Conclusions — Telestroke is a widespread and growing practice model. Important barriers to expansion amenable to change relate to organizational, technical, and educational domains and external economic and regulatory forces. (Stroke. 2012; 43:2078-2085.)

Key Words: telemedicine ■ telestroke ■ inventory ■ barriers

Stroke is the fourth leading killer in the United States and the leading cause of long-term disability. Approximately 800,000 people experience a stroke each year in the US.1 Successful management of acute ischemic stroke is extremely time-dependent. Ideally, the only Food and Drug Administration-approved treatment for acute ischemic stroke should be administered within 3 hours of the onset of stroke symptoms; however, recent guidelines recommend that selected patients can be treated up to 4.5 hours after symptom onset.2-4

The American Heart Association estimates that only 3% to 5% of ischemic stroke patients are treated with thrombolysis.5 There are many reasons that contribute to the uncommon use of intravenous recombinant tissue-type plasminogen activator (rt-PA) in the acute ischemic stroke setting: poor community awareness of stroke symptoms, lack of on-site stroke-care expertise, long distances to tertiary care hospitals, and concerns with the risks of intracranial hemorrhage.6,7 The use of telemedicine in the treatment of stroke has shown great promise for improving patient access to recommended stroke treatments in rural areas and other areas underserved by neurologists.8,9

Using telemedicine technologies, including high-quality videoconferencing for face-to-face interactions and remote viewing of images, the patient and the physician are not required to be in the same room, or even in the same state, for a high-quality care interaction to occur.10,11 Although telehealth programs have existed for many years, over the past decade, telemedicine programs focused on certain diseases have rapidly emerged as a sustainable model of care delivery;
this is especially the case in urgent care scenarios as in acute ischemic stroke.12–14

Little is known about the adoption or success of telestroke networks outside the context of federally funded programs or series published in the medical literature.12,14 With the US in the midst of an economic crisis, healthcare and payment reform occurring at both the national and state level, and a growing population of patients needing care for stroke, it is critical that a comprehensive assessment of telehealth adoption in specific diseases be performed.15,16 Our objective was to conduct an environmental scan of telemedicine-based stroke programs in the US and to identify both critical success factors and barriers to the development or sustainability of telestroke programs.

Methods
A dedicated project analyst carried out all data collection. She performed Google searches to find potential programs, contacted the programs identified to verify eligibility, secured their participation in the project, and distributed the survey. Once the online surveys were completed, the project analyst conducted in-depth telephone interviews with site representatives.

Online Information Search
A search for telestroke programs was conducted using several methods. A keyword search was performed in Google utilizing the terms telestroke, telemedicine, or stroke. Google alerts were also established so that any recently indexed online content pertaining to the above search terms were delivered by Google via e-mail. In addition, a list was generated from US News and World Reports 2009 Best Neurology Programs in the US, and these programs were searched for the possible presence of any telehealth programs related to stroke.17 When a potential program was identified, searches for contact information at the individual hospital websites were performed. Any personal contacts of the investigators were also used to identify relevant hospitals and individuals. Furthermore, several for-profit telehealth companies with programs in telestroke were contacted, and InTouch Health and REACH Call agreed to provide us with hospital contacts that otherwise were not identified through our search strategy. Finally, a personal list of known telemedicine stroke program directors and industry thought leaders from academia and for-profit companies from 1 of the authors (L.H.S.) and from the Office of Advancement of Telehealth at Health Resource Services Administration was used to complement the initial search. A more detailed description of the search methodology can be found online (Supplemental Methods).

Detailed information on the county population was obtained from the US Census Bureau.18 Rural hub hospitals were defined as nonmetropolitan by Rural-Urban Commuting Area codes, and for spokes as those located in areas outside of metropolitan centers where there is not ready access to specialist, intensive, and/or high-technology care, and where resources, both human and material, are lacking.19

People and Programs Contacted
A list of potential programs was compiled, and multiple attempts were made to contact all identified programs. Contact attempts included use of phone and/or e-mail when available. Each site was contacted repeatedly until the program declined or clarified that it did not offer telestroke services.

Online Survey
Using SurveyMonkey, an online survey tool was developed to assess various aspects of the telemedicine stroke programs. A copy of the final survey tool administered to participants is available online (Supplemental Table S1). The online survey contained 6 general questions (eg, contact information, organization information), specific questions about telestroke, and was distributed to participants along with a letter that explained the purpose of the survey. Before distributing the survey to any outside participants, the survey was piloted internally and was refined using members of the Partners Telestroke team to assess it for content, clarity, and thoroughness. Following the completion of the online survey, telephone interviews were conducted with each of the respondents.

Telephone Interviews
Participants were encouraged to share specific details about their program and were also able to request anonymity if they so chose for attribution of individual comments. The interviews were conducted over the telephone. All of the telephone interviews were recorded for the purposes of transcription. Each interview lasted about 30 minutes (range, 20–40 minutes).

Statistical Analysis
Descriptive statistical analyses of publicly available demographic and health services data on the programs contacted were performed. Discrete variables were analyzed by $\chi^2$ or Fisher’s exact test as appropriate, and continuous data with Wilcoxon Rank-Sum for nonparametric data or Student $t$ test for normally distributed data as appropriate.

Results
Ninety-seven potential programs across 43 states were identified and contacted to assess eligibility and offer participation. Of the 56 programs with confirmed active telemedicine programs in stroke, 38/56 programs (68%) from 27 different states agreed to participate and are displayed in Figure 1.

Of the 38 programs, 36 programs (95%) were traditional hub and spoke networks and 2 were hubless; there were 33 traditional medical center hubs and 1 spoke site, as well as 2 spokes with neurology coverage from a for-profit company (Figure 2). The person answering the survey was a physician in 52.6%, a registered nurse in 18.4%, a PhD in 2.6%, and an administrator in 24.4%. The questionnaire’s answers were not statistically different according to the occupation of the respondent. We therefore report the grouped results.

The hospital and county level characteristics of programs that did not participate were similar to the ones that did, in terms of county level data (total population, % population age ≥ 25 years, % of individuals below poverty line), annual hub hospital admissions, number of beds, and annual emergency department visits (Table 1).

Respondents identified the internal factors and motivations for implementing telestroke programs, characterized the organizational elements of their networks, identified current reimbursement models, and classified the importance of recognized barriers to broader program adoption.

Internal Factors and Motivations for Implementing Telestroke Programs
Current telestroke programs all support emergency department consultation for specialty care, and many also use the systems for patient triage when determining patient acceptance for transfer to primary or comprehensive stroke center care. Providing a community benefit (97%), improving clinical outcomes (92%), and improving clinical process effectiveness or provider knowledge (76%) were the 3 most common internal factors that prompted the creation of current telestroke programs (Table 2). Notably, revenue enhance-
ment, cost reduction, and bed management were among the lowest-ranking reasons to create a program. External forces, such as competitive forces in the marketplace (32%), and new state legislation (27%) or changes in reimbursement policies (22%), did influence programs.

The hospitals were all asked what the driving force was behind starting up these programs. In several cases, the hub hospitals were already receiving calls for help with patients and they found it difficult to manage cases without being able to visualize the patient or their brain imaging. Because many of the patients would end up being transferred to the hub hospital by default, the hubs found telemedicine was a good way to start managing the patients even before they arrived. Another frequently cited reason for starting telemedicine programs was that the hospital observed health disparities across their service area. A patient who is not living near a major medical center was perceived to be receiving a different level of care from someone who is.

Organizational Elements of Telestroke Networks

Networks varied in the size and scope of their mission and the duration of the program, but adoption has been increasing steadily with a dramatic rise in the last 2 years of the 3-year period reviewed. The mean number of spokes per hub increased significantly from 2007 to 2008 to 2009 (3.78 versus 7.60; P<0.05; range, 0–28). In 65.5% of hubs, >80% of spoke sites were rural, and in 51.7% of hubs, >80% of spokes were small hospitals (0–99 beds). The median telestroke program operating duration since 2000 across all US sites surveyed was 2.44 years (interquartile range, 1.36–3.44 years).

There was variability in terms of how often the spokes had a pre-existing relationship with the hub as part of their corporate network. Although some hubs support remote spoke sites that are only within their hospital’s formal organizational network (20%), or that are only outside their hospital’s formal organizational network (20%), the vast majority of hubs (60%) support spokes that are either within or outside their hospital’s formal organizational network. Formal written contracts or agreements are in place at all spokes in most networks (81%), and in at least some spokes at almost all programs (89%).

Sites use a variety of technologies to support their telestroke work, with essentially all sites (95%) using high-quality videoconferencing (2-way, real-time interactive video with high resolution and frame rates). Single-vendor technical solutions were common (Polycom, 24%; REACH Call, 18%; Tandberg, 11%; InTouch Health, 8%) and hybrid solutions were frequently used (multiple vendors, 21%). More than half of the programs (68%) review brain imaging as part of the consultation process, and almost half of the programs (49%) incorporate telephone-only consultation or store and forward (11%) when appropriate. At 56% of hubs, the systems used can only interact with other systems of the same models by the same manufacturer (closed communication networks). Most sites (68%) use the same basic approach to telemedicine that they used at the initiation of their program. Advice or mentoring from an outside organization before making tech-
technology or program design decisions were utilized by 60% of the telestroke programs evaluated.

The most common methods used to store and communicate the documentation of the telestroke consultation to the spoke site are listed in Table 3. Fewer than half of the programs have a dedicated electronic health record system specific to telestroke, and many sites use a combination of paper, dictation, and other means to document the care delivered. Consult multimedia files are archived to a variable degree, with the minority of sites retaining a video recording of the cases (17%).

The composition of the telestroke team varied by site, depending on the resources available at the hub, or by an outside entity if no hub was utilized. Whereas consults were most often (~75%) provided by specialists employed by the hub hospital’s organization, just over a quarter (~25%) of sites used outside contracted specialists as part of the telestroke team. Telestroke consultants currently practice medicine in the program’s state in 97% of the cases, and nearly all include a physician (97%); but, some programs also incorporate other providers, such as registered nurses (38%), advanced-practice nurses (11%), or physician assistants (8%).

![Figure 2. Diagram comparing 3 organizational models of a stroke telemedicine model: A, the expert teleconsultant is affiliated with the hub hospital that receives potential postconsultation transfers; B, more detailed schematic diagram of the consult process in a model that the teleconsultant is affiliated with the hub hospital showing the possibility of multipoint acute stroke consult; C, the teleconsultant is an employee of a for-profit telemedicine company unaffiliated with the receiving hub D, the teleconsultant is a private practice neurologist unaffiliated with the receiving hub.]

Table 1. Hospital (Hub of the Main Hospital of the Programs) and County (in Which the Hub is Located) Annual Characteristics of Participating and Non-Participating Programs

<table>
<thead>
<tr>
<th>County level</th>
<th>Programs That Participated in the Survey (mean±SD)</th>
<th>Programs That Did Not Participate in the Survey (mean±SD)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total population</td>
<td>1 020 000±1 672 215</td>
<td>1 580 000±2 546 299</td>
</tr>
<tr>
<td></td>
<td>Population of adults age ≥25 y</td>
<td>660 655±1 036 445</td>
<td>996 926±1 572 562</td>
</tr>
<tr>
<td></td>
<td>Population below poverty level</td>
<td>136 656±284 641</td>
<td>236 249±452 016</td>
</tr>
<tr>
<td>Hub hospital level</td>
<td>Annual no. of admissions</td>
<td>29 000±21 409</td>
<td>28 300±17 960</td>
</tr>
<tr>
<td></td>
<td>Bed size</td>
<td>608.49±449</td>
<td>552.39±373</td>
</tr>
<tr>
<td></td>
<td>Annual emergency room visits</td>
<td>64 300±42 663</td>
<td>63 700±40 635</td>
</tr>
</tbody>
</table>

There is round-the-clock access to dedicated technical support during the consultation process in most sites (86%), and this contributes to operating costs.

Clinical quality of the programs is measured in 91.9% of the programs evaluated, and includes specific case reviews for compliance with protocols (53%), and measurement of processes of care, such as treatment time intervals (44%) and patient satisfaction (6%). Additional services are also provided through the networks that go beyond the specific telestroke encounters including: providing follow-up clinical information (45%), quality metric reports (18%), education and training (9%), service utilization reports (3%), or all of the above (15%).

Current Financial and Reimbursement Models
Third-party health insurance payment for the physician services rendered was uncommon, with no applicable coverage in most networks (43%), followed by some private insurance (30%; Table 4). When available, oftentimes these payments were described as inadequate.

Importance of Recognized Barriers to Broader Program Adoption or Sustainability
Sites rated inability to obtain physician licensure (27.7%), lack of funds (27.7%), and lack of reimbursement (19.44%) as the most important barriers to program growth. The barriers most frequently mentioned during the telephone interviews were: licensing/credentialing challenges, lack of technology support at the spokes, lack of funds, and trouble with physician buy-in. Each site identified and ranked the barriers most likely to have an impact in increasing growth or development of telestroke if they were removed. Although lack of start-up or maintenance funds and lack of reimbursement were at the top of all lists, lack of physician buy-in at the spokes more than at the hubs emerged as an important barrier to growth; the administrative challenges related to licensure and credentialing were identified as a high-priority barrier to remove for telestroke programs.

Discussion
The results of this environmental scan demonstrate that current telestroke programs are steadily growing over the years evaluated, that all programs support emergency department consultation for specialty care, that most use the combination of real-time interactive video and teleradiology

Table 2. Important Institutional Goals (Left Column) and Internal Factors (Right Column) That Drove Creation of Telestroke Programs

<table>
<thead>
<tr>
<th>Main Purposes of the Telestroke Program</th>
<th>%</th>
<th>Key Internal Factors</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency room consultation</td>
<td>100</td>
<td>Provide a community benefit</td>
<td>97.3</td>
</tr>
<tr>
<td>Patient triage (admit vs transfer)</td>
<td>83.8</td>
<td>Improve clinical outcomes</td>
<td>91.9</td>
</tr>
<tr>
<td>Inpatient teleconsultation</td>
<td>46.0</td>
<td>Improve clinical processes</td>
<td>75.7</td>
</tr>
<tr>
<td>Provider education</td>
<td>29.7</td>
<td>Increase provider knowledge</td>
<td>75.7</td>
</tr>
<tr>
<td>Administrative meetings</td>
<td>21.6</td>
<td>Improve diagnostic accuracy</td>
<td>62.2</td>
</tr>
<tr>
<td>Patient/community education</td>
<td>16.2</td>
<td>Develop our hospital or referral network</td>
<td>59.5</td>
</tr>
<tr>
<td>Online/streaming grand rounds</td>
<td>16.2</td>
<td>Improve patient satisfaction</td>
<td>54.1</td>
</tr>
<tr>
<td>Outpatient teleconsultation</td>
<td>13.5</td>
<td>Enhance revenue</td>
<td>32.4</td>
</tr>
<tr>
<td>Clinical trial enrollment</td>
<td>13.5</td>
<td>Increase patient knowledge</td>
<td>35.1</td>
</tr>
<tr>
<td>Research</td>
<td>13.5</td>
<td>Enhance bed management</td>
<td>27.0</td>
</tr>
<tr>
<td>Intraoperative guidance</td>
<td>2.7</td>
<td>Reduce costs</td>
<td>18.9</td>
</tr>
<tr>
<td>Postoperative care</td>
<td>2.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>2.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Table 3. Methods Used to Store and Communicate Consultation Findings

<table>
<thead>
<tr>
<th>Medical Record Documentation Methods</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated telemedicine software package</td>
<td>44.44%</td>
</tr>
<tr>
<td>Organization’s EMR* by typing or dictation</td>
<td>13.88%</td>
</tr>
<tr>
<td>Spoke’s EMR via dictation</td>
<td>13.88%</td>
</tr>
<tr>
<td>Other (including combinations of above)</td>
<td>13.88%</td>
</tr>
<tr>
<td>No software—paper only</td>
<td>5.55%</td>
</tr>
<tr>
<td>No software—dictation only</td>
<td>2.77%</td>
</tr>
<tr>
<td>Email</td>
<td>2.77%</td>
</tr>
</tbody>
</table>

*EMR indicates electronic medical record.

| Table 4. Organizations That Contribute Financially to the Running of Telestroke Programs

<table>
<thead>
<tr>
<th>Financial Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizations</td>
</tr>
<tr>
<td>Hub hospitals</td>
</tr>
<tr>
<td>Spoke hospitals</td>
</tr>
<tr>
<td>Third-party payers</td>
</tr>
<tr>
<td>Government payers</td>
</tr>
<tr>
<td>Philanthropy</td>
</tr>
<tr>
<td>Insurance programs</td>
</tr>
<tr>
<td>Medicaid</td>
</tr>
<tr>
<td>Medicare</td>
</tr>
<tr>
<td>Private insurance</td>
</tr>
<tr>
<td>Tricare</td>
</tr>
<tr>
<td>None</td>
</tr>
</tbody>
</table>

Note the results are >100% because of the ability to multiselect.
to support the consultation process, and that, unfortunately, reimbursement for telestroke is still limited.

An important part of the application of a new technology depends on human factors and the ability to apply the new technology in a variety of scenarios, from research proof-of-concept environments to real-time acute care delivery interventions and novel practice settings. Modifying the barriers identified by this environmental scan appears a critical next step in realizing the tremendous potential of current and future telehealth applications for all citizens, not just those fortunate enough to live in areas serviced by existing programs.

Key activities that might promote expansion of telehealth services based on our results are: reimbursement for clinical services, streamlined licensure and credentialing, national standards for malpractice determinations, minimal technology performance standards, and incorporation of telehealth programs into comprehensive systems of care delivery models. The majority of the telestroke programs measure clinical quality, but they appear to do so by very disparate methods. National standards and designation-certification process specific for telestroke programs could help to homogenize such evaluations and to create benchmarks to allow appropriate comparisons between programs. In a recent survey of barriers to telemedicine in acute care units, respondents declared that telemedicine program success was still halted by licensing, credentialing, and malpractice protection, as well as costs, billing, and reimbursement issues.20

We found that coverage for telestroke services was uncommon, and that even when there were available payments, they were described as inadequate. Other authors have rated reimbursement as 1 of the most important issues for the success of telestroke systems in the US.10,16,21 Health insurance restrictions on reimbursement need to be modified to accept the validity of this new model of healthcare delivery. Medicare acknowledges the problem of reimbursement in acute stroke care and has created a higher-value diagnostic related group (DRG 559) for treatment of acute ischemic stroke with thrombolytics. Hospital costs have traditionally been greater than Medicare reimbursement for the acute care of patients treated with intravenous rt-PA, which includes not just the cost of the drug, but also advanced imaging, intensive care, and longer lengths of stay. The introduction of DRG 559 has provided more appropriate reimbursement for hospitals and removed the financial disincentive to use intravenous rt-PA if patients are admitted to the hospital where rt-PA was administered. However, for patients who receive rt-PA at a telestroke spoke hospital and then are transferred to the hub hospital, neither site is entitled to the higher DRG 559 payment.21–24 Stroke centers and telemedicine programs are associated with higher rates of intravenous thrombolyis administration within 3 hours of the onset of stroke symptoms. The first US cost-effectiveness analysis of telestroke was recently published and concluded that when a lifetime perspective is analyzed, telestroke seems cost-effective compared with usual care, mostly because telestroke costs are upfront and benefits of better stroke care are lifelong.25,26

More research is needed to demonstrate how these new models can be cost-effective for payers, especially outside the US. Allowing healthcare organizations more flexibility in how payment for services is covered and extending benefits to telehealth transactions would aid in adoption.

Sites rated inability to obtain physician licensure as 1 of the most important barriers to program growth and development. Because there is no national-level medical licensing and credentialing available for physicians, whenever a new spoke gets added to a telestroke network, physicians have to go through the credentialing process again. If the spoke is in another state, the physician must also go through the process of being licensed in that state.10,22 National repositories for physician data or national processes for licensure and credentialing are sorely needed, as is harmonization between regulatory agencies on required processes. Some states have already worked on decreasing the administrative problems that physicians face when they consult via telemedicine. The Model Act to Regulate the Practice of Medicine developed by the Federation of State Medical Boards calls for the issuance of special purpose licenses to physicians with a full license to practice in any state or US territory, as long as there have not been previous disciplinary actions taken against them.10,27 Expansion of telehealth services, especially across state lines, is not scalable without addressing this escalating administrative burden. Recently, The Centers for Medicare and Medicaid Services published a rule that implemented a new credentialing and privileging process for physicians providing telemedicine services. The rule permits hospitals to rely on the credentialing and privileging determinations of another hospital or telemedicine entity, rather than make an individualized decision based on the practitioner’s credentials and record. The new rule makes available a more streamlined process if hub and spoke wish to accept it, and will help to remove some unnecessary barriers to the use of telemedicine.28

Although essentially all sites investigated use high-quality videoconferencing to support consultation, storage and technology technical support were still extremely variable among the programs. Technology providers should be required to meet certain minimum specifications for acceptable performance to be certified as legitimate providers. These should be set by independent agencies, with input from key stakeholders. Ideally, the mode of data transmission must provide adequate bandwidth to transmit large amounts of data rapidly and safely; this is so computerized tomography scans can be sent to the hub hospital for concomitant evaluation by the spoke’s emergency department staff and the hub’s stroke team. Unfortunately, many suburban and rural areas do not have continuous high-speed bandwidth availability to support high-quality video transmission. Therefore, the presence of minimal infrastructure must be confirmed in hospitals that plan to participate in telestroke programs.10 In addition, standards supporting the integration of multimodality communication methods into a single-communication medium would enhance productivity and decrease costs.

A previous review of the published medical literature evaluating telestroke initiatives in 2009 found a total of 20 telestroke networks (12 networks in the United States, 3 networks in Canada, and 5 networks in Europe) and concluded that the long-term sustainability of telestroke practice
was threatened by unresolved legal, economic, and market factors. Our survey found similar barriers to telestroke growth. The same review urged the need for standardized measurements of telestroke quality of care and acceptable guidelines for telestroke practice. In the recommendations for the implementation of telestroke systems of care from the American Heart Association, important gaps to be addressed to warrant broad use of telemedicine included: discussion of licensure and liability legislation, development of admissible rules relating to the confidentiality of information, simplification of the process of requisition and conveying telemedicine appointments, improvement of the instruction of the end users, and development of economic models for reimbursement.

Our study has some important limitations. First, only 68% of identified programs participated in our survey. Although such a figure constitutes a high response rate for a typical survey, with response rates for physician surveys routinely in the 40% to 60% range, we cannot exclude the possibility of nonresponse bias. Nevertheless, programs that did and those that did not participate were similar in terms of hospital- and county-level data, suggesting that they had similar structural characteristics. County-level characteristics, although not the perfect surrogates for the structural characteristics of the programs, were the best available information about the nonparticipating programs. In addition, it is possible that nonrespondent programs might perform worse than those participating ones. Because our objective was not to measure the quality of the programs evaluated, but instead to conduct an environmental scan of telemedicine-based stroke programs in the US, we do not think that our results were biased based on the possibility of different program quality levels. Second, data such as number of teleconsultations and of telemedicine-guided intravenous rt-PA administration per program were not available. When the survey instrument was elaborated, we specifically avoided questions regarding volume of consults and costs, because we were afraid that unwillingness to disclose that information might lead to a low response rate. Finally, despite the interesting information provided by telephone interview, data acquired are subjective and not amenable to a more structured statistical evaluation, and no data were externally audited for accuracy.

Summary
The ability to identify and address the organizational, technical, and educational challenges in the context of the current economic, legal, and regulatory environment will determine the pace at which telestroke programs can expand and provide access to the many patients in need of increased health care. Increasingly, inequities in access to information technology will translate into disparities in access to health care, and therefore government and private initiatives will be necessary to ensure ubiquitous access to secure high-quality and high-speed bandwidth for telehealth applications. In conclusion, telestroke is a widespread and growing practice model. Important barriers to expansion relate mostly to organizational, technical, and educational domains internal to organizations, and economic and regulatory forces externally. National standards for licensure, credentialing, and reimbursement could have substantial impact in access to acute stroke care.

Acknowledgments
The authors gratefully acknowledge the support and constructive feedback provided by the Health Resources Services Administration program officers.

Sources of Funding
This study was supported (Dr Silva, S. Farrell, MBA, Dr Schwamm) in part by a contract from Health Resource Services Administration Requisition 09-HRS9923-AB (Stroke and Traumatic Brain Injury Telehealth Services).

Disclosures
Dr Silva, S. Farrell, MBA, E. Shandra, MBA and Dr Viswanathan report no disclosures. Dr Schwamm is chair of the American Heart Association Get With the Guidelines steering committee (unpaid) and a consultant to the Massachusetts Department of Public Health for Stroke Systems Development. The Massachusetts General Hospital employs Dr Schwamm and Dr Viswanathan and the hospital provides contracted telehealth services to hospitals in New England for telestroke.

References
The Status of Telestroke in the United States: A Survey of Currently Active Stroke Telemedicine Programs
Gisele S. Silva, Shawn Farrell, Emma Shandra, Anand Viswanathan and Lee H. Schwamm

 Stroke. 2012;43:2078-2085; originally published online June 14, 2012; doi: 10.1161/STROKEAHA.111.645861
 Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
 Copyright © 2012 American Heart Association, Inc. All rights reserved.
 Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/43/8/2078

Data Supplement (unedited) at:
http://stroke.ahajournals.org/content/suppl/2012/06/15/STROKEAHA.111.645861.DC1

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org//subscriptions/
SUPPLEMENTAL MATERIAL
Supplemental Methods

Online Information Search detailed description

A highly inclusive first pass strategy for identifying possible programs was undertaken. A search for telemedicine stroke programs, was conducted using several methods:

- A keyword search was performed in Google utilizing the terms: telestroke, telemedicine and stroke. Google alerts were also established so that any recently indexed online content (e.g. news, press releases, web pages, blog content, scientific articles) pertaining to the above search terms were delivered by Google via email.

- A list was generated from US News and World Report’s 2009 best Neurology programs in the United States, and these programs were searched for the possible presence of any telehealth programs. When a potential program was identified, searches were done of the individual hospital websites looking for information regarding telemedicine programs for contact information of the person in charge of the program or any contact phone numbers or e-mail addresses.

Using the various search mechanisms, potential hospital programs were identified. In addition, several for-profit telehealth companies with programs in telestroke were contacted and agreed to provide us with contact hospitals that otherwise were not identified through our search strategy. A list of names of programs was provided to us by two companies: InTouch Health TM (a privately held robotics technology company based in Santa Barbara, California) and REACH Call TM (a web-based telestroke tool developed to
provide a foundation for a rural stroke network that delivered acute stroke consults to rural community hospitals in Georgia). Finally a personal list of known telemedicine stroke program directors and industry thought leaders from academia and for-profit companies from one of the authors (LHS) and from the office of advancement of telehealth at Health Resource Services Administration (HRSA).
1. Contact Information

**1. Please enter your contact information.**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Organization:</th>
<th>City/Town:</th>
<th>State:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Email Address:</th>
<th>Phone Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Please enter your title within the organization.

3. Please briefly describe your role in relation to the telemedicine program.

4. Please enter the name of your telemedicine program if different from company name.

2. Organization Information

1. Which of the following describes your organization? Please select all that apply.

- [ ] Hospital Based Health Care Network
- [ ] Free Standing Academic Medical Center (AMC)
- [ ] Free Standing Hospital (non AMC)
- [ ] Public Hospital
- [ ] Health Center
- [ ] Outpatient Clinic
- [ ] Private Physician Office
- [ ] Other (please specify)
- [ ] For-Profit Organization
- [ ] Not-For-Profit Organization
- [ ] Regional Alliance / Consortium
- [ ] Federal Agency / Department / Program
- [ ] State Agency / Department / Program
- [ ] Health Insurer / Managed Care Org (MCO/HMO)
- [ ] Private Company

3. Telemedicine Program Description
1. In which clinical areas do you currently provide telemedicine based care using two-way, real-time interactive videoconferencing? Please select all that apply.

- Cardiology
- Dermatology
- Emergency / Triage
- Endocrinology
- Gastroenterology
- General Surgery
- Home Health
- Immunology
- Infectious Disease
- Internal Medicine
- Primary Care
- Pulmonary Care
- Radiology
- Mental Health
- Nephrology
- Neurology - Stroke
- Other (please specify)

- Neurology - General
- Nutrition
- Obstetrics and Gynecology
- Occupational Medicine
- Oncology
- Ophthalmology
- Occupational Medicine
- Orthopedics
- Pathology
- Pediatrics
- Podiatry
- Rehabilitation Therapy
- Rheumatology
- Speech Pathology
- Trauma - Traumatic Brain Injury (TBI)
- Trauma - General
- Urology

4. Stroke Telemedicine or Telestroke Services

1. Does your organization provide stroke telemedicine ("telestroke") services?

- Yes
- No

5. Telestroke Program - Purpose
### 1. Within the telestroke program, which of the following represents the purpose(s) of the program? Please select all that apply.

<table>
<thead>
<tr>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Room Consultation</td>
</tr>
<tr>
<td>Patient Triage (Admit vs. Transfer)</td>
</tr>
<tr>
<td>Intraoperative Guidance</td>
</tr>
<tr>
<td>Post Operative Care</td>
</tr>
<tr>
<td>Inpatient Teleconsultation</td>
</tr>
<tr>
<td>Outpatient Teleconsultation</td>
</tr>
<tr>
<td>Inpatient Telemonitoring</td>
</tr>
<tr>
<td>Clinical Trial Enrollment</td>
</tr>
<tr>
<td>Other (please specify)</td>
</tr>
<tr>
<td>Clinical Trial Telemonitoring</td>
</tr>
<tr>
<td>Home Health</td>
</tr>
<tr>
<td>Rehabilitation</td>
</tr>
<tr>
<td>Patient / Community Education</td>
</tr>
<tr>
<td>Provider Education (CME, CEU)</td>
</tr>
<tr>
<td>Online / Streaming Grand Rounds</td>
</tr>
<tr>
<td>Administrative Meetings</td>
</tr>
<tr>
<td>Research</td>
</tr>
</tbody>
</table>

### 6. Telestroke Program - Overview

1. When did the program begin?

2. Which of the following best describes your telemedicine program?

- ALL of the remote sites are a part of our formal organizational network
- NONE of the remote sites are part of our formal organizational network
- We serve remote sites that are BOTH within and outside of our formal organizational network
3. What internal factors prompted the creation of this program? Please select all that apply.

We wanted to:

- Provide a community benefit
- Enhance bed management
- Enhance revenue
- Reduce costs
- Develop our hospital or referral network
- Improve clinical outcomes

4. What factors in the local or regional environment were conducive to starting or growing the program? Please select all that apply.

- New state legislation
- New federal legislation
- New health department regulations/policy
- New EMS regulations/policy
- Changes in reimbursement
- Changes in licensing laws
- Competitive forces
- Changes in malpractice

7. Telestroke Program - Overview

1. How many remote sites do you/did you provide services to?
   - Calendar Year 2009 (To Date)
   - Calendar Year 2008
   - Calendar Year 2007

2. What percentage of the current remote sites are:

<table>
<thead>
<tr>
<th>Percentage of sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Hospitals (0-99 beds)</td>
</tr>
<tr>
<td>Medium Hospitals (100-399 beds)</td>
</tr>
<tr>
<td>Large Hospitals (400+ beds)</td>
</tr>
<tr>
<td>Rehabilitation Hospitals</td>
</tr>
<tr>
<td>Nursing Homes</td>
</tr>
<tr>
<td>Outpatient Clinics or Health Centers</td>
</tr>
</tbody>
</table>
### 3. What percentage of the current sites are:

<table>
<thead>
<tr>
<th>Percentage of sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
</tr>
<tr>
<td>Suburban</td>
</tr>
<tr>
<td>Urban</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

### 4. What percentage of the hospital sites are critical access or frontier hospitals?

<table>
<thead>
<tr>
<th>Percentage of sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical access hospitals</td>
</tr>
<tr>
<td>Frontier Hospitals</td>
</tr>
</tbody>
</table>

### 5. How many sites do you maintain signed contracts or written agreements with for the telemedicine services that you provide?

- All
- Some
- None
- Don't Know

### 8. Telestroke Program - Development / Leadership

1. Did an individual champion within your organization help start the program?

- Yes
- No

### 9. Telestroke Program - Development / Leadership

1. How important was the champion to the success of the program?

- Very Important
- Somewhat Important
- Neutral
- Somewhat Unimportant
- Very Unimportant
### Telestroke/TeleTBI Environmental Scan

#### 2. Which of the following best describes the role of the champion in your organization?

- [ ] Physician
- [ ] Nurse
- [ ] Other Allied Health Professional
- [ ] Administrator
- [ ] Other (please specify)

#### 10. Telestroke Program - Program Design and Technology

1. **What type(s) of technology do you currently use to support the consultation process in your telemedicine program? Please select all that apply.**

   - [ ] Two-Way, Real-Time Interactive Video
   - [ ] Telephone
   - [ ] Store and Forward
   - [ ] Brain Image Review
   - [ ] Other (please specify)

2. **Which model best describes the structure of your telemedicine program? Please select all that apply.**

   - [ ] Hub and Spoke
   - [ ] “Hubless” Network
   - [ ] Other (please specify)

3. **When performing a consultation who provides the advice? Please select all that apply.**

   - [ ] A specialist employed by my organization
   - [ ] Outside contracted specialists
   - [ ] Other (please specify)
4. Do your consultants currently practice medicine in your state?
   - Yes
   - No

5. If necessary, can the consultants access 24/7 tech support during the consultation process?
   - Yes
   - No

6. Which of the following most accurately describes the technology that your telemedicine program uses?
   - We use video conferencing systems that can connect to systems made by other vendors
   - We use video systems that can only connect to systems made by the same manufacturer
   - We use a combination of the two options listed above

7. Which of the following most accurately describes the most common method you use to store and communicate to the site the documentation of the telestroke consultation?
   - We use our organization’s EMR
   - We use the spoke EMR
   - We use a dedicated telemedicine software package
   - We use NO software (paper only)
   - We do not document the consultation
   - Other (please specify, including combinations of above)

8. Please list the systems most commonly used in your network for video, image transfer and data capture.
### Telesstroke/TeleTBI Environmental Scan

9. Are you still using the same basic approach to telemedicine that you started the program with (e.g. same video conferencing hardware, clinical documentation software, consulting physician specialist team)?

- Yes
- No

If NO, briefly describe what has changed.

10. Did you seek advice or mentoring from an outside individual or organization before making your technology or program design decision?

- Yes
- No

### 11. Telesstroke Program - Administration

1. What types of providers are routinely involved in the telemedicine consultation? Please select all that apply.

- MD / DO
- RN
- APRN
- PA
- Other (please specify)

2. Which of the following organizations contribute financially to the running of the program? Please select all that apply.

- Hub Hospitals
- Spoke Hospital
- 3rd Party Payors
- Government Payors
- Philanthropy
- Other (please specify)
3. Do you routinely get reimbursement from any of the following for providing telemedicine services? Please select all that apply.

- [ ] Medicaid
- [ ] Medicare
- [ ] Private Insurance
- [ ] Tricare
- [ ] None
- [ ] Other (please specify)

4. Do you monitor the clinical quality of your program?

- [ ] Yes
- [ ] No

If responding YES, please explain how.

5. How do you archive the telemedicine consults that you perform? Please select all that apply.

- [ ] Paper
- [ ] EMR
- [ ] Digital Images
- [ ] Video
- [ ] Audio
- [ ] Other (please specify)
6. What additional services do you provide to your remote sites? Please select all that apply.

- Follow-Up Clinical Information on Patients Transferred
- Service Utilization Reports
- Quality Metric Reports
- Other (please specify)

12. Telestroke Program - Barriers and Future Development

1. Please rank in numerical order the following barriers to implementing, maintaining, or growing your stroke telemedicine program. (1 being the greatest barrier and 16 being the smallest)

1) Inability to obtain additional malpractice (due to prohibitive cost or other reasons)
2) Inability to obtain physician licensure/credentialing
3) Inability to obtain patient consent
4) Inability to maintain patient confidentiality
5) Lack of standards of practice (or other clinical issues)
6) Lack of evidence of clinical efficacy
7) Lack of technology hardware at hub
8) Lack of technology hardware at spoke
9) Lack of IT support at hub
10) Lack of IT support at spoke
11) Lack of reliable high speed connection
12) Lack of reimbursement
13) Lack of physician availability at hub
14) Lack of physician buy in at hub
15) Lack of physician buy in at spoke
16) Lack of funds

2. If you could remove one of the barriers mentioned above, which one would it be? Please use the number located to the left of the identified barrier, NOT THE RANKING THAT YOU GAVE TO THE PARTICULAR BARRIER.
3. Please speculate: Three years from now, my organization will provide stroke telemedicine services to ___________ hospitals.

- more
- fewer
- the same number of

4. Please speculate: Three years from now, my organization will ______________ the breadth and scope of telemedicine services related to stroke that it provides to hospitals and patients (e.g. add home telemonitoring, add rehab hospital consultations).

- expand
- reduce
- maintain

13. Trauma or Traumatic Brain Injury (TBI) Telemedicine Services

1. Does your organization provide Trauma or Traumatic Brain Injury (TBI) telemedicine services?

- Yes
- No

14. Telemedicine TBI Program - Purpose
### Telestroke/TeleTBI Environmental Scan

1. Within the telemedicine TBI program, which of the following represents the purpose(s) of the program? Please select all that apply.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Room Consultation</td>
<td>☐</td>
</tr>
<tr>
<td>Patient Triage (Admit vs. Transfer)</td>
<td>☐</td>
</tr>
<tr>
<td>Intraoperative Guidance</td>
<td>☐</td>
</tr>
<tr>
<td>Post Operative Care</td>
<td>☐</td>
</tr>
<tr>
<td>Inpatient Teleconsultation</td>
<td>☐</td>
</tr>
<tr>
<td>Outpatient Teleconsultation</td>
<td>☐</td>
</tr>
<tr>
<td>Inpatient Telemonitoring</td>
<td>☐</td>
</tr>
<tr>
<td>Clinical Trial Enrollment</td>
<td>☐</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>☐</td>
</tr>
<tr>
<td>Clinical Trial Telemonitoring</td>
<td>☐</td>
</tr>
<tr>
<td>Home Health</td>
<td>☐</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>☐</td>
</tr>
<tr>
<td>Patient / Community Education</td>
<td>☐</td>
</tr>
<tr>
<td>Provider Education (CME, CEU)</td>
<td>☐</td>
</tr>
<tr>
<td>Online / Streaming Grand Rounds</td>
<td>☐</td>
</tr>
<tr>
<td>Administrative Meetings</td>
<td>☐</td>
</tr>
<tr>
<td>Research</td>
<td>☐</td>
</tr>
</tbody>
</table>

15. Telemedicine TBI Program - Overview

1. When did the program begin?

2. Which of the following best describes your telemedicine program?

   - ☐ ALL of the remote sites are a part of our formal organizational network
   - ☐ NONE of the remote sites are part of our formal organizational network
   - ☐ We serve remote sites that are BOTH within and outside of our formal organizational network
3. What internal factors prompted the creation of this program? Please select all that apply.

We wanted to:

- [ ] Provide a community benefit
- [ ] Enhance bed management
- [ ] Enhance revenue
- [ ] Reduce costs
- [ ] Develop our hospital or referral network
- [ ] Improve clinical outcomes

4. What factors in the local or regional environment were conducive to starting or growing the program? Please select all that apply.

- [ ] New state legislation
- [ ] New federal legislation
- [ ] New health department regulations/policy
- [ ] New EMS regulations/policy
- [ ] Changes in reimbursement
- [ ] Changes in licensing laws
- [ ] Changes in malpractice
- [ ] Competitive forces

16. Telemedicine TBI Program - Overview

1. How many remote sites do you/did you provide services to?

   Calendar Year 2009 (To Date)
   Calendar Year 2008
   Calendar Year 2007

2. What percentage of the current remote sites are:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage of sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Hospitals (0-99 beds)</td>
<td>□</td>
</tr>
<tr>
<td>Medium Hospitals (100-399 beds)</td>
<td>□</td>
</tr>
<tr>
<td>Large Hospitals (400+ beds)</td>
<td>□</td>
</tr>
<tr>
<td>Rehabilitation Hospitals</td>
<td>□</td>
</tr>
<tr>
<td>Nursing Homes</td>
<td>□</td>
</tr>
<tr>
<td>Outpatient Clinics or Health Centers</td>
<td>□</td>
</tr>
</tbody>
</table>
**Telestroke/TeleTBI Environmental Scan**

3. What percentage of the current sites are:

<table>
<thead>
<tr>
<th>Percentage of sites</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>6</td>
</tr>
<tr>
<td>Suburban</td>
<td>6</td>
</tr>
<tr>
<td>Urban</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
</tr>
</tbody>
</table>

4. What percentage of the hospital sites are critical access or frontier hospitals?

<table>
<thead>
<tr>
<th>Percentage of sites</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical access hospitals</td>
<td>6</td>
</tr>
<tr>
<td>Frontier hospitals</td>
<td>6</td>
</tr>
</tbody>
</table>

5. Do you maintain signed contracts or written agreements with each of these entities for the telemedicine services that you provide services to?

- [ ] Yes
- [ ] No
- [ ] Don't Know

**17. Telemedicine TBI Program - Development / Leadership**

1. Did an individual champion within your organization help start the program?

- [ ] Yes
- [ ] No

**18. Telemedicine TBI Program - Development / Leadership**

1. How important was the champion to the success of the program?

- [ ] Very Important
- [ ] Somewhat Important
- [ ] Neutral
- [ ] Somewhat Unimportant
- [ ] Very Unimportant
### Telestroke/TeleTBI Environmental Scan

2. Which of the following best describes the role of the champion in your organization?

- [ ] Physician
- [ ] Nurse
- [ ] Other Allied Health Professional
- [ ] Administrator
- [ ] Other (please specify)

### Telemedicine TBI Program - Program Design and Technology

1. What type(s) of technology do you currently use to support the consultation process in your telemedicine program? Please select all that apply.

- [ ] Two-Way, Real-Time Interactive Video
- [ ] Telephone
- [ ] Store and Forward
- [ ] Brain Image Review
- [ ] Other (please specify)

2. Which model best describes the structure of your telemedicine program? Please select all that apply.

- [ ] Hub and Spoke
- [ ] "Hubless" Network
- [ ] Other (please specify)

3. When performing a consultation who provides the advice? Please select all that apply.

- [ ] A specialist employed by my organization
- [ ] Outside contracted specialists
- [ ] Other (please specify)
### Telestroke/TeleTBI Environmental Scan

4. Do your consultants currently practice medicine in your state?
   - [ ] Yes
   - [ ] No

5. If necessary, can the consultants access 24/7 tech support during the consultation process?
   - [ ] Yes
   - [ ] No

6. Which of the following most accurately describes the technology that your telemedicine program uses?
   - [ ] We use video conferencing systems that can connect to systems made by other vendors
   - [ ] We use video systems that can only connect to systems made by the same manufacturer
   - [ ] We use a combination of the two options listed above

7. Which of the following most accurately describes the most common method you use to store and communicate to the site the documentation of the telemedicine consultation?
   - [ ] We use our organization's EMR
   - [ ] We use the spoke EMR
   - [ ] We use a dedicated telemedicine software package
   - [ ] We use NO software (paper only)
   - [ ] We do not document the consultation
   - [ ] Other (please specify, including combinations of above)

8. Please list the systems most commonly used in your network for video, image transfer and data capture.
### Telestroke/TeleTBI Environmental Scan

9. Are you still using the same basic approach to telemedicine that you started the program with (e.g. same video conferencing hardware, clinical documentation software, consulting physician specialist team)?

- [ ] Yes
- [ ] No

If NO, briefly describe what has changed.

10. Did you seek advice or mentoring from an outside individual or organization before making your technology or program design decision?

- [ ] Yes
- [ ] No

### 20. Telemedicine TBI Program - Administration

1. What types of providers are routinely involved in the telemedicine consultation? Please select all that apply.

- [ ] MD / DO
- [ ] RN
- [ ] APRN
- [ ] PA
- [ ] Other (please specify)

2. Which of the following organizations contribute financially to the running of the program? Please select all that apply.

- [ ] Hub Hospitals
- [ ] Spoke Hospital
- [ ] 3rd Party Payors
- [ ] Government Payors
- [ ] Philanthropy
- [ ] Other (please specify)
3. Do you routinely get reimbursement from any of the following for providing telemedicine services? Please select all that apply.

- Medicaid
- Medicare
- Private Insurance
- Tricare
- None
- Other (please specify)

4. Do you monitor the clinical quality of your program?

- Yes
- No

If responding YES, please explain how.

5. How do you archive the telemedicine consults that you perform? Please select all that apply.

- Paper
- EMR
- Digital Images
- Video
- Audio
- Other (please specify)
6. What additional services do you provide to your remote sites? Please select all that apply.

- Follow-Up Clinical Information on Patients Transferred
- Service Utilization Reports
- Quality Metric Reports
- Other (please specify)

21. Telemedicine TBI Program - Barriers and Future Development

1. Please rank in numerical order the following barriers to implementing, maintaining, or growing your TBI telemedicine program. (1 being the greatest barrier and 16 being the smallest)

1) Inability to obtain additional malpractice (due to prohibitive cost or other reasons)  
2) Inability to obtain physician licensure/credentialing  
3) Inability to obtain patient consent  
4) Inability to maintain patient confidentiality  
5) Lack of standards of practice (or other clinical issues)  
6) Lack of evidence of clinical efficacy  
7) Lack of technology hardware at hub  
8) Lack of technology hardware at spoke  
9) Lack of IT support at hub  
10) Lack of IT support at spoke  
11) Lack of reliable high speed connection  
12) Lack of reimbursement  
13) Lack of physician availability at hub  
14) Lack of physician buy in at hub  
15) Lack of physician buy in at spoke  
16) Lack of funds

2. If you could remove one of the barriers mentioned above, which one would it be? Please use the number located to the left of the identified barrier, NOT THE RANKING THAT YOU GAVE TO THE PARTICULAR BARRIER.

Barrier number
Barrier to remove
3. Please speculate: Three years from now, my organization will provide TBI telemedicine services to _______________ hospitals.

☐ more
☐ fewer
☐ the same number of

4. Please speculate: Three years from now, my organization will _______________ the breadth and scope of telemedicine services related to TBI that it provides to hospitals and patients (e.g. add home telemonitoring, add rehab hospital consultations).

☐ expand
☐ reduce
☐ maintain

22. Thank You

Thank you for your time. We will review your responses and, if necessary, contact you in the near future to arrange a follow-up telephone interview. If you have any questions about this survey please contact Emma Shandra at 617-724-4941 or eshandra@partners.org