

Trauma Systems: Improving Trauma Outcomes in North Carolina

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Since the 1970s, there has been a tremendous improvement in the outcomes for injured patients in North Carolina; the scope, significance, and virtue of this achievement are remarkable. This commentary reviews how the state has consistently decreased the burden of injury through its integrated, systems-based approach to trauma care.

During the past 40 years, there has been an extraordinary improvement in the outcomes of injured patients in North Carolina, yet few people fully appreciate the scope, significance, and virtue of this exemplary achievement [1, 2]. Since the 1970s, when injury was becoming recognized as an enormous public health problem, North Carolina and its trauma resources have consistently taken steps to ensure optimal outcomes for injured patients. During this time, North Carolina has become a national leader in trauma-systems development and injury management, with long-standing beneficial collaborations between state-level organizations and the North Carolina medical community. These remarkable, innovative relationships, formed and still sustained by passionate, enterprising individuals, were founded with a shared mission and commitment to decreasing the public health burden of trauma and injury. Today, the North Carolina trauma system of care consists of a variety of discrete components and layers, functioning together in an organized, integrated manner to save lives [3]. The relationships and overall vision on which this system of care was founded remain vibrant to this day, continually working and collaborating to improve trauma outcomes in North Carolina.

What Is a Trauma System?

A trauma system of care is an organized, coordinated network of health care resources that provides a broad spectrum of services and definitive medical and surgical care to the acutely injured trauma patient [3]. The services and care start at the scene of the injury, with local emergency medical services, and continue across several settings, including transporting vehicle, emergency department, operating room, intensive care unit, hospital floor, rehabilitation facility, and home [4]. The goal of this highly integrated, multilayered

system of injury management is to optimize the chances of survival for trauma victims by decreasing the risks, deleterious consequences, and overall burden of injury [3].

The trauma system consolidates the care of the most severely injured patients into a small number of hospitals qualified as trauma centers. Trauma centers have a high level of expertise and readiness in trauma care, as well as extremely specialized resources required for optimum care of injured patients [5]. The 3 levels of trauma center classification represent a ranking of the resources available at that center to care for injuries: level I centers offer the highest level of care, with the greatest readiness and the most resources, while level III centers have expertise and readiness below that of level I and level II centers but above that of a standard acute-care hospital [3]. Trauma center designation is extremely specific, and standards have been based on guidelines established by the American College of Surgeons Committee on Trauma (ACS/COT) [3].

Trauma centers serve as the lead hospitals within regional trauma systems, which are typically defined by geographic area. Geography, population density, and health care resources are inherently different in different regions of a state, as is true in North Carolina, and each regional trauma system is individualized on the basis of these factors to achieve optimal patient care [3]. For example, rural areas have large distances to cover and may depend more on helicopter transport, and coastal areas have special concerns related to recovery and transport of victims over water. Various manuals and consultation services are available to help with the complex development of trauma systems [1, 3, 4, 6].

History of the North Carolina Trauma System

The remarkable development and maturation of the statewide trauma system in North Carolina during the past 40 years parallels the recognition in the United States that injury presents a significant public health challenge. This understanding has motivated the close collaboration in North Carolina between governmental agencies and the medical community, including hospitals, emergency medical services professionals, and professional organizations, to create a unified system of management for traumatic injury [3].

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The North Carolina statewide trauma system is one of the oldest in the country and has its roots in the 1973 North Carolina Emergency Medical Service Act, which created the North Carolina Office of Emergency Medical Services (OEMS). The OEMS's mission is to improve and maintain high-quality emergency medical care, including trauma services, in North Carolina [7]. As the lead agency for trauma in North Carolina, the OEMS identifies hospitals with the interest and ability to provide comprehensive trauma care [1]. By 1980, the OEMS developed, on the basis of ACS/COT verification criteria, state designation guidelines for level I and level II trauma centers. By 1982, the following 3 hospitals had been approved as level I centers (current names are provided): Wake Forest University Medical Center (Winston-Salem), Duke University Hospital (Durham), and University of North Carolina (UNC) Hospitals (Chapel Hill) [7].

At the national level, in recognition of the important public health burden of trauma, Congress passed the Trauma Care Systems Planning and Development Act of 1986 to build a trauma system infrastructure across the United States. In 1990, Congress passed more trauma care legislation, Title XII of the Public Health Services Act, specific to the needs of the injured patient. Title XII created the Trauma-Emergency Medical Services Systems Program, which provides leadership to facilitate the development and improve the quality of statewide trauma systems [6].

In the early 1990s, concurrent with national trends, the OEMS received funding from the North Carolina Governor's Highway Safety Program to commission an assessment and critique of North Carolina's emergency medical services system by the National Highway Traffic Safety Administration (NHTSA). On the basis of the NHTSA recommendations, which were corroborated in November 1992 by the North Carolina Trauma System Task Force, the North Carolina legislature passed the Trauma System Act in 1993, which formalized a statewide trauma system. By 1996, this task force had outlined the structure and rules to define the state trauma system; these were approved in 1998 by the North Carolina legislature [7].

Today, North Carolina's trauma system is recognized as a mature, highly functional system, with a long history of designation, progressive OEMS leadership, a North Carolina Trauma Registry (NCTR), and wide cooperation between the state government, trauma centers, and local/regional emergency medical services. However, in 2005, when graded against all aspects needed to ensure a fully developed trauma system, the North Carolina system lacked a coordinated process to monitor the entire system's outcomes and lacked formal limitations, determined on the basis of community need, on the number of trauma centers (limitations are thought to be a good thing, as they allow the designation of trauma centers in regions and areas with the most need) [8].

With this feedback, the OEMS and the Emergency Medical Services Performance Improvement Center at the UNC-Chapel Hill School of Medicine now actively review

the outcomes associated with the state's trauma care system. This is being done through analysis of the linked North Carolina Outcomes Data System, which merges data involving motor-vehicle crashes, emergency medical services, emergency-department visits, hospital-discharge information, the NCTR, and medical-examiner data.

Given the national stature of North Carolina's trauma system and its collaborative, innovative leadership, it is surprising that the system lacks state financial support, specifically for trauma infrastructure. Additionally, there is no state funding to offset the costs of trauma centers' participation in trauma systems or for decreasing the financial burden on trauma centers for providing uncompensated care to uninsured patients. Funding is a major issue nationally, as only 15 states have any funded programs for trauma and trauma systems [4]. Because of this, only 8 states (California, Illinois, Maryland, New Jersey, New Mexico, New York, Oregon, and Washington) have comprehensive, well-developed trauma systems in place [8]. Despite the public health threat of trauma and injury, 12 states in the United States have no elements of a trauma system at all [3]. It is largely because of the variability in financial support that the maturity of trauma systems varies considerably by state.

Current North Carolina Trauma System Structure

The trauma system in North Carolina is regionally based, with overall direction at the state level, from the OEMS. The system consists of a network of 8 geographically defined regional trauma systems, each supported by a Regional Advisory Committee. The mission of each committee is to outline, establish, and maintain a coordinated trauma system at the regional level, with broad emergency medical services, hospital, and community input [1]. Regional Advisory Committees also conduct performance improvement and educational activities [1].

Each Regional Advisory Committee is overseen by a lead facility, which must be a designated level I or level II trauma center. All hospitals that are not designated trauma centers must be affiliated with a Regional Advisory Committee (only 12 of 122 hospitals in North Carolina are designated trauma centers). Nationally, fewer than 10% of all registered hospitals are level I or level II trauma centers [4], compared with 7% in North Carolina.

The 8 Regional Advisory Committees report at the state level to the State Trauma Advisory Committee (STAC), which works with the OEMS to optimize trauma care throughout North Carolina [7]. The State Trauma Advisory Committee's mission is to provide a public forum to facilitate trauma system development at the regional and state levels and to coordinate trauma activities between the state's various trauma stakeholders [1].

By North Carolina law, the OEMS has been assigned the statutory authority to designate hospitals as trauma centers [1]. Once designated by the state, a trauma center can vol-

untarily seek additional verification by the ACS/COT, which has been establishing guidelines for the care of injured patients since 1976 [3]. In 2004, the OEMS and the ACS/COT began to work together to jointly designate and verify trauma centers. This step has allowed trauma centers to complement the state's rigorous designation process with the process of national verification by ACS/COT. Of the 12 trauma centers currently in North Carolina, 6 are level I centers, 3 are level II, and 3 are level III (Table 1 and Figure 1) [7].

The Regional Advisory Committees, the State Trauma Advisory Committee, and the OEMS actively work to enhance North Carolina's existing trauma systems of care. While trauma care is exceptional in certain areas of North Carolina, in other areas it is less developed (Figure 1). The reasons are multifactorial, although the discrepancy in development is partly attributable to the fact that 50% of North Carolina's population lives in rural areas, making access to trauma care and the development of trauma systems in those areas challenging [1]. Concomitantly, for nearly half of North Carolina's population (47%), it will take more than 45 minutes to be transported from the scene of an injury to a level I or level II trauma center (this is termed "response time," defined as the driving or flight time needed to transport a patient from the scene of the injury to the nearest level I or level II trauma center, given the local road

infrastructure or flight patterns, respectively). In the continental United States, 70% of the population can be transported to one of these centers within 45 minutes [9].

Optimizing Trauma Outcomes

Injury is a major public health issue in North Carolina. On average, there are approximately 47,000 trauma admissions to the 122 North Carolina hospitals every year, or approximately 1 trauma admission every 11 minutes [1]. There are approximately 24,000 trauma admissions to the 12 North Carolina trauma centers every year (NCTR, unpublished data averaged for 2008 and 2009). Overall, 54% of deaths among North Carolina residents aged 1-44 years are injury related, almost double that of cancer and heart disease combined [1]. The leading cause of mortality among children, adolescents, and young adults is unintentional injury from motor-vehicle crashes [10].

These statistics on injury in North Carolina highlight its importance as a public health challenge for children and adults alike, and they make a strong argument for a continued commitment to develop and improve the statewide trauma system. The system should not only serve the current needs of the state, it should also anticipate future needs and have the capacity to expand to accommodate them [1]. In North Carolina, this has been happening consistently since the 1970s and 1980s.

Monitoring, evaluating, and improving trauma outcomes take place on a continuous basis across the entire spectrum of trauma care in North Carolina. These activities are done with weekly meetings at each trauma center; with quarterly meetings of each Regional Advisory Committee and the State Trauma Advisory Committee; with ongoing needs assessments at the local, regional, and state levels; with coordinated transportation of injured patients to trauma centers by ambulances and air medical resources; through the state's ACS-based Rural Trauma Team Development Courses; with public health and education campaigns; with supportive legislation and regulations; with vigilant attempts to secure more funding; with evaluation and updating of standards of care; with ongoing performance improvements; with establishment of guidelines and benchmarks; and with external reviews and audits [3]. All of these are functions of the integrated, inclusive North Carolina trauma system.

As part of the designation and verification process, trauma centers and programs must fulfill certain requirements and maintain standards to keep their accreditation. Among other things, the ACS requires trauma programs to demonstrate a continuous process, involving multidisciplinary performance improvement programs, for improving the care of injured patients. The goal of performance improvement programs is to reduce inappropriate variation in care and to improve patient safety [3]. Performance improvement programs in North Carolina represent the foundation of improving trauma outcomes, as they monitor patient care, assess adverse outcomes, and improve compli-

Table 1.
Trauma Centers in North Carolina, by Classification

Trauma center name and location, by classification	
Level I	
Wake Forest University Medical Center,	Winston-Salem ^{a,b}
Pitt County Memorial Hospital,	Greenville ^a
University of North Carolina Hospitals,	Chapel Hill ^{a,b}
Duke University Hospital,	Durham ^a
Carolinas Medical Center,	Charlotte ^a
WakeMed Health & Hospitals,	Raleigh
Level II	
Moses H. Cone Memorial Hospital,	Greensboro ^a
New Hanover Regional Medical Center,	Wilmington
Mission Hospitals,	Asheville
Level III	
High Point Regional Health System,	High Point
Cleveland Regional Medical Center,	Shelby
Carolinas Medical Center–NorthEast,	Concord

^aAmerican College of Surgeons Committee on Trauma trauma center.

^bAmerican Burn Association and American College of Surgeons burn center.

ance with benchmarks and quality-of-care indicators [11].

North Carolina has placed great emphasis on the performance improvement process. In a step that goes above and beyond national requirements, there is now a statewide performance improvement guideline, maintained by the North Carolina chapter of the ACS/COT, that all trauma centers must comply with. Furthermore, North Carolina has a combined trauma center and emergency medical services regional peer-review protection for all quality-improvement activities, meaning that North Carolina legislation protects the confidentiality of these data, records, reports, and discussions. These initiatives are unique to North Carolina and highlight the progressive, innovative approach to trauma care in the state.

All 12 of North Carolina's trauma centers, by means of their ACS and OEMS accreditation and mandate, also have an important role to play in reducing the impact of injury, by participating in injury prevention efforts. Injury prevention is crucial, as 50% of all patients who die of injury never reach a hospital or trauma center [3]. Prevention efforts are based on identification of specific injuries and risk factors, as determined by regional geography and patient populations. Examples of prevention efforts at the state level include programs such as Safe Kids, Click It or Ticket, and Booze It & Lose It [1]. North Carolina's trauma system is designed to get the right patient to the right place at the right time. To achieve this, proper triage is critical [3], and the inclusive North Carolina system mandates that a well-defined statewide triage strategy be in place. On the national level, the Centers for Disease Control and Prevention established widely accepted triage criteria, called Field Triage Guidelines, in 2006 for trauma systems and emergency medical services [12]. In an effort to standardize triage practices, North Carolina adopted these criteria (available at: <http://www.ncems.org/pdf/TraumaTriage2009.pdf>) in 2009.

Ensuring optimal outcomes for injured patients means that North Carolina's trauma system must be prepared for and able to adapt to multicase events, such as terrorist attacks and natural disasters. The September 11, 2001, terrorist strikes demonstrated that a well-functioning, well-prepared trauma system with a clear, predetermined disaster plan is an essential foundation of disaster readiness [13]. Ensuring the success of North Carolina's regional disaster plans has required large-scale coordination of multiple services, as well as intensive planning, organization, practice, repetition, and analysis [13].

Trauma centers and trauma systems around North Carolina are ready and waiting at all times, with highly trained personnel and advanced technology immediately available

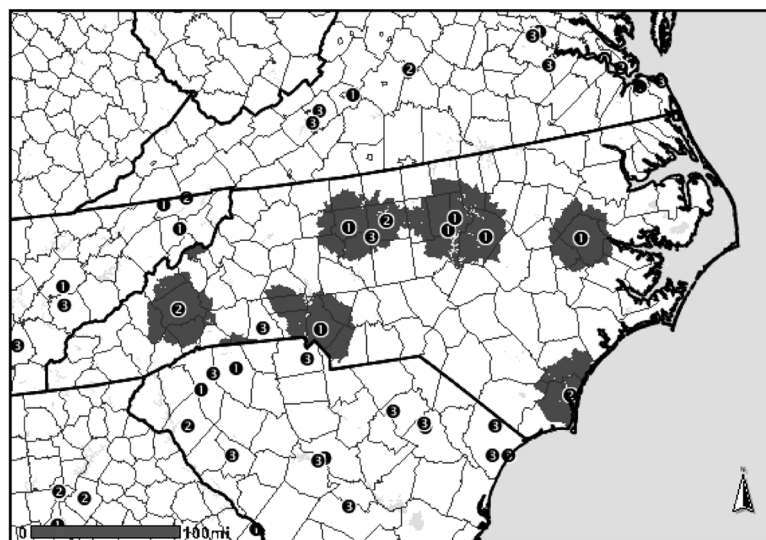
to rapidly diagnose and treat any kind of injury [13]. This not only takes coordination and planning, it also requires money. And yet trauma systems are continually threatened by inadequate funding [8]. Collectively, trauma centers experience a \$1 billion loss annually across the nation [5]. At the national level, funding by Congress for trauma depends on the year; in 2006, zero dollars went into the Trauma Care Systems Planning and Development Act [13]. Therefore, trauma systems and centers require outside funding for support. Without funding, trauma center closures are a reality [14], leaving entire geographic areas of the United States with no trauma coverage. This has not occurred yet in North Carolina, but the threat is ever present.

Trauma Research

Trauma research is a defining aspect of North Carolina's level I trauma centers, which are effective and productive in both research and scholarly activities, as is required by the ACS accreditation process [3]. These centers maintain highly successful trauma research programs and have produced a large number of trauma-related articles published in peer-reviewed journals. Each level I trauma center sets its own agenda for its particular interests and expertise within trauma care.

While there is cooperation among North Carolina's trauma centers that are conducting research, at present, no prospective, expansive research plan exists at the statewide level [1]. This partly reflects recent changes in the collection of data for the NCTR, as the state now directly maintains this resource. This transition has slowed a historically strong track record of publications based on NCTR data produced

Figure 1.
Trauma Center Coverage in North Carolina



Note. Reproduced from [9]. Black circles denote trauma centers, numerals denote trauma center classification level, and shaded areas denote regions (which include 53% of North Carolina residents) located ≤ 45 minutes from a level I or level II trauma center.

by North Carolina's trauma centers. Furthermore, the NCTR fails to capture injuries treated at the 110 North Carolina hospitals not designated as trauma centers [1, 6]. Therefore, the NCTR needs complete participation by all hospitals, as part of the inclusive system, and renewed leadership to once again make it an essential research tool to define the scope of injury in North Carolina.

Conclusion

There has been an extraordinary improvement in the outcomes of injured patients in North Carolina over the past 4 decades [1, 2]. All levels of the North Carolina trauma community now work together to provide a critical public health service that saves lives [3]. Ensuring optimal outcomes for injured patients, however, is by no means complete or guaranteed. At minimum, specific, permanent state funding for trauma systems is still needed, as is funding to offset the burden of uncompensated care. Additionally, coordination of data on outcomes, from all sources of state government,

should be shared at the regional level, to improve trauma systems of care, as these regional systems do not collect their own data. Furthermore, the NCTR needs all 122 of North Carolina's hospitals to participate in providing data. Finally, the research that made North Carolina a national leader in trauma-systems development must be reinvigorated.

Improving trauma outcomes is resource intensive and financially expensive, and it requires a massive, integrated, ongoing commitment from a diverse range of health care services, professionals, and organizations [3]. By maintaining this commitment, North Carolina will remain a national leader in the field of trauma and will continue to optimize the outcomes of the state's injured citizens for years to come. NCMJ

Acknowledgments

We thank Greg Mears and Michael C. Chang, for their review of the manuscript; and Lori Lowder, Jennifer Hinson, Brenda Harrington, McKenzie Cook, and Nadine Pfeiffer, for their assistance with the manuscript. *Potential conflicts of interest.* R.D.B. and J.W.M. have no relevant conflicts of interest.

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