Canadian Agency for Drugs and Technologies in Health

Agence canadienne des médicaments et des technologies de la santé

TECHNOLOGY REPORT

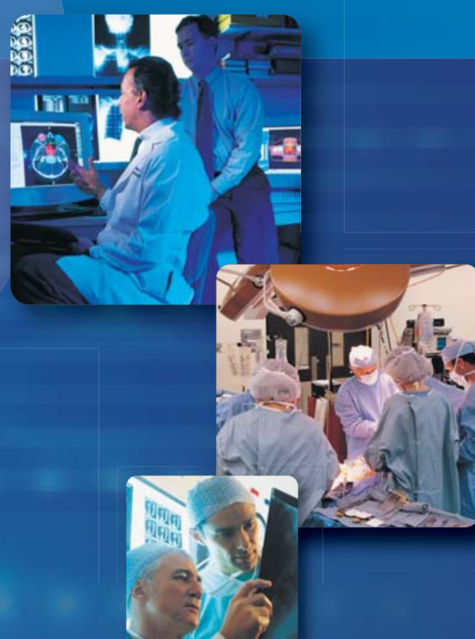
HTA

Issue 99

January 2008

*An amendment was made in April 2008.

Telehealth for Acute Stroke Management (Telestroke): Systematic Review of Analytic Studies and Environmental Scan of Relevant Initiatives



Supporting Informed Decisions

Until April 2006, the Canadian Agency for Drugs and Technologies in Health (CADTH) was known as the Canadian Coordinating Office for Health Technology Assessment (CCOHTA).

Publications can be requested from:

CADTH
600-865 Carling Avenue
Ottawa ON Canada K1S 5S8
Tel. (613) 226-2553
Fax. (613) 226-5392
E-mail: pubs@cadth.ca

or download from CADTH's web site:
http://www.cadth.ca

Cite as: Deshpande A, Khoja S, McKibbon A, Rizo C, Jadad AR. *Telehealth for Acute Stroke Management (Telestroke): Systematic review of analytic studies and environmental scan of relevant initiatives* [Technology report number 99]. Ottawa: Canadian Agency for Drugs and Technologies in Health; 2008. (The "first-last author-emphasis" approach is applied for the sequence of authors.)

Production of this report is made possible by financial contributions from Health Canada and the governments of Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Nunavut, Ontario, Prince Edward Island, Saskatchewan, and Yukon. The Canadian Agency for Drugs and Technologies in Health takes sole responsibility for the final form and content of this report. The views expressed herein do not necessarily represent the views of Health Canada or any provincial or territorial government.

CADTH is funded by Canadian federal, provincial, and territorial governments.

Legal Deposit – 2008
National Library of Canada
ISBN: 978-1-897465-40-0 (print)
ISBN: 978-1-897465-41-7 (online)
H0456 – January 2008

PUBLICATIONS MAIL AGREEMENT NO. 40026386
RETURN UNDELIVERABLE CANADIAN ADDRESSES TO
CANADIAN AGENCY FOR DRUGS AND TECHNOLOGIES IN HEALTH
600-865 CARLING AVENUE
OTTAWA ON K1S 5S8

Canadian Agency for Drugs and Technologies in Health

Telehealth for Acute Stroke Management (Telestroke): Systematic Review of Analytic Studies and Environmental Scan of Relevant Initiatives

Amol Deshpande, MD MBA[1]
Shariq Khoja, MD PhD[2]
Ann McKibbon, BSc MLS PhD[3]
Carlos Rizo, MD[4]
Alejandro R. Jadad, MD DPhil FRCPC[5]

January 2008

[1] Consultant, Foresight Links Corporation, Toronto
[2] Assistant Professor, Dept. of Community Health Sciences and Medical Director's Office, Aga Khan University, Karachi, Pakistan
[3] Associate Professor (Part-Time), Health Information Research Unit, Clinical Epidemiology and Biostatistics, McMaster University, Hamilton
[4] Candidate, Department of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ontario
[5] Professor, Chief Innovator and Founder of the Centre for Global eHealth Innovation, University Health Network and University of Toronto, Toronto

Reviewers

These individuals kindly provided comments on this report.

External Reviewers

Valerie Hagerman, BN Med
Regional Director, Telehealth
River Valley Health
Bear Island, New Brunswick

Karen Waite, RN BScN MBA
Executive Lead, Corporate Projects and Privacy
Ontario Telemedicine Network
Toronto, Ontario

CADTH Peer Review Group Reviewers

Valerie Ashworth, BA
Manager, Telehealth Program
Provincial Health Services Authority
Victoria, British Columbia

Mukul Sharma, MSc MD FRCPC
Deputy Director,
Canadian Stroke Network
Assistant Professor,
University of Ottawa
Medical Director,
Champlain Regional Stroke Program
Ottawa, Ontario

Authorship

Amol Deshpande provided the overall research lead and coordinated the project, including the design of data extraction tables, supervision of data extraction, confirmation of final selected trials, preparation of initial draft of the review, and participation in subsequent report revisions.

Alejandro R. Jadad conceived the project, developed the initial protocol, assisted in data extraction, and participated in all phases of report writing.

Carlos Rizo extracted and tabulated data for the environmental scan section of the report and assisted in report writing.

Ann McKibbon and Shariq Khoja selected trials and studies, extracted and tabulated data, and reviewed the final report.

All authors contributed to the revisions of the report.

Acknowledgements

We applied the "first-last author-emphasis" approach for the sequence of authors. We are grateful to Marina Englesakis, Information Specialist, for providing valuable feedback in developing the search strategy and completing searches of the databases, to Hammad Durrani (HD) and Cynthia Lokker (CL) for their assistance in data extraction, to Dijana Vasic and Vladan Jovic for their assistance in retrieving the articles for this review, and to Melissa Ohotski and Jessie Venegas-Garcia for their assistance in preparing citation lists. Martha Garcia, from Foresight Links Corporation, provided management and administrative oversight throughout all phases of the project.

Conflicts of Interest

The authors declare that they have no financial or non-financial conflicts of interest.

REPORT *IN BRIEF*

January 2008

Telehealth for Acute Stroke Management (Telestroke): Systematic Review of Analytic Studies and Environmental Scan of Relevant Initiatives

Technology

Any modality of telehealth (synchronous or asynchronous) that enables communication between a patient and health care providers, or among health care providers, for the purposes of assessing, treating, or rehabilitating stroke patients.

Issue

There is uncertainty about how telestroke programs can be optimally delivered. There have been several original studies evaluating telestroke services, but no systematic effort summarizing them.

Methods and Results

This systematic review was based on a search of five bibliographic databases completed in mid-December 2006, and a scan of relevant reference lists. It included 22 studies with original data on telestroke modalities assessing health outcomes, cost-effectiveness, patient and provider satisfaction, or process of care, published in English in a peer-review journal. Two independent teams of reviewers screened all articles and extracted data by consensus.

The environmental scan, which identified 15 organizations (two in Canada) providing telestroke services, was based on the articles included in the systematic review, as well as a review of 400 hits from Google.

Implications for Decision Making

- **Telestroke improves access to therapy.** Telestroke improves access to thrombolysis treatment, which may in turn reduce mortality and serious morbidity post-stroke. A high level of patient satisfaction has been documented with this service.
- **Uncertainty remains regarding cost-effectiveness and safety.** Conclusions regarding the economic impact and potential harm from telestroke services compared with face-to-face care could not be drawn from the available evidence.
- **Opportunities for further understanding exist.** The lack of standardized reporting of resources and outcomes precludes comparisons among programs and the determination of best practices. The creation of two programs in Canada opens the door to collaborative efforts that could lead to standardized evaluation frameworks, economies of scale for knowledge transfer, and a better understanding of the safety and resource implications of the services that the two programs offer.

This summary is based on a comprehensive health technology assessment available from CADTH's web site (www.cadth.ca): Deshpande A, Khoja S, McKibbon A, Rizo C, Jadad AR. *Telehealth for acute stroke management (telestroke): systematic review of analytic studies and environmental scan of relevant initiatives.*

Canadian Agency for Drugs and Technologies in Health (CADTH)
600-865 Carling Avenue, Ottawa ON Canada K1S 5S8 Tel: 613-226-2553 Fax: 613-226-5392 www.cadth.ca

***CADTH** is an independent, not-for-profit organization that supports informed health care decision making by providing unbiased, reliable information about health technologies.*

EXECUTIVE SUMMARY

The Issue

With 40,000 to 50,000 strokes in Canada each year and approximately 300,000 Canadians living with the effects of stroke at any given time, the estimated costs to the economy in 1997 was about $2.7 billion. Thrombolysis in acute stroke care has been shown to reduce subsequent morbidity and mortality if delivered within a narrow timeframe after the onset of symptoms. The use of telehealth by specialists to provide acute stroke care (known as "telestroke") could improve the process of care (including access to thrombolysis) and the health outcomes associated with stroke.

There has been no systematic effort to summarize the key messages regarding telestroke from the biomedical literature. If such an effort were to be undertaken, it should be done in a manner that policy makers and health care providers would find useful.

Objectives

Our objective was to evaluate the available data on the use of telehealth to deliver health services to acute stroke patients. This report describes:

- a systematic review of the peer-reviewed literature on the impact of telestroke initiatives on health outcomes, process of care (e.g., access to health services), health resources, and user satisfaction
- an environmental scan of organizations that provide acute telestroke services of relevance to Canadian policy makers.

The following questions were addressed regarding the use of telehealth in the delivery of acute stroke care:

- What evidence exists in the peer-reviewed literature to support the use of telestroke in the improvement of health outcomes?
- Does the use of telestroke improve access to health services?
- Does telestroke affect health care resource utilization?
- What is the level of user satisfaction regarding health services delivered through telestroke?
- What organizations and best practices are at the forefront of telestroke delivery?

Methods

A systematic review of the peer-reviewed literature was performed. A search was completed in mid-December 2006, using a refined strategy with clusters of terms related to telehealth and stroke that were applied to MEDLINE (from 1966), CINAHL (from 1982), HealthSTAR (from 1975), the Database of Abstracts of Reviews of Effects (DARE), and the Cochrane Library. This was complemented with a scan of reference lists of eligible reports.

Studies were included if they were published in an English-language peer-reviewed journal, if they contained original data on any telestroke modality, and if they assessed health outcomes, cost-effectiveness, user satisfaction, or process of care. Two independent teams of reviewers screened all articles, extracted data, and reached consensus on their findings.

The environmental scan was based on the information available in the articles that were included in the systematic review, complemented by a scan of 400 hits yielded by a search performed with the search engine Google.

Results

The systematic review included 22 original studies from the 863 citations identified. The included studies had diverse designs, interventions, and outcomes, precluding a meta-analysis. Eight studies were judged to be of high quality using standardized quality assessment tools. Most study reports included outcomes related to process of care issues and reported improved access to thrombolysis, acceptable "door-to-needle times" (time elapsed from the patient's arrival in hospital and the start of thrombolysis), and a decreased need to transfer patients across institutions. Three and six month post-event functional outcomes using telestroke services were comparable with those of face-to-face stroke care. Mortality rates were also similar. Patients and health care providers reported high levels of satisfaction, although few studies assessed this outcome in detail. Several telerehabilitation studies were identified during the search on telehealth services for post-acute stroke management. Although it is difficult to draw conclusions from this small sample of studies, the trend suggests that in post-stroke patients, telehealth led to improvements in caregivers' mental health and high levels of patient satisfaction. There was minimal evidence regarding the impact on resource utilization.

The environmental scan identified 15 telestroke programs worldwide, with more than half of them in North America. Programs had different approaches to staffing the centres, determining catchment areas, and measuring the number of interventions.

Conclusions

Stroke is a neurological condition that affects many Canadians, resulting in socioeconomic costs. The use of thrombolysis that is delivered within a narrow window of time after the presentation of symptoms has been shown to significantly reduce the burden of illness.

The use of telestroke seems to improve access to the administration of thrombolysis, could reduce the number of poor outcomes three and six months post-stroke, and may improve the quality of care in acute stroke management. Two studies assessed patient satisfaction. Both documented high levels of acceptability. It is unclear, however, whether this modality is cost-effective and safe relative to face-to-face care.

The evidence obtained for the use of telestroke in the rehabilitation of post-stroke survivors was not exhaustively reviewed, so no conclusions could be drawn. The few articles that were identified, however, suggest a trend towards improved caregivers' well-being. More research is warranted to determine the impact of telehealth on post-stroke care.

While several organizations have been identified to be at the forefront of telestroke, the lack of standardized reporting of resources and outcomes precludes comparisons among programs and the determination of best practices. The use of telestroke services seems to reduce inappropriate variations in practice. The recent creation of two programs in Canada opens the door for collaborative efforts that could lead to standardized evaluation frameworks, economies of scale for knowledge transfer, and a better understanding of the safety and resource implications of the services that they offer.

Telestroke, like telehealth in general, transcends distance and geographic boundaries. Canada has made strides in many areas of telehealth. The availability of picture archiving and communication systems (PACS) in almost 20% of all Canadian hospitals and free-standing imaging facilities (Canadian Institute for Health Information, 2005 figures) provides the foundation for telestroke care to play a greater role in Canada. The emerging telestroke programs, and their financial and political backers, have an opportunity to join efforts that could place Canada at the forefront of telestroke care, while ensuring that Canadians have access to the services that they expect, regardless of where they live.

TABLE OF CONTENTS

APPENDICES – available from CADTH's web site www.cadth.ca

1 INTRODUCTION

1.1 Background and Setting in Canada

Stroke is a term used to define an acute vascular event in the brain associated with bleeding or ischemia. Each year, stroke is responsible for the death of about 16,000 Canadians, making it the most common serious neurological condition requiring hospital admission and the fourth leading cause of death in Canada.[1] With 40,000 to 50,000 strokes in Canada each year and approximately 300,000 Canadians living with the effects of stroke at any given time, the estimated costs to the economy in 1997 was approximately $2.7 billion.[1]

Ischemic stroke, which accounts for 80% of all stroke cases, results from decreased blood flow to a portion of the brain with consequent cell death, while the less common form, hemorrhagic stroke, results from bleeding into the brain. Both types of stroke are potentially treatable. Hemorrhagic strokes may be amenable to surgery with the removal of blood clots or clamping of bleeding vessels. The successful treatment of ischemic stroke involves thrombolytic agents and requires a system capable of identifying and evaluating prospective candidates. Eligible patients include those diagnosed by radiological investigations (i.e., CT scan or MRI) with an acute ischemic stroke associated with a clinically meaningful neurological deficit within three hours of the onset of symptoms. A meta-analysis has demonstrated that favourable outcomes can be achieved at three months when thrombolysis is delivered within 90 minutes, compared with later administration.[2] Other systematic reviews show that the effectiveness of thrombolytic therapy could be optimal within three hours of the onset of symptoms, with positive effects still achievable up to 270 minutes. The odds of death increase beyond 270 minutes.[3] In Canada, the overall rates of treatment of acute stroke with the thrombolytic drug tissue plasminogen activator (tPA) are below 5%, with approximately 50% of patients failing to receive treatment in a timely fashion.[3]

The narrow time window for thrombolysis in acute stroke, and the relationship between time to treatment and outcome, have led to the exploration of strategies for the optimization of outcomes, including community-based education programs, designated stroke centres, and emergency room treatment protocols.[3] In the last decade, with the development of information and communication technologies, there has been growing interest in the role that telehealth applications could play to improve stroke management and patients' outcomes. This is known as "telestroke."[4,5]

The putative advantages of telestroke include:

- facilitation of expedient remote consultations with specialists from virtually any location
- reduction in the costs and risks associated with traditional telephone consultations and the transfer of patients from rural communities to hospitals by helicopter or ground transportation
- telementoring of primary care professionals through interactions with remotely located experts
- enhancement of stroke education through the use of Internet-based interactive applications by health-care professionals and patients
- improvement of thrombolytic therapy data collection efforts for research and quality assurance
- more efficient implementation of rehabilitation efforts.

1.2 Overview of Technology

The purpose of telestroke systems is to provide access to acute stroke specialists for those facilities lacking appropriate services. The transactions that occur using these systems could involve the remote clinical assessment of patients, measurement of a National Institute of Health Stroke Scale (NIHSS), review of radiological investigations to exclude cerebral hemorrhage, and instruction on the delivery of thrombolytics. In the broadest definition, telestroke includes the use of the traditional telephone to assist in the delivery of acute stroke care. This modality provides voice access to the treating practitioner and the neurological consultant. Newer systems involve audio-videoconferencing capabilities that allow neurological consultants to interact with acute stroke patients. These telehealth systems, for the purposes of stroke care, are implemented in one of two models: fixed-site and web-based.

The fixed-site model requires the neurological consultant to be located at a videoconferencing facility hosted at a hub hospital (also known as the "receiving site") when interacting with the requesting physician. This model typically uses a dedicated integrated services digital network (ISDN) line transmitting 30 frames per second, with two-way full motion, video, and audio teleconferencing, and with encryption of information at the remote site via virtual private networks.[6]

The web-based model also allows the neurological consultant to interact through videoconferencing (via a web-cam and real-time audio) with a requesting physician. This interaction could occur from almost any location, provided that there is access to a web-based application on the public internet, via any computer (or web-enabled device), and using wireless fidelity (WiFi) or wired broadband. Access to a patient's data and information transferred between the hub, rural sites, and the consultant's home or other remote computer access site is encrypted. The advantage of the web-based model is that time could be saved by avoiding travel by the consultant to hub sites, therefore shortening the onset to treatment time. Furthermore, for the neurological consultant, a request could be answered from any location where Internet access is available.

2 THE ISSUE

Stroke is still a disease with associated morbidity and subsequent socioeconomic costs. As a result, efforts have been made to improve and standardize stroke care. The use of telehealth to increase access to health services in the management of stroke is a potential solution.

Although telestroke has been the focus of many original studies, there have been no systematic attempts to synthesize the data available on its effectiveness and potential risks. The absence of a resource that gathers the best practices developed at leading telestroke organizations worldwide hinders the information transfer that could facilitate the assessment of telestroke. This report will try to fill the knowledge gap.

3 OBJECTIVES

Our objective was to provide a critical evaluation of the available data on the use of telehealth to deliver health services to acute stroke patients. For this report, the term "telestroke" was defined as the use of audio (including the telephone), video, and other telecommunications and electronic information processing technologies for the transmission of information and data relevant to the diagnosis and treatment of acute stroke.

This report describes:

- a systematic review of the peer-reviewed literature on the impact of telestroke initiatives on health outcomes, process of care (e.g., access to health services), health resources, and user satisfaction
- an environmental scan to help synthesize the available practices from organizations that provide telestroke services of relevance to Canadian policy makers.

The report addressed five questions:

- What evidence exists in the peer-reviewed literature to support the use of telestroke in the improvement of health outcomes?
- Does the use of telestroke improve access to health services?
- Does telestroke affect health care resource utilization?
- What is the level of user satisfaction regarding health services delivered via telestroke?
- What organizations and best practices are at the forefront of telestroke delivery?

Health outcomes were defined as an effect on individual health status or clinical consequence (e.g., increased compliance with treatment or reduced burden of illness) resulting from a telestroke intervention. Rates of diagnostic concordance, only if reported with other health or non-health outcomes, were considered for this category. Process of care outcomes described access to care, wait times, or time to completion for a clinical encounter using telestroke services. Resource utilization outcomes reported cost-effectiveness data or impact on health care resources such as hospital admissions, visit frequency, or rate of referrals. User satisfaction was broadly used to categorize any feedback from a patient or provider on satisfaction, expectations, or acceptance of clinical telestroke.

4 CLINICAL REVIEW

4.1 Methods

A protocol for this review was written a priori and followed throughout the review process. There were no significant deviations from the original protocol (Appendix 1). Article screening and data extraction were performed using TrialStat SRS 4.0 (Ottawa, Ontario), an online application that is designed to streamline the data capture for systematic reviews.

4.1.1 Literature search strategy

A search strategy combined two clusters of terms: one focused on telehealth and the other on stroke. The refined search strategy for MEDLINE appears in Appendix 2. The searches of all databases were completed in mid-December 2006. The searches were run on MEDLINE (from 1966), CINAHL (from 1982), HealthSTAR (from 1975), the Database of Abstracts of Reviews of Effects (DARE), and the Cochrane Library. The yield from the bibliographic database search was complemented with a scan of reference lists of eligible reports.

4.1.2 Selection criteria

An article was regarded as potentially eligible if it met all of the following criteria:

- It evaluated one or more telestroke services.
- It included original data on health outcomes, process of care, user satisfaction, or resource utilization.
- It was published in English, since 2000, in a peer-reviewed journal.

Articles on modalities of telestroke that focused exclusively on diagnostic concordance between telehealth and traditional face-to-face consultations were excluded.

4.1.3 Selection method

Two teams of reviewers (team 1, AM and CL; and team 2, SK and HD) independently screened each title and abstract of a potentially eligible report, categorizing them into three groups: "yes" (meets inclusion criteria according to information in the abstract), "not sure" (obtain the full publication to determine if it meets the inclusion criteria), and "no" (does not meet the inclusion criteria).

Two other reviewers (AJ and AD) resolved any discrepancies between the two teams by independently reviewing each title and abstract. If disagreements persisted, a final decision was reached by consensus between AJ and AD, or the unresolved discrepancy was labelled as "investigate further," and the full publication was obtained for review.

Hard copies of articles labelled as "yes," "not sure," or "investigate further" were obtained from electronic databases or inter-library loans. Where necessary, we contacted selected authors to request a copy of the publication.

4.1.4 Data extraction and abstraction strategy

The reviewers (team 1 and team 2) extracted data independently, using unmasked copies of the reports. When disagreements existed, the final data set was reviewed independently by AJ and AD. Any differences were resolved by consensus.

A standard data extraction form (Appendix 3) was used. From each report, data were extracted on:

- general characteristics (e.g., name of lead author, publication title, year of publication, country of study)
- study type (e.g., experimental or non-experimental); if non-experimental (i.e., observational), the study was recorded as a case series, a cross-sectional effort, a cohort, or case-control; whenever relevant, it will be stated if the study was retrospective or prospective
- technological characteristics of the telehealth platform (e.g., ISDN- or IP-based, resolution level)
- population of patients (e.g., sample size, demographic characteristics)
- patients' setting (e.g., rural or urban)
- originator of the consultation (e.g., family physician, nurse, community member)
- comparison group(s) (e.g., telephone advice)
- purpose of the consultation (e.g., acute, non-acute and educational, diagnostic, therapeutic support, follow-up)
- outcomes measured and main findings (e.g., impact on health outcomes, process of care, or finances).

4.1.5 Strategy for quality assessment

The methodological quality of each study, where relevant, was assessed using validated tools. The Jadad scale was used for randomized controlled trials (RCTs)[7] and the Downs and Black checklist, for observational studies and controlled clinical trials (CCT)[8] (Appendix 4). These tools are reliable and validated. Not all scales, however, have a specified cut-off point to distinguish between low- and high-quality studies. The median study quality score was used for this value where no pre-specified score existed.[9] In our review, RCTs were considered to be of high quality if they received a Jadad score greater than 3 points.

The Downs and Black checklist is traditionally scored as a 27-point scale for the first 26 items. The last question (question 27) is designed to assess the study's statistical power. Because the Downs and Black checklist was only used for qualitative studies (which do not involve statistical testing) and CCTs, we elected to use a modified score reported as "0" or "1," based on whether authors documented statistical power tests in the original article (score=1), or not (score=0). The modified scale allowed for a maximum score of 28 for any given study. A high-quality study was defined as a study with a median quality score greater than 14 points.

4.1.6 Data analysis methods

The reports were categorized into two groups: telestroke rehabilitation and acute telestroke management services. The results were presented qualitatively, based on the findings in the original studies.

A general description was provided for the set of publications meeting the inclusion criteria with general characteristics and quality scores presented for the individual publications. Evidence tables were produced to summarize the salient information extracted from the publications.

Meta-analysis was considered to be inappropriate because studies were deemed to display clinical heterogeneity. There were disparities among studies related to study design, clinical setting, and technological intervention.

4.2 Results

4.2.1 Quantity of research available

The literature search yielded 863 citations across all databases. Most of the articles were excluded during the first stage because they did not describe a telestroke modality. Two papers involving teleneurology were excluded: one was published in a non-peer-reviewed journal,[10] while the other did not include any original data.[11] One telehealth paper was excluded because telestroke modalities were not presented.[12]

Thirty-six potentially eligible publications were judged to have met the inclusion criteria, including one article[13] that was identified by an external reviewer after completion of the search strategy and while the review was still in draft form. The retrieval of the full-text version was required for further investigation. After review of the full-text version, 14 articles were excluded.

Table 1: List of excluded studies	
Study	**Reason for Exclusion**
Eljamel[14]	unable to retrieve full-text through multiple sources
Ickenstein[21]	discussed previously described study population
Schwab[13]	discussed previously described study population
Tran[10]	not published in peer-reviewed journal
Craig[11]	no telestroke service
Johnston[12]	no telestroke service
Audebert[15]	no original data reported
Demiris[16]	no original data reported
Hess[6]	no original data reported
McCue[17]	no original data reported
Quaglini[18]	no original data reported
Sugarman[19]	no original data reported
Audebert[20]	duplicate study
Handschu[23]	concordance only
Theodoros[24]	concordance only
Graham[25]	case study
Hauber[22]	brain injury population only

One article could not be retrieved after multiple attempts,[14] six did not describe original outcome data,[6,15-19] three were duplicates or based on previously published data;[13,20,21] and four were excluded because one addressed brain injury,[22] two focused on concordance only,[23,24] and one described a case report.[25] The excluded studies appear in Table 1.

Ultimately, 22 studies met the selection criteria and were included in this review. The QUOROM (Quality of Reporting of Meta-analyses) flow chart appears in Figure 1.

4.2.2 Study characteristics

a) Overview

All 22 studies were published after 2000. Ten originated from the US,[5,26-34] four from Germany,[35-38] two from Canada,[39,40] two from Hong Kong,[41,42] two from the Netherlands,[43,44] and one each from Italy[45] and Finland[46] (Appendix 5).

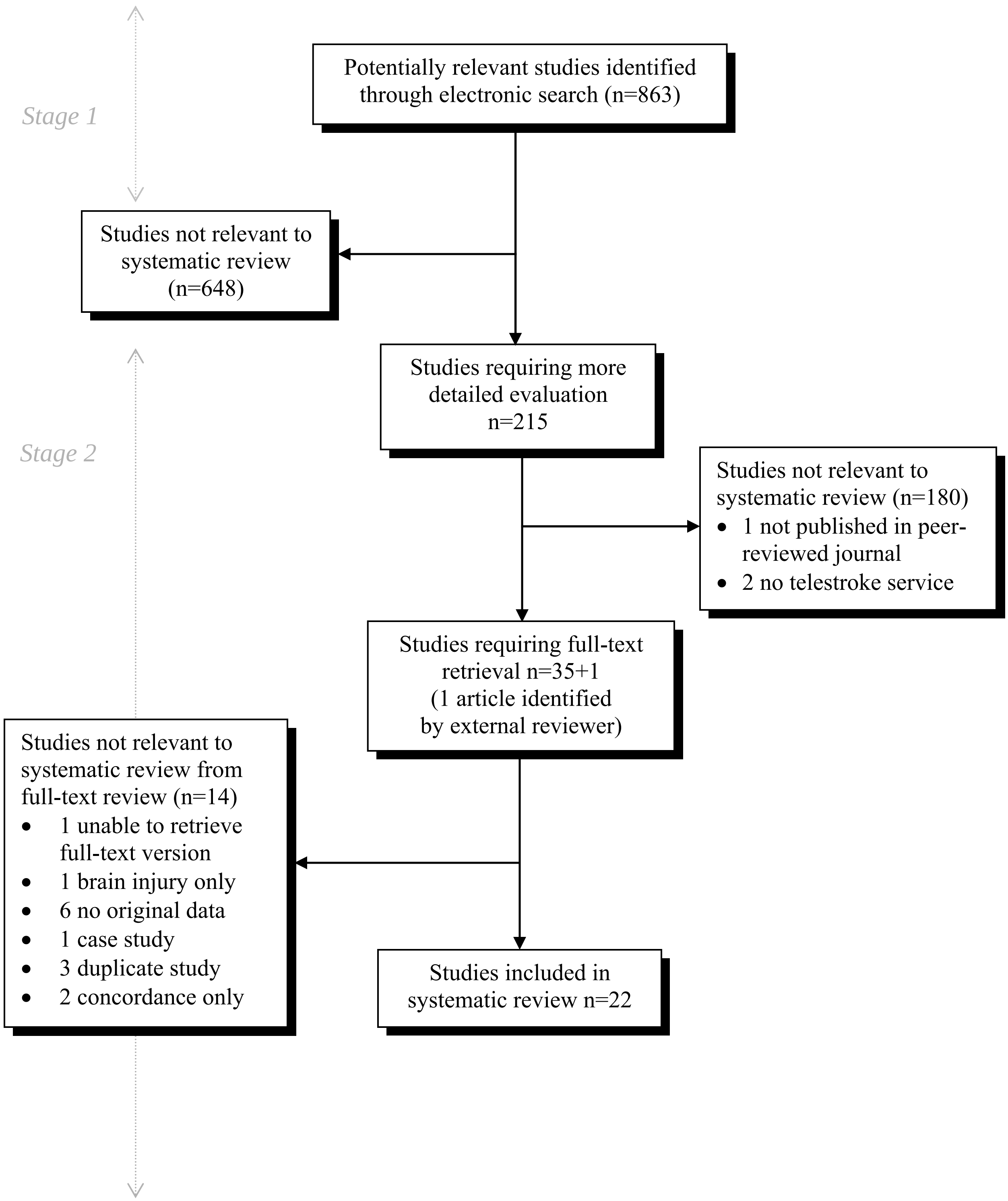
Fourteen studies assessed the impact of telehealth on acute stroke management, while eight reviewed its effect on rehabilitation in post-stroke survivors.

Twelve reports were published in clinical journals focused on neurological conditions (e.g., *Stroke*), while six publications appeared in telehealth journals.[34,40,42,44-46]

Twelve studies[30-34,36,38-41,43,45] documented the source of funding, with one[39] reporting industry funding.

There were three RCTs[26,41,43] and one CCT,[36] with the remainder a combination of case series and other forms of observational study design, mostly single prospective cohorts.

Figure 1: Selected reports (telestroke)



Study populations in all publications involved adults with acute stroke or post-stroke survivors, except one,[39] which addressed stroke in the pediatric population.

All 22 studies described the specific technologies used in the delivery of telestroke services. Five studies consisted of telephone-based interventions, with one study using a videophone.[32] The remaining articles described videoconferencing equipment with asynchronous technology to deliver radiological images to the consultant.

The outcome categories that were assessed included clinical effectiveness (11 studies), aspects of resource utilization (six studies), process of care issues (12 studies), and user satisfaction (three studies).

b) Quality assessments

Of the three RCTs[26,41,43] identified, one[26] was judged to be of high quality.

Of the remaining 19 studies, including the one CCT,[36] seven[5,6,27,35,37,38,42] were judged to be of high quality. Low-quality observational studies were uniformly deficient in failing to properly describe the population (e.g., no indication of source of sample) or provide adequate detail on the recruitment process (e.g., unable to determine the proportion of patients who were recruited compared with those asked to participate and reasons for non-participation). All non-RCTs failed to describe a statistical power calculation, resulting in a score of 0 for the modified question on the Downs and Black. Quality scores for individual studies appear in Appendix 5.

4.2.3 Data analyses and synthesis

A meta-analysis was considered to be inappropriate because of the heterogeneity of the studies, with respect to design and methodological quality. One-fifth of the studies were RCTs or CCTs. The remainder were observational studies with different designs (mostly case series and single prospective cohorts), completed in different settings, and using different outcome measures and endpoints.

a) Effects of hospital-based acute stroke management (Appendix 6)

The 14 studies that assessed the impact of telehealth on the management of acute stroke included five reporting data on health outcomes, 13 on process of care, two on resource utilization, and two involving patient or provider satisfaction.

Studies reporting data on "door-to-needle time" (time elapsed from the patient's arrival at the hospital and the beginning of thrombolysis) were classified under process of care outcomes, unless specific health outcome data were reported.

Health outcomes: One RCT[33] reported a reduction in six-month mortality for the teleradiology group (telephone call and transfer of images) relative to telephone consultation alone (24.7% versus 34.0%, P <0.025). The CCT[36] noted that poor outcomes after three months were reduced in the intervention group compared with controls (44% versus 54%, P <0.0001), and that treatment in network hospitals (those associated with the delivery of telestroke services) independently reduced the probability of a poor outcome (odds ratio 0.62, 95% CI 0.52 to 0.74; P <0.0001). Other reported benefits included improved quality of care and rehabilitative services with reduced mortality. Two studies[30,33] reported the absence of complications associated with the administration of tPA. One study based on a previously published population[13] identified comparable mortality rates between the telehealth group and the control (face-to-face stroke care) at three months (11.2% versus 11.5%, P = 0.55) and six months (14.2% versus 13%, P = 0.45). The same study reported comparable functional outcomes at six months on the modified Rankin scale (39.5% versus 30.9%, $P = 0.10$) and Barthel Index (47.1% versus 44.8%, $P = 0.44$).

Process of care: Several outcomes were addressed in the process of care category, including time required for consultation, door-to-needle time, and patients' access to thrombolysis for acute stroke as a result of telestroke availability. One RCT[41] comparing the use of telephone, teleradiology, or videoconferencing (VC) to deliver acute stroke care reported a longer consultation process time with the use of VC (real-time videoconferencing and transfer of radiology images) compared with the telephone (1.3 hours compared with 0.7 hour, $P < 0.003$), but comparable to that of teleradiology services. A study reported that consultation via telehealth for stroke care occurred within three hours for 25% of the study group and resulted in a mean time to consultation of 69 minutes with no difference between acute and sub-acute cases.[38] Another study[46] documented that the mean time to interpret one radiological case was 40 minutes when done at a distance, and that the impression was identical to the reference film in 86% of cases.

Several studies on telestroke reported data on door-to-needle time. In one study,[35] it was 76 minutes on average, including 15 minutes for consultation. Similar data were cited by Choi[33] (a mean of 85 minutes with a range of 27 to 165 minutes) and Schwamm[5] (106 minutes). Wang[29] reported evaluation times of 62.9 minutes with a door-to-needle time of 104.92 minutes (SD = 32.3 minutes). Hess[31] reported a drop in mean onset to treatment time from 143 minutes to 111 minutes after 10 patients, with 23% of them receiving treatment within 90 minutes and 60% treated in two hours.

Telestroke services also led to increased access to thrombolysis. Audebert[37] reported an increase from 10 patients receiving thrombolysis to 86 within a year of the beginning of a telestroke program. Frey[27] documented a 72% increase in the number of tPA-treated patients with the use of a telephone-based service. Another study reported that access to care increased from 0.8% before the implementation of the telestroke program, to 4.3% in the 12 months afterwards ($P < 0.001$).[33] Schwamm[5] described how 5.6% of patients (6/106 patients) received tPA during the intervention period compared with none in the two years before the start of their program, despite the availability of tPA.

Satisfaction with services: Data on satisfaction were sparse. In one study, physicians reported that the use of telestroke improved care in 95% of cases.[5] LaMonte[30] reported that patients and staff viewed positively the reassurance of interacting with a "live" stroke specialist.

Other effects: Audebert[36] reported that telestroke was associated with an increased rate of diagnosis of neurological conditions, and that it increased the use of CT-MRI, speech therapy, and occupational therapy. Another study[41] found that the diagnostic accuracy of the telephone-based system (63.8%) was significantly lower than that of the two other modalities (teleradiology 89.1%, $P < 0.0005$ or VC 87.7%, $P < 0.0005$). Schwamm[5] reported transfer avoidance in 11 of 24 cases.

b) Results of telerehabilitation for stroke care (Appendix 7)

The studies of home-based telerehabilitation post-stroke focused on health outcomes and patient and caregiver satisfaction. No outcomes were reported on resource utilization or process of care.

Health outcomes: Two RCTs[26,43] used regular telephones to deliver outreach programs to the caregivers of stroke survivors. Both reported the improved emotional well-being of caregivers in the intervention group. One study[26] reported reduced anxiety among caregivers, while the other[43] documented reduced levels of depression. The latter study[43] reported no other significant differences, while the former[26] noted improvement in the indicators of social functioning and mental health.

Two publications focused on interventions for stroke survivors.[42,45] One study[45] concluded that a lack of the health care practitioner's physical presence did not hamper motor learning. The other[42] noted that a service based on videoconferencing resulted in improved balance, strength, and self-esteem.

Patient satisfaction: Two studies reported data on patient satisfaction regarding the use of home-based telerehabilitation. Lai[42] reported that patients considered the intervention as good or excellent in 63% and 36% of cases respectively. Another study[34] on behavioural health care reported that patients were less satisfied with videoconferencing compared with face-to-face diagnosis with neuropsychologists, but generally were more satisfied when undergoing psychotherapy.

5 ECONOMIC ANALYSIS

The purpose of this systematic review was to present data to inform decision makers on the role that telehealth could play in delivering stroke care to Canadians. As a result, a formal economic analysis was not completed for this review. Data regarding cost-effectiveness and impact on resource utilization were collected from the studies identified in the clinical review, where available.

5.1 Resource Utilization

Few studies assessed the impact of telestroke on resource utilization. Wong[41] noted higher costs with teleradiology and videoconferencing compared with teleconferencing, although the results were not statistically significant. The costs were calculated by collecting the expenses that were directly related to a patient's hospital admission (e.g., in-patient admission, telehealth, operating room time). Audebert[36] reported that the mean stay was reduced in the group of hospitals supported by a telestroke program relative to care in hospitals without a specialized stroke service (10.7 days compared to 11.9 days, $P < 0.0001$). Schwamm[5] documented transfer avoidance through the use of telestroke. Averting the transfer of a patient may reduce resource utilization, although no cost data were provided.

6 HEALTH SERVICES IMPACT

6.1 Methods

6.1.1 Search strategy

Eligible organizations were identified through:

- a review of the 35 articles selected for full-text retrieval as potentially eligible for the systematic review
- a review of the first 200 hits obtained from each of two Google searches using the terms "telestroke" (15,200 hits) and "stroke telemedicine" (282,000 hits).

6.1.2 Selection criteria and methods

a) Selection criteria

An organization or initiative was selected if it:

- stated as one of its key objectives the promotion and use of telestroke services
- provided information about its services through any means (e.g., the web, through telephone, or face-to-face)
- generated data on the impact of such services.

b) Method

Two reviewers (AD and CR) screened the list of publications identified for full-text retrieval and independently extracted the name of the institutions involved. All duplicate institutions were removed.

The first Google search was performed to confirm that the institutions identified from the clinical review were involved in the delivery of telestroke services instead of being organizations that focused solely on research activities. The second Google search was performed to identify additional institutions providing telestroke services. (CR reviewed the first 200 hits from each of two search strategies.) The hits were reviewed to identify those organizations involved in the delivery of telestroke services. The results of the two searches were compared to eliminate duplicate organizations. The findings were then compared with the list from the journal publications to obtain a final list for data extraction.

6.1.3 Data extraction strategy

The following information was collected for each of the identified organizations:

- program name and contact details (e.g., postal address, telephone and fax numbers, URL)
- contact person and organizational leader, where possible
- available telestroke services (e.g., technology, staff, location, clinical scope, date of program inception, number of encounters with patients, and area of coverage)
- publications generated by the organization (author's name, e-mail, and affiliations)
- evidence of impact, based on the evaluation framework developed by the Oregon Evidence-based Practice Center during their systematic review of telehealth interventions on behalf of the US Agency for Healthcare Research and Quality (AHRQ);[47] efforts were made to answer the following questions to determine evidence of impact:
    - Does telestroke result in comparable diagnostic decisions and recommendations for clinical management?
    - Does telestroke result in comparable health outcomes?
    - Does the availability of telestroke services improve access?

6.1.4 Quality assurance

The Telemedicine Information Exchange (TIE) (http://tie.telemed.org/default.asp), a comprehensive repository of information about telehealth-related activities, was used to verify the contact information and program coverage details of each eligible organization. All institutions that were identified were contacted by e-mail. A standard template was forwarded to the institution so that the extracted information could be verified and any missing information obtained. Leaders of institutions or their assistants received a follow-up call to confirm receipt of the e-mail message and to obtain additional information.

Table 2: General characteristics of leading telestroke programs*							
Institution	**Location**	**Date of Inception**	**Technology**	**Comparable Diagnostic Decisions**	**Comparable Health Outcomes**	**Comparable Access**	**Other**
Canada							
Ontario Telemedicine Network	Canada (Ontario)	2002	SF+2-way VC system delivered over broadband	No	No	No	Telestroke is feasible intervention in Ontario; economic studies of telestroke recommended
Alberta Provincial Telehealth Program (Part of Alberta Provincial Stroke Strategy)	Canada (Edmonton, Alberta)	2005	Unclear	Unclear	Unclear	Unclear	Pediatric stroke consultations[38]
US							
University's Medical Center (combined efforts of University of Maryland, St. Mary's Hospital, and co-sponsor Bell Atlantic)	US (Maryland, Baltimore)	1999	SF+2-way VC system transmitted via ISDN	Yes[30]	Yes[30]	Yes[30]	Administration of rtPA during telemedicine consultation feasible and safe, and system well received; lack of reimbursement for telemedicine services could hinder widespread adaptation of telemedicine for remote acute stroke treatment
University of Texas Health Science Center	US (Texas, Houston)	2005	VC with secure transmission by a point-to- point VPN	No	No	No	Telestroke facilitated thrombolytic therapy for acute stroke patients and intended not to replace care provided by remote-site providers, but to address time and spatially related emergency need
Massachusetts General Hospital	US (Massachu-setts)	1995 (proof of concept) 2004	SF+2-way VC system transmitted at 256 to 384 kbps	Yes[5]	Yes[5]	Yes[5]	Telestroke can support emergency department-based evaluation of

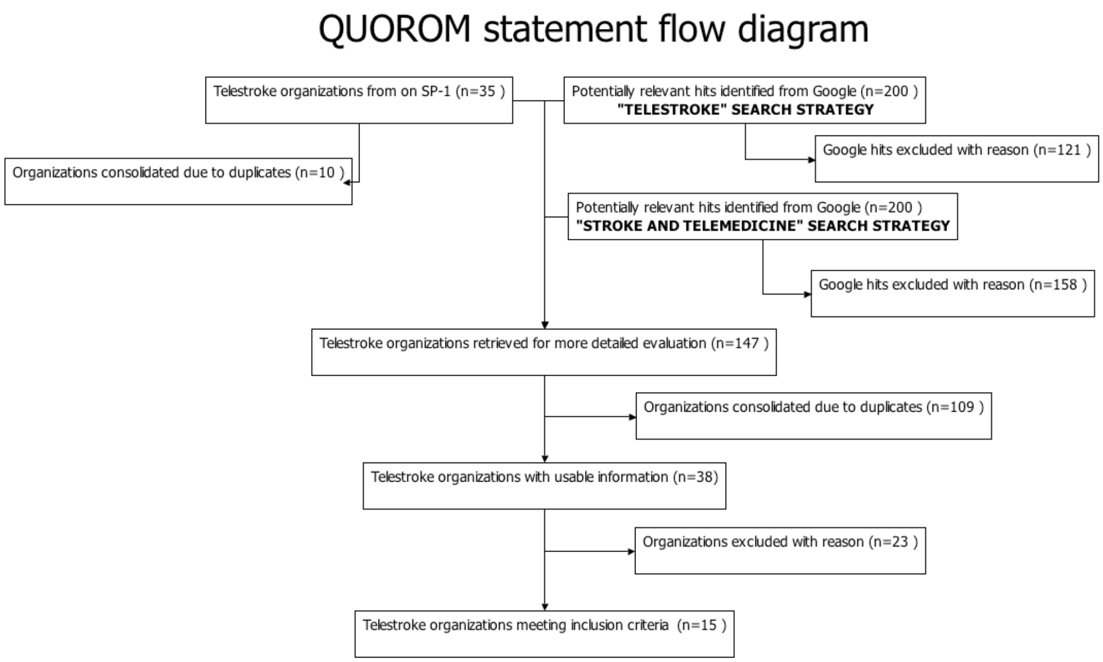
Table 2: General characteristics of leading telestroke programs*							
Institution	**Location**	**Date of Inception**	**Technology**	**Comparable Diagnostic Decisions**	**Comparable Health Outcomes**	**Comparable Access**	**Other**
							acute stroke and may facilitate tPA delivery in neurologically underserved facilities; physicians believed that TeleStroke consultation improved care in 95% of cases
Medical College of Georgia	US (Georgia, Augusta)	unclear	SF+2-way VC system delivered over Internet	Yes[31]	Yes[31]	Yes[31]	REACH telestroke system permits rapid and safe use of tPA in rural community hospitals
Barrow Neurological Institute	US (Arizona)	1998-2002	POTS	No	No	Yes[27]	tPA treatment with telephone support, followed by transport, effective and time-efficient
Telemedicine Stroke Program	US (New York)	Mid-September 2006	Web-based	Unclear	Unclear	Unclear	Unclear
University of Alabama School of Nursing, University of Alabama	US (Alabama)	Unclear	POTS	No	No	No	Problem-solving training by telephone may be useful for family caregivers of stroke survivors after discharge from rehabilitative facilities[26]

Table 2: General characteristics of leading telestroke programs*							
Institution	**Location**	**Date of Inception**	**Technology**	**Comparable Diagnostic Decisions**	**Comparable Health Outcomes**	**Comparable Access**	**Other**
Europe							
Rudolf Magnus Institute of Neuroscience, University Medical Center Utrecht	Nether-lands (Utrecht)	NA	POTS	No	No	No	Patients used fewer rehabilitation services and had lower anxiety scores[43]
San Camillo Hospital	Italy	Unclear	VC through TCP/IP protocol and point-to-point ISDN	No	No	No	Telerehabilitation may improve arm motor deficits due to stroke[45]
Städtisches Klinikum, München	Germany (Munchen)	1999	High-speed VC system (ISDN data transfer rates up to 2 Mb/s) to examine patients and transfer tele-radiological data of CT and MRI	Yes[37]	Yes[37]	Yes[37]	Treatment quality better in network hospitals; combined risk for death, institutionalized care, and severe disability lower in patients admitted to TEMPiS-clinics
Department of Neurology and Neurological Rehabilitation, Bezirkskranken-haus, Gunzburg, Germany	Germany (Gunzburg)	2001	SF+2-way VC system transmitted via ISDN	Unclear	Unclear	Yes[38]	Teleconsultation using videoconference system seems to be feasible and promising method to improve stroke care in rural areas; user satisfaction good concerning imaging and audio quality, and patient satisfaction very good or good in all cases; relevant contributions could be made in >75% of cases concerning diagnostic workup, CT assessment, and therapeutic recommendations

Table 2: General characteristics of leading telestroke programs*							
Institution	**Location**	**Date of Inception**	**Technology**	**Comparable Diagnostic Decisions**	**Comparable Health Outcomes**	**Comparable Access**	**Other**
University of Erlangen, Nuremburg, Germany, Stroke Unit	Germany	Unclear	ISDN	No	No	No	Telestroke feasible and realiable[23]
Chinese University of Hong Kong	China (Hong Kong)	Unclear	2-way VC system only via broadband (10Mbit/s)	Unclear	Unclear	Unclear	Telerehabilitation for community-dwelling stroke clients feasible and has high level of acceptance

*Evaluation framework implemented by team at Oregon Evidence-based Practice Center during systematic review of telehealth interventions on behalf of US Agency for Healthcare Research and Quality (AHRQ) used to complete this table.[47]
ISDN=integrated services digital network; NA=not applicable; POTS=plain old telephone system; SF=store-and-forward; TCP/IP=transmission control protocol/internet protocol; VC=videoconferencing; VPN=virtual private network

Figure 2: Telestroke institutions selected



QUOROM=Quality of Reporting of Meta-analyses

6.2 Environmental Scan Results

Fifteen organizations that provide telestroke services were identified (Figure 2). Two were located in Canada, seven in the US, three in Germany, and one each in Italy, the Netherlands, and China. Most organizations offered a combination of real-time and asynchronous services (Table 2).

Of the 15 organizations, four had data available matching all the elements of the evaluation framework proposed by Hersh.[47] Three of these organizations were in the US (Medical College of Georgia, Massachusetts General Hospital, and the University of Maryland Medical Center) and one in Germany (Städtische Klinikum,Table 2). Another program, the Barrow Neurological Institute in Arizona, met one of the elements.

6.2.1 Staffing issues

There was variability with respect to the number and type of staff who are employed by telestroke programs.

Most telestroke services surveyed have a multidisciplinary team composed of licensed physicians (neurologists and neurosurgeons, fellows, residents), nurse practitioners and registered nurses, information technology experts, program coordinators, and managers.

Establishing the number of staff in each telestroke institution was difficult because of the nature of the neurology services and departments that support them in the host hospitals, and the range of patients who are assessed. In a few cases, the staff was solely dedicated to providing telestroke services. In most institutions, however, the staff floated to support the telestroke services. In certain institutions, physicians supervised the telestroke operation without the aid of other allied health professionals, while in other organizations, services were managed by nurses only.

6.2.2 Volume of patients

It was difficult to obtain meaningful information from organizations regarding the volume of patients served by the programs. Disagreement about the unit of analysis was often cited as a reason for lack of data. For example, the Massachusetts General Hospital counts the number of stroke patients seen via telehealth, regardless of the number of videoconference encounters undertaken for a given patient. Conversely, the Ontario Telemedicine Network records encounters as the number of events undertaken to support non-scheduled emergency stroke consultations and the number of events where tPA is administered.

6.2.3 Coverage area

The radius of coverage for telestroke services ranged from 160 to 400 kilometres (100 to 250 miles). The limits of this coverage area were based on the number of telestroke centres in the same network and the distance of the satellite telestroke centres to a telestroke hub.

The telestroke initiative in Ontario offers the widest coverage for stroke patients (nine participating telestroke centres throughout the province). Most telestroke consultations are performed using videoconferencing across the Ontario Telemedicine Network and do not require the transportation of patients for tPA treatment.

Extended coverage is also facilitated by the use of air ambulance services. Centres such as the Massachusetts General Hospital use the maximum distance for safe air transport as the limiting factor to their telestroke reach.

In Canada and the US, the policies of the Ministry of Transportation and Department of Transportation respectively state that an air ambulance can be used instead of a land ambulance in the presence of the following criteria: when transfers cover a distance of at least 240 kilometres; all land ambulance alternatives have been exhausted; there are poor road conditions or severe weather; or specialized equipment or medical escorts are required. A few organizations used the telephone to connect with stroke patients and had a coverage area of up to 40 kilometres.

7 DISCUSSION

7.1 Systematic Review

Although most reports had poor methodological quality, there was consistency in the findings across the studies included in the review. Furthermore, most studies supported the empirical claims of earlier publications that suggested benefits from the use of telestroke but only addressed particular facets of this modality.[48]

Most studies showed improvement in health outcomes, including reduced mortality and morbidity at six months post-stroke.

Table 3: Telestroke programs: contact information and publications					
Institution	**Staff**	**Address**	**URL**	**Contact person**	**Publications**
Ontario Telemedicine Network*	6 neurologists	1090 Don Mills Road, Suite 500,Toronto Ontario, M3C 3R6; p: (416) 446-4110, f: (416) 446-4139	http://www.otn.ca/clinical_programs.html	Karen Waite,† Executive Lead, Corporate Projects and Privacy, OTN p:(416) 446-4110, ext. 4187	Waite[40]
Alberta Provincial Telehealth Program, Alberta Provincial Stroke Strategy	Unclear	2E3.16 Walter C. Mackenzie Health Sciences Centre, 8440-112 Street, Edmonton, Alberta, T6G 2B7	http://www.strokestrategy.ab.ca/telestroke.html	Dr. Ashfaq Shuaib, MBBS, FRCP(C) p: (780)407-6395 f: (780)407-1325 E-mail: ashfaq.shuaib@ualberta.ca	Kuhle[39]
University of Maryland Medical Center	Unclear	The Maryland Brain Attack Center, University of Maryland School of Medicine, 22 South Greene Street, Room N4W46, Baltimore, Maryland 21201 p: (410)328-5801, f: (410)328-7363	http://www.umm.edu/neurosciences/brainattack.html	Dr. Marian P. LaMonte, Neurologic Director and assistant professor of neurology	LaMonte[30]
University of Texas Health Science Center at San Antonio	Unclear	Neurosurgery Clinic UT Professional Building 6410 Fannin Street, Suite 1020 Houston, Texas 77030 (832) 325-7085	http://www.uth.tmc.edu/schools/med/neurosurg/index.htm	Nicole Porche, RN, nurse telestroke service	Choi[33]
Massachu-setts General Hospital	21 attending, 7 fellows, no nurses in program. 2 IT in program use telemedicine group	55 Fruit Street, VBK 9, Boston, Maryland 02114, p: (617)724-3999, f: (617) 228-4628, e-mail: telestroke@partners.org	http://telestroke.massgeneral.org/index.asp	Dr L. Schwamm, MD	Shafqat[48] Schwamm[5]
Medical College of Georgia	Unclear number of Specialized team of neurologists, neurosurgeon,	22 S Greene St, Room N4W46, Baltimore MD 21201	N/A	Dr. David Hess, MD	Hess[6,31]

Table 3: Telestroke programs: contact information and publications					
Institution	**Staff**	**Address**	**URL**	**Contact person**	**Publications**
	nurses, and other health professionals				
Barrow Neurological Institute	Unclear	500 West Thomas Road, Suite 300, Phoenix, Arizona 85013	http://www.thebarrow.org/intradoc-cgi/idc_cgi_isapi.dll?IdcService=SS_GET_PAGE&nodeId=5012151	Dr. James L. Frey, Director, Stroke Program,	Frey[27]
Telemedicine Stroke Program	Unclear	New York State Department of Health, Corning Tower, Empire State Plaza, Albany, NewYork 12237	http://www.health.state.ny.us/professionals/hospital_administrator/telestroke/reach.htm	Dr. Levin, Program Director	None
University of Alabama at Birmingham School of Nursing	Unclear	School of Nursing, University of Alabama at Birmingham, NB 407, 1530 3rd Ave South, Birmingham, Alabama 35294-1210	http://main.uab.edu/sites/nursing/		Grant[26]
Rudolf Magnus Institute of Neuroscience, University Medical Center Utrecht	Unclear	Rudolf Magnus Institute of Neuroscience, Stratenum Building , Room STR5.203 , Universiteits-weg 100 , 3584 CG, Utrecht, the Netherlands	http://www.rudolfmagnus.nl/	Krista Poel, Secretary	Boter[42]
San Camillo Hospital	Unclear	Department of Neurology and Psychiatry, Università Degli Studi di Padova via Giustiniani 5, Padua, 35100, Italy Department of Neurorehabilita-tion, San Camillo Hospital via Alberoni 70, Lido di Venezia, 30011, Italy	Not available	Lamberto Piron, MD	Piron[45]
Städtische Klinikum München	Unclear	Klinikum Bogenhausen; Städtisches Klinikum München GMBH; Englschalkinger Str. 77; 81925 München	http://www.tempis.de/content/view/5/40/	Dr. H Audebert, MD	Audebert[15,20,36]
Department of Neurology and	Unclear	Ludwig-Heilmeyer-Strasse 2, Günzburg, Bavaria, Germany 89312	http://www.bkh-guenzburg.de	Dr. Andreas Wiborg, MD	Wiborg[38]

Table 3: Telestroke programs: contact information and publications					
Institution	**Staff**	**Address**	**URL**	**Contact person**	**Publications**
Neurological Rehabilita-tion, Bezirks-krankenhaus, Günzburg, Bavaria, Germany					
Friedrich-Alexander Universität Erlangen-Nürnberg, Stroke Unit	Unclear		http://www.uni-erlangen.org/		Handschu[23]
Chinese University of Hong Kong, Shatin, Hong Kong	Unclear	Telemedicine Centre, Pathology Teaching Laboratories, Prince of Wales Hospital, The Chinese University of Hong Kong, Shatin, Hong Kong; p: (852) 2632-3337 / (852) 2145- 5215, f: (852) 2647-2763 / (852) 2635- 2521, e-mail: telemed@med.cuhk.edu.hk	http://tele.med.cuhk.edu.hk/index.htm	Professor Ho-Keung Ng	Lai[42] Wong[41]

f=fax; p=phone
*Ontario Telemedicine Network provides infrastructure to four regional provincial initiatives offering hyper-acute telestroke services. The four regions and corresponding referring telestroke sites are:
South West–Chatham Kent Health Alliance; Central South – Brantford General Hospital, Greater Niagara General Hospital; North East, North West, Greater Toronto Area – Hôpital régional de Sudbury Regional Hospital, St. Joseph's Health Centre, North Bay General Hospital (Scollard site), Sault Area Hospital (General site), Timmins and District Hospital;
East – Peterborough Regional Health Centre (Hospital Drive site), Pembroke Regional Hospital
There is a provincial initiative to consolidate the four regions into one governing structure. Definite timelines for this integration are unknown at the time of publication of this report.
†Ms. Karen Waite is responsible for the overall telestroke program, governance, and program development. At the Regional Program Director level, four individuals lead the telestroke programs: North – Jennifer Michaud (jmichaud@otn.ca); East – Jacinthe Desaulniers (jdesaulniers@otn.ca); West – Sue Hocking (shocking@otn.ca); Central/GTA – Maureen Wilkinson (mwilkinson@otn.ca)

Standardized measures regarding the assessment of morbidity would assist in the comparison between telestroke and usual care, and would facilitate comparisons across telestroke studies.

Two small studies of low quality and one high-quality study[35] commented on the complication rates associated with the administration of tPA through the use of telestroke. Future studies are needed to prove that the risk of complications associated with treatment in telestroke programs is no greater than that of face-to-face care.

Telestroke services seem to be consistently associated with enhanced process of care. Critical aspects, such as consultation and door-to-needle times, are improved, affording greater access to the delivery of tPA and a decrease in transfers of patients. Although these factors may imply cost-savings through reduced morbidity or avoidance of expensive care (e.g., transfer of patients), the resource implications of these effects remain unclear. One study performed a rudimentary analysis of the direct costs associated with treating patients with stroke and found no significant difference among telehealth modalities.[41] Another study[36] reported a decreased duration of hospital admission, which could result in reduced costs. In this study, however, there was a greater use of rehabilitative services in the intervention group. This may have eliminated any potential cost savings. Telestroke studies that assess cost-effectiveness, similar to other telehealth initiatives, have been criticized for their lack of rigour.[49] Unlike telehealth in general, however, telestroke is characterized by a defined clinical entity rather than a general medical specialty, e.g., dermatology. This focus could represent an ideal situation in which to perform a cost-benefit analysis, determining the “value for money” by accounting not only for the direct costs, but also for the resource implications of any associated reduction in morbidity and mortality. The complexities of such work should not be underestimated. The lack of technology standardization and processes across telestroke sites with the need for more robust cost-utility analysis and the ability to increase access to care are issues that should be considered. The value of such a study could have far-reaching impacts not only at the policy level but also for local health care decision makers (e.g., hospital administrators and physicians).

Although the search strategy for the review focused on acute stroke care, it identified eight articles involving telerehabilitation for post-stroke care. While there can be no conclusive remarks made based on this sample of publications, the studies seem to suggest that there may be benefit in the use of this service modality in the post-stroke phase. A more focused search strategy on telerehabilitation encompassing new technologies, such as virtual reality devices, assistive robotics, and other portal technologies designed to promote independent living in stroke survivors, would be needed to generate more robust conclusions.

7.2 Environmental Scan

Telestroke programs are a new development, with the oldest identified program dating back to the mid-1990s.

The environmental scan revealed that most telestroke programs are unique in terms of staffing requirements, technology, and unit of measurement for determining encounters with patients. Four of the 15 organizations documented the outcomes of telestroke compared with the traditional management of acute stroke. The dearth of reported outcome data from existing programs precludes the determination of the most efficient or effective best practices. Based on the data available (or lack thereof), there is a need for standardizing the measurements of the nature and quantity of resources (e.g., staff, technology, funding) needed to operate such organizations with the type of outcomes that such programs produce. Without this level of harmonization, it would be difficult to compare programs and it would make it almost impossible for new organizations to determine which practices ensure success.

Canada's two recently started programs, both of which sprung from established provincial telehealth initiatives, have unique opportunities for leadership. With more than half of the existing efforts located in North America, they could foster collaborative work geared to filling the gaps in knowledge, particularly those related to the safety of the interventions, the standardization of outcome measures, and the optimization of human and financial resources associated with telestroke care.

7.3 Study Limitations

This systematic review had several limitations. The search of databases was performed in December 2006. Telehealth, as with most fields in medicine, is evolving with new publications. Systematic reviews need to be updated regularly to ensure that the knowledge provided is based on new evidence.

The literature search was restricted to the English language. Large telestroke networks located outside North America, such as TEMPiS, have published many papers in English. Although there could be other reports published in other languages, previous studies have suggested that restricting literature searches to English does not bias systematic reviews of conventional medical interventions.[50]

The exclusion of unpublished studies in this systematic review could introduce bias.[51-53] The pursuit of grey literature, although important, was beyond the resources available for this review.

Reports on telerehabilitation were identified based on the generic search strategy, which focused on acute stroke care. Because telerehabilitation is broadly defined, some articles may not have been identified. Our results present weak evidence for telerehabilitation, so no conclusions could be drawn in this area. A focused systematic review might be able to determine its effectiveness.

The quality of almost ⅔ of the included studies was deemed to be poor. Despite this, the trends that were identified in the high-quality and low-quality literature were consistent.

8 CONCLUSIONS

Stroke is a neurological condition that affects many Canadians, resulting in socioeconomic costs. The use of thrombolysis that is delivered within a narrow window of time after the presentation of symptoms, has been shown to significantly reduce the burden of illness.

The use of telestroke seems to improve access to the administration of thrombolysis, could reduce the number of poor outcomes three and six months post-stroke, and may improve the quality of care in acute stroke management. Two studies assessed patient satisfaction. Both documented high levels of acceptability. It is unclear, however, whether this modality is cost-effective and safe relative to face-to-face care.

The evidence obtained for the use of telestroke in the rehabilitation of post-stroke survivors was not exhaustively reviewed, so no conclusions could be drawn. The few articles that were identified, however, suggest a trend towards improved caregivers' well-being. More research is warranted to determine the impact of telehealth on post-stroke care.

While several organizations have been identified at the forefront of telestroke, the lack of standardized reporting of resources and outcomes precludes comparisons among programs and the determination of best practices. The use of telestroke services seems to reduce inappropriate variations in practice. The recent creation of two programs in Canada opens the door for collaborative efforts that could lead to standardized evaluation frameworks, economies of scale for knowledge transfer, and a better understanding of the safety and resource implications of the services that they offer.

Telestroke, like telehealth in general, transcends distance and geographic boundaries. Canada has made strides in many areas of telehealth. The availability of picture archiving and communication systems (PACS) in almost 20% of all Canadian hospitals and free-standing imaging facilities (Canadian Institute for Health Information, 2005 figures) provides the foundation for telestroke care to play a greater role in Canada. The emerging telestroke programs, and their financial and political backers, have an opportunity to join efforts that could place Canada at the forefront of telestroke care, while ensuring that Canadians have access to the services that they expect, regardless of where they live.

9 REFERENCES

1. Statistics - Heart and Stroke Foundation of Canada http://www.heartandstroke.on.ca/site/c.pvI3IeNWJwE/b.3582081/k.BDB8/Stroke_Statistics.htm.
2. Hacke W, Donnan G, Fieschi C, et al. Association of outcome with early stroke treatment: pooled analysis of ATLANTIS, ECASS, and NINDS rt-PA stroke trials. *Lancet.* Mar 6 2004;363(9411):768-774.
3. Sharma M, Clark H, Armour T, et al. Acute stroke: evaluation and treatment. *Evid Rep Technol Assess (Summ).* Jul 2005(127):1-7.
4. Levine SR, Gorman M. "Telestroke" : the application of telemedicine for stroke. *Stroke.* Feb 1999;30(2):464-469.
5. Schwamm LH, Rosenthal ES, Hirshberg A, et al. Virtual TeleStroke support for the emergency department evaluation of acute stroke. *Acad Emerg Med.* Nov 2004;11(11):1193-1197.
6. Hess DC, Wang S, Gross H, Nichols FT, Hall CE, Adams RJ. Telestroke: extending stroke expertise into underserved areas. *Lancet Neurol.* Mar 2006;5(3):275-278.
7. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials.* Feb 1996;17(1):1-12.
8. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health.* Jun 1998;52(6):377-384.
9. Brouwers MC, Johnston ME, Charette ML, Hanna SE, Jadad AR, Browman GP. Evaluating the role of quality assessment of primary studies in systematic reviews of cancer practice guidelines. *BMC Med Res Methodol.* Feb 16 2005;5(1):8.
10. Tran BQ, Buckley KM, Prandoni CM. Selection & use of telehealth technology in support of homebound caregivers of stroke patients. *Caring.* Mar 2002;21(3):16-21.

11. Craig J, Chua R, Wootton R, Patterson V. A pilot study of telemedicine for new neurological outpatient referrals. *J Telemed Telecare.* 2000;6(4):225-228.

12. Johnston KC, Worrall BB. Teleradiology Assessment of Computerized Tomographs Online Reliability Study (TRACTORS) for acute stroke evaluation. *Telemed J E Health.* Fall 2003;9(3):227-233.

13. Schwab S, Vatankhah B, Kukla C, et al. Long-term outcome after thrombolysis in telemedical stroke care. *Neurology.* Aug 28 2007;69(9):898-903.

14. Eljamel MS, Nixon T. The use of a computer-based image link system to assist inter-hospital referrals. *Br J Neurosurg.* 1992;6(6):559-562.

15. Audebert H. Telestroke: effective networking. *Lancet Neurol.* Mar 2006;5(3):279-282.

16. Demiris G, Shigaki CL, Schopp LH. An evaluation framework for a rural home-based telerehabilitation network. *J Med Syst.* Dec 2005;29(6):595-603.

17. McCue MJ, Palsbo SE. Making the business case for telemedicine: an interactive spreadsheet. *Telemed J E Health.* Apr 2006;12(2):99-106.

18. Quaglini S, Caffi E, Boiocchi L, Panzarasa S, Cavallini A, Micieli G. Web-based data and knowledge sharing between stroke units and general practitioners. *AMIA Annu Symp Proc.* 2003:534-538.

19. Sugarman H, Dayan E, Weisel-Eichler A, Tiran J. The Jerusalem TeleRehabilitation System, a new low-cost, haptic rehabilitation approach. *Cyberpsychol Behav.* Apr 2006;9(2):178-182.

20. Audebert HJ, Wimmer ML, Hahn R, et al. Can telemedicine contribute to fulfill WHO Helsingborg Declaration of specialized stroke care? *Cerebrovasc Dis.* 2005;20(5):362-369.

21. Ickenstein GW, Horn M, Schenkel J, et al. The use of telemedicine in combination with a new stroke-code-box significantly increases t-PA use in rural communities. *Neurocrit Care.* 2005;3(1):27-32.

22. Hauber RP, Jones ML. Telerehabilitation support for families at home caring for individuals in prolonged states of reduced consciousness. *J Head Trauma Rehabil.* Dec 2002;17(6):535-541.

23. Handschu R, Littmann R, Reulbach U, et al. Telemedicine in emergency evaluation of acute stroke: interrater agreement in remote video examination with a novel multimedia system. *Stroke.* Dec 2003;34(12):2842-2846.

24. Hill AJ, Theodoros DG, Russell TG, Cahill LM, Ward EC, Clark KM. An Internet-based telerehabilitation system for the assessment of motor speech disorders: a pilot study. *Am J Speech Lang Pathol.* Feb 2006;15(1):45-56.

25. Graham LE, Flynn P, Cooke S, Patterson V. The interdisciplinary management of cerebral haemorrhage using telemedicine--a case report from Nepal. *J Telemed Telecare.* 2001;7(5):304-306.

26. Grant JS, Elliott TR, Weaver M, Bartolucci AA, Giger JN. Telephone intervention with family caregivers of stroke survivors after rehabilitation. *Stroke.* Aug 2002;33(8):2060-2065.

27. Frey JL, Jahnke HK, Goslar PW, Partovi S, Flaster MS. tPA by telephone: extending the benefits of a comprehensive stroke center. *Neurology.* Jan 11 2005;64(1):154-156.

28. Pierce LL, Steiner V, Govoni AL, Hicks B, Cervantez Thompson TL, Friedemann ML. Internet-based support for rural caregivers of persons with stroke shows promise. *Rehabil Nurs.* May-Jun 2004;29(3):95-99, 103.

29. Wang S, Gross H, Lee SB, et al. Remote evaluation of acute ischemic stroke in rural community hospitals in Georgia. *Stroke.* Jul 2004;35(7):1763-1768.

30. LaMonte MP, Bahouth MN, Hu P, et al. Telemedicine for acute stroke: triumphs and pitfalls. *Stroke.* Mar 2003;34(3):725-728.

31. Hess DC, Wang S, Hamilton W, et al. REACH: clinical feasibility of a rural telestroke network. *Stroke.* Sep 2005;36(9):2018-2020.

32. Buckley KM, Tran BQ, Prandoni CM. Receptiveness, use and acceptance of telehealth by caregivers of stroke patients in the home. *Online J Issues Nurs.* Sep 30 2004;9(3):9.

33. Choi JY, Porche NA, Albright KC, Khaja AM, Ho VS, Grotta JC. Using telemedicine to facilitate thrombolytic therapy for patients with acute stroke. *Jt Comm J Qual Patient Saf.* Apr 2006;32(4):199-205.

34. Schopp LH, Johnstone BR, Merveille OC. Multidimensional telecare strategies for rural residents with brain injury. *J Telemed Telecare.* 2000;6 Suppl 1:S146-149.

35. Audebert HJ, Kukla C, Vatankhah B, et al. Comparison of tissue plasminogen activator administration management between Telestroke Network hospitals and academic stroke centers: the Telemedical Pilot Project for Integrative Stroke Care in Bavaria/Germany. *Stroke.* Jul 2006;37(7):1822-1827.

36. Audebert HJ, Schenkel J, Heuschmann PU, Bogdahn U, Haberl RL. Effects of the implementation of a telemedical stroke network: the Telemedic Pilot Project for Integrative Stroke Care (TEMPiS) in Bavaria, Germany. *Lancet Neurol.* Sep 2006;5(9):742-748.

37. Audebert HJ, Kukla C, Clarmann von Claranau S, et al. Telemedicine for safe and extended use of thrombolysis in stroke: the Telemedic Pilot Project for Integrative Stroke Care (TEMPiS) in Bavaria. *Stroke.* Feb 2005;36(2):287-291.

38. Wiborg A, Widder B. Teleneurology to improve stroke care in rural areas: The Telemedicine in Stroke in Swabia (TESS) Project. *Stroke.* Dec 2003;34(12):2951-2956.

39. Kuhle S, Mitchell L, Andrew M, et al. Urgent clinical challenges in children with ischemic stroke: analysis of 1065 patients from the 1-800-NOCLOTS pediatric stroke telephone consultation service. *Stroke.* Jan 2006;37(1):116-122.

40. Waite K, Silver F, Jaigobin C, et al. Telestroke: a multi-site, emergency-based telemedicine service in Ontario. *J Telemed Telecare.* 2006;12(3):141-145.

41. Wong HT, Poon WS, Jacobs P, et al. The comparative impact of video consultation on emergency neurosurgical referrals. *Neurosurgery.* Sep 2006;59(3):607-613; discussion 607-613.

42. Lai JC, Woo J, Hui E, Chan WM. Telerehabilitation - a new model for community-based stroke rehabilitation. *J Telemed Telecare.* 2004;10(4):199-205.

43. Boter H. Multicenter randomized controlled trial of an outreach nursing support program for recently discharged stroke patients. *Stroke.* Dec 2004;35(12):2867-2872.

44. Buurke JH, Kleissen RF, Nene A, et al. A feasibility study of remote consultation to determine suitability for surgery in stroke rehabilitation. *J Telemed Telecare.* 2004;10(2):108-112.

45. Piron L, Tonin P, Trivello E, Battistin L, Dam M. Motor tele-rehabilitation in post-stroke patients. *Med Inform Internet Med.* Jun 2004;29(2):119-125.

46. Reponen J, Ilkko E, Jyrkinen L, et al. Initial experience with a wireless personal digital assistant as a teleradiology terminal for reporting emergency computerized tomography scans. *J Telemed Telecare.* 2000;6(1):45-49.

47. Hersh WR, Hickam DHS, S.M.Dana, T.L.Krages, K.P., Helfand M. *Telemedicine for the Medicare Population: Update.* Feb 2006. Publication No. 06-E007.

48. Shafqat S, Kvedar JC, Guanci MM, Chang Y, Schwamm LH. Role for telemedicine in acute stroke. Feasibility and reliability of remote administration of the NIH stroke scale. *Stroke.* Oct 1999;30(10):2141-2145.

49. Whitten PS, Mair FS, Haycox A, May CR, Williams TL, Hellmich S. Systematic review of cost effectiveness studies of telemedicine interventions. *BMJ.* Jun 15 2002;324(7351):1434-1437.

50. Moher D, Pham B, Lawson ML, Klassen TP. The inclusion of reports of randomised trials published in languages other than English in systematic reviews. *Health Technol Assess.* 2003;7(41):1-90.

51. Dickersin K, Min YI. Publication bias: the problem that won't go away. *Ann N Y Acad Sci.* Dec 31 1993;703:135-146; discussion 146-138.

52. Thornton A, Lee P. Publication bias in meta-analysis: its causes and consequences. *J Clin Epidemiol.* Feb 2000;53(2):207-216.

53. Hopewell S, McDonald S, Clarke M, Egger M. Grey literature in meta-analyses of randomized trials of health care interventions. *Cochrane Database Syst Rev.* 2007(2):MR000010.

APPENDICES

Available from CADTH's web site
www.cadth.ca