

“Last night, I worked with Peace River, a 55 year old who had a stroke, tPA was administered by the primary stroke centre. This morning I called them – he’s fully back to normal.” *(informant)*

From the other side, one referring site physician explains, “You have to feel supported by the education program and the consulting neurologists, to trust them to hear your problems and do something, and know they won’t hang you out to dry. You must have confidence that you are working with good partners.” In many sites, initial trepidation rapidly gave way to excitement: “The emergency department is thrilled to have the machine, have an expert on side, and provide a higher standard of care.” Informants described how some vocal opponents of rtPA have become its champions, once they experienced for themselves the difference it can make for their patients.

Where the champions are

Telestroke champions at referring sites arise from a broad cross-section of the health-care professions, with ER nurses prominent, as well as occupational and rehabilitation therapists, senior administrators, and imaging specialists. Successful front-line champions are rarely technology buffs, but health professionals who have become convinced that their patients are not receiving the best care. “Once you show what a difference telestroke can make, it’s what any reasonable person would do. Am I going to say, ‘No you can’t have the best treatment possible?’”

In so many conversations, we were impressed by the “must-do, can-do” attitude of those involved in telestroke programs, and their determination and initiative in circumventing roadblocks: “*Can’t* isn’t in my

vocabulary” said one. When the improved patient outcomes become compelling, there tends to be a “just get on with it” attitude which ignores non-clinical issues like governance structures, service agreements, payment schedules, etc. “Sometimes others provide resistance, but we just found ways to do it.” In one example, a small hospital had been struggling for a long time to introduce telestroke. Eventually a head ER nurse became its champion, and drove the preparation, training, and process changes. She was permanently on-call during the early months, and came in for every stroke patient to oversee the process, guide the physician on duty, and later help the ER nurses catch up with work disrupted by the stroke. In time, the value of telestroke became obvious, and there is now enthusiasm not only for rtPA, but for a wider range of best-practice stroke care, supported by telestroke.

Engaging whole telestroke sites

Although the importance of a site champion cannot be understated, informants have learned – the hard way – to engage the site staff as a whole, and not limit their focus to any specific provider group: “Lesson learned: we should have taken a broader view, included all health care providers, the nurse educator especially as a site leader. Training needs more creative approaches.” Furthermore, it is critical to *support proponents*, and not just focus on *persuading opponents*. For example, strong nurse championship of telestroke, combined with significant ER physician reluctance to use rtPA, could create a combative atmosphere without efforts to engage and connect all team members. While every provider group has unique issues and needs, most solutions require cross-disciplinary change: providers left out of the discussion are not likely to support the solutions. For example, radiologists must buy-in to giving stroke patients priority, and allow ER physicians to directly order basic CT scans. Internal medicine may need to expand on-call coverage to ensure capacity to admit stroke patients to the ICU, post-thrombolysis.

Most facilities have never administered rtPA for stroke before becoming a telestroke site, so telestroke requires a change in ER priorities and demands on resources. It’s not just business as usual, with a bit of technology added. The stroke patient who used to take almost no resources – because nothing could be done – suddenly becomes the ER’s overwhelming priority, and in a small hospital, can consume a significant portion of staff resources for several hours. ER staff recognize that “if they don’t move the patient out of the way, other people are at risk. So they’re asking, why do I want to create a critical care issue here?” Informants describe how “Physicians’ concerns included workload issues, not wanting to deal with patients they don’t know, feeling overwhelmed by the technology, high-stress demands, extra work.”

“Successful telestroke requires significant shift to a team mentality - you can’t be territorial anymore. It was a new way of thinking for us. But now it’s routine.” (informant)

Procedural changes aren’t restricted to thrombolysis. “One lesson learned was that we all focused on emergency, but forgot that after rtPA, the patients go to critical care – internal medicine needed to know what’s going on, to be in the loop so they could be ready to deal with patients that have been thrombolysed. You have to figure out if ICU has a bed, and they must be able to do 24 hour monitoring – the stroke patient can’t just go to the general medical ward. That has a big resource impact.” Internists, not just ER staff, need to be ready for complex, high-risk patients: “Again, the fear for the physicians is: ‘what if the patient hemorrhages post-thrombolysis? I am not equipped to deal with this.’ Internal medicine just fell ill-equipped, they are not specialists in neurology, and feel a little nervous.”

Informants asserted that an engaged site will find a change to overcome any barrier – and an unengaged site will find a barrier to overcome any change. One hospital couldn’t achieve good door-to-needle times because only the CT technician was allowed to turn on the CT, so imaging was delayed until the technician

was called in, turned on the machine, and waited 20 minutes for it to warm up. Such trivial barriers can seem insurmountable until there is the will for change. Now a nurse turns the CT scanner on as soon as EMS radios that they are on the way with a “hot stroke”. Other sites have changed their practice so that the CT machine is never turned off. At another hospital, the ER physician was not allowed to order a CT scan: only the radiologist could, but he was only available business hours. Providing participants with time to identify patients’ needs and work together to identify solutions has usually resolved these issues – but an important lesson is that rushed implementation is more likely to create than fix such barriers.

Engaging consulting neurologists

“Our neurologists have been amazing. Every time a new possible site was suggested, they jumped on board – “what can we do, how can we help?” They have flown all over the northern half of the province, providing education, mentoring and support; they’ve been willing to be on call and carry pagers. They really go beyond the call of duty.” *(informant)*

Neurologists have been major drivers of Alberta and Ontario’s successful telestroke services, both in making the case for telestroke in the first place, and in making it work. Without such champions, some provinces have struggled. A number of barriers can limit neurologists’ engagement in telestroke, top among them being their small numbers in many provinces. With few of them to care for a province’s worth of patients, telestroke can present a worrisome prospect. And where neurologists are mostly fee-for-service rather than academically-based, they will have limited availability to participate in the time-consuming administrative processes of system change and telestroke development.

Other concerns which have been expressed by neurologists who haven’t experienced telestroke include questions about the service itself: is the quality of the video consultation adequate, are patients better off transferred to a comprehensive stroke centre? “Once a patient gets to many of the less remote centres, the neurologists feel like ‘they’re only 45 minutes away from best-practice care here – why would I help them get less-optimal care when they’re so close?’ But the patient may have already traveled *hours* to get to that centre: they don’t *have* another 45 minutes.” Another issue is that neurologists do not typically engage in emergency care, and some may not wish to add this to their scope of practice.

In the most successful services, consulting neurologists already saw the stroke patients from across the larger catchment area as “theirs”, and telestroke simply as a means to provide them with better, faster care than they could receive otherwise. In Edmonton, for example, “Capital Health saw itself as very much in service to those five other health authorities.” A challenge for

“We created so many sites, some thought we might need to pull back. But sometimes you get a call from a place where there’s no telestroke centre nearby, and you know that person isn’t going to make it without one. So you know you need to support them all.” *(informant)*

particular consideration by provinces assessing the OTN network model, as opposed to the Alberta hub and spoke model, is whether it will be more difficult to attract consulting neurologists to take on the responsibility, work and cost of patients. For example, some neurologists involved in Ontario’s original small and rather personal networks were not able to make the transition to supporting a province-wide network. Even within natural referral areas, some provinces find that “our specialists resist taking calls from outside their patch;” this consultant challenge mirrors the referral-side issue of the reluctance of some hospitals to taking on greater stroke patient volumes through bypass protocols.

Remuneration

Remuneration features at the top of the list of telestroke barriers in the US, where neurologists may fear losing income when patients are treated at the primary stroke centre, rather than being transferred to their specialist care. Canadian neurologists are more concerned about their *increasing* workload, since telestroke enables them to engage in the care of an increasing proportion of stroke patients. In consequence, remuneration is less of an issue in Canada, but has still proven to be a barrier in some provinces. There are two issues: first, payment for the actual tele-consultation, and second, payment for on-call time. With respect to the consultation itself, BC, Ontario and Alberta have changed provincial fee schedules and/or contracts (where applicable) to include tele-consultations.

An on-call roster must provide for 24/7 telestroke coverage, recognizing that the neurologists will have local on-call responsibilities as well. Considerations include the willingness of physicians to provide the service, the scale of the demand, the number of participating neurologists, and their current remuneration models (i.e. academic payment plan vs. fee-for-service). In Alberta, most neurologists are salaried, telestroke consultants are all part of the same hospital, and there is no additional payment for the additional on-call time. In Ontario, most neurologists are fee-for-service, telestroke participants are distributed across the province, and OTN runs and pays for on-call time of both a primary and back-up telestroke consultant. In Ontario's pilot sites, the neurologists were originally volunteers, until the day when "there was a weekend no one wanted to do". Recognizing the risk of losing the valued telestroke service, the Ontario Ministry of Health quickly arranged for an on-call stipend, now seen as essential to maintaining neurologists' participation in the program. The BC pilot sites involved neurologists working under both funding models. BC does not currently fund telestroke on-call time: neurologists are compensated within their existing regional or hot-stroke based on-call agreements. However, as one informant notes, "as you ramp up to more and more sites, the neurologist can't this run off the corner of their desk! Expectations need to be set. Since we're only supporting a couple of sites, we are able to absorb it. But if it was being done on a provincial level, we would want 15-20 sites in total, and would need an independent fee schedule and an on-call stipend."

Fortunately, provinces now developing telestroke are able to draw on the experience of others in negotiating remuneration, but in some agreement has still proven very difficult to achieve. It is worth noting that while *lack* of remuneration may create a disincentive to participation in telestroke, *availability* of remuneration is rarely seen as an incentive. "The biggest push back comes from 'I've already got call; I don't want the money – it's not worth my while, I'm obligated to look at people in my own hospital.'" If the neurologists are convinced of the value of telestroke, they will find a way to make it happen. If they do not believe telestroke is worth doing, changing the billing codes won't change any minds.

"With the implementation of telestroke, your whole focus of care changes: it used to be 'poor stroke patients, put them in corner, because we can't do anything for them'. Now we have a totally new, overwhelming, priority. But at the beginning, we didn't have the buy-in for it, we hadn't done the education yet." (Key informant)

4. Effective support for the front-lines

Telestroke is less about adopting a technology than about changing the way stroke care is conceived and delivered. The telestroke site has to accept a new and disruptive mandate, build teams which connect the key players, and develop processes that ensure everyone knows what to do, and do it quickly in a busy ER.

Successful telestroke is clinically-driven, rather than technology-driven, and implemented to be responsive to the clinical realities of each site. “In the ER, there’s big heterogeneity – GPs, emergency physicians, internists. There’s a hesitancy to administer rtPA: they’re dealing with low volume and have limited experience, so they have low confidence in their expertise. Initial feedback was that people are intimidated, mystified, don’t feel capable – addressing this needs to be a big part of a strategy. It takes considerable resources to demystify telestroke, and give the site ownership. Not to mention preparing them for what to do when ‘the usual person’ isn’t in that day!”

Building the team

The different service providers implicated in stroke care must be moulded into a cohesive team, “so that when the patient shows up, everybody knows what to do.” One informant described the change: “I was an ER RN when telestroke was first implemented – I saw a brick wall, the nurses were terrified. But now we have a stroke team, working together, and the walls are gone. To go from being scared to death, to see what we can do now, is just amazing.” To make this happen, the site champion needs clinical and technical support, information, contacts, education, networks and other resources to help them engage colleagues and prepare the site. Although the frequent champions and implementers of telestroke, nurses may be ignored when educational efforts focus on engaging reluctant ER physicians. It should be recognized that the bulk of the work falls on nurse leaders, and they need support as agents of change.

“When a stroke comes in, everything else stops. We only have 2 RNs per shift, so one is tied up for a minimum of 2 hours, and it could be a lot longer if tPA is administered, or there are any complications.” *(informant)*

Adapting processes and protocols

Education and support personnel from the provincial strategy need to work with the new telestroke site staff to identify the changes to protocols, skills, order sets and workflow processes that will be needed. In sites without rtPA experience, it starts with redefining stroke itself: “We had to do a stroke code: it changed their understanding of stroke. Now it’s like an MI [myocardial infarction]– a demanding emergency.” Protocols and order sets have to be created, as well as plans for dealing with contingencies (medical, technological, weather), in addition to what happens after the thrombolysis.

The telestroke site will need to figure out how it can respond to these demands, given competing needs. The smaller the hospital, and the larger the new catchment area for stroke patients, the more dramatic the impact of a new telestroke service will be throughout the hospital, and not just the ER. Central support staff help site staff identify what needs to be done, and also their options and available resources. They need to understand where variation is acceptable and necessary, and where standardization is essential to effectiveness and patient well-being. For example, physician and nurse roles may be different in a small ER where only one physician is on duty: “We used to try to keep the physician in there for the entire telestroke consult. Now he can go help others, and we bring him back in for the final word. A telestroke consult can last up to 30 min – you can’t leave your only doctor in there for that long.” In response, some sites have trained nurses to do the remote patient assessment under the direction of the consulting neurologist, which frees the ER physician to attend other patients.

Clinical training

Training must address the heterogeneity of ER physicians and staff resources, the high turnover of health professionals in some rural settings, rotating locums, limited stroke training and experience for many

providers, and the confidence issues arising from substituting aggressive for palliative care. “When you’re looking at the ER, you have to realize they are dealing already with an expanded level of practice.” Service providers need to learn and practice the new clinical approaches; some sites use mock incidents before the first telestroke consultation takes place, and routinely to maintain team readiness.

Larger sites, even when not new to rtPA, still found the transition to telestroke challenging: “We did a lot of training of the critical care staff. We revamped the order sets half-way through the implementation: we had assumed they were in place – but they were either lost or outdated. So we brought together a multidisciplinary team at each site to revise/create an rtPA order set: it included pharmacy, internal, emergency physicians, critical care, nurse leaders. It turned out to be a really good exercise: they were all there, they all had to go through the Best Practice and see all the guidelines, which made it easy for them to do a refresher on best practice in both the ICU as well as the ER.”

Low physician participation in education sessions can be a challenge, but the more they are engaged in the planning process, the more likely they are to attend training. Many informants also emphasized the importance of having physician education led by other physicians who have telestroke experience. Face-to-face meetings with the consulting neurologists are important to build relationships with the people on the screen and ensure that both participants in the consultation understand the process, the data required, and the time constraints at both ends.

The decision to administer rtPA is seldom straightforward, and follow-on care can be complex. The neurologists play an ongoing training and mentoring role for the telestroke team with every consultation. Experienced telestroke consultants have learned that their responsibilities include assessing the site as well as the patients. As one explained, “We try to be very cautious with first cases, we don’t want early adverse events. We try to make sure there is good candidate selection, and they have developed some comfort with the process and the drug before we start getting a little more aggressive.” For example, in one case where an ER physician had no experience and extreme anxiety with rtPA, the consulting neurologist arranged for the patient be dripped and shipped, to release the physician from responsibility for the patient as soon as possible. As sites gain experience with rtPA, the need to transfer drops.

Maintaining telestroke capacity

Maintaining capacity and enthusiasm is difficult, and particularly so in rural sites with high physician turnover and low volume of stroke patients. These sites particularly need ongoing training resources: “On remote sites, a stroke only comes infrequently, with long periods in between, so it’s a challenge making sure everyone in ER knows how to use the equipment. You can train them all, but when the stroke arrives, in the meanwhile a whole new group has come in.” This reinforces both the importance of site leadership and ownership of the telestroke service, to keep readiness up-to-date, and also the need to continue to support referring sites long-term. Ideally, a comprehensive training program includes regular site visits by a telestroke coordinator to each of the telestroke sites, ongoing learning audits of recent cases, regular testing of equipment, and, when needed, mock telestroke consults to refresh. “We have telestroke training as part of the routine orientation of new people to the program. I also always meet with a new physician right away. I give them the locum binders for the stroke program, so they know what to expect, what it means to be a primary stroke centre.”

Another challenge is to maintain the sense of urgency that drives a reduction in “door-to-needle-time,” rather than having it slowly rise again, as some of the best sites fear may happen if the team loses its edge. “Re-education is difficult, as it has no funding. But you always need to be doing something to keep the momentum going, because you can see the momentum wax and wane.”

Technology training

The final step in preparing a new telestroke site is technology training. Ideally telestroke should impose minimal extra burden on the ER staff, and not depend on the oversight of a single individual. Staff must be prepared for what to do when the technology doesn't work, and know how to get immediate technical assistance. Mock consultations, with trouble-shooting, are effective. Some have supplemented formal group training with a more casual approach, a trainer "just being there for a day, to grab people as they go by. These one-on-one sessions were a bit more practical, hands-on: I could pull in whoever was about, so they could try out the equipment."

Monitoring and feedback

Telestroke teams need feedback to appreciate the impact of their work, and the ability to share their successes and challenges across the provincial network of telestroke sites. This is especially important for sites that practice mock consultations for months without an appropriate rtPA candidate coming into the ER. Enabling staff to learn about the people who benefit – whether it's a stroke patient able to walk out the door, or another who was helped to watch a daughter's graduation using the video-consulting equipment – all make telestroke meaningful to those involved. "We all respond to data and feedback. Regular feedback, especially highlighting excellence in care, speaks well."

Some sites debrief after every telestroke consultation, to identify what helped and hindered the process. In its early days, a typical site may have a door-to-needle time closer to two hours than the desired 1 hour, but with time and determination can aim to ultimately better Camrose's record, currently 34 minutes.

Who are the trainers?

The telestroke services in BC, Alberta and Ontario are structured and supported very differently, but their consistent conclusion is the importance of having core people whose job is to make telestroke happen and support all sites. A central agency has knowledge that transcends all sites, and the ability to see and share across the whole system, can provide a consistent and effective approach to site launch and education, and cultivate with the participation of the sites shared standards, order sets, protocols, and check lists. A challenge for BC is that the pilot nature of telestroke did not allow for either dedicated or ongoing support; staff had many other responsibilities, and moved to other sites once sites were launched.

Alberta originally embedded its telehealth staff into local clinical teams, where they were part of the ongoing stroke system changes; participants ascribe much of Alberta's successful implementation to this approach. The telestroke coordinators were usually clinicians themselves, and their role was very operational, engaging with clinical care on the front lines. "In telehealth, we hired clinical teams, run mostly by nurses, not techies. At the start, it was all about gaining buy-in: it was not really about technology, it was about the concept of physicians practicing in a different way."

Ontario did not have an equivalent central body with authority to make clinical practice change. In consequence OTN initially took on significant responsibility for clinical aspects of telestroke as well as the technical ones which are its mandate. Over time, its experience became embodied in the OTN toolkit for new telestroke sites, which includes "protocols, orders, everything a site would need." In contrast to Alberta, the OTN role is more technical advisory to the sites during set-up, rather than operational in clinical implementation. In preparing a new site, the "absolutely fundamental first step is to identify a site lead and coordinator;" OTN ensures a physician champion is in place and there is appropriate sign-off

from the head of the ER or ICU, and spends 1-2 days on site, which then becomes responsible for its own implementation, with the Local Health Integration Networks (LHIN) and regional stroke networks, which have the budget and infrastructure to support education. Since its creation, the Ontario Stroke Network is also taking on an increasing role in central coordination and pulling together shared resources.

“When you put the machine in the process, it’s important to realize that the trick is not the technology. It’s about connecting the two physicians and changing the attitude and therefore the system.” *(informant)*

5. Relationships and trust

Informants consistently placed overwhelming importance on building relationships and trust among telestroke participants. Because rtPA is just one part of the continuum of care, participants need confidence in the whole continuum; otherwise, “You’ll never thrombolyse the patient based on advice from a guy you’ve never met.... You *have* to trust them.” This issue received such strong emphasis from so many informants that although it is also embedded in other factors, we felt it necessary to identify as a key success factor in and of itself.

Change management literature stresses the link between building trust and success. Informants equally agree this is key to engaging front lines and recruiting champions. The involvement of the consulting neurologists in setting up new telestroke sites is important in building trust with the referring site physicians, particularly in smaller sites where ER physicians may have little stroke experience. If the physician and the hospital are going to take on the responsibility for administering rtPA, they need absolute confidence in the system built around the telestroke consultation as well. The ER physician needs to feel comfortable enough with the consultant to ask “stupid” questions about stroke care or the technology. “The site took a lot of convincing. The neurologist went out, did face-to-face work with the physicians – that was building the connection; they knew who they were taking to, that was trust. He had a bit of knowledge too, but it was the trust that was really important. It can’t be an anonymous neurologist on the screen: the ER physicians need comfort, assurance that the patient will be properly managed, that they themselves will know what to do.”

Some neurologists described the importance of knowing the referring site in order to temper their advice, providing more conservative advice to less experienced physicians, and taking more aggressive approaches to treatment when appropriate. Knowledge of the referring site’s geography, vulnerability to weather, resources and competencies all also factored into the neurologist’s advice about when to transfer patients, and reassures the ER physician that the advice they are receiving is appropriate.

6. Coordinated infrastructure and systems

“The telestroke pilots were supported by three different legacy providers... Each developed its own solutions including videoconferencing and access to CT images. This makes it difficult for OTN to support given the variety in solutions and in the distribution of responsibility for technical support. This fragmentation significantly constrains the possibility of expansion and makes it virtually impossible for neurologists participating in different call groups to assist one another.”
Extracted from *Provincial Hyper-Acute Telestroke System Business Case, OTN 2007.*

Telestroke draws on much infrastructure created for other and/or broader purposes. With the exception of dedicated videoconferencing equipment, it is difficult to distinguish telestroke technology from

investments (this issue is addressed further in section 7 on Costs); here, we focus on infrastructure needs without debating what should be charged to the telestroke budget. At minimum, a province-wide telestroke infrastructure includes: a call referral management service; two-way videoconferencing; province-wide CT image access; 24/7 on-call neurologists, CT and laboratory technicians; enthusiastic telehealth support and coordination; and enabling provincial policies and laws in areas such as privacy.

Telestroke equipment

Telestroke requires three main types of communications infrastructure; in Canada, these generally operate in parallel using different systems and technologies:

- a) Means to contact the neurologist on call to indicate that a consultation is needed
- b) A two-way videoconferencing system
- c) A system to provide the neurologist with access to the CT image

a) Making contact

The referring ER staff must be able to alert the neurologist on call that a consultation is needed. In a one-to-one network this could be done through a direct phone call, assuming the primary stroke centre knows the neurology call schedule. In anything larger, a specialized call routing service is desirable. Alberta uses RAAPID (Referral, Access, Advice, Placement, Information and Destination), a provincial call centre that provides consultation, referral, admission, discharge, and repatriation services for all health services province-wide. Ontario uses its similar CritiCall service. However, it may be difficult for other non-emergency-based systems to deal with telestroke urgency.

“Once we had the machines, we could easily move them anywhere – it’s just a matter of a network cables, a couple of switches from Radio Shack.... it wasn’t much.” *(Key informant)*

b) Videoconferencing

Videoconferencing equipment is needed in the referring ER plus wherever the consulting neurologist is located.

The ER videoconferencing equipment can be fixed (easier and neater), but increasingly telestroke services recommend a portable set-up that is always available regardless of which consultation rooms are occupied. The videoconferencing equipment must be dedicated exclusively to hyper-acute stroke, or else it may be in use when the stroke patient arrives. In the ER, conventional equipment includes a battery-powered, portable cart with laptop computer, monitor, microphone, speakers, webcam with local and remote zoom, tilt, and panning capability, high-speed internet access, an IP/ISDN connection for videoconferencing, and data encryption. The consultant neurologist needs simpler equipment, a computer with a display adequate for the interpretation of the CT scan and patient assessment, the ability to manipulate the ER camera remotely, and a webcam. The two-way videoconferencing system should allow the patient, attending health care provider and the consulting neurologist to see and hear each other with good sound quality and light, and without transmission delays. Telestroke communications in Canada are usually routed through secure, dedicated, private networks, which ensure patient confidentiality but have considerable installation and operating costs. Internationally, many networks are now migrating to commercial internet providers, using encrypted transmission, rather than using dedicated networks.

c) Image retrieval

A system is needed which can rapidly transmit CT images from the referring site to the neurologist at a resolution that permits interpretation of the image so as to rule out a hemorrhagic stroke. The key to achieving rapid CT interpretation is PACS (Picture Archiving and Communication System), which, operating

on a universal standard (DICOM), allows rapid transmission, archiving and retrieval of image data, linked to an indelible patient identifier. The large images, as much as 1 GB per file, are usually sent to a repository, where they can be accessed and viewed by the neurologist.

Most provinces now have a PACS, though many are collections of smaller and partially-coordinated systems, rather than a comprehensive, province-wide system. In Alberta, telestroke and PACS were emerging simultaneously, so while “Telestroke was built onto what PACS was already doing,” it was also jumping the gun, with the result that “imaging was a bit cobbled together in the early days – there were a lot of work-arounds. But diagnostic imaging really stepped up – they could have made this impossible. We saw some people really understand the clinical case, and make it happen.” Eventually, two repositories were established, for the south and north of Alberta, with almost the whole province using the same vendor (thanks to provincial incentives) and having access through the Netcare portal, an electronic health record system. Even that didn’t solve all problems however, as images can sit in a queue for 15 minutes before neurologists could access them, requiring a separate “urgent access” process.

In contrast, OTN bypassed Ontario’s PACS entirely, as it consisted of too many separate systems with limited interoperability; OTN uses a separate e-film system instead. Ontario is still seeking the final answer to consistent imaging access, and is working on developing a system by which every hospital with CT can push their images to a web-based application, where neurologists can logon and view. It is still uncertain, however, whether this system will be able to support emergency applications: “The big expense is the ability to share the CT images: there is no simple solution in Ontario, but we hope soon....”

Because existing PACS are not seamless even when available across a province, access is often theoretically possible but difficult to achieve in practice. BC for example has province-wide PACS, but the various systems are not interoperable. Image sharing across regional boundaries is limited to the recently developed Imageexpress, which only supports image transfer from provincial facilities to Vancouver. The creation of Imageexpress was propitious for the telestroke pilot, whose consulting neurologists were in the Vancouver site: “If that hadn’t just happened, it would have been sort of like in the cold war if the Russians were trying to look at the Americans’ plans.” But even with the new system, “As soon as we get the call, we ask for images; there’s usually a 20 minute delay – but that’s not so significant if you’re 20 minutes away from hospital anyway.” However, if the neurologist is taking call from home, a 20 minute delay in accessing images would be unacceptable.

In conclusion, while informants in almost every province reported available province-wide PACS, this infrastructure may nonetheless not be ready to support province-wide telestroke services.

Telecommunications infrastructure

Rapid access to PACS needs to be supported by adequate bandwidth to transmit the large CT images. In most provinces this does not appear to be an issue, but informants report that in Manitoba telecommunications infrastructure is insufficient, and as a result, it currently takes 30 minutes for a CT scan to be sent from one referring site to the consulting site. “But the solution requires us to lay new fibre optics in the ground! This is a pretty intensive requirement, especially when you’re dealing with places that don’t even have winter roads. So we’re really struggling – how can we do this in a different model?” A CT image usually consists of some 1000 scans which are reconstructed by the radiologist upon receipt. Manitoba is assessing whether the file might be constructed and compressed before sending, or whether it might be possible to identify an essential subset of images, and send a smaller file that way. There are also network optimization solutions that have been shown to reduce transmission times for medical images from 20 to one minute (23).

In contrast, when telestroke was first established in Alberta, it was able to use Alberta's Supernet, a fully-secure, province-wide broadband network which was a world leader at the time. For the Edmonton-based network, Capital Health provided infrastructure funds, which were particularly important for covering the cost of the \$50,000+ bridge⁶ to support the videoconferencing.

Clinical infrastructure

Referring sites need a CT scanner, which is not a telestroke barrier, since scanners are now widely available in regional hospitals across Canada, and availability continues to increase (24). Discussion with informants across the country suggested that most of the regional hospitals being considered as potential telestroke sites already had CT available. In Ontario, for instance, there are 80 hospitals with a CT scanner, but only 20 of those currently provide telestroke services.

Nevertheless, to ensure full provincial coverage, sites may be identified that do not yet have CT: this was the case in a couple of Alberta's early telestroke sites, where a site's eagerness outstripped its infrastructure. Local fundraising efforts for a CT scanner supplemented stroke strategy resources, and potential telestroke availability was found to be a good fundraising incentive.

CT images must be obtainable 24/7, which has been difficult for smaller sites. However, as only a plain CT scan is required, many facilities have cross-trained an X-ray technician to provide CT coverage at night. The involvement of radiologists varies considerably by site, even within a single network. Some radiologists review and assess all stroke CTs immediately 24/7 and provide a report to the neurologist, which is incorporated into the telestroke videoconference consultation; others do so during business hours only; while at others radiologists only review the CTs the next day, and provide a report oriented towards the patient's longer-term care. The general view was that radiology review was not required when a neurologist was available, but if available at the referring site could offer an alternative consultation and a back-up plan if a neurologist was not available, or unable to see the image. Some telestroke sites see a handful of strokes a year, while others see hundreds, so radiologists, like ER physicians, vary considerably in their experience in assessing stroke.

A further 24/7 requirement is for urgent laboratory services: blood coagulation studies are usually done prior to rtPA. However, this requirement did not appear to present any challenges for informants.

Key considerations in telestroke technology

At-home access

At-home access for the consultant neurologist after-hours is highly desirable. It makes the on-call neurologist immediately available (no travel time to their office), and reduces the burden of being on-call, increasing neurologists' willingness to participate in telestroke. Lack of at-home access, stemming from privacy and technical issues, is a negotiating roadblock in some provincial telestroke planning.

BC has no at-home access, but both Alberta and Ontario provide it, in quite different ways. Edmonton has two portable videoconferencing monitors, which are taken home by the on-call neurologist: "this has required a lot of support from the AHS's fabulous telehealth people - their willingness to make this happen has really broadened the program." Neurologists can download a PACS viewer onto their home

⁶ A videoconference bridge assembles video streams from different sources, which may have different video quality, and creates a single video feed that can be viewed by all participants.

computers to access images via a VPN, with special clearance to address privacy issues (viewer software is Windows-based, but can be run in emulation on a Mac). However, telehealth staff can't officially support the home-based system, and take-home monitors must be in constant rotation among the neurologists – which works so long as the consultants are well-motivated, not to mention all co-located.

In Ontario, OTN has developed a simple solution which works well for its distributed consultants. OTN negotiated with the two major broadband providers, Bell and Rogers, to build a standard service package which is used by all OTN's telestroke neurologists; it includes computer, camera, software, and internet connection. Neurologists lease and pay for the equipment in order to have telehealth in their homes; the cost is \$150/month, "a nominal business expense, which is reasonable for the business generated." Rogers or Bell will undertake the primary installation, and then OTN staff install OTN-managed routers, which ensure the encryption of the data. Unlike a VPN system, neurologists can stay connected and don't have to spend time logging on, or worry about access or security. In the early days, to ensure security and speed, the province was paying for T1 lines into each neurologist's house, at a cost of \$1,400/month. As the internet has sped up and costs have come down, OTN has found that regular DSL lines and standard business videoconferencing solutions can now support telestroke.

Telehealth and the technical team

Informants emphasized the importance of focusing on the "health" side of telehealth. It is noteworthy that Ontario and Alberta both developed telestroke on the foundation of strong, functionally-independent and province-wide *telehealth* groups, not on existing IT departments. Both telehealth groups were clinically-driven, and focused on patient needs as opposed to technological opportunities. Strong clinical telehealth leadership that can draw on willing IT expertise is seen as the ideal combination; when balancing technology optimization versus clinical considerations, clinical need should usually win.

Traditional IT departments focus on administrative and business functions, but are neither structured nor resourced to support clinical activities, so may have difficulty dealing with the unique needs of telestroke. As one telestroke implementer explained, "If we were part of IT we would be looked on as a tool, not as part of clinical care, and we would never have embedded a person into the clinical program. But instead we sat with the physicians and nurses, and we worked with them very collaboratively."

Without an experienced telehealth group as a driver, informants often found inflexible IT policies as significant barriers, particularly in trying to work across regions: "I have a lot of experience with telehealth, and the biggest surprise for me was the amount of power the IT department has over collaborations that would result in better services – they can be the showstopper. The CEO (of the health authority) would say 'make it happen' but the IT people would have tons of policies and roadblocks to prevent it. The power of these people, and the time involved to make changes – I didn't expect that."

As expected, many telestroke programs have been plagued by technical failures. International experience suggests that between 10-24% of consultations experience problems (25). This points to the importance of ongoing support and maintenance, mock consultations, routine checks of little-used networks, and backup plans in case of technical failures. OTN, for example, routinely checks connections with neurologist's home computers. Several informants reported situations where, in a pinch, a CT image was held up to the video camera for the neurologist to see it. The most common technical glitch reported in Alberta seems to be that neurologists cannot easily locate the image in the repository, which suggests user difficulties must be addressed as strenuously as technical ones.

Because of its pilot nature, and the large sites involved, telestroke in BC was particularly reliant on sites' existing technical personnel; "In retrospect, I would have focused more on all the different stakeholders in the sites – the server guys, the network guys – so we were all building an ecosystem. There are so many parts that need to work in harmony. It needs a sound foundation, starting with wires embedded in the wall to the data foundations and PACS. It's like Jenga – stacking, or removing pieces until it topples." The site technology team, like the clinical team, needs to be identified and established well before it's needed.

Purchasing advice

Informants recommended investing in a particular technology, and purchasing software and hardware, only *after* the service requirements and standards for a network are determined, and the sites are engaged and ready. Buying equipment beforehand guarantees that it will sit in a cupboard, or require expensive and inconvenient upgrades by the time it is actually going to be used. Planning for a telestroke network must also include maintenance and replacement costs of hardware and software, upgrades and expansions, as well as likelihood of obsolescence and replacement by emerging technologies.

Ease of use and reliability are particularly important in the ER setting. Time and staff resources are limited in emergency situations, and the ER physician may have little or no experience with the equipment. The process must be simple, fast and seamless or it won't be used. If training or support is inadequate, or staff tell their colleagues how difficult the process is, the telestroke service will fall into disuse.

Since all Canadian jurisdictions already operate telehealth services (26), the obvious approach would be to take advantage of existing investments in infrastructure. However, telestroke technology and help desk support must be available both instantly, and 24/7; it cannot be shared with other services, and has no tolerance for error. Infrastructure which is perfectly adequate for other uses may not work for telestroke: for example, the call referral system or PACS may not be fast enough for emergency use. In practice, then, telestroke has special needs for support and infrastructure so that new investments are required. Nonetheless, it is important that telestroke equipment is interoperable with existing telehealth equipment, data links, and databanks. A considerable advantage for emerging telestroke services is that most Canadian hospitals now have telehealth connections, and therefore already have the network infrastructure (bridges, cables, etc) for videoconferencing installed; new telestroke services should be able to use this existing infrastructure.

"You're playing Russian roulette if you use telestroke equipment for something else, and a stroke comes in."
(informant)

Security and privacy

Different technological approaches have different capacities and mechanisms to address the security of patient data. Privacy legislation and its operational interpretation vary widely, and may restrict technology options. For example, a single hub/spoke telestroke service could be run on a cheap, simple, web-based platform, with a smartphone at each end, but such a neat technology solution is unlikely to be acceptable to Canadian privacy commissioners. Confidentiality considerations, rather than technical issues, have been the biggest reason why at-home access is such a contentious issue, and have dictated the solutions implemented in Alberta and Ontario.

Privacy issues also impact the ability to share patient information and images across health regions, even within a single province. In BC, for example, although PACS exists province-wide, firewalls, privacy legislation, and concerns raised by the new technology meant a Privacy Impact Assessment was required to allow neurologists to view patient charts and images coming from another health region. "(The privacy

officers) couldn't believe we were even asking to do this – they thought it violated every code, and said the neurologist can't look at the chart. We said it was done all the time, by phone and fax!"

Future trends in telestroke technology

Technology everywhere is shifting from specialized and expensive hardware to cheap consumer devices, and many informants believe the iPhone has sufficient resolution to be used for neurology teleconsultations (27). "Apps" are already available for iPhones (28) as well as for Android-based smartphones, eliminating the need for videoconference bridges and telehealth workstations for consultants, and making consultation possible anytime, anywhere, within cellphone or wireless internet range. However, along with the improved access, portability and user-friendliness of smartphones and tablets, come additional security concerns, of which the most obvious are the loss of the device, and electronic or physical eavesdropping on consultations conducted in a public place. Key requirements are that no patient information should be stored on the device at the end of the consultation, and that any connection to a patient interaction or records database requires strong authentication.

Already, telestroke networks outside Canada are taking advantage of the new technologies (29). For example, the JEMS system (30) consists of a proprietary server and compression technology to send up to 4 encrypted video streams and an audio feed to any mobile device with the JEMS "app", over public cell phone carriers. The consultant can receive the alerting call, view and interact with the patient, and see the CT scan on their mobile device, without need for any central services, such as an image repository, and, since the server is supposed to be "plug and play", there is no need for 24/7 technical support.

A trial using an iPhone for recording the remote neurological exam at the telestroke site and for interpretation by the neurologist showed that the remote and primary stroke centre ratings on the NIH stroke scale were in excellent agreement. The conclusion was that "the iPhone 4 is an economical mobile solution that can be used to assess stroke patients remotely with high fidelity and can be readily incorporated into a telestroke network" (31). With the conclusion that smartphones can be used both for image interpretation and the teleconsultation aspects of telestroke, it is hard to see how equipment costs can be considered a barrier to the widespread implementation of telestroke. Use of bring-your-own services is clearly the future of telestroke, and telehealth in general (32).

7. Funding

Other provinces point with envy at the \$30M and \$42M investments in Ontario and Alberta's integrated stroke strategies, and wonder how they could ever afford telestroke. On the other hand, Ontario and Alberta informants suggest hyper-acute telestroke for thrombolysis actually requires very little investment. What are the real costs of telestroke?

"It's self-sustaining, there's very little cost to it. \$27k and a little bit of labor, and you're flying." (informant)

In trying to identify how much telestroke costs, one feels like the characters in a Douglas Adams novel who learn that the answer is 42 – and must now try to figure out the question. Alberta and Ontario implemented telestroke as part of large-scale systems changes, building on major investments in stroke, health care, telehealth, and ICT. The challenge is in identifying how much of these larger investments should be ascribed to telestroke: all were essential, but none were undertaken for the sake of telestroke.

Direct telestroke technology costs

Alberta and BC reported a one-time cost of about \$25,000 to purchase videoconferencing technology for each added telestroke site, and those costs have dropped considerably (estimated now at about \$10,000 – or down to the price of a pair of iPhones if you can satisfy the privacy commissioner). Stripped to its most basic, that is the main added cost of telestroke as compared to providing the same care without telestroke. A one-time cost of \$10,000 compares rather well to hiring a stroke neurologist (if any were available, that is), at an average *annual* cost of \$250,000. These estimates assume that the central technology, such as the bridge, is already in place for other IT/ telehealth applications, which appears to now be the case across Canada (a bridge would not be required in an iPhone-based service). In early telestroke development when no such infrastructure yet existed, installation of a bridge able to support province-wide videoconferencing might cost \$50,000.

Many informants in Alberta and Ontario note that people, not funding, is the issue. In Alberta, for example, one informant explained that “There’s no doubt we needed the money for the infrastructure, but ironically, a lot of the funding wasn’t spent. The big thing was the champions in the zones, the initial people they hired into the programs. Anything to do with clinical telehealth, it’s got to have stakeholder engagement or they won’t go in the room or see the value of the equipment. It’s amazing what clinicians will do with the most minimal technology, if they really believe in it.” Another concurs: “We could have spent a lot more, but we had a standard in place, and we didn’t get additional equipment. It’s more about the resources, the champions - you don’t need loads of money to make it successful.”

Costs of practice change to support telestroke

As described in the sections on *Engaging/ Supporting the front lines*, there is a significant body of work to be done before a site is ready to take on administering rtPA. The implementation of provincial stroke strategies often involves the creation of regional stroke coordinators; building telestroke readiness can be a core part of their role. In the absence of this key resource, there would need to be a large investment in *telestroke* coordinators, who would then need to undertake much the same work in building clinical readiness across the site to deal with urgent stroke patients. Fundamentally, creating and learning to use new protocols which treat stroke as a medical emergency takes time and investment – but the amount that which relates to “how to use the machine”, as opposed to “how to view and treat stroke patients in a completely different way” – is comparatively small.

In Alberta, a wide range of people contributed time to telestroke-enabling practice change, as well as telestroke itself. Provincial telehealth staff were embedded in the clinical teams to support clinical practice change, including engaging sites, education and training, and on-site support. Regional and hospital positions were created to implement the overall strategy. The effort, time and costs specific to the creation of the telestroke service alone are impossible to disaggregate. However, more recent costs are somewhat more identifiable. For example, when Alberta launched its latest telestroke site at High Level, preparation included education on assessing stroke patients using NIHSS, managing acute stroke patients, and administering rtPA. There was also a mock telestroke incident to ensure all communication channels and equipment were functional, and the staff knew how to use them. In addition, one of the stroke neurologists from Edmonton travelled to High Level to orient the ER physicians. We estimate the training personnel costs for these activities at around \$4,000-\$5,000.

Now that OTN has developed specific training materials and guidelines over years of experience, preparing and launching a new telestroke site is fairly straightforward and well-defined endeavour for them, requiring ~1-2 days of high-level involvement to obtain site agreements, plus 1-2 days of OTN staff

on site for set-up and training. However, costs to the health system are embedded in ongoing operations, including the time of the site lead, its coordinator, and other hospital staff; as well as for the Local Health Integration Network and the regional stroke network and coordinators, who all play large roles in telestroke education, clinical development and support.

Ultimately, some spoke sites require substantive efforts to engage in a telestroke network, while others need less. Site preparation is probably the easiest place to cut costs, by focusing only on the tangible outcomes, such as changed order sets and protocols. However, informants emphasized that upfront investment in site preparation reduced later costs of repairing poorly-functioning telestroke services.

Clinical care cost-shifting

Informants and the research both suggest that, at worst, telestroke should be able to pay for itself. As no two evaluations or research reports choose a common set of costs to ascribe to telestroke, comparison is difficult. However, *acute* care costs should at worst be stable with the introduction of telestroke, and available evidence suggests they should decrease in the long term as a result of fewer transfers, cheaper local care, and shorter acute care stays. Camrose in Alberta, for example, found cost savings as a result of much shorter stays, while Edmonton profited from reduced transfers. By using telestroke to deliver expanded secondary prevention services, Alberta significantly reduced stroke cases despite an aging population. Unfortunately, studies tend to look at one specific impact (such as reduced transfers) and not system-wide, long-term impacts. What is clear, however, is that the costs and savings of telestroke are accruing in different places. Costs are shifting down towards emergency care in smaller hospitals, while savings accrue at an escalating rate as you move downstream past acute care to rehabilitation, long-term care, social services and finally, to greatest telestroke impacts, reduced economic burden on society.

The increased clinical costs of telestroke are most notable when a small facility suddenly takes on a large catchment of stroke patients through bypass protocols. Westlock Hospital in Alberta, for example, previously transferred all stroke patients the 90km to Edmonton. It now treats and provides comprehensive care for around 100 acute ischemic stroke patients a year – no small feat for a hospital with 45 beds, and ER staff of 1 nurse plus a hospital-wide float, and one physician. “It’s an amazing success really, that all these changes were made without the Ministry adding any extra operational funding for all those CTs, rtPA, follow on care, etc . Our diagnostic imaging manager never anticipated the demand, and went into huge deficit the first year.” Furthermore, as hospital expertise grows, “We are getting more patients brought here - other sites, EMS, neurologists will all suggest ‘bring them to Westlock’. So yes, telestroke has huge impact on hospital costs! We went into a huge deficit, it was a very stressful year. The ER people who set up the program have to be strong and able to stand up for their stuff.”

Those costs can clearly be a deterrent to a hospital becoming a telestroke site. Informants elsewhere describe an example where “telestroke didn’t work there so well - it was just easier for them to transport than to treat - to keep the patient, administer the rtPA, and manage them over the longer term. If you thrombolysed the patients, you keep them, and that’s a *huge* impact on your budget.”

An important role for provincial leadership in telestroke is to look at funding models and assess the incentives and disincentives for best practice care. Mechanisms are needed to ensure that funding follows the patient, if these additional costs are not to be a barrier to sites willing to administer rtPA. Block-grant funding of hospitals, in particular, can be a disincentive to adopting telestroke. In Ontario, the introduction of partial patient-based hospital funding may help to remove this disincentive. Despite the differences in the economic issues between telestroke in Canada and the USA, it remains good advice that

“A critical success factor for increasing adoption and deployment of telehealth is a transparent reimbursement model for institutions, physicians and allied health care providers.”(26)

Costs of infrastructure development and health systems change

The majority of the “telestroke” costs described to us by informants are in fact costs of creating and implementing a provincially-organized system of stroke care in which telestroke can function. Most provincial stroke strategy funding has been invested in changing the system and the people in it, designating sites, building stroke units, rehabilitation sites, and prevention services, all of which enable telestroke, but which will generally be done whether or not telestroke is planned.

Others costs ascribed to telestroke are part of the technical upgrading of province-wide health care systems (for example, PACS, call referral centres, upgrading paramedic skills and EMS protocols), and telehealth capacity (for example, training telehealth staff, expanding bandwidth, building telecom bridges). Since telestroke cannot exist without these foundations, these costs are important to consider. Where provinces have already made these investments, telestroke is a cheap add-on. Where such infrastructure needs to be factored into the telestroke budget, telestroke looks prohibitively expensive.

In Alberta, the opportunity to use telestroke was part of the incentive for overall system change to best practice care, and telestroke was developed within the broader changes. In consequence, the larger systems change is seen as part of the telestroke implementation process, but the costs of telestroke are buried in that reorganization. In Ontario, much of the systems change preceded telestroke development, so the additional investments made in OTN to support telestroke are somewhat more technology-focused and distinguishable. But as OTN has a *telehealth* mandate, not a *telestroke* mandate, much of the investment in telestroke is part of building broader telehealth infrastructure, personnel and capacity, and cannot be ascribed specifically to telestroke either; in fact the province itself no longer provides OTN with line-item telestroke funding.

So what does telestroke actually cost?

We conclude that while it is expensive to create a provincial system of best practice stroke care, there is only a small incremental cost to using telestroke to give more people access to that best practice care, once that system has been established. The further a province is from establishing a system of stroke care, the more expensive telestroke appears to be.

In the literature, the costs included and excluded in telestroke descriptions have limited their comparability to the Canadian setting. For example, various US telestroke services charge referring sites anywhere from \$1500 to \$100,000 a year, suggesting a wide range of incremental costs for adding telestroke sites, but providing no information about what it costs the system overall to operate, nor what it cost to create the telestroke service in the first place. In another example from an Australian telestroke grant proposal, AUS\$38,000 (=CAD\$) was proposed as the amount needed to create a service, but while the proposal includes equipment, drugs, data collection and neurologist remuneration, it does *not* include training, staff or telecommunications costs, let alone any larger costs associate with site preparation or stroke care practice change. We have provided some numbers for costs and benefits gleaned from interviews and the literature in the appendices.

In Canada, publically-available provincial documents provide no hints of what they consider to have been their overall investment in building telestroke. Telestroke leaders in Alberta and Ontario could not tell us either. In 2006 and 2007, before the Ontario’s telestroke pilots were fully merged, the Ontario Ministry of

Health (MOHLTC) was providing \$1M annually to support telestroke, with 21 consulting neurologists at 6 sites supporting 11 referral sites. At that time, OTN noted that “MOHLTC will be investing close to \$5M (including matching funding from Canada Health Infoway) over the next 2.5 years to develop emergency telemedicine applications, of which a portion of this funding will be directed towards expansion of Telestroke services.” (33)

In summary, we are unable to discover exactly how much hyperacute telestroke for thrombolysis costs, because what is included in calculating the costs of a telestroke service varies so much, and there are so many hidden subsidies obtained through incremental usage of existing services. Furthermore, many of the costs which were incurred in setting up telestroke in Ontario and Alberta can now be achieved for dramatically less, and much of the infrastructure which had to be created from scratch at the time is now commonplace across Canada. Even if those involved in creating existing services could identify what they had cost, the numbers would have no relevance to the cost of setting up telestroke today.

Despite this less-than-helpful cost analysis, we nonetheless feel confident in concluding that telestroke is not expensive: we estimate in the order of \$100,000-\$150,000 per year for a single hub-spoke arrangement, including amortised equipment costs, operating and salary costs. Because of fixed network costs, the cost of adding additional sites decreases progressively until the hub reaches saturation.

The BC telestroke proposal

A useful test case against which to assess expectations regarding telestroke costs is the current BC telestroke proposal (see box below), which includes a detailed costing model, based on BC’s own telestroke pilots as well as extrapolations from the Alberta and Ontario experiences. This model estimates it would cost about \$4.1M over 4 years to set up a province-wide telestroke system in BC, with operational costs of \$5.3M over those first four years, and then \$2.4M annually thereafter. This model includes the direct costs of technology, a new referral management system, and front-line education. Like OTN, but unlike Alberta, the model includes neurologists remuneration as a cost of telestroke, plus clinical costs associated with rtPA. In fact, two-thirds of the ongoing budget (\$1.6M/ \$2.4M) is for rtPA alone.

Case Study: BC Telestroke proposal – Costs for 4 years

Implementation costs, to include 5 consulting sites in Year 2, and 17 referring sites by years 3- 4

Start-up costs: - \$4.1 million

Hospital facilities work	\$70,000
End-point videoconferencing equipment	\$588,600
Health authorities costs (includes five regional telestroke coordinators)	\$2.4M
External costs (includes training, education, miscellaneous)	\$1.1M

Operational costs: \$5.3 million

Drugs costs, technical support and on-call service	\$5.3M
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Costs after Year 5: \$2.4 million annually

Technical support by SSO (bridging, scheduling and service desk functions)	\$208,800
On-call and consultation billing	\$405,000
Administration of tPA (including \$1M drug costs)	\$1.6M
Central staff costs (physician lead, program manager support staff)	\$223,000

It is important to note that the proposal is part of a broader \$34M provincial Stroke Action Plan, which includes a number of key elements required for successful telestroke, such as: creating a provincial body to lead change, site designations, and bypass protocols; creating stroke units and best practice sites across the province; site training and engagement; and monitoring and evaluation. However, regional coordinators are costed to telestroke, since they were not included in a broader stroke strategy budget.

How telestroke is funded

Many telestroke services, worldwide, were established only because they obtained research grants, or pilot/feasibility grants from health authorities, or were part of a specially-funded stroke strategy. The transition from soft-funded research intervention to base-funded health-care practice has been difficult for many services. In the USA, networks are sustained by a combination of: government grants; hub hospital budgets; membership fees from spoke hospitals to hubs which cover an agreed number of “free” consultations; fee-for-service payments; and service contracts based on the size of the spoke hospital and expected number of consultations. A number of commercial service providers offer “turnkey” packages that cover purchase and installation of equipment, communications infrastructure and technical assistance, and the consultant’s professional services.

In Canada, there is a similar variability. In Alberta, Ontario and BC, some equipment and personnel start-up costs were covered by Canada Health InfoWay grants. At the time, these grants were seen as instrumental in making the case for telestroke. In retrospect, several informants suggested that the actual amount needed was less than envisaged, and probably could have been found much more easily, and with less restrictive conditions, from provincial and regional resources. However, those sources may not have been willing to fund telestroke without the proof of concept supported by Canada Health InfoWay grants.

In Ontario, four separate telestroke pilots were run for several years with grants from the Ontario MOHLTC and support from the Canadian Stroke Strategy. After the pilots were merged under the OTN, the Ministry continued to fund telestroke through OTN, but within a larger envelope for telehealth.

In Alberta, the provincial stroke strategy provided all regions with stroke grants, to be used as they chose to deliver any elements of the strategy. In addition, the province’s telehealth department both obtained and provided grants specifically for telestroke, training, supporting, and placing increasing numbers of expert telestroke personnel in regions across the province. These stroke strategy and telehealth grants were especially important as a source of fractional release time to allow a wide range of health professionals to participate in planning and site preparation for telestroke. Regional support was also important, particularly from the former Capital Health Authority in Edmonton, which provided seed funds to fill personnel gaps in the technology-focused Canada Health InfoWay grants, and purchase key technology (including a costly bridge), when there were gaps in other sources of funding. Even so, a large portion of the costs are clinical operating costs, and these are absorbed in the operating budgets of the referring hospitals. One important aspect of the Edmonton network was the emphasis from day one on looking for ways to transition telestroke costs from soft funding. The case was made that these costs were a key part of ongoing stroke care, with the result that “Every time there was a successful telestroke grant, Capital Health would fund that project on a permanent basis.”

Options to expand access across Canada

Availability of telestroke services across Canada

While existing telestroke services are limited, there is significant interest in expanding telestroke across most of Canada, as can be seen in the table below.

Widespread telestroke services	Alberta	Hyperacute care: 2 hubs, 14 spokes Stroke prevention: 3 hubs, 52 spokes
	Ontario	Hyperacute care: network of 5 consulting, 19 referring centres
Pilot telestroke sites	British Columbia	Hyperacute care: 2 hubs, 4 spokes
Telestroke in advanced planning	Manitoba	Pilot plans for 1 hub, 3 spokes to be operational ~fall 2013, sites identified
	New Brunswick	Proposal for 2 pilots, 1 in each region, sites to be identified
Telestroke in early planning	Newfoundland	Planning for pilot with 4 sites in one region
	Quebec	No firm plans available
Alternative approaches for hyper-acute care	Nova Scotia	Local administration, phone support available if needed Telestroke not seen as a current need
	PEI	Bypass to comprehensive stroke centre May wish to pursue telestroke to enhance access
	Saskatchewan	Local rtPA administration, phone support available if needed May wish to pursue telestroke to enhance access Prevention/rehabilitation pilot with telehealth, 1 site/ 1 hub

Why does Canada have so little telestroke?

The Canadian Stroke Strategy was successful in catalyzing the creation of integrated provincial stroke strategies across the country. However, although acute care is a priority in every strategy, there has been limited emphasis on telestroke. Interviews with stroke and telestroke leaders, providers and policy makers across the country suggest a number of reasons for the low priority given to telestroke.

Telestroke is seen as too expensive

Almost all informants are clear that telestroke should be implemented as a component of a comprehensive stroke strategy. Most provinces are still in earlier stages of strategy implementation, and working with limited funding. If telestroke requires first undertaking an expensive reorganization of provincial stroke care and developing sites of best practice, then its cost is seen as prohibitive. This is a text-book example of "Le mieux est l'ennemi du bien."

Telestroke = rtPA = low priority

The Canadian Stroke Strategy focuses on telestroke as a means to increase rtPA use, as the most obvious and urgent need. This emphasis is logical, given that rtPA is the only effective treatment for acute stroke and rates are low across most of Canada. However, the result is that for most our informants, telestroke is equated with thrombolysis, not seen as a component of the broader continuum of stroke care. Due largely to provider antipathy to rtPA, reinforced by the CAEP policy against the regular use of rtPA, telestroke is not seen as a priority: rtPA - and by implication telestroke - is seen to benefit only “a select few”. Provinces are reluctant to pursue telestroke when their emergency physicians say they have no need for it and wouldn’t use it. With emphasis on prevention and stroke units *instead of*, rather than *with*, telestroke, the opportunity to engage specialists and connect care throughout the continuum is lost.

Telestroke shouldn’t be developed in isolation

Informants emphasize that providing rtPA without strengthening the care systems during and after its administration is less effective, undesirable, and potentially dangerous. A focus on developing telestroke strictly to support thrombolysis, and in isolation from other stroke system improvement, was not well-supported. Generally, where telestroke has been proposed or piloted as a purely rtPA-related function, resistance from front-line providers has been high, and implementation difficult.

Costs and benefits are unevenly distributed

Another major challenge to telestroke implementation is that costs and cost-savings occur in different cost centres. Best practice care is not more expensive than current practices – in fact, in the long term it could help save billions every year. But most of the benefit does not accrue to those who pay the costs. The costs of telestroke fall primarily on regional hospitals – the primary stroke centres, while the benefits accrue increasingly further downstream in reduced rehabilitation, disability, and social costs.

Provincial leadership is essential

Successful telestroke implementation requires province-wide systems changes which are difficult to achieve on an institutional or regional basis. Telestroke requires standards and common approaches across the province: most elements should be developed centrally, then adapted and implemented locally. Until provinces are prepared to take full ownership of their stroke strategies and lead in their implementation, stroke leaders will struggle to implement the necessary changes, including telestroke.

Recommendations

Recommendation 1: Expand telestroke across Canada

The research literature provides sound evidence that hyperacute telestroke for thrombolysis saves lives, reduces disability, and is highly cost-effective. In almost every province, support for expanding telestroke to improve access to best practice stroke care was strong. Telestroke is seen as a critical component of a quality system of stroke care, with an important role to play throughout the continuum of care. Even where a comprehensive stroke care system is unaffordable, telestroke for rtPA is better than no rtPA.

Our unequivocal recommendation is thus to expand telestroke services across the country.

Recommendation 2: Use a regional support model

The next question is then whether to pursue a single, cohesive national telestroke service model, or rather to work with each region individually to expand telestroke efforts piece by piece across the country. In making our recommendation, we looked at the key success factors which have been identified for telestroke, and considered the ability of each model to best help those success factors flourish. From the wise advice we received from across the country, we conclude that the core of *truly effective* telestroke is:

- ⇒ Active provincial leadership, provided through an organized system of stroke care
- ⇒ Key champions and engagement on the front-lines

We believe these core attributes are best served by enabling strong provincial and local leadership, with peer support and knowledge exchange, an approach informants saw as highly desirable and beneficial.

We therefore recommend that the expansion of telestroke services should be supported on a region-by-region basis across Canada, not as a single national telestroke initiative.

Recommendation 3: Provide timely telestroke support

Across Canada there are experienced telestroke sites, champions and leaders, as well as emerging telestroke services, eager to participate in national discussion and exchange with their peers. Canada has developed considerable expertise in stroke quality assessment, through the stroke audit, ICES, and Accreditation Canada. There are a number of key forums and networks which are connecting people and supporting exchange, including the Canadian Stroke Network and the Canadian Stroke Congress. These forums and networks should be leveraged to provide timely support to regions and provinces as they assess and implement telestroke. Examples of the support provided could include:

- G. Creating a repository of telestroke-relevant documents
- H. Sharing information between provinces about telestroke activities across the country
- I. Connecting people interested in telestroke for the purposes of knowledge exchange using existing forums such as the Canadian Stroke Congress
- J. Evaluating and comparing telestroke models and alternatives and applicability in various jurisdictions
- K. Identifying and assessing lessons learned, defining best practices, and setting standards for telestroke services

- L. Providing strategic advice on the implementation of telestroke provided by those with telestroke experience

We therefore recommend that existing stroke organizations and networking forums be leveraged to provide timely support and coordination for regions and provinces as they implement telestroke.

List of Abbreviations

AHS	Alberta Health Services
CADTH	Canadian Agency for Drugs and Technologies in Health
CAEP	The Canadian Association of Emergency Physicians
CIHI	Canadian Institute for Health Information
CPAC	Canadian Partnership Against Cancer
CSC	Comprehensive Stroke Centres (Hubs)
CSN	Canadian Stroke Network
CSS	Canadian Stroke Strategy
CT	Computerized Axial Tomography
DICOM	Digital Imaging and Communications in Medicine
DSL	Digital subscriber line
EMS	Emergency Medical Services
ER	emergency room
ICES	Institute for Clinical Evaluative Sciences (Toronto)
IT	Information technology
ITC	Information technology and communications
MOHLTC	Ontario Ministry of Health and Long-Term Care
MRI	Magnetic resonance imaging
NIH	National Institutes of Health of the USA
NIHSS	NIH stroke scale
OTN	Ontario Telemedicine Network
PACS	Picture Archiving and Communication System
rtPA,tPA	recombinant tissue plasminogen activator
T1	a fibre optic line that can carry data at a rate of 1.544 megabits per second
TIA	transient ischemic attacks
VPN	virtual private network

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Appendix A: Key informants (interviews and site visits)

Name	Organization
Jo Amelio Jason Kettle	Telehealth director, clinical Telehealth director, technology and infrastructure, Alberta Health Services
Shirley Garnier	North Zone Stroke Lead, Alberta Health Services
Agnes Joyce	Clinical Network Officer, Cardiac and Stroke Strategic Clinical Network Alberta Health Services
Judi McCaustlin	Manager, RAAPID North, Alberta Health Services
Melissa McKenzie	Clinical telehealth coordinator, Alberta Health Services
Deanne Stanton	PACS application specialist, Alberta Health Services
Colleen Taralson	Acting Program Manager , Stroke Program, Edmonton Area Alberta Health Services
Sharlene Stayberg	Senior Manager, Clinical and Research Policy Unit Alberta Health and Wellness
Dale Weiss	Operations Manager, Edmonton Zone Alberta Health Services Emergency Medical Services
Gayle Thompson	Program Manager, Alberta Provincial Stroke Strategy
Pam Aikman	Provincial Director, Stroke Services BC Provincial Health Services Authority
Helen Truran	Regional Manager, Telehealth, Northern Health Telestroke Clinical Lead, BC Stroke Strategy
Lynette Lutes Nicole Whitaker	Regional Stroke Manager (<i>previous role</i>) Assistant, Stroke Program (<i>previous role</i>) Capital Health (Alberta)

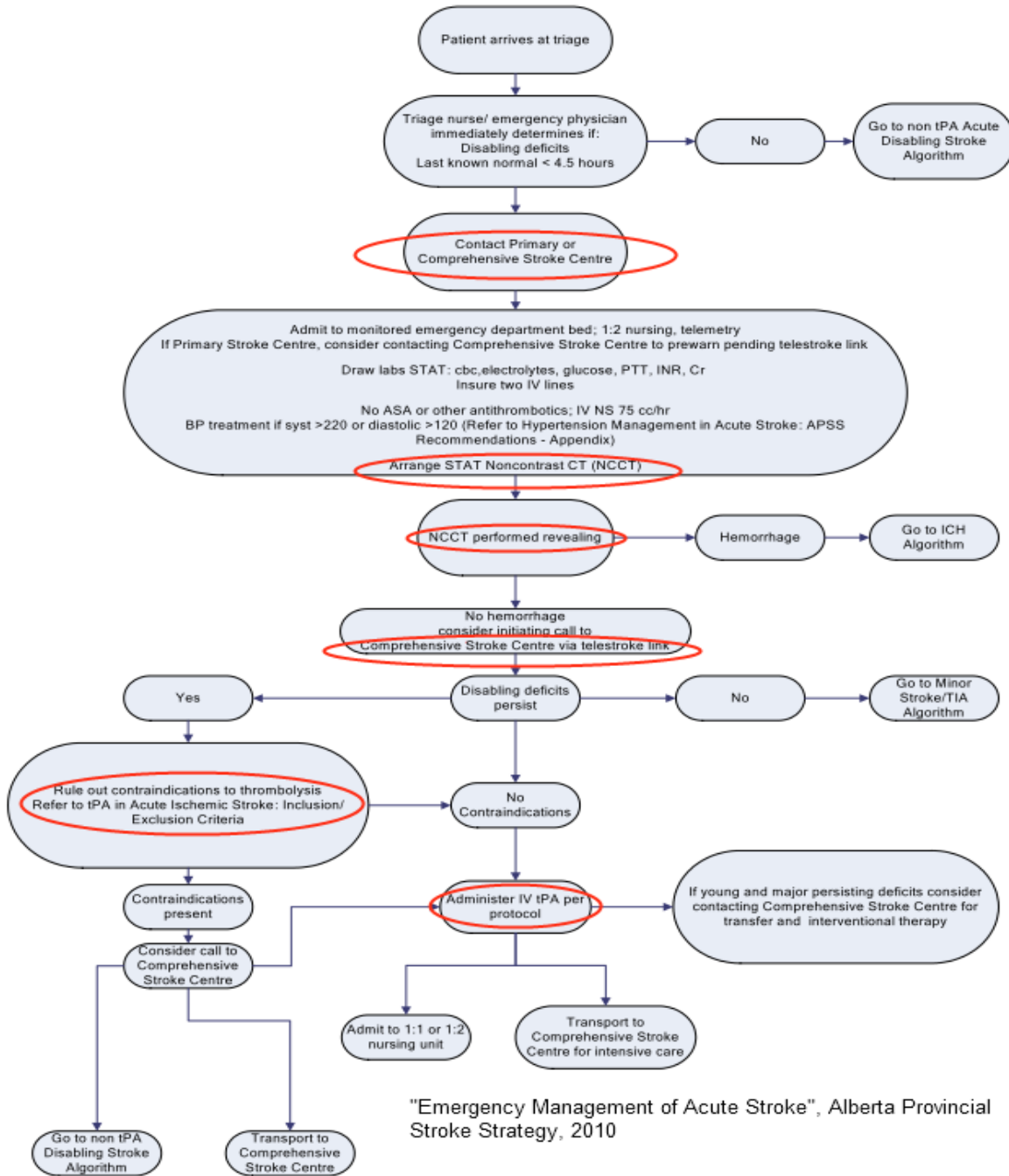
Blaine Iskiw	Director, Telehealth (<i>previous role</i>), Capital Health (Alberta)
Katie White	Stroke Consultant, Cardiovascular Health Nova Scotia
Neala Gill	Program Manager, Cardiovascular Health Nova Scotia
Brent Woodley	Clinical Nurse Educator, Chilliwack General Hospital (BC)
Cassie Chisholm	Regional Stroke Coordinator, Eastern Health (Newfoundland)
Kevin Harrison	Regional Stroke Coordinator, Fraser Health Authority
Carolyn MacPhail	Provincial Stroke Coordinator, Community Hospitals and Primary Care Division, Health PEI , (<i>information provided via email</i>)
Gwen Gordon	Director, Stroke Strategy, Heart and Stroke Foundation of Saskatchewan
Brie DeMone	Executive Director, Health System Innovation, Manitoba Health
Louise Clément	Medical Advisor, Quebec Stroke Strategy Ministère de la Santé et des Services sociaux (Québec)
Joanne Reid	Provincial Telehealth Coordinator Newfoundland and Labrador Centre for Health Information
Darren Jermyn	Regional Director, Northeastern Ontario Stroke Network Chair, Telestroke Steering Committee
Tim Rutledge	President & CEO, North York General Hospital (Ontario)
Chris O'Callaghan	Executive Director, Ontario Stroke Network
Linda Kelloway	Best Practices Leader, Ontario Stroke Network
Frank Silver	Telestroke Medical Director, Ontario Telemedicine Network Director, University Health Network Stroke Program Toronto Western Hospital
Angela Nickoloff	Program Lead Emergency Services, Ontario Telemedicine Network
Manish Rughani	Technical Operations, Ontario Telemedicine Network
Jennifer Mills Beaton	Manager, Emergency Services, Ontario Telemedicine Network
Rob Williams	CMO, Ontario Telemedicine Network
Ed Brown	CEO, Ontario Telemedicine Network
David Silverberg	Neurologist, Prince Edward Island
Stephen J. Phillips	Clinical advisor, Cardiovascular Health Nova Scotia Professor of Medicine (Neurology), Dalhousie University Director, Acute Stroke Program, Queen Elizabeth II Health Sciences Centre
Cheryl King And MANY associates	Heart and Stroke Clinician, St. Mary's Hospital, Camrose
Patrick O'Byrne	Director, Hospitals and Specialty Care , Acute and Emergency Services Branch,

	Saskatchewan Health
Deborah Jordan	Executive Director, Acute and Emergency Services Branch Saskatchewan Health
Jennifer Greene	Therapies Consultant, Continuing Care & Rehabilitation Community Care Branch, Saskatchewan Health
Diane Tucker	Project Manager, Acute and Emergency Services Branch Saskatchewan Health
Michael Kelly	Assistant Professor of Surgery, Division of Neurosurgery University of Saskatchewan Neurosurgeon, Saskatoon Health Region and Regina Qu'Appelle Region
Khurshid Khan	Neurologist, University of Alberta Hospital
Devin Harris	Clinical Associate Professor, Department of Emergency Medicine University of British Columbia Department of Emergency Medicine, St. Paul's Hospital
Philip Teal	Sauder Family and HSF of BC&Y Professor of Clinical Stroke Research Clinical Professor of Neurology, Faculty of Medicine University of British Columbia
Lise Guerrette-Daigle	Executive Vice-President, Acute Care Facilities Vitalité Health Network (New Brunswick)
Yves Laurandeau	Director of Therapeutic and Rehabilitation Services Vitalité Health Network (New Brunswick)
Stéphane Legacy	Vice-President, Professional and Diagnostic Services Vitalité Health Network (New Brunswick)
Marie-Michelle Noël Guignard	Stroke Coordinator Vitalité Health Network (New Brunswick)
Karen Bouman	Site Administrator
Mohamed Shereef	GP, Emergency Physician
Sherry Gough	Care Manager, Acute Nursing
Evelyn Koshurba	Supervisor, Diagnostic Imaging Westlock Healthcare Centre (Alberta)

Appendix B: Algorithm for rtPA

Note: Telestroke components are outlined in red

4.1 t-PA Acute Disabling Stroke Algorithm – Emergency Department



Appendix C: Comparison of telestroke in the USA and Canada

Issue	USA	Canada
Numbers	~ 33. Largest serves 120 sites in 12 states, with ~12,000 consultations/yr. First patient in 1999.	~ 6. Largest serves 20 sites in ON, with ~500 consultations/yr. First patient in 2002.
Structure	Hub and spoke, plus “third party services” provided by commercial services, which have a national and even international reach.	Mostly hub and spoke, within province. OTN operates a network model, and Alberta services some parts of N.E. BC, N.W. Sask, and NWT
Procedures	Mostly drip and ship, especially if third-party services provided.	Mostly drip and keep, but some drip and ship at smaller hospitals, e.g. NW Ontario.
Technology	Many “turnkey” commercial services available, as well as custom-designed services.	Publicly-funded and operated services, designed independently for each service.
Professional incentives	Neurologists’ in-house case-mix shifts towards complicated patients transferred from primary stroke centres. Internists, intensivists, and hospitalists at spokes gain new knowledge and skills. Nurses and rehabilitation therapists prefer to work with rtPA-treated patients because they know they can make a difference and observe rapid progress.	
Financial incentives for spoke hospital	Positive: offering telestroke services gives a competitive edge in sometimes over-serviced community hospital marketplace. Receive additional reimbursement for thrombolysis.	Negative: Most stroke patients are no longer transferred to tertiary centres, and are therefore occupying acute care beds. However, additional patients are offset by rtPA treatment, which results in shorter stays for many cases
Financial incentives for hub hospital	Positive: drip and ship boosts profitable stroke patient numbers and may secondarily boost number of other neurological patients referred	Likely neutral: fewer uncomplicated stroke patients, but now complicated cases with longer stays and greater cost. Workload of individual neurologists increases.
Reimbursement	Complex and difficult negotiations with multiple payers, but as telestroke used more widely, reimbursement now becoming a standard	Provincial fee schedules recognise teleconsultation. Negotiations to add this activity may have been long but are not complicated, and models now exist.
Credentiailling	Was major impediment, complex and difficult negotiations between independent health care institutions. Recently Joint Commission has established a facilitated reciprocal credentialing process for telemedicine services	Not a significant issue. Resolved simply and/mostly informally, using standard expectations for any referral/ consultation without telestroke.
Inter-jurisdictional issues	Becoming more complex: many states now requiring full licensure of out-of-state teleconsultants	Most provinces require some sort of licensure for out-of-province tele-consultants, but not usually full licensure. There are no policy needs served by complexity: it can be a simple and free, and ample precedents exist.
Privacy, security	Compliance with federal Health Insurance Portability and Accountability Act of 1996 (HIPAA) Privacy Rule is required, and variable state laws may also apply if they are not contrary to HIPAA. In practice, many third-party providers operate across state lines.	Significant differences in provincial legislation and restrictions would probably make interprovincial services very difficult. In some provinces, transfer of images and patient information and videoconferencing can be problematic between regions, and sometimes even between sites in the same region.

Appendix D: Cost and benefits of telestroke

Costs

Because of the enormous variability in financial models and the way most telestroke services for hyper-acute care are provided, a detailed budget for a typical telestroke network that includes the cost of equipment purchase and maintenance, all incremental personnel costs, IT and telecommunication costs, and professional services, is impossible to provide. Here are some partial figures that give a “ballpark” idea of the costs of telestroke

- An widely quoted older figure for provision of equipment at each primary stroke centre was \$25,000, but that figure has now fallen to \$10,000 and is still decreasing
- The actual cost of the TEMPiS network in Bavaria, which provides a “virtual stroke unit” connecting two comprehensive stroke centres and 12 telestroke sites was reported as €100,000 per year, or \$11,000 per spoke per year⁷
- Details in a grant application⁸ for annual costs of setting up a single Australian telestroke site service are as follows:

At the comprehensive stroke centre:		
	24/7 On call payments to neurologists	AUS \$30,024
	Modem rental	\$1,440
At the telestroke site:	Telehealth cart	\$2,100
	Data collection and analysis	\$4,750
	rtPA per patient	\$1,200

Training costs, additional staff costs, and telecommunications costs were assumed by the primary stroke centre and the regional health authority, and so this request of approx AUS\$38,000 (=CDN\$) is an underestimate of the true cost.

- At the Alberta telestroke sites, personnel costs for a part-time coordinator and an additional ER nurse probably did not exceed \$100,000/yr.
- For one of “turnkey” services offered in the USA (REACH), the referring hospital pays for the initial equipment purchase, \$3,500-\$4,500 per month for a neurologist, and \$2,000 to \$3,000 per month for technical support, for a total cost of \$69,300 to \$93,300 per year.⁹

⁷ H. J. Audebert, “Telemedicine for Safe and Extended Use of Thrombolysis in Stroke: The Telemedic Pilot Project for Integrative Stroke Care (TEMPiS) in Bavaria,” *Stroke* 36, no. 2 (January 13, 2005): 287–291.

⁸ “Victorian Rural Telestroke Project.pdf”, n.d., [http://docs.health.vic.gov.au/docs/doc/2C15D62D01503FC5CA2578EE00012F39/\\$FILE/Victorian%20Rural%20Telestroke%20Project.pdf](http://docs.health.vic.gov.au/docs/doc/2C15D62D01503FC5CA2578EE00012F39/$FILE/Victorian%20Rural%20Telestroke%20Project.pdf).

- The Arizona Telemedicine Program (ATP) charges referring hospitals an annual membership fee of \$1,500 to \$5,000 based on the level of service requested. These fees cover 30 percent of ATP’s total costs, which are therefore up to \$16,600/yr¹⁰
- A regional hospital in rural Wisconsin that is a spoke of the UW Health Comprehensive Stroke Program estimated its annual telestroke cost at \$19,000, including equipment and consultants fees¹¹. This hospital appeared to use telestroke consultations about 30 times per year.
- If the telestroke site already has a CT scanner operational 24/7, telestroke won’t make the same demands on its budget than if the is scanner only operational during office hours. The major cost is salary and professional fees, but these will be different in every setting.

Cost avoidance

The Utah telestroke network has identified savings from earlier access to care, appropriate triage, differential diagnosis of transient neurological symptoms, increased access to thrombolytics and increased rtPA use in patients for whom it is indicated, and decreased disability. To this we can add shorter hospitalization for rtPA-treated patients, more patients treated in less-expensive secondary care facilities (the primary stroke centres), more patients discharged to homecare rather than in-patient rehabilitation or nursing home care, reduced rehabilitation and drug costs, reduced family travel expenses, reduced loss of productive work time for the patient and family caregivers, improved primary and secondary prevention resulting in fewer subsequent serious strokes, and overall more QALYs for the at-risk population. In their landmark study on the cost-effectiveness of telestroke, Nelson et al¹² found that the incremental cost of telestroke over a person's lifetime was less than \$2500 per quality-adjusted life year (QALY)¹³. In other words, it is extraordinarily cost-effective compared to other common medical procedures and therapies (Table).

Table: Cost-effectiveness of some procedures and treatments (cost/quality-adjusted life year)	
Procedure	Cost-effectiveness
Telestroke	\$2,500 ¹⁴
Knee arthroscopy to repair torn cruciate ligament	\$5,783 ¹⁵

⁹ Detailed Technology Analysis. Tele-Stroke (NEHI (New England Healthcare Institute), July 17, 2009), http://www.nehi.net/publications/43/detailed_technolgy_analysis_telestroke.

¹⁰ Ibid.

¹¹ Bob Herdrich, MS, RN, “Telemedicine at Work in Rural Wisconsin: TeleStroke”, June 18, 2009, <http://www.waha.org/education/rural/telemedicine3.pdf>.

¹² Nelson RE, Saltzman GM, Skalabrin EJ, Demaerschalk BM, Majersik JJ., “The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke.,” *Neurology* 77, no. 17 (n.d.): 1590–8.

¹³ They calculated the cost-effectiveness of telestroke by comparing the incremental costs and quality-adjusted life years saved of stroke patients treated by telestroke to those treated by usual care in a hospital without telestroke or a stroke expert available.

¹⁴ Nelson RE, Saltzman GM, Skalabrin EJ, Demaerschalk BM, Majersik JJ., “The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke.”

¹⁵ James H Lubowitz and David Appleby, “Cost-effectiveness Analysis of the Most Common Orthopaedic Surgery Procedures: Knee Arthroscopy and Knee Anterior Cruciate Ligament Reconstruction,” *Arthroscopy: The Journal of Arthroscopic & Related Surgery: Official Publication of the Arthroscopy Association of North America and the International Arthroscopy Association* 27, no. 10 (October 2011): 1317–1322.

Biennial fecal occult blood testing as screen for colorectal cancer	\$3,000-11,000 ¹⁶
Combination anti-retroviral therapy for AIDS	\$10,000-20,000 ¹⁷
Kidney dialysis	\$129,090 ¹⁸

Recent information from the UK (in press reports and news releases from service providers^{19, 20}) concerns the telestroke network established by the Lancashire & Cumbria Cardiac and Stroke Network, which serves a health region of 1.6M people. The capital cost of establishing this network, was \$14M, but, based on early experience, it will deliver savings in health care costs and disability care of \$11M a year, a spectacularly short payback of capital. In human terms, thanks to the service, each year there will be 24 fewer deaths, 36 patients with reduced disability, and 40 with no symptoms or disabilities resulting from their stroke.

In the absence of a comprehensive analysis of cost savings in the Canadian context, we can provide some indications that telestroke is a good investment:

“One out of every eight patients treated with rtPA walks out of the hospital within four to five days and returns to a normal life. If that patient wasn’t treated with rtPA and instead went to long-term care, however, the first year costs about \$100,000 just for the bed. When compared with the \$1,500 cost of rtPA and \$10,000 to \$20,000 in imaging costs, the economic rationale for rapid imaging, diagnosis and rtPA is clear.”²¹ Stroke patients who have received rtPA require fewer days of in-patient rehabilitation, and a higher proportion are discharged to home or community care ²², where many can resume employment.

At the largest primary stroke centre in the Northern Alberta Telestroke network, “The average length of stay for rtPA treated patients was three days compared to seven days for patients not treated with rtPA. This resulted in a reduction of 1015 fewer days for patient care. At a daily cost of \$903 Canadian, the cost saving was estimated at \$916,545 at this site (or \$3600 per patient just for acute care). In the year prior to the implementation of the telestroke program at this site, 144 patients were transferred to University of Alberta Hospital. During the second year of the availability of the telestroke service, this number decreased to only 15 patients, a 92.5% reduction”²³ We can thus add a further \$60,000 saved

¹⁶ “Research on the Comparative Effectiveness of Medical Treatments: Issues and Options for an Expanded Federal Role” (Congressional Budget Office, December 2007), <http://www.cbo.gov/ftpdocs/88xx/doc8891/12-18-comparativeeffectiveness.pdf>.

¹⁷ “Can Cost-Effective Health Care=Better Health Care? - January 14, 2010 -Winter 2010 - Harvard Public Health Review - Harvard School of Public Health”, n.d., <http://www.hsph.harvard.edu/news/hphr/winter-2010/winter10assessment.html>.

¹⁸ Chris P. Lee, Glenn M. Chertow, and Stefanos A. Zenios, “An Empiric Estimate of the Value of Life: Updating the Renal Dialysis Cost-Effectiveness Standard,” *Value in Health* 12, no. 1 (January 2009): 80–87.

¹⁹ <http://www.multisense.co.uk/markets/healthcare-2/stroke-services/telemedicine-telestroke-a-good-practice-case-study/>

²⁰ <http://www.guardian.co.uk/government-computing-network/2012/may/28/telestroke-lancashire-cumbria-nhs>

²¹ “Telestroke Networks Make a Mark,” *Health Imaging*, November 2011, http://www.healthimaging.com/index.php?option=com_articles&view=article&id=30150:telestroke-networks-make-a-mark.

²² M. Meyer et al., “Assessing the Impact of Thrombolysis on Progress Through Inpatient Rehabilitation After Stroke: a Multivariable Approach,” *International Journal of Stroke* (January 2012): n/a–n/a.

²³ Khurshid Khan et al, “Telestroke in Northern Alberta: A Two Year Experience with Remote Hosp,” *Can. J. Neurol. Sci.* 37 (2010): 808–813.

just for ambulance costs, and for more remote primary stroke centres these savings become even more significant. The full air ambulance cost to fly an acute stroke patient from High Level, Alberta, to Edmonton, a distance of 700kms, is about \$36,000²⁴. Telestroke renders such transfers unnecessary. The impact on families of not having to travel to the CSC is also significant: return airfare from High Level to Edmonton is \$1,000.

In the business case for the creation of the Ontario Telehealth Network²⁵, it was estimated that expanded telestroke services would allow 621 patients annually to receive rtPA who would not otherwise receive it. rtPA administration results in a cost-avoidance of \$5,438 per patient (2012 dollars), due to reduced hospital and nursing home care. The expanded service that reached those 621 patients would avoid \$3.4M in annual costs. It would seem reasonable to conclude that a provincial telestroke system that costs \$5,000 or less per annum per patient receiving rtPA is both reducing health care costs and improving health outcomes. Extrapolating these figures from Ontario to Nova Scotia, for example suggests that a telestroke investment of \$260,000 per annum in that province would be cost-effective.

Nationally, an increase in rtPA rates from the 2010 average of 7.4% to a mere 10% was estimated to avoid annual direct costs of \$13.6M, due to 4,351 fewer acute care days, and 43,902 fewer residential care days and a further \$5.2M in indirect costs (10). The potential for telestroke to increase the rtPA rate is significant: in the northern Alberta network, the rate exceeds 20%, and it is over 30% among patients admitted to hospitals in the OTN.

The numbers presented here relate to telestroke used for acute thrombolysis only. If telestroke is used to deliver comprehensive stroke care, cost-avoidance rises.

Appendix E: Future expansions of rtPA

We have described the telestroke challenges and opportunities of yesterday. With rapid technological advances already in progress there are additional ways of increasing the population eligible for rtPA treatment, which further leverages the utility of telestroke.

Extending the time window for rtPA A major clinical trial (IST-3) has just reported on the effects of rtPA administered in the 4.5-6h window, concluding that “thrombolysis within 6 h improved functional outcome” (52). Extending the time window up to 6h doesn’t reduce the need for telestroke, quite the reverse: “time is brain” and so earliest thrombolysis remains the goal (53). But many patients now denied rtPA because they arrived too late at the primary stroke centre to be considered for thrombolysis might receive lesser but still significant benefit from the rapid door-to-needle times that telestroke allows.

Reducing contraindications to rtPA Blood-based biomarkers may in future identify patients with a particularly high risk of hemorrhagic complications or reduced efficacy of thrombolysis. For example, levels of molecules such as astroglial S100-B, fibronectin and matrix metalloproteinase-9 (MMP-9) have

²⁴ Estimated from the annual cost of the STARS Medevac service (from annual report 2010) x flying time from High Level to Edmonton in the fastest helicopter (AgustaWestland AW139) in the STARS fleet/total mission hours flown in 2010 (from annual report).

²⁵ Provincial Hyper-Acute Telestroke System Business Case (Submitted To: Ontario Ministry of Health and Long-Term Care: ONTARIO TELEMEDICINE NETWORK, December 2007).

been shown to correlate strongly with hemorrhagic complications (54). These biomarkers could be used in addition to the CT scan and teleconsultation to increase the safety of rtPA administration at primary stroke centres.

Patients who lie outside the current guidelines include those who are elderly (over 80 years of age), and who are making a good recovery on their own: both groups, particularly the elderly, could be considered for inclusion. Recently it has been shown that rtPA is beneficial for patients of all age groups (52)(55), and already in Alberta the elderly are now eligible for rtPA.

The majority of strokes are mild, but mild or rapidly improving initial stroke deficits are a frequent reason for non-use of rtPA treatment (56). The PRISMS trial, currently in progress will determine the efficacy of rtPA in a population with mild stroke. If it shows that patients with mild stroke also benefit from rtPA, the cost savings in the USA from reduced disability would be about \$200M a year (57)

Decision-support tools that allowed improved assessment of individual risk of intracerebral hemorrhage would be valuable in reducing reluctance on the part of patients or physicians to use rtPA.(58)

Advances in imaging technology to reveal survivable penumbra and merit of rtPA. About one-quarter of stroke patients are disqualified from receiving rtPA because they discover their stroke only on awakening, so there is no way of telling how long it has been since the stroke actually occurred. Newly-developed MRI techniques can identify brain tissue that is not yet dead, and could be restored if perfusion could be re-established (59). This technique may identify those most likely to benefit from rtPA, even after the 4.5 h (now 6h?) window closes, or if the time since stroke is unknown. Automated image analysis software may even be able to rapidly identify candidate patients, without the need for radiology consultation (60). While this development is most likely to benefit those receiving care in CSCs, in northern Alberta five of the 11 primary stroke centres do have MRI on site.

rtPA plus/versus clot retrieval A number of clinical trials are underway looking at the advantages of giving rtPA intravenously, and if imaging shows it hasn't been effective, then giving rtPA intra-arterially, with or without surgical clot retrieval attempts using a variety of mechanical endovascular recanalisation devices, such as the MERCI retriever (61). Using ultrasound plus rtPA to bust the clot more effectively has also had promising results (54).

New and adjunct therapies (rtPA plus neuroprotection, anti-inflammatories) Newer thrombolytic agents such as tenecteplase have longer half-lives and are more fibrin-specific than rtPA, reducing the risk of systemic bleeding complications. Desmoteplase, from vampire bats, is also not neurotoxic, though its thrombolytic efficacy in stroke has not yet been proven (54) (61). Anti-inflammatory and neuroprotective agents are being tested in animal studies to see if they offer additional protection to brain cells while the thrombolytic agent is helping restore perfusion, and novel anti-platelet agents are being tested in combination with clot-retrieval devices to prevent fresh thrombus formation.