

# Trauma and Emergency Cardiac and Stroke Systems

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Definition: Comprehensive statewide systems providing injury and illness prevention services and timely and appropriate delivery of trauma and cardiac and stroke treatment for people with traumatic injury and acute illness events. This chapter reports In-hospital deaths and survival of trauma patients, timely receipt of procedures to open clogged arteries for heart attack patients, and timely receipt of medication to dissolve clots for some stroke patients as measures of system effectiveness. (Additional information in [Technical Notes](#).)

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## Summary

Washington's Trauma and Emergency Cardiac and Stroke Systems are components of the larger healthcare system for treating patients with life-threatening injuries and illness. In addition to facilitating timely access to appropriate emergency care, these systems help to assure a coordinated approach to care, from prevention to acute care to rehabilitation.

Trauma and emergency cardiac and stroke events are leading causes of hospitalization and death in Washington.<sup>1</sup> In 2010, according to the Washington Trauma Registry (WTR) and the Comprehensive Hospital Abstract Reporting System (CHARS), there were 15,160 trauma, 10,254 emergency cardiac and 14,640 stroke hospitalizations in Washington State.

Outcomes and treatment for these patients have been improving. The percent of all trauma patients dying from injuries decreased from about 9% in 1995 to 5% in 2010. During the same time period the percent surviving serious injury, based on high injury severity scores, increased from about 77% to 87%. In 2010, about 91% of heart attack patients received a procedure to open clogged arteries within 90 minutes of arriving at a hospital, compared to 74% in 2009.<sup>2</sup> Of stroke patients who arrived within the 4.5-hour treatment window at a hospital able to administer the medication, the percent that were treated increased from 73% in 2009 to 80% in 2010.<sup>3</sup>

National organizations including the Institute of Medicine, American College of Surgeons, American Heart Association and American Stroke Association recommend a systems approach to reduce death and disability from

trauma and emergency cardiac and stroke events.

## Overview

Washington's coordinated systems approach to trauma and cardiac and stroke care came from two laws. In 1990, the Washington Emergency Medical Services and Trauma Act authorized development of the state's trauma care system. In 2010, the Legislature passed the Emergency Cardiac and Stroke Care Act that expanded the system to cover emergency cardiac and stroke events.

Systematic approaches to the care of patients with traumatic injury and emergency cardiac and stroke events follow best practices set by the Institute of Medicine, American College of Surgeons, American Heart Association and American Stroke Association.<sup>4,5,6,7,8,9</sup> The result is a comprehensive approach that facilitates appropriate care with the best possible patient outcomes.

Other chapters in this report elaborate on different types of injury, heart disease and stroke without focusing on specific care management issues. This chapter describes Washington's strategy to ensure timely and appropriate care for acute medical events, with a focus on the most life-threatening events: traumatic injuries, and emergency cardiac and stroke events.

## The Systems Approach

Washington's systems approach to trauma, and cardiac and stroke events is a comprehensive approach that provides:

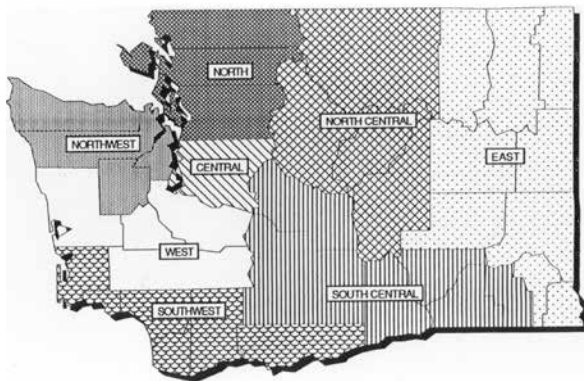
- Injury and illness prevention.
- Emergency medical services (EMS) care.
- Hospital emergency department care that includes resuscitation, stabilization and transfer when needed.

- Hospital inpatient care.
- Rehabilitation services.
- System monitoring and evaluation.

A systems approach to trauma and emergency cardiac and stroke events is cost-effective.<sup>10</sup> It helps to assure appropriate and adequate care with the goal of reducing death and disability as well as the resulting personal and societal burden.<sup>6,7,8,9,11,12,13,14,15,16</sup>

Although the goal of optimal care is the same statewide, these systems recognize that flexibility is essential to meeting this goal in each community. There are eight care regions in Washington. Every two years, each of eight EMS and Trauma Care Regional Councils<sup>17</sup> prepares a plan to meet its goals subject to state Department of Health review and approval.

EMS and Trauma Care Regions



Ultimately, the mission of any systemic approach to care comes down to this simple maxim: Get the right patient to the right resources in the right amount of time. Several broad strategies help accomplish this task.

**Emergency medical services (EMS).** The department licenses EMS agencies and certifies EMS personnel. They must meet specific standards for equipment, training and response times. EMS providers follow medical protocols established by their county medical program director. The department currently licenses almost 500 ambulance and aid services and certifies 17,442 EMS providers.

**Pre-hospital patient care procedures (PCPs).** PCPs are guidelines that address the severity of the event, pre-hospital medical treatment needed, and procedures that provide the

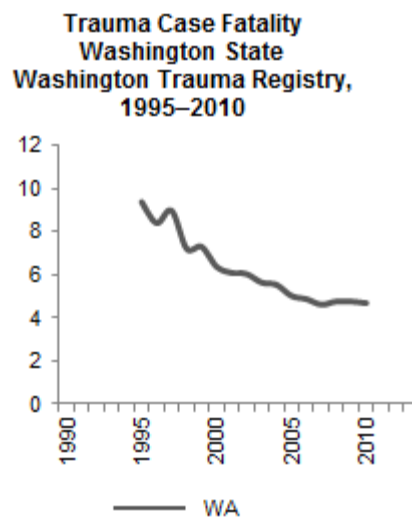
appropriate level of care in the right amount of time.

**Identification of hospital-based care.** Hospitals provide emergency and inpatient care for patients with life-threatening conditions, including resuscitation, stabilization, diagnosis, surgery, intensive care and rehabilitation. The department classifies hospitals at different levels depending on resources available and types of services offered. A Level I hospital provides the most comprehensive care, 24 hours a day, seven days a week.

In addition to 100 designated trauma services with five levels of care, Washington has 80 cardiac centers with two levels and 79 stroke care centers with three levels of care.

### Time Trends

**Trauma.** One measure of trauma system effectiveness is the number-of-hospital deaths from traumatic injury.

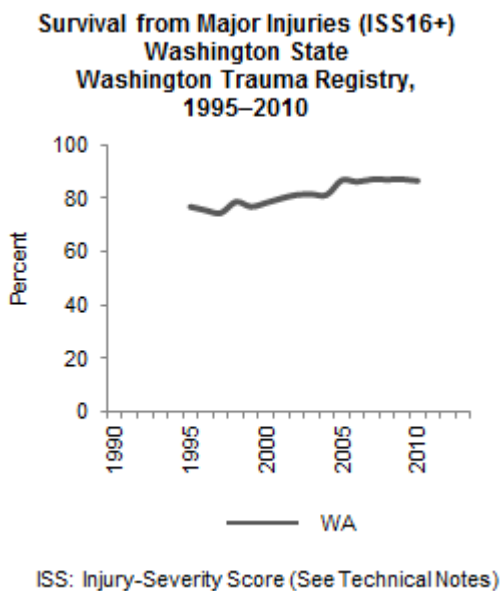


During 1995–2010, 10,592 deaths occurred out of 192,599 cases reported in the Washington Trauma Registry. In 1995, the rate was 9% and by 2010, it had fallen to 5%.

The Injury Severity Score (ISS) categorizes trauma severity. Injuries with ISSs less than 9 are mild, such as simple cuts or sprains. ISS 9–15 indicates a moderate injury, such as a broken leg or single organ injury, while ISS 16–75 indicates a major injury, such as head injury, major abdominal injury and injury involving two or more major parts of the body. Most patients with ISS less than 16 survive unless there are complications, such as age extremes or conditions like heart or respiratory disease. While severely injured patients with ISS 16

or higher may be in a life-threatening situation, many benefit from timely and appropriate pre-hospital and hospital care.

Survival of severely injured patients (ISS 16 or greater) measures the success of the trauma care system. In 1995, about 77% of severely injured patients survived. In 2010, the survival rate reached about 87%.

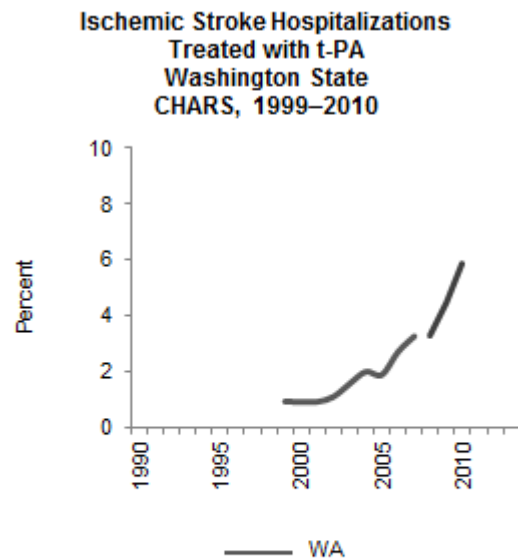


**Cardiac and stroke.** Studies show that reducing time to treatment for cardiac and stroke events saves lives.<sup>7,8,9</sup> Faster treatment also reduces disability by minimizing physical damage and preserving functional status in patients.

In 2002, the Department of Health established the need for a standard approach to emergency cardiac and stroke care to reduce time to treatment.<sup>18</sup> Since then, several hospitals in Washington have shown large reductions in time to treatment for heart attack. Among 31 hospitals that perform percutaneous coronary interventions (PCI—a procedure to open clogged arteries), the average time from emergency department arrival to opening the clogged arteries has decreased from 95 minutes in 2004 to 67 minutes in 2010.<sup>2</sup>

In Washington, the percent of patients hospitalized for ischemic stroke (strokes caused by blood clots) that received acute reperfusion therapy with tissue plasminogen activator (t-PA—a clot-dissolving medication) increased from 0.9% in 1999 to 3.3% in 2007. In 2008, coding for this procedure changed, resulting in a

break in the trend (see [Technical Note](#)). From 2008 to 2010, use of t-PA increased from 3.3% to 5.9% of stroke patients overall. Stroke is a particularly time-critical condition because the clot-dissolving medication can only be given within 4.5 hours of stroke onset.<sup>19</sup> Many patients do not receive t-PA because they get to the hospital too late, or the hospital does not have the resources to provide it. Among those who arrived within the required 4.5 hours at a hospital able to administer t-PA, the percent who were treated with t-PA rose from 73% in 2009 to 80% in 2010.<sup>3</sup>



t-PA : clot dissolving medication administered within 4.5 hours of symptom onset. The break in the trend is a result of changing coding for this procedure.

## 2010 and 2020 Goals

*Healthy People 2010* did not include targets specific to trauma and emergency cardiac and stroke systems. In contrast, *Healthy People 2020* includes two goals that have national targets and can be measured in Washington. These include:

- Increase to 91.4% the population in the continental United States with access to trauma care within one hour by ground or air ambulance.
- Increase the percent of eligible heart attack patients receiving PCI within 90 minutes of hospital arrival to 97.5%.

Barring extreme weather events, all Washington residents live within an hour of a level I or II trauma center either by air or ground ambulance.<sup>20</sup> Thus, Washington has met the 2020 national target. In

Washington 91% of heart attack patients received PCI treatment within 90 minutes of arriving at a hospital in 2010, up from 74% in 2009.<sup>2</sup> If progress continues, Washington will likely meet the national target for PCI.

### Geographic Variation

Trauma and emergency cardiac and stroke care require intense use of health services. Highly skilled and well-equipped pre-hospital and hospital care providers must be available at all times to achieve timely, optimal care. These resources are not equally available across Washington. Nationally, unique challenges in receiving timely, optimal emergency care in rural areas result in increased mortality.<sup>21,22</sup> This is likely to be true in Washington as well.

**Long transport times.** Rapid response is challenging in rural and wilderness areas. Long distances to the scene of the emergency and from the emergency to a hospital add to delays in providing treatment. Washington's response times vary from eight minutes in urban areas to 45 minutes in rural settings.

**Reliance on volunteer EMS providers.** The lack of full-time, paid pre-hospital providers in rural areas limits the level of care available. Volunteers often cannot provide advanced paramedic services. Forty percent of all Washington's certified EMS providers are volunteers, and rural providers are much more likely to be volunteers than those in urban settings.

**Rural hospital factors.** Rural hospitals serve a vital role in emergency care, but they usually are not the final destination. Local resources in rural areas help assure that patients are stabilized before transfer for inpatient care. Limited diagnostic capabilities and delayed or incomplete surgical capabilities add to higher mortality than in urban areas.<sup>23,24</sup> Fewer available physicians and limited opportunities to treat patients add to the challenges of rural hospital-based care.

**Pre-hospital diagnostic tools.** Paramedics can use ECG (electrocardiograph) machines to tell if a patient is having a heart attack. This helps them decide which hospital to take the patient to and allows them to give the hospital advance notice so it can prepare for the patient. This pre-notification can save significant time, improving patient outcomes. Only 13% of EMS providers in Washington are paramedics. These paramedics

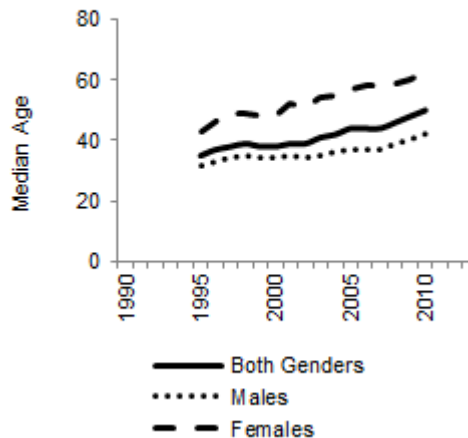
are primarily in urban areas, leaving most of Washington's rural areas without this time-saving resource.

### **Age and Gender**

**Trauma.** Trauma used to afflict mainly the young. As Washingtonians age, the age of most trauma victims has also increased. During 1995–2010, the median age of all trauma patients rose from 35 to 50 years. In 1995, only one in every five seriously injured (ISS 16+) trauma patients was 55 years or older. In 2010, nearly half of all serious injuries (about 45%) involved patients ages 55 or older. For trauma care, age is an important factor, regardless of injury severity, with increased mortality after age 55.<sup>25</sup> Though the median age is increasing for both genders, women tend to experience trauma later in life than men do. In 2010, the median age for males in the trauma registry was 42 years while it was 63 years for females.

Most injuries in older adults involve women who fall due to slipping or tripping. Given that many older adults are on blood thinners, a minor impact to the head can easily lead to deadly brain hemorrhage.<sup>26</sup> Head injuries due to falls are a major contributor to deaths in elderly trauma patients.

**Median Age of Trauma Patients  
Washington State  
Washington Trauma Registry,  
1995-2010**



**Cardiac and stroke.** Statewide age and gender data on receipt and timeliness of appropriate care for cardiac and stroke events are not readily available. Several studies done elsewhere show that older adults and females experience more treatment delays for cardiac events before and after hospital arrival.<sup>27</sup> Gender and age differences were not associated with treatment delay for stroke.<sup>28</sup> It is not



known whether these findings would be similar in Washington.

### **Economic Factors and Education**

**Trauma.** The trauma registry does not include data on patient income or education. Studies done elsewhere did not find differences in accessing trauma care associated with income or education, because most states have well-developed trauma systems that are available to all residents.<sup>29</sup> Given that all Washington residents have access to trauma care, this is likely to be the case in Washington also.

**Cardiac and stroke.** Statewide economic and education data on receipt and timeliness of appropriate care for cardiac and stroke events are not readily available. Several studies show that people of lower socioeconomic status experience more treatment delays for cardiac events before and after hospital arrival.<sup>27</sup> Several studies indicate that educational level of stroke patients is unrelated to treatment delay whereas results are mixed for income level.<sup>28</sup> It is not known whether these findings would be similar in Washington.

### **Race and Ethnicity**

**Trauma.** Data on race and ethnicity are missing for more than 20% of patient records in the Washington trauma registry and as such are not presented here. Racial and ethnic disparities in accessing trauma care have not been studied extensively. We found one study—using a nationwide representative sample of emergency department visits—that shows no racial or ethnic differences in accessing trauma care.<sup>30</sup>

**Cardiac and stroke.** Statewide racial and ethnic data on receipt and timeliness of appropriate care for cardiac and stroke events are not readily available. Several studies have shown that racial and ethnic minorities (nonwhite race) experience more treatment delays for emergency cardiac events before and after hospital arrival.<sup>27</sup> Many studies show that race or ethnicity is unrelated to treatment delay for stroke, although some researchers have found longer delays for blacks, Asians and Pacific Islanders.<sup>28</sup> It is not known whether these findings would be similar in Washington.

### **Barriers to Care**

**Costs and reimbursement levels.** EMS services and emergency departments must care

for all emergency patients regardless of ability to pay. Although studies found that ability to access trauma services was not associated with income, quality of services might vary. Nationally, one barrier to high-quality trauma care is that providers can be reluctant to participate in the system because of the high cost of providing trauma care and the low reimbursement rates. Low Medicaid reimbursement in particular creates barriers for hospitals and physicians in areas with high Medicaid enrollment. To remedy this, Washington State has created the Trauma Care Fund, which provides grants and increased reimbursement for providers treating Medicaid patients.

Reimbursement rates are less of a barrier for cardiac and stroke providers because most patients are older and covered by Medicare or other insurance. In some areas of the state, there is competition among providers for these patients.

**Physician specialist availability.** Washington's goal is to maintain at least one Level I or II trauma hospital in each EMS and trauma care region (see [Technical Note](#)). Due to the limited availability of specialty providers such as neurosurgeons and orthopedic surgeons, four regions are without a Level I or II trauma hospital.

The limited availability of neurology services is also an issue in stroke care, particularly in rural areas. Emergency physicians can treat most strokes, but they usually want to consult with a neurologist before administering the clot-dissolving medication t-PA. Many rural hospitals have contracted with larger hospitals that have 24-hour neurology coverage and provide remote consultation.

**Delays in seeking medical attention.** A major challenge in the timely treatment of cardiac and stroke events is that people wait too long to get medical attention. Educating the public to recognize signs and symptoms and to understand the importance of calling 9-1-1 immediately is a key component of the emergency cardiac and stroke system.

### **Intervention Strategies**

According to the American College of Surgeons, American Heart Association and American Stroke Association, Washington's Trauma and Emergency Cardiac and Stroke Systems are themselves interventions, which follow best practices set by these national organizations<sup>4,5,6,7,8,9</sup> For further improvement, the department uses additional strategies that affect all systems and are consistent with these best practices.

**Quality improvement programs.** To provide continuous monitoring and evaluation of quality of care, the department supports ongoing quality improvement at local, regional and state levels in collaboration with quality improvement committees in each of the eight EMS and trauma care regions. This support enables pre-hospital and hospital providers to conduct confidential review of trauma and emergency cardiac and stroke care provided, addressing both individual patient care and system-wide design and management issues. Several data sources directly support care reviews and system improvement activities:

- **Washington EMS Information System (WEMSIS).** The WEMSIS is a statewide EMS patient care database to promote evidence-based decision-making and EMS quality improvement. It helps evaluate outcomes related to pre-hospital patient care, developing evidence-based curricula and medical protocols, and monitoring and evaluating EMS system response and performance.
- **Washington Trauma Registry (WTR).** The WTR collects demographic and clinical data on trauma patients from pre-hospital agencies and trauma-designated acute care services. The WTR helps evaluate system effectiveness.
- **Data sources for emergency cardiac and stroke care.** The department is working with partners and stakeholders to find existing sources of data and modify them to evaluate system effectiveness and improve care.

**Clinical practice guidelines.** To reduce variability of care and increase use of evidence-based medicine, Washington's Medical Directors develop a series of clinical practice guidelines using evidence-based approaches from the published medical literature. The department reviews these guidelines and gives them to all clinical providers participating in Washington's Trauma and Emergency Cardiac and Stroke Systems to ensure a consistent approach.

**Pre-hospital continuing education.** Providing adequate continuing education to providers in rural areas presents a special challenge. A volunteer's time is limited. The EMS agencies that heavily depend on volunteers usually have

limited resources. In addition, travel distances in rural areas can be significant. These factors add to difficulties recruiting and retaining an adequate number of properly trained EMS personnel in rural settings.

To assist EMS personnel in meeting the requirements for recertification, ongoing training and evaluation programs (OTEP) allow people to train locally using training materials approved by their county medical directors and the department. OTEP provides hands-on skills training for specific EMS topics. The individual must then demonstrate competency in these skills. This allows them to receive credit toward recertification education requirements. These regularly scheduled OTEP offerings ensure that EMS personnel maintain their knowledge and patient care skills to provide the best care to injured and critically ill patients.

**Telestroke.** Telestroke programs extend the limited neurology resources in Washington to rural hospitals. Telestroke brings neurology expertise to a stroke patient's bedside via video conferencing or phone consultation, and helps emergency department staff assess and treat eligible stroke patients with t-PA inside the 4.5-hour treatment window.

**Enhanced reimbursement.** This intervention affects only the Trauma System. Designated trauma services must be ready to receive patients at all hours of the day and night. The cost for a Level I or II trauma center to assure readiness exceeds \$2 million per year.<sup>31</sup> Low Medicaid reimbursement rates and a growing uninsured population create barriers for hospitals and physicians to participate in the system. In 1997, the Washington Legislature established the Trauma Care Reimbursement Fund, which receives funds from a surcharge to fines for moving motor vehicle violations and motor vehicle sales and leases. It provides grants to pre-hospital and hospital providers and allows for enhanced reimbursement rates for Medicaid trauma patients. The Department of Health continues to work closely with the Health Care Authority in planning and managing distribution of the funds, which total more than \$20 million per year.

**See Related Chapters:** [Hospitalization](#), [Motor Vehicle Crashes](#), [Traumatic Brain Injury](#), [Falls among Older Adults](#), [Drug Abuse and Overdose](#), [Drowning](#), [Suicide](#), [Homicide](#), [Youth Violence](#), [Domestic Violence](#), [Child Abuse and Neglect](#), [Coronary Heart Disease](#), [Stroke](#)

## Data Sources

Washington Trauma Registry (WTR), Office of Community Health Systems, Department of Health, 1995-2010,

Washington Comprehensive Hospital Abstract Reporting System (CHARS), Center for Health Statistics, Department of Health, 1987-2010.

## For More Information

Office of Community Health Systems (360) 236 2800, <http://www.doh.wa.gov/PublicHealthandHealthcareProviders/EmergencyMedicalServicesEMSSystems/EMSandTrauma.aspx>;

<http://www.doh.wa.gov/PublicHealthandHealthcareProviders/EmergencyMedicalServicesEMSSystems/EmergencyCardiacandStrokeSystem.aspx>

## Technical Notes

**The Trauma Registry reports on trauma, not on all hospitalized injuries:** The trauma inclusion criteria are: an injured patient (ICD-9 codes 800-904.9 and 910-959.9) who is admitted to a hospital for more than 48 hours (or any admission for a child through age 14); or who is transferred from the first receiving facility to another hospital; or who is airlifted from the scene; or for whom the hospital's trauma resuscitation team is activated; or who dies in the hospital. These inclusion criteria identify injured patients who could most benefit from an effective trauma system based on not just severity but also acuteness of their conditions. Trauma deaths occurring out of hospital are not included in the registry, with the exception of those who die in transport.

**Trauma service levels:** Washington's only Level I service for traumatic injuries (Harborview Medical Center) provides the highest level of resources for the most complex injuries or illness. Level V services are unique to Washington and represent the role that small rural hospitals and clinics play in the trauma system. Level V trauma services offer resources to assess, resuscitate, stabilize and transfer major trauma patients. Levels II through IV maintain varying resources and capabilities that fall between those of Level I and V. Among Washington's acute care hospitals, 85% are designated to provide some level of trauma service.

**Definition of emergency cardiac and stroke events related to emergency care:** Emergency cardiac events include hospitalizations from heart attack, unstable angina and cardiac arrest (ICD-9 codes 410, 411 and 427.5 in the first nine diagnoses, respectively). Stroke events include hospitalizations with ICD-9 codes 430-438 in the first nine diagnoses.

**Injury Severity Score:** This is a summary score for traumatic injuries. The ISS is calculated as the square of the abbreviated injury score (AIS). If more than one injury occurs, the highest AIS value is selected from each of up to

six body regions (head/neck, face, thorax, abdominal and pelvic contents, limbs, and skin). The three highest of these are squared and summed. If any AIS score is six, then the ISS is 75. The ISS ranges from one (least severe) to 75 (usually fatal). See Champion, Sacco, Copes: Injury Severity Scoring Again. *Journal of Trauma*. 1995;38:94.

**T-PA treatment:** The data is from 35 hospitals in Washington that use GWTG-Stroke, a national quality improvement program used to measure stroke treatment performance. These hospitals treated 74% of stroke hospitalizations in 2010. Only patients who arrive within 4.5 hours of symptom onset are eligible for acute reperfusion therapy with t-PA. The majority of stroke patients arrives outside this treatment window, or may be ineligible for other reasons.

Ischemic stroke hospitalizations treated with t-PA include hospitalizations with ICD-9 codes 433-434 in the first nine diagnoses that also had a procedure code of 99.10 for t-PA administration in the CHARS database. In 2008, an additional ICD9 diagnosis code, V45.88, became effective for identifying t-PA administration if a patient had been given treatment in one hospital and then was transferred to another hospital. While this method produced similar results as national analysis from the same type of inpatient data, it may grossly underestimate treatment rates.<sup>32</sup> Coding of hospitalizations depends on billing requirements, which may limit the documentation of actual treatment given.<sup>32,33</sup>

## Emergency percutaneous coronary intervention

**(angioplasty/stenting):** The data is from the 32 Washington hospitals that participate in the Washington state-based Clinical Outcomes Assessment Program (COAP) registry and quality improvement program and perform emergency percutaneous coronary intervention (angioplasty/stenting). These hospitals treated around 90% of heart attack hospitalizations in 2010. The COAP registry is integrated with ACC's national CathPCI<sup>®</sup> Registry. Public data on median time to treatment is available at <http://www.coap.org/for-the-public/2010-median-time-from-emergency-room-arrival-to-balloon-inflation-door-to-balloon-time>.

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## Endnotes

<sup>1</sup> National Center for Health Statistics. *Health, United States: with special feature on death and dying* (HDDS Publication No. 76-641496). Washington, DC: U.S. Government Printing Office; 2010.

<sup>2</sup> Clinical Outcomes Assessment Program (COA), Foundation for Health Care Quality/CathPCI® Registry, American College of Cardiology (ACC) Foundation.

<sup>3</sup> American Heart Association/American Stroke Association Get With The Guidelines Registry (GWTG) Stroke Module.

<sup>4</sup> Committee on Trauma: American College of Surgeons. Resources for Optimal Care of Injured Patient. Chicago, IL: American College of Surgeons; 2006.

<sup>5</sup> Committee on the Future of Emergency Care in the United States Health System. *Hospital Based Emergency Care: At the Breaking Point*. Washington, DC: The National Academies Press; 2007.

<sup>6</sup> Jacobs AK., Antman EM, Faxon DP, Gregory T, Solis P. Development of systems of care for ST-elevation myocardial infarction patients: Executive Summary. *Circulation*. 2007;116:217-230.

<sup>7</sup> Rokos, IC. Rationale for establishing regional ST-elevation myocardial infarction receiving center (SRC) networks. *Am Heart J*. 2006;152:661-667.

<sup>8</sup> Nichol G, Aufderheide TP, Eigel B, et al. Regional Systems of Care for Out-of-Hospital Cardiac Arrest: A Policy Statement From the American Heart Association. *Circulation*. 2010;121:709-729.

<sup>9</sup> Schwamm LH, Pancioli A, Acker JE, et al. Recommendations for the Establishment of Stroke Systems of Care: Recommendations from the American Stroke Association's Task Force on the Development of Stroke Systems. *Stroke*. 2005;36:690-703.

<sup>10</sup> Miller TR, Levy DR. The effect of regional trauma care system on costs. *Arch of Surg*. 1995;130(2):188-193.

<sup>11</sup> Celso B, Tepas J, Langland-Orban B. A systematic review and meta-analysis comparing outcomes of severely injured patients treated in trauma centers following the establishment of trauma systems. *J Trauma*. 2006;60(2):371-378.

<sup>12</sup> Chiara O, Cimbanassi S. Organized trauma care: does volume matter and do trauma centers save lives? *Curr Opin Crit Care*. 2003;9(6):510-514.

<sup>13</sup> Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. *J Trauma*. 1999;47(suppl 3):S25-S33.

<sup>14</sup> Mullins RJ, Mann NC. Population-based research assessing the effectiveness of trauma systems. *J Trauma*. 1999;47(suppl 3):S59-S66.

<sup>15</sup> Mackenzie EJ. Review of evidence regarding trauma system effectiveness resulting from panel studies. *J Trauma*. 1999;47(suppl 3):S34-S41.

<sup>16</sup> MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med*. 2006;354(4):366-378.

<sup>17</sup> The EMS and Trauma Care Regional Councils are: Central (King County), East (Adams, Asotin, Ferry, Garfield, Lincoln,

Pend Oreille, Spokane, Stevens, and Whitman counties), North (Island, San Juan, Skagit, Snohomish, and Whatcom counties), North Central (Chelan, Douglas, Grant, and Okanogan counties), Northwest (Clallam, Jefferson, Kitsap, and Mason counties), South Central (Benton, Columbia, Franklin, Kittitas, Walla Walla, and Yakima counties), Southwest (Clark, Cowlitz, Klickitat, southern Pacific, Skamania, and Wahkiakum counties), and West (Grays Harbor, Lewis, northern Pacific, Pierce, and Thurston counties).

<sup>18</sup> *State of the State, Emergency Cardiovascular Care in Washington State*. Olympia, WA: Washington State Department of Health. Published November 15, 2002.

<sup>19</sup> Lansberg MG, Bluhmki E, Thijs VN. Efficacy and safety of tissue plasminogen activator 3 to 4.5 hours after acute ischemic stroke: a metaanalysis. *Stroke*. 2009;40:2438-2441.

<sup>20</sup> Washington State Department of Health's analysis of air transport times by the GIS Unit on January 6, 2012 showed that 100% of Washington's population and land mass is within a 60 minute flight time. The analysis looked at the 60 minute (155 miles) flight radius from each currently designated level I or II Trauma Service. In addition, the current version of the State Air Medical Service Plan (Oct. 2010) demonstrates that over 90% of the residential population is within a 30-minute response time from flight bases to scene and 30-minute response time from scene to a level I or II designated Trauma Service.

<sup>21</sup> Gonzalez RP, Cummings G, Mulekar M, Rodning CB. Increased mortality in rural vehicular trauma: identifying contributing factors through data linkage. *J Trauma*. 2006;61(2):404-409.

<sup>22</sup> Rogers FB, Madsen L, Shackford S, et al. (2005). A needs assessment for regionalization of trauma care in a rural state. *Am Surg*. 2005;71(8):690-693.

<sup>23</sup> Esposito TJ, Sanddal TL, Reynolds SA, Sanddal ND. Effect of a voluntary trauma system on preventable death and inappropriate care in a rural state. *J Trauma*. 2003;54(4):663-669.

<sup>24</sup> Esposito TJ, Maier RV, Rivara FP, et al. The impact of variation in trauma care times: urban vs. rural. *Prehosp Disaster Med*. 1995;10:161-167.

<sup>25</sup> Kuhne CA, Ruchholtz S, Kaiser GM, Nast-Kolb D. Mortality in Severely Injured Elderly Trauma Patients: When Does Age Become a Risk Factor? *World J Surg*. 2005;29(11):1476-1482.

<sup>26</sup> Franko J, Kish KJ, O'Connell BG, Subramanian S, Yuschak JV. Advanced Age and Preinjury Warfarin Anticoagulation Increase the Risk of Mortality After Head Trauma. *J Trauma*. 2006;61(1):107-110.

<sup>27</sup> O'Connor RE, Bossaert L, Arntz HR, et al. Acute Coronary Syndrome Chapter Collaborators. Part 9: Acute coronary syndromes: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation*. 2010;122(16 suppl 2):S422-S465.

<sup>28</sup> Moser DK, Kimble LP, Alberts MJ, et al. Reducing delay in seeking treatment by patients with acute coronary syndrome and stroke: a scientific statement from the American Heart Association Council on cardiovascular nursing and stroke council. *Circulation*. 2006;114(2):168-182.

<sup>29</sup> Committee on the Future of Emergency Care in the United States Health System. *Hospital Based Emergency Care: At the Breaking Point*. Washington, DC: The National Academies Press; 2007.



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<sup>30</sup> Shafi S, Gentilello LM. Ethnic Disparities in Initial Management of Trauma Patients in a Nationwide Sample of Emergency Department Visits. *Arch Surg*. 2008;143(11):1057-1061.

<sup>31</sup> Taheri PA, Butz DA, Lottenberge L, Clawson A, Flint LM. The cost of trauma center readiness. *Am J Surg*. 2003;187:7-13.

<sup>32</sup> Kleindorfer D, Xu Y, Moomaw CJ, Khatri P, Adeoye O, Hornung R. US geographic distribution of t-PA utilization by hospital for acute ischemic stroke. *Stroke*. 2009;40:3580-3584.

<sup>33</sup> Albright K, Martin-Schild S, Morales M, Grotta J. Comment on US Geographic Distribution of Recombinant Tissue Plasminogen Activator Use by Hospitals for Acute Ischemic Stroke. *Stroke*. 2010;41:e189.