Telestroke: Overcoming Barriers to Lifesaving Treatment in Rural Hospitals

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Abstract

Telestroke is the use of telemedicine specifically for stroke care. In the United States, about 40 neurologists are available per 100,000 persons. Acute ischemic stroke is often misdiagnosed by primary care or emergency medicine physicians in up to 30 percent of cases. A key advantage of using telestroke is the ability to treat patients in an efficient manner in rural areas where neurologists may not always be readily accessible. The purpose of this research study was to assess the main barriers of telestroke network implementation in rural hospitals. The methodology applied was a systematic literature review with a total of 75 sources used. Significant barriers exist preventing widespread success and adoption of telestroke, including high upfront capital expenditures, insufficient reimbursement by payers, and regulatory hurdles. While the telestroke referral network adds a significant financial burden on hospitals through infrastructure costs such as equipment purchases, staffing, training, and maintenance of the network, it can offer cost savings from the hospital's point of view while also improving patient outcomes. From a regulatory perspective, the use of telestroke has been tied to telehealth regulations and may not be well defined in all areas in terms of medical board rules, national standards, or clarifications of malpractice surrounding the use of this technology.

Keywords: barriers; financial; legal; neurologists; rural hospitals; telestroke

Introduction

In 2015, the Centers for Disease Control and Prevention (CDC) listed stroke as the fifth leading cause of death in the United States. Stroke affects approximately 800,000 patients per year.[1] Treatment of patients with stroke and its associated expenses have been estimated to have total direct and indirect costs in the United States of $62.7 billion in 2013.[2,3] It has also been forecasted that stroke costs will continue to outpace inflation and will be $183 billion by 2030.[4] Those who survive are often classified among the highest and most serious long-term disability patients. Stroke is a disease with a high social and economic impact.[5] It has been reported that nearly 1.1 million stroke survivors struggle with performing basic activities of daily living.[6,7] Annual costs of lost productivity resulting from stroke have been projected to rise from approximately $34 billion annually in 2013 to more than $56 billion in 2013.[8]

Slightly more than 40 percent of the US population resides outside of areas that offer easy accessibility to a primary stroke center during a stroke.[9,10] According to the 2010 Census, approximately 19.3 percent of the US population lives in rural areas,[11] many of which lack the permanent presence of an intensivist or an expert neurologist. Healthcare facilities with a neurologist on staff are not readily available in most rural areas, and as a result, small rural facilities often cannot provide the level of service needed by patients during a stroke.[12] Numerous healthcare facilities have been making efforts to improve offerings and quality of healthcare provided in rural areas to a level comparable to that provided in urban areas.[13] In 2010, the US Census Bureau identified rural areas as those that include all population, territory, and housing not included within an urban area. Urban areas have at least 1,000 people per square mile, with surrounding census blocks having an overall density of at least 500 people per square mile.[14]

As of the publication date of this article, the only treatment approved by the US Food and Drug Administration (FDA) for acute ischemic stroke thrombolysis is intravenously administered tissue plasminogen activator (tPA).[15,16] Given within three hours from the onset of symptoms of stroke, tPA works by dissolving the clot and increasing blood flow to the brain and can significantly improve recovery after stroke.[17] Because of the shortage of neurologists, with approximately 40 specialists per

100,000 US residents, rural hospitals do not have access to the resources needed to diagnose and administer tPA, whereas urban stroke centers do.[18]

Telemedicine for stroke, also known as telestroke, helps to reduce time to treatment and reduce the effect of the shortage of neurologists in rural underserved areas.[19] Under the telestroke model, neurologists are enabled to communicate, using digital technology, with on-site physicians who are treating patients at facilities that do not have adequate stroke expertise. An off-site neurologist can perform neurological assessments and triage of a patient, evaluate brain imaging, and aid bedside healthcare providers in diagnosis, avoidance of contraindications, and treatment, including administering intravenous tPA, which reduces mortality and long-term disability.[20] Intravenously administered tPA works by dissolving an oxygen-depriving clot in the brain and increases blood flow to the brain.[21] Administering tPA less than three hours from the onset of symptoms can improve the recovery of patients from a stroke and may lessen the severity of negative outcomes that may occur.[22,23]

According to the American Heart Association, telestroke involves developing a network connection through audiovisual systems that allow physical examination of the patient from a distance and evaluation of complementary tests, such as CT or MRI. The neurologist referral center can better identify those patients who will benefit from transfer to the stroke center and indicate the appropriate treatment, saving crucial time in this pathology.[24]

Typically, a telestroke network model is made up of one hub, which is an urban healthcare facility, and one or more outlying rural healthcare facilities operating as spokes.[24] As a whole, telemedicine is the practice of medicine at a distance, assisted by the electronic transfer of data, such as vital signs and imaging, through audio and video.[25] The telestroke model allows neurologists to treat thrombolysis by communicating using real-time audiovisual technology, allowing on-site physicians without extensive experience treating stroke to provide assessment data to neurology specialists who have extensive training, which may help improve outcomes in patients receiving this lifesaving treatment. Although the technology continues to change, some facilities have started using robots as an audiovisual technology tool.[26]

Although telestroke services can expedite access to treatment, implementation is impeded by barriers such as financial constraints and legal challenges. Operating a telestroke center is a large financial and operational commitment and requires the engagement of a number of stakeholders, both organizational and professional.[27,28] The development of a telestroke program requires capital investment in infrastructure, including computer hardware and related software; two-way real-time audiovisual equipment; high-speed bandwidth that is capable of supporting fast, high-quality video and data transmission; information technology support services; and other related costs. As a result, telestroke programs often seek financial assistance from the government or foundations to help with the monumental upfront capital expenses.[29] In addition, numerous regulatory issues have been identified as obstacles to implementing and sustaining telestroke programs. Physician licensing, credentialing for medical staff privileges at individual facilities, malpractice liability, and reimbursement limitations are all significant hurdles for telestroke.[30]

The purpose of this research study was to assess the main barriers to implementation of telestroke networks in rural hospitals.

Methodology

The methodology utilized in this literature review followed the principles of a systematic review. For the intent of this research query, a comprehensive and exhaustive evaluation was not feasible because of the abundance of studies of heterogeneous quality.

The literature review was conducted in three distinct stages:

1. Determining the search strategy, and identifying and collecting literature;
2. Establishing inclusion criteria, scrutinizing text for relevancy, and analyzing the literature data; and
3. Identifying appropriate categories.

Step 1: Literature Identification and Collection

The electronic databases PubMed, ScienceDirect, EBSCOhost, LexisNexis Academic, ProQuest, Academic Search Premier, and Google Scholar were searched for the following terms: “telestroke” AND “rural hospitals” OR “telestroke barriers” OR “implementation of telestroke” OR “shortage of neurologists in rural areas” OR “implementation” OR “outcomes.” Reputable

websites, including those of the CDC, American Hospital Directory, American Heart Association, American Hospital Association, American Stroke Association, American Telemedicine Association, the US Census Bureau, and other reliable healthcare information sources, were also used. Other sources addressing the benefits and barriers related to implementation and utilization of telestroke services in the treatment of stroke were also used. Citations and abstracts identified in the search were also assessed to identify relevant articles.

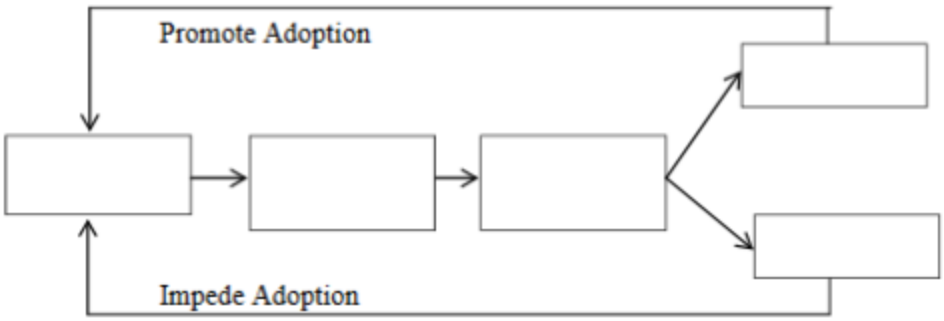
Step 2: Establishing Inclusion Criteria and Literature Analysis

Given the technology- and enterprise-oriented nature of the current study, literature was selected to include the technological and organizational impacts of the use of telestroke and telestroke services. The search was limited to sources published between 2003 and 2016 in an attempt to stay current in the research study. The search was also limited to sources attainable as full texts and written in the English language. The methodology and results of the identified texts were analyzed, and key papers were identified and included within the research query. References were reviewed and determined to have satisfied the inclusion criteria if the material provided accurate information about telestroke services in rural hospitals with a particular focus on the benefits of and barriers to its implementation in this setting. Among all articles identified and reviewed, 73 references met the inclusion criteria, did not meet the exclusion criteria, and were selected for this research study. All of the 75 articles selected and reviewed for this research study supported telestroke application. Of the 75 articles utilized, 44 articles identified both financial and legal barriers, while 28 articles specifically addressed financial constraints of implementing telestroke and 11 articles specifically addressed legal challenges of implementing telestroke, as described in the results section.

Step 3: Literature Categorization

Researchers followed the conceptual framework of Yao, Chu, and Li.[31] The use of this conceptual framework in this study is appropriate because the focus of both studies is to show how new technologies (telestroke in this case) can be applied in healthcare settings to improve the care of patients. This outline was utilized to allow clear identification of the benefits of telestroke services and barriers to the implementation of telestroke services in rural health systems. To research the problems involved in the current processes of telestroke services, it was first necessary to recognize the existing problems and issues that drive and impede adoption of telestroke services in rural hospitals/healthcare systems (see Figure 1). This approach has been successfully replicated in previous studies, increasing its internal validity.[32,33]

Figure 1: Conceptual Research Framework



Source: Adapted from Yao, W., C. H. Chu, and Z. Li. "The Use of RFID in Healthcare: Benefits and Barriers." *Proceedings of the 2010 IEEE International Conference on RFID Technology and Applications (RFID-TA)* (2010): 128–34.

Results

Impact of Telestroke Technology

The impact of the unavailability of neurological consultation and recommendation is accentuated when studies are considered that show that thrombolytic treatment is effective in specialized centers but ceases to be effective if administered in hospitals with little experience, because bleeding risks are associated with tPA and careful screening of patients by a neurologist is necessary to ensure that it can be administered safely and effectively. Should the stroke symptoms be caused by a hemorrhagic or bleeding stroke, tPA could worsen the symptoms because it prevents blood from clotting.[34,35] Usually patients

arriving at a local hospital with a suspected acute stroke are urgently transferred to a larger regional or university-affiliated medical center.[36] This move typically takes 30 to 90 minutes, after which the patient is reevaluated by the neurologist on call. Under these conditions, in most cases, the therapeutic window for thrombolytic therapy has been consumed, considering that it often takes a period of time to get the patient seen and triaged the first time, thus depriving virtually all stroke patients in rural areas of the most effective treatment in the acute phase.[37] In cases where it is possible to safely administer intravenous tPA, time lost in transfer is very important because it is well known to have a negative effect on subsequent functional recovery.[38] The main benefit of telestroke that translates into a financial impact is that the use of telestroke in rural hospital networks increases the number of patients who receive tPA relative to usual care and decrease the need for required transfers. In the traditional care of stroke patients, a high percentage of patients are transferred because stroke specialist's care was simply not available, and often patients do not receive tPA in the recommended time frame. With the use of telestroke, the availability of stroke specialty care allows these transfers to decrease to 52 percent of patients receiving tPA.[39] Initiatives to reduce latency of medical helicopters have managed to moderately increase the number of patients treated with tPA, although at a high cost-benefit ratio, mainly because 80 percent of patients transferred are ultimately not candidates for thrombolytic therapy.[40]

Despite its limitations, a healthcare model based on urgent road transport of stroke patients has a positive impact because a seemingly simple measure such as urgent evaluation by a neurologist clearly improves prognosis because it allows the immediate adoption of the most appropriate therapeutic measures and early identification of complications.[4142] In order to save time, new protocols have been developed whereby suspected stroke patients bypass the nearest hospital, thus shortening the time to treatment and increasing the percentage of candidates for thrombolytic treatment.[43] These strategies were included in the 2012 recommendations from the Brain Attack Coalition; however, there is a widespread view that new information and communication technology has to play a key role in the future.[44,45]

The shortage of neurologists in rural areas is a multifactorial problem. First, the rationale of staffing a full-time neurologist may not be justified in a small rural facility.[46] Costs to recruit and retain such a specialist could be difficult to fund, thereby limiting the physician compensation a rural facility could support. Additionally, smaller facilities may lack the technology to provide the necessary services to a treat a stroke patient.[47] A study by LaMonte et al. evaluated the effectiveness of telestroke services compared with in-person services and found that patients were diagnosed and treated more quickly when receiving telestroke assessments than when relying on in-person assessments (17 minutes versus 33 minutes).[48] Additionally, unnecessary transfers of patients did not only reduce reimbursement for the rural hospital, but also increased the expenses to the rural hospital in the form of the actual cost of the transportation of the patient if not covered by insurance.[49]

Financial Constraints of Implementing Telestroke

In addition to regulatory barriers, there are financial barriers to the implementation of telestroke. Costs are broken down into four categories: equipment, installation and maintenance, training, and clinical resources. While costs vary, the average cost to implement telestroke is $46,000.[50] Financial barriers have remained a major hurdle for any telestroke network due to lack of reimbursement from governmental and private payers and the capital investment needed for telestroke technology. Most telestroke networks in the United States consist of one hub and seven spoke hospitals.[51] Costs vary, ranging between $5,000 and $6,000 a month for a single telestroke robot, in addition to the cost of an installed telestroke base station, which can be more than $10,000. The variation in cost depends on the vendor selected, the implementation of equipment such as the integration of a picture archiving and communication system (PACS), software upgrades, training, the need for clinical resources such as nurses and physicians, and installation and maintenance.[52,53] The hub or spoke hospital can pay the costs related to telestroke.[54] According to Schwamm et al, The Centers for Medicare and Medicaid Services (CMS) requires that two-way, real-time, interactive audio/video telestroke technology be used and specifies that the spoke hospital must be in a county not included in a metropolitan statistical area or be in a rural area with a neurologist shortage.[55] A study of telestroke reimbursement, performed by the American College of Emergency Physicians, has noted that while Medicare has lagged behind other payers, the reimbursement was the same for telestroke, from January 2007 to January 2013, as for face-to-face stroke treatment, with three restrictions: location, qualifying facility, and approved procedure.[56] CMS requires the telemedicine claim to include both the originating site (spoke facility), which is where the patient is located at the time the treatment is administered, and a distant or hub site, which is where the treating neurologist is located. The telehealth facility fee is paid to the spoke facility and should be submitted utilizing HCPCS code Q3014, which is for the telehealth originating facility fee. Until 2014, only originating sites in rural areas with low populations were eligible for telehealth reimbursement; however, the policy has been recently amended to include originating sites in rural areas of urban and high-population counties.[57]

The lack of reimbursement has been documented in a study by Silva and colleagues, who surveyed 38 active telestroke systems operating in 27 US states. It was found that reimbursement was absent for more than 40 percent of sites. Sites rated lack of program funds (27.77 percent) and lack of reimbursement (19.44 percent) as the most important barriers to program growth.[58]

The following codes have been the most common when billing for the initial and follow-up telestroke visits and are presented here along with their national average reimbursement per CMS guidelines: G0425, emergency department (ED) or initial inpatient telehealth consultation for 30 minutes, $100.25; G0426, ED or initial inpatient telehealth consultation for 50 minutes, $136.41; G0427 ED or initial inpatient telehealth consultation for 70 minutes, $203.01; G0406, follow-up inpatient telehealth consultation, limited for 15 minutes, $43.03; G0407, follow-up inpatient telehealth consultation, intermediate for 25 minutes, $78.62; and G0408, follow-up inpatient telehealth consultation, complex for 35 minutes, $113.05 (see Table 1).[59]

Table 1: Telestroke Reimbursement by the Centers for Medicare and Medicaid Services Using CPT Codes and HCPCS Codes

Code	Description	Reimbursement
CPT 99201-99215	All telehealth services for office and other outpatient visits	Based on level of acuity (office versus emergency department)
CPT 99241	Telehealth consultation code	Facility: $79.13
HCPCS G0425, G0426, G0427	Telehealth consultations, emergency department or initial in patient (30, 50, or 70 minutes)	G0425: $ 100.25 G0426: $ 136.41 G0427: $ 203.01
HCPCS G0406, G0407, G0408	Subsequent telehealth care day (15, 25, or 35 minutes)	G0406: $43.03 G0407: $78.62 G0408: $113.05
Source: Centers for Medicare and Medicaid Services. "Physician-Fee-Schedule Look-up Tool." 2016. (accessed September 29, 2016).		

As noted, telestroke networks typically have one hub, which provides the telestroke service, with several spokes receiving the telestroke service.[60] It has been reported that as the spoke-to-hub transfer rate increased from 0 to 100 percent, the result was a reduction in costs for the telestroke network as a whole; however, the hub facility, at the expense of each spoke facility, saw a rise in costs.[61,62] One study evaluating the cost-effectiveness of telestroke networks reported that the use of telestroke could save $2,227 per patient in nursing home costs alone, after taking into account the costs of setting up and maintaining the network and providing tPA.[63]

The capability to remotely assess a patient using an audiovisual program model is an important but costly feature of current telestroke technology, as stroke experts value the accuracy of decision making permitted by visually examining a patient through telestroke technology.[64] In a review of telestroke infrastructure costs for both spoke and hub facilities, which were adjusted to 2011, it was found the initial implementation costs were an average of $184,819 per telestroke network. Included in these costs, for each component identified, were the videoconferencing system, $831; hub maintenance fees, $4,257; network program manager, $54,671; additional personnel at the hub facility, $91,615; telemedicine system at the spoke facility, $28,252; and spoke maintenance fees, $5,193.[65] Equipment used for telestroke is suggested to last for three years and during those three years is to be depreciated using straight-line depreciation. It is also suggested that two nurses and one physician from each spoke hospital be trained by one nurse and one physician from the hub hospital.[66,67] Prices for telestroke services provided on a monthly basis vary depending on the vendor, but an upscale appraisal for a single telestroke system having 24/7/365 coverage, with an integrated security socket platform, was between $5,000 and $6,000 per month in 2011.[68]

Although a telestroke referral network adds a significant financial burden on hospitals through infrastructure costs such as the costs of equipment purchases, staffing, and training, it has been suggested as a probable cost-saving plan from the hospital's point of view, while also improving patient outcomes in terms of patient discharges.[69] A business analysis of telestroke models reported that telemedicine clinics could generate a positive net cash flow each year and break even by the fourth year.[70,71]

Nelson et al. in 2011 estimated the costs associated with telestroke appeared to be cost-effective when compared with the usual care without telestroke.[72] This study also showed that use of telestroke care extended life and increased quality of life for stroke patients at a relatively low cost.[73] Damaerschalk et al. reported that stroke patients living in rural areas who received care via a telestroke network had, on average, nearly $1,500 less in costs over their lifetime, compared with stroke patients who did not receive telestroke care.[74] The savings were primarily attributed to reduced resource utilization, including nursing home care and inpatient rehabilitation. When comparing a rurally located patient receiving routine stroke care at a community hospital, a patient treated in the context of a telestroke network incurred $1,436 lower costs and gained 0.02 quality-adjusted life-years over a lifetime.[75]

In a statement before the Communication, Technology, Innovation and the Internet Subcommittee of the Committee on Commerce, Science, and Transportation of the US Senate, the American Hospital Association (AHA) noted that one of the greatest challenges for providers using telehealth technologies was being reimbursed for telehealth services.[76] Inconsistencies among payers have existed specifically between governmental payers, in that Medicare as a federal payer has lagged behind private payers, and Medicaid as a state payer has varied from state to state. In addition, the AHA reported significant expansion on the private payer side, remarking that some states have passed laws that require private payers to cover telehealth services. In 2015, the American Telemedicine Association produced a telemedicine gap analysis stating that 23 states, such as Colorado, Kentucky, and Virginia, as well as the District of Columbia, have enacted telemedicine parity laws.[77]

Large health systems, including Mayo Clinic, have lobbied Medicare to address the national dilemma of Medicare policies in which telehealth reimbursement has been limited by facility type, specific procedures, and locations defined as a health professional shortage area or a county outside of a metropolitan statistical area.[78] Various Medicare Severity Diagnostic Related Groups (MS-DRGs) are billable for stroke, including acute ischemic stroke with thrombolytics; however, a reimbursement barrier exists if patients receive thrombolytic therapy at the spoke hospital and are then transferred to the hub, because neither the spoke nor the hub is eligible to bill for certain MS-DRGs for both government and private payers.[79,80] The American Hospital Directory has acknowledged that reimbursement has varied geographically for the various MS-DRGs, with hospitals being reimbursed slightly different amounts based on hospital-specific factors, such as wage index, and inpatient MS-DRG reimbursement for stroke in 2011 ranging from $9,123 to $42,511.[81]

Similar to Medicare, Medicaid reimburses for telehealth, but reimbursement is limited to areas in the CMS definition of nonmetropolitan statistical areas and health professional shortage areas. Medicaid policies differ by state, but unlike Medicare, most state Medicaid plans do not have geographic restrictions on telehealth such as the limitation to nonmetropolitan statistical areas that is required by Medicare.[82] According to the Department of Health and Human Services, coverage has been also limited to medically necessary real-time consultation and must be billed for a specific service with a documented written report provided to the referring physician. If implemented appropriately, telestroke can be cost-efficient and payers should reimburse for telestroke consultation, whereas currently there are inconsistencies in reimbursement and therefore a barrier to implementation of the technology.[83]

Legal Challenges of Implementing Telestroke

Damaerschalk et al. in 2011 reported that in addition to legislation on reimbursement, state regulatory issues such as licensing of out-of-state physicians, malpractice liability, and credentialing at multiple facilities has resulted in legal barriers that hinder implementation of telestroke.[84] Furthermore, hub-and-spoke systems involve patients and providers at different facilities that could cross state lines, requiring separate state licensing. Because telestroke networks may cover multiple states and healthcare is licensed at the state level, physicians are required to be licensed in the state(s) where they practice; however, with telestroke they can consult on patients located in another state where the provider might not have a license and where the physician is not physically located, creating a legal barrier (especially for the hub institution).[85] Although there has been a lack of state statutes governing licensure of providers related to telehealth, states such as Tennessee have moved toward interstate licensing as a way to address these legal barriers.[86] In addition, many medical practice acts require legislative action to be changed and have a long window for implementation.

Similar to the licensing concerns, there have been concerns with medical liability and malpractice related to care in which telemedicine is provided to a patient by a provider who is in a different state. Multistate issues relate to standard of care, liability, and whether the provider's insurance covers cross-border care.[87] Specific to telestroke, there has been no indication that providing telestroke consultations has increased the malpractice risk when compared with providing on-site consultation.

According to multistate legal claims, providers have the potential to be open to suits in two locations: the state where the hub is located and the state where the spoke is located.[88]

The Joint Commission has indicated that credentialing is how hospitals review a provider's education, background, training, and experience to determine if the provider is competent to practice. The barrier exists when new hospitals are added to the spoke, requiring the credentialing of all the hub physicians, which is costly and time consuming.[89] The hub hospital must ensure that all of its specialists are properly credentialed at each spoke, which is compounded when a new specialist is added at the hub.[90]

Discussion

The purpose of this research study was to explore and identify the existing barriers to telestroke network implementation. The results of this review suggest that the financial and legal barriers have had a negative effect on the implementation of telestroke due to diverse sources of costs and the telestroke providers being vulnerable to legal action in both the state in which the patient was physically located and the state in which the telecommunication was provided.[91] This literature review supports that financial constraints and legal barriers are the top two barriers in the deployment of any telestroke program.

One of the major obstacles to telestroke are the costs. The start-up and maintenance expenses, followed by the lack of reimbursement for services provided, have contributed to a reluctance to implement telestroke programs. Developing a viable business model that will provide long-term sustainability of the implemented telestroke program has been a challenge. In some instances, the hub completely funds the program and provides the spoke facility with needed equipment and consultations at no charge.[92] The Office for the Advancement of Telehealth noted in 2013 that federal or local grants were sometimes utilized to help cover costs, but often programs used capital budget funds, hoping that the spoke facilities would subsequently purchase the telestroke services to offset costs.[93]

Technical barriers also exist and require on-site know-how and financial investment to overcome. Spoke facilities use a variety of technologies to support a telestroke network. Spoke sites must implement and maintain infrastructure that includes high-definition, two-way interactive videoconferencing, which can be expensive. Another challenge also reported by Silva et al. was that in 56 percent of hubs, the systems used could interact only with other systems of the same model by the same manufacturer.[94] In addition, rural facilities acting as spoke sites must build interfaces for data storage and retrieval with an electronic health record system that is interoperable with the hub's electronic health record system, which might add more cost.

The other aspect of the financial constraints that hospitals often face is the limited ability to bill third-party and government payers for telestroke consultation.[95] Both government and private third-party health insurance payments for physician services rendered have been slow to adopt telestroke as a standard of care. A 2012 study survey showed that about 40 percent of telestroke sites stated that lack of reimbursement and funds were significant issues related to telestroke services.[96] Reimbursement has been highly inconsistent depending on the geographical region or system in which telestroke services have been provided. Medicare has reimbursed for telestroke consultations and services in some states but not in all 50 states.[97] Without adequate reimbursement and revenue flow, providers have been reluctant to invest in this type of technology. The national Medicaid program and Children's Health Insurance Program have noted that live video is the most frequently covered telehealth service, whereas remote patient monitoring services and store-and-forward technologies are reimbursed by only a handful of state Medicaid programs. According to the Center for Connected Health Policy in 2014, some states have embraced the Medicare policy, which has limited coverage of telestroke services to only individuals in rural or underserved areas.[98] Medicare reimbursement lags behind other third-party payers because of strict regulations. This barrier reduces hospitals' ability to use telestroke to increase access to care.

Regulatory barriers have been challenges for telestroke programs to overcome. Hub institutions may use multiple neurologists to cover the telestroke network, and therefore state licensure laws for providers have been a source of complication for medical facilities desiring to practice telestroke in states other than the ones in which they are located, because of the lack of portability of health professional licenses.[99] In the survey of implemented telestroke programs by Silva et al., 27 percent of programs stated that licensure of physicians was a significant barrier to the implementation and use of telestroke.[100] In 2011, CMS streamlined the licensure and process for obtaining privileges; however, there is still no national-level medical licensing and credentialing for medical providers, so when a new spoke is added to the telestroke network, providers are forced to repeat the licensing process.[101] If the spoke is located in another state, the telestroke provider is required to be licensed in that

specific state as well. The law concerning licensure of telestroke providers has been expanding; however, it remains inconsistent from state to state, and even within states there have been gaps in the law, which creates a level of uncertainty. Only few states, such as Tennessee, have moved toward interstate licensing as a solution to these legal hurdles. Finally, from a regulatory perspective, the use of telestroke has been tied with telehealth regulations and may not be well defined in all areas in terms of medical board rules, national standards, or clarifications of malpractice surrounding the use of this technology.

Telestroke has permitted hospitals without access to neurologists to provide thrombolytic therapy to stroke patients. Patients displaying symptoms of stroke can be observed by a neurologist, who can also see the patient's brain scans to assess for damage caused by a hemorrhage or a blocked artery. A significant part of the population lives in areas that are geographically remote from large hospitals, and the permanent presence of an expert neurologist at each of the district hospitals is unfeasible. Several strategies have been suggested to address these problems, and one of them is telestroke, which has reduced transfers for patients receiving tPA. This translates to significant financial impact for healthcare settings, payers, and ultimately patients.

Despite the potential of telestroke, its benefits, and the technical advancement of its application, certain limitations have to be recognized. The use of telestroke is still limited and remains highly fragmented. While healthcare facilities have expressed their commitment to widen the deployment of telestroke, most programs have been small-scale ventures that have not been incorporated into healthcare systems. It has been observed that telemedicine networks, whether urban or rural, need a significant capital investment for equipment and technical support, which can be an estimated as ranging from $46,000 up to a high cost of $200,000 or more per spoke.[102] The components of the total cost of development and maintenance of telestroke network include the equipment, information technology support, essential administrative and clinical personnel, and personnel training and education.[103] The success of telestroke programs depends on having the financial means to sustain the program.

This study was limited because of the restrictions in the search strategy used, such as the number of databases searched, and researchers' bias and publication bias may have affected the availability and quality of the research identified during the search. Furthermore, although much general research about telestroke exists and a significant number of studies have examined barriers to the implementation of telestroke, the vast majority of those studies have examined the universal premise of telestroke and quality outcomes, whereas the research about implementation costs/reimbursements and state-to-state legal barriers is sparse.

Reimbursement for telestroke services should not be based on a facility's rural or urban location but should be applicable anywhere the services are available. Current Procedural Terminology (CPT) codes need to be updated to include services such as telestroke and should include specific codes for the patient monitoring and management that is needed in a remote facility.

Further research using a systematic review with a meta-analysis should be performed to provide a more precise measurement of the effects (e.g., costs, savings, and reimbursement) of the implementation and maintenance of telestroke programs in healthcare facilities using technology.

Consistency among physician licensing across state borders is essential. Laws need to be implemented to enforce interstate licensing as well as to incorporate reimbursement provisions that require insurance companies to adequately reimburse providers for telestroke services.

Conclusion

Telestroke has allowed hospitals without neurologists on staff to provide thrombolytic therapy to stroke patients. Deploying this technology to treat patients in a critical time period has demonstrated improved outcomes in patients who do not have access to a large hospital with a neurologist on staff. However, the absence of program funds, lack of reimbursement or inappropriate reimbursement by payers, and inability to obtain providers' licensure at the state level have been the most important barriers to the deployment of most telestroke programs.

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Notes

[1] Mozaffarian, D., E. Benjamin, A. S. Go, et al. "Heart Disease and Stroke Statistics—2016 Update: A Report from the American Heart Association." *Circulation* 133 (2016): e38–e360.

[2] Roger, V., A. Go, D. Lloyd-Jones, E. Benjamin, J. Berry, W. Borden, et al. "Heart Disease and Stroke Statistics—2012 Update: A Report from the American Heart Association." *Circulation* 125, no. 1 (2012): e2–e220.

[3] Go, A. S., D. Mozaffarian, V. L. Roger, E. Benjamin, J. D. Berry, W. B. Borden, et al. "Heart Disease and Stroke Statistics —2013 Update: A Report from the American Heart Association." *Circulation* 127, no. 1 (2013): e6–e245.

[4] American Heart Association. "Costs to Treat Stroke in America May Double by 2030." American Heart Association Policy Statement, May 22, 2013. (accessed December 29, 2016).

[5] Wechsler, L. R., J. W. Tsao, S. R. Levine, R. J. Swain-Eng, R. J. Adams, B. M. Demaerschalk, et al. "Teleneurology Applications: Report of the Telemedicine Work Group of the American Academy of Neurology."*Neurology* 80, no. 7 (2013): 670–76.

[6] Goldstein, L., Matchar, D., J. Hoff-Lindquist, G. Samsa, and R. Horner. "VA Stroke Study: Neurologist Care Is Associated with Increased Testing But Improved Outcomes." *Neurology* 61, no. 6 (2003): 792–96.

[7] Smith, M., J. Lieu, J. Frytak, and M. Finch. "30-Day Survival and Re-hospitalization for Stroke Patients According to Physician Specialty." *Cerebrovascular Diseases* 22, no. 1 (2006): 21–26.

[8] Ovbiagele, B., L. B. Goldstein, et al. "Forecasting the Future of Stroke in the United States: A Policy Statement from the American Heart Association and American Stroke Association." *Stroke* 44, no. 8 (2013): 2361–75.

[9] Shultis, W., R. Graff, C. Chamie, C. Hart, P. Louangketh, M. McNamara, et al. "Striking Rural-Urban Disparities Observed in Acute Stroke Care Capacity and Services in the Pacific Northwest: Implications and Recommendations." *Stroke* 41, no. 10 (2010): 2278–82.

[10] Cutting, S., J. Conners, V. Lee, S. Song, and S. Prabhakaran. "Telestroke in an Urban Setting." *Telemedicine Journal and E-health* 20, no. 9 (2014): 855–57.

[11] US Census Bureau. "2010 Census Urban and Rural Classification and Urban Area Criteria." (accessed December 31, 2016).

[12] Damaerschalk, B. M., M. L. Miley, T. J. Kiernan, B. J. Borrow, D. A. Corday, K. E. Wellik, et al. "Stroke Telemedicine." *Mayo Clinic Proceedings* 84, no. 1 (2009): 53–64.

[13] Nago, K., A. Koschel, H. Haines, L. Bolitho, and B. Yan. "Rural Victorian Telestroke Project." *Internal Medicine Journal* 42, no. 10 (2011): 1088–95.

[14] US Census Bureau. "Proposed Urban Area Criteria for the 2010 Census." (accessed December 31, 2016).

[15] Go, A. S., D. Mozaffarian, V. L. Roger, E. Benjamin, J. D. Berry, W. B. Borden, et al. "Heart Disease and Stroke Statistics—2013 Update: A Report from the American Heart Association."

[16] Jauch, E. C., J. L. Saver, H. P. Adams Jr., A. Bruno, J. J. Connors, B. M. Demaerschalk, et al. "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* 44, no. 3 (2013): 870–947.

[17] Adeoye, O., R. Hornung, P. Khatri, and D. Kleindorfer. "Recombinant Tissue-Type Plasminogen Activator Use for Ischemic Stroke in the United States: A Doubling of Treatment Rates over the Course of 5 Years." *Stroke* 42, no. 7 (2011): 1952–55.

[18] Damaerschalk, B. M., M. L. Miley, T. J. Kiernan, B. J. Borrow, D. A. Corday, K. E. Wellik, et al. "Stroke Telemedicine."

[19] Nago, K., A. Koschel, H. Haines, L. Bolitho, and B. Yan. "Rural Victorian Telestroke Project."

[20] Schwamm, L., H. Audebert, P. Amarenco, N. Chumbler, M. Frankel, M. George, et al. "Recommendations for the Implementation of Telemedicine within Stroke Systems of Care: A Policy Statement from the American Heart Association." *Stroke* 40, no. 7 (2009): 2635–60.

[21] Wechsler, L. R., J. W. Tsao, S. R. Levine, R. J. Swain-Eng, R. J. Adams, B. M. Demaerschalk, et al. "Teleneurology Applications: Report of the Telemedicine Work Group of the American Academy of Neurology."

[22] Adeoye, O., R. Hornung, P. Khatri, and D. Kleindorfer. "Recombinant Tissue-Type Plasminogen Activator Use for Ischemic Stroke in the United States: A Doubling of Treatment Rates over the Course of 5 Years."

[23] Timpano, F., L. Bonanno, A. Bramanti, F. Pirrotta, L. Spadaro, P. Bramanti, and P. Lanzafame. "Tele-Health and Neurology: What Is Possible?" *Neurological Sciences*34, no. 12 (2013): 2263–70.

[24] Schwamm, L., H. Audebert, P. Amarenco, N. Chumbler, M. Frankel, M. George, et al. "Recommendations for the Implementation of Telemedicine within Stroke Systems of Care: A Policy Statement from the American Heart Association."

[25] Kazley, A., R. Wilkerson, E. Jauch, and R. Adams. "Access to Expert Stroke Care with Telemedicine." *Frontiers in Neurology* 12, no. 3 (2012): 44.

[26] Wu, T., C. Nguyen, C. Ankrom, J. Yang, D. Persse, F. Vahidy, et al. Prehospital Utility of Rapid Stroke Evaluation Using In-Ambulance Telemedicine." *Stroke* 45, no. 6 (2014): 2342–47.

[27] Cho, S., E. V. Khasanshina, L. Mathiassen, D. C. Hess, S. Wang, and M. E. Stachura. "An Analysis of Business Issues in a Telestroke Project." *Journal of Telemedicine and Telecare* 13, no. 10 (2007): 257–62.

[28] Cho, S., and L. Mathiassen. "The Role of Industry Infrastructure in Telehealth Innovations: A Multi-level Analysis of a Telestroke Program." *European Journal of Information Systems* 16, no. 10 (2007): 738–50.

[29] Chelius, L., J. M. Hook, and M. P. Rodriguez. *Financial Analysis of Open Door Community Health Centers' Telemedicine Experience*. 2010. (accessed May 21, 2017).

[30] Rogove, H., D. McArthur, B. Demaerschalk, and P. Vespa. "Barriers to Telemedicine: Survey of Current Users in Acute Care Units." *Telemedicine Journal and E-health* 2012;18(1):48–53.

[31] Yao, W., C. H. Chu, and Z. Li. "The Use of RFID in Healthcare: Benefits and Barriers." *Proceedings of the 2010 IEEE International Conference on RFID Technology and Applications (RFID-TA)* (2010): 128–34.

[32] Deslich, S., and A. Coustasse. "Expanding Technology in the ICU." *Telemedicine Journal and E-health* 20, no. 5 (2014): 485–92.

[33] Coustasse, A., S. Tomblin, and C. Slack. "Impact of Radio-Frequency Identification (RFID) Technologies on the Hospital Supply Chain: A Literature Review." *Perspectives in Health Information Management* (Fall 2013).

[34] Sisters of St. Mary (SSM) Health System. "SSM Neuroscience Leading the Way in Acute Stroke Treatment." (accessed October 8, 2016).

[35] George, B. P., N. J. Scoglio, J. I. Reminick, B. Rajan, C. A. Beck, A. Seidmann, K. M. Biglan, and E. R. Dorsey. "Telemedicine in Leading US Neurology Departments." *Neurohospitalist* 2, no. 4 (2012): 123–28.

[36] French, D., T. McGeorge, and E. Jauch. "Timely Prehospital Management of Stroke Victims Crucial for Patient Outcome." *Journal of Emergency Medical Services* (2015).

[37] Hyland, A. "Patients in Rural Areas of Kansas Are Receiving Better Access to Stroke Care." *University of Kansas Medical Center News*, July 31, 2013. (accessed March 15, 2016).

[38] Hoody, D., S. Hanson, D. Carter, and T. Zink. "Implementing a System of Stroke Care in a Rural Hospital." *Minnesota Medicine* 91, no. 10 (2008): 37–40. Available at http://www.minnesotamedicine.com/Past-Issues/Past-Issues-2008/October-2008 (accessed March 15, 2016).

[39] Nelson, R. E., G. M. Saltzman, E. J. Skalabrin, B. M. Demaerschalk, and J. J. Majersik. "The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke." *Neurology* 77, no. 17 (2011): 1590–98.

[40] Müller-Barna, P., G. J. Hubert, S. Boy, U. Bogdahn, S. Wiedmann, P. U. Heuschmann, and H. J. Audebert. "TeleStroke Units Serving as a Model of Care in Rural Areas: 10-Year Experience of the TeleMedical Project for Integrative Stroke Care." *Stroke* 45, no. 9 (2014): 2739–44.

[41] Agarwal, S., and E. A. Warburton. "Teleneurology: Is It Really at a Distance?" *Journal of Neurology* 258, no. 6 (2011): 971–81.

[42] Cho, S., L. Mathiassen, and M. Gallivan. "Crossing the Chasm: From Adoption to Diffusion of a Telehealth Innovation." In G. León, A. M. Bernardos, J. R. Casar, et al. (Editors), *Open IT-Based Innovation: Moving towards Cooperative IT Transfer and Knowledge Diffusion.* Boston, MA: Springer, 2008, 361–78.

[43] Higashida, R., M. J. Alberts, D. N. Alexander, T. J. Crocco, B. M. Damaerschalk, C. P. Derdeyn, et al. "AHA/ASA Policy Statement: Interactions within Stroke Systems of Care." *Stroke* 44, no. 8 (2013): 2961–84.

[44] Schneck, M. J., and S. Morales-Vidal. "Telestroke: Time Is Brain and the Time Is Now."*Journal of Stroke and Cerebrovascular Diseases* 21, no. 7 (2012): 519–20.

[45] Storm, A., F. Günzel, and S. Theiss. "A Model for Telestroke Network Evaluation." In B. Hu, K. Morasch, S. Pickl, and M. Siegle (Editors), *Operations Research Proceedings 2010*. Berlin, Germany: Springer, 2011, 551–56.

[46] Ollove, M. "To Survive, Rural Hospitals Join Forces." The PEW Charitable Trusts. August 17, 2015. (accessed October 3, 2016).

[47] American Academy of Neurology. *Position Statement on Stroke Care*. 2010. (accessed October 6, 2016).

[48] LaMonte, M., M. Bahouth, Y. Xiao, P. Hu, C. Baquet, and C. Mackenzie. "Outcomes from a Comprehensive Stroke Telemedicine Program." *Telemedicine Journal and E-health* 14, no. 4 (2008): 339–44.

[49] Demaerschalk, B. M. "Telemedicine or Telephone Consultation in Patients with Acute Stroke." *Current Neurology and Neuroscience Reports* 11, no. 1 (2011): 42–51.

[50] Miley, M., B. Demaerschalk, N. Olmstead, T. Kiernan, D. Corday, V. Chikani, and B. J. Bobrow. "The State of Emergency Stroke Resources and Care in Rural Arizona: A Platform for Telemedicine." *Telemedicine Journal and E-health* 15, no. 7 (2009): 691–99.

[51] Switzer, J. A., B. M. Demaerschalk, J. Xie, F. Liangyi, K. F. Villa, and E. Q. Wu. "Cost-Effectiveness of Hub-and-Spoke Telestroke Networks for the Management of Acute Ischemic Stroke from the Hospitals' Perspectives." *Circulation: Cardiovascular Quality and Outcomes* 6, no. 1 (2013): 18–26.

[52] Miley, M., B. Demaerschalk, N. Olmstead, T. Kiernan, D. Corday, V. Chikani, and B. J. Bobrow. "The State of Emergency Stroke Resources and Care in Rural Arizona: A Platform for Telemedicine."

[53] Freeman, W. D., K. M. Barrett, K. A. Vatz, and B. M. Demaerschalk. “Future Neurohospitalist: Teleneurohospitalist.” *The Neurohospitalist* 2, no. 4 (2012): 132–43.

[54] Hess, D. C., and H. J. Audebert. “The History and Future of Telestroke.” *Nature Reviews Neurology* 9, no. 6 (2013): 340–50.

[55] Schwamm, L., H. Audebert, P. Amarenco, N. Chumbler, M. Frankel, M. George, et al. “Recommendations for the Implementation of Telemedicine within Stroke Systems of Care: A Policy Statement from the American Heart Association.”

[56] American College of Emergency Physicians. “Telemedicine for Medicare Patients.” 2016. (accessed September 29, 2016).

[57] Centers for Medicare and Medicaid Services. “Physician-Fee-Schedule Look-up Tool.” 2016. (accessed September 29, 2016).

[58] Silva, G. S., S. Farrell, E. Shandra, A. Viswanathan, and L. H. Schwamm. “The Status of Telestroke in the United States.” *Stroke* 43 (2012): 2078–85.

[59] Centers for Medicare and Medicaid Services. “Physician-Fee-Schedule Look-up Tool.”

[60] Merchant, K. A. S., M. M. Ward, and K. J. Mueller. *Hospital Views of Factors Affecting Telemedicine Use*. RUPRI Center for Rural Health Policy Analysis: Rural Policy Brief. 2015.

[61] Switzer, J. A., B. M. Demaerschalk, J. Xie, F. Liangyi, K. F. Villa, and E. Q. Wu. “Cost-Effectiveness of Hub-and-Spoke Telestroke Networks for the Management of Acute Ischemic Stroke from the Hospitals’ Perspectives.”

[62] Damaerschalk, B. M., H. M. Hwang, and G. Leung. “Cost Analysis Review of Stroke Centers, Telestroke, and rt-PA.” *American Journal of Managed Care* 16, no. 7 (2010): 537–44.

[63] Damaerschalk, B. M., J. A. Switzer, J. Xie, L. Fan, K. F. Villa, and E. Q. Wu. “Cost Utility of Hub-and-Spoke Telestroke Networks from Societal Perspective.” *American Journal of Managed Care* 19, no. 12 (2013): 976–85.

[64] Damaerschalk, B. M., H. M. Hwang, and G. Leung. “Cost Analysis Review of Stroke Centers, Telestroke, and rt-PA.”

[65] Nelson, R. E., G. M. Saltzman, E. J. Skalabrin, B. M. Demaerschalk, and J. J. Majersik. “The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke.” *Neurology* 47, no. 1 (2011): 1251–58.

[66] Earnshaw, S. R., D. Jackson, R. Farkouh, and L. Schwamm. “Cost-effectiveness of Patient Selection Using Penumbral-based MRI for Intravenous Thrombolysis.” *Stroke* 40, no. 5 (2009): 1710–20.

[67] Freeman, W. D., K. M. Barrett, K. A. Vatz, and B. M. Demaerschalk. “Future Neurohospitalists: Teleneurohospitalist.”

[68] French, B., E. Day, C. Watkins, A. McLoughlin, J. Fitzgerald, M. Leathley, et al. “The Challenges of Implementing a Telestroke Network: A Systematic Review and Case Study.” *BMC Medical Informatics and Decision Making* 13 (2013): 125.

[69] McCue, M. J., and S. E. Palsbo. “Making the Business Case for Telemedicine: An Interactive Spreadsheet.” *Telemedicine Journal and E-health* 12, no. 2 (2006): 99–106.

[70] Damaerschalk, B. M., H. M. Hwang, and G. Leung. “Cost Analysis Review of Stroke Centers, Telestroke, and rt-PA.”

[71] Damaerschalk, B. M., J. A. Switzer, J. Xie, L. Fan, K. F. Villa, and E. Q. Wu. “Cost Utility of Hub-and-Spoke Telestroke Networks from Societal Perspective.”

[72] Nelson, R. E., G. M. Saltzman, E. J. Skalabrin, B. M. Demaerschalk, and J. J. Majersik. “The Cost-effectiveness of Telestroke in the Treatment of Acute Ischemic Stroke.”

[73] Ibid.

[74] Damaerschalk, B. M., J. A. Switzer, J. Xie, L. Fan, K. F. Villa, and E. Q. Wu. "Cost Utility of Hub-and-Spoke Telestroke Networks from Societal Perspective."

[75] Ibid.

[76] American Hospital Association. *Statement of American Hospital Association before the Communications, Technology, Innovation and the Internet Subcommittee of the Committee on Commerce, Science, and Transportation of the U.S. Senate*. 2015. (accessed April 15, 2016).

[77] Thomas, L., and G. Capistrant. *State Telemedicine Gaps Analysis Coverage & Reimbursement*. American Telemedicine Association. 2015. (accessed March 15, 2016).

[78] Spencer, J. "Mayo Makes Case for Medicare Reimbursement for Telemedicine." *The Star Tribune*, July 4, 2015. (accessed April 15, 2016).

[79] Damaerschalk, B. M., and D. L. Durocher. "How Diagnosis-related Group 559 Will Change the US Medicare Cost Reimbursement Ratio for Stroke Centers." *Stroke* 38, no. 10 (2007): 1309–12.

[80] Center for Connected Health Policy. *State Telehealth Laws and Medicaid Program Policies*. 2015. (accessed April 15, 2016).

[81] American Hospital Directory. Subscription Dataset. 2011. Available at http://www.ahd.com (accessed April 16, 2016).

[82] Center for Connected Health Policy. *State Telehealth Laws and Medicaid Program Policies*. 2015.

[83] Aita, M. C., K. Nguyen, R. Bacon, and K. M. Capuzzi. "Obstacles and Solutions in the Implementation of Telestroke: Billing, Licensing, and Legislation." *Stroke* 44, no. 9 (2013): 3602–6.

[84] Demaerschalk, B. M., B. J. Bobrow, R. Raman, et al. "Stroke Team Remote Evaluation Using a Digital Observation Camera in Arizona: The Initial Mayo Clinic Experience Trial." *Stroke* 41 (2010): 1251–58.

[85] Kulcsar, M., S. Gilchrist, and M. G. George. "Improving Stroke Outcomes in Rural Areas through Telestroke Programs: An Examination of Barriers, Facilitators, and State Policies." *Telemedicine Journal and E-health* 20, no. 1 (2014): 3–10.

[86] Aita, M. C., K. Nguyen, R. Bacon, and K. M. Capuzzi. "Obstacles and Solutions in the Implementation of Telestroke: Billing, Licensing, and Legislation."

[87] American Hospital Association. *Statement of American Hospital Association before the Communications, Technology, Innovation and the Internet Subcommittee of the Committee on Commerce, Science, and Transportation of the U.S. Senate*.

[88] Freeman, W. D., K. M. Barrett, K. A. Vatz, and B. M. Demaerschalk. "Future Neurohospitalist: Teleneurohospitalist."

[89] Timpano, F., L. Bonanno, A. Bramanti, F. Pirrotta, L. Spadaro, P. Bramanti, and P. Lanzafame. "Tele-Health and Neurology: What Is Possible?"

[90] Schwamm, L., H. Audebert, P. Amarenco, N. Chumbler, M. Frankel, M. George, et al. "Recommendations for the Implementation of Telemedicine within Stroke Systems of Care: A Policy Statement from the American Heart Association."

[91] American Hospital Association. *Statement of American Hospital Association before the Communications, Technology, Innovation and the Internet Subcommittee of the Committee on Commerce, Science, and Transportation of the U.S. Senate*.

[92] de Bustos, E. M., T. Moulin, and H. J. Audebort. "Barriers, Legal Issues, Limitations and Ongoing Questions in Telemedicine Applied to Stroke." *Cerebrovascular Diseases* 27, no. 4 (2009): 36–39.

[93] US Department of Health and Human Services. HRSA. "Telehealth Programs". 2015.

[94] Silva, G. S., S. Farrell, E. Shandra, A. Viswanathan, and L. H. Schwamm. "The Status of Telestroke in the United States."

[95] Stradling, D. A. "Telestroke: State of the Science and Steps for Implementation." *Critical Care Nursing Clinics of North America* 21, no. 4 (2009): 541–48.

[96] Silva, GS., Farell S. Shandra, W., Viswanathan, A., and L. Schwamm. The status of telestroke in the United States: A survey of currently Active Stroke Telemedicine Programs. Stroke, 43:2078-2085.

[97] National Conference of State Legislatures. *Covering and Reimbursing Telehealth Services*. 2016. (accessed March 15, 2016).

[98] Center for Connected Health Policy. *State Telehealth Laws and Medicaid Program Policies*.

[99] Office of the Advancement of Telehealth. *Grantee Profiles*. 2013. (accessed March 15, 2016).

[100] Silva, G. S., S. Farrell, E. Shandra, A. Viswanathan, and L. H. Schwamm. "The Status of Telestroke in the United States."

[101] Johansson, T., and C. Wild. "Telemedicine in Acute Stroke Management: Systematic Review." *International Journal of Technology Assessment in Health Care* 26, no. 2 (2010): 149–55.

[102] Fanale, C. V., and B. M. Demaerschalk. "Telestroke Network Business Model Strategies." *Journal of Stroke and Cerebrovascular Diseases* 21, no. 7 (2012): 530–34.

[103] American Heart Association. "Costs to Treat Stroke in America May Double by 2030." American Heart Association Policy Statement. May 22, 2013. (accessed December 29, 2016).

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