Monitoring and Improving Acute Stroke Care:
The North Carolina Stroke Care Collaborative

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The North Carolina Stroke Care Collaborative is a stroke care quality-improvement (QI) program that provides performance data to hospitals continuously, allowing for rapid feedback and for development of QI initiatives. Between 2005 and 2012, 89,413 stroke cases were enrolled, and the proportion of patients receiving defect-free care improved from 52% to 79%. However, important areas for improvement remain.

Approximately 795,000 new or recurrent strokes occur annually in the United States, making stroke the fourth leading cause of death and a leading cause of long-term disability [1]. Until the 1980s, declines in stroke mortality were thought to be more consistent with improved risk factor profiles than with improvements in the quality of stroke care. More recently, decreases in the number of hospital case fatalities suggest that improved survival after acute stroke contributes significantly to the continued decline in stroke mortality [1].

The Joint Commission (JC), the American Heart Association (AHA), the American Stroke Association (ASA), the American Academy of Neurology (AAN), and the Centers for Disease Control and Prevention (CDC) promote stroke care quality-improvement (QI) efforts through the development and dissemination of evidence-based stroke care guidelines [2, 3]. Despite evidence supporting the benefit of implementing evidence- and consensus-based guidelines [4], gaps remain between such recommendations and the care that is being delivered in hospitals [5, 6].

To reduce these gaps, a number of initiatives have been developed, including the JC's Primary Stroke Center Certification Program and the AAN's Stroke Practice Improvement Network initiative [7]. In addition, QI programs such as the AHA's "Get with the Guidelines–Stroke" and the CDC's Paul Coverdell National Acute Stroke Registry (PCNASR) program have been launched with the goal of improving acute stroke care in the United States.

In 2004, after a 2-year pilot program and a development phase, North Carolina was one of several states selected by the CDC to implement a PCNASR program, which was named the North Carolina Stroke Care Collaborative (NCSCC).

With the exception of Veterans Affairs (VA) hospitals, all hospitals with a dedicated emergency department (ED) in North Carolina are eligible to participate in the NCSCC. Between January 2005 and June 2012, 68 of the 110 eligible hospitals in the state enrolled nearly 90,000 patients into the NCSCC (Figure 1). Patients who are 18 years of age or older who present with signs or symptoms consistent with a clinical diagnosis of acute ischemic stroke (IS), intracerebral hemorrhage (ICH), subarachnoid hemorrhage (SAH), transient ischemic attack (TIA), or an *International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM)* discharge diagnosis code indicating a stroke or TIA (codes 430-436) are eligible for enrollment.

Participating hospitals are encouraged to consecutively enroll all eligible stroke cases based on presenting signs and symptoms at the time of ED presentation or hospital admission and to collect specific data elements measuring quality of care and performance concurrent with care throughout the hospitalization. However, some hospitals have retrospectively identified cases based on *ICD-9-CM* discharge diagnosis codes and abstracted the required data elements from medical records or used a combination of methods. In 28% of cases enrolled through June 2012, performance measures were documented concurrent with care.

Hospital staff enter data elements—including patient demographics, medical history, diagnostic procedures, medical treatments, and discharge plans—into an interactive, online data management tool created specifically for the NCSCC. Additional details of the study design have been published elsewhere [8]. To minimize selection bias and for feasibility [9], informed consent is not required, and no patient identifiers are collected. This study was approved by the University of North Carolina at Chapel Hill Institutional Review Board (IRB) and individual hospitals' IRBs where required.

The NCSCC facilitates quality improvement (QI) by promoting and supporting timely collection and analysis of key quality-of-care indicators. Consistent with other PCNASR registries, data elements include the 11 acute stroke per-

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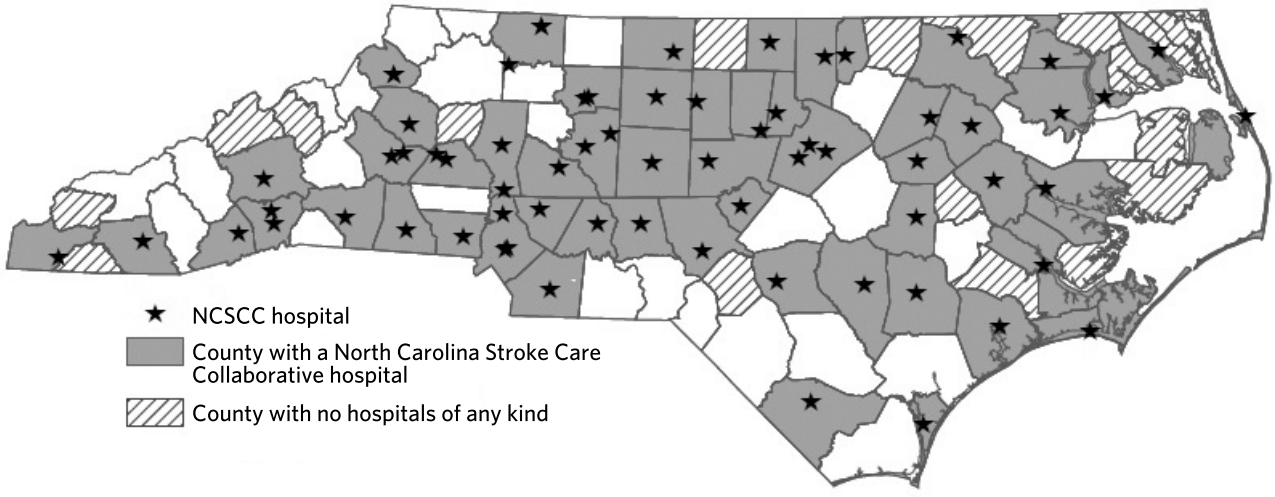
FIGURE 1.
Counties with North Carolina Stroke Care Collaborative Hospitals, 2005 - 2012.



Note: Data are from North Carolina Stroke Care Collaborative.
*Data from June 30, 2012

formance measures developed by the JC in collaboration with the CDC and the AHA/ASA. A summary index, *defect-free care*, was created to indicate whether or not a patient received all performance measures for which he or she was eligible. Reports featuring performance measures are accessible to hospital staff at any time via an interactive web-based interface and allow comparison with aggregate NCSCC hospital performance data. These up-to-date reports facilitate immediate feedback and serve as a basis for planning QI initiatives. To enhance QI activities, more-detailed analyses of data elements are provided regularly. Monthly QI webinars, updated practice guidelines, regional hospital workshops, interhospital conference calls, and a grant award program funding innovative QI projects designed by hospital staff to address their specific needs have also been provided. Hospitals are encouraged to share QI intervention information with hospital administrators and boards to facilitate policy and system changes.

The following definitions are used for NCSCC analyses: hospital size (small, fewer than 100 beds; midsize, 100-349 beds; large, 350 or more beds); teaching hospital (50 full-time equivalent interns and residents, or at least $3 million allocated to graduate medical education); stroke unit (designated area within a hospital where staff with training in stroke management provide care); acute stroke team (experienced personnel who respond to a code pager and deliver stroke care, as well as a multidisciplinary task force that works daily to facilitate patient access to treatment); ED acute stroke protocol (standardized process designed to quickly identify and triage patients and initiate treatment orders); thrombolytic therapy protocol (written chain of actions followed by ED staff when a patient presents with signs and symptoms of stroke); primary stroke center (JC-accredited primary stroke centers).

Of the 68 hospitals participating in the NCSCC between January 1, 2005 and June 30, 2012, the majority were classified as midsize facilities (Table 1). Six were teaching hospitals, 15 were in a rural or small-town area, 8 were critical access hospitals, and 26 were certified stroke centers. Fewer than half reported having an acute stroke team in place; however, more than half reported having a stroke team–like resource, and nearly all reported having an ED protocol for administering thrombolytic therapy to IS patients.

A total of 89,413 cases were registered during this period. The majority of patients were female (53.2%), and Caucasian (73.0%), with a mean age of 68.6 years (range, 18-109 years). More than half (59.7%) of registered cases were discharged with an *ICD-9-CM* diagnosis code of IS, 13.8% with a diagnosis of hemorrhagic stroke, 17.0% with a diagnosis of TIA, and fewer than 1% with a diagnosis of ill-defined stroke.

Fewer than half (46.5%) of cases arrived at the hospital via emergency medical services (EMS). Of those transported by EMS and having documented times, the median time from symptom onset to calling EMS was 1.1 hours (interquartile range [IQR], 0.3-4.1 hours). Time from symptom onset to hospital arrival was not recorded or was unknown for 49.5% of IS cases. For those with available data, the median delay from symptom onset to hospital arrival was 2.8 hours (IQR, 1.2-6.8), with 40.9% arriving within 2 hours of symptom onset and 51.8% arriving within 3 hours. Thrombolytic therapy was administered to 46.6% of eligible IS cases. Prolonged delay in arrival was the primary documented reason for half of IS cases being deemed ineligible for thrombolytic therapy.

The median length of stay (LOS) in the hospital for

TABLE 1.
Selected Characteristics of the Hospitals That Participated in the North Carolina Stroke Care Collaborative from January 2005 - June 2012

Characteristic	No. (%)
	(N = 68)
Hospital size	
Small (<100 beds)	13 (19.1)
Midsize (100-349 beds)	36 (52.9)
Large (≥ 350 beds)	19 (27.9)
Teaching hospital	6 (8.8)
Small town or rural hospital[a]	15 (22.1)
Critical Access Hospital	8 (11.8)
Certified Primary Stroke Center	26 (38.2)
	(N = 45)[b]
Has acute stroke team	20 (44.4)
Has thrombolytic therapy stroke protocol	44 (97.8)
Has emergency department ischemic stroke protocol	38 (84.4)
Has stroke unit	3 (6.7)
Has neurosurgeon on staff	15 (33.3)

[a]The designation "small town or rural" is based on US Department of Agriculture rural-urban commuting area (RUCA) codes and applies to areas having an urban core population area with a population of less than 10,000.
[b]For 5 characteristics, N = 45 because information about those characteristics was unavailable for 23 hospitals.

patients was 3 days (IQR, 2-6 days). Median LOS varied by stroke type, from 6 days for hemorrhagic cases, to 4 days for IS cases, and 2 days for TIA cases. Overall, 56.9% of cases were discharged home. More than half (66.5%) of all cases were able to ambulate independently both before and after the stroke or TIA.

The JC goal of 85% or more of patients receiving the treatment described in all of the performance measures was met for 7 of the 11 indicators, including receipt of prophylaxis for deep vein thrombosis, antithrombotic medication upon discharge, use of anticoagulant therapy for patients with atrial fibrillation, use of antithrombotics within 48 hours of hospitalization, discharge on statin therapy, smoking cessation counseling, and consideration of a rehabilitation plan (Table 2). This goal was not met for use of thrombolytic therapy, discharge on cholesterol-reducing medication, dysphasia screening, and stroke education. Overall, adherence was highest for discharge on antithrombotic medication (97.7%) and lowest for thrombolytic therapy administration to eligible IS patients (46.6%). The proportion of cases that received defect-free care increased from 52% in 2005 to 79% in 2012, for an average of 3.9% annual improvement (Table 2).

Data collected by the NCSCC on JC acute stroke performance measures and other indicators of care has allowed for timely, comparative feedback to participating hospitals, enabling the development, implementation, and tracking of targeted hospital-specific QI initiatives. Delivery of defect-free care has improved by an average of nearly 4% per year among NCSCC hospitals. These results are similar to those of a national stroke care QI program [10].

However, gaps in access to optimal care still exist. Notably, fewer than half of eligible IS cases (those arriving within 2 hours of symptom onset) received thrombolytic therapy. Administration of thrombolytic therapy to eligible patients routinely has the lowest compliance reported in registry studies of JC performance measures [10]. In NCSCC data, the primary documented reason for IS cases being deemed ineligible for thrombolytic therapy has been delay in patient arrival. Previous NCSCC findings suggest that using EMS is associated with more timely diagnostic testing and interpretation of results [11]. Together, these data highlight the continued importance of public education campaigns to heighten the awareness of stroke signs and symptoms and the importance of calling 911 when a stroke is suspected. Improvement in this area will require community outreach interventions that evaluate progress with the same level of rigor as in-hospital QI.

The majority of NCSCC hospitals have stroke units and IS protocols in the ED, and more than a third are certified stroke centers; however, fewer than half have an acute stroke team, and only a third have neurosurgeons on staff. Hospital-level improvements in the organization and delivery of stroke care have been demonstrated to be important factors in the quality of care delivered [12, 13]. Delivery of care in a specialized stroke unit has been shown to reduce the likelihood of death and disability by up to 30%, and implementation of ED and thrombolytic therapy protocols has been shown to significantly reduce door-to-imaging time delays and improve the likelihood of IS patients receiving thrombolytic therapy [14]. Although certain hospital characteristics (eg, larger size, teaching status, and urban setting) may predispose hospitals to provide higher quality care, meaningful hospital-level changes can still be made in smaller centers to ensure that state-of-the-art acute stroke care is delivered to all segments of the population. Strategies such as telemedicine and improved coordination with EMS, including ambulance rerouting and transfer agreements, can lead to meaningful improvements in the quality of stroke care delivered [15].

All hospital-based QI programs face important challenges, including sustainment of funding and the provision of infrastructure to support electronic data collection and complete case ascertainment. Compromises between the desire to collect high-quality data and practical feasibility can lead to biased, nonrepresentative case sampling. However, NCSCC hospitals have captured 83.7% of all acute stroke cases that enter the hospital. This high case ascertainment rate may be attributed to the use of both prospective and retrospective case capture methods and to freedom from any requirement to obtain written consent. While allowing for two methods of case capture may increase case ascertainment and improve data completeness, it may also introduce a source of variability in comparative analysis.

The NCSCC is a voluntary program, and hospitals that participate may have greater capacity to deliver stroke QI

TABLE 2.
Adherence to Stroke Performance Measures of Care in North Carolina Stroke Care Collaborative Hospitals, January 2005 - June 2012

Performance Measure	Adherence Among Eligible Cases, %
Patient received deep vein thrombosis prophylaxis[a]	90.8
Patient was discharged on antithrombotic medication[b]	97.7
Patient with atrial fibrillation received anticoagulant therapy[b]	85.7
Ischemic stroke patient received thrombolytic therapy[c]	46.6
Patient received antithrombotics within 48 hours of hospitalization[b]	95.9
Patient was discharged on cholesterol-reducing medication[d]	75.5
Patient was discharged on statin therapy[e]	86.3
Patient was screened for dysphasia[a]	68.7
Patient was given stroke education[f]	69.8
Patient was given smoking cessation counseling[g]	94.5
Patient was considered for a rehabilitation plan[h]	94.1
Defect-Free Care	
2005	52
2006	54
2007	52
2008	59
2009	68
2010	71
2011	75
2012	79

[a]All stroke patients, excluding TIA and stroke patients who were NPO throughout hospitalization.
[b]All stroke and TIA patients without contraindications.
[c]Ischemic stroke patients presenting to hospital within 2 hours of symptom onset.
[d]Ischemic stroke and TIA patients, excluding those with hemorrhagic stroke and those with stays of less than 24 hours.
[e]Ischemic stroke patients.
[f]All stroke and TIA patients.
[g]All stroke and TIA patients with history of current smoking.
[h]All stroke patients (TIA patients excluded).

than do nonparticipating hospitals, which may limit the generalizability of NCSSC findings. Although NCSCC hospitals may differ somewhat from other hospitals in the state, participating hospitals come from all geographic regions of North Carolina and represent a mix of academic and nonacademic, rural and urban, and small and large hospitals. Because the NCSCC requires no fee for participation, barriers to participation were low.

A particular strength of the NCSCC is its collaboration with the North Carolina Division of Public Health and other key stakeholders, enabling a natural link for hospital-level and regional and statewide primary and secondary stroke prevention activities.

The NCSCC provides a wide variety of hospitals in North Carolina with a valuable and sustainable mechanism for creating data-driven support for targeted QI programs. Overall, participating hospitals are providing recommended care in many performance areas for the treatment of acute stroke, and substantial improvements have been made over time in the provision of recommended treatments for which patients are eligible. These data highlight the importance of hospitals' dedication to providing a coordinated system of care. NCMJ

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