

# Statewide Assessment of Hospital-Based Stroke Prevention and Treatment Services in North Carolina

## Changes Over the Last 5 Years

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**Background and Purpose**—The first published statewide assessment of stroke prevention and treatment services in the United States was carried out in North Carolina in 1998. The purpose of the present study was to measure changes in these services that may have occurred over the last 5 years.

**Methods**—A 1-page questionnaire was sent to each facility in the state in February 2003. Results were compared with the 1998 survey.

**Results**—Complete responses were obtained from each of the state's 128 facilities. The proportions of hospitals providing CT angiography (35% versus 55%,  $P \leq 0.01$ ), diffusion-weighted MRI (20% versus 45%,  $P \leq 0.01$ ), transesophageal echocardiography (45% versus 59%,  $P \leq 0.02$ ), and inpatient rehabilitation services (25% versus 43%,  $P \leq 0.01$ ) increased over the 5 years. There was a trend toward more facilities having tissue plasminogen activator protocols (43% versus 54%,  $P \leq 0.09$ ) but a decrease in the proportion of hospitals with interventional radiologists (23% versus 15%,  $P < 0.01$ ). There was no change in the proportion of the state's population living in a county with a basic stroke prevention and treatment center, with the proportion residing in a county with an advanced center increasing by 12%. Entire regions of the state lacked either type of center, and only 14% had even the essential infrastructure recommended for a Brain Attack Coalition-type primary stroke center. There was no difference in the proportions of hospitals with organized stroke teams, those having a stroke acute care unit, those using stroke care maps, or hospitals having community awareness programs.

**Conclusions**—Certain technologies have become more widely available, but hospital investments in stroke-related programs have not appreciably increased. (*Stroke*. 2003;34:2945-2950.)

**Key Words:** cerebrovascular disorders ■ data collection ■ diagnosis ■ emergency medical services  
■ primary prevention ■ thrombolytic therapy

One of the first comprehensive statewide assessments of hospital-based stroke-related prevention and treatment services was conducted in North Carolina in 1998.<sup>1</sup> At that time, full "basic" services (defined as facilities providing emergency department services; offering treatment of acute ischemic stroke with intravenous recombinant tissue plasminogen activator [tPA]; and performing brain CT scan, carotid ultrasonography, cerebral angiography, transthoracic echocardiography [TTE], and carotid endarterectomy) were available in at least 1 hospital in the county of residence of 52% of the state's population. Important for time-dependent interventions, no basic or advanced facilities (the latter providing more complex diagnostic and therapeutic procedures) were available in entire regions of the state. However, in just over 1.5 years after the approval of intravenous tPA by the US Food and Drug Administration, 74% of the state's population

resided in a county with at least 1 hospital indicating that it was prepared to treat patients with it.<sup>2</sup>

Two years after this assessment in North Carolina, a similar study was carried out in Illinois with the same methodology.<sup>3</sup> In the intervening years, national organizations, including the National Institute of Neurologic Disorders and Stroke, American Stroke Association, National Stroke Association, and other organizations, had continued programs and developed new initiatives aimed at public and professional stroke-related education and at fostering improvements in the organization and delivery of stroke care. The more recent survey revealed that 93% of residents in Illinois lived in a county with at least 1 acute-care facility having a tPA treatment protocol. However, as with the earlier assessment in North Carolina, the Illinois study found potential barriers to stroke care based on a lack of availability of personnel, diagnostic technologies, and programs.

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**North Carolina Stroke Prevention and Treatment Facilities Survey -2003**

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

**Diagnostic tests and procedures:**

<input type="checkbox"/>	Platelet count, PT/PTT, blood glucose	Available 24/7?	YES	NO
<input type="checkbox"/>	Brain CT scan	Available 24/7?	YES	NO
<input type="checkbox"/>	Brain MRI scan	Available 24/7?	YES	NO
<input type="checkbox"/>	Diffusion-weighted MRI			
<input type="checkbox"/>	Magnetic resonance angiography			
<input type="checkbox"/>	CT angiography			
<input type="checkbox"/>	Catheter-based cerebral angiography			
<input type="checkbox"/>	Carotid duplex ultrasonography			
<input type="checkbox"/>	Transcranial doppler ultrasonography			
<input type="checkbox"/>	Transthoracic echocardiography			
<input type="checkbox"/>	Transesophageal echocardiography			

**Programs and Services:**

<input type="checkbox"/>	On-going stroke quality improvement program			
<input type="checkbox"/>	Carotid endarterectomy (_____ number of procedures/year)			
<input type="checkbox"/>	Emergency department			
<input type="checkbox"/>	Acute stroke team			
<input type="checkbox"/>	Stroke care map			
<input type="checkbox"/>	Pre-written stroke care orders			
<input type="checkbox"/>	Stroke intravenous t-PA protocol			
<input type="checkbox"/>	Endovascular neuro-interventionalist	Available 24/7?	YES	NO
<input type="checkbox"/>	Neurologist	Available 24/7?	YES	NO
<input type="checkbox"/>	Community stroke awareness program			

**Clinics/ Facilities:**

<input type="checkbox"/>	Anticoagulation clinic
<input type="checkbox"/>	Stroke Acute Care Unit (or equivalent)
<input type="checkbox"/>	Inpatient Acute Rehabilitation

Has your facility treated any stroke patients with intravenous t-PA over the last year?  
YES (Approximate Number \_\_\_\_\_) NO

Has your facility treated any stroke patients with intra-arterial thrombolysis over the last year?  
YES (Approximate Number \_\_\_\_\_) NO

**Figure 1.** The 2003 North Carolina Stroke Prevention and Treatment Facilities Survey.

Just after completion of the Illinois study, the Brain Attack Coalition (BAC), a multidisciplinary group with representatives from major professional organizations involved with the delivery of stroke care, published recommendations for the establishment and operation of primary stroke centers as an approach to improve the medical care of stroke patients.<sup>4</sup> The purpose of the present study was to repeat a comprehensive assessment of hospital-based stroke prevention and treatment services in North Carolina to measure changes that may have occurred as a result of both ongoing national programs and the promulgation of the BAC Primary Stroke Center recommendations.

## Methods

The methodology used in the 1998 North Carolina survey was modified for the present study.<sup>1</sup> As previously, a list of all inpatient medical facilities in North Carolina was obtained from the state's Division of Facilities (n=128). In February 2003, a revised 1-page survey (Figure 1) was mailed to the medical directors of each facility with a cover letter explaining its purpose and signed by both the acting director of the North Carolina Department of Health and Human Services and by the study principal investigator. The survey was then sent by fax to those not responding to the mailing, with telephone follow-up as necessary.

Both the 1998 and the current survey collected several categories of data relating to the availability of stroke prevention and treatment services. These included a variety of diagnostic studies useful in the management of patients with cerebrovascular disease and a series of programs and services: the availability of an emergency department, a Stroke Acute Care Unit or its equivalent, an acute stroke team, stroke tPA protocol, hospital stroke care map, prewritten stroke orders, community stroke awareness programs, the 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, intravenous tPA treatment protocols, brain CT, transthoracic echocardiography, carotid ultrasonography, and cerebral angiography and performing carotid endarterectomy. Advanced centers had all these basic services plus brain MRI, MR angiography, transesophageal echocardiography (TEE), transcranial Doppler ultrasonography, and an interventional radiologist on staff. To obtain additional information relevant to the institutional infrastructure required to fulfill BAC Primary Stroke Center recommendations,<sup>4</sup> the new survey also queried the immediate availability (ie, 24 hours a day, 7 days a week) of blood studies (platelet count, prothrombin time/activated thromboplastin time, blood glucose), brain CT scan, and whether they had a stroke quality improvement program. For the present analysis, these capabilities, in addition to having an emergency department, a stroke care map, a tPA treatment protocol, and prewritten stroke care orders, were deemed the essential parts of the BAC recommendations. Centers were also asked whether they treated any patients with intravenous or intra-arterial tPA over the preceding year; the approximate number of patients treated; the number of carotid endarterectomies performed; and the immediate availability of brain MRI scan, a neurologist, and an endovascular neurointerventionalist.

We used  $\chi^2$  statistics to compare the characteristics of facilities in 1998 with those in 2003. 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 year 1990 census. The same calculations were based on the year 2000 census for the 2003 survey.

## Results

The 1998 survey included all 125 facilities with inpatient beds as listed in North Carolina's Division of Facilities directory. Since 1998, 5 facilities either closed or merged with another hospital, and 8 additional facilities were listed. Complete responses were obtained from each of the 128 facilities in the current state directory, again providing comprehensive statewide data. These 128 hospitals were located in 85 of the state's 100 counties (versus 84 in 1998).

The Table compares the proportions of state's hospitals in 1998 and 2003 having each of the listed programs and services. The proportions of hospitals providing CT angiography, diffusion-weighted MRI, TEE, and inpatient rehabilitation services significantly increased over the 5 years between the 2 surveys. This translated into higher proportions of the state's residents living in counties with at least 1 facility providing these procedures. There was a trend ( $P>0.05$  to  $P<1.0$ ) toward relatively more facilities having tPA treatment protocols but a decrease in the proportion of hospitals with interventional radiologists. Because facilities adopting tPA protocols were in counties that previously had a hospital with these protocols, there was no change in the proportion of state residents with access to these hospitals based on their county of residence (the Table). The proportion of North Carolina's residents living in counties with hospitals having an interventional radiologist decreased by  $\approx 10\%$ . There were no differences in the remaining procedures and services. Of hospitals performing carotid endarterectomy, 53% did  $<20$ , with 37% doing  $<5$  operations over the prior year.

The availabilities of basic and advanced stroke prevention and treatment centers were compared using the definitions included in the 1998 survey. The number of basic centers was unchanged, but the number of advanced centers doubled, although the difference was not significant. The geographic distribution of these centers by county in 1998 and 2003 is

Programs and Services

	Hospitals, %			Population, %	
	1998	2003	P≤	1998	2003
<b>Diagnostic tests</b>					
Brain CT	87	87	0.91	94	97
Brain CT 24/7	...	83	...	...	94
CTA	35	55	0.01	55	82
Brain MRI	78	80	0.68	92	95
Brain MRI 24/7	...	24	...	...	53
MRA	57	66	0.15	80	86
DW-MRI	20	45	0.01	44	73
TTE	62	70	0.14	82	88
TEE	45	59	0.02	74	83
Carotid ultrasound	82	79	0.59	93	94
TCD	27	32	0.40	55	60
Catheter angiography	38	30	0.18	70	64
Blood 24/7	...	90	...	...	95
<b>Services</b>					
Emergency department	88	86	0.63	96	96
Neurologist on staff	55	54	0.83	81	81
Neurologist 24/7	...	30	...	...	62
Interventional radiology	23	15	0.01	51	42
Interventional radiology 24/7	...	9	...	...	30
Carotid endarterectomy	43	41	0.68	72	70
Inpatient rehabilitation	25	43	0.01	47	64
<b>Organizational features</b>					
Stroke care map	34	30	0.50	58	61
tPA protocol	43	54	0.09	74	75
Prewritten orders	...	34	...	...	65
Stroke acute care unit	18	19	0.95	45	48
Stroke team	18	16	0.56	42	43
Anticoagulation clinic	6	12	0.14	23	38
Community awareness	27	27	1.00	57	50
Quality improvement program	...	34	...	...	59
<b>Center type</b>					
Basic	18	21	0.59	52	50
Advanced	6	12	0.14	26	38
BAC	...	14	...	...	43

Comparisons of the proportions of North Carolina hospitals and the proportions of the state's population residing in a county with each of the indicated programs and services in 1998 and 2003.

CTA indicates CT angiography; MRA, magnetic resonance angiography; DW-MRI, diffusion-weighted MRI; TTE, transthoracic echocardiography; TEE, transesophageal echocardiography; TCD, Transcranial Doppler ultrasonography; IR, interventional radiology; tPA, tissue plasminogen activator; BAC, Brain Attack Coalition. 24/7 indicates availability 24 hours/day, 7 days/ week. Blood indicates complete blood count, prothrombin time, activated partial thromboplastin time, and glucose.

shown in Figure 2. Five counties that previously had at least 1 facility fulfilling the 1998 definition of a basic center no longer had a hospital meeting these criteria. However, 4 counties gained basic centers, 1 gained an advanced center, and 3 that previously had a basic center now had an advanced center. Overall, there was no change in the proportion of the

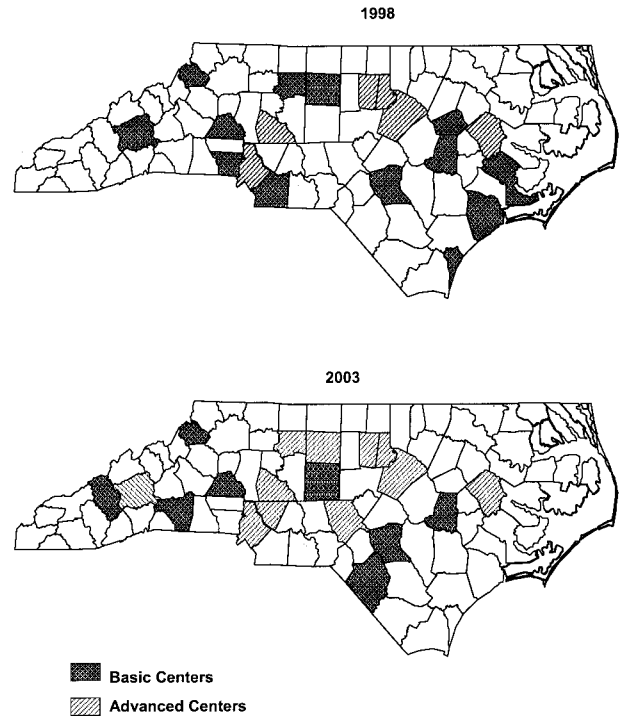


Figure 2. Statewide distribution by county of basic and advanced stroke prevention and treatment centers (see text for definitions) in 1998 (top) and 2003 (bottom).

state's population living in a county with a basic center; the proportion residing in a county with an advanced center increased by 12%. Because of the change in their geographic distributions, there was a slight decrease in the proportion of the population living in a county with either a basic or an advanced center (52% in 1998 versus 50% in 2003). Figure 3 shows counties with at least 1 facility reporting to have the essential infrastructure to meet BAC recommendations for a primary stroke center. These facilities are clustered in counties in the central part of the state.

Overall, 52% of facilities indicated having used tPA for ischemic stroke over the prior year. This included all the basic and advanced centers and all the hospitals with the described qualifications of a BAC primary stroke center. In addition, 39% of those not meeting the definition of a basic or advanced center and 44% of non-BAC-type centers indicated

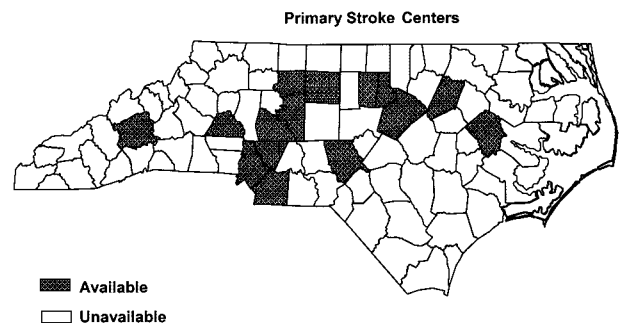


Figure 3. Statewide distribution by county of facilities with the basic infrastructure necessary to meet BAC recommendations for primary stroke centers.

using tPA. Of those facilities giving tPA for ischemic stroke, 20% did not have a tPA protocol, 70% lacked an organized stroke team, 53% did not use a stroke care map, and 44% did not have prewritten orders. The 55 hospitals that provided estimates treated a median of 3 patients with tPA over the prior year (range, 1 to 50). Of those hospitals that reported using tPA, the estimated number of patients treated was nonsignificantly higher in basic centers (median, 6 versus 3; Mann-Whitney *U* test,  $P=0.18$ ) and was significantly higher in both advanced (median, 9 versus 3;  $P=0.01$ ) and BAC-type (median, 7 versus 3;  $P=0.02$ ) centers than in hospitals not fulfilling these criteria.

### Discussion

The development and organization of stroke prevention and treatment services in North Carolina occurs on a voluntary basis but is influenced by a variety of factors. By obtaining complete responses from every facility in North Carolina, the surveys conducted in 1998 and 2003 provide unique data for tracking changes in the state's hospital-based healthcare infrastructure related to stroke. Over these 5 years, there have been significant increases in the dissemination of certain advanced technologies such as CT angiography, diffusion-weighted MRI imaging, and TEE, with corresponding increases in the proportions of the state's population living in counties with at least 1 facility offering these tests. There has also been a substantial increase in the number of facilities with inpatient rehabilitation services. These types of changes are not surprising because they can be associated with increased revenues for the hospitals offering the services.

National studies have reported an underuse of anticoagulation for stroke prophylaxis in patients with atrial fibrillation.<sup>5</sup> Anticoagulation clinics may facilitate the safe use of warfarin.<sup>6</sup> Although the difference was not statistically significant, the proportion of hospitals with anticoagulation clinics doubled between 1998 and 2003. In future studies, the rates of anticoagulation in high-risk atrial fibrillation patients could be correlated with the availability of anticoagulation clinics to determine whether their availability leads to increased use of warfarin.

Intravenous tPA remains the only specific treatment approved by the US Food and Drug Administration for patients with acute ischemic stroke. The safe use of tPA requires that it be given according to the protocol used in the clinical trial on which its approval was based.<sup>7</sup> Complication rates can increase when the protocol is violated.<sup>8–10</sup> There was a statistical trend toward a higher proportion of hospitals using tPA protocols, but because of these hospitals' geographic locations, there was no difference in the proportion of the state's residents living in counties with a hospital having a tPA treatment protocol.

In contrast to the more widespread availability of advanced technologies and despite ongoing national efforts, there has been virtually no other change in hospitals' organizational features and programs related to stroke prevention and treatment. The use of stroke care maps and organized stroke teams and the proportion of hospitals having a stroke acute care unit or its equivalent were unchanged. Although comparative data from 1998 are not available, only one third of

facilities had prewritten stroke care orders or stroke-related quality improvement programs in 2003. Although these types of measures have been associated with improvements in both the process and outcome of care,<sup>11–14</sup> they require investments in personnel time and other resources that may not lead to readily apparent returns. Even hospitals giving tPA often lacked many of these programs.

BAC recommendations for primary stroke centers had not yet been published when the 1998 survey was conducted.<sup>4</sup> These recommendations are focused primarily on characteristics deemed important to facilitate hyperacute stroke therapies. Although there is some overlap, these recommendations differ from the definition of basic stroke prevention and treatment centers that was used in 1998. There remains no agreed-on set of characteristics defining an advanced stroke prevention and treatment center. Using the described definitions, we found an  $\approx 10\%$  increase in the proportion of the state's hospitals with either a basic or an advanced center (the Table). Importantly, there has been an interval change in the geographic distribution of these centers (Figure 2). In particular, there was a loss of centers in counties in the eastern portion and greater concentration of centers in the central portion of the state. As a result, there was a slight (2%) decrease in the proportion of the population residing in a county with either a basic or an advanced center. Of centers indicating that they used tPA over the prior year, both advanced and BAC-type centers treated more patients than hospitals that did not have the necessary infrastructure available. Based on current guidelines, tPA for ischemic stroke must be given within 3 hours of symptom onset,<sup>7</sup> with better outcomes associated with earlier treatment.<sup>15</sup> Therefore, this geographic disparity may have important treatment implications. This type of data will be of critical importance for the statewide development of stroke care systems.

Only a small proportion of the state's hospitals fulfilled the major BAC infrastructural recommendations for a primary stroke center.<sup>4</sup> A stroke unit is required only for those primary centers providing ongoing in-hospital care, and neurosurgical services need to be available only through timely referrals. As a result, these features were not included as essential in the present analysis. Whether the facility had an identified stroke center director or a continuing medical education program was not evaluated. Furthermore, assessment of the actual compared with the reported availability of the indicated services was not verified. Therefore, the actual number of BAC-type primary stroke centers in North Carolina is likely less than reflected in this survey. Even based solely on the criteria used in this study, it is apparent that entire regions of the state do not have even a single facility with the infrastructure in place to qualify as a BAC-type primary stroke center (Figure 3).

A series of studies document the relative lack of public knowledge of stroke risk factors, warning signs, and symptoms.<sup>16–19</sup> This is true even among high-risk persons with access to medical care residing in North Carolina, a part of the country's "stroke belt."<sup>18</sup> Comprehensive programs, including public and professional education, have the potential to affect the number of patients seeking timely acute stroke treatment.<sup>20</sup> Hospital-based personnel often spearhead local

public health education programs. However, only 27% of facilities had community stroke awareness programs, a proportion that did not change between 1998 and 2003. The proportion of the population living in counties with these programs actually decreased over the 5-year period. As with the organizational programs previously discussed, mounting and sustaining community stroke educational programs requires a commitment of personnel and resources.

Several other findings should be highlighted. The availability of carotid endarterectomy has remained stable over the last 5 years. In the present study, each hospital was asked to estimate the numbers of these procedures performed over the prior year. Many hospitals did only a few of these operations. As with other procedures, there is a general inverse relationship between complication rates and the number of carotid endarterectomies a center performs.<sup>21–23</sup> Because carotid endarterectomy is rarely emergent, patients and referring physicians should generally seek high-volume, low-complication-rate centers. The proportion of hospitals with an interventional radiologist significantly decreased between 1998 and 2003. This likely was due to a reduction in lower-volume programs. Used in many academic and some community hospitals, intra-arterial thrombolytic therapy is not formally approved for use in patients with acute ischemic stroke. Approval of this approach will have an uncertain population impact unless more widespread availability of the necessary infrastructure can be supported. Although 80% of hospitals had brain MRI scans, fewer than a quarter indicated that they could perform the study 24 hours a day, 7 days a week. Current acute stroke treatment guidelines indicate that brain CT may be preferred as the first imaging study because MRI detection of acute intracerebral hemorrhage has not been fully validated.<sup>7</sup> Clear demonstration of an impact of acute brain MRI compared with CT on stroke outcomes would provide an impetus for investing in the personnel required to have the test immediately available in centers that already have the necessary technology.

The methods used in the present study have several advantages. Although a variety of factors probably were important, complete responses were again obtained by limiting the length of the survey to a single printed page and including only questions that respondents could readily address. However, this type of study also has limitations. Reported availability of programs and services might differ from those actually available. This may be particularly true for the immediate availability of certain tests or procedures. There is no assessment of the quality of care (including the actual use of time-sensitive diagnostic tests and treatments) or outcomes, and the number of patients treated with tPA was not verified. Population-based estimates of availability were based on county of residence. A hospital located near the border of a county might also be used by those living in an adjoining county and may not be available to those living at the opposite side of the county in which it is located.

Despite these inherent limitations, the present study provides unique and important data reflecting changes (or lack of changes) in the statewide availability of stroke prevention and treatment services in North Carolina. Certain technologies have become more widely available over the last 5 years, but

hospitals' investments in stroke-related programs have not appreciably increased. Few had even the basic infrastructure necessary to meet BAC recommendations for primary stroke centers, and it is clear that unsupported voluntary efforts aimed at improving the organization of stroke care have not had their desired impact. Federal legislation currently being developed (the Stroke Treatment and Ongoing Prevention Act) could provide the assistance necessary to effect change. As was done in Illinois, studies similar to ours could be carried out in other states to help planners develop statewide stroke care systems. Repeating this type of study periodically will provide a measure of the effectiveness of these efforts.

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