CANADIAN STROKE BEST PRACTICE RECOMMENDATIONS

Acute Stroke Management Evidence Tables

Seventh Edition, Update 2022

Section 4: Emergency Department Evaluation and Management of Patients with Transient Ischemic Attack and Acute Stroke – Virtual Care (Telestroke)

Heran M, Shamy M (Writing Group Chairs)
on Behalf of the Canadian Stroke Best Practice Recommendations
Acute Stroke Management Writing Group and in collaboration with the
Canadian Stroke Consortium

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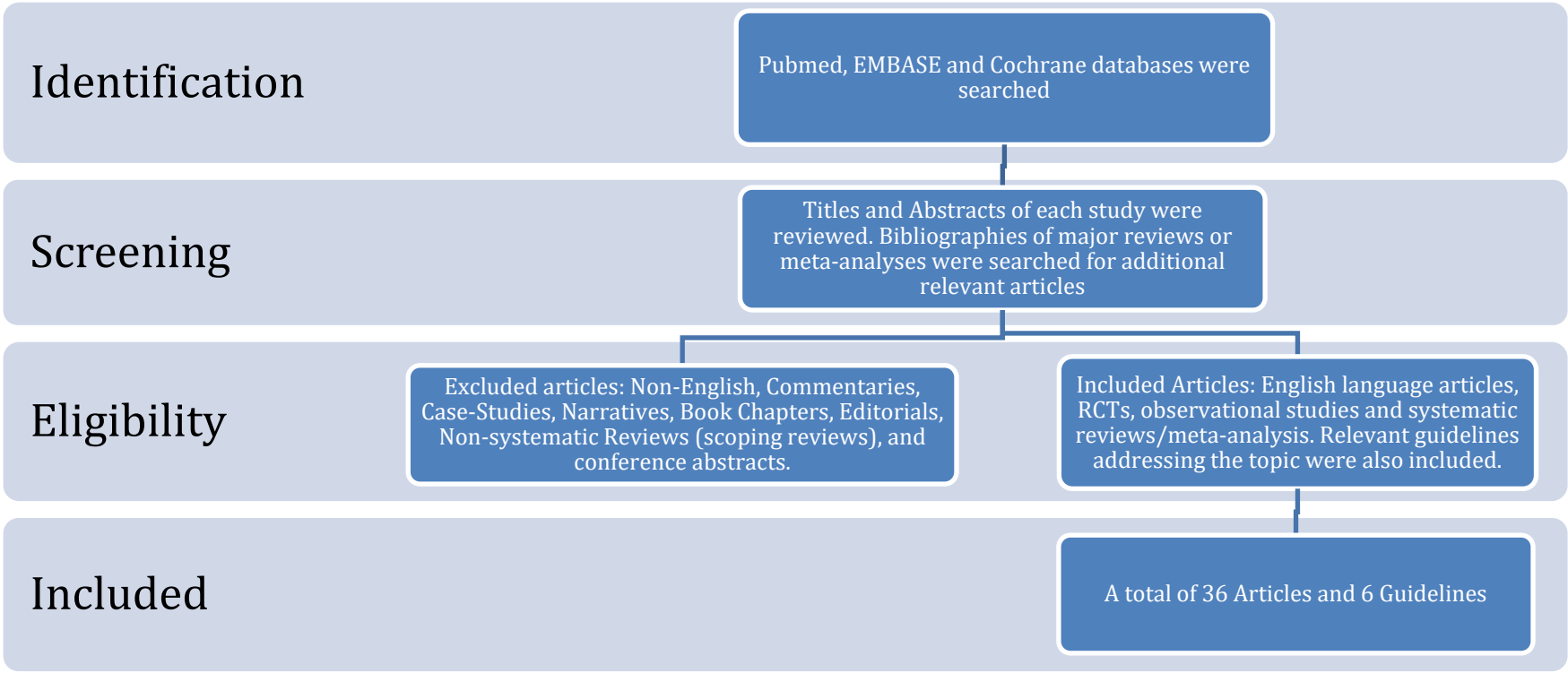
Search Strategy



Pubmed, EMBASE and the Cochrane Central Register of Controlled Trials databases were search using medical subject. Titles and abstract of each article were reviewed for relevance. Bibliographies were reviewed to find additional relevant articles. Articles were excluded if they were: non-English, commentaries, case-studies, narrative, book chapters, editorials, non-systematic review, or conference abstracts. Additional searches for relevant best practice guidelines were completed and included in a separate section of the review.

Published Guidelines

Guideline	Recommendations
Lou M, Ding J, Hu B, et al. **Chinese Stroke Association guidelines for clinical management of cerebrovascular disorders: executive summary and 2019 update on organizational stroke management** **S*troke Vasc Neurol*. 2020 Sep;5(3):260-269.**	*Importance of telemedicine* ► Smart phones, tablets and other communication tools can assist neurologists to assess the severity of prehospital stroke and make reasonable clinical decisions for patients with stroke. (Class I, level of evidence A) ► Telestroke can shorten the time of intravenous thrombolysis and improve the thrombolytic rate in patients with AIS. (Class I, level of evidence A) ► Rt-PA intravenous thrombolysis may be as safe and effective as in-hospital thrombolysis in patients with AIS guided by telestroke. (Class IIb, level of evidence B) ► Telestroke can provide guidance and support for rehabilitation treatment and secondary prevention of patients with stroke. (Class IIb, level of evidence C) ► Telestroke can optimise the allocation of health resources and reduce medical costs. (Class IIb, level of evidence C) ► Under the guidance of the government and the overall planning of the national/provincial stroke quality control centre, it may be reasonable to construct a regional stroke telemedicine network. (Class IIa, level of evidence B) *Operation and management of telemedicine* ► Comprehensive stroke centres should actively promote telemedicine, strengthen the integration of medical resources and form a stroke medical network covering the surrounding primary stroke centres or primary hospitals. (Class IIb, level of evidence B)
Hubert GJ, Santo G, Vanhooren G, Zvan B, Tur Campos S, Alasheev A, Abilleira S, Corea F. **Recommendations on telestroke in Europe** ***European Stroke Journal* 2019; 4: 101-109.** **(selected)**	Recommendations for the criteria for, the organization of, and the equipment needed for i) a telemedicine stroke centre (TSC) (hub), ii) a telemedicine-assisted stroke unit (TSU) and iii) the telemedicine-assisted stroke ready hospital unit (TSRH), are presented.
Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al; on behalf of the American Heart Association Stroke Council.	**1.6. Telemedicine** 1. For sites without in-house imaging interpretation expertise, teleradiology systems approved by the US Food and Drug Administration are recommended for timely review of brain imaging in patients with suspected acute stroke. Class I; LOE A

Guideline	Recommendations
2018 Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. ***Stroke.* 2018; Mar;49(3):e46-e110**	2. When implemented within a telestroke network, teleradiology systems approved by the US Food and Drug Administration are useful in supporting rapid imaging interpretation in time for IV alteplase administration decision making. Class I; LOE A. 3. Because of the limited distribution and availability of neurological, neurosurgical, and radiological expertise, the use of telemedicine/ telestroke resources and systems can be beneficial and should be supported by healthcare institutions, governments, payers, and vendors as one method to ensure adequate 24/7 coverage and care of acute stroke patients in a variety of settings. Class IIa; LOE C-EO. 4. Telestroke/teleradiology evaluations of AIS patients can be effective for correct IV alteplase eligibility decision making. Class IIa; B-R. 5. Administration of IV alteplase guided by telestroke consultation for patients with AIS may be as safe and as beneficial as that of stroke centers. Class IIb; LOE B-NR. 6. Providing alteplase decision-making support via telephone consultation to community physicians is feasible and safe and may be considered when a hospital has access to neither an in-person stroke team nor a telestroke system. Class IIb; LOE C-LD. 7. Telestroke networks may be reasonable for triaging patients with AIS who may be eligible for interfacility transfer in order to be considered for acute mechanical thrombectomy. Class IIb; LOE B-NR.
Demaerschalk BM, Berg J, Chong BW, et al. **American Telemedicine Association: Telestroke Guidelines.** ***Telemed J E Health* 2017;23(5):376-89.**	This document focuses on the acute phase of stroke, including both pre- and in-hospital encounters for cerebrovascular neurological emergencies. These guidelines describe a network of audiovisual communication and computer systems for delivery of telestroke clinical services and include operations, management, administration, and economic recommendations. These interactive encounters link patients with acute ischemic and hemorrhagic stroke syndromes with acute care facilities with remote and on-site healthcare practitioners providing access to expertise, enhancing clinical practice, and improving quality outcomes and metrics. These guidelines apply specifically to telestroke services and they do not prescribe or recommend overall clinical protocols for stroke patient care. Rather, the focus is on the unique aspects of delivering collaborative bedside and remote care through the telestroke model.
Schwamm LH, Holloway RG, Amarenco P, Audebert HJ, Bakas T, Chumbler NR, Handschu R, Jauch EC, Knight WA IV, Levine SR, Mayberg M, Meyer BC, Meyers PM, Skalabrin E, Wechsler LR; on behalf of the American Heart Association Stroke Council and the Interdisciplinary Council on Peripheral Vascular Disease.	**Class I recommendations** 1. High-quality videoconferencing systems are recommended for performing an NIHSS-telestroke examination in nonacute stroke patients, and this is comparable to an NIHSS-bedside assessment. Similar recommendations apply for the European and Scandinavian Stroke scales (Class I, Level of Evidence A). 2. The NIHSS-telestroke examination, when administered by a stroke specialist using high-quality videoconferencing, is recommended when an NIHSS-bedside assessment by a stroke specialist is not immediately available for patients in the acute stroke setting, and this assessment is comparable to an NIHSS-bedside assessment (Class I, Level of Evidence A). 3. Teleradiology systems approved by the FDA (or equivalent organization) are recommended for timely review of brain CT scans in patients with suspected acute stroke (Class I, Level of Evidence A).

Guideline	Recommendations
A review of the evidence for the use of telemedicine within stroke systems of care: a scientific statement from the American Heart Association/American Stroke Association. ***Stroke* 2009;40:2616 –2634.**	4. Review of brain CT scans by stroke specialists or radiologists using teleradiology systems approved by the FDA (or equivalent organization) is useful for identifying exclusions for thrombolytic therapy in acute stroke patients (Class I, Level of Evidence A). 5. When implemented within a telestroke network, teleradiology systems approved by the FDA (or equivalent organization) are useful in supporting rapid imaging interpretation in time for thrombolysis decision making (Class I, Level of Evidence B). 6. It is recommended that a stroke specialist using high-quality videoconferencing provide a medical opinion in favor of or against the use of intravenous tPA in patients with suspected acute ischemic stroke when on-site stroke expertise is not immediately available (Class I, Level of Evidence B). 7. When the lack of local physician stroke expertise is the only barrier to the implementation of inpatient stroke units, telestroke consultation via high-quality videoconferencing is recommended (Class I, Level of Evidence B). 8. Assessment of occupational, physical, or speech disability in stroke patients by allied health professionals via high-quality videoconferencing systems using specific standardized assessments is recommended when in-person assessment is impractical, the standardized rating instruments have been validated for high-quality videoconferencing use, and administration is by trained personnel using a structured interview (Class I, Level of Evidence B). 9. Telephonic assessment for measuring functional disability after stroke is recommended when in-person assessment is impractical, the standardized rating instruments have been validated for telephonic use, and administration is by trained personnel using a structured interview (Class I, Level of Evidence B). **Class II recommendations** 1. High-quality videoconferencing is reasonable for performing a general neurological examination by a remote examiner with interrater agreement comparable to that between different face-to-face examiners (Class IIa, Level of Evidence B). 2. Implementation of telestroke consultation in conjunction with stroke education and training for healthcare providers can be useful for increasing the use of intravenous tPA at community hospitals without access to adequate onsite stroke expertise (Class IIa, Level of Evidence B). 3. Compared with traditional bedside evaluation and use of intravenous tPA, the safety and efficacy of intravenous tPA administration based solely on telephone consultation without CT interpretation via teleradiology are not well established (Class IIb, Level of Evidence C).

Guideline	Recommendations
	4. Prehospital telephone-based contact between emergency medical personnel and stroke specialists for screening and consent can be effective in facilitating enrollment into hyperacute neuroprotective trials (Class IIa, Level of Evidence B). 5. Delivery of occupational or physical therapy to stroke patients by allied health professionals via high-quality videoconferencing systems is reasonable when in-person assessment is impractical (Class IIa, Level of Evidence B).

Evidence Tables

Remote NIHSS Assessment

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Alasheev et al. 2017 **Russia** **Prospective study**	NA	90 patients who had sustained a stroke within the previous 48 hours. Patients were recruited between March1, 2014 and July 31, 2014. Mean age was 64.5 years, 52% were men.	NIHSS scores were assessed by 6 stroke neurologists grouped in 15 pairs. Every patient was assessed once at the bedside and once remotely. Remote examination was performed by a neurologist through high-quality videoconferencing assisted by a nurse at the patient's bedside.	**Primary outcome:** The number of patients with a cumulative difference of ≤ 3 NIHSS points	Median bedside NIHSS score was 5 vs. 6 for remote assessment. The discrepancy between bedside and remote total NIHSS scores of ≤ 3 points in total NIHSS score was in 85.6% (95% CI 76.6–92.1%) of patients. Quadratically weighted kappa for the total NIHSS score was 0.91 (95% CI 0.87–0.95), p < 0.001). Remote assessments took significantly longer to complete (median of 8 vs. 6 minutes). The lowest agreement for individual NIHSS items was for facial palsy, limb ataxia and LOC commands.
Smith et al. 2016 ***(iTREAT)*** **USA** **Prospective study**	NA	27 simulated ambulance runs in 2 states (California and Virginia)	Actors portrayed 4 scripted stroke scenarios in 2 settings (in hospital bed and remotely in telestroke-equipped ambulance) and were assessed by 2 neurologists who completed NIHSS	**Primary Outcome:** Reliability of NIHSS through remote assessment	Intraclass correlation coefficient for all simulations combined was 0.96, 95% CI 0.92-0.98.
Van Hooff et al. 2013 **Belgium** **Feasibility study**	NA	NA	Technical feasibility and reliability of the Unassisted TeleStroke Scale (UTSS), a 16-item stroke severity scale designed to be administered by	**Primary Outcome:** Correlation between NIHSS and UTSS scores	Telestroke assessment was feasible in all scenarios with minor technical difficulties reported in 12 cases. The mean time to administer the UTSS was 3.1 minutes.

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			telestroke systems, was assessed using 2 trained healthy volunteers, simulating 41 stroke syndromes during transport to hospital. Communication between a remote expert and 2 ambulances was established using an ambulance equipped with a telestroke system and a 4th generation mobile network.		There was a strong correlation between the UTSS and NIHSS scores (Spearman p=0.90, p<0.001). The intraclass correlation coefficient for single measures was 0.98, p<0.001. There was excellent agreement between raters for 12 items, and moderate agreement for 3 items.

Safety, Feasibility and Process Times Associated with Telestroke Systems for Thrombolysis

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Sanders et al. 2016 **USA** **Retrospective study**	NA	Patients treated with t-PA in 4 states. Median NIHSS score was 8. Median age was 62 years, 54% male.	The outcomes of 165 patients (2012-2014) who were treated with t-PA using the AcuteCare Telemedicine system that included 20 hospitals were compared to those of 65 patients who were also treated with t-PA using the same telemedicine system from 2010-2012 when	**Primary outcomes:** Door-to-needle (DTN) time for tPA administration, call-to-needle (CTN) time, and final diagnosis **Secondary outcomes:** door-to-call (DTC) time, onset-to-needle (OTN) time, and call-to-response (CTR) time	The median DTN time in the later cohort was significantly shorter (74.5 vs. 93 minutes, p<0.01). (Data were missing for 13.9% of patients) The median CTN time in the later cohort was significantly shorter (41 vs. 56 minutes, p<0.01). Data were excluded for 2.4% of patients The median DTC time in the later cohort was significantly shorter (31 vs. 38 minutes, p<0.01). Data were excluded for 21.1% of patients).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
			there were only 7 participating hospitals.		The median CTR time was similar between groups (1 vs. 2 minutes, p=0.098. The mean OTN was 179.4 minutes for patients in the earlier cohort vs. 149 minutes in the later cohort.
Agarwal et al. 2014 **UK** **Retrospective study**	NA	7 district hospitals in East England providing out-of-hours access to thrombolysis on weekends and evenings, delivered by 10 stroke specialists, using a telemedicine cart (pc + high-resolution CCTV camera, with videoconferencing software).	During the pilot phase, which included 4 regional hospitals (Sept 2009-Jan 2010), there were 43 telestroke consults. Between Nov 2010 and 2011, 142 telemedicine consults were conducted	**Primary outcomes:** Number of patients treated with t-PA, time to treatment, symptomatic ICH (sICH), in-hospital mortality	Pilot phase: 15 patients (35%) received thrombolysis. Mean age of patients was 72 years. Median NIHSS score was 13, mean onset-to-needle time was 131 minutes. There were no sICHs. Beyond the pilot phase, 74 patients (52.1%) received thrombolysis. Mean age of patients was 69 years. Median NIHSS score was 10, median onset-to-needle time was 169 minutes. 7.3% of patients experienced an sICHs and in-hospital mortality was.8.1%.
Hess et al. 2005 **USA** ***Remote Evaluation of Acute isChemic Stroke (REACH)*** **Clinical feasibility study**	NA	A rural hub & spoke telestroke model including 8 hospitals in Georgia was developed in 2003. The system included 2-way audio and 1-way video.	194 stroke consults originating between March 2003 and Feb 2005 were reviewed.	**Primary outcomes:** Number of patients treated with tPA, onset to treatment (OTT) time, presence of hemorrhage, time to treatment, of symptomatic ICH (sICH), in-hospital mortality	30 patients (15.5%) received t-PA. mean age was 62 years. 60% were female. Mean baseline NIHSS score was 15.4, median 12.5. Mean OTT was 122 minutes, 60% of patients were treated within 2 hours of stroke. There were no incidences of sICH. In-hospital mortality was 7%. 29 patients were not treated with t-PA because they were initially seen beyond the time window.
Schwamm et al. 2004 **USA**	NA	A telestroke system using videoconferencing was set up between an island-based hospital and a specialized stroke	Data from 24 patients admitted with acute ischemic stroke and assessed using the telestroke system over	**Primary outcomes:** Number of patients treated with tPA, presence of hemorrhage, time to treatment, and patient	8/24 patients were eligible for tPA treatment. Of these, 6 were treated with tPA. Significantly more patients received tPA after telestroke was implemented (6 vs. 0, p=0.03).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Retrospective study		centre to enable consultations between ER MDs and stroke neurologists, 24 hours/day.	the 27-month study period, were reviewed. t-PA utilization rates 2 years before and after the implementation of the telestroke system were also evaluated. A total of 106 patients were admitted to the ER with acute ischemic stroke during the time when telestroke services were available and 100 patients presented before the system was implemented.	and physician satisfaction.	Hemorrhage: One patient had asymptomatic ICH; one patient had symptomatic ICH. Time from symptom onset to treatment: 142 ±20 min. Satisfaction: More than 96% of physicians and neurologists were satisfied with the quality of the videoconferencing, with their confidence in managing patients within this system of care, and believed that the system improved patient care. 85.7% of patients felt the system was equally as good as a face-to-face encounter.
La Monte et al. 2003 **USA** **Retrospective study**	NA	A single regional stroke centre provided acute stroke consultations that could be initiated by any healthcare provider in the state using hospital-based telephone and video conferencing systems.	Review of 50 consultations from 1999-2001.	**Primary outcomes:** % of patients treated with thrombolytic agents, adverse events.	21 patients were managed using teleconference. Of these, 5 (23.8%) received t-PA. No complications associated with treatment were reported. Diagnoses based on videoconferences included ischemic stroke, SAH, ICH, TIA, seizure and hypoglycemia. 27 consultations were conducted using the telephone (2 were aborted due to technical difficulties) and 21, using videoconsultations. Main reasons for not using videoconsultations were: attending physician not on site where telemedicine equipment was located, patients> 3 hours of symptom onset, exclusion from thrombolysis therapy made based on clinical assessments. Staff and patients expressed satisfaction with the service.

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Wiborg et al. 2003 **Germany *Telemedicine in Stroke in Swabia (TESS)* project** **Retrospective study**	NA	7 rural hospitals and a single stroke unit connected via a video conferencing system. 623 patients were admitted with a diagnosis of stroke during the study period (March 2001-Sept. 2002).	In the rural hospitals, all departments had access to the remote stroke unit, although the decisions of if/when to consult were at the discretion of the treating physician. All teleconferences were conducted by 4 senior neurologists. Immediately following a teleconsultation, both the stroke neurologist and the local physician completed a teleform.	**Primary outcomes:** Items to be completed included: reasons for no, immediate or delayed consolation, relevance of consolation (diagnostic work-up, CT assessment, ultrasound assessment and therapeutic procedures, rated on a 3-point scale) and ratings of the teleconference quality imaging/audio quality, rated on a 5-point scale, with 1=very good and 5=very bad).	153 (25%) patients received teleconsultation. Of these, 87 patients (57%) had an ischemic stroke, 9 (6%) had an ICH and 17 (11%) suffered a TIA. 25 patients (16%) had a diagnosis different from the primarily suspected stroke. Patients who were treated using teleconference were younger compared with those who were not (67.5 vs. 75.2 yrs., p=0.001). Average duration of the teleconference was 15 minutes. Teleconsultation took place within the first 3 hours after admission to the local hospital (n=35), within 6 hours (n=54) and > 24 hours (n=40). In the diagnostic workup category, ratings for relevant contributions ranged from 41% to 80% for the local physicians and from 37% to 79% for the neurologists. In the CT assessment category, ratings for relevant contributions ranged from 21% to 47% for the local physicians and from 6% to 48% for the neurologists. In the therapeutic decision category, ratings for relevant contributions ranged from 6% to 57% for the local physicians and from 4% to 69% for the neurologists. The mean imaging quality scores of patients and CTs were 1.9 and 2.1, respectively. The mean audio quality was rated as 2.6 and 2.4 by the local and stroke neurologists. Mean patients' satisfaction rating with the experience was 1.5.

Efficacy of Telestroke Systems (+/- thrombolysis)

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Audebert et al. 2009 **Germany** ***TEMPis*** **Controlled study**	CA: ☒ Blinding patient: ☒ assessor: ☒ ITT: ☑	3,060 acute stroke patients admitted to hospital within 3 days of stroke onset. Patients living in intuitions at the time of stroke or whose residential status was unknown were excluded.	The outcomes of patients from 5 community hospitals with telemedicine access from 2 stroke centres (intervention group, n=1,938) were compared with those from 5 control hospital without specialized stroke services or access to telemedicine (n=1,122). Indications for teleconsultations were predefined as: patients potentially suitable for thrombolysis, intracranial hemorrhages, severe strokes and uncertainty about diagnostic other therapeutic procedures	**Primary Outcomes:** Combined outcomes of death/need for institutionalization and death/dependency, (mRS>3 or Barthel Index score <60) assessed at 12 and 30 months	At 12 months, significantly fewer patients in the intervention group were dead or in an institution (32.1% vs. 35.8%, p=0.038). After adjustment, the difference was no longer significant (OR=0.89, 95% CI 0.75-1.07, p=0.223). At 30 months, there was no difference in the proportion of patients who were dead or institutionalized (42% vs. 45.1%, p=0.094). (Adjusted OR=0.93, 95% CI 0.78-1.11, p=0.40). At 12 months, significantly fewer patients in the intervention group were dead or dependent (46.1% vs. 55.5%, p<0.001, adjusted OR=0.65, 95% CI 0.54-0.78, p<0.001). At 30 months, significantly fewer patients in the intervention group were dead or dependent (53.3% vs. 58.4%, p=0.006, adjusted OR=0.82, 95% CI 0.68-0.98, p=0.031).
Pedragosa et al. 2009 **Spain** **Retrospective study**	NA	A telemedicine system, which linked the neurologist at a stroke centre with a community hospital using videoconferencing	Outcomes of patients admitted to the community hospital before and after the implementation of a	**Outcomes for all patients:** percentage of patients with ambulance transfer to stroke centre, % of patients with	More patients were treated with tPA following the implementation of the telemedicine service (9 vs. 19, p=0.073). **All patients with stroke:** Following implementation, there was a significant decrease in the number of patients needing urgent ambulance transfer to the stroke centre (17% vs. 10%, p=0.04) and unnecessary transfers to the stroke centre (51% vs. 20%,

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		was established to provide consultation for potential treatment with tPA when the neurologist at the community hospital was not available. 201 patients with acute stroke were admitted to hospital in 2006, before the telemedicine system was established and 198 patients were admitted in 2007.	telemedicine system were evaluated.	neurologist evaluation, % of unnecessary transfers to stroke centre (defined as patients who were retransferred to their hospital within 24 hours having not received tPA), % of patients admitted to the stoke unit, % of patients receiving tPA. **Outcomes for only patients treated with t-PA:** discharge NIHSS score, number of symptomatic and asymptomatic hemorrhagic strokes	p=0.02). There was an increase in the number of patients receiving neurological evaluation (17% vs. 38%, p<0.01). **Only patients receiving tPA:** Following the implementation, there was a significant decrease in the mean time from symptom onset to treatment (210 min vs. 162 min; p=0.05), an increase in the percentage of patients treated within the 3-hour window (30% vs. 68%, p=0.04) and in the percentage of patients treated at the local hospital (0% vs. 63%, p=0.001). There were no significant differences before and after the implementation of the program for median NIHSS discharge score (5 vs. 4, p=0.96) or percentage of patients with symptomatic or asymptomatic hemorrhages (0% vs. 0%, p=1.00, and 20% vs. 22%, p=0.89 respectively). Data from the satisfaction survey found that patients reported benefits from the telemedicine system and physicians found it helpful.
Audebert et al. 2006 **Germany *TEMPiS*** **Controlled study**	NA	6,610 acute stroke patients from 12 regional hospitals and 2 stroke centres	Comparison of outcomes between patients admitted to regional (n=4,727) and stroke centres (n=1,883), a portion of whom received t-PA. Data was collected prospectively over 1 year. In the regional hospitals, neurology	**Primary Outcomes:** Vital status at 7 days, ICH within 36 hours of treatment	Of the 2,603 patients presenting to one of the regional hospitals with an ischemic stroke, 115 (4.4%) were treated with t-PA. Of the 1,286 patients presenting to a stroke centre with ischemic stroke, a significantly higher number 110 (8.8%) were treated with tPA (p<0.01). The baseline characteristics of patients treated at the 2 types of institutions were similar, with a few exceptions: more patients in the stroke centres had hyperlipidemia (44.5% vs. 23%) and atrial fibrillation (40.9% vs. 20.9%) and higher mean systolic BPs (123 vs. 116mm Hg). There were no differences between regional and stroke centres for the outcomes of:

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
			services were provided by internal medicine (n=10) and neurology departments (n=2). Consultations for thrombolysis were conducted using videoconferencing.		Symptomatic hemorrhages: 7.8% vs. 2.7%, p=0.14 Mortality within 7 days: 3.5% vs. 0.9%, p=0.37 In-hospital mortality: 3.5% vs. 4.5%, p=0.74 Mean time from stroke onset to hospital admission was significantly longer for patients in the stroke centres (74 vs. 64 min, p<0.01) Mean time from admission to treatment was significantly longer for patients treated in regional hospitals (68 vs. 61 min, p=0.003) There was no difference in the mean time from stroke onset to treatment between groups (134 vs. 135 min, p=0.81)

Efficacy & Safety of Telestroke for Treatment with Thrombolysis

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Wilcock et al. 2021 **USA** **Prospective study**	NA	153,272 patients presenting to hospital with acute ischemic stroke between January 2008 and June 2017. Mean age was 78.8 years, 58% were women.	The outcomes of patients who were treated at hospitals with and without telestroke capacity, were compared, by matching. Matching was done 1:1 using both hospital and patient characteristics. There were 643 hospitals with telestroke capacity (n=76,636 patients) and a similar	**Primary outcomes:** Reperfusion treatment (thrombolysis or thrombectomy), 30-day mortality, spending through 90 days from admission, and days spent living in the community after discharge.	The frequency of reperfusion therapies was significantly higher at telestroke hospitals (6.8% vs 6.0%; difference, 0.78 percentage points; 95% CI 0.54-1.03, p < .001). The risk of receiving thrombolysis and thrombectomy, were both significantly higher with telestroke (RR=1.12, 95% CI 1.08 to 1.17 and RR=1.42, 95% CI 1.25 to 1.62, respectively). 30-day mortality was significantly lower in the telestroke hospitals (13.1% vs 13.6%; difference, 0.50 percentage points; 95% CI, 0.17-0.83, p =0.003). There was no difference between groups in the number of days spent living in the community after discharge (60.25 vs. 60.22, p=0.93), or institutional spending ($26,560 vs. $26,524, p=0.31).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
			number of patients and hospitals without telestroke capacity. Hospitals that already had local stroke expertise were excluded.		
Porter et al. 2018 **Canada** **Retrospective study**	NA	2,099 adult patients with ischemic stroke who were treated in acute care hospitals and received IV t-PA during two fiscal years 2010/2011 and 2012/2013 (April 1 to March 31). Median age was 72 years, 47% were women.	The outcomes of patients treated using the Ontario Telestroke Program (OTP, n=214) were compared with those treated at regional stroke centres, district stroke centres and non-designated centres (n=1,885)	**Primary outcomes:** 7- and 90-day mortality, symptomatic intracerebral hemorrhage (sICH), and poor functional outcome (mRS ≥3) at discharge Analyses were adjusted for age group, sex, atrial fibrillation, comorbidity score, stroke severity, hospital type, stroke unit, year, telestroke, rural residence	The administration of t-PA using telestroke was not associated with an increased risk of death within 7 or 90 days (adjusted HR=1.29, 95% 0.68- 2.44 and adjusted HR=1.01, 95% CI 0.67-1.50, respectively). The administration of t-PA using telestroke was not associated with an increased risk sICH or poor outcome (adjusted HR=0.71, (95% 0.29-1.71 and adj HR=0.75, 95% CI 0.46-1.23, respectively).
Zhai et al. 2015 **China** **Systematic review & meta-analysis**	NA	8 studies prospective (n=5), or retrospective (n=3) observational with two-arm designs that examined the use of a telestroke system for delivery of thrombolytic agents. The number of subjects in each study ranged from 45-2,935. Mean baseline NIHSS	Studies that compared the outcomes of patients treated with t-PA through telemedicine vs. traditional in-hospital care	**Primary outcome:** Favourable outcome (using mRS, not defined) **Secondary outcomes:** ICH and mortality	Mean or median time between stroke onset and treatment ranged from 113-188 (telemedicine) and 100-157 minutes (in-hospital). There was no significant increase in the odds of a favourable outcome associated with telestroke (OR=1.28, 95% CI 0.92-1.76, p=0.14). Results from 5 studies included. There was no increased risk of symptomatic ICH associated with telestroke (OR=1.08, 95% CI 0.47-2.5, p=0.85). Results from 5 studies included.

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		scores ranged from 10-19			There was no increased risk of mortality associated with telestroke (OR=0.95, 95% CI 0.82-1.11, p=0.51). Results from 4 studies included.
Fong et al. 2015 **China** **Retrospective study**	NA	152 patients admitted to a single centre from 2009-2012 with acute ischemic stroke. Mean age was 66 years, 60% male. Median baseline MIHSS score was 12.	The outcomes of patients who had been treated with thrombolysis onsite (n=102) were compared with those of patients who received the same therapy via telemedicine (telephone consult + teleradiology (n=50)	**Primary outcome:** mRS score at 3 months, symptomatic ICH (extravascular blood in the brain associated with an increase of ≥4 points of NIHSS, or death)	Median onset-to-door time was significantly shorter for patients in the telestroke group (44 vs. 54 min, p=0.015). Median CT-to-needle time, door-to-needle time and onset-to -needle time were all significantly longer in the telemedicine group. The rate of sICH was similar between groups (4.9% vs. 4.0%, p=1.00) 3-month mortality was similar between groups (12% vs. 8.3%, p=0.58). The number of patients who experienced a good outcome (mRS 0-1) was similar between groups (43.0% vs. 52.1%, p=0.30)
Chowdhury et al. 2012 **UK** **Controlled study**	NA	97 patients who received tPA following confirmed diagnosis of an ischemic stroke, treated within 3 hours of symptom onset.	Comparison of outcomes of patients treated at a single centre with specialized stroke expertise during regular business hours (Mon-Fri 0900-1700 hrs) (n=52) vs. patients treated outside of regular hours using telemedicine (n=45)	**Primary Outcomes:** Symptomatic ICH within 24-36 hours following treatment, 3-month mortality, proportion of patients with good outcome (mRS≤2) and poor outcome, (mRS3-6) at 3 months.	The only significant baseline difference between groups was a higher number of patients who were current smokers in the telemedicine group (31% vs. 13%, p=0.03). There were no significant differences between groups on any of the outcomes assessed (face-to-face vs. telemedicine groups) ICH: 7.7% vs. 4.4%, p=0.7 3-month mortality: 15.5% vs. 11%, p=0.6. Favourable outcome: 36.5% vs. 42%, p=0.9 Median stroke onset to treatment and admission to treatment times were significantly longer for patients in the telemedicine group (125 vs. 100 min, p=0.001 and 61 vs. 33 min, p<0.001, respectively.
Johansson et al. 2011	NA	351 patients ≥18 years treated between 2006-2009	Comparison of outcomes of patients treated with	**Primary Outcomes:** Mortality, discharge destination, stroke onset to	The only significant baseline difference between groups was a higher number of patients who were current smokers in the telemedicine group (32% vs. 16%,

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Austria *Telestroke System in Salzburg (TESSA*) **Controlled study**		with tPA within 4.5 hours of symptom onset.	telemedicine via videoconference at 5 regional hospitals (n=47) vs. those treated on a stroke unit (n=304). Following thrombolysis, patients at the regional hospital were transferred to the stroke unit for ongoing care.	needle time, proportion of patients with good functional outcome at 3 months (mRS≤1)	p=0.032). Mean NIHSS scores were similar between groups (9.9 vs. 10.4, p=0.73). There was no difference in the proportion of patient discharged home from hospital (31% vs. 26%, p=0.48). At 3 months, there was no difference in the proportion of patients with good outcome (47% telemedicine vs. 32% stroke unit, p=0.69), mortality (19% vs. 13%, p=0.25), or proportion of patients living at home (80% vs. 90%, p>0.05). Stroke onset to needle time was 113 min (telestroke) vs. 122 min (stroke unit), p=0.26.
Zaidi et al. 2011 **USA** **Controlled study**	NA	A university-affiliated hospital (hub) that provided consultations to 12 spoke hospitals. 142 acute stroke patients who received treatment with tPA	Comparisons of the outcomes of patients treated by the same neurologists, either in person, at the stroke center (n=59) or by telestroke, using videoconferencing (n=83) at a community hospital.	**Primary Outcomes:** Onset to treatment time, door-to-needle time, proportion of patients with favourbale outcome at 3 months (mRS ≤2), mortality, symptomatic/asymptomatic ICH at 3 months	There was no difference in the mean time from stroke onset to treatment between groups: 157 (stroke centre) vs. 145 min (telestroke), p=0.09. The mean time from arrival at hospital to treatment was shorter for patients in the stroke centre group (68 vs. 90 min, p<0.01). There were no significant differences in clinical outcomes between groups (stroke centre vs. telestroke) Percentage of patients with mRS ≤2: 22% vs. 35%, p=0.09 Mortality:37.5% vs. 42.1%, p=0.60 Asymptomatic ICH: 18.6% vs. 16.2%, p=0.70 Symptomatic ICH: 5.1% vs. 1.2%, p=0.10
Sairanen et al. 2011 **Finland** **Controlled study**	NA	5 community hospitals, served by the Helsinki University Central Hospital (HUCH), the hub hospital. Spoke hospital all had stroke units and	Comparison of patients treated with tPA by telestroke (n=61) over 2 years compared with those treated at a stroke centre (n=985).	**Primary Outcome:** Time to treatment, ICH within first 10 days, 3-month mortality, proportion of patients with mRS scores ≤1 and ≤2.	There were no differences in any of the clinical outcomes between groups (telestroke vs. stroke centre) 3-month mortality: 11.5% vs. 10.2%, p=0.662 Patients with mRS≤2: 49.1% vs. 58.1%, p=0.214 Patients with mRS≤1: 29.4% vs. 36.8%, p=0.289 ICH:6.7% vs. 9.4%, p=0.427

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		thrombolysis treatment available during regular working hours. 106 patients considered eligible candidates for thrombolysis treatment.	Most patients who received telestroke services remained at the spoke facilities where they continued to receive care		The mean onset to treatment time for telestroke patients was 120 min.
Pervez et al. 2010 **U.S.** **Controlled study**	NA	33 spoke hospitals (12 were connected via videoconferencing and 21 through phone connection) to a regional stroke centre 296 patients who received tPA within 3 hours of stroke onset and were subsequently transferred to the regional stroke centre (RSC).	The outcomes of patients that arrived at the regional stroke center and those who were treated by telephone/telemedicine, were compared.	**Primary Outcome:** Symptomatic intracranial hemorrhages (sICH), mRS assessed at 3, 6 and 12 months and death.	Treatment with tPA was initiated in 181 (16.1%) cases at the spoke hospitals and in 115 (38.9%) at the RSC. sICH: There were no significant differences in number of sICHs between patients treated at the spoke hospitals and RSC (3.9% vs. 5.2%, p=0.58). There were no significant differences in distributions of patients in each mRS category between the spoke hospitals and RSC groups at each of the time points. Adjusted for age, time to tPA and NIHSS score, there were no significant differences in the odds of having a lower mRS score between patients whose tPA was initiated in an OSH vs. RSC (OR=1.09; 95% CI 0.77 to 1.55; p=0.64). There were no significant differences in in-hospital mortality rates between patients receiving tPA (14.9% vs. 17.45, p=0.57).
Switzer et al. 2009 **USA** **Controlled study** ***Remote Evaluation of***	NA	The telestroke REACH system connects a neurologist at a comprehensive stroke centre with 9 spoke hospitals, located in rural Georgia through a	Outcomes were compared between patients who received tPA administration remotely using the telestroke system and patients who receive tPA at the	**Primary Outcome:** Onset to treatment time and complications (symptomatic hemorrhagic conversion (sICH)) sICH assessed via. CT scan at 24 hours.	There were no significant differences in the mean onset to treatment times for patients receiving tPA at the tertiary care centre vs. patients receiving tPA remotely (146 vs. 128 min, p=0.0651). 35% and 50% of the patients at the hub and spoke centres were treated with tPA within 120 minutes, respectively.

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Acute isChemic Stroke (REACH)		videoconferencing system. REACH was developed to support decision making for tPA. Patients treated with tPA were transferred to the tertiary centre. 50 patients were eligible for and received tPA treatment through REACH. 26 patients were treated with tPA at the hub centre.	central tertiary care hospital.		There were no significant differences in the percentage of patients experiencing a sICH between the two groups (0 vs. 2, p=1.00).
Schwab et al. 2007 **Germany** **Observational Study *TEMPiS (Telemedic Pilot Project for Integrative Stroke Care):***	NA	170 patients who received tPA following telestroke consultation and 132 consecutive patients who had been treated in one of the two stroke centres and received tPA over the same time period.	Comparison of the outcomes between the two groups of patients	**Primary outcomes:** Mortality, good functional outcomes (defined as a Barthel Index score ≥95 or mRS score ≥1). .	Mean time from stroke onset to administration of tPA: 141 min (community hospitals); 144 min (stroke centre). There were no statistically significant differences in deaths between the groups at both 3 months (11.2% vs. 11.5%, OR= 1.0; 95% CI 0.7-1.4; p=0.550) or 6 months (14.2%, vs. 13%, OR= 0.9; 95% CI 0.5-1.8; p=0.448). There were no statistically significant between-group differences in the proportion of patients who experienced a good outcome using BI criteria at either 3 months (45.1% vs. 40.1%, OR= 1.3; 95% CI 0.8-2.1; p=0.197) or 6 months (47.1% vs. 44.8%, OR= 1.1; 95% CI 0.6-1.8; p=0.443). There were no statistically significant between-group differences in the proportion of patients who experienced a good outcome using mRS criteria: at either 3 months (38.2% vs. 33.7%, OR= 1.2; 95% CI 0.7-2.0; p=0.258) or 6 months (39.5% vs. 30.9%, OR= 1.5; 95% CI 0.9-2.4; p=0.095).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
					Age and baseline NIHSS score were the most significant predictors of good functional outcome. Group assignment (telemedicine vs. stroke centre) was not a significant predictor.
Frey et al. 2005 **USA** **Controlled study**	NA	126 acute stroke patients, who were neurologically intact prior to stroke, treated over a 4-year period.	Comparison of outcomes of patients treated at 43 community hospitals, which used telephone consultations to facilitate tPA administration with subsequent transport to the stroke centre (n=53) and patients treated in-house at the same stroke centre (n=73)	Increase in tPA usage in community hospitals, discharge destination, mortality, and time from stroke event to tPA administration.	The number of patients treated in community hospitals increased by 72% over the study period. Patients in the telephone consultation group were older (mean: 67 vs. 62 years, p=0.04). Stroke severity was lower in the in-house treated group (data not provided). Mean stroke onset to t-PA treatment times were similar in both groups (~160 minutes). Brain hemorrhages were low for patients in both groups (data not provided) Significantly more patients in the in-house group were discharge home (41 vs. 16, p=0.004). Significantly more patients in the telephone consultation group were transferred to a skilled nursing facility after discharge (11 vs. 3, p=0.003). 4 patients in the telephone group died during hospitalization vs. 1 patient in the in-house group (p=0.08).
Audebert et al. 2005 ***TEMPiS (Telemedic Pilot Project for Integrative Stroke Care):*** **Germany**	NA	A telemedicine system, using videoconferencing to enable 24-hour consultations with neurologists, was set up between 12 community hospitals and 2 specialized stroke centres. Interhospital	The outcomes of 106 patients admitted to hospitals who had been treated with tPA using the telemedicine system, were evaluated.	In-hospital mortality, inpatient length of stay, intracranial hemorrhage (ICH). Assessments were conducted at 36 hours (CT scan for ICH) and at discharge (death and length of stay).	Mean ±sd time from stroke onset to administration of tPA: 141±27 mins. Mortality: 10.4% of patients died in hospital. Inpatient length of stay: median length of stay in hospital was 12 days. Intracranial Hemorrhage: 25% of patients experienced hemorrhages based on the CT scan within 36 hours of treatment with tPA.

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Retrospective study **Muller-Barna et al. 2014** **Retrospective study 10-year outcomes**		transfers were centrally coordinated.			**10-year outcomes (2014)** The number of consultations increased from 1,928 (2003) to 4,513 (2012). Recommendations for transfers from regional hospitals to stroke centres decreased significantly from 11.5% (2003) to 7.0% (2012), p<0.001. The number of patients treated with thrombolysis increased over the study period from 2.6% of all patients admitted to hospital with ischemic stroke in 2003 to 15.5% in 2012. Median onset-to-treatment time decreased significantly from 150 to 120 minutes (p<0.001). 7-day mortality following treatment with thrombolysis remained stable over the study period (6.3%, p for trend =0.12).

Effectiveness of Telemedicine vs. Telephone Consultation for Stroke

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Meyer et al. 2012 **USA** ***STRokE DOC-Long-Term Outcome (LTO)***	CA: ☑ Blinding patient: ☒ assessor: ☑ ITT: ☒	75 subjects or surrogates of subjects who had participated in the STRokE DOC trial	6- & 12-months outcomes of subjects participating in the STRokE DOC trials were evaluated using a standardized questionnaire (n=37 telemedicine, n=38	**Primary outcome:** Mortality and proportion of patients with mRS scores ≤1 at 6 months **Secondary outcome:** Mortality and proportion of patients with mRS	Of the 222 patients who were recruited initially, 35 had died within 3 months. Mean time from enrollment was 3.96 years There were no differences in 6- month outcomes between groups (telephone vs. telemedicine) mRS score 0-1: 50% vs. 34%, p=0.23 Mortality: 15% vs. 21%, p=0.38

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
RCT			telephone) administered over the telephone. Missing values for mortality outcomes were imputed.	scores ≤1 at 12 months, recurrent stroke	Recurrent stroke :4% vs. 6%, p=0.61 There were no differences in 12-month outcomes between groups (telephone vs. telemedicine) mRS score 0-1: 18% vs. 13%, p=0.23 Mortality: 17% vs. 25%, p=0.19 For subset of patients who received tPA 44% and 27% of subjects in the telephone and telemedicine groups had mRS scores of 1-2 at 6 months, (p=0.64) respectively.
Meyer et al. 2008 **USA** **RCT** ***Stroke Team Remote Evaluation using a Digital Observation Camera (STRokE DOC)***	CA: ☑ Blinding patient: ☒ assessor: ☑ ITT: ☒	222 patients ≥18 years presenting with symptoms of acute stroke.	Patients were randomized to receive telemedicine (n=111), using real-time, 2-way audio/video and DICOM viewer or telephone (n=111) consultations to assess the patient's candidacy for tPA treatment. Consultations were provided by staff at a single hub institution to patients located at 4 remote sites.	**Primary outcome:** Correct treatment decision re: appropriateness for tPA evaluated by blinded, expert adjudication **Secondary outcomes:** Proportion of patients with good outcome at 90 days (mRS≤1, or Barthel Index score 95-100), mortality, ICH	There were no baseline differences between groups. Mean NIHSS scores were significantly higher in the telemedicine group (11.4 vs. 9.5, p=0.002). The number of patients treated with tPA was similar between groups (28% vs. 23%, p=0.425). Mean times from stroke onset to tPA were 157 and 143 min in the telemedicine and telephone groups, respectively (p=0.137). Correct treatment decisions were made more often using telemedicine (98% vs. 82%, OR=10.9, 95% CI 2.7-44.6, p=0.0009). There were no differences between groups (telemedicine vs. telephone) for any of the clinical outcomes ICH: 7% vs. 8%, p=1.00 Good outcome: BI 95-100: 33% vs. 48%, p=0.287 mRS 0-1: 30% vs. 32%, p=1.00 Mortality: 39% vs. 12%, p=0.034 Mortality adjusted for baseline NIHSS: OR=3.4, 95% CI 0.6-19, p=0.168.

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
					Losses to follow-up: n=14 (7 from each group)
Demaerschalk et al. 2010 **USA** ***STRokE DOC Arizona Telestroke Trials*** **Pooled analysis**	NA	276 patients ≥18 years presenting with symptoms of acute stroke.	The results from the STRokE DOC trial were combined with those of a smaller unpublished study with an identical study protocol (STRoke DOC AZ) in which 54 patients were randomized to either a telemedicine group (n=27) or telephone consultation group (n=27). The results from the larger STRokE DOC trial suggested that telemedicine was superior while the results from the smaller trial failed to replicate this finding (no significant differences between treatment groups).	**Primary outcome:** Correct treatment decision re: appropriateness for tPA evaluated by blinded, expert adjudication **Secondary outcomes:** Proportion of patients with good outcome at 90 days (mRS≤1, or Barthel Index score 95-100), mortality, ICH	Mean NIHSS scores were significantly higher in the telemedicine group (10.6 vs. 7.7, p=0.006). The number of patients treated with tPA was similar between groups (29% telemedicine vs. 24% telephone, p=0.41). Mean times from stroke onset to tPA were 158 and 150 min in the telemedicine and telephone groups, respectively (p=0.137). Correct treatment decisions were made more often using telemedicine (96% vs. 83%, OR=4.2, 95% CI 1.69-10.46, p=0.002). There were no differences between groups (telemedicine vs. telephone) for any of the clinical outcomes ICH: 8% vs. 6%, p=1.00 BI: 95-100: 46% vs. 55%, p=0.17 mRS 0-1: 36% vs. 45%, p=0.20 Mortality: 16% vs. 12%, p=0.49
Khan et al. 2010 **Canada** **Retrospective study**	NA	Consultations were provided over a 2-year period to 7 spoke hospital (4 using videoconferencing and 3 using telephone consultation) from a single university-affiliated hub hospital. None of the spoke	Compared outcomes among those patients who were treated by telephone consultation and telemedicine.	**Primary outcome:** Favourable outcome (mRS 0-1) at three months, cost savings.	There was no significant difference in the mean time from stroke onset to tPA administration between the video consult and phone consults groups (171 vs. 179 minutes, p=0.76). There was no significant difference in the proportion of patients experiencing a favourable outcome at 3 months p=0.689).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		hospitals had stroke units. 44 patients were eligible for and received tPA. 34 patients were treated using videoconferencing and 10 using telephone consultation.			Cost savings: Patients who received tPA in the remote hospitals experienced a reduced length of stay in hospital compared to those patients that did not receive tPA. 1,015 days saved at $903/day results in an approximate $916,545 savings at one site. Loss to follow-up: 4 (9%) of patients.
Handschu et al. 2008 **Germany** **Controlled study** ***Stroke Care using Telemedicine in Northern Bavaria (STENO)***	NA	151 patients admitted to local hospitals with symptoms of acute stroke	Comparison of outcomes of patients treated by telemedicine (n=77) or telephone (n=74) consultation provided by 2 stroke centres to 2 local hospitals. Consulting sites alternately weekly between telephone and telemedicine consultation types. (No info on tPA administration was provided)	**Primary outcomes:** 10-day mortality, need for institutional care	Number of patients identified with ischemic stroke was 91(60%). Fewer patients in the telemedicine group were transferred to a stroke centres (9.1% vs. 14.9%, p<0.05). Mortality was higher in patients in the telephone group (6.8% vs. 1.3%, p<0.05). Diagnoses made based on telephone consultation needed to be corrected more frequently (17.6% vs. 7.1%, p<0.02). 5.4% of patients in the telephone group required institutional care compared with 2.6% of patients in the telemedicine group (p=0.58)

Cost-Effectiveness of Telemedicine

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Nelson et al. 2016 **USA** **Cost-effectiveness analysis**	NA	Patients who were admitted with acute ischemic stroke to one of the spoke hospitals in the Providence Oregon Telestroke Network (2 hub hospital and 17 spoke hospitals	Comparison of in-hospital costs prior to the implementation of the telestroke system (up to 2 years prior, n=98) and up to 3 years after the start date of the telestroke system (n=766). Actual reimbursement costs were used (not estimates). A decision analytic model was used to estimate probabilities of the consequences of treatment decisions at critical points (e.g. t-PA vs. no t-PA). Stroke severity based on NIHSS scale was also included in the models.	**Primary outcomes:** Costs, incremental costs, Quality-adjusted life years (QALYs), incremental cost-effectiveness ratio (ICER), calculated from the perspective of both the spoke and hub perspectives.	Mean hospital costs for patients who received t-PA were slightly higher for spoke vs. hub hospitals (US$19,928 vs. US$17,244). Mean hospital costs for patients who did not receive t-PA were higher at hub hospitals (US$17,133 vs. US$8538). **Spoke perspective** Depending on the percentage of implementation costs the spoke hospital assumed, the ICER was: 0%: $1,322/QALY 50% $25,991/QALY 100%: $50,687/QALY Telestroke dominated (lower cost, better outcome) for patients with less severe strokes (NIHSS <5) when hospitals assumed 50% and 100% of costs. **Hub perspective** Depending on the percentage of implementation costs the spoke hospital assumed, the ICER was: 0%: $71,703/QALY 50% $47,0333/QALY 100%: $22,363/QALY Telestroke dominated (lower cost, better outcome) for patients with less severe strokes (NIHSS <5) when hospitals assumed 0%, 50% and 100% of costs.
Switzer et al. 2013 **USA** **Cost-effectiveness analysis**	NA	NA (theoretical model)	Using a decision analytic model, comparison of costs and outcomes associated with patients presenting with acute ischemic stroke to spoke hospitals with	**Primary outcome:** 5-year costs for hub/spoke hospitals.	The model predicted that 114 fewer ischemic stroke patients would present to the hub hospital each year, and 16 more patients would present to one of the spoke hospitals. From the network perspective, there was an overall costs savings of $358,435 during the first 5 years.

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
(hospital perspective)			and without telestroke access. Assumptions: an established telestroke system with 7 spokes hospital and a single hub hospital with 1,112 ischemic stroke patients presenting to the ER/yr. Costs, (telestroke start-up, costs for spoke/hub and patient costs, patient transfer costs, long-term costs), event probabilities, (tPA vs. no tPA, endovascular treatment/no endovascular treatment) and discharge destinations, based on mRS scores) were based on 2 author's affiliated institutions actual costs.		The model also predicted that 45 additional patients could be treated with tPA and 20 more could receive endovascular therapy if a telestroke system were in place. This would also result in an additional 6.1 patients being discharged home/yr. with an equal number of decreases in admissions to rehab and nursing homes. The hub hospital would incur costs of $405K/yr while the spoke hospitals would save $109K/yr. With cost sharing arrangements, the model predicted that each hospital could save $45K over 5 years. The model was sensitive to the number of spoke hospital, the number of transfers and the number of patients treated with endovascular therapy. Cost savings increased with increasing numbers of spoke hospitals. As transfer rates increased, costs savings to the networks decreased. Additional savings were predicted when endovascular therapy was reduced by 50% and 75%.
Nelson et al. 2011 **USA** **Cost-effectiveness analysis (societal perspective)**	NA	NA (theoretical model)	Using a decision analytic model, comparison of costs and outcomes associated with patients presenting with acute ischemic stroke to spoke hospitals with and without telestroke access	**Primary outcomes:** Costs, incremental costs, Quality-adjusted life years (QALYs), incremental cost-effectiveness ratio (ICER), associated with 90-day and lifetime horizons.	90-day costs for usual care and telestroke were $13,872 vs. $14,274 (incremental cost=$402). The respective QALYs were 0.119 and 0.123. ICER=$108,363/QALY Lifetime costs for usual care and telestroke were $130,343 vs. $133,527 (incremental cost=$3,184). The respective QALYs were 8.85 and 10.15. ICER=$3,449/QALY

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
			Assumptions: an established telestroke system with 8 spokes hospital and a single hub hospital staffed with 4 neurologists, with telestroke capability from the hospital or physician's home. Costs, (telestroke infrastructure costs for spoke/hub and patient costs, patient transfer costs, long-term costs), event probabilities, (tPA vs. no tPA and discharge destinations, based on mRS scores) were estimated using the published literature.	Willingness to pay threshold was $50K/QALY	For start-up telestroke networks, the 90 day ICERs for hospitals with 1 and 3 spokes were $480,258/QALY and $196,910/QALY. For start-up telestroke networks, the lifetime ICERs for hospitals with 1 and 3 spokes were $3,509/QALY and $2,701/QALY. ICERS varied considerably in sensitivity analyses when input parameters (# patients /spoke and transfer costs) were varied. Monte Carlo simulations yielded ICERs of <$50K 99.7% and 37.5% of the time for lifetime and 90-day horizons, respectively.
Demaerschalk et al. 2010 **USA** **Systematic review**	NA	24 studies evaluating cost analysis of tPA, stroke centres and telemedicine. There were no inclusion/exclusion criteria stated. Search terms included stroke, cost and telemedicine	Narrative reporting of the results from 6 studies that examined aspects of costs associated with telemedicine for stroke	**Primary outcome:** Incremental cost-effectiveness ratio, (ICER) cost savings	No cost-effectiveness articles were found. Most articles focused on the cost of implementation and/or operational costs associated with the systems, although the specific costs/savings ($) associated with telemedicine from any of the 6 studies included, were reported.

Abbreviations

CA: concealed allocation	CI: confidence interval	ITT: intention-to-treat
NA: not assessed	NOS: Newcastle-Ottawa scale	RR: relative risk
OR: odds ratio	sICH: symptomatic intracerebral hemorrhage	

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