Statewide Hospital-Based Stroke Services in North Carolina
Changes Over 10 Years

Larry B. Goldstein, MD, FAAN, FAHA

Background and Purpose—Statewide assessments of stroke prevention and treatment services were performed in North Carolina in 1998 and 2003. The 2003 survey found certain technologies, but not stroke-related programs, were more widely available. The survey was repeated in 2008 to determine whether there was an interval change in accessibility.

Methods—A 2-page questionnaire was sent to each North Carolina hospital. Results were compared with the 1998 and 2003 surveys.

Results—Complete responses were obtained from each of the state’s emergent stroke care hospitals. The proportions providing CT angiography and diffusion-weighted MRI increased between each period (each \( P<0.05 \)); the use of care maps and intravenous tissue plasminogen activator protocols increased between 2003 and 2008 but not between 1998 and 2003. There were no changes in availability of MRI, MR angiography, catheter angiography, carotid ultrasound, transcranial Doppler, transthoracic echocardiography, or in the proportions of hospitals having a stroke unit, having a neurologist or neurointerventionalist readily available, or providing stroke-related public education (each \( P>0.05 \)). The proportions of hospitals having a group of “basic” stroke capabilities did not change (18%, 21%, and 20%, respectively, \( P>0.05 \)). In 2008, 41% of North Carolina’s population resided in a county with at least 1 Primary Stroke Center and an additional 40% in a county using telemedicine or having a transfer plan for patients with acute stroke.

Conclusions—The availability of certain diagnostic tests, but not specialty staff or stroke units, increased in North Carolina hospitals between 1998 and 2008. Although there was no change in stroke-related hospital-based organizational features between 1998 and 2003, there were improvements between 2003 and 2008, possibly reflecting programs aimed at developing stroke care systems. (Stroke. 2010;41:00-00.)

Key Words: cerebrovascular disorders ● emergency medical services ● prevention

A 2001 report of the Institutes of Medicine of the National Academy of Science noted the fragmentation of health-related services in the United States and recommended the development of coordinated systems of health care.1 Experts viewed such systems as particularly important for the treatment of patients with acute stroke.2 Because the likelihood of benefit from acute reperfusion therapy with intravenous tissue plasminogen activator (tPA) is time-dependent, there has been particular emphasis on identifying hospitals organized to rapidly deliver this treatment. The Brain Attack Coalition (BAC) published recommendations for Primary Stroke Centers (PSCs),3 and the Joint Commission began a program to certify hospitals meeting a set of standards based on the BAC’s criteria. Some states also began their own certification programs independent of the Joint Commission.

Understanding hospitals’ stroke-related resources, organizational capabilities, and programs is also essential for developing regional and statewide stroke care systems. A comprehensive statewide survey of hospital-based stroke prevention and treatment capabilities was conducted in North Carolina in 1998, 1½ years after approval of intravenous (IV) tPA by the Food and Drug Administration but before the BAC’s PSC recommendations or organized statewide programs to develop stroke care systems.4-5 The survey found that IV tPA stroke protocols had been adopted in 43% of the North Carolina hospitals and was available to 74% of the state’s population based on their county of residence. The survey also revealed that services that may improve outcomes and reduce costs (eg, stroke teams, stroke units, care maps) were not widely used. A group of “basic” stroke prevention and treatment services was available to 52% of the state’s population based on county of residence with entire regions of the state having limited or no readily available acute stroke-capable hospitals. When the survey was repeated 5 years later, certain technologies had become more widely available, but hospital-based stroke-related programs had not appreciably increased with a persistence or worsening of the previously identified geographic disparities.6

The Joint Commission began to certify PSCs in 2003, the American Stroke Association’s recommendations for stroke care systems were published in 2005, and the North Carolina legislature established a Stroke Advisory Council charged
with promoting the development of coordinated stroke care in the state in 2006. In addition, the American Heart Association Get-With-The-Guidelines stroke patient management tool and data registry as well as the Centers for Disease Control and Prevention’s North Carolina Cooperative Stroke Registry became active during this period. A comprehensive survey of the state’s hospital-based stroke capabilities was repeated in 2008 to provide data in support of the North Carolina Stroke Advisory Council’s efforts. Because the survey had been carried out twice previously, it also affords the opportunity to assess the impact of these various programs on the availability and organization of stroke services.

Methods

The methodology used in the 19981 and 20032 North Carolina surveys was modified for the present study. As previously, a list of all North Carolina hospitals was obtained from the state’s Division of Facilities (n = 135). In April 2008, a 2-page survey (Supplemental Figure I, available online at http://stroke.ahajournals.org) was mailed to the medical directors of each hospital with a letter from the North Carolina Department of Health and Human Services and the study principal investigator explaining its purpose. Although hospital-level data could be used for stroke system planning by the state, a condition of the survey was that only county-level data would be publically reported. The survey was then sent by fax to those not responding followed by personal contact by American Heart Association personnel and telephone follow-up as necessary. The final survey was completed in May 2009.

The 1998, 2003, and the current surveys collected several categories of data related to the availability of stroke prevention and treatment services. These included diagnostic studies and a series of programs and services (emergency department, Stroke Acute Care Unit or its equivalent, acute stroke team, stroke IV tPA protocol, stroke care map, prewritten stroke orders, community stroke awareness programs, performance of carotid endarterectomy, and whether the hospital had a neurologist on staff). In 1998, “basic” centers were defined as those having an emergency department, IV tPA treatment protocol, brain CT, transthoracic echocardiography, carotid ultrasonography, catheter angiography, and performing carotid endarterectomy. To obtain additional information relevant to institutional infrastructure required to fulfill BAC PSC recommendations,3 the 2003 and 2008 surveys also queried the immediate availability (ie, 24 hours/day, 7 days/week) of blood studies (platelet count, prothrombin time/activated thromboplastin time, blood glucose), brain CT scan, and if they had a stroke quality improvement program. For the 2008 survey, this was qualified to specify that the program be based on national quality improvement markers (eg, Joint Commission, North Carolina Collaborative Stroke Registry, or Get-With-The-Guidelines Stroke). For the 2003 and 2008 analyses, these capabilities, in addition to having an emergency department, a stroke care map, an IV tPA treatment protocol, and prewritten stroke care orders, were deemed as the essential parts of the BAC recommendations (ie, “BAC-type” capabilities). Hospitals were also asked whether they had a neurologist or an endothelial neurointerventionist on staff. Hospitals certified by the Joint Commission as PSCs were also recorded in the current report (the program was not active at the times of the 1998 and 2003 surveys). In addition, non-Joint Commission hospitals that had a policy or plan to transfer patients with acute stroke outside their capabilities to another facility or that routinely use remote (telephone/telemedicine) support for the management of patients with acute stroke were identified.

Population data used to calculate the proportion of the state’s residents living in counties with hospitals providing specific stroke-related services in 1998 were based on the 1990 census. The calculations were based on the 2000 census for the 2003 and current surveys.

χ² statistics were used to compare the availabilities of specific programs between time periods.

Results

Of the 135 facilities potentially caring for patients with acute stroke in 2008, 24 did not provide emergency stroke care, were federal facilities, or had closed, leaving 111 hospitals located in 83 of the state’s 100 counties. Complete responses were obtained from each of the hospitals for each survey, providing comprehensive, statewide data for each period.

The Table compares the proportions of state’s hospitals in 1998, 2003, and 2008 having the listed programs and services and the proportion of the state’s population residing in a country with at least 1 hospital providing each. Comparisons based on the proportions of the state’s population are all significant (each P < 0.001).

The proportions of hospitals providing CT angiography and diffusion-weighted MRI increased between each survey and were mirrored by increases in availability to the state’s population based on county of residence. The proportions of hospitals having transesophageal echocardiography increased over the 5 years between the first 2 surveys, but not thereafter. There was an increase in the numbers of hospitals having CT scanners between 2003 and 2008 but no change in availability to the population, suggesting that additional hospitals within the same counties obtained the test. There were no changes in the availability of other diagnostic tests.

The proportion of hospitals having inpatient rehabilitation services increased between 1998 and 2003 and the proportion having emergency departments increased between 2003 and 2008. The proportions having a neurologist or neurointerventionalist, or providing carotid endarterectomy, were unchanged or decreased. Availability of all of these services to the state’s population was also unchanged or decreased.

Organizational features of stroke care, including the use of stroke care maps, IV tPA protocols, and the proportions of hospitals having a stroke unit (or its equivalent), a stroke team, an anticoagulation clinic, or a community education program, were unchanged between 1998 and 2003. In contrast, the proportion using care maps and having IV tPA protocols, having prewritten stroke orders, and having a stroke team increased between 2003 and 2008 and were generally mirrored by increased availability to the state’s population.

The BAC’s PSC criteria were not yet published at the time of the 1998 survey. There were no changes in numbers of “basic” centers as defined for the 1998 survey over the subsequent 10 years. Hospitals having BAC PSC-type infrastructures increased between 2003 and 2008.

Sixteen hospitals in 13 counties have been certified by the Joint Commission as PSCs since the program began in 2003 (available to 41% of the state’s population based on county of residence). Facilities in an additional 19 counties routinely used remote (telephone/telemedicine) support for the management of patients with acute stroke, potentially extending these services to an additional 12% of the state’s population. Hospitals in 54 counties (36% of the state’s population) had a policy or plan to transfer patients with acute stroke outside their capabilities to another appropriate facility. Nineteen percent of the state’s population resided in a county without a PSC or a facility that used remote acute stroke care support or had a transfer plan or policy.
The Figure shows changes in the geographic distribution of “basic” stroke prevention and treatment hospitals by North Carolina county for each survey period. PSCs certified by the Joint Commission are also shown for 2008 (the program did not begin until after the 2003 survey was completed).

**Discussion**

This study provides comprehensive data describing changes in the availability of hospital-based stroke prevention and treatment services in an entire state between 1998 and 2008. The data are particularly useful because 100% of the state’s hospitals provided complete responses to each of the 3 surveys. The extraordinary response rates were likely obtained by directing the questionnaire to hospital senior management, keeping the survey short, having the survey mailed with a cover letter from the state’s Department of Health and Human Services, agreeing to publically report county but not individual hospital-level data, and resurveying nonresponders by mail, then fax, and then telephone. In the case of the 2008 survey, American Heart Association staff also obtained survey responses. It is unlikely that there were major changes in services over the 13 months that elapsed between the time the survey was first sent to the time the last response was received; however, some minor additional changes might have occurred.

The proportions of North Carolina hospitals offering certain stroke-related diagnostic tests increased over the 10-year period. The Table below shows the availability of various programs and services in North Carolina hospitals from 1998 to 2008.

<table>
<thead>
<tr>
<th>Table. Availability of Programs and Services, 1998–2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----------------------</td>
</tr>
<tr>
<td>Diagnostic tests</td>
</tr>
<tr>
<td>Brain CT</td>
</tr>
<tr>
<td>CTA</td>
</tr>
<tr>
<td>Brain MRI</td>
</tr>
<tr>
<td>MRA</td>
</tr>
<tr>
<td>DW MRI</td>
</tr>
<tr>
<td>TTE</td>
</tr>
<tr>
<td>TEE</td>
</tr>
<tr>
<td>Carotid ultrasound</td>
</tr>
<tr>
<td>TCD</td>
</tr>
<tr>
<td>Catheter angiography</td>
</tr>
<tr>
<td>Services</td>
</tr>
<tr>
<td>Emergency department</td>
</tr>
<tr>
<td>Neurologist on staff</td>
</tr>
<tr>
<td>Neurologist 24/7</td>
</tr>
<tr>
<td>Neurointerventionalist (N-I)</td>
</tr>
<tr>
<td>N-I 24/7</td>
</tr>
<tr>
<td>CEA</td>
</tr>
<tr>
<td>Rehabilitation</td>
</tr>
<tr>
<td>Organizational features</td>
</tr>
<tr>
<td>Stroke care map</td>
</tr>
<tr>
<td>tPA protocol</td>
</tr>
<tr>
<td>Prewritten orders</td>
</tr>
<tr>
<td>SACU</td>
</tr>
<tr>
<td>Stroke team</td>
</tr>
<tr>
<td>Anticoagulation clinic</td>
</tr>
<tr>
<td>Community awareness</td>
</tr>
<tr>
<td>Quality improvement program</td>
</tr>
<tr>
<td>Center type</td>
</tr>
<tr>
<td>Basic</td>
</tr>
<tr>
<td>BAC</td>
</tr>
</tbody>
</table>

CTA indicates CT angiography; MRA, MR angiography; DW, diffusion-weighted; TTE, transthoracic echocardiography; TEE, transesophageal echocardiography; TCD, transcranial Doppler ultrasonography; CEA, carotid endarterectomy; SACU, Stroke Acute Care Unit or equivalent; Blood, complete blood count, prothrombin time, activated partial thromboplastin time, and blood glucose concentration. See text for definitions of “basic” and “BAC”-type hospitals. Comparisons of the proportions of the state’s population are all significant (each P<0.001).
period with significant increases in CT angiography and diffusion-weighted MRI. One notable exception is catheter angiography, which was available to 10% less of the state’s population based on county of residence in 2008 than in 1998. This is consistent with declines in the proportion of the hospitals having neurointerventionalists with similar reductions in availability based on county of residence. This may be explained by a reduction in smaller hospitals that may not have had the volume of patients required to sustain the types of services provided by these specialists. Transfer agreements between hospitals with and without these services may help improve availability.

Although there were no significant differences in the proportion of hospitals having organizational features considered to improve the delivery of stroke-related care between 1998 and 2003, there were several notable improvements between 2003 and 2008 (ie, the use of stroke care maps, tPA protocols, prewritten orders, and stroke teams). The use of prewritten stroke orders, not assessed in 1998, also increased over the later period. These changes occurred contemporaneously with the introduction of several programs aimed at improving the organization and delivery of stroke-related care. Despite the increases in the proportions of hospitals having these programs and services, there were only modest or no improvements in their availability to the state’s population between 2003 and 2008 (ie, stroke care maps, 1%; tPA protocols, 7%; prewritten orders, 7%; stroke teams, 6% increases). This discrepancy is likely because additional hospitals in the same county began to provide these services.

A national study of Academic Medical Centers found no change in the proportion of patients with stroke arriving at hospitals within 2 hours of symptom onset between 2001 and 2004 (37% versus 38%, P = 0.63); however, the rate of IV tPA use increased over this period (14% to 38%, P < 0.0001), suggesting system-level improvements in the organization of in-hospital care. Despite the increases in the accessibility of specific diagnostic tests and improvements in hospitals’ organizational features over the 10-year period, there were no major differences in hospitals’ offerings of stroke educational programs to their communities. Improving stroke symptom recognition and response is a critical first step in obtaining timely emergency care. Yet, public knowledge of stroke symptoms remains poor, particularly in uninsured immigrant populations. Although knowledge alone does not necessarily lead to changes in health behaviors, an increase in educational programs tailored by hospitals to their local communities may help.

The proportions of hospitals having a group of “basic” stroke prevention and treatment capabilities (as defined in 1998 before BAC recommendations and the Joint Commission PSC certification process) remained stable over the 10 years, but accessibility based on county of residence declined (Table). This reflects an increase in the number of hospitals within the same county fulfilling these criteria coupled with a decrease in the numbers of counties having these resources (Figure). Importantly, this was accompanied by an overall increase in the geographic disparity in these facilities with particular gaps in the west, northeast, and southeast portions of the state. As also seen in the figure, there was an even greater geographic disparity in the distribution of Joint Commission-certified PSCs (the Joint Commission requirements differ from those of “basic” centers; therefore, some counties with a Joint Commission PSC do not have a “basic” hospital and some counties with a “basic” hospital do not have a Joint Commission PSC), presenting a barrier limiting the accessibility to time-sensitive reperfusion therapies for residents of these regions. Many North Carolina hospitals without the expertise to support hyperacute interventions used remote (telephone/telemedicine) support and/or a policy or plan to transfer patients with acute stroke to another facility. Nearly 20% of the state’s population, however, resided in a county without a PSC and without a facility that used telephone/telemedicine support or had a standing transfer plan. Knowledge of hospitals’ existing resources can help target facilities for PSC development and those without this potential to develop alternative strategies such as telemedicine to provide optimal care.

Both the American Stroke Association Get-With-The-Guidelines Stroke program and the Centers for Disease Control and Prevention-sponsored North Carolina Cooperative Stroke Registry provide patient management tools with feedback and became active between the last 2 surveys.
Use of the Get-With-The-Guidelines Stroke tool is associated with improvements in the monitored process measures. There was a nonsignificant increase in the number of hospitals having a stroke quality improvement program between 2003 and 2008. Only the 2008 survey queried whether the program was based on national measures (eg, Joint Commission, North Carolina Collaborative Stroke Registry, Get-With-the-Guidelines Stroke). These were being used by less than half the hospitals in the state.

The rates of IV tPA administration in regional networks range from 1% to 18%. One study analyzing administrative data found that none of the 11 BAC stroke center elements, most of which are required for Joint Commission PSC certification, were associated with lower in-hospital mortality or the frequency that patients with stroke were discharged home. There were no relationships between a hospital’s number of stroke center elements and in-hospital mortality, discharge to home, length of hospitalization, or costs; however, 4 of the 11 elements were associated with a greater frequency of use of IV tPA.

A combination of community, paramedic, and hospital-based education can also increase IV tPA use. At least 1 study evaluated the impact of triage to PSCs on a community-wide basis. The system resulted in overall improvements in a variety of process measures and an increase in IV tPA use rates. Like with the assessment of the impact of BAC PSC elements, there were no differences in peristroke complications or in the proportions of patients discharged home.

There is, therefore, a paucity of data showing that patients with stroke treated in PSCs have better outcomes as compared with non-PSCs. North Carolina counties with stroke centers were found to have lower stroke-related mortality than counties without such centers; however, this type of analysis is subject to several potentially important biases and does not prove causality. A study that included >360,000 Medicare beneficiaries age >65 years hospitalized with acute ischemic stroke evaluated whether hospitals certified within the first years of the Joint Commission program had better outcomes than noncertified hospitals at least 11 months and up to 4 years before the certifications began. After multi-variable risk adjustment, the patients who were treated at hospitals with future Joint Commission PSCs were found to have lower risks of death during the acute hospitalization, lower 30-day rates of death, all-cause readmission, or readmission for selected stroke complications. These data suggest Joint Commission PSC designation identifies hospitals with better stroke outcomes but does not address the benefits of the certification process itself because these hospitals had better outcomes up to several years before the program began.

Since publication of the statewide assessment of hospital-based stroke prevention and treatment services in North Carolina in 1998, similar studies have been carried out in other regions and countries. The American Stroke Association is promoting the use of this strategy nationwide as an aid for stroke system development. Although there remains a need to rigorously evaluate the impact of stroke systems, including the PSC certification process on patient outcomes, these efforts should lead to improved patient access and, combined with the use of quality improvement tools such as Get-With-the-Guidelines Stroke, improved quality of stroke care.

Acknowledgments
I thank members of the North Carolina Stroke Advisory Council for suggesting modifications of the survey questionnaire and staff of the Mid-Atlantic Affiliate of the American Heart Association for help in obtaining responses to the survey.

Sources of Funding
The North Carolina Stroke Prevention and Treatment Facilities Survey was supported through a grant from the North Carolina Department of Health and Human Services (Contract 02028-08).

Disclosures
None.

References


## North Carolina Stroke Prevention and Treatment Facilities Survey -2008

Facility name: __________________________________________

Survey completed by: _______________________________ Title: __________________________

Does your facility care for patients with acute stroke?  
☐ YES  ☐ NO

*If your facility does not care for patients with acute stroke, please stop and return to the address below.

Please check below to indicate the availability of the indicated programs or services at your facility. If available, check whether they can be performed 24/7 where indicated.

### Diagnostic tests and procedures:

- Platelet count, PT/PTT, blood glucose  
  - Available 24/7?  
  - YES  ☐ NO
- Brain CT scan  
  - Available 24/7?  
  - YES  ☐ NO
- Brain MRI scan  
  - Available 24/7?  
  - YES  ☐ NO
- Diffusion-weighted MRI
- Magnetic resonance angiography
- CT angiography
- Catheter-based cerebral angiography
- Carotid duplex ultrasonography
- Transcranial Doppler ultrasonography
- Transesophageal echocardiography
- Transesophageal echocardiography

### Programs and Services:

- Use acute stroke clinical care pathway based on national guidelines
- Stroke quality improvement program assessing national quality improvement markers (e.g., Joint Commission, Coverdell)?
- Carotid endarterectomy (_______ number of procedures/year)
- Carotid angioplasty/stenting (_______ number of procedures/year)
- Emergency department
- Acute stroke team
- Pre-written stroke care orders
- Stroke intravenous t-PA protocol
- Endovascular neuro-interventionalist  
  - Available 24/7?  
  - YES  ☐ NO
- Neurologist  
  - Available 24/7?  
  - YES  ☐ NO
- Conduct at least 2 public stroke related educational/ screening programs each year
- Provide stroke patients with educational materials related to stroke prevention, treatment and calling 911 for relevant symptoms
- Provide inpatient evaluation and education for post-discharge rehabilitation needs
- Provide a current list of post-discharge stroke-related community resources

*Figure 1.*
Clinics/Facilities:
☐ Anticoagulation clinic
☐ Stroke Acute Care Unit (or equivalent)
☐ Inpatient Acute Rehabilitation

Has your facility treated any stroke patients with intravenous tissue plasminogen activator (t-PA) over the last year?  ☐ YES (Approximate Number _______)  ☐ NO

Has your facility treated any acute stroke patients with acute endovascular intervention over the last year?  ☐ YES (Approximate Number _______)  ☐ NO

Does your facility routinely use remote (i.e., telephone/telemedicine) support for the management of your patients with acute stroke?  ☐ YES  ☐ NO

Does your facility have a policy or plan in place to transfer acute stroke patients outside your capabilities to another appropriate facility?  ☐ YES (Up to 2 primary facility name(s))  ☐ NO

Does your facility have an inpatient rehabilitation unit for stroke patients?  ☐ YES  ☐ NO

If YES, do your rehabilitation providers evaluate compliance with the national (Joint Commission or CARF) guidelines for post-acute care?  ☐ YES  ☐ NO

Do key staff caring for stroke patients complete at least 2-hours of accredited stroke-related continuing education annually?  ☐ YES  ☐ NO

If your facility is not a Joint Commission-certified Primary Stroke Center

Do you have a pending application?  ☐ YES  ☐ NO

If not, are you planning to submit an application?  ☐ YES  ☐ NO

What are your current hospital-based and community needs for improving stroke care?

Please return by mail using the enclosed envelope or by FAX using the enclosed FAX cover sheet by __________________.
Statewide Hospital-Based Stroke Services in North Carolina. Changes Over 10 Years
Larry B. Goldstein

Stroke. published online February 18, 2010;
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2010 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/early/2010/02/18/STROKEAHA.109.572750.citation

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/