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Impact of simulation training on a telestroke network

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Abstract

Background: Stroke is a leading cause of morbidity and mortality in Brazil, where there are significant imbalances in access to specialized stroke care. Telemedicine networks allow patients to receive neurological evaluation and intravenous thrombolysis in underserved areas, where performance measures are challenging.

Aims: To describe the impact caused by adequate stroke care training, using realistic simulation, in a developing country telestroke network.

Methods: Retrospective observational study comparing the number of all stroke diagnoses, thrombolysis rate, door-to-needle time and symptomatic intracranial hemorrhage after intravenous thrombolysis, during one year providing just algorithms and orientation in stroke care to spoke facilities (phase 1), with the results achieved along one year after the beginning of ongoing live training sessions (phase 2).

Results: The mean number of patients diagnosed with stroke increased from 7.5 to 16.58 per month ($P = 0.019$) rising from 90 patients during phase 1 to 199 in phase 2. There was a reduction in the mean door-to-needle time from 137.1 to 95.5 min (−41.58; 95% CI −62.77 to −20.40). The thrombolysis and symptomatic intracranial hemorrhage rates had a non-significant decrease from 21.31% to 18.18% (OR 0.82; 95% CI 0.39 to 1.71) and 12.5% to 7.69% (OR 0.58; 95% CI 0.046 to 7.425), respectively.

Conclusions: Realistic simulation stroke care training provided by stroke centers to spoke facilities seems to significantly reduce door-to-needle time and enhance adherence in a telestroke network.

Keywords

Telemedicine, stroke, telestroke, thrombolysis, door to needle time, training, tissue-type plasminogen activator, developing country

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Introduction

Stroke is the second leading cause of death[1] and third cause of disability adjusted life years[2] in Brazil, where few hospitals have the expertise in stroke treatment, even in more developed urban regions such as the metropolitan area of Rio de Janeiro. A telemedicine network seems to be a feasible,[3–9] cost effective[10] and safe[11] alternative to overcome these difficulties, allowing expansion of patient access to adequate neurological evaluation in the acute phase,[12] including the correct indication and management of intravenous thrombolysis (IVT) with tissue-type plasminogen activator (tPA).[13]

Even after the implementation of a telestroke program, system usage and spoke facilities' performance measures could be inadequate due to lack of experience, considering their low patient volume. We hypothesized that continuous training using realistic simulations could lead to greater network usage, decreased door to needle times (DNTs) as well as greater safety.

Aims

To estimate the impact caused by adequate stroke care training on the performance of a Brazilian telestroke network.

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Methods

Infrastructure

Our network operates in a "hub and spoke" model, in which Hospital Pró-Cardíaco (HPC), with at least one neurologist present $24 \times 7 \times 365$, serves as reference to community emergency departments (EDs) in the metropolitan area of Rio de Janeiro: three emergency clinics without inpatient beds – Campo Grande, Nova Iguaçu and Tijuca – and two hospitals – Hospital Pasteur (HP) and Hospital de Clínicas Mário Lioni (HCML) (Table 1). HCML joined the telemedicine network in August 2015, the remaining started when the telemedicine program began in February 2013. All of them have an ED, laboratory, and computed tomography (CT) scanner. Magnetic resonance image is available only at HP. All institutions belong to the same private healthcare organization. Our network is intended to assist not only stroke but also other neurological emergencies. The consultant neurologist assesses the radiologic images through remote access to a spoke facility desktop running a digital imaging and communications in medicine (DICOM) viewer. The activities started after installation of a stationary remotely controlled pan-tilt-zoom camera (Polycom EagleEye III, 1920×1080 resolution and 12× optical zoom), a high-definition monitor, and a videoconference system (Polycom HDX 6000, 720p, 30 fps) in each ED, including HPC, in February 2013. Video, audio, and scans transmission are done through broadband internet.

Workflow

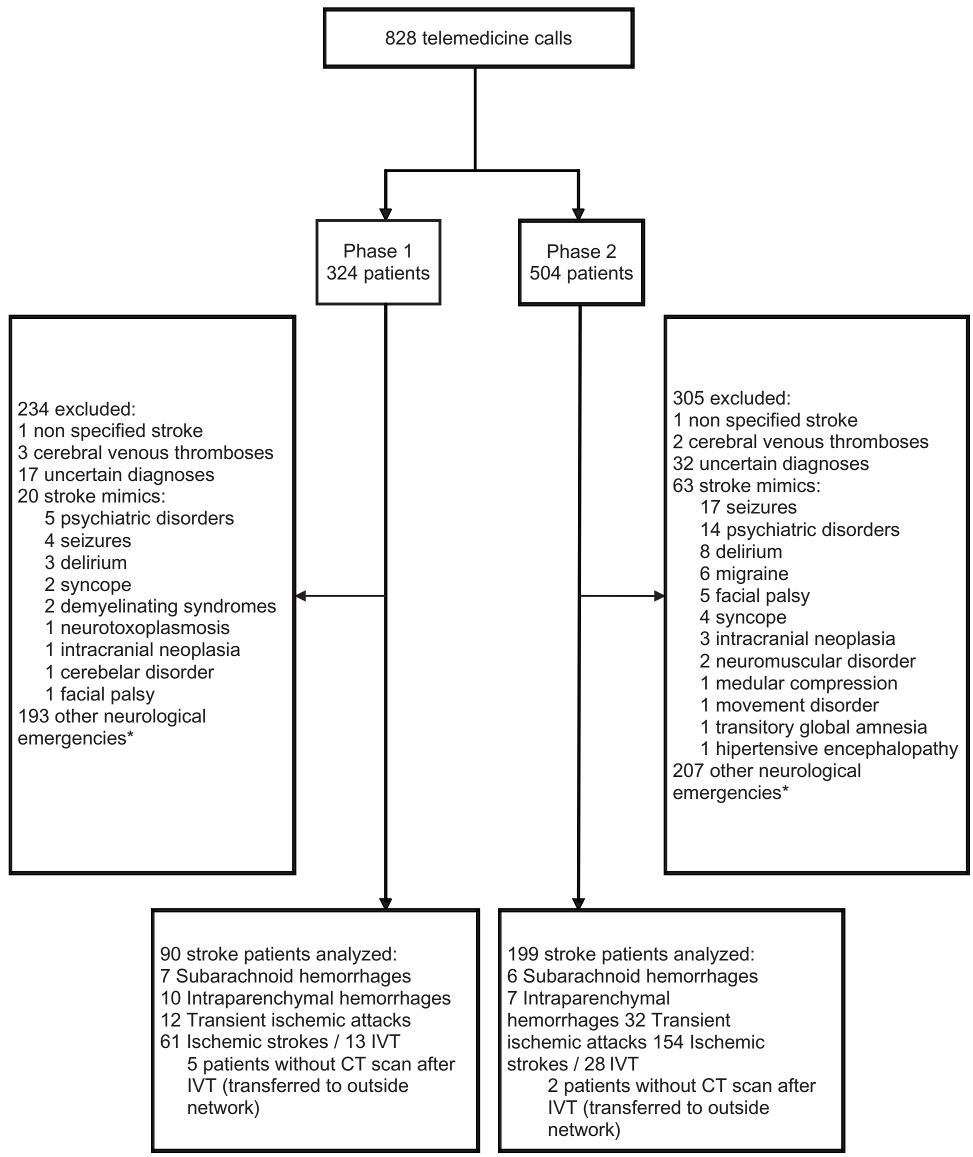
All telemedicine consultations were performed with physicians on both sides following patients' informed consent, as demanded by the Federal Medicine Council – the Brazilian agency that supervises and regulates the local medical practice. The neurologist was in charge of recommending care for stroke patients based on current guidelines,[14] monitor IVT when indicated in patients who presented to spoke facilities within 4.5 h of symptoms onset,[15] and advise best practice in other neurological emergencies. Consultations were prospectively recorded by the neurologist in a standardized form designed to collect relevant data[16] such as clinical presentation, time of stroke onset, cardiovascular risk factors, the result of complementary tests, diagnostic hypothesis, proposed treatments, time of tPA infusion, and complications. All forms were pooled in a database used for analysis. Information collected in spoke facilities were also used to correct or complement data when these were absent or not recorded. We included in analyses patients diagnosed with acute ischemic stroke (AIS), transient ischemic attack (TIA), intraparenchymal hemorrhage (IPH), and aneurysmal subarachnoid hemorrhage (SAH) (Figure 1). Stroke not specified as ischemic or hemorrhagic, cases which the neurologist was unsure about the actual diagnosis (i.e. inability to differentiate between stroke and Todd's paralysis), and stroke mimics were excluded (Figure 1). We began to systematically collect the arrival time of patients in each facility in July 2014, allowing calculation of the DNT of patients receiving tPA (Figure 2). In Brazil, health insurances provide access only to hospitals predetermined in contracts. Therefore, none of the patients were transferred to HPC due to commercial issues. Instead, they preferably stayed in spoke hospitals. The other facilities transferred patients to hospitals after initial care, sometimes outside the

Table 1. Spoke facilities characteristics and performance

	HP	HCML	CGF	NIF	TF
Distance from HPC in miles	10.5	18	36	27.6	6.5
Mean ED visits/month in 2015	13100	8600	7000	7900	3500
N of IVT previous to telemedicine	6	0	0	0	0
N of IVT previous to study period	11	0	1	2	2
N of IVT phase1	11	–	0	2	0
N of IVT phase 2	18	9	0	0	1
Mean DNT phase 1 in minutes	109	–	–	129.5	–
Mean DNT phase 2 in minutes	93	103	–	–	97

HPC: Hospital Pró-Cardíaco; HP: Hospital Pasteur; HCML: Hospital de Clínicas Mário Lioni; CGF: Campo Grande facility; NIF: Nova Iguaçu Facility; TF: Tijuca facility; ED: emergency department; IVT: intravenous thrombolysis; DNT: door-to-needle time.

Figure 1. Study design.
IVT: intravenous thrombolysis. *Traumatic brain injury, headaches, seizures, confusional states, meningitis, intracranial neoplasias, intoxications, neuromuscular diseases, demyelinating, metabolic and movement disorders.



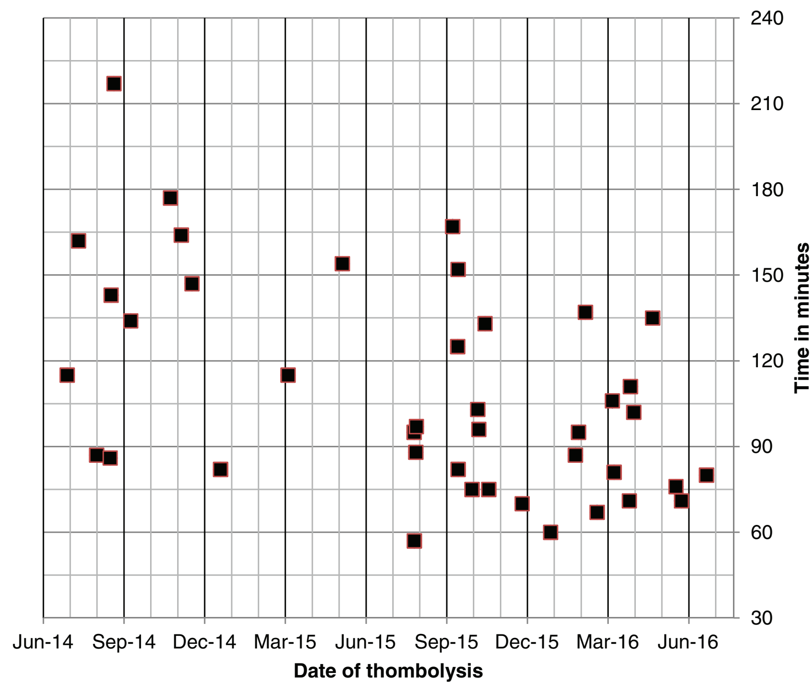
network. All of them were instructed to repeat the CT scan 12 to 36 h after infusion. We have maintained frequent contact with assisted units to manage problems and improve workflow. All facilities followed the same written algorithm guiding on how to address a suspected stroke patient (see Supplemental Appendix 1).

This study was approved by our local ethics committee, who waived the requirement for informed consent from patients, and by the Brazilian National Ethics Committee in Research (CONEP; N° 67337617.0.0000.5533).

Intervention

HPC began to provide stroke care training to all spoke ED staff, including physicians, radiologists, and nurses in July 2015. Trainings were held in a realistic environment for this purpose in HPC, consisting of a brief focused lecture on practical aspects of stroke care, followed by live simulation of cases where various professionals involved in patient management are encouraged to actively participate (see Supplemental Appendix 2). These cases were based on real patients previously treated at HPC. All trainings were guided by a neurologist, and designed to expose trainees to pitfalls faced in

Figure 2. Door-to-needle time records.
Door-to-needle times measured along study period from all spoke facilities; 41 patients: 13 during phase 1, from July 2014 to June 2015; and 28 during phase 2 (since live training sessions), from July 2015 to June 2016.



different settings and stimulating teamwork. From July 2015 to June 2016, there were 18 training sessions with 122 attendees from spoke facilities and prehospital care.

Outcomes

We compared the number of stroke diagnoses, DNT, IVT, and symptomatic intracranial hemorrhage (sICH) rates, during one year before start of live training sessions, from July 2014 to June 2015 (phase 1), to the results achieved since the start of such sessions, from July 2015 to June 2016 (phase 2). Scans performed after IVT were accessed by the authors and intracranial hemorrhage classified as in European Cooperative Acute Stroke Study I (ECASS I) cohort.[17] Since we did not have follow-up data from all patients but could have access to scans, we used parenchymal hematoma type 2 (PH2) as a surrogate to sICH.[18]

Statistical analysis

Univariate analyses comparing each study phase were performed using either Chi-square or *t*-tests for categorical or continuous variables, respectively. We adjusted linear regression models considering DNT as a dependent variable using each phase (phase 1: from July 2014 to June 2015; and phase 2: from July 2015 to June 2016) as well as either the type of the spoke unit (hospital or emergency clinic) or the ED patient volume as covariates. We also adjusted the same models using the number of months since the beginning of the study (considering July 2014 as a reference) instead of the study phase. Finally, since HCML was included only during phase 2, we adjusted the same models excluding this unit as a sensitivity measure.

Results

From July 2014 to June 2016, there were 828 telemedicine calls. Stroke accounted for 289 of them (34.9%) (Figure 1). There were 215 AIS, 44 TIA, 17 IPH, and 13 SAH; 276 stroke patients had demographics and risk factors recorded, described in Table 2. Twenty-nine IVT (70.73%) were performed at HP, nine at HCML (21.95%), two at Nova Iguaçu (4.87%), and one at Tijuca facility (2.43%) (Table 1).

A total of 90 patients presented with stroke during phase 1. There were 61 AIS cases and 13 (21.31%) have received tPA with a mean DNT of 137.15 min; 199 patients were diagnosed in phase 2, comprising 154 AIS, of which 28 were thrombolysed (18.18%), with a mean DNT of 95.57 min (Table 3).

Table 2. Demographic data

Demographics	Phase 1 N = 90	Phase 2 N = 199
Patient characteristics		
Mean age (SD)	57.62 (16.3)	63.59 (16.5)
Male sex	47 (52.22%)	96 (48.24%)
Systemic arterial hypertension	66 (73.33%)	139 (69.84%)
Diabetes mellitus	23 (25.55%)	64 (32.16%)
Previous stroke	17 (18.88%)	42 (21.1%)
Smoke	11 (12.22%)	28 (14.07%)
Dyslipidemia	5 (5.55%)	28 (14.07%)
Coronary artery disease	9 (10%)	23 (11.55%)
Atrial fibrillation / flutter	10 (11.11%)	17 (8.54%)
Obesity	10 (11.11%)	14 (7.03%)
Previous TIA	5 (5.55%)	6 (3.01%)
Carotid stenosis	1 (1.11%)	10 (5.02%)
Congestive heart failure	2 (2.22%)	1 (0.5%)
Valvular prosthesis	1 (1.11%)	0 (0.0%)
Patients without complete records	3 (3.33%)	10 (5.02%)
Stroke type		
AIS	61 (67.77%)	154 (77.5%)
Mean NIHSS in all AIS[a] (SD)	5.80 (5.93)	6.23 (6.24)
Mean NIHSS in IVT patients[a](SD)	9.08 (6.45)	8.81 (6.00)
TIA	12 (13.33%)	32 (16%)
IPH	10 (11.11%)	7 (3.5%)
SAH	7 (7.77%)	6 (3%)

IVT: intravenous thrombolysis; AIS: acute ischemic stroke; TIA: transient ischemic attack; IPH: intraparenchymal hemorrhage; SAH: subarachnoid hemorrhage.
[a]5 patients in phase 1, and 15 in phase 2 (one of them received IVT) without NIHSS record.

Therefore, we have observed an increase from an average of 7.5 to 16.58 stroke diagnoses per month. The IVT rate showed a non-significant decrease from 21.31% to 18.18% (OR 0.82; 95% CI 0.39 to 1.71) (Table 3). In addition, the overall mean DNT decreased 41.58 min with training (95% CI −62.77 to −20.40) (Table 3). Results were essentially the same adjusting for the ED volume in each institution (−42.42 min; 95% CI −64.06 to −20.76). Excluding HCML patients from analysis, because it was not included yet in phase 1, the result is also very similar (−45.52; 95%CI −68.70 to −22.35).

We had access to eight scans performed 12 to 48 h after IVT from the 13 tPA patients in phase 1. Seven had no hemorrhage, but one presented with PH2, resulting in a sICH rate of 12.5%. The remaining

Table 3. Outcomes

Outcomes	Phase 1	Phase 2	OR (95% CI)	P
Mean Number of stroke/month (SD)	7.5 (2.78)	16.58 (7.70)	–	0.019
Number of IVT	13 (21.31%)	28 (18.18%)	0.81 (0.39 to 1.71)	0.598
Mean DNT in minutes	137.15	95.57	− (−62.77 to −20.40)	0.001
sICH[a]	12.5%	7.69%	0.58 (0.046 to 7.425)	0.678

[a]Five patients in phase 1 and two patients in phase 2 without available image after tPA.
DNT: door-to-needle time; IVT: intravenous thrombolysis; sICH: symptomatic intracranial hemorrhage classified as in ECASS I.

were patients transferred to hospitals out of the network. We also had access to 26 control scans of 28 patients that received tPA in phase 2, 4 presented intracranial hemorrhage, 2 classified as PH1 and 2 as PH2 (1 parenchymal hematoma and 1 SAH), resulting in a sICH rate of 7.69%. Therefore, there was a decrease from 12.5 to 7.69% in sICH rate since the beginning of training sessions (OR = 0.58; 95% CI 0.046–7.425) (Table 3).

Discussion

Our telemedicine network began to operate in February 2013. Stroke is our main focus, although other neurological emergencies are also assisted. Nowadays, six spoke facilities take part of the network. For the purpose of this study, we compared equal periods of 12 months before and after the provision of regular live training sessions. Our absolute number of patients may seem low, but this could be explained by the fact that our network includes only private hospitals, accessible to only the 25% of Brazilian population with health insurance.[19]

Another limitation is that we were not able to compile data on functional outcomes of patients 90 days after treatment, because many patients were transferred to hospitals outside the network, and recording of this data was not yet standardized among the facilities involved.

The number of stroke diagnoses more than doubled with the training sessions. We hypothesize three possible reasons: higher awareness about the disease amongst ED staff, greater adherence to telemedicine as a clinical tool, and community recognition of spoke facilities as a regional stroke care center. These points can lead to better patient care due to improvement of health professionals' knowledge about the disease, its various different features, and management. As telemedicine use increases, and as assisted hospitals are seen as a reference by the community – in Brazil, patients can choose which hospital to go as long as it is included in their health insurance contract – fewer opportunities for an effective treatment will be missed. The rate of IVT had a non-significant decline from 21.3% to 18.3% not because of lesser adherence to protocol, but due to a greater demand for telemedicine, comprising more patients not suitable to tPA (Figure 1).

The great impact of training sessions in our study was the significant decrease in the overall mean DNT from 137.15 to 95.57 min (−41.58; 95% CI −62.77 to −20.40), emphasizing the important role of continuous monitoring and management of process measures in the implementation of new technologies and practices. We could not dissociate statistically the sole effect of training from time curve learning. However, we compared the results of the most experienced spoke facility before training sessions with the results achieved by a new facility on training, HCML. HP is the only spoke facility that had treated stroke patients with tPA before telemedicine program: six patients received IVT during the four years preceding the network implementation, likewise other 11 patients from February 2013 to June 2014 with telemedicine orientation, before the study period (Table 1). HCML has joined the network in August 2015, after the training sessions had started, and had no record of previous IVT to stroke patients. The former, with more expertise, had a mean DNT of 109 min during phase 1, while the latter achieved 103 mean DNT in phase 2, with ongoing training sessions. This suggests that adequate training has an independent impact on DNT regardless of the spoke facility experience.

Another possible influence could be the individual performance of HCML, which joined our network during phase 2. After excluding its nine patients, the adjusted analysis turned out to be even better (−45.52; 95% CI −68.70 to −22.35), confirming that the result was not exclusively due to this facility. It is interesting to note that the mean DNT achieved by HP in phase 2, was 91.33 min. Unfortunately, only two patients during the study period received IVT within 60 min DNT as proposed also in a telestroke scenario.[16]

Our figures are comparable to other published telestroke series from more developed countries. Agarwal et al.[20] reported a mean 94.9 DNT and 7.3% sICH rate in the East of England Telestroke project, while Wang et al.[6] got a 104.9 mean DNT and no sICH in REACH.[6] Sanders et al.[21] reported 104.6 mean DNT at a first study, with 3.7% sICH and then, in the following two years, an improvement to 81 min with 5% sICH.[22]

We found a non-significant OR to decreased sICH after training (12.5 to 7.69%, OR = 0.58; 95% CI 0.046–7.425). This can be due to the small sample size and the high number of missed patients lost to follow-up. Even in the worst scenario, if all missed patients presented sICH in phase 2 and no hemorrhage in phase 1, the result would still be non-significant (OR = 2; 95% CI 0.2–19.914; $p = 0.591$).

Another limitation of our study is that our results were very influenced by HP, where 71% of IVT took place. With a growing network, we believe this issue will diminish in future studies.

The narrow timeframe for tPA and the concerns about possible cerebral hemorrhage make thrombolysis decision uncomfortable for many physicians.[23] Counting on a neurologist opinion rapidly available through videoconference seems a good solution, as evidences show reliability of neurological examination[24,25] and image assessment[26] using telemedicine. But constant surveillance of outcomes and transferring experience from hub to spoke facilities is crucial for a telemedicine program to improve in quality.

In summary, we found that adequate training of spoke facilities in a telestroke network seems to lead to increased system usage (measured by the number of diagnoses), and reduced DNT.

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Authors' contributions

Valério S Carvalho Jr study concept and design; database management, analysis and interpretation; manuscript elaboration.
Miguel R Picanço manuscript and tables revision for intellectual content.
André Volschan study design and manuscript review for intellectual content.
Daniel C Bezerra study supervision, statistical analysis, critical review of manuscript for intellectual content.

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References

1. DATASUS. Informações de saúde (Tabnet). Mortalidade 1996 a 2014. Mortalidade geral. Ministério da Saúde, http://tabnet.datasus.gov.br/cgi/tabcgi.exe?sim/cnv/obt10uf.def (accessed 20 January 2017).
2. Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990– 2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016; 388: 1603–1658.
3. Levine SRM. "Telestroke": the application of telemedicine for stroke. *Stroke* 1999; 30: 464–469.
4. LaMonte MP, Bahouth MN, Hu P, et al. Telemedicine for acute stroke: triumphs and pitfalls. *Stroke* 2003; 34: 725–728.
5. Wiborg A and Widder B. Teleneurology to improve stroke care in rural areas: the Telemedicine in Stroke in Swabia (TESS) Project. *Stroke* 2003; 34: 2951–2956.
6. Wang S, Gross H, Lee SB, et al. Remote evaluation of acute ischemic stroke in rural community hospitals in Georgia. *Stroke* 2004; 35: 1763–1768.
7. Audebert HJ, Kukla C, von Claranau SC, et al. Telemedicine for safe and extended use of thrombolysis in stroke: The Telemedic Pilot Project for Integrative Stroke Care (TEMPiS) in Bavaria. *Stroke* 2005; 36: 287–291.
8. Switzer JA, Hall C, Gross H, et al. A web-based telestroke system facilitates rapid treatment of acute ischemic stroke patients in rural emergency departments. *J Emerg Med* 2009; 36: 12–18.
9. Audebert HJ, Schultes K, Tietz V, et al. Long-term effects of specialized stroke care with telemedicine support in community hospitals on behalf of the Telemedical Project for Integrative Stroke Care (TEMPiS). *Stroke* 2009; 40: 902–908.
10. Nelson RE, Saltzman GM, Skalabrin EJ, Demaerschalk BM and Majersik JJ. The cost-effectiveness of telestroke in the treatment of acute ischemic stroke. *Neurology* 2011; 77: 1590–1598.

11. Kepplinger J, Barlinn K, Deckert S, et al. Safety and efficacy of thrombolysis in telestroke: a systemic review and meta-analysis. *Neurology* 2016; 87: 1–8.
12. Meretoja A, Keshtkaran M, Saver JL, et al. Stroke thrombolysis: save a minute, save a day. *Stroke* 2014; 45: 1053–1058.
13. National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue plasminogen activator for acute ischemic stroke. The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. *N Engl J Med* 1995; 333: 1581–1587.
14. Jauch EC, Saver JL, Adams Jr HP, et al. Guidelines for the early management of patients with acute ischemic stroke. *Stroke* 2013; 44: 870–947.
15. Hacke W, Kaste M, Bluhmki E, et al. ECASS Investigators. Thrombolysis with alteplase 3 to 4.5 hours after acute ischemic stroke. *N Engl J Med* 2008; 359: 1317–1329.
16. Wechsler LR, Demaerschalk BM, Schwamm LH, et al. Telemedicine quality and outcomes in stroke: a scientific statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke* 2017; 48: e3–e25.
17. Hacke W, Kaste M, Fieschi C, et al; for the ECASS Study Group. Intravenous thrombolysis with recombinant tissue plasminogen activator for acute hemispheric stroke: the European Cooperative Acute Stroke Study (ECASS). *JAMA* 1995; 274: 1017–1025.
18. Fiorelli M, Bastianello S, von Kummer R, et al. Hemorrhagic transformation within 36 hours of a cerebral infarct: relationships with early clinical deterioration and 3-month outcome in the European Cooperative Acute Stroke Study I (ECASS I) cohort. *Stroke* 1999; 30: 2280–2284.
19. Dados gerais. Agência Nacional de Saúde Suplementar, www.ans.gov.br/perfil-do-setor/dados-gerais (accessed 11 July 2017).
20. Agarwal S, Day DJ, Sibson L, Barry PJ, Collas D and Metcalf K. Thrombolysis delivery by a regional telestroke network – experience from the UK National Health Service. *J Am Heart Assoc* 2014; 3: e000408.
21. Sanders KA, Figiel C, Kiely JM, Gwynn MW and Johnston LH. Expanding access to intravenous tissue-type plasminogen activator treatment with a practice-based telestroke system. *J Stroke Cerebrovasc Dis* 2013; 22: e546–e548.
22. Sanders KA, Patel R, Kiely JM, Gwynn MW and Johnston LH. Improving telestroke treatment times in an expanding network of hospitals. *J Stroke Cerebrovasc Dis* 2016; 25: 288–291.
23. Brown DL, Barsan WG, Lisabeth LD, Gallery ME and Morgenstern LB. Survey of emergency physicians about recombinant tissue plasminogen activator for acute ischemic stroke. *Ann Emerg Med* 2005; 46: 56–60.
24. Wang S, Lee SB, Pardue C, et al. Remote evaluation of acute ischemic stroke: reliability of national institutes of health strokes scale via telestroke. *Stroke* 2003; 34: e188–e192.
25. 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* 2003; 34: 2842–2846.
26. Johnston KC and Worrall BB. Teleradiology Assessment of computerized tomographs online reliability study (TRACTORS) for acute stroke evaluation. *Telemed J E Health* 2003; 9: 227–233.