EMERGENCY MEDICAL SERVICES CAPACITY FOR PREHOSPITAL CARE OF STROKE PATIENTS IN NORTH CAROLINA

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ABSTRACT

MEHUL D. PATEL: Emergency Medical Services Capacity for Prehospital Care of Stroke Patients in North Carolina
(Under the direction of Wayne D. Rosamond)

An acute stroke requires immediate medical attention. Emergency medical services (EMS) can positively impact acute stroke patients through early identification and expedited transport to specialized acute care facilities. However, EMS systems are not equally qualified and prepared to respond to, evaluate, and manage stroke patients in a timely manner.

The aims of this dissertation were twofold. First, the capacity of EMS systems in North Carolina (NC) for prehospital stroke care was assessed. Education of EMS personnel on stroke should continue to be an area of focus, particularly the frequency and content of trainings. Significant progress has been made in prehospital stroke care in NC, specifically with the use of standardized patient care protocols, validated scales and screening tools, destination plans, and advance notification policies. However, improvements in the use of stroke destination plans and communication of stroke screen results remain to be realized. Overall deficiencies in EMS stroke care capacity were observed regardless of system patient volume and population density.

Secondly, prehospital time intervals for EMS responses to patients suspected of having a stroke were evaluated. While national consensus guidelines recommend EMS responds to a stroke patient in 9 minutes and spends no more than 15 minutes at the scene before transport, almost half of suspected stroke events took longer than

recommended in NC in 2009-2010. EMS units that responded with lights and sirens were associated with shorter time intervals, suggesting that a greater sense of urgency leads to expedited responses. Furthermore, EMS systems that included specific instructions in their stroke protocols to limit scene time were associated with significantly shorter time units spent at the scene with a suspected stroke patient.

Prehospital stroke care requires continuous monitoring and quality improvement efforts at the system and personnel levels. This dissertation identified areas of system capacity in need of improvement and evaluated predictors of prehospital delays in NC. Other regions in the United States could similarly assess their stroke experiences using these tools. Finally, further study of the impact of EMS stroke care on emergency department and hospital processes are warranted.

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LIST OF ABBREVIATIONS

AHA/ASA	American Hearth Association/American Sroke Association
ALS	Advanced Life Support
APCO	Association of Public-Safety Communications Officials
BLS	Basic Life Support
CDC	Centers for Disease Control and Prevention
CI	confidence interval
CIS	Credentialing Information System
Co.	county
CPSS	Cincinnati Prehospital Stroke Scale
CQI	Continuous Quality Improvement
CT	Computed Tomography
ED	Emergency Department
EMD	Emergency Medical Dispatch
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
EMSPIC	EMS Performance Improvement Center
IQR	Interquartile Range
IV	Intravenous
LAPSS	Los Angeles Prehospital Stroke Screen
min	minute
MPDS	Medical Priority Dispatch System
MRI	Magnetic Resonance Imaging
NC	North Carolina

NCCEP	NC College of Emergency Physicians
NEMSIS	National Emergency Medical Information System
NHTSA	National Highway Traffic Safety Administration
OEMS	Office of EMS
OMB	Office of Management and Budget
PreMIS	Prehospital Medical Information System
PSC	Primary Stroke Center
US	United States

I. INTRODUCTION

An acute stroke requires immediate medical attention. For every minute an ischemic stroke goes untreated, the typical patient loses an estimated 1.9 million brain cells (Saver 2006). Emergency medical services (EMS) can positively impact acute stroke patients through early identification and expedited transport, thus leading to more timely delivery of treatments, notably thrombolytic therapy (Schwamm et al. 2005). With proper education and resources, EMS personnel are capable of performing screening tests for stroke in the field, initiating patient evaluation, and directly transporting appropriate patients to a specialized stroke center (Kothari et al. 1999b; Kidwell et al. 2000; Gladstone et al. 2009). However, current levels of EMS education and prehospital care practices for stroke patients are not well characterized and vary by region (Brice et al. 2008; Tsai 2008; Greer et al. 2012). Within a state like North Carolina (NC), EMS capacity may further vary by population size and density.

In this dissertation, EMS capacity for the prehospital care of stroke patients in NC was assessed with respect to education and training of EMS personnel, the use of prehospital screening tools, and policies on the management and transport of patients. Given the time urgency of current stroke treatment, American Heart Association/American Stroke Association (AHA/ASA) guidelines emphasize the completion of prehospital stroke care in the shortest amount of time possible (Acker et al. 2007; Jauch et al. 2013), so prehospital time intervals for EMS responses to patients with stroke were also investigated.

The following **specific aims** were addressed:

1. **Assessed current EMS capacity in NC to respond to, evaluate, and manage stroke patients**
    a. Evaluated variations in EMS stroke care capacity
    b. Estimated changes in EMS stroke care capacity since 2001
2. **Identified individual and ecological predictors of EMS time intervals among stroke patients**
    a. Evaluated distributions and correlates of EMS time intervals among stroke patients
    b. Estimated the association of EMS systems having detailed stroke protocols with minimization of time spent at scene with stroke patients

Stroke is a leading cause of death and disability in the United States (US), and EMS can play an important role in the care and treatment of stroke patients. This work identified areas of EMS stroke care capacity for improvement in NC. Also, the investigation of prehospital time intervals among stroke patients advanced the understanding and suggested ways to improve EMS responses. Findings from this dissertation not only have direct applications to EMS quality improvement in NC but can be generalized to prehospital stroke care in the entire US.

II. BACKGROUND AND SIGNIFICANCE

A. Burden of Stroke

Stroke is the 4th leading cause of death in the US, behind heart disease, cancer, and chronic lower respiratory disease (Miniño et al. 2011). National annual stroke mortality rates declined 34% from 1996 to 2006. The reasons for this decline are still not thoroughly understood but may be linked to a combination of reduced risk factors, particularly from better hypertension management, and improved case fatality, due to better treatment strategies (Luepker et al. 2006; Sturgeon and Folsom 2007). Nonetheless, stroke remains an important cause of mortality in the US accounting for 134,148 deaths in 2008 (Miniño et al. 2011). Studies of stroke incidence observed higher rates in the elderly, males, and blacks (Roger et al. 2011). While age-adjusted rates of first-ever stroke have been found to be stable over the 1990's, rates among blacks remained higher than among whites (Kleindorfer et al. 2006b), and although incidence has declined in the most recent decade, this was mostly observed in whites (Kleindorfer et al. 2010).

The state of NC has the 4th highest stroke death rate in the country from 2005-2007 (Roger et al. 2011); in 2006, the overall state rate was 52.4 per 100,000 compared to 43.6 per 100,000 for the entire nation (Huston 2010). NC is in the region of the southeastern United States referred to as the "Stroke Belt," where stroke mortality has been higher than average over the last 50 years (Figure 2.1). Furthermore, eastern NC is part of the "Stroke Buckle," the coastal plain regions of Georgia, South Carolina, and NC that have some of the highest stroke death rates in the country. According to the most recent “Burden of Cardiovascular Disease in North Carolina” report, stroke led to 4,477 deaths among North Carolinians in 2008 (Huston 2010). Although there were more female stroke deaths, males were more likely to die of stroke at a younger age. Similar to the rest of the US, blacks have higher stroke mortality rates compared to whites, and among blacks, males have higher rates than females. In 2007, there were 28,149 hospital discharges for stroke in NC, and even though age-adjusted hospitalization rates have declined since 1997, substantial numbers of North Carolinians

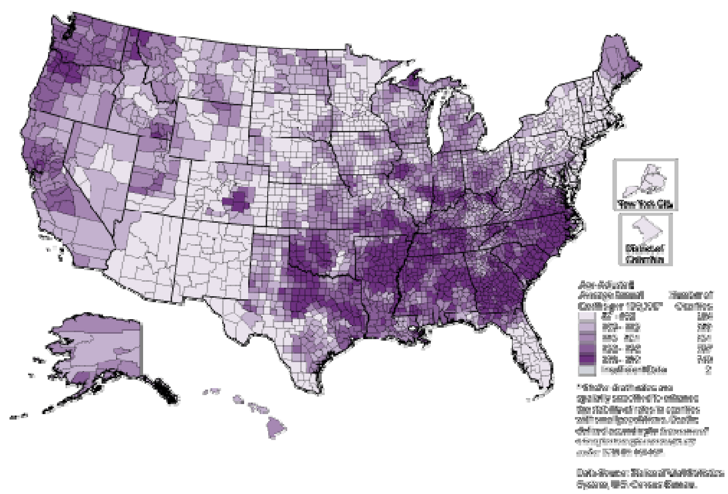


Figure 2.1. Age-adjusted Stroke Death Rates, Adults Ages 35 and Older, by County, 2000-2004

continue to be hospitalized for stroke. Similar to stroke mortality, rates of stroke hospitalization are higher among males and in the coastal plain regions of NC.

Long-term disability is also a serious concern in the aftermath of a stroke. A significant proportion of stroke survivors require outpatient rehabilitation, and depending on the severity of the stroke, around 15% to 30% can become permanently disabled and many more experience functional limitations (Asplund et al. 1998). Females have greater post-stroke disability than males. In the Framingham Heart Study, about one-third of female stroke survivors were limited in daily activities (e.g. eating, walking, dressing) 3 to

6 months after stroke, which was almost twice the proportion of men (Petrea et al. 2009). Independent of age and sex, black stroke survivors are more likely to report activity limitations than whites (McGruder et al. 2005). In terms of economic burden, Brown et al. (2006) projected the direct and indirect cost of ischemic stroke in the US to exceed $2 trillion for the period 2005-2050.

In conclusion, stroke-related disability can pose a large burden to individuals, their families, and the healthcare system. Better primary and secondary prevention can significantly reduce the public health and economic burden of stroke. The prevention and control of stroke risk factors and public knowledge of stroke signs and symptoms are critical areas for improvement. Stroke awareness programs inform the general public of the warning signs of stroke and the importance of calling 9-1-1 as soon as symptoms are experienced or witnessed. Acute care of stroke patients is also an important prevention strategy and can significantly impact survival and recovery.

B. Acute Stroke Care

Considerable advancements in acute care of stroke patients have been made in the last 20 years, notably the approval of thrombolytic therapy (i.e. recombitant tissue plasminogen activator, tPA) for ischemic stroke (National Institute of Neurological Disorders and Stroke: rt-PA Stroke Study Group 1995), which significantly improves patient outcomes when administered in a qualified acute care facility within 3 hours of symptom onset (Marler et al. 2000; Adams et al. 2007; del Zoppo et al. 2009). Therefore, it is imperative acute stroke victims seek medical care as soon as possible and receive diagnostic assessment and medical evaluation in a timely manner. Despite the availability of an effective evidence-based treatment, very few ischemic stroke patients actually receive thrombolytics (Deng et al. 2006; Kleindorfer et al. 2009), in part due to prehospital delays (del Zoppo et al. 2009). In fact, it has been reported that only 40% of stroke patients in the US arrive to the hospital or emergency department (ED) within the optimal 2 hours since onset (Lichtman et al. 2009) while a comprehensive review found reports of the percent arriving within 3 hours ranging from 6% to 92% (Evenson et al. 2009).

Medical treatment options for intracerebral and subarachnoid hemorrhages, such as antihypertensive agents and surgical interventions, are not as effective as thrombolytics are for ischemic strokes (Broderick et al. 2007; Morgenstern et al. 2010); however, hemorrhagic strokes are also serious medical emergencies and require immediate attention. Several acute conditions, such as seizures, migraines, and hypoglycemia, are referred to as “stroke mimics” because they cause neurological symptoms similar to a stroke (Suyama and Crocco 2002). Although these conditions may not be as serious to the patient, it is necessary to rule out a stroke as soon as possible. Regardless of the type of stroke, brain imaging, such as head computed tomography (CT) or magnetic resonance imaging (MRI), is needed to diagnose and to select the best treatment strategy. Furthermore, recent definitions of transient ischemic attack require neuroimaging to determine the risk of further ischemia (Saver and Kidwell 2004). The “Stroke Chain of Survival” (Figure 2.2) summarizes the actions (8 D’s) across the stroke continuum of care that typically need to occur to assure patient survival and recovery (Jauch et al. 2010). Emergency medical services are generally involved with the first 3 D’s: “Detection,” “Dispatch,” and “Delivery.” Treatment strategies will vary based on patient’s condition, care provider’s decision, and facility resources. Nonetheless, essential emergency stroke care is prompt neurologic examination and brain imaging followed by immediate medical therapy

“Detection”	Recognition of stroke signs and symptoms
“Dispatch”	Call 9-1-1 and priority EMS dispatch
“Delivery”	Prompt transport and prehospital notification to hospital
“Door”	Immediate ED triage
“Data”	ED evaluation, prompt laboratory studies, and CT imaging
“Decision”	Diagnosis and decision about appropriate therapy
“Drug”	Administration of appropriate drugs or other interventions
“Disposition”	Rapid admission to stroke unit or critical-care unit

Figure 2.2. Stroke Chain of Survival

C. Role of Emergency Medical Service

1. Background on EMS

EMS refers to the provision of out-of-hospital emergency medical care to patients with injuries and acute illnesses. Throughout the world, models of EMS care generally fall under one of the two categories: physician-led and those led by out-of-hospital care professionals such as emergency medical technicians (EMT) and paramedics. The Franco-German model is physician-led, where the doctor is brought to the patient, while the Anglo-American model utilizes specialists like EMTs as the first medical contact (Dick 2003). Traditionally, the latter model’s main purpose is to stabilize and transport the patient as expeditiously as possible to an acute care facility, sometimes referred to as the “scoop and run” approach. On the other hand, the “stay and play” approach of the Franco-German model emphasizes care for the patient by qualified emergency physicians at the scene or in the home, when appropriate. These different models have led to significant differences in the organization of EMS across countries, and their relative effectiveness has been the subject of much study and debate, especially in the trauma literature (Spaite et al. 1995). This dissertation focused on the prehospital specialist-based model rather than the physician-led model since the former is the routine in the US.

The development of modern EMS and its systems in the US reached a pivotal point with the passage of the Emergency Medical Services Systems Act of 1973, which increased federal EMS funding and promoted the development of comprehensive regional systems of EMS care. The US Public Health Service Act (Section 1201 (1)) states that an EMS system "provides for the arrangement of personnel, facilities, and equipment for the effective and coordinated delivery in an appropriate geographic area of health care services under emergency conditions (occurring either as a result of the patient's condition or of natural disasters or similar conditions) and which is administered by a public or nonprofit private entity which has the authority and the resources to provide effective administration of the system." However, the federal funding generally failed to produce lasting EMS systems due to the lack of local interest and provisions (Suburban Emergency Management Project 2005a).

In the 1990's, the health care system faced changes as hospitals became financially overburdened with an unanticipated increase in trauma patients, many of whom were poor and uninsured (Suburban Emergency Management Project 2005b). In response, Congress appropriated federal funds to reimburse hospitals for uncompensated costs of trauma care. The Trauma Care Systems Planning and Development Act of 1990 (Public Law 101-590) required states demonstrate, in order to receive funds, that their trauma care was coordinated between EMS and hospitals as inclusive trauma systems of care. Although many hospitals resisted this designation due to fear of additional burden of uninsured patients, many states encouraged the planning and development of trauma systems and significant progress was made over the decade. Riding this momentum, in 1996, the National Highway Traffic Safety

Administration and the Health Resources and Service Administration jointly developed and produced the “EMS Agenda for the Future” – a milestone document outlining the new vision for EMS in the US. It stated, “This new entity [EMS] will be developed from redistribution of existing health care resources and will be integrated with other health care providers and public health and public safety agencies. It will improve community health and result in more appropriate use of acute health care resources. EMS will serve as the public emergency medical safety net” (NHTSA 1996). To realize this vision, the document proposes ongoing development of 14 essential attributes of EMS, including integration of health services, EMS research, medical direction, communication systems, and evaluation. National, state, and local EMS organizations have taken different steps to achieve this singular vision.

2. EMS in North Carolina

The mission of the NC Office of EMS (OEMS) is to “foster emergency medical systems, trauma systems and credentialed EMS personnel to improve in providing responses to emergencies and disasters which will result in higher quality emergency medical care being delivered to the residents and visitors of North Carolina”. Established in 1973, this agency is funded to oversee and coordinate EMS training standards, credentialing of EMS providers and 9-1-1 dispatchers, and in general developing the components of an EMS system (Pratt 2007). Then in 1999, after the national “EMS Agenda for the Future” was published, new areas, such as EMS research, systems finance, and information systems, were beginning to be addressed. This led to the passing of two landmark EMS bills in 2001: the EMS Act of 1973 Update (House Bill (HB) 452) and the Regulation of EMS Act (HB 453). Becoming law on January 1, 2002, the new legislation required additional structure for EMS in the state. The definition of the “Statewide EMS System” called for the full integration of EMS with other health care providers and the public health system (HB 452 § 143-507). A key piece in the legislation placed the responsibility of providing EMS to the public with the county board of commissioners, which established local county-based EMS systems. Each system was required to submit a comprehensive plan for local EMS to the NC OEMS, and all EMS providers and dispatchers within a county must be licensed to operate as part of the county's EMS system. This resulted in further coordination of the 850 EMS agencies and thousands of personnel providing services and care in NC (Pratt 2007). In 2010, the entire state adopted standard EMS protocols, developed by the NC OEMS and the NC College of Emergency Physicians (NCCEP). The 2009 NCCEP Patient Care Treatment Protocols (see Appendix A for the suspected stroke protocol) were to be implemented starting January 1, 2010. In order to have modified or added to the statewide protocol, the local EMS system must have received approval from the state EMS medical director.

EMS personnel in the US are generally credentialed at one of four levels (from lowest level to highest): first responder, EMT-Basic (EMT-B), EMT-Intermediate (EMT-I), and EMT-Paramedic (EMT-P or "paramedic"). First responders usually arrive first to the scene before other EMS personnel. According to nationally developed curricula (Margolis 2007), they need to know cardiopulmonary resuscitation, airway management, circulation evaluation, bleeding control, and other basic patient evaluation and management skills. Basic-level EMTs have more advanced knowledge of medical emergencies and additional skills like the use of automated external defibrillator devices. Intermediate-level EMTs have additional clinical education and can administer certain medications by intravenous (IV) and perform and interpret electrocardiograms (ECG). Paramedics are the highest level of EMS personnel and tend to have more advanced knowledge and experience and are more skilled at procedures, such as endotracheal intubation and IV access. Systems with only first responders or EMT-Bs are considered to provide basic life support (BLS) services while systems with either EMT-Is or -Ps provide advanced life support (ALS) services.

Local EMS systems in NC are authorized to set education and training requirements for each of these certification levels, though the NC OEMS provides minimum requirements and curricula for initial certification and continuing education. For initial certification, first responders are required at least 69 hours of didactic teaching and skills practice while EMT-Bs, EMT-Is, and paramedics are required more hours of education (169, 256, and 1,096 hours, respectively). In addition, each certification level requires at least 96 hours of continuing education every 4 years. In regards to 9-1-1 dispatchers, the NC OEMS requires at least 24 hours of education for the emergency medical dispatch (EMD) certification level. A high school or general educational development (GED) education is required for all EMS professions while EMT-Is are required to have post-secondary level reading and writing skills and basic math skills. Moreover, paramedics in NC are required to have taken an anatomy and physiology course. In December 2011, there were 2,038 first responders, 23,877 EMT-Bs, 2,621 EMT-Is, 7,246 paramedics, and 2,160 EMDs for a total of 37,942 certified EMS personnel in NC (EMS Performance Improvement Center 2012a).

3. Prehospital Care of Stroke

EMS has the potential to benefit many acute stroke patients, but numerous studies have reported only about a half (ranging from 39-66%) of acute stroke patients in the US utilized and were transported to the hospital by EMS (Menon et al. 1998; Rosamond et al. 1998; Kothari et al. 1999a; Porteous et al. 1999; Morris et al. 2000; Schroeder et al. 2000; Wein et al. 2000; Williams et al. 2000; Lacy et al. 2001; Adeoye et al. 2009; George et al. 2009; Rose et al. 2008; Patel et al. 2011), with similar estimates from other parts of the world (Harraf et al. 2002; Koutlas et al. 2004; Li et al. 2005;

Maestroni et al. 2008). EMS transport, compared to private modes (e.g. neighbor's personal car, taxi), has been shown to have the greatest impact on reducing delays from onset to hospital arrival and delays in hospital evaluation and treatment administration. Not only do patients who initiate contact with EMS arrive faster to the ED or hospital, but they are also evaluated faster while in the hospital (e.g. seen by a physician, received CT scan) (Menon et al. 1998; Rosamond et al. 1998; Kothari et al. 1999a; Wester et al. 1999; Morris et al. 2000; Lacy et al. 2001; Harraf et al. 2002; Bohannon et al. 2003; Katzan et al. 2003; Chang et al. 2004; Rossnagel et al. 2004; John et al. 2005; Centers for Disease Control and Prevention (CDC) 2007; Maestroni et al. 2008; Rose et al. 2008). These studies were conducted in various geographic locations (US, Europe, Asia) and among different stroke patient populations, such as final hospital diagnosis, ED diagnosis, and initial clinical impression. Furthermore, studies accounted for potential confounding by stroke severity in various ways. Nonetheless, these studies found consistent associations and arrived at similar conclusions.

The destination ED or acute care facility may also receive prenotification of a suspected stroke and mobilize resources (e.g. clear the CT scanner) while the patient is en route (Abdullah et al. 2008; McKinney et al. 2013; Patel et al. 2011). Reduced delays are expected to result in timelier and more frequent administration of tPA. Additional research suggests EMS utilization and prehospital notification increases tPA rates in ischemic stroke patients and reduces the time to treatment (Abdullah et al. 2008; Kim et al. 2009), though most studies have been conducted in populous urban settings. Moreover, some EMS systems are beginning to implement destination plans that allow EMS responders to bypass local hospitals and directly transport patients to a comprehensive stroke center where specialized stroke care like the administration of thrombolytic therapy can be provided (Quain et al. 2008; Perez de la Ossa et al. 2009; Gladstone et al. 2009). Further research is needed to demonstrate how these benefits in delays and access to treatment translate into improvements in patient health, such as survival and functional status.

Besides an emergency 9-1-1 response and ambulance transport to an acute care facility, the prehospital care of stroke patients by EMS personnel (i.e. EMTs, paramedics) varies between providers and EMS systems (Garrison and Brice 2007). Research has shown that EMS personnel are capable of accurately identifying strokes in the field using validated prehospital stroke assessment tools. There are numerous stroke screening tools that have been developed and field-tested in the US (Smith et al. 1999; Kothari et al. 1999b; Kidwell et al. 2000; LaCombe et al. 2000; Tirschwell et al. 2002; Gordon et al. 2005; Nazliel et al. 2008) and abroad (Harbison et al. 2003; Bray et al. 2005a; Chenkin et al. 2009) (see Appendix B for a summary). All vary in terms of comprehensiveness and diagnostic accuracy, and while some underperformed in certain settings, the use of these scales is generally considered to improve stroke identification by EMS professionals in the field. The Cincinnati Prehospital Stroke Scale (CPSS) and the Los Angeles Prehospital Stroke Screen (LAPSS) are currently recommended for use by EMS providers in the US (Acker et al. 2007) (Figure 2.3).

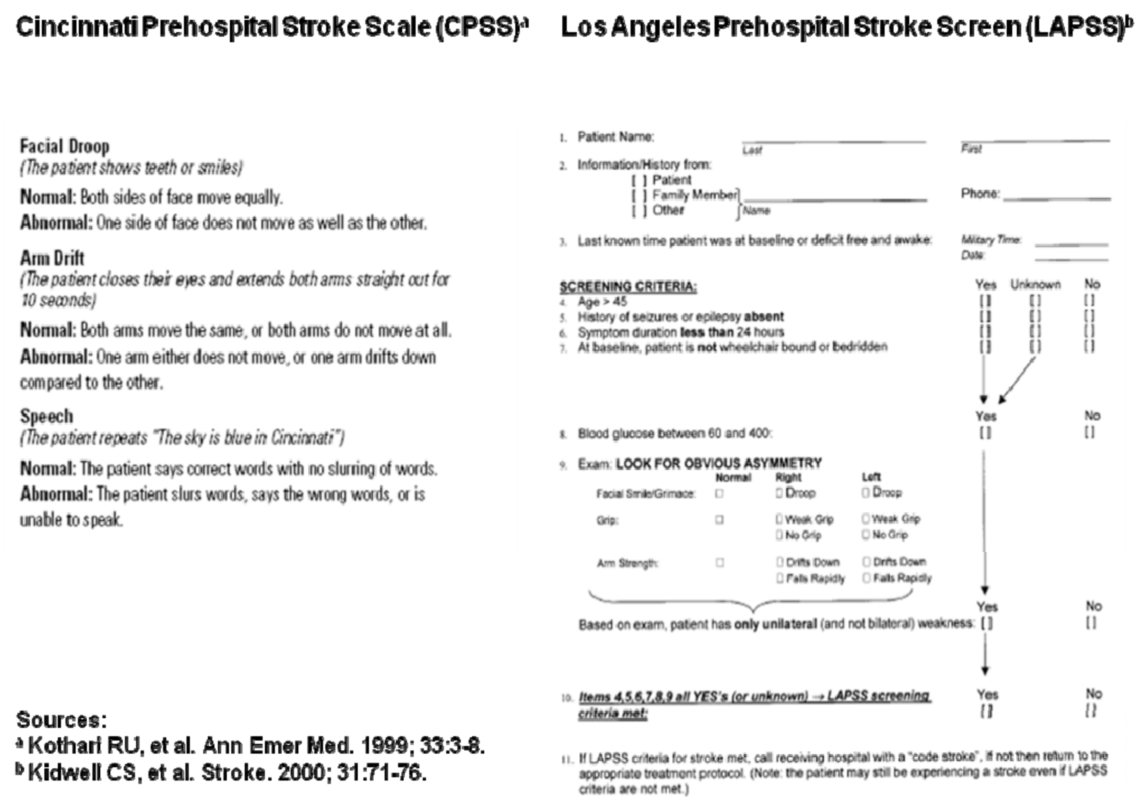


Figure 2.3. Two commonly used prehospital stroke screening tools

The CPSS was first piloted in 1995 by Kothari and colleagues at the University of Cincinnati as an out-of-hospital stroke diagnosis tool to be used by both physicians and EMS personnel (Kothari et al. 1997). It consists of three physical examination items from the NIH stroke scale found to be most useful in the rapid and accurate identification of stroke patients - facial droop, arm drift, and abnormal speech. A validation study by CPSS creators showed high agreement between EMS and ED physician on all three scale items (Kothari et al. 1999b). Also, they reported high inter-rater reliability between multiple paramedics and EMTs for total score (r=0.89) and each item (r's=0.78-0.91). Also for prehospital providers, a single abnormality in the CPSS had moderate sensitivity (59%) and high specificity (88%) in the identification of hospital diagnosed strokes. However, recent reports of CPSS sensitivity and specificity vary widely (Bray et al.

2005b; Ramanujam et al. 2008; Frendl et al. 2009; Bergs et al. 2010; Bray et al. 2010), which may be due to differences in the certification levels of EMS personnel, educational interventions, and the populations under study.

The LAPSS was designed and developed in 1997 by researchers at UCLA Medical Center (Kidwell et al. 1998). Based on a physical examination of facial paresis, arm drift, and hand grip strength, a LAPSS positive patient is 45 years or older, has no history of seizures, has symptoms lasting fewer than 24 hours, is not wheelchair bound or bedridden, has a normal blood glucose level (60-240 mg/dL), and a unilateral deficit in at least one of the physical exam items. In a validation of their screening tool, Kidwell et al. (2000) found paramedics identified strokes among patients with relevant neurologic symptoms with a sensitivity of 91% and specificity of 97%, compared to an independent reviewer's diagnosis using ED charts. In the Houston Paramedic and Emergency Stroke Outcomes (HoPSTO) study, paramedics trained in a modified LAPSS (excluding the age criterion) had similarly high sensitivity and specificity (95% and 98%, respectively) (Wojner-Alexandrov et al. 2005).

Given that the LAPSS is more comprehensive (e.g. history, blood glucose levels), it is not surprising that it has been found to be less sensitive but more specific than the 3-item CPSS in direct comparisons (Bray et al. 2005a; Bergs et al. 2010). Also, in a relatively small Belgium study, the LAPSS was more accurate than the CPSS (77% vs. 71%) although it was slightly less accurate in a study in Melbourne (80% vs. 84%). This discrepancy could be explained by differences in study population and paramedic training. Nonetheless, the LAPSS generally outperforms the CPSS in diagnostic accuracy while the CPSS is more favorable in other regards: proven reliability (Kothari et al. 1999b) and ease of use (Kothari et al. 1997; Liferidge et al. 2004; Hurwitz et al. 2005).

Stroke patient care protocols are useful tools and are used by many EMS agencies (Brice et al. 2008; Tsai 2008) (see Appendix A for the NC standardized version). Written instructions state the specific screening tools and additional steps for documenting onset time, measuring blood glucose level, recording cardiac rhythm, determining thrombolytic eligibility, and minimizing on-scene time (Sayre 2002). Since timeliness is critical for these therapies, it is recommended to minimize the time spent at the scene, preferably to less than 10 (Sayre 2002; Millin et al. 2007) or 15 minutes (Acker et al. 2007; Jauch et al. 2013). Further, EMS personnel may be expected to follow a written plan to identify the best hospital destination and to notify the hospital prior to arrival. More advanced prehospital stroke care practices, such as treating hypoxia or administering neuroprotective agents, have been proposed, but these are not currently supported by evidence (Sayre et al. 1997; Sayre 2002; Crocco et al. 2003; Saver and Kidwell 2004; Millin et al. 2007). Stroke care best practices for EMS providers are often locally determined, but national consensus reports recommend a set of measures to be used to evaluate EMS performance and quality of care (Adams et al. 2007; Millin et al. 2007), which have been adopted in NC (Williams et al. 2009). These performance measures include: 1) stroke screen performed using a validated tool (i.e. CPSS, LAPSS), 2) time of symptom onset (or last known well) noted, 3) assessed for thrombolytic therapy eligibility, 4) blood glucose checked for hypoglycemia or hyperglycemia, 5) cardiac rhythm checked for arrhythmias, and 6) minimized total time spent on-scene. However, the provision of these measures in the field is not well-known.

To initiate an EMS response, patients experiencing stroke-like symptoms call 9-1-1 themselves, but most commonly it is called by a family member or bystander (Rosamond et al. 2005). Their first emergency medical contact is with the telecommunicator who receives the call and dispatches EMS to the patient’s location. These dispatchers, especially in EMD-certified call centers, may use pre-approved, standardized triage algorithms to guide EMS dispatch, such as the Medical Priority Dispatch System (MPDS) or the Association of Public-safety Communications Officials (APCO) system. For example, the MPDS dispatch protocol, “Card 28,” (Figure 2.4) directs the line of questioning the dispatcher proceeds through as the caller provides information suggesting a stroke. However, not all call centers use these standardized protocols (Evenson et al. 2007). Although reports of dispatchers predicting a stroke are as low as 40% (Porteous et al. 1999; Ramanujam et al. 2008; Buck et al. 2009), telecommunicators can save time with the early recognition of stroke and the appropriate EMS dispatch. To improve dispatcher recognition, a study is underway to assess the effectiveness of adding a dispatcher-administered CPSS to the MPDS protocol (Govindarajan et al. 2011; Govindarajan et al. 2012). In fact, others have already found success in directing laypersons via telephone to administer the CPSS (Liferidge et al. 2004; Hurwitz et al. 2005), though these studies were not conducted in a field setting. Nevertheless, 9-1-1 dispatchers are an untapped resource for the prehospital recognition and management of suspected stroke.

Figure source: **Govindarajan P,** Ghilarducci D, McCulloch C *et al.* Comparative evaluation of stroke triage algorithms for emergency medical dispatchers (MeDS): prospective cohort study protocol. *BMC Neurol* 2011;**11**:14.

Figure 2.4. Card 28 in the Medical Priority Dispatch Systems (MPDS) protocol to evaluate stroke

4. Stroke Systems of Care

The delivery of acute stroke therapies can be expedited and enhanced through the integration of healthcare facilities, agencies, and providers into a stroke system of care (Schwamm et al. 2005; Acker et al. 2007; Alberts et al. 2011). According to the AHA/ASA Task Force on the Development of Stroke Systems, a stroke system of care “should coordinate and promote patient access to the full range of activities and services associated with stroke prevention, treatment, and rehabilitation” (Schwamm et al. 2005). Since emergency treatment for acute stroke primarily occurs in the hospital, some hospitals are becoming certified as Primary Stroke Centers (PSC), or facilities with specialized resources and personnel to provide advanced stroke care, particularly the administration of tPA (Alberts et al. 2011). On the other hand, other hospitals are unable or not willing to administer tPA in stroke patients around the clock. A recent study found almost 45% of Georgia, South Carolina, and NC residents do not live within 30 minutes of a Joint Commission-certified PSC, and furthermore, a large percent of stroke deaths occur in regions not serviced by these recognized stroke care centers (Khan et al. 2011). Another recent study suggests admission to a specialized stroke center is associated with increased thrombolytic use and modestly lower mortality (Xian et al. 2011), although this warrants further research. Nonetheless, stroke systems of care are needed to coordinate the timely delivery of treatments within regions with varying emergency care capabilities and resources.

Multiple national groups, including AHA/ASA and the Brain Attack Coalition, are now emphasizing the importance of incorporating EMS into regional stroke systems of care for the primary role of prehospital management (Morgenstern et al. 2003; Schwamm et al. 2005; Acker et al. 2007). Emphasis is placed on EMS systems to ensure that personnel involved in 9-1-1 telecommunication, emergency medical dispatch, and EMS response and transport receive training, tools, and protocols that meet current prehospital stroke care guidelines. Many EMS prehospital protocols incorporate triage and destination plans to aid in the decision to where to transport a patient suspected of experiencing an acute stroke. Furthermore, the dispatch centers that answer 9-1-1 calls play an important role in who responds in these situations and with what priority. A number of studies have shown some reduction in delay times and increase in treatment through the coordination of stroke responses between dispatch centers, EMS agencies, and EDs (Morgenstern et al. 2002; Perez de la Ossa et al. 2008; Puolakka et al. 2010). Finally, an effective system of stroke care requires continuous quality improvement and the development and ongoing monitoring of performance measures for its components (Acker et al. 2007). Evaluation of both process and outcome measures and feedback to providers are essential to assure optimal care and service delivery. Process performance measures for EMS can include stroke screen performed or on-scene time minimized while patient outcome measures like mortality and functional status also need to be evaluated as a part of quality improvement. Lastly, as new treatment modalities for stroke emerge, EMS systems must continue to collaborate with other components of the entire stroke system of care.

5. EMS System Capacity

An EMS system is the organization and coordination of EMS care providers and 9-1-1 dispatchers for a specific geographic service area. The care and services provided by these professionals partially depends on their education and training, resources (e.g. written patient care protocols) available to them, and the implementation of policies and plans encouraging best practices – all of which are encompassed under the term "capacity" (see later sections for more detailed description). This term is often used in this dissertation to refer to an EMS system's actual and potential ability to optimally respond to and manage patients in the prehospital setting, where examples of capacity would be the number of certified paramedics in a system, training of EMS providers to perform a certain medical procedure, and instituting a policy that encourages a recommended patient care practice.

There is believed to be significant variation between EMS systems and the care they provide (Garrison and Brice 2007). Research has shown significant regional variability in out-of-hospital trauma care in the US, and while the authors posit potential reasons like system organization, medical direction, and paramedic training, they were not further investigated (Bulger et al. 2007). Prehospital management of acute stroke also varies by EMS system and region and can depend on personnel certification level and system capacity. Studies have shown the accuracy of stroke identification by prehospital care provider increases after given appropriate education and training (Smith et al. 1999; Harbison et al. 2003; Wojner et al. 2003; Wojner-Alexandrov et al. 2005); however, not all EMS personnel receive stroke-specific education and training on a regular basis (Crocco et al. 1999). Hospitals, in their capacity to optimally treat and manage stroke patients, are commonly assessed and monitored(Goldstein et al. 2000; Ruland et al. 2002; Okon et al. 2006; Albright et al. 2009; Goldstein 2010; Okon et al. 2010; Shultis et al. 2010). In fact, researchers have found improvements in NC hospitals from 1998-2008 (Goldstein 2010). Similarly, EMS systems need to be regularly assessed and monitored for their capacity to manage stroke patients in the prehospital setting.

D. Public Health Significance

Over the last decade in NC, roughly 28,000 patients per year were hospitalized for stroke (Huston 2010). Given about half of stroke patients in NC arrive to the hospital by EMS (Rose et al. 2008; Patel et al. 2011), an estimated 14,000 stroke patients came in contact with an EMS care provider, and this figure does not include out-of-hospital stroke deaths and stroke mimics that could potentially initiate an EMS response as well. Although some have shown only 3% of ambulance transports had a final stroke diagnosis, 34% of runs were non-traumatic, neurological complaints (Kidwell et al. 2000). Therefore, prehospital care practices for stroke may be relevant to a substantial number of EMS encounters, not just the ones for “real” strokes. In conclusion, EMS already impacts a large number of stroke patients in NC annually and could be even greater if more people (or witnesses) called 9-1-1 when experiencing (or observing) stroke-like symptoms.

Studies on EMS and acute stroke patients up to this point have demonstrated a benefit of EMS transport over private means, but there has been only limited research in the differences between EMS systems and their impact on patient care. EMS systems cover the entire scope of prehospital patient care from licensing and employing 9-1-1 dispatchers and EMS care providers to setting standards for education and training and patient care protocols and policies. A systems-approach is one way to initiate change in order to improve patient, as shown in the trauma literature (Ornato et al. 1985). However, there is currently little information on EMS systems of stroke care. Assessing the current state of EMS system capacity for stroke and evaluating changes over time and areas for improvement are the first steps in identifying new ways to improve the prehospital care of stroke patients.

III. REVIEW OF THE LITERATURE

This dissertation explored the topic of EMS and prehospital stroke care. This chapter presents the current state of knowledge and a critical review of the literature for these specific aims:

Specific Aim 1. Assessed current EMS capacity in NC to respond to, evaluate, and manage stroke patients

a. Evaluated variations in EMS stroke care capacity
b. Estimated changes in EMS stroke care capacity since 2001

Specific Aim 2. Identified individual and ecological predictors of EMS time intervals among stroke patients

a. Evaluated distributions and correlates of EMS time intervals among stroke patients
b. Estimated the association of EMS systems having detailed stroke protocols with minimization of time spent at scene with stroke patients

A. Specific Aim 1 – EMS stroke care capacity

1. EMS systems

EMS is organized differently across the US. Generally, in each state, EMS personnel are employed by EMS agencies, and one or more agencies will be certified to respond to 9-1-1 calls and transport patients for a geographic region. The NC OEMS sets the minimum requirements for training and oversees the credentialing of EMS agencies. In NC, state legislation passed in 2001 mandated the creation of “local” county-based EMS systems to coordinate the credentialing of EMS agencies for each county under the broader oversight of the NC OEMS EMS (Mears et al. 2010). Whereas in many states, EMS personnel are employed and overseen by agencies, NC has a unique organization with an additional level within the personnel-agency-system-state structure. Each EMS system has a medical director, a licensed physician who provides medical oversight and, with guidance from the NC Office of EMS, can set educational requirements or modify patient care protocols, for example. However, the involvement of medical directors in local EMS tends to vary (Greer et al. 2012).

2. EMS capacity for prehospital stroke care

a) EMS Education and Training

The current level of stroke education and training provided to EMS personnel is not well-known. Further complicating the matter is that educational curricula and requirements are not set to national standards; they are regulated at the local level, which leads to considerable variation between regions (Alberts et al. 2011). A nationwide mailed survey of EMTs in 1999 found 87% were required at least 1 hour of stroke education as part of initial training, although only half had subsequent sessions for continuing education (Crocco et al. 1999). Education was largely in reference to knowledge of stroke signs and symptoms, risk factors, types and mimics, and management and treatment. The authors state that almost all respondents could correctly define a stroke and list the major stroke signs and risk factors. However, two-thirds were unaware of the 3-hour tPA window, and a substantial proportion (25%) felt stroke could be treated on a nonemergent basis. Only the higher levels of EMT (intermediate and paramedic) were sampled, so excluding EMT-Bs would expect to overestimate the overall frequencies of stroke education and knowledge. Also, of the 983 EMTs randomly sampled from a national database and mailed a survey, only 36%

responded, and although responders and non-responders were equivalent on demographic factors, there is some concern for selection bias. The low response rate may be due to a lack of interest in the survey content and the burden of completing then mailing back the questionnaire.

Recently, two cross-sectional telephone surveys (adapted from Crocco et al. (1999)) of Montana EMTs in 2006 and 2009, as part of the Montana Stroke Initiative, investigated stroke knowledge among licensed EMTs (McNamara et al. 2008; Oser et al. 2010). EMT knowledge was relatively low for awareness of stroke signs and symptoms (60%), risk factors (45%), and the 3-hour tPA window (57%) (McNamara et al. 2008), and furthermore, the Montana Stroke Initiative EMS continuing education program included these focus areas, and no significant improvements were seen (Oser et al. 2010). On the other hand, a significantly higher percentage of EMTs reported training on stroke screens in 2009 (62%) compared to in 2006 (42%) (Oser et al. 2010). Although the generalizeability of EMS in Montana to other regions, like populous urban areas, may not be valid, they surveyed a representative sample of all EMT levels and first responders, unlike Crocco et al. Although the response rates for both surveys (55% and 46%, respectively) were higher than Crocco et al.'s national survey, participation was still low (Oser et al. 2010). In general, participation has been much better for surveys of EMS agency directors and chiefs while responses from EMTs tend to be more difficult to obtain. Nonetheless, these findings support the need for more stroke education among EMS personnel.

Generally, the stroke-specific education and training requirements of EMS personnel are locally determined. In 2001, EMS researchers in NC mailed surveys to the 83 largest EMS agencies (Brice et al. 2008). Of the 72 responding, 89% reported providing their EMS personnel some stroke education in the past 2 years, and of those, 55% provided at least 5 hours of training. Stroke risk factors, signs and symptoms, and pathophysiology were topics often covered (>90%) while education on stroke scales and thrombolytic therapy were less common (69% and 62%, respectively). Even though the survey had a high response rate (86%), these estimates may be upwardly biased since only the largest agencies, presumably with the most resources, were selected for the survey. Also, these results are from over 10 years ago and may not reflect current EMS stroke care capacity. A more recent survey of Minnesota EMS agencies was conducted in 2006 (Tsai 2008). EMS directors were queried on the frequency and format of stroke trainings provided to their EMS personnel. They reported 60% are trained in stroke at least once a year and another 30% every 2 to 3 years. A large majority of trainings were offered in classrooms (70%) compared to DVD or video (10%) and online (3%) formats. The specific topics covered in stroke trainings were not investigated. While all Minnesota agencies were surveyed, the response rate was 77% (Tsai 2008), somewhat lower than the comparable NC survey (Brice et al. 2008).

b) EMS Protocols, Practices, and Policies

Like education and training requirements for EMS professionals, there are no national standards of patient care protocols and policies for stroke. These are left to the discretion of the local medical director and state regulatory office. Crocco et al.'s (1999) national survey of EMTs found only 60% reported their department had a stroke protocol (i.e. a specific set of instructions on the management of a stroke patient). Meanwhile, the 2006 survey of Montana EMTs also found nearly the same proportion (61%) reported a stroke protocol, albeit within a smaller region (McNamara et al. 2008) . Oser et al. (2010) observed a significant increase to 69% after a repeat survey three years later. In fact, improving stroke protocol use was a goal of the Montana Stroke Initiative. In other regions of the US, 83% of EMS agencies in NC reported a protocol for the prehospital management of stroke patients (Brice et al. 2008) while a lower percent (76%) in

Minnesota reported stroke protocols (Tsai 2008). While most NC EMS agencies reported the use of a stroke protocol in 2001, a significant proportion (17%) reported no stroke protocol, and many of the protocols provided were missing specific instructions on stroke patient evaluation and hospital prenotification and transport (Brice et al. 2008). However, since January 1, 2010, all NC EMS systems are required to implement a standard stroke protocol.

EMS care of stroke patients may be insufficient given the lack of knowledge among EMTs. In 1999, Crocco et al. (1999) found about one-third of EMT-Is and 20% of paramedics did not know stroke patient management strategies (i.e. IV insertion, oxygen administration, blood glucose measurement, cardiac montoring). However, more recent EMT surveys in Montana found 90-100% were able to identify these strategies in both 2006 and 2009 (McNamara et al. 2008; Oser et al. 2010), so this may not be currently as much of a concern. They observed only 62% reported the use of stroke screening tools in 2009, although usage increased from 40% in 2006 (Oser et al. 2010). While the recent increase of stroke scale use in Montana may be due to efforts of the Montana Stroke Initiative, the 2006 survey findings are fairly consistent with 44% of NC agencies in 2001 and 47% of Minnesota agencies in 2006 reporting the use of stroke scales by their EMS personnel (Brice et al. 2008; Tsai 2008).

Policies to provide advance notification to the hospital of a potential stroke patient were fairly prevalent in NC and Minnesota (72% and 78%, respectively) (Brice et al. 2008; Tsai 2008). Moreover, 87% of EMTs in Montana reported prenotifying the hospital of a stroke (Oser et al. 2010). In addition, Tsai (2008) found that 37% of agencies reported the existence of a written transportation and destination plan for stroke patients. Recently introduced NC legislation states: “Emergency medical services systems shall adopt written policies and procedures to facilitate the identification and transport of suspected stroke victims to an appropriate health care facility” (HB 1396 §

131E-321). While Brice et al. (2008) did not investigate this in 2001, the NC OEMS has since developed a standard stroke destination plan template and mandated its implementation by January 1, 2010 (see Appendix C for NC stroke destination plan template). However, current usage of the plan in NC is not known. Moreover, it is not known whether these plans provide written guidance on patient transport to a specialized stroke center. Other EMS stroke plans and programs, such as prehospital identification and rapid transport, have been documented in other regions of the US (i.e. Pacific Northwest, Iowa, Illinois) (Ruland et al. 2002; Albright et al. 2009; Shultis et al. 2010). However, researchers used hospital-based surveys relying on hospital personnel to report on EMS, so results are likely inaccurate and unreliable given that some have observed hospitals are largely unsure of EMS policies and practices (Shultis et al. 2010).

3. Regional variations in EMS stroke capacity

Several deficiencies in EMS capacity have been noted in rural areas. In their review of articles on emergency care of acute stroke, Leira et al. (2008) found no articles suggesting rural prehospital stroke care was superior to urban care. Rural EMS personnel tend to be volunteers, less educated, and less experienced compared to their urban counterparts (Leira et al. 2008). Furthermore, in general, they receive less technical support and medical direction (Knott 2003). The same disparities are expected to be present for capacity specific to the prehospital care of stroke patients. Although McNamara et al. (2008) found similar stroke knowledge between EMTs in rural and urban counties, they observed significantly less stroke screen training and use of stroke screening tools and stroke protocols in rural counties. Moreover, while these parameters improved over time, urban-rural disparities persisted (Oser et al. 2010). However, these findings may not be applicable to other regions outside of Montana, so it is important to replicate these results in other areas.

In general, there is insufficient knowledge on regional disparities in EMS stroke capacity in the US. On the other hand, several studies have addressed differences in access to hospital stroke services and care for Americans, mostly between urban and rural areas (Ruland et al. 2002; Okon et al. 2006; Gropen et al. 2009; Miley et al. 2009; Okon et al. 2010; Pedigo 2010; Shultis et al. 2010; Khan et al. 2011). Regardless of the region, these studies consistently found better hospital-based stroke capacity in urban settings. However, differences in EMS stroke care capacity by population density are not known. The EMS agency surveys in Minnesota (Tsai 2008) and NC (Brice et al. 2008) did not investigate demographic or socioeconomic disparities in EMS stroke care capacity in their respective states.

B. Specific Aim 2 – EMS time intervals among stroke patients

Given the time urgency of acute stroke treatment, it is critical for patients experiencing an acute stroke to present to the ED or hospital as soon as possible and preferably within 2 hours of symptom onset (National Institute of Neurological Disorders and Stroke: rt-PA Stroke Study Group 1995). Although patient delay to seek medical attention is the largest contributor to prehospital delay, EMS times also play a role, and transport of the patient should begin as soon as possible (Sayre 2002). Nationally accepted standards define EMS "response time" as the interval from the time a 9-1-1 call is received to the time a responding EMS unit arrives at the scene and EMS "scene time" as the amount of time spent with the patient at the scene before commencing transport (Acker et al. 2007). AHA/ASA guidelines state EMS response and scene times for suspected stroke patients to be less than 9 min and 15 min, respectively, at least 90% of the time, though acceptable limits can be locally determined based on resources, population density, and geography (Acker et al. 2007; Jauch et al. 2013). Nonetheless, previous reports of prehospital time intervals for stroke have, on average, exceeded the recommended benchmarks (Table 3.1). Although most of these estimates are from single, mostly urban regions, current evidence suggests there remain ample opportunity to improve EMS response and scene times.

Table 3.1. Previous US reports of EMS time intervals among stroke patients

Lead Author (Publication Year)	Study size, N	Response time	Scene time
Evenson (2001)	50	mean 8.3 min	mean 19.5 min
Wojner (2003)	446	mean 9.9 min	mean 16.7 min
Wojner-Alexandrov (2005)	1,063	mean 9.7 min	mean 18.2 min
Rosamond (2005)	104	median 8 min	median 19 min
Kleindorfer (2006)	978	mean 6.5 min, median 5 min	mean 14.1 min, median 13 min
Frendl (2009)	154	n/a	means 17-19 min
Ramanujam (2009)	440	medians 5-6 min	medians 19-20 min
Shaeffer (2009)	561	mean 8.9 min	mean 14.3 min

1. Individual and Ecological Predictors

A study of stroke patients transported by EMS found the use of lights and sirens to the scene was associated with significantly shorter response time (-4.4 min) and scene time (-9.3 min) intervals, whereas age, gender, and race were not found to be associated (Evenson et al. 2001). The authors suggested the role of lights and sirens was due to heightened urgency brought on by emergency dispatch. However, Ramanujam et al. (2009) observed only 1-min shorter median response and scene times with stroke recognition by EMD. Another investigation into neighborhood socioeconomic status and EMS responses for stroke found poorer communities were associated with longer response time (1.3 min) but shorter scene time (-3.4 min), though these differences were considered relatively small and not clinically significant (Kleindorfer et al. 2006a). In addition, stroke patients of black race had marginally longer scene times.

These are the primary studies to have examined individual or ecological predictors of EMS times among stroke patients. Evenson et al. (2001) and Kleindorfer et al. (2006a) were limited in the identification of stroke patients from hospital records and, thus, potentially missing patients with a clinical impression of stroke in the prehospital setting. On the other hand, Ramanujam et al. (2009) enrolled patients with an EMD, EMS, or hospital diagnosis of stroke. Finally, these studies were also limited to relatively advanced EMS systems and more densely populated areas, and their findings may not be generalizable to other regions.

2. Evaluation of EMS Stroke Protocols

Since 2010, the NC EMS stroke protocol (Appendix A) has provided specific instructions for EMS responders to limit scene time to 10 minutes. However, in 2001, 83% of NC EMS agencies surveyed reported the use of a stroke protocol, of which only 50% gave specific instructions to minimize scene time (Brice et al. 2008). A more recent survey in nine states found 81% of EMS agencies had a specific on-scene time benchmark for responding to stroke (Greer et al. 2012). To our knowledge, no studies have evaluated the impact of protocols on minimizing EMS scene times among stroke patients. There have been limited studies on the impact of interventions to minimize EMS scene times for patients with stroke. The Houston Paramedic and Emergency Stroke Outcomes (HoPSTO) study, an educational intervention to improve EMS and hospital stroke care, found mean scene times for suspected stroke patients unexpectedly increased from 16.7 to 18.2 min after training in prehospital stroke identification (Wojner-Alexandrov et al. 2005). Frendl et al. (2009) trained EMS personnel on prehospital stroke screening and observed a moderate decrease in mean scene time (19 versus 17 min). These studies simply compared mean scene times and, thus, may have missed important differences that are detectable using other statistical methods (Austin and Schull 2003; Do et al. 2013).

C. Synopsis

1. Specific Aim 1

Deficiencies in EMS personnel training in prehospital stroke care have been documented nationally and in various regions since 1999 (Crocco et al. 1999; McNamara et al. 2008; Oser et al. 2010). Areas of greatest need include education on stroke screening tools and eligibility for thrombolytic therapy. Additional assessments are needed on current levels of stroke education and training and on whether deficits are lessening over time, if at all. With a greater emphasis on use of stroke protocols and screening tools and policies on hospital prenotification and destination plans, recent improvements in these aspects of EMS stroke management are expected. In fact, the Montana Stroke Initiative observed significantly higher usage of stroke protocols and screenings tools among EMTs from 2006 to 2009 (Oser et al. 2010). Regarding the role of agencies, the 2001 NC survey found 83% reported stroke protocols while only 44% reported stroke screens, and the 2006 Minnesota survey found 76% and 47%, respectively (Brice et al. 2008; Tsai 2008), though there are concerns on the accuracy of these estimates. Furthermore, policies on advance notification to the hospital and direct transport to a specialized stroke care facility for potential stroke patients are known to exist, but the current prevalence of such policies and plans for the prehospital management of stroke is not known. In conclusion, updated assessments of EMS stroke care capacity are needed to better understand current variation and evaluate changes over time.

2. Specific Aim 2

Reports of EMS response and scene time intervals among stroke patients suggest at least 50% are not meeting recommended benchmarks, so improvements in EMS times remain to be realized. Previous studies have identified response with lights and sirens, stroke recognition by EMD, race, and neighborhood income as factors associated with EMS time intervals. Evaluation of a diverse, multi-system region may provide further insight into ways to reduce EMS times. Furthermore, EMS systems vary in the presence of protocols to instruct personnel to limit scene time and having specific scene time benchmarks (Brice et al. 2008; Greer et al. 2012), but there have been no studies of the association of such system-level variation with EMS scene times among stroke patients.

IV. STATEMENT OF SPECIFIC AIMS

Specific Aim 1. Assessed current EMS capacity in NC to respond to, evaluate, and manage stroke patients

a. Evaluated variations in EMS stroke care capacity

b. Estimated changes in EMS stroke care capacity since 2001

For the first aim, a statewide internet-based survey of EMS system capacity for prehospital stroke care in NC was conducted in 2012. Administrative directors of all 100 local EMS sytems were invited to participate. Respondents were queried on stroke training provided to EMS personnel and system practices and policies regarding care of stroke patients. Detailed analyses of system destination plans and patient care protocols for stroke were also conducted. Variation in overall EMS stroke care capacity was evaluated according to system patient volume and population density. Using data from a similar survey of NC EMS agencies in 2001 (Brice et al. 2008), I estimated statewide changes in EMS stroke care capacity over the past decade.

Hypotheses: Considering the diversity of NC in terms of population density, I hypothesized some areas of EMS capacity would be lacking, including the frequency and educational content of stroke trainings. However, since efforts have been made to standardize EMS care of stroke in NC, some aspects were expected to be high and to have significantly improved since 2001. Previous research has found deficient EMS resources in rurals (Leira et al. 2008), so similar findings were expected of rural systems in NC.

Rationale: A prior assessment of EMS in NC found deficiencies in stroke capacity, including personnel education and training, use of stroke protocols and screening tools, and hospital prenotification (Brice et al. 2008). However, in the last 10 years, major national and statewide changes have occurred in the prehospital management and care of stroke patients, including the use of standardized protocols and validated stroke screening tools and the development and use of destination plans (Acker et al. 2007; Alberts et al. 2011; Williams et al. 2009). An updated assessment would provide insight into the current state of EMS stroke care capacity in NC and improvements, if any, as a result of statewide standardization of prehospital stroke care.

Specific Aim 2. Identified individual and ecological predictors of EMS time intervals among stroke patients

a. Evaluated distributions and correlates of EMS time intervals among stroke patients
b. Estimated the association of EMS systems having detailed stroke protocols with minimization of time spent at scene with stroke patients

In the second aim, distributions of EMS time intervals for suspected stroke events occurring in NC in 2009-2010 were evaluated. Data on EMS responses for stroke patients were obtained from the NC Prehospital Medical Information System (PreMIS), a statewide electronic healthcare record for the evaluation of EMS patient care and system performance (Mears et al. 2010). EMS response (i.e. dispatch to at scene) and scene (i.e. at scene to left scene with patient) time intervals for suspected stroke events were calculated and compared to nationally recognized benchmarks (Acker et al. 2007). EMS times were also compared according to system patient volume and population density and various individual-level factors. I further investigated the role of system capacity in an evaluation of scene times by whether NC EMS systems used protocols with instructions on minimizing time spent at the scene.

Hypotheses: Previous studies of EMS responses for stroke have found longer than desired average prehospital time intervals. I hypothesized EMS time intervals in this study would be the same or marginally shorter. Regarding individual factors, response mode to scene (i.e. lights and sirens) was expected to predict shorter response times whereas older patient age would be associated with longer scene times. Rural regions were expected to have greater response times due to sparse populations, though there was no reason to expect scene times would significantly differ from more densely populated areas. Since EMS personnel are instructed to follow the appropriate protocol for a particular patient condition, I expected to observe shorter scene times among systems with protocols having specific instructions on minimizing scene times compared to no instructions at all.

Rationale: According to AHA/ASA guidelines, EMS response and scene times for suspected stroke patients should be less than 9 min and 15 min, respectively, at least 90% of the time (Acker et al. 2007; Jauch et al. 2013). Previous reports of EMS time intervals for stroke have exceeded the recommended benchmarks. A better understanding of EMS times and their predictors could identify ways to improve EMS responses for stroke patients.

V. METHODS

A. Overview

The first aim of this dissertation was to study the current EMS system capacity for prehospital stroke care in NC. An internet-based survey was conducted in 2012 to collect information on prehospital stroke care capacity from all 100 local EMS systems. To estimate changes in EMS stroke care capacity in NC since 2001, data from this survey were compared to responses from a previous survey (Brice et al. 2008). Abstraction of EMS stroke protocols and destination plans was also conducted to assess system capacity. Priority measures of EMS stroke care capacity were combined into a summary score.

The second aim was to describe the distributions of EMS time intervals for suspected stroke events and to evaluate individual and ecologic correlates. Using 2009-2010 data from the NC PreMIS, EMS response and scene time intervals among stroke patients were calculated and regressed on patient, incident, and system characteristics in multi-level modeling. Furthermore, data from stroke protocol abstraction in the first aim were incorporated to estimate the differences in scene times by whether systems had protocols with instructions on limiting scene time.

The methods for data collection, management, and analysis are described in this chapter. Study design and procedures were approved by the University of North Carolina-Chapel Hill Institutional Review Board.

B. Study Region and Context

1. Organization of EMS in NC

The mission of the NC OEMS is to oversee and guide EMS credentialing and service delivery within and across counties. Starting in 2002, all 100 NC counties were required by state law to form an EMS system that consolidates the credentialing of EMS agencies and professionals within that county. Ultimately, 100 EMS systems were created, with Pasquotank and Camden counties combining into a single system and the Cherokee Tribal Nation forming its own system in Swain county. Figure 5.1 illustrates the hierarchical organization of EMS in NC; where from the bottom up, EMTs are employed by EMS agencies, one or more agencies operate within an EMS system, and all 100 systems are under the oversight of the state regulatory office. For example, the Orange County EMS system is serviced solely by Orange County EMS while four EMS agencies service the Wake County EMS system, the largest agency being Wake County EMS (see Figure 5.1).

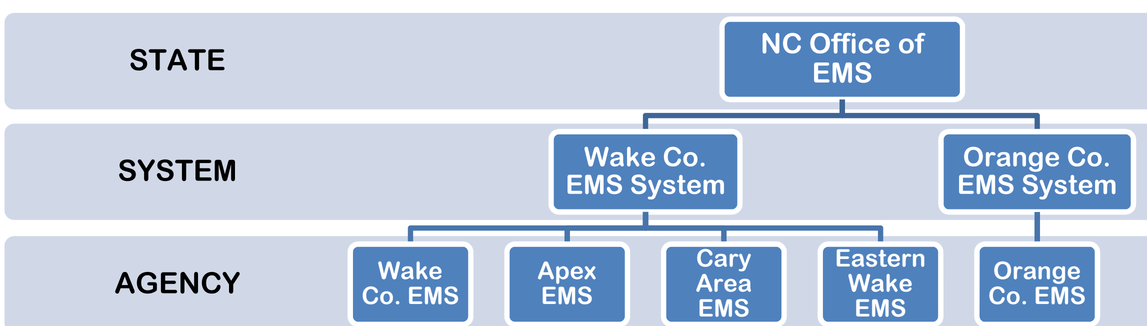


Figure 5.1. Organizational Structure of EMS in North Carolina, Orange and Wake Counties

Each system is appointed a medical director to provide guidance on patient care and overall medical oversight. A head EMS administrator, or EMS Director, is also appointed and supervises EMS providers and manages the daily operations of the EMS system. The system's continuing education and recertification program for EMS personnel is headed by a training officer, who maintains certifications as an EMT and EMS instructor. The county emergency telecommunications center is a separate entity from the EMS agencies but handles the 9-1-1 calls for law enforcement and other emergency services in the area and, if certified, provides EMD. Therefore, 9-1-1 call centers can be considered part of the EMS system.

2. NC EMS Data System

Another key component of this 2002 legislation was the creation of an electronic healthcare records data system that allows systems to collect and submit EMS records into a statewide database for the evaluation of patient care and system performance. Currently, all NC EMS agencies are mandated by law to input data on all EMS records of patient encounters. These data are maintained by the EMS Performance Improvement Center (EMSPIC), at the University of North Carolina at Chapel Hill Department of Emergency Medicine, as PreMIS. In 2008, more than 540 EMS agencies entered 1.2 million electronic EMS records into the PreMIS database (Mears et al. 2010). A primary function of EMSPIC is developing and implementing data analysis programs to allow EMS systems, using their data in PreMIS, to evaluate and improve the care provided for specific patient populations (e.g. trauma, cardiac arrest, stroke). However, this is a relatively new database, and the degree of data quality and completeness is still largely unknown. Implications of these data issues for research of EMS patient care are not clear.

Another application in the NC EMS data system is the Credentialing Information System (CIS). It is also web-based, and it maintains personnel rosters, status of vehicles, educational facilities, and contact information. The credentialing of all EMS professionals and agencies are also included in this centralized data system. This provides an important function in ensuring the quality of EMS personnel in the state (Mears et al. 2010). For example, an agency can easily look up, using CIS, the credentials, background checks, or any disciplinary actions for a paramedic being interviewed for employment (Mears et al. 2010). This database can also provide data on general characteristics of each NC EMS system, such as the number of EMTs employed and number of patient care reports by EMS system.

C. Data Sources and Collection

1. EMS Stroke Care Survey (2012)

A 31-item survey was developed to collect information on the stroke care capacity of EMS systems in NC. The survey focused on the frequency and educational content of stroke trainings and information about stroke care practices and policies of EMS systems. Questions were adopted from other published surveys of EMS stroke care capacity (Brice et al. 2008; Tsai 2008) or developed with expert input from 2 local EMS medical directors. General EMS system characteristics, including pay structure and level of service, and 9-1-1 dispatch services were also assessed. The survey instrument is provided in Appendix D. A web version of the survey was designed using the Qualtrics software system. The web interface and functionality were pre-tested by a sample of 3 doctoral students. The survey was self-administered and responses were saved online in Qualtrics. At the end of survey administration, data were downloaded and imported into SAS version 9.2 (Cary, NC).

For this statewide assessment of EMS capacity, names and contact information of the 100 local EMS administrative directors were retrieved from the NC *Dial Codes Directory* (NC OEMS, available December 5, 2011) and invited by email to complete the web-based survey. They were chosen as key informants since they supervise EMS personnel and manage the daily operations of their systems. Instructions encouraged respondents to elicit information from others in their organizations, such as training officers and medical directors, as needed. Unique links to the online survey were emailed on June 4, 2012. The introductory text in the email included a statement ensuring the respondent's confidentiality (i.e. no contact information will be released, no county- or system-specific data will be reported) and the risks (i.e. none) and benefits (i.e. better our understanding) of completing the survey. Reminder emails were sent one and two weeks after the initial invite. Follow-up phone calls were made to nonrespondents, and the option to complete the survey by phone was given. The survey was closed on August 24, 2012.

2. Past NC EMS survey (2001)

As previously discussed, Brice et al. (2008) conducted a survey of NC EMS agencies in 2001. With the permission of these researchers, I acquired the data on general and stroke-specific services from this survey and computed paired differences between the 2001 and current survey responses. Specific survey items are shown later in Table 5.3.

3. EMS protocols and destination plans

In NC, the stroke patient care protocol was standardized by the NC OEMS and required in all systems starting in 2010. Pre-existing 2009 local stroke protocols were collected from all 100 NC EMS systems. These protocols were assessed similar to Brice et al.'s (2008) detailed analysis of stroke protocols in 2001. Two reviewers (Mr. Mehul Patel and Ms. Chailee Moss) independently abstracted protocols for various aspects of prehospital stroke care, including but not limited to signs and symptoms, differential diagnoses, prehospital stroke screen, glucose check, cardiac rhythm check, thrombolytic screen, onset time documentation, and minimization of scene time. Disagreements were adjudicated by a third reviewer (Dr. Jane Brice). In addition, colleagues had collected stroke triage and destination plans from NC EMS systems and abstracted names and types (i.e. Primary Stroke Center, stroke capable, community) of destination hospitals listed.

4. Credentialing Information System (CIS)

The CIS was queried for general characteristics of NC EMS systems, including the number and certification levels of personnel currently in service and the number of patient care reports over a given time period. No names or personal information of individual personnel were collected.

5. NC county population estimates

Metropolitan and micropolitan statistical areas are geographic units delineated by the US Office of Management and Budget (OMB). A metropolitan area is defined as a basic set of counties with at least one urbanized location of 50,000 or more population, and a micropolitan area contains an urban core of at least 10,000 but less than 50,000 population. Adjacent counties with a high degree of economic and social integration, as determined by the US OMB, are grouped into a single statistical area. At the time of this work, the most recent, publically available delineation of metropolitan and micropolitan counties was released in December 2009 and based on the US Census Bureau's July 1, 2007 to July 1, 2008 population estimates (US Office of Management and Budget).

6. NC Prehospital Medical Information System (PreMIS)

The NC PreMIS collects more than 200 data elements on aspects of the EMS incident such as patient demographics, response times, patient assessment and evaluation, procedures and protocols used, and disposition (see Appendix E for the complete list of NC data elements). Each data element follows the standardized format determined by the National EMS Information System (NEMSIS), and each NC EMS system is responsible for entering data on every patient encountered. At the time of this work, 2009-2010 data were the most recent available, and there was substantial variability between systems in the completeness and quality of these data. Therefore, data quality and completeness were further explored in this dissertation.

Among patients 18 years of age and older for whom EMS responded to a 9-1-1 call originating in NC between January 1, 2009 and December 31, 2010, data on any patient with a possible neurological condition were obtained from PreMIS. Then a suspected stroke event was defined as any EMS response in which the personnel's impression of the patient's condition was stroke or the personnel documented use of a stroke protocol. Alternate definitions of suspected stroke event were also explored.

D. Data Management and Processing

1. Specific Aim 1 – EMS stroke care capacity

EMS system capacity is an abstract concept and cannot be defined by a single measure. The EMS system survey provided information on various aspects of EMS capacity specific to stroke. System capacity for prehospital stroke care was conceptualized into 2 domains: 1) education and training and 2) practices and policies. Table 5.1 summarizes the key survey items (see Appendix D for survey instrument) that were used to define capacity within these domains.

Table 5.1. Domains and measures of EMS system capacity for prehospital stroke management

Domain	**Measure**	**Survey item(s)***
Education and Training	Frequency of stroke education	Items 20, 21, 22
	Stroke topics covered	Item 20b
	Formats offered	Item 23
Practices and Policies	Transport lights and sirens	Item 13
	Stroke scale or screening tool use	Items 17, 17b, 19
	Destination plan use	Item 16
	Policy to prenotify hospitals	Item 14

* See Appendix D

A summary score of EMS stroke care capacity was created using parameters recommended by national and local experts (Acker et al. 2007; Williams et al. 2009). Ideally, a stroke capable EMS system should address four priority areas: education and training, protocol and screening, destination plan, and continuous quality improvement (CQI). Systems responding to our survey were given points based on each of the measures described below and in Table 5.2. The four priority areas were equally weighted with a maximum of 3 points each, allowing an overall maximum stroke care capacity score of 12 points. We incorporated survey responses on stroke education hours provided, frequency of trainings, and educational content. In NC, the stroke patient care protocol was standardized by the state EMS regulatory office and required in all systems starting in 2010. We further included survey data on the use of validated stroke screening tools and whether results are always communicated to the destination hospital. NC EMS systems are also required to have a written stroke destination plan, so we additionally assessed whether they always used the destination plan. The abstraction of destination hospitals from stroke destination plans was used to determine whether the system listed a Joint Commission-certified Primary Stroke Center as a destination and, thus, had a plan to transport to a recognized stroke center. Finally, systems were characterized as engaging in CQI by whether they examined PreMIS data in the past year to evaluate their performance in providing stroke care (EMS Performance Improvement Center 2012b).

Table 5.2. EMS Stroke Care Capacity Scoring System, North Carolina 2012

Priority Areas and Measures	Points
1. Education and Training	
At least 2 hours of stroke training provided a year	1
Personnel trained on stroke at least once a year	1
Trainings cover basic stroke educational topics[a]	1
2. Protocol and Screening	
Standardized stroke protocol	1
Validated stroke scale or screening tool[b]	1
Always communicate stroke scale or screen results to hospital	1
3. Destination Plan	
Written stroke destination plan	1
Always use the stroke destination plan	1
Plan to transport to a stroke center	1
4. Continuous Quality Improvement	
Data-driven performance feedback on stroke care in past year	3
Total EMS Stroke Care Capacity Score	12 (maximum)

[a] Topics include stroke risk factors, signs and symptoms, pathophysiology, and scale or screening tool

[b] Validated stroke scales and screens included the Los Angeles Prehospital Stroke Screen, the Cincinnati Prehospital Stroke Scale, and the Miami Emergency Neurologic Deficit exam

We computed descriptive statistics for the EMS stroke care capacity scores among all responding NC systems. Scores were categorized as: 0-3, 4-6, 7-9, and 10-12 points. Frequencies of scores were compared by annual patient volume of the EMS system and county population density. Annual patient volume of the system was assessed with the number of patient care reports from January 1 through March 31, 2012, as recorded in the NC Credentialing Information System (EMS Performance Improvement Center 2012a), and then multiplied by 4 to estimate the number of patients per year. These counts were categorized into 3 groups: <5,000, 5,000-20,000, and >20,000 events per year. The population density status of counties was classified as metropolitan or micropolitan as defined by the US OMB, and remaining counties were classified as rural.

In 2001, Brice et al. (2008) mailed a survey to 83 NC EMS agencies, and 72 returned response. To make direct comparisons with the current survey, questions on stroke education and training, transport by lights and sirens, validated stroke scale or screening tool use, and policy to advance notify hospital from the 2001 survey were repeated, though the wordings of some items may slightly differ (Table 5.3). Responses from both surveys were matched on agency/system name, and the comparison analysis was restricted to only those EMS systems with data in both surveys. This subset of EMS systems was compared to all NC systems on patient volume, number of EMS personnel, and level of service.

Table 5.3. Comparison of EMS system stroke capacity between current 2012 survey and previous 2001 survey

Measure	Survey item (2001)[a]	Survey item (2012)[b]
Stroke training	15. In the past 2 years, have your personnel with the highest level of certification training received an educational session on stroke?”	20. In the past 2 years, have the EMS providers in your system received at least one educational session on stroke?
Hours of stroke training	15.1. Please estimate total number of hrs spent on stroke training in past 2 years	21. In the past 2 years, please estimate the total number of hours spent on stroke training
Stroke topics	15b. **If YES**, what topics did the training session cover?”	20b. **If YES**, what topics do the training sessions typically cover?
Transport lights and sirens	12. If a patient having a stroke has stable vital signs, will the patient be transported with lights and sirens?	13. If a patient suspected of having a stroke has stable vital signs, will the patient be transported with lights and sirens?
Stroke screening tools	16. Are there any specific diagnostic tools or scales that you use to identify whether or not a patient is having a stroke?	17. Do your EMS providers use any specific prehospital screening tools to identify whether or not a patient is having a stroke?
Prenotify hospitals	13. Is it your policy to notify hospitals in advance for all stroke patients who may be thrombolytic candidates?”	14. Is it your policy to notify hospitals in advance for all suspected stroke patients?

[a] Brice et al. 2008
[b] See Appendix D

2. Specific Aim 2 – EMS time intervals among stroke patients

Among suspected stroke events identified from 2009-2010 PreMIS data, the outcomes of interest were EMS response time and scene time. Response time was defined as the time from 9-1-1 call to EMS arrival at the scene. While this is the accepted definition (Acker et al. 2007), the time of 9-1-1 call can be missing in records, so response time was also defined as the time from EMS notified to arrival at the scene, as in a previous study (Rosamond et al. 2005). Scene time was defined as the time from EMS arrival at the scene to departure with the patient. For the analytic sample, events were excluded if missing key time points or having an impossible (<0 min) or extreme (>2 hrs) computed time interval.

Based on previous studies and availability of data, various individual-level factors were selected for this aim, including patient age (18 to 44, 45 to 64, 65 to 84, 85+ years), sex, and race (white, black, other). In addition, incident characteristics included time of day (12:00 to 7:59 AM, 8:00 AM to 5:00 PM, 5:01 to 11:59 PM), day of week (weekday versus weekend), location (home/residence, health care facility, other (e.g. businesses, offices, schools, etc.)), and response mode to scene (lights and sirens versus no lights and sirens). Lastly, ecological factors were system annual patient volume (<5,000, 5,000-20,000, >20,000 events per year) and county population density (metropolitan, micropolitan, rural), as defined in the first aim.

As previously noted, 2009 stroke protocols were abstracted for instructions regarding the minimization of scene time and whether a specific time limit was provided. Systems with a specific limit for time spent on scene on their protocol were classified as "Specific time limit provided" while those with only general instructions were classified as "General instructions to limit scene time" and those with no stroke protocol or no scene time instructions were classified as "No instructions to limit scene time". EMS scene times for suspected stroke events in 2009 were compared across these 3 categories of protocol instructions.

E. Statistical Analysis

1. Specific Aim 1 – EMS stroke care capacity

The change in EMS stroke care capacity measures between time periods was calculated on both absolute [($p_{2012} – p_{2001}$)×100%] and relative [($p_{2012} – p_{2001}$)/ p_{2001}×100%] scales. A relative change greater than 10% was considered meaningful. The statistical difference between paired proportions was tested using two-sided McNemar's exact p-value. Two-sided Fisher' exact and Wilcoxon rank sum tests were used for categorical and non-normal continuous data, respectively. A p-value less than 0.05 was considered statistically significant.

2. Specific Aim 2 – EMS time intervals among stroke patients

Descriptive statistics on response and scene times for suspected stroke events were calculated. The 90th percentile response and scene times were presented for comparison to benchmarks (9 and 15 min, respectively). Given the 2-year time period of these data, descriptive statistics on EMS times were also presented by calendar year quarter to examine trends over time.

To evaluate individual and ecologic correlates of EMS times, linear models were fit separately for each time interval outcome regressed on the covariates of interest. Mixed linear modeling (Laird and Ware 1982) was used to account for clustering of observations within systems. A random effect for system was specified with variance components variance structure. A p-value less than 0.05 for the type III test of fixed effect was considered statistically significant. Quantile regression (Koenker and Bassett Jr 1978) was used to estimate how pre-specified percentiles of the response and scene time distributions varied by covariates. Since time intervals were positively skewed, adjusted quantile regression models were fit to estimate the difference in 50th percentile, or median, times. Also, 90th percentile benchmarks were compared using this method.

Quantile regression parameters were estimated using the interior point algorithm (Karmarkar 1984), and 95% confidence intervals (CI) were constructed with bootstrap standard errors. A p-value less than 0.05 for the likelihood ratio test was considered statistically significant. Statistical models were fit in SAS version 9.2 (Cary, NC).

Alternate case definitions were used to explore the sensitivity of results on missing data for personnel's impression and documented protocols used. Dispatch complaints of stroke were included to potentially retrieve relevant events missed with the main case definition. Conversely, analyses were conducted among only those events with documented use of a stroke protocol, presumably restricting to events specifically in which EMS personnel used the protocol to direct patient care.

Quantile regression was used to estimate how the 10^{th} to 90^{th} percentiles of the scene time distribution in 10-percentile intervals varied by stroke protocol classification: specific time limit, general instructions, or no instructions (referent). The main association of interest was the difference in the 90^{th} percentile of scene time by stroke protocol instructions because the recommended benchmark for EMS scene time is less than 15 min for at least 90% percent of suspected stroke patients. Since large, modernized systems may be more likely to have advanced protocols and a greater sense of urgency for stroke, regression models were adjusted for annual patient volume and metropolitan status to account for potential confounding. Event counts among low volume and nonmetropolitan systems were insufficient to test for statistical interaction of the association between presence of protocol instructions and scene time. To further investigate the role of patient volume and metropolitan status, we fit models in the subgroup of high volume (i.e. >20,000 patients annually) and metropolitan EMS systems.

Since a statewide shift to standardized protocols took place at the beginning of 2010, we were concerned that some systems classified as having general only or no instructions, based on protocols at the start of 2009, may have switched to the state protocol at some point in the year and, hence, subjected suspected stroke events occurring after this point to specific scene time limit instructions. To explore the potential impact of misclassification bias, we repeated analyses stratified by calendar year quarter (e.g. first quarter represents events occurring in January through March) to examine whether associations varied by time of year, assuming less protocol misclassification in earlier time periods. Alternative case definitions were also used here to explore the impact of missing data on estimates of the protocol-scene time association.

VI. RESULTS

The following chapter presents results for each specific aim and the manuscripts that were prepared.

A. Specific Aim 1 – EMS stroke care capacity

1. Assessment of current EMS stroke care capacity in NC

The 100 NC EMS systems vary widely in the number of currently employed EMS personnel (median 120, interquartile range (IQR) 66-235) and estimated annual patient volume (median 8,004; IQR 3,754-17,848) (EMS Performance Improvement Center b). Based on NC county population estimates, 40 EMS systems service metropolitan areas, 30 micropolitan, and 30 rural.

Responses to the 2012 survey on EMS stroke care capacity were ultimately obtained from 98 of the 100 NC EMS systems. The initial email invitation was sent on June 4th requesting responses by June 15th, and by the first deadline, individuals from 28 systems had responded. After an email reminder was sent, 14 additional responses were received, for a total of 42 as of June 25th. Follow-up phone calls were made from June 25th through August 3rd. I, Mr. Patel, verified or corrected the contact information on record with the called party and reminded him/her of the survey. This resulted in another 47 responses and 89 total. From August 6th through 17th, Ms. Moss attempted a second phone contact and conducted the survey over telephone when the called agreed. An additional 9 responses were collected in this way. The survey was permanently closed on August 24th with 98 total respondents. Although no EMS systems overtly refused to participate, personnel at the 2 nonresponding systems were unable to be contacted. These systems were typical in terms of service level (e.g. BLS, ALS), annual patient volume, and county population density.

Primary survey respondents were administrative directors (N=80), training officers (N=12), and a medical director (N=1) or were not reported (N=5). Seven surveys listed a second participant (e.g. training officer, clinical educator, ED nurse). Survey responses on general system characteristics and 9-1-1 dispatch are shown in Table 6.1. No systems are entirely volunteer-based and only 2 provide service at the BLS level, whereas the others provide all or some ALS service. A substantial proportion of respondents did not know or did not respond to questions on stroke education or pre-arrival instructions by 9-1-1 dispatchers in their systems. Responses on measures of EMS system stroke care capacity are summarized in Table 6.2. In addition, 33% of systems reported the use of more than one validated stroke scale or screening tool. A substantial proportion of systems (21%) did not know the month in which the standardized stroke protocol was implemented. Of those reporting at the minimum the year of protocol implementation, almost half (48%) reported 2009 and the other almost-half (49%) reported 2010 while 3% reported 2011. Similarly, the month in which the stroke destination plan was implemented was not reported by 15%. However, 48% reported the year 2009, 48% reported 2010, and 3% reported 2011.

In 2009, prior to the 2010 switch, 95 NC EMS systems had a stroke protocol. The large majority of these protocols included some information on assessing suspected stroke patient history (89%), signs and symptoms (91%), and differential diagnoses (85%). Other aspects of prehospital stroke care were included to varying degrees, including stroke screening (91%), blood glucose check (99%), cardiac rhythm check (45%), thrombolytic eligibility screening (59%), onset time documentation (78%), transport per destination plan (43%), prenotification to destination (37%), and

Table 6.1. Characteristics of Emergency Medical Services (EMS) Systems in North Carolina 2012 (N=98)

System Characteristics	**No.**	**%**
General		
Pay status		
Entirely paid	50	51%
Mixed paid and volunteer	48	49%
Entirely volunteer	0	0%
Level of service		
ALS only	31	32%
Both ALS and BLS	65	66%
BLS only	2	2%
Providers have educational requirements above state requirements	66	67%
Have first responders that arrive before EMS	86	88%
Have policy to determine transport destination hospital	94	96%
9-1-1 Dispatch		
Dispatchers receive additional training above state requirements		
Yes	54	55%
No	36	37%
Don’t know	8	8%
Dispatchers use triage guide or algorithm		
Yes (MPDS, APCO, etc.)	75	77%
No	21	21%
Don’t know	2	2%
Dispatchers receive at least one educational session on stroke		
Yes	46	47%
No	20	21%
Don’t know	31	32%
Did not respond	*1*	
Dispatchers provide pre-arrival instructions for suspected stroke		
Yes	65	68%
No	20	21%
Don’t know	10	11%
Did not respond	*3*	

Table 6.2. Characteristics of Emergency Medical Services (EMS) Stroke Care Capacity, North Carolina 2012 (N=98 EMS Systems)

Domains and Measures	**No.**	**%**
Education and Training		
Stroke training provided in past 2 years	93	95
Median (IQR) hours of stroke trainings provided in past 2 years[a]	7.0	4.0-10.0
Frequency of personnel trained on stroke[a]		
More than once a year	21	23
Once a year	47	51
Every 2 or more years	21	23
Only when initially certified	3	3
Stroke educational topics covered in trainings[a, b]		
Risk factors	74	80
Signs and Symptoms	92	100
Pathophysiology	72	78
Scale or Screening tool	87	95
Thrombolytic therapy	61	66
All 5 stroke educational topics covered[a]	50	54
Format of stroke training sessions[a, b]		
Classroom	91	99
Online	41	45
DVD or video	21	23
Practices and Policies		
Suspected stroke patients transported by lights and sirens		
Yes	30	31
No	10	10
Choice made by crew	58	59
Validated stroke scale or screening tool used[c]	94	96
Specific stroke scale or screening tool used[b, d]		
Los Angeles Prehospital Stroke Screen (LAPSS)	62	66
Cincinnatti Prehospital Stroke Scale (CPSS)	49	52
Miami Emergency Neurologic Deficit (MEND) exam	17	18
Frequency of stroke scale or screen results communicated to destination hospital[d]		
Always	43	46
Very Often	44	47
Sometimes	5	5
Rarely	2	2
Never	0	0
Frequency of stroke destination plan use		
Always	47	49
Very Often	37	39
Sometimes	6	6
Rarely	5	5
Never	1	1
Policy to advance notify hospital if suspected stroke patient	96	98

[a] Among those who provided stroke training (N=93 (1 did not answer))

[b] Not exclusive categories

[c] Validated stroke scales and screens included the Los Angeles Prehospital Stroke Screen, the Cincinnati Prehospital Stroke Scale, and the Miami Emergency Neurologic Deficit exam
[d] Among those who used a validated stroke scale or screen (N=94)

minimization of scene time (81%). Furthermore, of the 77 systems with stroke protocol instructions to minimize scene time, only 4 stated a specific time limit, of which 3 specified 10 min while 1 specified 15 min.

2. Variation in EMS stroke care capacity

The EMS stroke care capacity score was described previously (Table 5.2). Across the 98 EMS systems analyzed, stroke care capacity scores ranged from 4 to 12 points (higher score equals greater capacity – Figure 6.1). The median score was 7 (IQR 6-9), and 3 systems scored the maximum 12 points. Most systems provided at least 2 hours of stroke training per year (78%), trained personnel on stroke at least once a year (69%), and covered the basic stroke educational topics (66%). However, only 44%

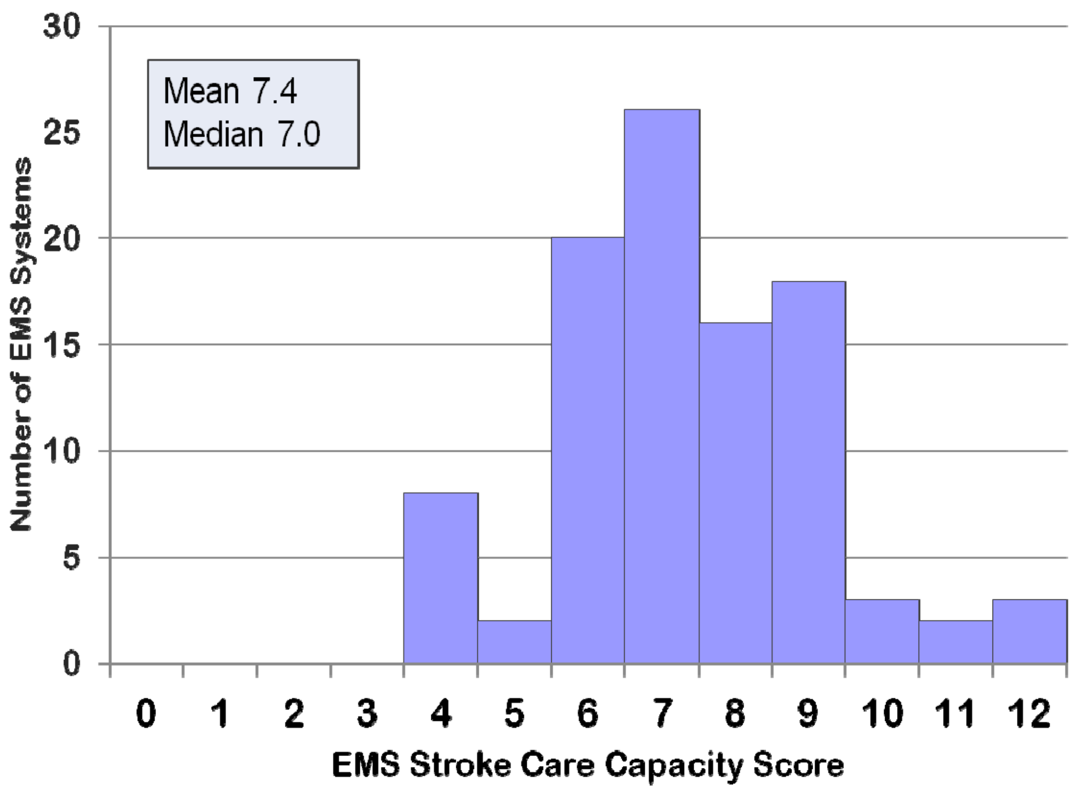


Figure 6.1. EMS stroke care capacity scores, North Carolina 2012 (N=98)

demonstrated all three of the measures of stroke education and training; moreover, 12% had none. Given the NC OEMS required each system to implement a standardized stroke protocol and written destination plan, all systems were assured one point each for priority areas "Protocols and Screening" and "Destination Plan". Furthermore, almost all systems (95%) had a written plan for transport to a stroke center. Nonetheless, less than half of systems (44% and 45%, respectively) scored maximum points in these two priority areas. CQI, specifically performance feedback, was relatively uncommon, with only 13% of EMS systems having evaluated their data on stroke patient care in the past year. Overall, categorized EMS stroke care capacity scores in NC showed room for improvement (Figure 6.2). Although no EMS systems scored under 4 points, 30 systems scored 6 points or fewer. High EMS capacity scores (i.e. 10-12 points) were observed regardless of patient volume and population density.

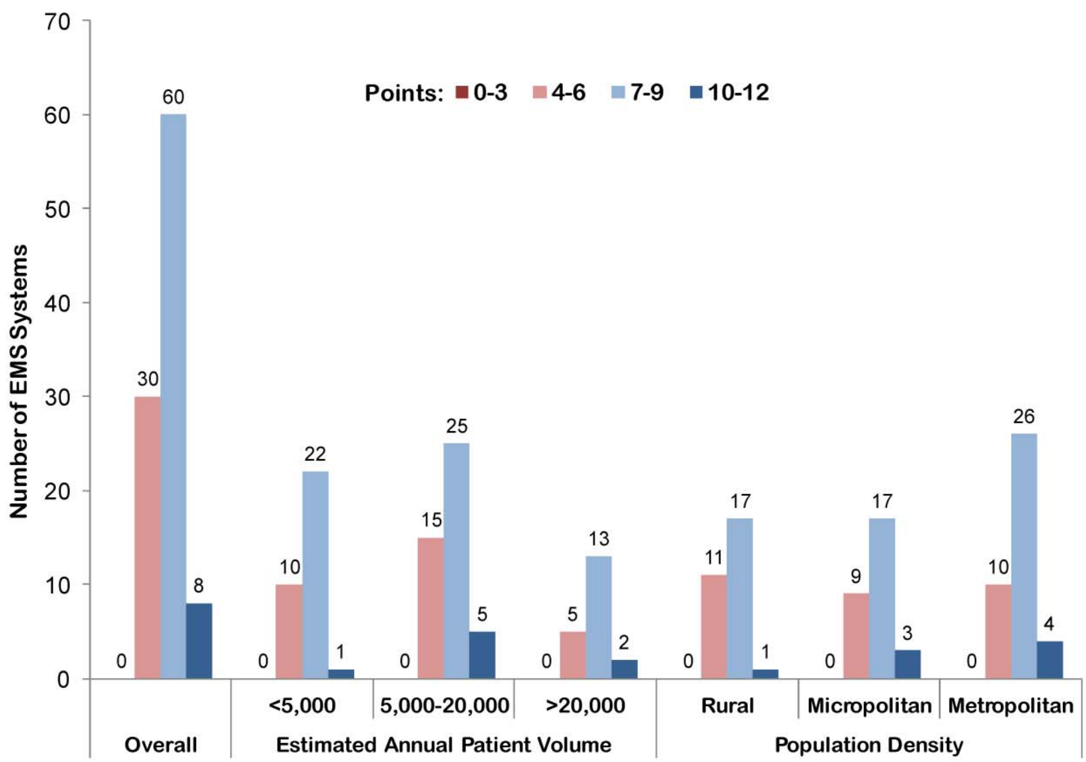


Figure 6.2. EMS stroke care capacity scores in categories, overall and by patient volume and population density, North Carolina 2012 (N=98)

3. Changes in EMS stroke care capacity since 2001

For direct comparisons between time periods, we utilized data on 70 EMS systems that participated in the 2001 and 2012 surveys. Absolute and relative changes in specific measures of EMS stroke care capacity are shown in Table 6.3.

Table 6.3. Changes in EMS Stroke Care Capacity between 2001 and 2012, North Carolina (N=70 EMS Systems)

Domains and Measures	2001 Survey	2012 Survey	Absolute Change	Relative Change	McNemar's Exact p (unless otherwise noted)
Education and Training					
Stroke training provided in past 2 years	90%	97%	7%	8%	0.18
Median hours of stroke training provided in past 2 years[a]	4.0	6.0	2.0	---	0.08[b]
Stroke educational topics covered in trainings[a]					
Risk factors	81%	77%	-4%	-5%	0.70
Signs and Symptoms	89%	97%	9%	10%	0.11
Pathophysiology	81%	74%	-7%	-9%	0.36
Scale or Screening tool	61%	93%	31%	51%	<0.001
Thrombolytic therapy	55%	65%	10%	18%	0.25
Basic four stroke educational topics covered[a, c]	54%	67%	13%	24%	0.12
Practices and Policies					
Suspected stroke patients transported by lights and sirens					0.85[d]
Yes	11%	31%			
No	17%	9%			
Choice made by crew	71%	60%			
Validated stroke scale or screening tool used[e]	23%	96%	72%	312%	<0.001
Policy to advance notify hospital if suspected stroke patient	71%	100%	29%	40%	---

[a] Did not provide stroke training treated as 0 hours and no educational topics covered
[b] Wilcoxon rank sum test
[c] Topics include stroke risk factors, signs and symptoms, pathophysiology, and scale or screening tool
[d] Fisher's exact test

[e] Validated stroke scales and screens included the Los Angeles Prehospital Stroke Screen, the Cincinnati Prehospital Stroke Scale, and the Miami Emergency Neurologic Deficit exam

System-specific changes between 2001 and 2012 in select stroke care capacity measures are illustrated in Figure 6.3. More details are provided in the following manuscript.

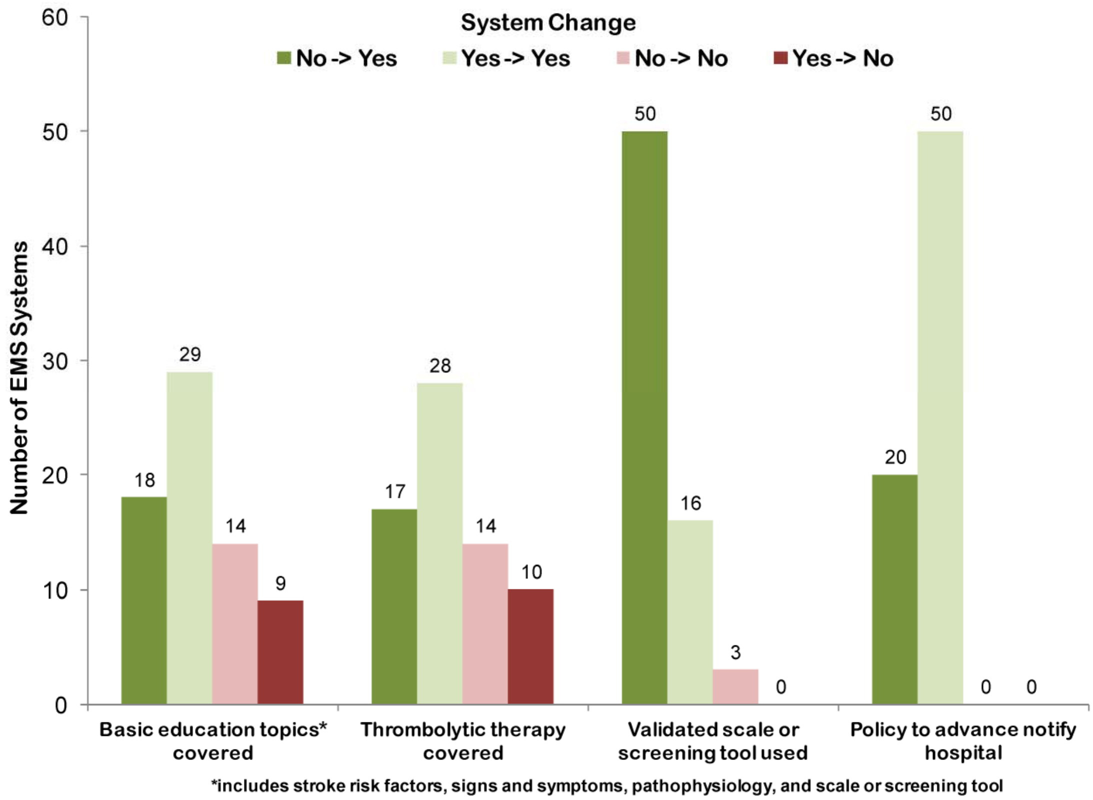


Figure 6.3. System-specific changes between 2001 and 2012 in select EMS stroke care capacity measures, North Carolina (N=70)

4. Manuscript 1: Emergency Medical Services Capacity for Prehospital Stroke Care in North Carolina

This subchapter constitutes the first manuscript. Coauthors included the committee members listed on the title page. This manuscript focuses on the results of the EMS stroke care capacity survey and summary score and details the changes in

EMS stroke capacity since 2001. It was accepted for publication in *Preventing Chronic Disease* on May 22, 2013.

a) Introduction

Emergency medical services (EMS) can positively impact acute stroke patients through early identification and expedited transport and thus more timely delivery of treatments, notably thrombolytic therapy (Schwamm et al. 2005). With proper education and use of protocols, EMS personnel can screen for stroke in the field, initiate patient evaluation, and directly transport appropriate patients to a specialized stroke center (Kothari et al. 1999b; Kidwell et al. 2000; Gladstone et al. 2009). However, current levels of EMS education and prehospital care practices for stroke patients are not well characterized and vary by location (Brice et al. 2008; Tsai 2008; Greer et al. 2013).

Improving EMS capabilities to respond to and manage acute stroke patients is important since stroke is a major cause of death and disability in the United States (US) and especially in North Carolina (NC) (Roger et al. 2011). In response to this burden, state legislation was passed in 2006 to address the availability of stroke-related resources among both NC hospitals and EMS systems (Holmes and Puckett 2012). This legislation led to the development and implementation of standardized EMS stroke care practices and policies. By 2010, all NC EMS systems were required to use a standardized protocol to guide the prehospital care of stroke patients and a written destination plan to facilitate the transport of stroke patients to the most appropriate hospital.

A comprehensive statewide survey of NC EMS agencies was conducted in 2001, and EMS education on stroke and the use of stroke protocols were found to be lacking (Brice et al. 2008). However, in the last 10 years, major national and statewide changes have occurred in the prehospital management and care of stroke patients, including the use of standardized protocols and validated stroke screening tools and the development and use of destination plans (Acker et al. 2007; Alberts et al. 2011; Williams et al. 2009).

We examined the current stroke education and training provided to personnel and stroke care practices and policies of EMS in NC and evaluated statewide changes since 2001. Given advancements in prehospital stroke care and recent EMS implementation of stroke policies, we hypothesized improvements in EMS stroke care capacity over the past decade.

b) Methods

Study Design and Data Collection

A 31-item survey was developed to collect information on the stroke care capacity of EMS systems in NC. The survey focused on the frequency and educational content of stroke trainings and information about stroke care practices and policies of EMS systems. Questions were adopted from other published surveys of EMS stroke care capacity (Brice et al. 2008; Tsai 2008) or developed with expert input from 2 local EMS medical directors. General EMS system characteristics, including pay structure and level of service, were also assessed. The survey instrument and methodology were approved by the University of North Carolina at Chapel Hill Institutional Review Board. A copy of the survey is available at http://www.unc.edu/~kevenson/_2012_NC_EMS_StrokeSurvey.pdf.

North Carolina's 100 county-based EMS systems consolidate the state's more than 35,000 EMS personnel and more than 540 EMS agencies (Mears et al. 2010). For our statewide assessment of stroke care capacity, the 100 EMS administrative directors were identified from the state regulatory office directory and invited to complete the web-based survey. They were chosen as key informants since they supervise EMS personnel and manage the daily operations of their systems. Instructions encouraged respondents to elicit information from others in their organizations, such as training officers and medical directors, as needed. Links to the online survey were emailed in June 2012. Reminder emails were sent one and two weeks after the initial invite. Follow-up phone calls were made to nonrespondents, and the option to complete the survey by phone was given.

Data Processing and Analysis

We devised a summary score of EMS stroke care capacity using parameters recommended by national and local experts (Acker et al. 2007; Williams et al. 2009). Ideally, a stroke capable EMS system should address four priority areas: education and training, protocol and screening, destination plan, and continuous quality improvement (CQI). Systems responding to our survey were given points based on each of the measures described below and in Table 5.2. The four priority areas were equally weighted with a maximum of 3 points each, allowing an overall maximum stroke care capacity score of 12 points. We incorporated survey responses on stroke education hours provided, frequency of trainings, and educational content. In NC, the stroke patient care protocol was standardized by the state EMS regulatory office and required in all systems starting in 2010. We further included survey data on the use of validated stroke screening tools and whether results are always communicated to the destination hospital. NC EMS systems are also required to have a written stroke destination plan, so we additionally assessed whether they always used the destination plan and had a specific plan for transporting patients to a recognized stroke center. Finally, systems were characterized as engaging in CQI by whether they examined standard electronic data in the past year to evaluate their performance in providing stroke care (EMS Performance Improvement Center 2012b).

We computed descriptive statistics for the EMS stroke care capacity scores among all responding NC systems. Scores were categorized as: 0-3, 4-6, 7-9, and 10-12 points. Frequencies of scores were compared by estimated annual patient volume of the EMS system and county population density. Annual patient volume was estimated with the number of total EMS events occurring in the past year, as recorded in the NC Credentialing Information System (EMS Performance Improvement Center 2012a), and then categorized into 3 groups: <5,000, 5,000-20,000, and >20,000 events. The population density of counties was categorized into metropolitan, micropolitan, and rural as defined by the US Office of Management and Budget (2009).

In 2001, a survey mailed to 83 NC EMS agencies was returned by 72 respondents (Brice et al. 2008). To make direct comparisons between the current and 2001 surveys, we repeated questions on stroke education and training, transport by lights and sirens, validated stroke scale or screening tool use, and policy to advance notify hospital from the 2001 survey. We acquired the 2001 survey responses from the study authors and matched them to our survey by EMS provider. The comparison analysis was restricted to only those EMS systems with data in both surveys (N=70). We compared this subset of EMS systems to all NC systems on patient volume, number of EMS personnel, and level of service and found minimal differences.

The change in EMS stroke care capacity measures between time periods was calculated on both absolute $[(p_{2012} – p_{2001})\times 100\%]$ and relative $[(p_{2012} – p_{2001})/p_{2001}\times 100\%]$ scales. A relative change greater than 10% was considered meaningful. The statistical difference between paired proportions was tested using two-sided McNemar's exact p-value. Two-sided Fisher's exact and Wilcoxon rank sum tests were used for categorical and non-normal continuous data, respectively. A p-value less than 0.05 was considered statistically significant.

c) Results

North Carolina EMS Systems

Of the 100 NC EMS systems, 2 currently provide service at the basic life support (BLS) level only whereas the remaining provide all or some advanced life support (ALS) service. Also, NC EMS systems vary widely in the number of currently employed EMS personnel (median 120, interquartile range (IQR) 66-235) and estimated annual patient volume (median 8,004; IQR 3,754-17,848) (EMS Performance Improvement Center 2012a). Based on NC county population estimates, 40 EMS systems service metropolitan areas, 30 micropolitan, and 30 rural.

2012 EMS Stroke Survey

We received survey responses from 98 of the 100 EMS systems in NC. While most respondents completed the survey online, 9 were conducted by phone. Primary survey respondents were administrative directors (N=80), training officers (N=12), and a medical director (N=1) or were not reported (N=5). Seven surveys listed a second participant (e.g. training officer, emergency department nurse). The vast majority of EMS systems (95%) provided at least one stroke training to EMS personnel in the past 2 years (Table 6.2). Seventy-four percent of these trained their personnel on stroke at least once a year. The educational content of trainings always included stroke signs and symptoms and very frequently stroke scales or screening tools (95%), while thrombolytic therapy was addressed in only 66% of trainings. In-person classroom trainings were almost always offered, but other formats reported included online courses and videos. Almost all EMS systems surveyed used a validated stroke scale or screening tool, such as the Los Angeles Prehospital Stroke Screen (LAPSS) (66%) (3) or the Cincinnati Prehospital Stroke Scale (52%) (CPSS) (2). However, only 46% reported always communicating stroke scale or screen results to the destination hospital. Similarly, only

49% reported always using a destination plan to decide the hospital to transport to. Lastly, 98% of EMS systems reported having a policy to advance notify the destination hospital when transporting a suspected stroke patient.

EMS Stroke Care Capacity Score

Across the 98 EMS systems analyzed, stroke care capacity scores ranged from 4 to 12 points (higher score equals greater capacity). The median score was 7 (IQR 6-9), and 3 systems scored the maximum 12 points. Most systems provided at least 2 hours of stroke training per year (78%), trained personnel on stroke at least once a year (69%), and covered the basic stroke educational topics (66%). However, only 44% demonstrated all three of the measures of stroke education and training; moreover, 12% had none. Given the state regulatory office required each system to implement a standardized stroke protocol and written destination plan, all systems were assured one point for each. Nonetheless, less than half of systems (44% and 45%, respectively) scored maximum points in these two priority areas. Performance feedback was relatively uncommon, with only 13% of EMS systems having evaluated their data on stroke patient care in the past year. Overall, EMS stroke care capacity scores in NC showed room for improvement (Figure 6.1). Although no EMS systems scored under 4 points, 30 systems scored 6 points or fewer. High EMS capacity scores (i.e. 10-12 points) were observed regardless of patient volume and population density (Figure 6.2).

Comparison of 2001 & 2012 Surveys

For direct comparisons between time periods, we utilized data on 70 EMS systems that participated in the 2001 and 2012 surveys (Table 6.3). We observed a moderate, positive change in the percentage of EMS systems providing stroke trainings and the overall median number of hours of stroke training provided. While education on stroke risk factors and pathophysiology slightly decreased, stroke signs and symptoms and thrombolytic therapy education increased considerably. We observed significant evidence of large absolute and relative increase (31% and 51% change, respectively) in education on stroke scales or screening tools. Furthermore, coverage of the "basic" four stroke educational topics (i.e. risk factors, signs and symptoms, pathophysiology, and scale or screening tool) also increased from 54% to 67%. The greatest change was the increase in use of validated stroke scale or screening tools (from 23% to 96%). A policy to notify hospitals in advance of stroke patient arrival existed at a high proportion (71%) in 2001, and all remaining systems had adopted such a policy by 2012. Figure 6.3 illustrates the system-specific changes between 2001 and 2012 on a select number of stroke care capacity measures. The 13% net absolute increase in the basic stroke educational topics covered was the result of 18 systems that improved and 9 that worsened. Conversely, the considerable improvement in use of validated stroke scale or screening tool was driven by 50 systems with a positive change versus only 3 systems that changed negatively.

d) Discussion

Our study found aspects of EMS stroke care capacity in NC were close to universal, including stroke trainings, use of validated stroke scales or screening tools, and a policy to advance notify hospitals of suspected stroke. However, data on other measures of stroke education and training and prehospital practice and policies suggested room for improvement. Among EMS systems that provided stroke trainings, almost one-third did not cover the basic stroke educational topics. Of the systems surveyed, 69% trained their personnel on stroke at least once a year. This was only moderately greater than 60% of Minnesota EMS agencies surveyed in 2006, one of the few published, statewide assessments of EMS stroke care capacity (Tsai 2008).

While almost all EMS systems in NC used a validated stroke scale or screening tool, less than half regularly communicated the results to the destination hospital. This finding is somewhat consistent with only 34% of Minnesota EMS agencies in 2006 verbally reported stroke scale findings (Tsai 2008). Moreover, almost all NC systems (98%) reported a policy to advance notify hospitals of suspected stroke patients, so there appears to be an inconsistency between policy and compliance. Previous studies observed that prenotification by EMS personnel of a suspected stroke can significantly reduce in-hospital delays and increase treatment rates (Abdullah et al. 2008; Patel et al. 2011; McKinney et al. 2013). Follow-up to our quantitative work could use qualitative methods or intervention studies to better understand the translation of advance notification policies into EMS communication practices.

Bypass of local community hospitals for specialized stroke centers by EMS is a recommended policy and practice for many stroke systems of care (Acker et al. 2007). Furthermore, all NC EMS systems are required to implement a destination plan for stroke. In comparison, only 37% of EMS agencies in Minnesota reported having such a plan (Tsai 2008). Although a plan is required in NC, our survey showed that only about half of EMS systems always use their plan and another 12% never or only sometimes use it, suggesting that even with a statewide policy implementation, local systems are complying at varying degrees. Differences in the publicizing of legislation and enforcement of EMS policies across the state may have impacted local compliance, though we did not investigate in this study.

We found overall room for improvement in EMS stroke care capacity as 92% of systems scored less than 10 points. Of the main priority areas, CQI was the least addressed, with only 13 systems (13%) having examined stroke care performance data in the past year. A Utah-based study examined the feasibility of using electronic EMS records for monitoring prehospital stroke care and found that only 58% of EMS agencies entered data into an electronic system and data elements were missing in many records (Shaeffer et al. 2011). However, EMS systems in NC are required to enter standardized data elements electronically, so all should have the necessary data for performance feedback (Williams et al. 2009). Moreover, a statistical analysis report on stroke patient data was recently designed and developed to improve EMS systems (Williams et al. 2009). Nonetheless, we found few systems generate these reports, and more work is needed to encourage data-driven CQI in NC and in other states.

While low patient volume and rural locations are reported to have limited EMS stroke care capacity (McNamara et al. 2008; Oser et al. 2010; Shultis et al. 2010; Williams et al. 2012; Greer et al. 2013), our comparisons by patient volume and population density did not reveal strong variation by these characteristics. In fact, our findings show low volume and rural systems in NC can have high capacity. However, given this study's small size, further investigation is needed to address the relationship between EMS stroke care capacity and system size and location.

There were considerable improvements in NC EMS capacity since 2001, especially in the education and use of validated stroke scale or screening tools. These positive changes could be due to the initiation of stroke scale or screen use after 2001 or the switch from a locally developed tool to a standard, validated one, like the LAPSS or CPSS. Findings from comparable surveys are consistent with this increasing trend over the past decade. While stroke scale use was reported in 45% of Minnesota EMS agencies in 2006 (Tsai 2008), a more recent survey in nine states across the US reported 80% of EMS agencies used a stroke scale, though the use of a validated tool was not specified (Greer et al. 2013). Other significant positive changes were observed in education on all basic stroke topics, thrombolytic therapy education, and policy to advance notify of stroke. It is important to note that while overall positive changes were observed, several systems had changed in a negative direction, such as in the case of stroke educational topics coverage. Finally, although a formal policy evaluation was beyond the scope of this study, our findings show that statewide standardization of EMS stroke care was associated with improvements in capacity. Furthermore, other states and regions that implement similar policies may also undergo significant improvements.

Strengths & Limitations

Although survey questions were not validated, we developed our survey with input from subject matter experts, similar to previous surveys (Brice et al. 2008; Tsai 2008). Our results are based on self-report and subject to inaccurate responses. However, respondents were selected based on their expected knowledge of their systems, and they also had the option to work with others in completing the survey. Only two of the 100 systems did not respond for unknown reasons, and in terms of service level (e.g. BLS, ALS), patient volume, and population density, they were well-represented by those that did respond. Our EMS stroke care capacity score was based on expert opinion and guideline recommendations and has not been independently validated. However, this score can be easily replicated in other regions, and we believe provides a useful summary of overall EMS capacity for stroke. In light on no previous literature, we chose to equally weight each of the priority areas. We encourage further research on modifications of our scoring method. Finally, a significant strength of our study was the direct system-specific comparisons between two time periods. Although change analyses were restricted to only 70 EMS systems, these systems serviced about 81% of the 9.5 million population in NC. Furthermore, in terms of level of service, patient volume, and population density, this subset of systems was very similar to all NC EMS systems.

Conclusion

Our findings reveal areas of progress as well as those in need of improvement in the capacity of EMS systems to optimally care for stroke patients in NC. Personnel education activities should continue to be an area of focus, especially the content of stroke training sessions. Significant progress has been made in the institution of standardized patient care protocols, validated scales and screening tools, destination plans, and advance notification policies. However, improvements in the use of destination plans and communication of stroke screen results remain to be realized. Given its large stroke burden and recent statewide actions to advance stroke care, NC was a unique setting for this study. Many of the improvements observed in this study could be explained by statewide efforts to standardize prehospital stroke care and encourage best practices like bypassing local hospitals for stroke centers, although secular trends also likely played a role. While other states may not require standardized protocols and destination plans, this study offers an example of the improvements that can occur after similar policy changes. Nonetheless, for local health services planning and quality improvement, it is important to continuously monitor the capacity of EMS systems to respond to and manage stroke patients. Further study is needed to understand how stroke capacity translates into actual EMS care received

B. Specific Aim 2 – EMS time intervals among stroke patients

1. Distributions of EMS times among stroke patients

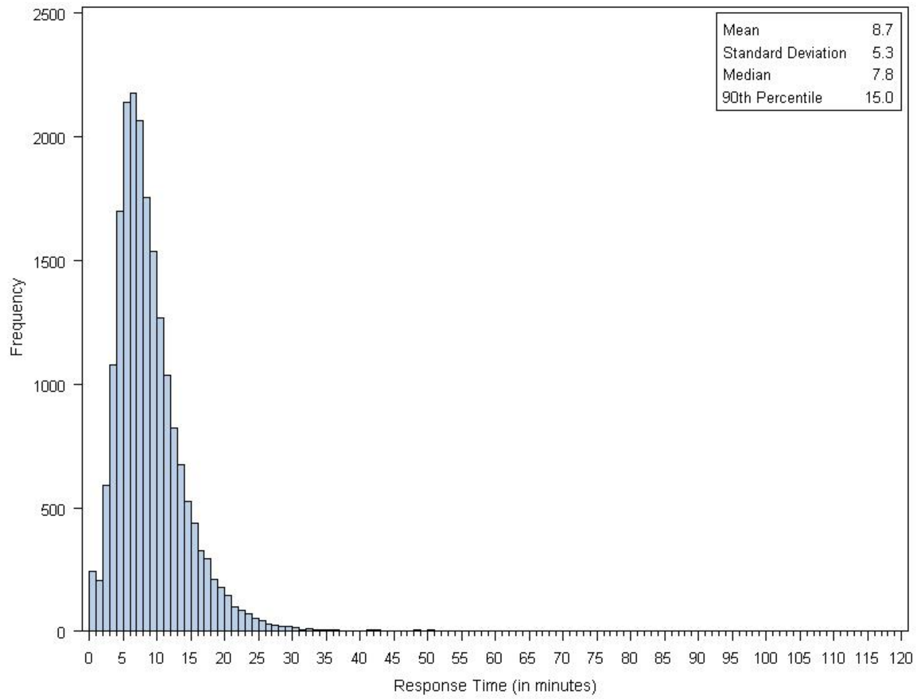
In the PreMIS database, we identified 199,092 records for a 9-1-1 response within a NC EMS system occurring 2009-2010 in which the patient had a possible neurological condition. Of these, 21,113 events had a documented impression of stroke or a stroke protocol used. Nine hundred ninety-five (5%) events were excluded if missing either the date or time of EMS unit notification, arrival on scene, or departure from scene with patient. Ninety-seven (0.5%) were excluded for invalid time intervals (i.e. <0 min), and another 63 (0.3%) were excluded for extreme times (i.e. >2 hrs), resulting in 19,958 eligible suspected stroke events for the main analysis.

The date and time of the 9-1-1 call was missing for 5,981 (30%) of records, so the EMS response time interval was defined, for this analysis, to start when the EMS unit was notified. Based on available data, the time from 9-1-1 call to notification of EMS unit was minimal on average (mean = 1.8 min, median = 1.2 min). The distributions of EMS response and scene times are shown in Figure 6.4. The 90^{th} percentiles exceeded benchmarks by 6.0 and 9.6 min, respectively. Furthermore, both EMS response and scene times did not appear to vary substantially by calendar time (Figure 6.5).

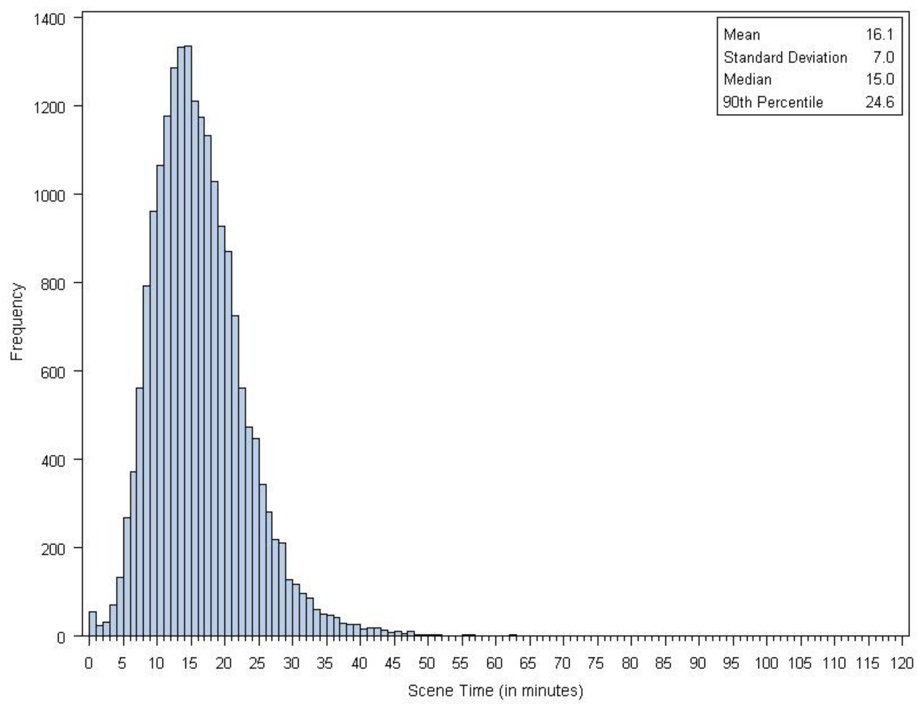
2. Individual and ecological correlates of EMS times

The individual and ecological characteristics of stroke events are summarized in Table 6.4. The majority of patients were older, female, and white. Events were more likely to have occurred during the daytime, on a weekday, and in the home. EMS was more likely to respond to the scene with lights and sirens. As expected, most events were within high volume systems and metropolitan counties.

Multivariable regression results are shown in Tables 6.5 and 6.6. Significant predictors of response time included patient race and event time of day, but these were not considered meaningful due to weak magnitude of estimates in general. Mean response times were almost 2 min shorter when EMS responded with lights and sirens, though the differences in medians and 90^{th} percentiles were less pronounced. EMS response times to homes compared to health care facilities or other locations (e.g. public places) were 2-3 min longer regardless of whether differences in means, medians, or 90^{th} percentiles were modeled. Metropolitan and micropolitan (versus rural) counties

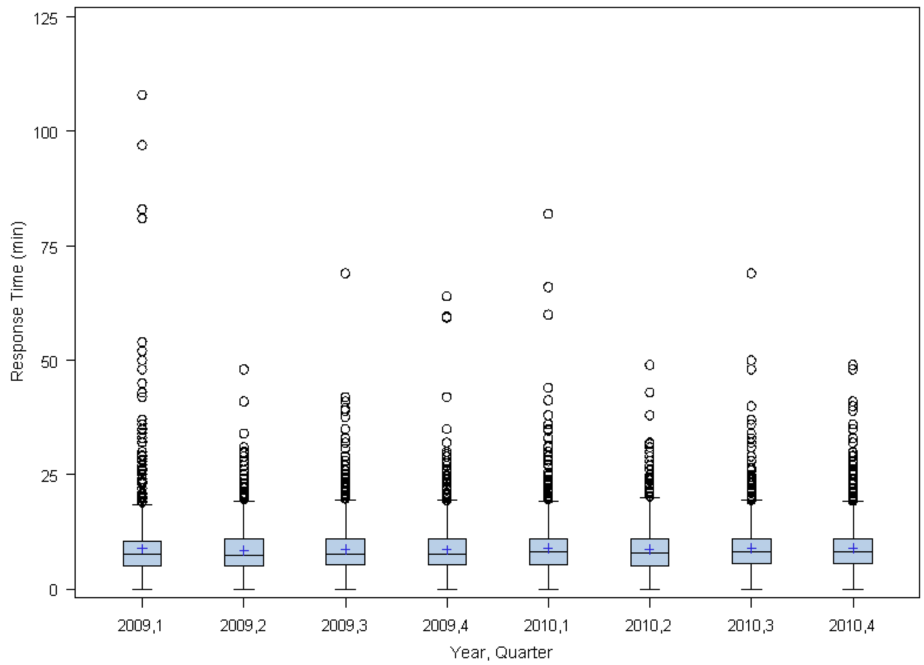


(a)

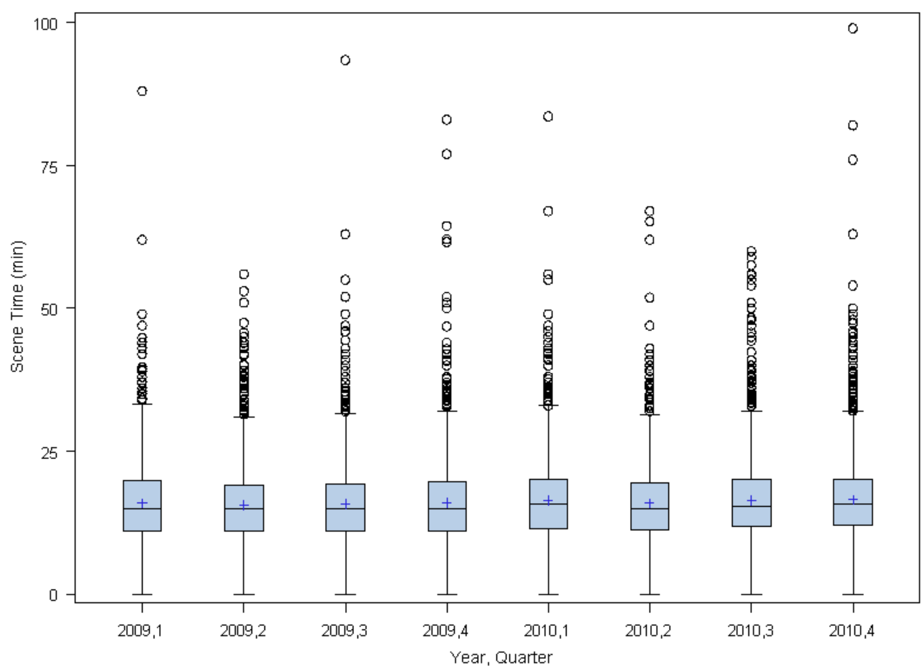


(b)

Figure 6.4. Frequency histograms of (a) response time and (b) scene time among stroke events, North Carolina 2009-2010



(a)



(b)

Figure 6.5. Boxplots of (a) response time and (b) scene time by calendar period among stroke events, North Carolina 2009-2010

Table 6.4. Individual and Ecological Characteristics of Stroke Events, 2009-2010 (N=19,958)

Covariate		**No.**	**%**
Individual			
Patient age			
	18-44 years	1,811	9
	45-64 years	5,938	30
	65-84 years	8,667	43
	85+ years	3,542	18
Patient gender			
	Female	11,410	57
	Male	8,548	43
Patient race			
	White	11,863	64
	Black	5,425	29
	Other	1,345	7
	missing	*1,325*	
Time of day			
	12-8AM	2,818	14
	8AM-5PM	11,275	56
	5PM-12AM	5,865	29
Day of week			
	Weekday	14,616	73
	Weekend	5,342	27
Response mode to scene			
	Lights and Sirens	15,522	78
	No Lights and Sirens	4,436	22
Scene location type			
	Home/Residence	12,958	69
	Health Care Facility	2,796	15
	Other (e.g. public places)	2,929	16
	missing	*1,275*	
Ecological			
System patient volume			
	<5,000/year	2,219	11
	5,000-20,000/year	7,228	36
	>20,000/year	10,511	53
County population density			
	Rural	2,179	11
	Micropolitan	4,888	24
	Metropolitan	12,891	65

Table 6.5. Regression Results for Response Time Intervals (in Minutes) among Stroke Events, 2009-2010 (N=17,510)

Covariate	**Mixed Linear Model**			**Quantile Regression Models**					
				Median			**90th percentile**		
	Est	95% CI	p	Est	95% CI	p	Est	95% CI	p
Patient age			0.05			0.17			0.11
18-44 years	0.39	0.08, 0.70		0.25	-0.04, 0.54		0.26	-0.31, 0.84	
45-64 years	0.23	0.01, 0.46		0.20	-0.01, 0.41		0.62	0.11, 1.13	
65-84 years	0.11	-0.10, 0.32		0.10	-0.08, 0.28		0.44	-0.07, 0.96	
85+ years (ref)	0			0			0		
Patient gender			0.04			0.35			0.51
Female	-0.15	-0.30, 0.00		-0.07	-0.20, 0.07		-0.11	-0.45, 0.23	
Male (ref)	0			0			0		
Patient race			<0.001			<0.001			<0.001
White (ref)	0			0			0		
Black	-0.79	-0.98, -0.61		-0.95	-1.11, -0.79		-1.24	-1.63, -0.85	
Other	-0.51	-0.87, -0.14		-0.75	-1.01, -0.49		-2.16	-2.79, -1.53	
Time of day			<0.001			<0.001			<0.001
12-8AM	0.65	0.41, 0.88		0.68	0.45, 0.92		0.72	0.20, 1.23	
8AM-5PM	-0.26	-0.43, -0.09		-0.17	-0.32, -0.01		-0.33	-0.70, 0.03	
5PM-12AM (ref)	0			0			0		
Day of week			0.93			0.44			0.36
Weekend	-0.01	-0.17, 0.16		-0.07	-0.21, 0.07		0.19	-0.55, 0.19	
Weekday (ref)	0			0			0		
Response mode to scene			<0.001			<0.001			<0.001
Lights and Sirens	-1.86	-2.10, -1.61		-0.33	-0.50, -0.17		-0.76	-1.14, -0.38	

No Lights and Sirens (ref)	0			0			0		
Scene location type			<0.001			<0.001			<0.001
Home/Residence (ref)	0			0			0		
Health Care Facility	-2.02	-2.24, -1.81		-1.92	-2.09, -1.75		-2.84	-3.25, -2.43	
Other	-1.91	-2.12, -1.7		-1.60	-1.78, -1.42		-2.26	-2.70, -1.83	
System patient volume			0.92			<0.001			0.003
>20,000/year	-0.26	-1.56, 1.04		0.27	-0.07, 0.60		-1.09	-1.81, -0.37	
5,000-20,000/year	-0.18	-1.20, 0.83		0.72	0.38, 1.05		-0.44	-1.17, 0.28	
<5,000/year (ref)	0			0			0		
County population density			0.04			<0.001			<0.001
Metropolitan	-1.45	-2.61, -0.30		-1.40	-1.78, -1.02		-4.16	-4.86, -3.46	
Micropolitan	-1.09	-2.21, 0.02		-1.03	-1.42, -0.64		-2.07	-2.78, -1.35	
Rural (ref)	0			0			0		

Est = estimate; CI = confidence interval; ref = referent

Table 6.6. Regression Results for Scene Time Intervals (in Minutes) among Stroke Events, 2009-2010 (N=17,510)

Covariate	**Mixed Linear Model**			**Quantile Regression Models**					
				Median			**90th percentile**		
	Est	95% CI	p	Est	95% CI	p	Est	95% CI	p
Patient age			<0.001			<0.001			0.001
18-44 years	-1.99	-2.41, -1.58		-2.39	-2.84, -1.94		-1.81	-2.72, -0.90	
45-64 years	-1.06	-1.36, -0.75		-1.32	-1.67, -0.97		-1.03	-1.71, -0.35	
65-84 years	-0.34	-0.62, -0.06		-0.43	-0.76, -0.10		-0.48	-1.17, 0.20	
85+ years (ref)	0			0			0		
Patient gender			0.08			0.04			0.98
Female	0.18	-0.02, 0.38		0.22	0.01, 0.43		0.01	-0.45, 0.46	
Male (ref)	0			0			0		
Patient race			0.08			0.15			0.34
White (ref)	0			0			0		
Black	0.01	-0.23, 0.26		0.03	-0.21, 0.28		-0.27	-0.77, 0.22	
Other	0.54	0.05, 1.02		-0.42	-0.92, 0.08		0.30	-0.60, 1.20	
Time of day			<0.001			<0.001			<0.001
12-8AM	0.98	0.66, 1.30		1.21	0.80, 1.61		1.07	0.44, 1.70	
8AM-5PM	-0.08	-0.30, 0.15		-0.04	-0.28, 0.19		-0.52	-1.01, -0.04	
5PM-12AM (ref)	0			0			0		
Day of week			0.36			0.49			0.28
Weekend	-0.10	-0.32, 0.12		-0.07	-0.30, 0.17		0.26	-0.24, 0.76	
Weekday (ref)	0			0			0		
Response mode to scene			<0.001			<0.001			<0.001
Lights and Sirens	-1.03	-1.36, -0.70		-1.53	-1.80, -1.25		-2.43	-2.97, -1.88	
No Lights and Sirens (ref)	0			0			0		

Scene location type			<0.001			<0.001			<0.001
Home/Residence (ref)	0			0			0		
Health Care Facility	-0.71	-1.00, -0.42		-0.97	-1.31, -0.63		-0.73	-1.36, -0.10	
Other	-1.70	-1.98, -1.42		-1.45	-1.71, -1.18		-2.26	-2.80, -1.71	
System patient volume			0.84			0.01			0.30
>20,000/year	-0.50	-2.26, 1.26		0.28	-0.30, 0.86		-0.89	-2.00, 0.21	
5,000-20,000/year	-0.14	-1.51, 1.23		-0.12	-0.64, 0.40		-0.72	-1.82, 0.38	
<5,000/year (ref)	0			0			0		
County population density			0.24			<0.001			<0.001
Metropolitan	-1.34	-2.90, 0.22		-1.46	-2.02, -0.90		-2.34	-3.34, -1.35	
Micropolitan	-0.90	-2.40, 0.61		-0.17	-0.72, 0.38		-0.45	-1.37, 0.48	
Rural (ref)	0			0			0		

Est = estimate; CI = confidence interval; ref = referent

were also associated with shorter response times in all regression models, with the strongest difference in 90th percentile response times between metropolitan and rural counties (-4.2 min, 95% CI -4.9, -3.5 min). On the other hand, system annual patient volume did not appear consistently associated with EMS response time.

Significant individual predictors of scene time included patient age, time of day, response with lights and sirens, and location type. The magnitude of estimates tended to be strongest for 90th percentile scene time, though this varied. As expected, scene times were shorter for younger ages and responses with lights and sirens. The strongest individual predictor, response with lights and sirens, was associated with a 2.4-min reduction in 90th percentile scene times. In addition, events that occurred in the early morning compared to daytime had slightly longer scene times; EMS responses to homes and health care facilities had longer scene times than responses to other locations. No consistent associations were detected between system annual patient volume categories while metropolitan (versus rural) counties had significantly shorter scene times with the greatest difference in 90th percentiles (-2.3 min, 95% CI -3.3, -1.4 min).

When alternate case definitions were used to identify suspected stroke events, the distributions of EMS response and scene time intervals were very similar (Table 6.7). While the individual and ecological characteristics of the more inclusive case definition (i.e. stroke impression, protocol used, or dispatch complaint) were very similar to the main case definition, stroke events identified by protocol use only tended to occur more in high volume and metropolitan EMS systems. In general, major individual and ecological predictors of EMS response and scene time intervals did not change with different case definitions. However, after restricting to only events for which a stroke protocol was used, estimated response time differences comparing metropolitan to rural systems were roughly 1 min farther from the null. Complete regression results are shown in Appendix F.

Table 6.7. Distributions of EMS time intervals by Case Definitions for Stroke Events in the Prehospital Medical Information System, North Carolina, 2009-2010

Case Definition	**Response Time (in minutes)**				**Scene Time (in minutes)**			
	Mean	(SD)	Median	(90th Percentile)	Mean	(SD)	Median	(90th Percentile)
1) Stroke Impression or Protocol (N=19,958)	8.7	(5.3)	7.8	(15.0)	16.1	(7.0)	15.0	(24.6)
2) Stroke Impression, Protocol, or Dispatch Complaint (N=42,161)	8.9	(5.2)	8.0	(15.0)	16.4	(7.6)	15.2	(25.2)
3) Stroke Protocol (N=11,624)	8.5	(4.7)	7.5	(14.1)	15.7	(6.6)	15.0	(24.0)

SD = standard deviation

3. Manuscript 2: Association of EMS stroke protocols with minimizing time spent at scene with stroke patients

This subchapter presents the results for subaim 2b as the second manuscript. Coauthors included dissertation committee members and Ms. Chailee Moss. This manuscript was accepted for publication in *Prehospital Emergency Care* on June 20, 2013.

a) Introduction

An acute stroke requires immediate medical attention. For every minute an ischemic stroke goes untreated, the typical patient loses an estimated 1.9 million brain cells (Saver 2006). Current acute stroke therapy with intravenous tissue plasminogen activator can prevent further tissue death and potentially rescue damaged tissue when administered to eligible patients within 3 to 4.5 hours of symptom onset (Saver 2013).

Appropriate prehospital care of stroke patients by emergency medical services (EMS) personnel ensures timely identification, evaluation, and transport (Jauch et al. 2013). Moreover, EMS use by stroke patients has been associated with shorter times to initial physician evaluation, brain imaging, and intravenous thrombolysis (Kothari et al. 1999a; Morris et al. 2000; Lacy et al. 2001; Katzan et al. 2003; CDC 2007; Rose et al. 2008).

Given the time urgency of current stroke treatment, EMS systems are recommended to capture and continually review specific time parameters that measure the timeliness of their prehospital stroke care (Jauch et al. 2013). According to American Stroke Association guidelines, the on-scene time, or amount of time EMS personnel spend with the patient before transport, should be less than 15 minutes (min) for stroke, excluding extenuating circumstances (Jauch et al. 2013; Acker et al. 2007). Systems are encouraged to monitor and improve the 90^{th} percentile of all response times since this metric best describes performance for the majority of patients.

In a 2008 survey in 9 states, 81% of EMS agencies reported having a specific scene time benchmark for responding to stroke (Greer et al. 2013), though the presence of a time benchmark was not objectively assessed. EMS protocols provide written instructions for evidence-based prehospital care of patients with a particular condition and often vary by the type and amount of information provided. Therefore, we assessed 2009 stroke protocols from North Carolina (NC) EMS systems for the presence of scene time instructions. Furthermore, we sought to determine whether having a stroke protocol with a specific scene time limit was associated with less time EMS spent on scene with stroke patients.

b) Methods

Study Setting and Data Collection

In 2003, NC's 100 local EMS systems were established to organize the state's more than 35,000 EMS personnel and more than 540 EMS agencies on a county basis (Mears et al. 2010). All protocols, medical direction, and quality assurance activities occur at the system rather than the agency level. We retrospectively collected existing 2009 EMS stroke protocols from all NC systems. Two reviewers (MDP and CM) independently assessed stroke protocols for instructions regarding the minimization of on-scene time and whether a specific time limit was provided. Disagreements were adjudicated by a third reviewer (JHB). Systems with a specific limit for time spent on scene on their protocol were classified as "Specific time limit " while those with only general instructions were classified as "General instructions " and those with no stroke protocol or no scene time instructions were classified as "None". The EMS system's annual patient volume was estimated with the number of total EMS events occurring in the past year, as recorded in the NC Credentialing Information System (EMS Performance Improvement Center 2012a), and then categorized into 3 groups: <5,000, 5,000-20,000, and >20,000 events. EMS systems were classified as metropolitan based on the county population (US OMB 2009).

We analyzed EMS responses occurring in 2009 with data from the NC Prehospital Medical Information System (PreMIS), a statewide electronic healthcare record used for evaluation of EMS patient care and system performance (EMS Performance Improvement Center 2012b). The PreMIS database collects more than 200 data elements defined in the National EMS Information System dataset (NEMSIS 2012). Each patient encounter by EMS in NC is submitted to PreMIS, amounting to over 1 million records per year. This database includes detailed data on the patient condition and care provided by EMS across the entire state. We defined a suspected stroke event as any 9-1-1 response in which the EMS personnel's impression of the patient's condition was stroke or the EMS personnel documented use of a stroke protocol. The outcome of interest was the time EMS personnel spent with the patient before transport, or "scene time," which was defined as the time from EMS arrival at the scene to departure with the patient. For the final eligible sample, events were excluded if missing either EMS arrival or departure time, having an invalid computed scene time (i.e. $\leq$0 minutes), or scene time exceeded 2 hours. This study was approved by the University of North Carolina at Chapel Hill Public Health-Nursing Institutional Review Board.

Statistical Analysis

Descriptive statistics for scene times in suspected stroke events were calculated overall and by system-level protocol instructions and other system-level factors of interest (i.e. annual patient volume and metropolitan status). Quantile regression (Koenker and Bassett Jr 1978) was used to estimate how the 10^{th} to 90^{th} percentiles of the scene time distribution in 10-percentile intervals varied by stroke protocol classification: specific time limit, general instructions, or no instructions (referent). The main association of interest was the difference in the 90^{th} percentile of scene time by stroke protocol instructions because the recommended benchmark for EMS scene time is less than 15 min for at least 90% percent of suspected stroke patients. Since large systems may be more likely to have advanced protocols and a greater sense of urgency for stroke, regression models were adjusted for annual patient volume and metropolitan status to account for potential confounding. Event counts among low volume and nonmetropolitan systems were insufficient to test for statistical interaction of the association between presence of protocol instructions and scene time. To further investigate the role of patient volume and metropolitan status, we fit models in the subgroup of high volume (i.e. >20,000 patients annually) and metropolitan EMS systems. Quantile regression parameters were estimated using the interior point algorithm (Karmarkar 1984), and 95% confidence intervals (CI) were constructed with bootstrap standard errors. Statistical models were fit in SAS version 9.2 (Cary, NC).

Sensitivity Analysis

Thirty-two percent of records in the PreMIS database were missing data on both EMS personnel's impression and protocol(s) used, whereas only 11% of records were missing the complaint determined by 9-1-1 dispatch. In an attempt to capture any events missed by the primary case definition, we included events for which dispatch reported stroke to the responding EMS unit and then repeated analyses to investigate the sensitivity of results to differences in case definition. We also conducted analyses only among events with documented use of a stroke protocol, presumably restricting to just those in which EMS personnel used the protocol to direct patient care.

c) Results

Descriptive Characteristics

In 2009, the 100 NC EMS systems varied in their stroke protocols: 23 were classified as having no instructions regarding scene time; 73 classified as having general instructions to minimize scene time; and 4 classified as having a specific limit for scene time. Annual patient volume also varied (median 8,004; interquartile range 3,754-17,848), and 40 of 100 EMS systems serviced metropolitan counties.

In the PreMIS database, we identified 96,688 records for a 9-1-1 response within a NC EMS system occurring in 2009 in which the patient had a possible neurological condition (Figure 6.6). Of these, 10,155 events had a documented impression of stroke or a stroke protocol used. Three hundred ninety-nine (4%) events were excluded if either the date and time of EMS unit arriving on scene or unit left scene with patient was missing, and 33 (0.3%) were excluded for invalid or extreme scene times, resulting in 9,723 eligible suspected stroke events for the main analysis.

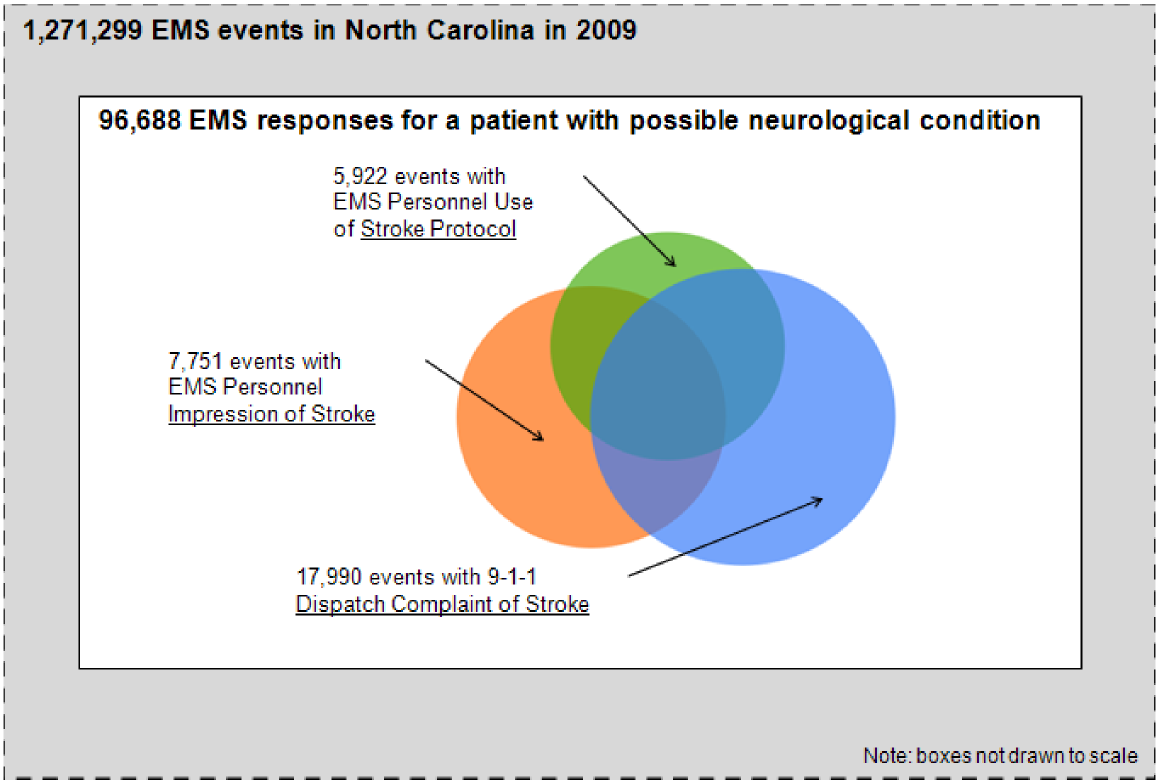


Figure 6.6. Diagram of Suspected Stroke Events in the Prehospital Medical Information System, North Carolina, 2009

Table 6.8. Distribution of Scene Times among Stroke Events by Stroke Protocol Instructions and Other Covariates, Prehospital Medical Information System, North Carolina, 2009 (N=9,723)

	Number of EMS Systems	Number of Stroke Events	Scene Time (in minutes)	
			Mean (Standard Deviation)	**Median (90th Percentile)**
Protocol Instructions on Scene Time				
Specific Time Limit	4	1,728	14.3 (5.9)	13.6 (22.0)
General Instructions	63	5,146	16.2 (7.2)	15.0 (25.0)
None	19	2,849	16.2 (6.8)	15.3 (24.6)
Annual Patient Volume				
>20,000	18	4,987	15.8 (6.9)	15.0 (24.0)
5,000-20,000	40	3,608	15.8 (6.9)	15.0 (25.0)
<5,000	28	1,128	16.4 (7.7)	16.0 (25.0)
Metropolitan Status				
Yes	34	6,518	15.4 (6.6)	14.4 (23.7)
No	52	3,205	16.8 (7.5)	16.0 (26.0)

There were 86 EMS systems represented in this analysis (Table 6.8). No eligible suspected stroke events were identified from the other 14 NC EMS systems either due to no occurrences within the time period or incomplete data in PreMIS. Only 4 systems were found to have a specific limit for scene time provided in the stroke protocol although these 4 systems accounted for 18% of the eligible suspected stroke events for this study. The mean scene time was 15.9 min (standard deviation 6.9 min), and median scene time was 15.0 min (interquartile range 11.0-19.5 min). The 90th percentile was 24.3 min and well exceeded the 15-min benchmark. The median and 90% percentile scene times for systems with stroke protocols with a specific time limit were about 2-3 minutes shorter when compared to both general only and no instructions. General and no instructions had roughly equivalent scene time distributions. While there were minimal differences by system patient volume, metropolitan systems had about 2-min shorter scene times.

Adjusted Associations

After adjusting for annual patient volume and metropolitan status, systems having stroke protocols with a specific time limit (versus no instructions) remained associated with shorter scene times across the range of percentiles estimated (Figure 6.7). The most pronounced quantile regression estimate was at the 90th percentile (-2.2 min, 95% CI -3.1 to -1.3 min), meaning the greatest scene time for 90% of stroke patients was 2-min less if there was a specific time limit provided as opposed to no instructions. Quantile regression estimates comparing general to no instructions remained close to the null value.

In the subgroup analysis within high patient volume and metropolitan EMS systems, we observed a similar magnitude for the 90th percentile comparison of specific time limit and no instructions (-2.5 min, 95% CI -3.5 to -1.4 min) while the comparison of general to no instructions was substantially greater than the null (2.0 min, 95% CI 0.9 to 3.1 min), suggesting that having general instructions as opposed to none in the protocol has longer scene times for stroke patients in this subpopulation.

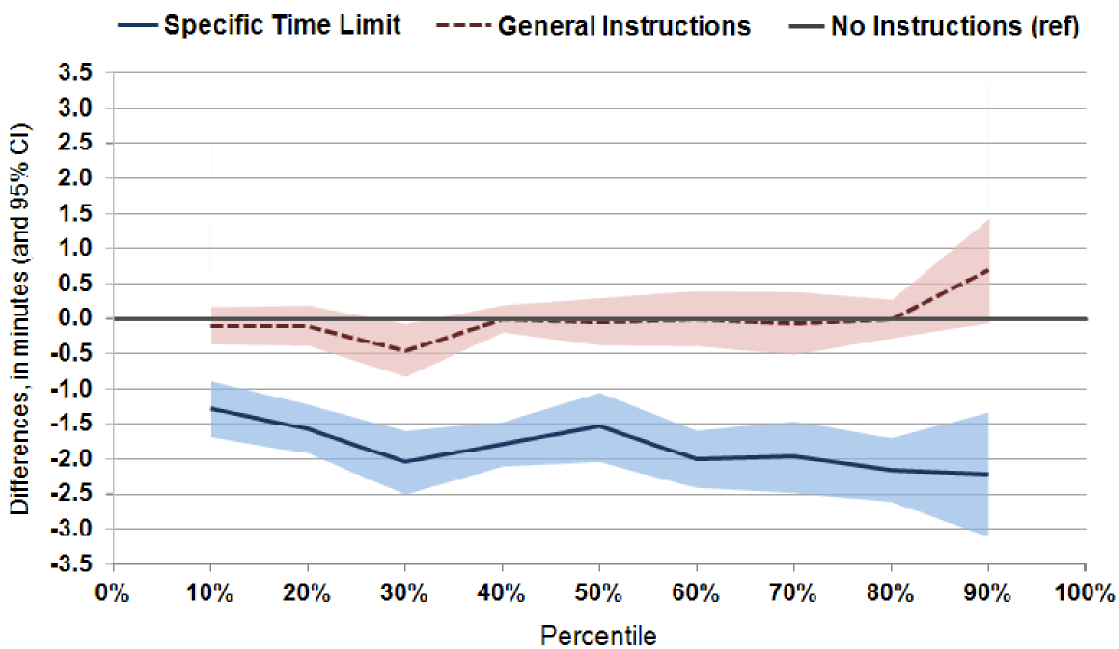


Figure 6.7. Adjusted Differences in Scene Time for Suspected Stroke by Type of Protocol, Prehospital Medical Information System, North Carolina, 2009

Sensitivity Analysis

Our primary case definition resulted in 9,723 eligible suspected stroke events (Table 6.9). The inclusion of dispatch complaints of stroke resulted in 20,750 total eligible events. Among this larger group, the association of specific time limit to no instructions was still negative though attenuated (-1.7 min, 95% CI -2.5 to -1.0). In addition, when we restricted to only those eligible events in which a stroke protocol was used (N=5,740), the specific time limit association was very similar (-2.1 min, 95% CI -3.1 to -1.0 min); however, general instruction (versus none) was now associated with shorter scene time, though weakly (-1.0 min, 95% CI -2.1 to 0.1 min). Overall, the sensitivity of these results to differences in case definition appears minimal.

Table 6.9. Adjusted Differences in 90th Percentile Scene Time by Case Definitions of Suspected Stroke Events in the Prehospital Medical Information System, North Carolina, 2009

Case Definition **Protocol Instructions on Scene Time**	**Stroke Events (N)**	**Regression Estimate (95% CI)**	
1) Stroke Impression or Protocol	9,723		
Specific Time Limit		-2.2	(-3.1, -1.3)
General		0.7	(-0.2, 1.5)
None (ref)		0	
2) Stroke Impression, Protocol, or Dispatch Complaint	20,750		
Specific Time Limit		-1.7	(-2.5, -1.0)
General		0.0	(-0.6, 0.6)
None (ref)		0	
3) Stroke Protocol	5,740		
Specific Time Limit		-2.1	(-3.1, -1.0)
General		-1.0	(-2.1, 0.1)
None (ref)		0	

CI = confidence interval; ref = referent

d) Discussion

In this study of suspected stroke events, we found a 2.2-min reduction in 90th percentile scene times for stroke patients in EMS systems having stroke protocols with a specific time limit compared to protocols with no instructions on scene time. No significant difference in scene time was detected in EMS systems with general protocol instructions compared to none. While a 2.2-min reduction in the 90th percentile scene time makes up only 9% of the 24.6-min scene time among no protocol instructions, the percentage of the modifiable scene time would be greater because there is always a minimum amount of time needed to, for example, access and load the patient (Honigman et al. 1990). Moreover, we believe lower scene time represents a heightened sense of urgency in EMS personnel, which could have a cascading effect on the transport time and perhaps even emergency department processing times. In fact, previous research on EMS responses for trauma showed a strong correlation between scene time and transport time (Hedges et al. 1988). Additionally, a study of acute myocardial infarction patients found achieving benchmarks for EMS response, scene, and transport times was associated with reduced time to reperfusion (Studnek et al. 2010). Similar studies of prehospital time intervals and stroke treatment would be informative.

Our findings highlight the importance of detailed protocols for the prehospital care and management of stroke patients. Since use of EMS protocols provide some assurance of best medical practices and appropriate delivery of care, additional studies are needed to provide information to guide their development and implementation. To our knowledge, no previous studies have estimated the effect of stroke protocols on reducing scene time. There have been limited studies on the impact of interventions to minimize EMS scene times for patients with stroke. The Houston Paramedic and Emergency Stroke Outcomes (HoPSTO) study, an educational intervention to improve EMS and hospital stroke care, found mean scene times for suspected stroke patients unexpectedly increased from 16.7 to 18.2 min after training in prehospital stroke identification (Wojner-Alexandrov et al. 2005). Frendl et al. (2009) trained EMS personnel on prehospital stroke screening and observed a moderate decrease in mean scene time (19 versus 17 min). These studies simply compared mean scene times and, thus, may have missed important differences that are detectable using quantile regression methods (Austin and Schull 2003; Do et al. 2012).

The average scene time in our study is comparable to previous reports from the US, which range from 13 to 20 min (Evenson et al. 2001; Wojner et al. 2003; Rosamond et al. 2005; Wojner-Alexandrov et al. 2005; Kleindorfer et al. 2006a; Frendl et al. 2009; Ramanujam et al. 2009; Shaeffer et al. 2009). Notably, only 50% of suspected stroke events had a scene time of 15 min or less, whereas the benchmark is at least 90% of stroke patients. Starting in 2010, the NC regulatory office of EMS mandated the use of standardized protocols throughout the state, of which the stroke protocol (available at http://www.ncems.org/pdf/Pro33-SuspectedStroke.pdf) specifically instructs responders to limit scene time to 10 minutes. However, we found only 4% of NC EMS systems in 2009 provided specific time limits in their stroke protocols. According to a 2008 survey of EMS agencies in 9 states, 81% of respondents reported their agencies had an on-scene time limit for responding to stroke patients (Greer et al. 2013), though this study did not objectively assess protocols. Nonetheless, there still remain opportunities to improve EMS scene times for stroke, perhaps through protocol development and implementation at the agency or state level.

Since a statewide shift to standardized protocols took place at the beginning of 2010, we were concerned that some systems classified as having general only or no instructions, based on protocols at the start of 2009, may have switched to the state protocol at some point in the year. Since protocol misclassification was more likely at the near the end of 2009, we repeated analyses stratified by calendar year quarter (e.g. first quarter represents events occurring in January through March). Associations among stroke events occurring in the first quarter of 2009 were similar to overall associations, whereas the weakest association between a specific time limit and no instruction was observed during the last quarter. This attenuation suggests systems could have adopted the new protocol during the time range of this study.

A major strength of this study was the use of existing data from a geographic region with both urban and rural areas. While we evaluated a single state, most previous studies of EMS scene times for stroke have focused solely on local, mostly metropolitan regions (Wojner-Alexandrov et al. 2005; Kleindorfer et al. 2006a; Ramanujam et al. 2009). We were able to adjust for volume and population density of the EMS system, though our sample size was limited by the presence of only 4 systems with specific scene time limits on their protocols, in which most suspected stroke events were from high volume and metropolitan systems. Within this subpopulation, the association of specific time limits on minimizing scene time remained similar to the overall association.

Unlike previous studies using patients with a final hospital diagnosis of stroke, our study population was composed of patients with a prehospital impression of stroke. Although a number of these would not have had a stroke diagnosis, they are relevant to the study of prehospital stroke care since they should be managed like a stroke by EMS personnel, if only to be later ruled out. To our knowledge, this is the largest study to date of EMS scene times for stroke, which was made possible by the availability of electronic records on EMS events across NC. We previously noted missing data in PreMIS as a major limitation. For key elements (i.e. personnel's impression and protocols used) needed to identify suspected stroke events, data were missing for almost one-third of records. In sensitivity analyses, we varied the case definition to include more events and found the major findings to remain the same. Completeness and quality of scene time data were less of a concern. We had to exclude only 4% of events due to missing or invalid times, which was better than a previous study of electronic EMS records, in which only 70% of suspected stroke events could had sufficient information to calculate scene time (Shaeffer et al. 2009). In addition to state and system efforts to ensure that electronic EMS records are collected accurately and completely, we recommend further research on the implications of data completeness and quality.

We used 2 independent reviewers and an expert adjudicator to classify systems by their stroke protocol instructions regarding scene time, if any, at a given time. However, we were not able to assess changes in protocols prior to this time or during the study period. The main association of shorter scene times for specific time limits compared to no protocol instructions could be explained by the influence of extraneous factors on EMS system protocols and personnel response times. We did not control for other potentially confounding system-level factors, such as the role of emergency medical dispatch and medical direction (Ramanujam et al. 2009; Greer et al. 2013), but given the amount standardization across NC, we do not feel these strongly influenced our results.

e) Conclusion

In this statewide analysis, EMS personnel spent at most 24 min with 90% of suspected stroke patients before commencing transport to the hospital. We estimated a roughly 2-min reduction among EMS systems that stated a specific time limit on the suspected stroke patient care protocol, even compared to systems with general instructions to minimize scene time. Our findings suggest that systems can modestly improve scene times by specifying a limit in their patient care protocols. Moreover, these improvements may be markers of a greater sense of urgency among EMS personnel when responding to stroke. Further studies, ideally experimental, are needed on the effect of system protocols on EMS response times and the eventual impact on stroke outcomes.

VII. DISCUSSION

A. Summary of Findings

1. Specific Aim 1 – EMS stroke care capacity

This dissertation found several areas of EMS stroke care capacity that were met by almost all NC EMS systems, including stroke educational training, specific education on stroke scales and screening tools, use of validated stroke scales and screening tools, and policy to advance notify hospitals. On the other hand, several specific areas showed room for improvement, including the frequency of stroke educational trainings, coverage of basic stroke educational topics, communication of stroke screening results to the hospital, and use of the written destination plan. In addition, data-based performance feedback was uncommon (13%) among NC EMS systems. The summary score of selected EMS education policy measures revealed variation in EMS stroke care capacity. In NC, where there has been recent statewide standardization of prehospital stroke care capacity, no systems scored poorly (i.e. 0-3 points) on the summary score. However, only 8% of systems scored high (i.e. 10-12 points), and this variation did not differ by system patient volume or population density, suggesting systems of all sizes could be improved.

The comparison of 2001 and 2012 time periods showed considerable improvements in the education of EMS personnel and use of validated stroke scales and screening tools and the existence of a hospital prenotification policy, which could be the result of recent statewide implementation of EMS protocols and destination plans.

Moderate improvement in the coverage of all basic stroke educational topics was observed but further improvements are needed to achieve optimal EMS capacity.

Further standardization of educational requirements, patient care practices, and policies may be the key to improving EMS capacity to care for stroke patients. However, statewide requirements would limit the freedom of local directors to consider available resources and population needs in determining the requirements for local EMS systems. Certification of EMS systems as "stroke capable", analogous to hospital programs like the Joint Commission PSC certification, could encourage local leaders to pursue optimal EMS stroke care capacity.

2. Specific Aim 2 – EMS time intervals among stroke patients

In these data, EMS response and scene time intervals were longer than recommended yet consistent with previous studies. Select individual covariates and county population density significantly predicted EMS response and scene times to varying degrees. The strongest individual predictor of response times, scene location type (i.e. home/residential, health care facility, other/public place), was associated with 2-3 min longer times among responses to homes compared to health care facilities or other public places. In addition to health care and public locations being easier to find than residences, the presence of health care professionals or simply more bystanders may heighten the urgency with which 9-1-1 calls are made and responded to by dispatchers and EMS units.

Response with lights and sirens was the strongest predictor of scene times (2.4-min reduction of 90th percentile), which may due to urgency in the 9-1-1 call or response by dispatch or EMS as a result of the patient's severity of symptoms or condition. It is also possible EMS systems with a policy to respond to stroke with lights and sirens are more likely to systemically minimize scene times. Overall, metropolitan (and in some cases, micropolitan) counties had the shortest EMS time intervals. It is expected that more sparsely populated areas would require more time to respond whereas time spent at the scene would not vary as much. On the contrary, metropolitan counties had as much as 4 min less scene time than rural counties, which suggests greater urgency with which EMS personnel assess suspected stroke patients.

In the evaluation of stroke protocol instructions, 18% of stroke events (N=1,728) were in EMS systems having protocols with a specific limit for scene time while the majority (53%, N=5,146) were in systems with only general instructions to minimize scene time. In adjusted analyses, there was a 2.2-min reduction in EMS scene times for 90% of stroke patients where a specific time limit was provided on stroke protocols compared to protocols with no instructions on time limit, whereas no significant difference in scene time was detected comparing protocols with general instructions to none. Where most protocols assessed had instructions on minimizing scene time, the presence of a specific time limit as opposed to only general instructions perhaps has a significantly greater impact on the urgency with which EMS personnel assess stroke patients.

Various methods for the identification of stroke events from PreMIS were explored. Although the total number of stroke events varied by case definition, major findings and overall conclusions did not change with different case definitions. Even though the complaint recorded by dispatch was used to identify all potential strokes, relevant events were possibly missed given the degree of incomplete data on EMS personnel's impression and protocols used. Furthermore, some regression estimates varied, though not substantially, with different case definitions.

Roughly half of stroke events exceeded consensus benchmarks for EMS response and scene times, indicating timely EMS stroke care remains to be realized. The major predictors of EMS response and scene times are related to the level of urgency involved with the stroke event, which, whether based in the patient's condition, dispatcher's response, or care provided by EMS, was not further investigated in this dissertation. However, interventions to heighten the sense of urgency in all involved, through public health messages and dispatch and EMS capacity improvements, could reduce EMS times.

B. Dissemination Plan

Findings from this dissertation will be disseminated to key stakeholders, including EMS and stroke care researchers and policymakers. As a research project, select findings went into the preparation of two manuscripts for submission to peer-reviewed journals. In addition, results from the second manuscript were presented at the 2013 AHA/ASA Quality of Care and Outcomes Research Scientific Sessions (May 16, 2013).

Given the practical aspects of this work, I feel the need to directly share these findings with key stakeholders including the state Heart Disease and Stroke Prevention program, the state OEMS and local systems, and other advocacy and public health groups. Therefore, I plan to present key findings at meetings of the NC OEMS, AHA/ASA local affiliate, NC Stroke Advisory Council, and any other interested local or state organizations. In addition, I will create a 2-pager fact sheet (see Appendix G for a draft) and distribute it to survey participants and stakeholders via email and the internet.

C. Public Health Implications

EMS transport of stroke patients has been associated with better and timelier acute care and treatment. Furthermore, optimal EMS care has the potential to reduce stroke mortality and disability. Before EMS care practices can be properly studied, it is important to first understand the context within which EMS care providers operate. Results from this dissertation provided information on current EMS system capacity to respond to and manage stroke patients and offered insight into areas in need of improvement. Moreover, comparison of EMS stroke care capacity between time periods highlighted the aspects that improved and other aspects in which improvement remains to be realized. The results from this dissertation have practical applications to EMS capacity for managing stroke patients in NC but also contribute generalizable knowledge for improving prehospital stroke care in the US. Deficiencies in EMS stroke capacity for NC were identified and observed regardless of system patient volume and population density, so these findings could be externally valid to a variety of regions. Before broader efforts to improve system capacity are implemented, more surveillance of EMS stroke care is needed to inform quality improvement programs.

The timely presentation, evaluation, and treatment of stroke patients are essential to ensuring effective treatment and favorable health outcomes. Prehospital and in-hospital delays are often the reason stroke patients are not treated with thrombolytics. EMS systems and their personnel have the ability reduce delays through emergency response, prehospital screening, and rapid transport and prenotification to the most appropriate acute care facility. On the most part, EMS response and scene times compose only a small proportion of prehospital delays. However, after accounting for the minimum necessary time for EMS dispatch, travel, and patient evaluation at the scene, much of the EMS times observed in this work could be minimized through better training and use of prehospital screening tools and greater urgency in responding to suspected stroke events. Protocol development and implementation is one viable avenue to address EMS scene times. Finally, it is hypothesized that faster EMS responses could translate to faster transport and initial processing in the ED.

In recent years, an estimated 14,000 stroke patients in NC arrived to the hospital by EMS per year, approximately half of all hospitalized strokes in the state. As public health messages continue to emphasize calling 9-1-1 in the event of a stroke, EMS could potentially be the initial medical contact for thousands more stroke patients annually. Therefore, EMS is currently important to acute stroke care and could have a much larger role going forward.

D. Strengths & Limitations

Strengths of the first specific aim included high participation in the EMS stroke care survey and the study of a relatively large sample of systems. Since survey questions were not tested for psychometrics, the reliability and validity of results are uncertain. Results were summarized into a single stroke care capacity to provide an overall indication and encourage future comparisons and further research. Previous survey results were used for a direct comparison of NC EMS systems, which allowed the estimation of changes in EMS stroke care capacity over the past decade though only in a subset of systems.

The second specific aim used existing electronic records from multiple EMS systems within a diverse region. However, the analysis was limited by few systems in some subgroups. Since EMS records have information on the initial impression of each event, the study population represented the entire spectrum of patients among which prehospital stroke care was required. Key data elements were missing in a large proportion of records, and validity of these data was not certain. System protocols and scene times among stroke patients were moderately associated, but protocols and their instructions could exist for reasons related to scene time and, moreover, may have changed over the study period. An experimental or quasi-experimental study of protocol content and implementation would provide stronger evidence of their impact on prehospital stroke care.

E. Future Directions

There is a need for more scientific assessments of EMS stroke care capacity in other states and regions, which can then be summarized into the broader context of EMS and prehospital stroke care. Surveys may be the most efficient way to conduct these assessments, but more work is needed to develop and validate standard questions. Furthermore, surveys will provide useful data, but qualitative research could lead to further insight into the reasons behind variations in capacity.

Ongoing surveillance of EMS capacity, whether by periodic surveys or other methods, would help guide planning, implementation, and evaluation of EMS quality improvement efforts. A national surveillance system would provide a basis for setting standards and prioritizing the allocation of emergency medical resources. A coordinated approach between related acute disease, like stroke, myocardial infarction, and cardiac arrest, would be prudent.

More research is needed on the impact of EMS capacity on care practices. Formal evaluations of educational interventions or policy implementation could provide valuable evidence. Pre-existing electronic databases allow for retrospective studies, but these data need to be thoroughly assessed for systematic error and non-ignorable missingness. Electronic health record systems, like PreMIS, could serve as ready-made platforms on which to conduct population-based studies. Finally, future studies should investigate the translation of EMS care practices to patient treatment and outcomes.

F. Conclusions

EMS has the potential to ensure timely identification, evaluation, and transport of stroke patients, but EMS systems vary in their capacity to respond to and manage stroke patients. States, like NC, have standardized EMS stroke care capacity with statewide patient care protocols and required written destination plans. However, the use of destination plans and communication with hospitals are in need of improvement, along with basic stroke education.

Prehospital stroke care requires continuous monitoring and quality improvement efforts. EMS response and scene times tend to be substantially longer than recommended, and these times could be reduced by instilling a greater sense of urgency among EMS personnel responding to stroke patients. One possible effective approach to minimize scene times would be for EMS systems to include a specific time limit on stroke protocols.

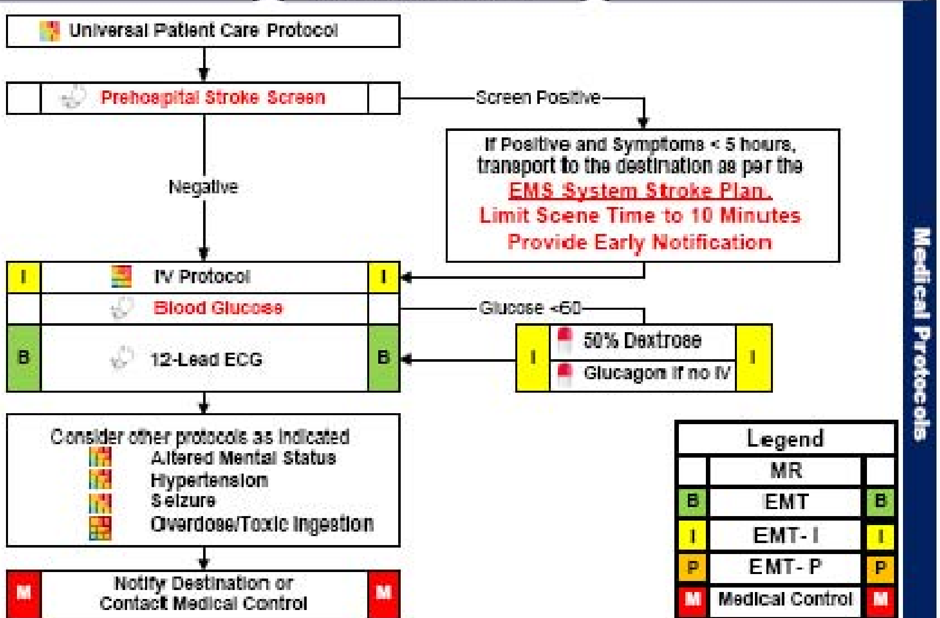
APPENDIX A. NC EMS Suspected Stroke Protocol

Suspected Stroke

History
- Previous CVA, TIA's
- Previous cardiac / vascular surgery
- Associated diseases: diabetes, hypertension, CAD
- Atrial fibrillation
- Medications (blood thinners)
- History of trauma

Signs and Symptoms
- Altered mental status
- Weakness / Paralysis
- Blindness or other sensory loss
- Aphasia / Dysarthria
- Syncope
- Vertigo / Dizzyness
- Vomiting
- Headache
- Seizures
- Respiratory pattern change
- Hypertension / hypotension

Differential
- See Altered Mental Status
- TIA (Transient ischemic attack)
- Seizure
- Hypoglycemia
- Stroke
  - Thrombotic or Embolic (~85%)
  - Hemorrhagic (~15%)
- Tumor
- Trauma



Pearls
- Recommended Exam: Mental Status, HEENT, Heart, Lungs, Abdomen, Extremities, Neuro
- Items in Red Text are key performance measures used in the EMS Acute Stroke Care Toolkit
- The Reperfusion Checklist should be completed for any suspected stroke patient. With a duration of symptoms of less than 5 hours, scene times should be limited to 10 minutes, early destination notification/activation should be provided and transport times should be minimized based on the EMS System Stroke Plan.
- Onset of symptoms is defined as the last witnessed time the patient was symptom free (i.e. awakening with stroke symptoms would be defined as an onset time of the previous night when patient was symptom free)
- The differential listed on the Altered Mental Status Protocol should also be considered.
- Elevated blood pressure is commonly present with stroke. Consider treatment if diastolic is > 110 mmHg.
- Be alert for airway problems (swallowing difficulty, vomiting/aspiration).
- Hypoglycemia can present as a localized neurologic deficit, especially in the elderly.
- Document the Stroke Screen results in the PCR.
- Document the 12 Lead ECG as a procedure in the PCR.

Protocol 33 — 2009

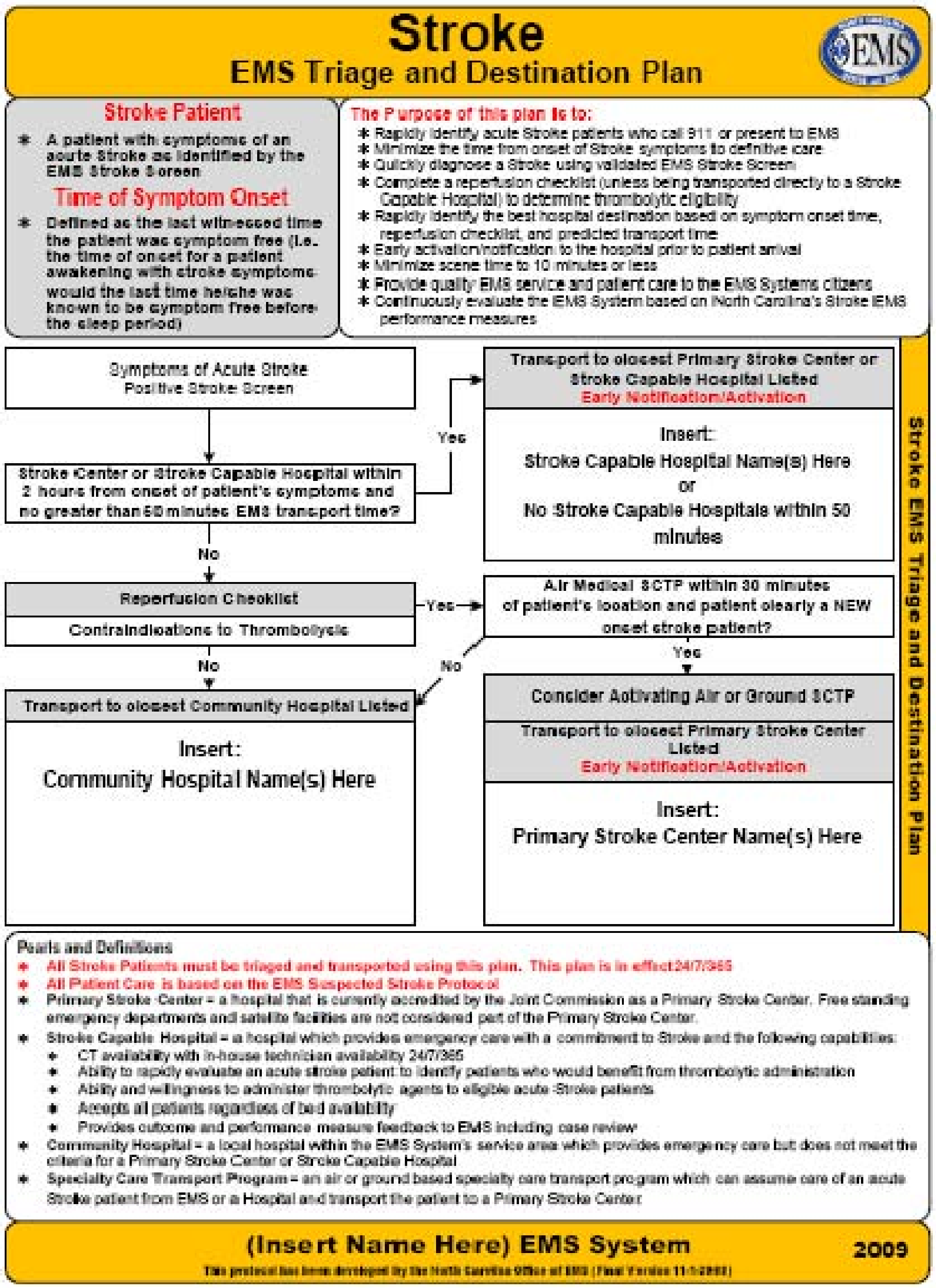
Any local EMS System changes to this document must follow the NC OEMS Protocol Change Policy and be approved by OEMS

APPENDIX B. Summary of Prehospital Stroke Assessment Tools

Prehospital Stroke Assessment Tool	Study	Study Characteristics	Main Findings
NIH Stroke Scale (NIHSS)	Smith, WS. 1999	San Francisco, CA (1997)	Paramedics trained in NIHSS Se = 91%
Cincinnati Prehospital Stroke Scale (CPSS)	Kothari, RU. 1999	Cincinnati, OH (1997)	~10 mins to train; <1 min to perform Se = 59%, Sp = 88%
Los Angeles Prehospital Stroke Screen (LAPSS)	Kidwell, CS. 1998 + Kidwell, CS. 2000	Los Angeles, CA (1997-8)	46% paramedics completed LAPSS Among all runs, Se = 86%, Sp = 99% Among neuro. only, Se = 91%, Sp = 97%
Miami Emergency Neurologic Deficit (MEND) Examination	LaCombe, DM 2000 + Gordon, DL 2005	Miami, FL (1997-9)	12 item exam ~3 min to complete
Shortened NIH Stroke Scale (sNIHSS)	Tirschwell, DL. 2002	3 pooled clinical trials (1997-2000)	shortened NIHSS from 15 to 8 and 5 items C statistic = 0.76-0.77
Face Arm Speech Test (FAST)	Harbison, J. 2003	United Kingdom (2000)	similar to CPSS 79% accuracy
Melbourne Ambulance Stroke Screen (MASS)	Bray, JE. 2005	Melbourne, Australia (2002-3)	1-hour paramedic training Se = 90%, Sp = 74%
Los Angeles Motor Scale (LAMS)	Nazliel, B. 2008	Los Angeles, CA (1996-2006)	3-item prehospital stroke severity scale Strong agreement with NIHSS
Ontario Prehospital Stroke Screening Tool	Chenkin, J. 2009	Toronto, Canada (2005-6)	PPV = 90%, NPV = 88%

Se = sensitivity, Sp = specificity, PPV = positive predictive value, NPV = negative predictive value

APPENDIX C. NC EMS Stroke Destination Plan Template



APPENDIX D. 2012 NC EMS Stroke Survey Instrument

"Cover Letter" text for invitation email

Dear EMS Director,

We invite you to take a brief online survey on prehospital acute stroke care in local EMS systems throughout North Carolina (unique link provided below).

This survey is being conducted by the Departments of Emergency Medicine and Epidemiology at the University of North Carolina at Chapel Hill and is jointly supported by the North Carolina Stroke Care Collaborative and the EMS Performance Improvement Center and has been approved by the North Carolina Office of EMS and the UNC Public Health-Nursing IRB.

Our aim is to query local EMS systems on their trainings, resources, and services for treating acute stroke patients in the field. This information will be useful to identifying new ways to improve prehospital stroke care in North Carolina and beyond.

As EMS director, you have been invited to participate in this survey given your knowledge of the local EMS system's educational trainings and services provided. There are no risks to you for completing this survey. The benefits include contributing to a greater understanding of the capability of EMS systems to provide quality stroke care. It is vital that every EMS system in North Carolina responds to this survey. However, please know that your participation is voluntary, and once you begin the survey, you may quit at any time. Confidentiality of you and your organization is assured.

Follow this link to the Survey:
${l://SurveyLink?d=Take the Survey}

Or copy and paste the URL below into your internet browser:
${l://SurveyURL}

Your complete response is requested by June 15, 2012. We greatly appreciate your time and assistance, and if you have any questions or concerns, please contact us at EMS_Stroke_Study@unc.edu.

Thank you for helping to advance the field of EMS and acute stroke care.

Sincerely,

Mehul Patel, MSPH
Graduate Student
Department of Epidemiology

Jane Brice, MD MPH
Associate Professor
Department of Emergency Medicine

Wayne Rosamond, PhD
Principal Investigator
NC Stroke Care Collaborative

Antonio Fernandez, PhD NREMT-P
Director of Research
EMS Performance Improvement Center

north carolina Stroke Care Collaborative

EMSpic PERFORMANCE IMPROVEMENT CENTER

Thanks for your participation!

This survey is divided into two sections:

1) General EMS Resources, Services, and Training

2) EMS Resources, Services, and Training for Stroke.

All questions are regarding your local EMS system. The first section asks general questions. The second section contains more specific items, such as number of stroke trainings in the past 2 years, so you may need to look up some information. Please feel free to engage others in your organization, like a training officer or medical director. There are a few items on the 9-1-1 dispatch services provided in your system. You may not know all of this information, but please answer to the best of your knowledge.

Please feel free to contact me with any questions or concerns.

Sincerely,

Mehul Patel
[redacted]
EMS_Stroke_Study@unc.edu

Enclosure:
EMS System Director Stroke Questionnaire

SECTION 1: GENERAL EMS RESOURCES, SERVICES, AND TRAINING

1. Please specify your local EMS system: ____________________________

2. What is the pay status of the EMS providers in your system?
   1 ☐ Volunteers
   2 ☐ Paid
   3 ☐ Both Volunteers and Paid

3. What level of service does your system provide?
   1 ☐ Basic Life Support (BLS) only
   2 ☐ Advanced Life Support (ALS) only
   3 ☐ Both BLS and ALS

4. Does your system have first responders that arrive before EMS?
   1 ☐ Yes
   2 ☐ No

5. Are the EMS providers in your system required to receive additional continuing education training that is above and beyond the North Carolina state requirements?
   1 ☐ Yes
   2 ☐ No

6. Do you have a policy or policies that determine which hospital patients are transported to?
   1 ☐ Yes
   2 ☐ No

7. Please list the names of the hospitals (top 5) to which you usually transport?
   ____________________________ ____________________________
   ____________________________ ____________________________
   ____

8. Are your ground transports allowed to cross state lines?
   1 ☐ Yes
   2 ☐ No

9. Are patients ever transported from the scene to the hospital via air/helicopter?
   1 ☐ Yes
   2 ☐ No

For the following questions on 9-1-1 dispatch services in your system, please answer to the best of your knowledge.

10. Are your 9-1-1 dispatchers required to receive additional continuing education training that is above and beyond the state requirements?
    1 ☐ Yes
    2 ☐ No
    3 ☐ Don't know

11. Do your 9-1-1 dispatchers use any sort of guide or triage algorithm to make a dispatch determination?
    1 ☐ Yes, Associated Public-Safety Communications Officers, Inc. (APCO)
    2 ☐ Yes, Medical Priority Dispatch System (MPDS)
    3 ☐ Yes, Other. Please specify:__________________
    4 ☐ No
    5 ☐ Don't know

SECTION 2. EMS RESOURCES, SERVICES, AND TRAINING FOR STROKE

12. In your system, when was the North Carolina EMS patient care treatment protocol for stroke (Suspected Stroke, Protocol 33, NC OEMS 2009) implemented?
    Month:_____ Year:_____

    Has your system changed the 2009 NC OEMS version (i.e. added medications or procedures, rearranged the order of care)?
    1 ☐ Yes, please briefly explain how:____________ ______________________________
    2 ☐ No

13. If a patient suspected of having a stroke has stable vital signs, will the patient be transported with lights and sirens?
    1 ☐ Yes
    2 ☐ No
    3 ☐ Choice made by crew

14. Is it your policy to notify hospitals in advance for all suspected stroke patients?
    1 ☐ Yes
    2 ☐ No

15. In your system, when was the 2009 Stroke EMS Triage and Destination Plan (NC OEMS 2009) implemented?
    Month:_____ Year:_____

    Has your system changed the 2009 NC OEMS version (i.e. changed time parameters, modified Pearls and Definitions)?
    1 ☐ Yes, please briefly explain how:____________ ______________________________
    2 ☐ No

16. How frequently do your EMS providers use the plan to decide the destination of suspected stroke patients?
    1 ☐ Always (100%)
    2 ☐ Very Often (75 – 99%)
    3 ☐ Sometimes (25 – 74%
    4 ☐ Rarely (1 – 24%)
    5 ☐ Never (0%)

17. Do your EMS providers use any specific prehospital screening tools to identify whether or not a patient is having a stroke?
    1 ☐ Yes
    2 ☐ No

    IF "YES", Which stroke screening tools are used in your system? (CHECK ALL THAT APPLY)
    1 ☐ Cincinnati Prehospital Stroke Scale (CPSS)
    2 ☐ Los Angeles Prehospital Stroke Screen (LAPSS)
    3 ☐ Miami Emergency Neurologic Deficit (MEND) examination
    4 ☐ Other. Please specify:__________________

18. Do your EMS providers record stroke screening results anywhere?
    1 ☐ Yes, please list where (i.e. run sheet, PreMIS): ________________
    2 ☐ No

19. How frequently do your EMS providers communicate stroke screening results to the destination hospital?
    - 1 ☐ Always (100%)
    - 2 ☐ Very Often (75 – 99%)
    - 3 ☐ Sometimes (25 – 74%
    - 4 ☐ Rarely (1 – 24%)
    - 5 ☐ Never (0%)

For the following questions on <u>stroke education and training</u>, answer for the highest level of service (i.e. BLS or ALS) in your system.

20. In the past 2 years, have the EMS providers in your system received at least one educational training on stroke?
    - 1 ☐ Yes
    - 2 ☐ No

    IF "YES", what topics do the training sessions typically cover? (CHECK ALL THAT APPLY)
    - 1 ☐ Stroke risk factors
    - 2 ☐ Stroke signs and symptoms
    - 3 ☐ Pathophysiology of stroke
    - 4 ☐ Stroke screens or scales (i.e. CPSS, LAPSS)
    - 5 ☐ Thrombolytic therapy (i.e. eligibility, contraindications)
    - 6 ☐ Other (please list)_______________________________

21. In the past 2 years, please estimate the total number of hours spent on stroke training:
    ____total hours in past 2 years

22. How frequently do EMS providers in your system receive stroke trainings?
    - 1 ☐ More than once a year
    - 2 ☐ Once a year
    - 3 ☐ Once every 2-3 years
    - 4 ☐ Only when initially certified
    - 5 ☐ Never receive a training

23. How are stroke trainings customarily offered? (CHECK ALL THAT APPLY)
    - 1 ☐ In person (classroom/seminar)
    - 2 ☐ Online (internet/web)
    - 3 ☐ DVD or Video
    - 4 ☐ Other. Please specify:___________________

    IF "ONLINE", do you use the "Saving Lives: Understanding Stroke" online course?
    - 1 ☐ Yes
    - 2 ☐ No

For the following questions on 9-1-1 dispatch services in your system, please answer to the best of your knowledge.

24. In the past 2 years, have your 9-1-1 dispatchers received at least one educational session on stroke?
    1 ☐ Yes
    2 ☐ No
    3 ☐ Don't know

25. If the 9-1-1 dispatcher suspects that the patient may be having a stroke, does he or she use a stroke protocol for dispatch (e.g. MPDS "Card 28")?
    1 ☐ Yes
    2 ☐ No
    3 ☐ Don't know

26. If the 9-1-1 dispatcher suspects that a stroke is occurring, does he or she provide pre-arrival instructions to the caller?
    1 ☐ Yes
    2 ☐ No
    3 ☐ Don't know

CONTACT INFORMATION

If we have further questions regarding this survey, may we contact you?
1 ☐ Yes
2 ☐ No

Please provide the name(s) of the individual(s) completing this survey:

Respondent #1
Name: ___________________________
Job Title: _________________________
Organization: _____________________
Phone: ___________________________
Email: ___________________________

Respondent #2 (if applicable)
Name: ___________________________
Job Title: _________________________
Organization: _____________________
Phone: ___________________________
Email: ___________________________

We would appreciate any feedback that you may have on this survey. Please provide comments:
___________________________ ____
____
____

APPENDIX E. NC PreMIS Data Elements

North Carolina (NCCEP) EMS Data Elements

NEMSIS Data Element		NEMSIS	NC
E01_01	Patient Care Report Number	✓	X
E01_02	Software Creator	✓	X
E01_03	Software Name	✓	X
E01_04	Sofware Version	✓	X
E02_01	EMS Agency Number	✓	X
E02_04	Type of Service Requested	✓	X
E02_05	Primary Role of the Unit	✓	X
E02_06	Type of Dispatch Delay	✓	X
E02_07	Type of Response Delay	✓	X
E02_08	Type of Scene Delay	✓	X
E02_09	Type of Transport Delay	✓	X
E02_10	Type of Turn-Around Delay	✓	X
E02_12	EMS Unit Call Sign (Radio Number)	✓	X
E02_16	Beginning Odometer of Responding Vehicle		X
E02_17	On-Scene Odometer of Responding Vehicle		X
E02_18	Patient Destination Odometer of Responding Vehicle		X
E02_20	Response Mode to Scene	✓	X
E03_01	Complaint Reported by Dispatch	✓	X
E03_02	EMD Performed	✓	X
E03_03	EMD Card Number		X
E04_01	Crew Member ID		X
E04_02	Crew Member Role		X
E04_03	Crew Member Level		X
E05_02	PSAP Call Date/Time	✓	X
E05_04	Unit Notified by Dispatch Date/Time	✓	X
E05_05	Unit En Route Date/Time	✓	X
E05_06	Unit Arrived on Scene Date/Time	✓	X
E05_07	Arrived at Patient Date/Time	✓	X
E05_09	Unit Left Scene Date/Time	✓	X
E05_10	Patient Arrived at Destination Date/Time	✓	X
E05_11	Unit Back in Service Date/Time	✓	X
E05_12	Unit Cancelled Date/Time		X
E05_13	Unit Back at Home Location Date/Time	✓	X
E06_01	Last Name		X
E06_02	First Name		X
E06_03	Middle Initial/Name		X
E06_04	Patient's Home Address		X
E06_05	Patient's Home City		X
E06_06	Patient's Home County		X
E06_07	Patient's Home State		X

Red = National EMS Data Elements

Potential Data Elements by EMS Toolkit Topic

NEMSIS Data Element		NEMSIS	NC
E06_08	**Patient's Home Zip Code**	✓	X
E06_09	Patient's Home Country		X
E06_10	Social Security Number		X
E06_11	**Gender**	✓	X
E06_12	**Race**	✓	X
E06_13	**Ethnicity**	✓	X
E06_14	**Age**	✓	X
E06_15	**Age Units**	✓	X
E06_16	Date of Birth		X
E06_17	Primary or Home Telephone Number		X
E07_01	**Primary Method of Payment**	✓	X
E07_15	Work-Related		X
E07_16	Patient's Occupational Industry		X
E07_17	Patient's Occupation		X
E07_34	**CMS Service Level**	✓	X
E07_35	**Condition Code Number**	✓	X
E07_37	Air Ambulance Modifier for Condition Code Number		X
E08_01	Other EMS Agencies at Scene		X
E08_03	Estimated Date/Time Initial Responder Arrived on Scene		X
E08_05	**Number of Patients at Scene**	✓	X
E08_06	**Mass Casualty Incident**	✓	X
E08_07	**Incident Location Type**	✓	X
E08_08	Incident Facility Code		X
E08_11	Incident Address		X
E08_12	Incident City		X
E08_13	Incident County		X
E08_14	Incident State		X
E08_15	**Incident ZIP Code**	✓	X
E09_01	**Prior Aid**	✓	X
E09_02	**Prior Aid Performed by**	✓	X
E09_03	**Outcome of the Prior Aid**	✓	X
E09_04	**Possible Injury**	✓	X
E09_05	Chief Complaint		X
E09_06	Duration of Chief Complaint		X
E09_07	Time Units of Duration of Chief Complaint		X
E09_08	Secondary Complaint Narrative		X
E09_09	Duration of Secondary Complaint		X
E09_10	Time Units of Duration of Secondary Complaint		X
E09_11	**Chief Complaint Anatomic Location**	✓	X
E09_12	**Chief Complaint Organ System**	✓	X

Red = National EMS Data Elements

Potential Data Elements by EMS Toolkit Topic

NEMSIS Data Element		NEMSIS	NC
E09_13	**Primary Symptom**	✓	X
E09_14	**Other Associated Symptoms**	✓	X
E09_15	**Providers Primary Impression**	✓	X
E09_16	**Provider's Secondary Impression**	✓	X
E10_01	**Cause of Injury**	✓	X
E10_02	Intent of the Injury		X
E10_03	Mechanism of Injury		X
E10_04	Vehicular Injury Indicators		X
E10_05	Area of the Vehicle impacted by the collision		X
E10_06	Seat Row Location of Patient in Vehicle		X
E10_07	Position of Patient in the Seat of the Vehicle		X
E10_08	Use of Occupant Safety Equipment		X
E10_09	Airbag Deployment		X
E10_10	Height of Fall		X
E11_01	**Cardiac Arrest**	✓	X
E11_02	**Cardiac Arrest Etiology**	✓	X
E11_03	**Resuscitation Attempted**	✓	X
E11_04	Arrest Witnessed by		X
E11_05	First Monitored Rhythm of the Patient		X
E11_06	Any Return of Spontaneous Circulation		X
E11_08	Estimated Time of Arrest Prior to EMS Arrival		X
E11_09	Date/Time Resuscitation Discontinued		X
E11_10	Reason CPR Discontinued		X
E11_11	Cardiac Rhythm on Arrival at Destination		X
E12_01	**Barriers to Patient Care**	✓	X
E12_02	Sending Facility Medical Record Number		X
E12_03	Destination Medical Record Number		X
E12_07	Advanced Directives		X
E12_18	Presence of Emergency Information Form		X
E12_19	**Alcohol/Drug Use Indicators**	✓	X
E12_20	Pregnancy		X
E14_01	Date/Time Vital Signs Taken		X
E14_02	Obtained Prior to this Units EMS Care		X
E14_03	Cardiac Rhythm		X
E14_04	SBP (Systolic Blood Pressure)		X
E14_05	DBP (Diastolic Blood Pressure)		X
E14_06	Method of Blood Pressure Measurement		X
E14_07	Pulse Rate		X
E14_08	Electronic Monitor Rate		X
E14_09	Pulse Oximetry		X

Red = National EMS Data Elements

Potential Data Elements by EMS Toolkit Topic

NEMSIS Data Element		NEMSIS	NC
E14_10	Pulse Rhythm		X
E14_11	Respiratory Rate		X
E14_12	Respiratory Effort		X
E14_13	Carbon Dioxide		X
E14_14	Blood Glucose Level		X
E14_18	Glasgow Coma Score-Qualifier		X
E14_19	Total Glasgow Coma Score		X
E14_20	Temperature		X
E14_21	Temperature Method		X
E14_22	Level of Responsiveness		X
E14_23	Pain Scale		X
E14_24	Stroke Scale		X
E14_25	Thrombolytic Screen		X
E14_27	Revised Trauma Score		X
E14_28	Pediatric Trauma Score		X
E15_01	NHTSA Injury Matrix External/Skin		X
E15_02	NHTSA Injury Matrix Head		X
E15_03	NHTSA Injury Matrix Face		X
E15_04	NHTSA Injury Matrix Neck		X
E15_05	NHTSA Injury Matrix Thorax		X
E15_06	NHTSA Injury Matrix Abdomen		X
E15_07	NHTSA Injury Matrix Spine		X
E15_08	NHTSA Injury Matrix Upper Extremities		X
E15_09	NHTSA Injury Matrix Pelvis		X
E15_10	NHTSA Injury Matrix Lower Extremities		X
E15_11	NHTSA Injury Matrix Unspecified		X
E16_01	Estimated Body Weight		X
E16_02	Broselow/Luten Color		X
E16_04	Skin Assessment		X
E16_05	Head/Face Assessment		X
E16_06	Neck Assessment		X
E16_07	Chest/Lungs Assessment		X
E16_08	Heart Assessment		X
E16_09	Abdomen Left Upper Assessment		X
E16_10	Abdomen Left Lower Assessment		X
E16_11	Abdomen Right Upper Assessment		X
E16_12	Abdomen Right Lower Assessment		X
E16_13	GU Assessment		X
E16_14	Back Cervical Assessment		X
E16_15	Back Thoracic Assessment		X

Red = National EMS Data Elements

Potential Data Elements by EMS Toolkit Topic

NEMSIS Data Element		NEMSIS	NC
E16_16	Back Lumbar/Sacral Assessment		X
E16_17	Extremities-Right Upper Assessment		X
E16_18	Extremities-Right Lower Assessment		X
E16_19	Extremities-Left Upper Assessment		X
E16_20	Extremities-Left Lower Assessment		X
E16_21	Eyes-Left Assessment		X
E16_22	Eyes-Right Assessment		X
E16_23	Mental Status Assessment		X
E16_24	Neurological Assessment		X
E17_01	Protocols Used		X
E18_01	Date/Time Medication Administered		X
E18_02	Medication Administered Prior to this Units EMS Care		X
E18_03	**Medication Given**	✓	X
E18_04	Medication Administered Route		X
E18_05	Medication Dosage		X
E18_06	Medication Dosage Units		X
E18_07	Response to Medication		X
E18_08	**Medication Complication**	✓	X
E18_09	Medication Crew Member ID		X
E18_10	Medication Authorization		X
E19_01	Date/Time Procedure Performed Successfully		X
E19_02	Procedure Performed Prior to this Units EMS Care		X
E19_03	**Procedure**	✓	X
E19_04	Size of Procedure Equipment		X
E19_05	**Number of Procedure Attempts**	✓	X
E19_06	**Procedure Successful**	✓	X
E19_07	**Procedure Complication**	✓	X
E19_08	Response to Procedure		X
E19_09	Procedure Crew Members ID		X
E19_10	Procedure Authorization		X
E19_12	Successful IV Site		X
E19_13	Tube Confirmation		X
E19_14	Destination Confirmation of Tube Placement		X
E20_01	Destination/Transferred To, Name		X
E20_02	Destination/Transferred To, Code		X
E20_03	Destination Street Address		X
E20_04	Destination City		X
E20_05	Destination State		X
E20_06	Destination County		X
E20_07	**Destination Zip Code**	✓	X

Red = National EMS Data Elements

Potential Data Elements by EMS Toolkit Topic

NEMSIS Data Element		NEMSIS	NC
E20_10	**Incident/Patient Disposition**	✓	X
E20_14	**Transport Mode from Scene**	✓	X
E20_15	Condition of Patient at Destination		X
E20_16	**Reason for Choosing Destination**	✓	X
E20_17	**Type of Destination**	✓	X
E22_01	**Emergency Department Disposition**	✓	X
E22_02	**Hospital Disposition**	✓	X
E22_03	Law Enforcement/Crash Report Number		X
E23_03	Personal Protective Equipment Used		X
E23_04	Suspected Intentional, or Unintentional Disaster		X
E23_05	Suspected Contact with Blood/Body Fluids, EMS Injury/Death		X
E23_07	Personnel Exposed		X
E23_10	Who Generated this Report?		X

Red = National EMS Data Elements

APPENDIX F. Supplementary Tables of Regression Result

Table F.1. Regression Results for Response Time Intervals (in Minutes) among Stroke Events, 2009-2010, Case Definition #2 (N=34,787)

Covariate	**Mixed Linear Model**			**Quantile Regression Models**					
				Median			**90th percentile**		
	Est	95% CI	p	Est	95% CI	p	Est	95% CI	p
Patient age			<0.001			<0.001			<0.001
18-44 years	0.44	0.23, 0.65		0.41	0.21, 0.61		0.59	0.09, 1.1	
45-64 years	0.37	0.22, 0.53		0.35	0.18, 0.51		0.96	0.6, 1.32	
65-84 years	0.21	0.06, 0.35		0.16	0.03, 0.29		0.62	0.26, 0.97	
85+ years (ref)	0			0			0		
Patient gender			0.02			0.95			0.46
Female	-0.13	-0.23, -0.02		0.00	-0.09, 0.09		-0.08	-0.34, 0.18	
Male (ref)	0			0			0		
Patient race			<0.001			<0.001			<0.001
White (ref)	0			0			0		
Black	-0.85	-0.98, -0.72		-0.96	-1.08, -0.84		-1.22	-1.49, -0.94	
Other	-0.51	-0.78, -0.23		-0.84	-1.04, -0.65		-1.81	-2.36, -1.26	
Time of day			<0.001			<0.001			<0.001
12-8AM	0.71	0.54, 0.87		0.66	0.47, 0.84		1.00	0.49, 1.51	
8AM-5PM	-0.28	-0.4, -0.17		-0.22	-0.34, -0.1		-0.33	-0.61, -0.04	
5PM-12AM (ref)	0			0			0		
Day of week			0.57			0.95			0.93
Weekend	0.03	-0.08, 0.15		0.00	-0.1, 0.11		0.01	-0.25, 0.28	
Weekday (ref)	0			0			0		
Response mode to scene			<0.001			<0.001			<0.001
Lights and Sirens	-1.87	-2.05, -1.68		-0.41	-0.55, -0.27		-1.17	-1.5, -0.84	

No Lights and Sirens (ref)	0			0			0		
Scene location type			<0.001			<0.001			<0.001
Home/Residence (ref)	0			0			0		
Health Care Facility	-2.12	-2.28, -1.97		-1.98	-2.09, -1.87		-3.58	-3.87, -3.28	
Other	-1.96	-2.11, -1.82		-1.69	-1.83, -1.54		-2.96	-3.25, -2.66	
System patient volume			0.51			<0.001			<0.001
>20,000/year	-0.69	-1.86, 0.47		0.14	-0.11, 0.39		-0.96	-1.48, -0.44	
5,000-20,000/year	-0.34	-1.25, 0.57		0.66	0.41, 0.91		-0.39	-0.89, 0.11	
<5,000/year (ref)	0			0			0		
County population density			0.10			<0.001			<0.001
Metropolitan	-1.13	-2.17, -0.09		-1.26	-1.51, -1.01		-3.71	-4.25, -3.17	
Micropolitan	-0.78	-1.78, 0.22		-1.00	-1.28, -0.72		-2.33	-2.88, -1.77	
Rural (ref)	0			0			0		

Est = estimate; CI = confidence interval; ref = referent

Table F.2. Regression Results for Scene Time Intervals (in Minutes) among Stroke Events, 2009-2010, Case Definition #2 (N=34,787)

Covariate	Mixed Linear Model			Quantile Regression Models: Median			Quantile Regression Models: 90th percentile		
	Est	95% CI	p	Est	95% CI	p	Est	95% CI	p
Patient age			<0.001			<0.001			<0.001
18-44 years	-2.68	-3.00, -2.37		-2.81	-3.13, -2.48		-2.72	-3.49, -1.96	
45-64 years	-1.45	-1.68, -1.21		-1.60	-1.87, -1.34		-1.20	-1.72, -0.69	
65-84 years	-0.23	-0.45, -0.02		-0.33	-0.58, -0.08		-0.21	-0.74, 0.32	
85+ years (ref)	0			0			0		
Patient gender			0.07			0.16			0.53
Female	0.14	-0.01, 0.30		0.13	-0.05, 0.31		0.13	-0.26, 0.51	
Male (ref)	0			0			0		
Patient race			0.002			0.36			0.21
White (ref)	0			0			0		
Black	-0.10	-0.29, 0.08		-0.13	-0.34, 0.08		-0.32	-0.73, 0.09	
Other	0.61	0.20, 1.02		-0.13	-0.51, 0.25		0.13	-0.61, 0.87	
Time of day			<0.001			<0.001			<0.001
12-8AM	0.92	0.67, 1.16		0.99	0.69, 1.3		1.47	0.80, 2.14	
8AM-5PM	-0.09	-0.26, 0.09		-0.01	-0.22, 0.21		-0.26	-0.68, 0.16	
5PM-12AM (ref)	0			0			0		
Day of week			0.49			0.89			0.11
Weekend	0.06	-0.11, 0.23		0.01	-0.2, 0.22		0.34	-0.05, 0.72	
Weekday (ref)	0			0			0		
Response mode to scene			0.02			<0.001			<0.001
Lights and Sirens	-0.32	-0.6, -0.04		-1.13	-1.37, -0.9		-1.54	-2.02, -1.06	

No Lights and Sirens (ref)	0			0			0		
Scene location type			<0.001			<0.001			<0.001
Home/Residence (ref)	0			0			0		
Health Care Facility	-1.40	-1.64, -1.17		-1.60	-1.85, -1.34		-2.31	-2.77, -1.85	
Other	-1.84	-2.06, -1.62		-1.62	-1.88, -1.36		-2.79	-3.24, -2.33	
System patient volume			0.90			<0.001			0.29
>20,000/year	-0.36	-2.02, 1.29		0.34	-0.08, 0.76		-0.39	-1.28, 0.50	
5,000-20,000/year	-0.10	-1.4, 1.19		-0.13	-0.53, 0.27		-0.64	-1.49, 0.21	
<5,000/year (ref)	0			0			0		
County population density			0.08			<0.001			<0.001
Metropolitan	-1.67	-3.14, -0.19		-1.74	-2.10, -1.38		-2.57	-3.42, -1.71	
Micropolitan	-1.34	-2.77, 0.08		-0.66	-1.05, -0.26		-1.69	-2.52, -0.86	
Rural (ref)	0			0			0		

Est = estimate; CI = confidence interval; ref = referent

Table F.3. Regression Results for Response Time Intervals (in Minutes) among Stroke Events, 2009-2010, Case Definition #3 (N=10,586)

	Mixed Linear Model			Quantile Regression Models					
Covariate				Median			90th percentile		
	Est	95% CI	p	Est	95% CI	p	Est	95% CI	p
Patient age			0.44			0.38			0.56
18-44 years	0.30	-0.06, 0.65		0.23	-0.12, 0.57		0.20	-0.51, 0.91	
45-64 years	0.11	-0.14, 0.37		0.23	-0.01, 0.46		0.48	-0.14, 1.11	
65-84 years	0.11	-0.12, 0.34		0.15	-0.08, 0.38		0.34	-0.25, 0.94	
85+ years (ref)	0			0			0		
Patient gender			0.31			1			0.66
Female	-0.09	-0.26, 0.08		0.00	-0.16, 0.16		0.08	-0.37, 0.52	
Male (ref)	0			0			0		
Patient race			<0.001			<0.001			<0.001
White (ref)	0			0			0		
Black	-0.83	-1.03, -0.63		-0.92	-1.09, -0.76		-1.63	-2.09, -1.17	
Other	-0.51	-0.87, -0.15		-0.84	-1.11, -0.56		-2.33	-2.89, -1.78	
Time of day			<0.001			<0.001			<0.001
12-8AM	0.71	0.44, 0.97		0.60	0.31, 0.89		0.78	0.05, 1.5	
8AM-5PM	-0.29	-0.47, -0.1		-0.25	-0.45, -0.05		-0.41	-0.93, 0.11	
5PM-12AM (ref)	0			0			0		
Day of week			0.58			1			0.66
Weekend	0.05	-0.13, 0.24		0.00	-0.18, 0.18		-0.15	-0.62, 0.32	
Weekday (ref)	0			0			0		
Response mode to scene			<0.001			0.25			0.39
Lights and Sirens	-1.79	-2.11, -1.47		-0.13	-0.34, 0.08		-0.29	-0.81, 0.23	
No Lights and Sirens (ref)	0			0			0		

Scene location type			<0.001			<0.001			<0.001
Home/Residence (ref)	0			0			0		
Health Care Facility	-2.10	-2.35, -1.85		-1.89	-2.09, -1.69		-2.95	-3.48, -2.42	
Other	-1.72	-1.96, -1.49		-1.33	-1.58, -1.08		-1.93	-2.51, -1.36	
System patient volume			0.82			<0.001			0.62
>20,000/year	0.28	-1.12, 1.68		1.21	0.49, 1.92		-0.23	-1.49, 1.04	
5,000-20,000/year	0.36	-0.77, 1.5		1.53	0.8, 2.26		0.03	-1.17, 1.23	
<5,000/year (ref)	0			0			0		
County population density			0.01			<0.001			<0.001
Metropolitan	-1.85	-3.07, -0.64		-2.37	-3.07, -1.67		-5.27	-6.36, -4.18	
Micropolitan	-1.66	-2.83, -0.49		-1.95	-2.7, -1.2		-2.70	-3.86, -1.54	
Rural (ref)	0			0			0		

Est = estimate; CI = confidence interval; ref = referent

Table F.4. Regression Results for Scene Time Intervals (in Minutes) among Stroke Events, 2009-2010, Case Definition #3 (N=10,586)

Covariate	**Mixed Linear Model**			**Quantile Regression Models**					
				Median			**90th percentile**		
	Est	95% CI	p	Est	95% CI	p	Est	95% CI	p
Patient age			<0.001			<0.001			0.002
18-44 years	-1.84	-2.35, -1.34		-2.14	-2.73, -1.56		-1.68	-2.75, -0.61	
45-64 years	-1.21	-1.57, -0.84		-1.17	-1.53, -0.8		-1.22	-2.03, -0.42	
65-84 years	-0.46	-0.79, -0.12		-0.49	-0.89, -0.1		-0.29	-1.04, 0.46	
85+ years (ref)	0			0			0		
Patient gender			0.007			0.01			0.27
Female	0.33	0.09, 0.58		0.37	0.09, 0.66		0.26	-0.25, 0.78	
Male (ref)	0			0			0		
Patient race			0.008			0.32			0.1
White (ref)	0			0			0		
Black	0.05	-0.24, 0.35		-0.18	-0.48, 0.13		-0.54	-1.04, -0.04	
Other	0.80	0.28, 1.32		-0.33	-0.82, 0.16		0.33	-0.44, 1.1	
Time of day			<0.001			<0.001			<0.001
12-8AM	1.13	0.75, 1.52		1.30	0.86, 1.75		1.33	0.55, 2.11	
8AM-5PM	-0.04	-0.31, 0.23		-0.19	-0.5, 0.13		-0.38	-0.95, 0.19	
5PM-12AM (ref)	0			0			0		
Day of week			0.73			0.48			0.43
Weekend	-0.05	-0.31, 0.22		-0.11	-0.44, 0.21		0.26	-0.37, 0.9	
Weekday (ref)	0			0			0		
Response mode to scene			<0.001			<0.001			<0.001
Lights and Sirens	-1.23	-1.68, -0.77		-1.84	-2.19, -1.49		-2.49	-3.19, -1.8	

No Lights and Sirens (ref)	0			0			0		
Scene location type			<0.001			<0.001			<0.001
Home/Residence (ref)	0			0			0		
Health Care Facility	-0.61	-0.97, -0.26		-0.74	-1.11, -0.38		-1.00	-1.8, -0.19	
Other	-1.75	-2.09, -1.41		-1.53	-1.89, -1.16		-2.26	-2.88, -1.64	
System patient volume			0.75			0.01			0.96
>20,000/year	-0.76	-2.77, 1.25		0.72	-0.25, 1.69		0.20	-1.48, 1.87	
5,000-20,000/year	-0.33	-1.96, 1.3		0.21	-0.72, 1.14		0.20	-1.38, 1.78	
<5,000/year (ref)	0			0			0		
County population density			0.28			<0.001			<0.001
Metropolitan	-1.06	-2.8, 0.69		-2.70	-3.52, -1.89		-2.54	-3.98, -1.1	
Micropolitan	-0.02	-1.7, 1.66		-0.82	-1.66, 0.02		-0.34	-1.75, 1.06	
Rural (ref)	0			0			0		

Est = estimate; CI = confidence interval; ref = referent

APPENDIX G. NC EMS Stroke Survey Fact Sheet (Draft)

NORTH CAROLINA EMS STROKE SURVEY – *Research Brief & Policy Implications*

In the summer of 2012, the directors of the 100 local EMS systems in North Carolina were invited to participate in a survey on their systems' trainings, resources, and services for treating acute stroke patients in the field. Data were collected and analyzed from 98 EMS systems.

Out of the 98 NC EMS systems that responded to the survey,

"The Good"

- 95% provided stroke education and training in past 2 years
- 96% used validated stroke scale or screening tool*
  *Cincinnati Prehospital Stroke Scale, Los Angeles Prehospital Stroke Screen, Miami Emergency Neurologic Deficit Exam
- 98% had policy to advance notify hospital of suspected stroke patients

"Room for Improvement"

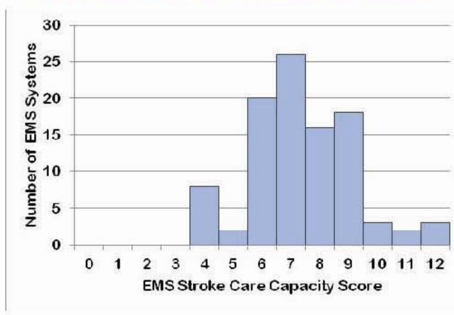
- 71% covered basic stroke educational topics*
  *stroke risk factors, signs and symptoms, pathophysiology, scales and screening tools
- 46% always communicated stroke scale or screen results to destination hospital
- 49% always used stroke triage and destination plan

EMS Stroke Care Capacity Score – 4 Priority Areas and 10 Measures

Priority Areas and Measures	Points
1. Education and Training	
At least 2 hours of stroke training provided a year	1
Personnel trained on stroke at least once a year	1
Trainings cover basic stroke educational topics	1
2. Protocol and Screening	
Standardized stroke protocol	1
Validated stroke scale or screening tool	1
Always communicate stroke scale or screen results to hospital	1
3. Destination Plan	
Written stroke destination plan	1
Always use the stroke destination plan	1
Plan to transport to a Primary Stroke Center	1
4. Continuous Quality Improvement	
Ran a stroke toolkit in the past year*	3

*only 13 EMS systems ran a stroke toolkit in the past year

Score can range from 0 (worst) to 12 (best)



- only 3 systems scored a perfect 12
- majority of systems scored 7 or lower

Recent statewide policies on prehospital stroke care…

1) Standardized Patient Care Protocols

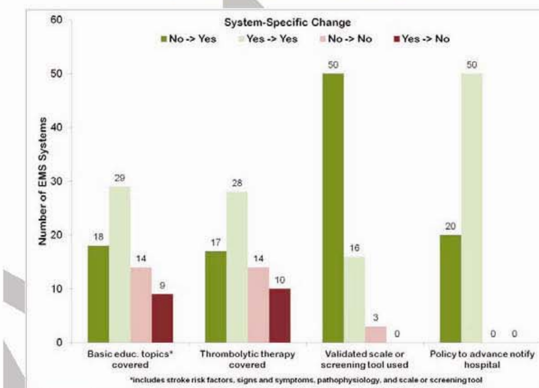
2) Written Triage and Destination Plans

…could explain improvements in EMS stroke care capacity over the past decade.

Comparing 2001 and 2012 EMS surveys

- Education on stroke scale or screening tool
  - improved from 61% to 93%
- Use of validated stroke scale or screening tool
  - improved from 23% to 96%
- Policy to advance notify hospital of suspected stroke patients
  - improved from 71% to 100%

Some EMS systems improved (and some worsened)



Policy Implementation Recommendations:

- Communicate stroke scale or screen findings to the destination hospital
- Use the stroke triage and destination plan
- Perform periodic review of performance data
  - Run a stroke toolkit

Full publication: Patel MD, Brice JH, Evenson KR, Rose KM, Suchindran CM, Rosamond WD. Emergency Medical Services Capacity for Prehospital Stroke Care in North Carolina. *Preventing Chronic Disease* (in press)

MORE INFORMATION AVAILABLE AT:

North Carolina EMS Stroke Survey 2012. Available at http://www.unc.edu/~kevenson/_2012_NC_EMS_StrokeSurvey.pdf

AHA/ASA Guidelines for the Early Management of Patients With Acute Ischemic Stroke. Available at http://stroke.ahajournals.org/lookup/doi/10.1161/STR.0b013e318284056a

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