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Stroke

SPECIAL REPORT

Recommendations for Regional Stroke Destination Plans in Rural, Suburban, and Urban Communities From the Prehospital Stroke System of Care Consensus Conference

A Consensus Statement From the American Academy of Neurology, American Heart Association/American Stroke Association, American Society of Neuroradiology, National Association of EMS Physicians, National Association of State EMS Officials, Society of NeuroInterventional Surgery, and Society of Vascular and Interventional Neurology: Endorsed by the Neurocritical Care Society

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Noteworthy advances in the care of patients with acute ischemic stroke (AIS) have occurred in the past 5 years. In 2015, studies of endovascular therapy (EVT) for patients with AIS due to large vessel occlusions (LVOs) demonstrated unequivocal benefit in carefully selected patient populations using stent retriever devices. As a result, in 2015, the American Heart Association (AHA)/American Stroke Association (ASA) released a guideline update reiterating the importance of intravenous (IV) alteplase and recommending "patients should receive EVT with a stent retriever if they meet all the…criteria." However, the benefits of treatment from IV alteplase and EVT are both time sensitive. Thus, the previous AHA/ASA 2005 Recommendations for the Establishment of Stroke Systems of Care required significant revision to ensure timely access to both critical therapies and to reflect the full range of stroke center certifications, including the recently created Joint Commission–approved thrombectomy-capable stroke center (TSC) certification program, intended to serve regions without comprehensive stroke centers to perform EVT. In response to the identified need to develop a set of consensus recommendations for prehospital destination plans tailored to specific population environments, a committee of leading national experts in prehospital acute stroke care was convened at the AHA/ASA International Stroke Conference in January 2018. There was consensus on the need for regional customization of stroke systems of care (SSOCs) to address differences in resources, hospital certifications, geography, and population density and to educate prehospital providers on new models of AIS care, particularly thrombectomy, and how they impact the SSOCs. This article outlines their recommendations and is intended to augment the most recent AHA SSOC policy statement published in 2019.

Key Words: brain ischemia ■ certification ■ consensus ■ geography ■ stents

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The Food and Drug Administration approval of IV alteplase in 1996 transformed treatment for AIS and remains the cornerstone of care to this day. This was the first acute therapy focused on reperfusion of ischemic tissue in AIS, potentially reducing stroke morbidity and mortality. To increase access to this new reperfusion therapy for as many eligible stroke patients as possible, it was necessary to integrate all regional stakeholders, especially Emergency Medical Services (EMS), involved in the care of patients with AIS into an effective SSOC.[1] In 2015, AIS care dramatically changed again when several randomized clinical trials reported the benefit of EVT for patients with AIS secondary to LVOs. Soon thereafter, EVT received a class 1 level A recommendation from the AHA/ASA and became a standard of care for select patients with severe AIS.[2–4] The demonstration of the efficacy of endovascular reperfusion therapy prompted the need to update SSOC to recognize regional stroke center reperfusion capabilities and to address unique regional geographic circumstances.

In response to the identified need to develop a set of consensus recommendations for prehospital destination plans tailored to specific population environments, a committee of leading national experts in prehospital acute stroke care was convened at the AHA/ASA International Stroke Conference in January 2018. Attendees of this Prehospital SSOC Consensus Conference were selected by the societies represented and reflected the diversity of health care providers and settings found in the United States (see the participant list). The conference specifically focused on SSOC with an emphasis on the needs of the prehospital community. With the addition of EVT for LVO, the prehospital community now had to incorporate LVO scores in the initial assessment and make transport decisions based on the potential eligibility for IV thrombolysis and EVT. This document represents the final consensus recommendations of the conference attendees and their respective supporting or endorsing societies. The recommendations are intended to serve as a resource for those involved in creating and overseeing regional SSOCs (eg, EMS directors, hospitals, stroke advisory groups, and local and state government regulatory authorities). Lastly, these recommendations reflect the current needs and opportunities relevant to SSOCs in the United States, yet similar challenges and solutions exist globally.

BACKGROUND—SSOCS

In 2019, the AHA published an update to the first policy statement in 2005 from the ASA Task Force on the Development of Stroke Systems, Recommendations for the Establishment of SSOCs, to reflect the changes needed in this new environment of stroke care, with sections explicitly addressing prehospital stroke screening tools and severity scales and preferential triage of selected patients with suspected severe stroke due to LVO to the nearest EVT-capable stroke center.[1,5] Similarly, under the auspices of the AHA/ASA national initiative to advance systems of care for patients with acute, high-risk, time-sensitive disease states, the AHA/ASA also updated its Mission: Lifeline Stroke EMS Acute Stroke Routing Algorithm (Figure 1; also available at https://www.stroke.org/-/media/stroke-files/ems-resources/ems-algorithm-acute-stroke-routing.pdf?la=en) to incorporate potential EVT eligibility into prehospital transport considerations, thus supporting regional SSOC efforts to facilitate appropriate and timely care for all AIS patients. These updates reviewed the framework for the 4 levels of stroke care facilities utilized in the current SSOC. In response to the perceived need for greater access to thrombectomy in areas distant from comprehensive stroke centers (CSCs), several of the organizations that certify or accredit stroke centers introduced the fourth level of certification for hospitals that can effectively perform EVT but do not meet all the criteria for CSC. We will refer to this level as a TSC but other terms referring to similar centers include "Thrombectomy Stroke Center" and "Primary Stroke Center Plus." In particular, the policy statement recommended that (1) "in prehospital patients who screen positive for suspected stroke, a standard prehospital stroke severity assessment tool should be used to facilitate triage. In the absence of new data, it is reasonable to tailor the Mission:Lifeline Stroke algorithm to the needs of the community," and (2) "when several hospital options exist within similar travel times, EMS should seek care at the facility capable of offering the highest level of stroke care. Further research is needed to establish travel time parameters for hospital bypass in cases of prehospital suspicion of LVO."[5]

The 2019 Stroke System of Care recommendations article recognized this new level of EVT capability, "The proper role of TSCs in communities without any access to thrombectomy is straightforward; its role in a community that already has access to a CSC is more controversial, and plans for patients with suspected LVO should always seek the center of highest capability when interfacility travel time differences are short." Challenges exist in implementing this doctrine due to concerns over the practicality of such triage, large shifts in patient allocation between hospitals, market/health care system forces, and risks of harm from overcrowding at CSCs due to overtriage. An accompanying editorial by Dr Robert Harrington, AHA President, highlighted the need for 3 areas of consideration. (1) Independent third-party organizations should "create and apply the standards for certification and accreditation.[6]" (2) Local SSOCs, not national accrediting bodies, should identify "how best to implement these elements into a SSOC that meets their needs and resources and to define the types of hospitals that should qualify as points of entry for patients with suspected LVO strokes…" (3) In areas with long travel times

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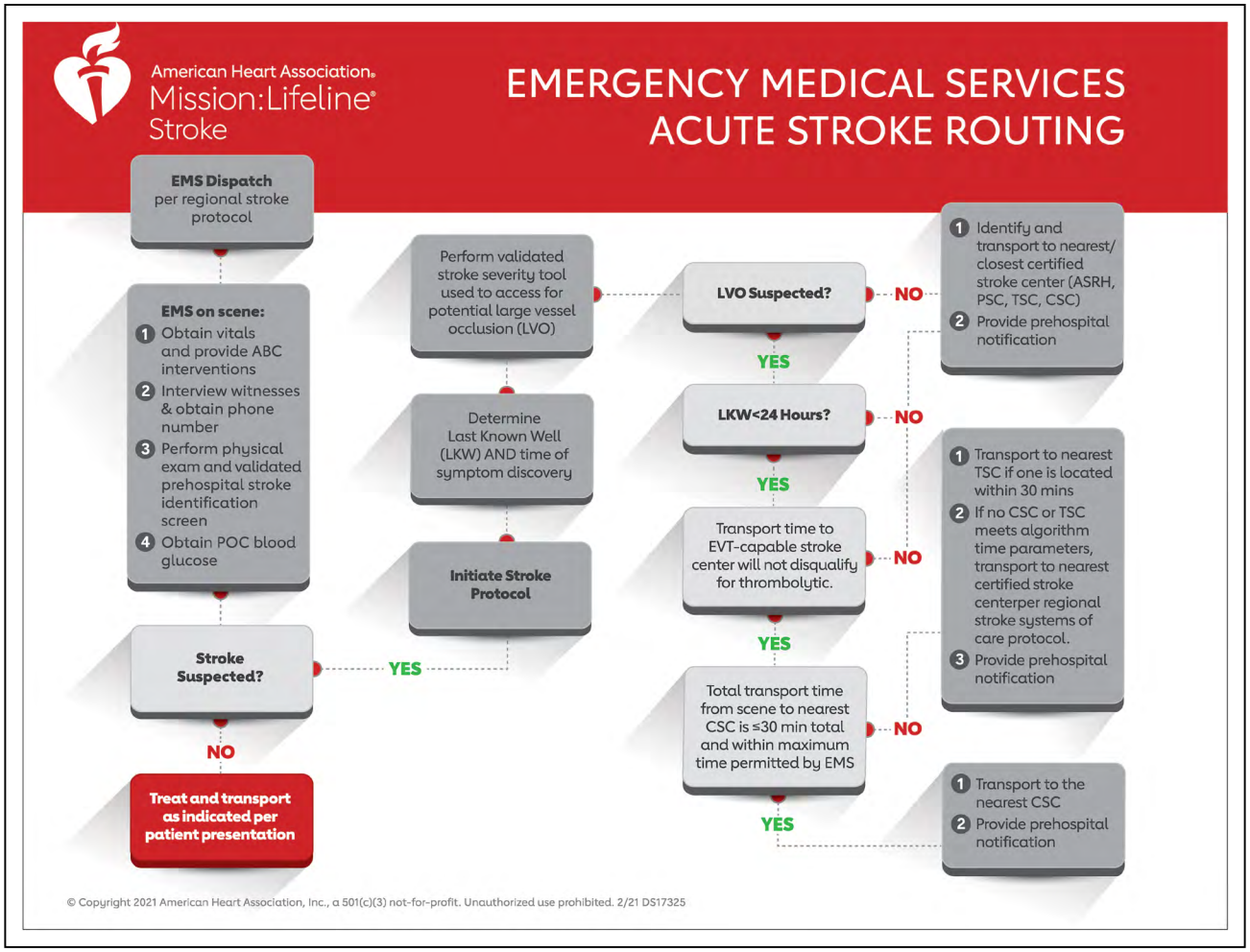

Figure 1. Mission: Lifeline Stroke Emergency Medical Services (EMS) Acute Stroke Routing Algorithm.
ABC indicates airway, breathing and circulation; ASRH, acute stroke-ready hospital; CSC, comprehensive stroke center; EVT, endovascular therapy; LKW, last known well; LVO, large vessel occlusion; POC, point of care; PSC, primary stroke center; and TSC, thrombectomy-capable stroke center. Reprinted from the American Heart Association with permission. Copyright ©2021.

to a CSC, "TSC programs should be part of the SSOC…" and "…they should have criteria for performance that are similar to that of a CSC for the subset of patients with ischemic stroke." Lastly, Dr Harrington recognized "Ideally, when geography permits, locales will identify a CSC as the ideal choice for a suspected LVO patient if an ambulance needs to choose among several destinations, including Primary Stroke Centers and TSCs."

With varying levels of stroke center certifications and unique regional and geographic considerations, local SSOC plans and implementations will vary widely. Regional stakeholders must collaborate to consider local prehospital and health care resources, individual stroke center capabilities and performance, and geographic considerations to create an optimally adapted SSOC and destination protocol to ensure effective and efficient stroke care. When the initial Mission: Lifeline Stroke algorithm was introduced, it conservatively recommended triaging patients with suspected LVO to an EVT-capable center only when this added no more than 15 minutes of additional travel time and recognized that nonurban areas may need to modify these recommendations. While this was reasonable for urban areas with multiple nearby hospitals, more explicit guidance for how to modify these approaches for suburban and rural environments was urgently needed, and this consensus document was an effort to address that need. Formal and informal feedback was solicited through multiple avenues as the consensus conference proceedings were shared. These include the Joint Commission (JC) public comment period for the TSC certification program, and formal presentation to multiple AHA committees (Stroke Council, Mission: Lifeline Stroke Committee, AHA JC Stroke Technical Expert Panels, Hospital Accreditation Science Committee, and the SSOC Advisory Group). The most current Mission: Lifeline Stroke algorithm has modified transport time considerations incorporating longer transport times based, in part, on several triage models.

The coronavirus disease 2019 (COVID-19) pandemic further emphasizes the need for flexible adaptation of prehospital triage and interfacility transport in response to local and regional factors. Preferential routing of suspected LVO patients to centers with thrombectomy capability

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may be of even greater importance when in-hospital and interfacility delays are amplified in conditions such as the COVID-19 pandemic. Continuous assessment of local resources and challenges by those administering SSOC are necessary to ensure locally optimal performance.

BACKGROUND—HEALTH CARE RESOURCES

To best design a regional SSOC, a detailed understanding of hospital stroke capabilities is required. To do so, most SSOCs will rely on independent third-party assessments of regional hospital capabilities before they are incorporated in prehospital destination plans. To promote the optimal quality of care and patient safety provided by health care facilities, various agencies or organizations periodically monitor and assess the quality of care at health care facilities. State departments of health, professional organizations, and third-party independent organizations frequently provide assessment and review services for both overall care (accreditation) and disease-specific care (certification). In the United States, the Centers for Medicare and Medicaid Services utilizes third-party organizations such as the JC to recognize health care facilities that meet the Centers for Medicare and Medicaid Services standards for patient safety and overall quality of care. Recognition by these accreditation and certification organizations is a condition of licensure for receiving Medicare and Medicaid reimbursements. Regional health care planning entities design disease-specific systems of care building, in part, on these platform accreditation and certification programs. It is important to understand the accreditation, certification, and designation definitions and roles as SSOCs are developed.

Accreditation

Health care facilities achieve accreditation by undergoing an internal self-assessment, as well as a third-party, external review process to measure the level of performance against established standards. The accreditation process focuses on quality of care and patient safety by measuring a facility's performance and the impact of its quality improvement (QI) programs as required for meeting the Centers for Medicare and Medicaid Services Medicare conditions of participation. Hospital accreditation remains the cornerstone process to ensure health care facilities are committed to meeting overall high patient safety standards. Hospitals in the United States may receive core accreditation from 1 of the 4 Centers for Medicare and Medicaid Services–approved organizations: the JC, Det Norske Veritas, Healthcare Facilities Accreditation Program, and Center for Improvement in Healthcare Quality. To avoid duplication in services, confusion over differing standards and the risk of lower quality often observed in self-attestation programs, state departments of health, or other regulatory bodies should utilize nationally recognized accreditation programs in the development and implementation of local, regional, and state SSOC.

Certification

Health care facilities may also apply for certification in specific clinical/disease areas. Certification typically builds upon an existing facility's accreditation and recognizes unique programs or services it provides (eg, ischemic stroke, heart disease, total joint replacement, and perinatal care). The process of certification is similar to accreditation in that it involves an internal self-assessment of care quality and patient safety that is measured against established standards, and an onsite review by a third party, and is provided by multiple independent organizations. It is essential that when multiple organizations provide certification for the same level of center recognition, the standardized performance measures used should be consistent across the certifying organizations to ensure those parties responsible for center designation can make accurate comparisons of capabilities and avoid a race to the bottom of lowering requirements to capture greater certification market share. Unfortunately, certification organizations do not currently utilize fully harmonized criteria for stroke center certification, particularly as it relates to minimum case volumes or physician training and experience. Regulatory authorities in each state should endorse a uniform set of standards that all hospitals must meet regardless of which certifying body they select to ensure an equal playing field for all centers.

The groundwork for stroke center certification was introduced by the National Institute of Neurological Disorders and Stroke in 1996, and many of its recommendations and time targets were incorporated into the AHA/ASA Advanced Cardiac Life Support program in 2000 as the Stroke Chain of Survival[7] and the Brain Attack Coalition programmatic structures in 2000.[8] In 2002, a second National Institute of Neurological Disorders and Stroke symposium focused on barriers to delivering acute stroke treatment and encouraged stakeholders "to create stroke care networks to match and optimize patient needs and available resources."[9] These recommendations were followed by the 2005 AHA/ASA Recommendations for the Establishment of Stroke Systems of Care,[1] the 2013 Interactions Within Stroke Systems of Care,[10] the 2013 Brain Attack Coalition article on Acute Stroke-Ready Hospitals (ASRHs),[11] and the 2019 update to the SSOC[5] article, which articulated the foundations for the current 4-level SSOC and corresponding certifications. While the exact names for each level of care vary by certifying organization, we used the AHA/ASA terminology, which represents the majority of certified hospitals and the language emerging in local and regional regulations. The 4 levels, ASRH, primary stroke center (PSC), TSC, and CSC, are described in detail elsewhere and summarized in Table 1.[5,10]

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Level of Care: ASRH

An ASRH is typically a smaller facility that is unable to provide the full level of inpatient care available at a PSC. This type of hospital provides the majority of stroke care in rural or isolated suburban areas though few have sought formal certification and most rely heavily on telestroke for emergent stroke expertise and thrombolysis. The roles of an ASRH are to stabilize the patient, provide specific acute stroke care therapies including IV thrombolysis, and arrange timely transportation of patients to the nearest stroke center as determined by the patient's clinical status and further treatment indications. It is anticipated that within any rural region, at least 1 hospital would function as an ASRH and ideally seek formal certification, and EMS should preferentially triage suspected stroke patients to the nearest ASRH in these communities.

Level of Care: PSC

PSCs are typically small- to midsized community hospitals with dedicated inpatient stroke units that care for the majority of stroke patients with typical ischemic strokes who do not require EVT, neurosurgical interventions, or neurocritical care unit level care or who have multisystem disease. Some rural communities may have access to a nearby PSC, but the majority are located in or near suburban or urban areas. PSCs that perform EVT are not currently required to collect and report metrics on these procedures, although it is highly desirable.

Level of Care: TSC

TSCs are hospitals as described above that meet all criteria for PSCs but also provide EVT and must meet the same resource requirements, data collection, and reporting for EVT as CSCs.[12] Unfortunately, most of the newly certified TSCs have appeared in communities with existing access to a CSC, rather than in areas without access to emergent EVT. This poses a challenge to EMS providers when faced with the choice of multiple destinations and to EMS regulators when deciding whether or not to include TSCs in the local destination plans.

Level of Care: CSC

CSCs provide the full suite of services 24/7 for all stroke types including all hemorrhagic strokes.[13] CSCs provide the full complement of stroke neurology, critical care, and neurosurgical personnel and infrastructure to manage the most complex ischemic and hemorrhagic stroke patients. These tertiary and quaternary facilities serve as centralized centers within mature SSOC and leverage the known volume-outcome relationships in cerebrovascular disease.[14] It remains unknown what impact the new TSC designation will have on thrombectomy experience at the proposed TSCs and currently certified CSCs. Although the total number of LVO cases is expected to increase, insufficient total cases per hospital may dilute local hospital and provider experience and adversely affect patient outcomes because a higher volume of cases is well known to be associated with improved performance.[15,16]

Estimates from ≈1250 PSCs and 250 CSCs that are formally certified and participate in national stroke QI programs suggest that initiatives focused on improving thrombolysis rates and reducing door-to-needle times (eg, AHA/ASA Target: Stroke and CDC Paul Coverdell National Acute Stroke Registry) have increased IV alteplase use to 8% to 15% of US patients hospitalized with AIS.[17,18] In 2011, 81% of US residents could access a thrombolysis-capable stroke hospital (Figure 2) within 60 minutes by ground and 56% could access an EVT-capable center within 60 minutes by ground and 83% by ground or air.[19]

Table 1. Levels and Capabilities of Hospital Stroke Certifications

Characteristics	ASRH	PSC	TSC	CSC
Location	Typically rural	Often urban/suburban	Often urban/suburban	Typically urban
Stroke team accessible/available 24/7	Yes	Yes	Yes	Yes
Noncontrast CT available 24/7	Yes	Yes	Yes	Yes
Advanced imaging available 24/7 (eg, CTA/CTP/MRI/MRA/MRP)	No	Possibly	Yes	Yes
Intravenous thrombolysis capable 24/7	Yes	Yes	Yes	Yes
Thrombectomy capable 24/7	No	Possibly	Yes	Yes
Diagnose stroke etiology and manage poststroke complications	Unlikely	Yes, routine	Yes, complex	Yes, complex
Admit hemorrhagic stroke	No	Possibly	Possibly	Yes
Clip/coil ruptured intracranial aneurysms	No	Unlikely	Possibly	Yes
Dedicated stroke unit	No	Yes	Yes	Yes
Neurocritical care unit and expertise	No	Possibly	Possibly*	Yes
Clinical stroke research performed	Unlikely	Possibly	Possibly	Yes

Source: American Heart Association, Inc.[5] ASRH indicates acute stroke-ready hospital; CSC, comprehensive stroke center; CT, computed tomography; CTA, computed tomography angiography; CTP, computed tomography perfusion; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; MRP, magnetic resonance perfusion; PSC, primary stroke center; and TSC, thrombectomy-capable stroke center.

*Access to neurocritical care expertise required and may be provided by telemedicine.

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However, though the requirements vary between certification programs, there are limitations on the number of sites that could qualify for CSC certification, based on the current and proposed process and infrastructure program elements, as well as minimal annual patient and procedural volumes or specific services (eg, thrombectomy, neurosurgical interventions, and neurointensive care). Ideally, certification would be based on risk-adjusted outcomes rather than the proxy of process and volumes, but the mechanisms to implement this are currently lacking. All stakeholders in SSOC should advocate for the public reporting of patient-centric quality measures from all elements of their SSOC.

It is estimated that roughly 250 US hospitals will be able to achieve CSC certification under current standards. The need for access to EVT outstrips this CSC supply substantially, but it is important that standards for CSCs not be lowered to meet the need for EVT but rather that a TSC standard is developed and implemented that provides all the capacity of a PSC plus the additional elements needed for EVT.[20] Given these limitations, it is critical that communities without ready access to a CSC be provided with alternative methods to rapidly and reliably access high-quality EVT (Table 1).

The JC and AHA/ASA established a certification process for TSC in 2018 to encourage high-performing PSCs that offered EVT but did not meet all the criteria for CSC certification to seek this new certification to perform EVT in a responsible and data-driven manner in regions without ready access to a CSC. The additional TSC requirements must be met on top of the base PSC certification requirements and include the additional standards, data elements, and measures for performing EVT required for CSC but without the CSC requirements related to the care of patients with hemorrhagic stroke. With the efficacy of EVT now proven up to 24 hours since last known well in imaging selected patients and the introduction of TSC, it has become necessary to provide more nuanced guidance to EMS agencies and public health authorities to create feasible, practical, reliable, and sustainable destination plans for prehospital triage of suspected stroke cases in this era of complex assessment and intervention.

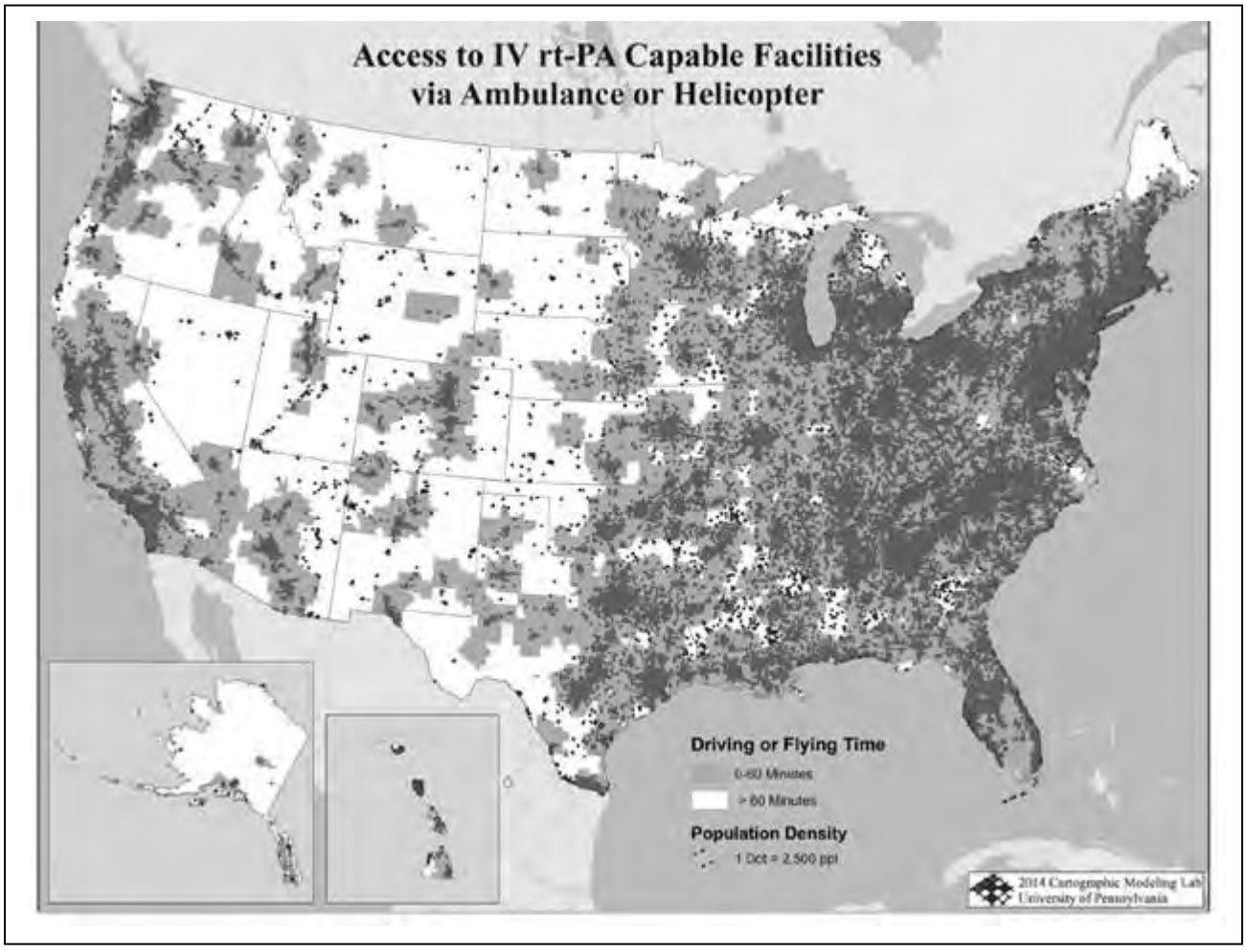

Figure 2. Access to thrombolysis-capable hospitals by ground or air medical transport.
Access by ground or air to intravenous recombinant tissue-type plasminogen activator (IV r-tPA)-capable hospitals within 60 minutes. Reprinted from Adeoye et al19 with permission. Copyright ©2014, the American Heart Association.

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Designation

Within the context of a disease-specific regional system of care, designation typically refers to a hospital recognition process developed at a state or local level with guidance from a multistakeholder advisory committee. State and local governments first establish criteria to categorize hospital capabilities for a specific condition or disease state (eg, adult and pediatric trauma, stroke, and myocardial infarction).[21] Some states independently conduct their own certification programs (eg, stroke certification in New York[22] and Massachusetts[23]), recognize certification by national organizations, or utilize a certification process combining both. Trauma and ST-segment–elevation myocardial infarction systems of care incorporating hospital destination plans have been established and have demonstrated clear benefits of reduced morbidity and mortality,[24–26] with recent data suggesting that independent third-party verification and higher case volumes are associated with improved patient outcomes.[27–29] Before the availability of national certification options, several states were pioneers in developing SSOC, but due to limited resources and an abundance of pressing regulatory issues, these early designation or certification programs lacked many of the critical features of independent certification programs such as robust data collection and monitoring, participation in a national QI registry, and third-party verification. Unlike certification organizations that set the standards for sites to gain certification, states can and should be the governing bodies that regulate the use and content of prehospital stroke algorithms. This includes the detailed requirements for which levels of a multitiered stroke center certification should qualify for a site to become a preferential destination for suspected stroke and the customization of best practice regulatory models to fit their communities based on local and regional hospital performance, patient needs, and resource availability. A minority of states have statewide EMS protocols that are mandatory for agencies to implement, while many more publish voluntary guidelines that may be adopted by individual agencies at their discretion. State and regional EMS oversight committees, through legislative or regulatory authority, should incorporate hospital certification levels into destination plans/protocols that are evidence based or consensus driven to direct EMS destination decisions in the field.[30] This article seeks to assist regulatory agencies in crafting regional regulations and destination plans for regional SSOC focused on scene triage. While the timely and reliable execution of interfacility transport is another important topic in acute stroke care and EMS transport, the details of performing interfacility transport and defining the appropriate destination for patients with acute stroke was not in scope for this article on consensus-based recommendations for prehospital triage.

METHODS

At the in-person meeting, the organizing committee began by outlining the current state of stroke care, reviewing pertinent literature, and discussing developments that are expected in the near future. A broad discussion among all attendees was held on the differing needs of each type of community. There was consensus on the need for regional customization of SSOC to address differences in resources, geography, and population density and to educate providers on new models of AIS care, particularly thrombectomy, and how they impact the SSOC.

The committee created 3 working groups to focus on AIS care, based on community characteristics, defined as rural, suburban, and urban areas, to serve as consensus development panels.[31] The individual panels met during the conference to discuss their particular community, the unique challenges faced, and potential solutions. All conference attendees reconvened, and each panel provided a report on their discussions.

After the in-person conference, the working groups continued the consensus process remotely, developing multiple iterations of the written recommendations by circulation among the members. A final comprehensive set of recommendations was formulated, which served as the draft work product of the conference and was circulated for review by all participating committee members for comment and feedback. Consensus was achieved among the members during the development of the recommendations, and as such, formal voting on each recommendation was not held. After committee member review and revision of the document, it was sent to all participating organizations for review and consideration for endorsement. Based on organizational feedback, 2 iterative drafts were recirculated incorporating comments from the organizations and for final endorsement consideration.

These recommendations will require updating as new evidence emerges on the benefits of various transport protocols. The opinions expressed in this statement are the views of the authors and the endorsing organizations and not necessarily those of their employers.

Community Classification for SSOC: Urban, Suburban, and Rural

Those tasked with developing and implementing regional SSOC face unique challenges as a function of their regional EMS and health care resources, geography, and population density. The working groups were created to discuss rural, suburban, and urban areas and produce unique summaries and recommendations for SSOC for each geography. There are many competing definitions of what defines urban versus rural communities, from Census Bureau definitions based exclusively on population density to the Federal Office of Rural Health Policy, which incorporates distance to health care facilities, but all rely fundamentally on the US Census Tract definitions of the 10- or 21-level rural-urban commuting area (RUCA) code system.[32] The RUCA codes classify US census tracts using measures of population density, urbanization, and daily commuting.

For this article, we define 3 types of SSOCs based on RUCA codes and time-based access to a stroke center capable of performing EVT, but not all communities will fit perfectly into these categories, and so local adaptions may be necessary.

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- We define a rural SSOC modification as appropriate for a nonmetropolitan region or a metro area region designated by a RUCA code from 4 to 10. These areas generally have low population densities (<50 000 residents), limited local general health care resources, few nearby ASRHs or PSCs, and often no CSCs/TSCs within a 60-minute transport time by ground EMS although they may be reachable by air medical transport.
- We define a suburban SSOC modification as appropriate for larger residential communities adjacent to an urban core, with RUCA codes of 2 to 3. These areas generally have a population density closer to the urban core threshold and may have access to both nearby community hospitals and suburban or urban advanced stroke centers (eg, CSC and TSC) within a 30- to a 60-minute transport time by air or ground EMS. It is in suburban SSOC where there may be the greatest number of destination options and thus the greatest challenges for prehospital decision-making.
- We define an urban SSOC modification as appropriate for a metro region with a RUCA code of 1. These areas generally have high population densities (≥50 000 residents) and abundant health care resources, with access to ≥1 CSCs/TSCs within a 30-minute transport time by ground EMS.

These definitions are overly simplistic by design and are to be used as guiding principles rather than rigid categories. Each regional authority will need to adopt the proposed modifications most representative of their specific circumstances. While many regions will encounter unique obstacles for establishing an appropriate SSOC, they will likely also share many similar challenges in both the prehospital and in-hospital settings. After identifying common themes in rural, suburban, and urban areas, the committee further discussed unique challenges requiring consideration.

RESULTS

The 3 groups identified several important general themes. Many prehospital and in-hospital challenges are widespread, including financial pressures, fragmentation of care, physician and allied health care personnel shortages and burnout, and emergency department (ED) visit volumes that are either too high or too low for high-reliability stroke care. These challenges are compounded by the fact that triage algorithms risk becoming overly complex for such a high-impact but low-frequency event as AIS, which accounts for <5% of all EMS transports, ED visits, or hospital admissions.[33] The working groups identified a set of common principles relevant to all regional SSOC and prehospital stroke triage algorithms.

Common Principles

Regional SSOC

A region-specific SSOC should be developed by all local stakeholders with consideration and integration of all regional stroke resources. Stroke advisory committees should be created and include representatives from all regional EMS services (including air medical transport), EMS medical directors, public safety answering points, hospitals of all certification levels, patient advocacy groups, professional/medical societies, and local and state governments. These advisory committees should also include policymakers to develop and implement feasible local prehospital destination plans for EMS, interhospital collaborations, and discussions tailored to local geography and other available resources such as nearby EVT-capable centers (CSC and TSC). The destination plans should also require data collection and reporting of evidence-based measures (Table 2) with benchmark comparisons to peer organizations and timely performance feedback. Prehospital records, including the National EMS Information System data elements, should be incorporated into stroke registries to enhance total system performance assessment. As new national quality measures become available, they too should be incorporated (http://www.nemsqa.org/completed-quality-measures).

Destination Plans

Ideal destination plans are complex, nuanced, and factor in all available data sources including traffic patterns, site-specific performance data on the frequency of use, and timeliness of guideline-recommended IV thrombolytics and EVT, and their associated clinical outcomes. All EMS agencies providing services within the regional SSOC should be involved in the creation, administration, and auditing of compliance of the destination plan. This will ensure the harmonization of stroke resources (training materials, scales, scores, and protocols) and facilitate mutual aid. However, to be effective in real-world settings, EMS agencies should implement simple and actionable destination plans based upon both time and severity for patients with suspected AIS. Regional destination plans should consider general eligibility for IV thrombolytics and for those patients with suspected LVO within 24 hours of last known well should prioritize a nearby CSC over other centers of lower capability when available within acceptable transport times, expressed in both absolute terms of maximum travel time and additional interval time from the scene to all available stroke centers.[34]

Public Education

All members of the SSOC should be engaged in public education efforts regarding stroke risk factors, warning signs, and symptoms of a stroke (eg, Face Arm Speech Test[35] and Balance, Eyes, Face, Arm, Speech, Time[36]) and the importance of calling 911 for a person experiencing stroke signs and symptoms.

911 Stroke Screening

Public safety answering points (eg, 911 call centers) should utilize specific screening protocols for potential stroke patients and prioritize EMS dispatch at

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Table 2. Examples of Consensus-Based Quality Improvement or Performance Measures for Assessment of the Acute Phase of Stroke Systems of Care

1	911 dispatcher use of suspected stroke algorithms: percentage of confirmed stroke patients transported to a hospital by EMS and in whom stroke dispatch algorithm was used.
2	Identification of suspected strokes: percentage of confirmed stroke patients transported to a hospital by EMS and identified as suspected strokes.
3	Documentation of last known well and symptom discovery times: percentage of confirmed stroke patients transported to a hospital by EMS for whom a last-known-well time or time of discovery of stroke symptoms was documented.
4	Evaluation of blood glucose: percentage of confirmed stroke patients transported to a hospital by EMS for whom blood glucose was evaluated by EMS.
5	Stroke screen performed and reported: percentage of confirmed stroke patients transported to a hospital by EMS for whom a validated regional or national stroke screen tool was used with documentation of the result.
6	Stroke severity score performed and reported: percentage of confirmed stroke patients transported to a hospital by EMS for whom a validated regional or national stroke severity tool was used to identify suspected LVO with documentation of the result.
7	Advanced notification with triage findings: percentage of stroke transports in whom EMS provided a stroke alert prenotification to the receiving hospital and provided additional information about a patient's status.
8	EMS use of regional destination protocol: percentage of stroke transports in whom EMS triaged the patient according to their approved regional triage protocol.
9	On-scene times for suspected stroke: distribution of times for suspected stroke patients transported to a hospital by EMS with a goal for on-scene time ≤15 min.
10	DIDO at the first hospital before transfer: distribution of times for confirmed stroke patients transported to a hospital by EMS who were transferred to a higher level stroke center for time-critical therapy, with a goal for DIDO ≤60 min.
11	Time from EMS first medical contact to stroke alert notification: distribution of times for confirmed stroke patients transported to a hospital by EMS from the time from first medical contact to initiation of stroke alert notification to the receiving hospital.
12	Time from EMS first medical contact to brain imaging: distribution of times for confirmed stroke patients transported to a hospital by EMS from the time from first medical contact to start of first brain imaging.
13	Time from first medical contact to EVT: distribution of times for confirmed stroke patients transported to a hospital by EMS from the time from first medical contact to the first pass of endovascular thrombectomy device.

DIDO indicates door-in door-out; EMS, emergency medical services; EVT, endovascular therapy; and LVO, large vessel occlusion.

the appropriate level for patients screening positive for acute stroke.[37–39] In conjunction with EMS, public safety answering points should utilize QI processes to review screening and dispatch for patients transported by EMS who are suspected of having a stroke and whenever possible, review the final clinical hospital diagnoses. Call takers should have annual stroke education training requirements to maintain knowledge and proficiency.

Integration of Regional EMS Into the SSOC

1. Stroke management protocols, and valid, evidence-based stroke screening tools and severity scales for identifying suspected acute stroke and those potentially due to LVO, should be harmonized across all first responder and EMS agencies in a given geographic region to facilitate training and communication among health care providers.[40,41] Stroke severity tools require further refinement to maximize sensitivity and specificity.
2. EMS agencies should ensure that stroke management education is provided at least yearly and is integrated as a core care competency for their EMS providers. This training should be developed and delivered in conjunction or consultation with the agency's stroke hospitals and local/regional EMS partners.
3. All EMS agencies within a region should adopt, in conjunction with their local, regional, and state EMS and hospital stakeholders, a single, valid, evidence-based stroke screening tool and severity scale for identifying suspected acute stroke and those due to LVO.[40,41]
4. EMS agencies should develop and utilize, in conjunction with their local, regional, and state EMS and hospital stakeholders, stroke destination plans based on stroke hospital locations and capability, anticipated transport times, and patient acuity.[42] The local algorithm should include consideration of air medical transport for longer transport distances.
5. Regional interfacility transport agencies should be trained for the safe and rapid transport of stroke patients, including patients who received thrombolytics or who require consideration for EVT.
6. EMS agencies should develop uniform and integrated prehospital stroke notification protocols with their receiving stroke hospitals. Prehospital notification enables better preparation at the hospital and activation of parallel strategies, such as direct transport of the patient to the computed tomography (CT) scanner by EMS on ED arrival and rapid evaluation of the patient by the emergency physician and stroke team when appropriate.

ED Stroke Expertise

EMS should prioritize hospitals that have ED staff who can assess and treat patients and have immediate access to local and regional stroke expertise either onsite or via telemedicine as required, to ensure rapid IV thrombolysis administration for eligible patients.

Advanced Imaging

For patients with suspected LVO, rapid access to intracranial vessel imaging and interpretation should be available at most initial destination hospitals recommended in

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prehospital triage algorithms. In all regions, ASRHs and PSCs should develop plans to implement noninvasive vessel imaging (eg, CT or magnetic resonance angiography) in selected patients, with rapid interpretation by staff onsite or via teleradiology. These images should be made available for review by regional CSC or TSC stroke team personnel with adjunctive telemedicine if needed to facilitate the selection of patients who may be candidates for thrombectomy. In the future, automated image interpretation of CT angiography and perfusion imaging by artificial intelligence or machine learning–enabled algorithms will likely facilitate further improvements in patient selection for treatment or transfer. The acquisition of CT or magnetic resonance perfusion imaging at ASRHs and PSCs should be considered based on individual patient characteristics or after consultation with the potential EVT receiving facility to minimize door-in-door-out (DIDO) times.

Evidence-Based Inpatient Stroke Care

When options exist, prehospital destination plans and interfacility transport policies should prioritize the transport of patients to a hospital with a dedicated stroke unit for poststroke care unless compelling circumstances favor them being triaged to or remaining at a local hospital without a stroke unit. Patients who receive initial care at an ASRH or basic receiving facility that does not have a stroke unit should generally be transferred to a higher level of stroke care for admission and evaluation.

Coordinated Interfacility Transport

When prehospital severity scores suggest the presence of an LVO, EMS personnel should alert the receiving hospital of the suspected LVO to facilitate subsequent rapid interfacility transport if the initial hospital is not EVT capable. Interfacility transport by ground or air should be rapidly available and integrated into all SSOCs. When options exist, prehospital destination plans and interfacility transport policies should prioritize transport of suspected LVO patients to a hospital with well-defined evaluation and stabilization protocols to minimize DIDO times for patients requiring transfer. It is important that when determining the optimal interfacility transfer destination, hospital personnel weigh the many factors that contribute, such as continuity of care following telestroke consultation, time to thrombectomy for potentially eligible subjects, and patient preference. The transfer destination should reflect a patient-centered decision, and hospital-corporate affiliation per se should not be a driving factor in decision-making.

Rapid Access to Appropriate Level of Care

The regional SSOC should ensure rapid access to the appropriate level of care, during both the prehospital and hospital phases of care. In general, when >1 stroke center is within close proximity from the scene, transport to the highest level of care is preferable, and EMS should generally transport a patient with suspected LVO to the center with the highest level of care available if within acceptable transport times from the scene, subject to certain patient characteristics (eg, refusal by an otherwise competent patient, strong patient preference, or previously expressed limitations on the care that are inconsistent with performing EVT).[43–45] Regional interfacility transport agencies should be trained for the safe and rapid transport of stroke patients, including patients who received thrombolytics or who require consideration for EVT.

Coordinated QI

All participating prehospital agencies should engage in QI programs coordinated with the SSOC as a whole, with an emphasis on dispatch, response, field triage, and transitions of care. Agencies should assess their adherence to recommended prehospital performance goals in acute stroke care.[4]

Required Data Collection and Reporting

States should require standardized data collection and reporting from health care entities and data sharing and transparency consistent with the exceptions to privacy laws governing routine health care operations and QI.[30,46] These systems should include elements from the provision of stroke care from stroke detection and 911 activation through hospital discharge.[47] Clinical outcomes should be used to assess the effectiveness of the regional SSOC. Because no randomized trial data exist to support a definitive recommendation on the acceptable additional time when considering triaging a patient with suspected LVO to a CSC, ongoing research is critical to ensure optimal stroke care. During implementation, EMS systems and personnel will need time to become proficient in the performance, collection, and reporting of stroke screens and severity scores, the capture of relevant time intervals, and the assessment of triaged patients to permit quality assurance activities and case review. The data obtained from regional SSOC implementation and new research findings should be reviewed with members of the regional SSOC advisory committee and used to modify destination plans accordingly.

Variation in Maximum Transport Times Based on Community Classification

As the site of care shifts from sparsely resourced rural areas to suburban and urban communities with increasing numbers of hospital options for transport, the availability of ≥1 nearby advanced-level stroke centers becomes more likely and the impact of long travel times out of the EMS service area lessens. This resource distribution probability is reflected in our maximum total transport time, which is the greatest for rural areas at 60 minutes and is progressively reduced by 15-minute increments for suburban areas to 45 minutes and urban areas to 30 minutes to minimize the likelihood of extensive transport

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times in areas where locally advanced care options exist. These transport times are based, in part, on mathematical models of SSOC in the literature that have identified additional transport times for each region.[48] Of note, the proposed times are meant to serve as starting points for local discussion; regional SSOC authorities may consider unique local circumstances and experiences to modify destination protocols and maximum transport times. In the future, optimal transport times will be determined, in part, by considering specific performance data from the various stroke centers within the SSOC.

Specific Modifications to SSOC Recommendations by Community Classification

Rural Challenges

Prehospital Care

Rural areas frequently are adjacent to >1 county, region, or state and are often served by a single health care facility or hospital with limited health care resources. Rural areas face many challenges in providing optimal stroke care. Rural EMS directors are more likely than their urban counterparts to report problems with recruiting and retaining designated EMS medical directors and personnel, especially for agencies that rely on volunteers, and rural agencies are less likely to implement QI programs or provide continuing education for EMTs and paramedics.[49] Rural EMS providers will encounter stroke patients less frequently than those in busy urban areas, making retention and execution of prehospital stroke protocols and skills more challenging. To be effective, education should be made available via online distribution channels and regional EMS conferences and be part of mandatory state continuing education requirements. In some areas, EMS services may be provided by EMTs or advanced EMTs, rather than paramedics, and these individuals may need additional support to achieve effective stroke recognition and triage. Complexity should be minimized in stroke triage protocols to facilitate uniform and consistent execution by a wide range of personnel. Given the longer scene-to-hospital transport times in rural areas, technologies that provide remote access to stroke expertise in the vehicle either via telehealth or artificial intelligence to assist in diagnosis and triage may be especially beneficial in rural areas.[50] Rural EMS agencies and their medical directors could benefit from ongoing support from regional CSC expertise for regular training and updates in evidence-based prehospital and hospital acute stroke care.

EMS personnel often face a difficult choice of whether to transport a stroke patient to the nearest hospital or to a more advanced center that may be significantly further away, often in the opposite direction. This decision may also include whether or not to activate air medical transport. These triage decisions have multiple implications, for the patient and the service area, because long transport times may involve interstate travel or leave the EMS service area understaffed for other emergencies. Stroke triage for EMS is further complicated, especially in rural areas, if the only nearby small or critical access hospital closes or persists only as a freestanding ED and by the reality that local EMS performs not only scene response but also interfacility transports. This will limit EMS destination options, increase transport times to the next nearest facility, and increase the amount of time that EMS vehicles and personnel are outside their designated service area and unable to respond to other emergencies.[51,52]

Health Care Facilities

Rural hospitals face similar challenges as EMS. They experience low annual volumes of stroke patients, increasing the challenge of retention and efficient and reliable execution of stroke care protocols. Rural hospitals may face financial and personnel shortages to a greater extent than their more urban counterparts. While a stroke coordinator is an essential resource at any stroke center, longevity in the role may be especially important at rural hospitals where they often contribute across a wide array of activities including abstraction, data entry, data monitoring, reporting, QI, and facilitating transitions of care. Institutional support for advancing the education of the stroke coordinator, and recognition of its importance to achieving high-quality stroke care and may enhance satisfaction and reduce burnout in this role. This is another area where regional stroke expertise (such as from an affiliated CSC) can assist with ongoing education and performance improvement.

Access to neurological expertise at the bedside is frequently unavailable at rural hospitals. This problem is exacerbated in the event a stroke patient requires consultation with other specialists, such as cardiologists, who may also be in limited supply. The best inpatient stroke care occurs in the setting of a dedicated stroke unit, yet rural hospitals often do not have the requisite inpatient volume or dedicated nursing and allied health personnel to staff a formal stroke unit. Although telestroke has further expanded access to neurological expertise in underserved areas, challenges remain for rural areas (Figure 2).

Many rural hospitals lack the necessary infrastructure and resources to provide advanced stroke imaging or treatments beyond noncontrast brain CT and IV thrombolysis. However, while many types of advanced brain imaging such as magnetic resonance imaging or contrast-enhanced CT perfusion are not available, CT angiography is increasingly being implemented in rural hospitals with interpretation onsite or via teleradiology.[53] When implemented in a manner that does not significantly increase DIDO times, these CT angiography images should be made available for review by the

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stroke team personnel at the regional CSC or TSC partner with adjunctive telestroke evaluation as needed to facilitate selection of patients who may be candidates for thrombectomy.[54] Regional CSCs should provide ongoing support to rural hospitals to improve local capacity and together develop rapid interfacility transfer protocols that minimize DIDO times and optimize care in the face of these challenges. Given that as many as 75% of suspected strokes due to LVO do not receive EVT when they arrive at the regional CSC/TSC due to the absence of LVO or progression of ischemia, triage strategies should prioritize the principle that all eligible patients receive IV thrombolysis before transfer.[55,56]

Specific Recommendations for Rural SSOCs

1. Rural hospitals should work with area stakeholders to develop prehospital response and destination plans with consideration for long transport times and the potential role of air medical transport. Efforts should prioritize ensuring thrombolysis within 4.5 hours from last known well is locally available for all eligible patients. For those patients with suspected LVO, efficient transport to a thrombectomy-capable center (CSC or TSC) should occur as soon as possible.
2. In rural communities or those where large distances separate stroke centers, patients with suspected LVO should be routed directly to a CSC if the additional transport time beyond the nearest TSC does not exceed 30 minutes and the maximum total transport time from scene to CSC does not exceed 60 minutes. If no CSC is within 60 minutes, then EMS should go directly to a TSC if the additional transport time beyond the nearest PSC or ASRH does not exceed 30 minutes and the maximum total transport time from scene to TSC does not exceed 60 minutes. If no CSC or TSC exists within 60 minutes of total travel time, then EMS should go to the nearest ASRH or PSC. If patients are medically unstable or unsafe for prolonged transport, EMS should follow local protocols to determine appropriate destinations.
3. When no CSC or TSC is available within 60 minutes of ground transport time, SSOC should include air medical transport options, define maximum allowable transport times, and consider implementing advanced brain imaging options at rural community hospitals to identify eligible candidates for EVT to keep the costs and potential harms of overtriage to a minimum during interfacility transfer to a distantly located CSC or TSC. If feasible, these communities should work with surrounding area health care systems to prioritize the development of a regional TSC that is reachable within 60 minutes by ground transport or by air medical transport if needed.
4. EMS destination plans should prioritize rural hospitals (or freestanding EDs if no rural hospital is available) that have formal collaboration agreements with regional CSCs (or TSCs) for access to expert stroke consultation, often via telestroke. Such collaborations can help to determine whether interventions such as thrombectomy or neurosurgical services, or advanced care setting such as a neurocritical care unit, are required for any given patient. Written transfer agreements should be in place, and rural sites should implement QI processes such as Mission: Lifeline Stroke to optimize and monitor DIDO times.
5. EMS providers in rural areas without access to EVT centers within a 60-minute transport time should transport suspected stroke patients to the nearest ASRH or PSC, especially for patients within the IV thrombolysis treatment window.

All rural hospitals should have an identified regional partner for advanced stroke care and a predetermined plan for rapid escalation of care, early notification of the regional partner, and rapid interfacility transfer when needed. Algorithms should include in parallel simultaneous notification of the CSC/TSC that operates in partnership with the rural hospital and activation of the EMS agency that will provide interfacility transport. Interfacility transport should be at the level of ALS or higher when available. If >1 local destination option exists, EMS should preferentially transport patients to the nearest local hospital that has these protocols in place.

1. EMS should bypass a nearby rural hospital and use direct transport to access a higher level of acute care only when per local EMS system acute stroke triage algorithms and restrictions on maximum allowable travel out of the service area. All rural communities should assess their local health care resources and acute stroke triage algorithms and make the modifications necessary to create a sustainable model for optimal health care outcomes that recognizes existing local constraints. Patients with suspected LVO who are beyond thrombolysis windows may require a different destination than those who are early in the ischemic window.
2. EMS destination plans should prioritize rural hospitals that identify and support internal hospital stroke resources, including a dedicated stroke coordinator, and that seek to become certified as an ASRH to track their performance on evidence-based stroke care.
3. Stakeholders should work with regional resources to establish rapid interfacility transport mechanisms for patients requiring EVT or a higher level of acute care. In rural areas, interfacility transfers will likely require local EMS for transport so the impact on service should be considered. Additionally, EMS providers who participate in interfacility transport of stroke

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patients should be trained in postthrombolysis management for those patients requiring interfacility transport, and transport of those patients should occur without delay. Completion of the thrombolysis infusion at the initial hospital should not delay interfacility transport in those potentially eligible for EVT except in exceptional circumstances.

4. EMS destination plans should prioritize rural hospitals that participate in a regional stroke QI program. Delays to definitive care should be carefully examined. All providers in the SSOC should provide feedback to each other about the acute stroke triage algorithms and destination plans including EMS and rural and regional hospital staff. The process improvement should be patient centered and include all steps in the chain of acute stroke care.
5. Stroke centers in rural areas should seek to partner with their regional CSC to provide access to stroke research and QI opportunities when feasible and commensurate with their capabilities.

Suburban Challenges

Prehospital Care

Suburban communities are often served by multiple EMS systems (eg, paid municipal, hospital based, and volunteer) and have multiple possible hospital destinations. Highly specialized hospitals may exist in suburban areas and serve both local suburban and nearby urban communities, while other suburban areas may be served by community hospitals with more limited health care resources. Distance, traffic, and county and state boundaries may all impact destination plans, taking patients to hospitals of different levels of stroke capability. Rapid residential growth in some areas of the country is transforming rural areas into suburban and suburban to urban without the requisite expansion of health care resources. In some major metropolitan areas, large medical centers have relocated from the urban core to densely populated suburbs. In some communities, EVT-capable hospitals have proliferated in dense geographic concentration largely driven by market forces rather than the determination of need, creating overserved and underserved areas in a single region (Figure 3).

Health Care Facility

With higher population densities than rural areas, most suburban hospitals will admit a greater number of stroke patients than rural hospitals. This greater number of admissions may justify a greater degree of dedicated stroke coordinator support and more emphasis on staff stroke education and QI. Most stroke certification programs have explicit requirements for annual stroke education for staff in key areas of the hospital where stroke patients receive care.

EDs at suburban hospitals may also have 24/7 availability of advanced imaging, including CT angiography and perfusion imaging, but despite the ability to perform advanced imaging, there may be delays in obtaining timely image interpretation, which may negatively affect DIDO times for EVT-eligible patients. Efforts should be made to reduce DIDO times and door-to-needle times through participation in national stroke QI programs. Recent data demonstrate that compared with PSCs, CSCs have significantly higher rates of thrombolysis treatment, shorter median door-to-needle times, and more cases treated within 60 minutes of arrival, such that additional transport time to a nearby CSC may still lead to a greater likelihood of thrombolysis and faster onset to thrombolysis times for many patients.[34,57]

Most suburban hospitals do not perform EVT or if they do, lack 24/7 EVT capability; patients treated at hospitals that perform EVT infrequently may experience greater delays in treatment initiation and worse outcomes compared with patients treated at hospitals with higher volumes. Sites performing EVT should strive for 24/7 capability and CSC or TSC certification to allow integration into designation programs.[58] At a minimum, states should require that noncertified centers performing EVT adhere to the common standards for EVT performance, data collection, and reporting for measurement and participate in a national QI program for EVT.

Access to neurocritical care, emergent and elective neurosurgical services, and advanced diagnostics is an important part of the complete care for complex stroke patients, and transfer to a CSC may be indicated for patients even when they are not eligible for thrombolysis or EVT (eg, large-territory ischemic stroke, hemorrhagic stroke, rare causes of stroke, and complex comorbidities). Similarly, the limited availability of onsite stroke and rehabilitation specialists can impact patient outcomes when stroke patients are admitted to facilities that lack these services.[59] Many factors such as low volumes of stroke patients, high costs of certification, and proximity to other certified stroke centers may discourage some suburban hospitals from seeking stroke center certification. Regardless of capabilities and certifications, however, all providers should receive ongoing education and training in the triage and management of stroke patients.

Specific Recommendations for Suburban SSOCs

1. Like all geographic regions, suburban communities should establish an SSOC to maximize treatment opportunities for patients eligible for reperfusion strategies. In suburban communities with >1 destination option, patients with suspected LVO should be routed directly to a CSC if the additional transport time past the nearest TSC does not exceed 30 minutes and the maximum total transport time from scene to CSC does not exceed 45 minutes. If no CSC is within 45 minutes, then EMS should go directly to a TSC if the additional transport time past the nearest PSC or ASRH does not exceed 30

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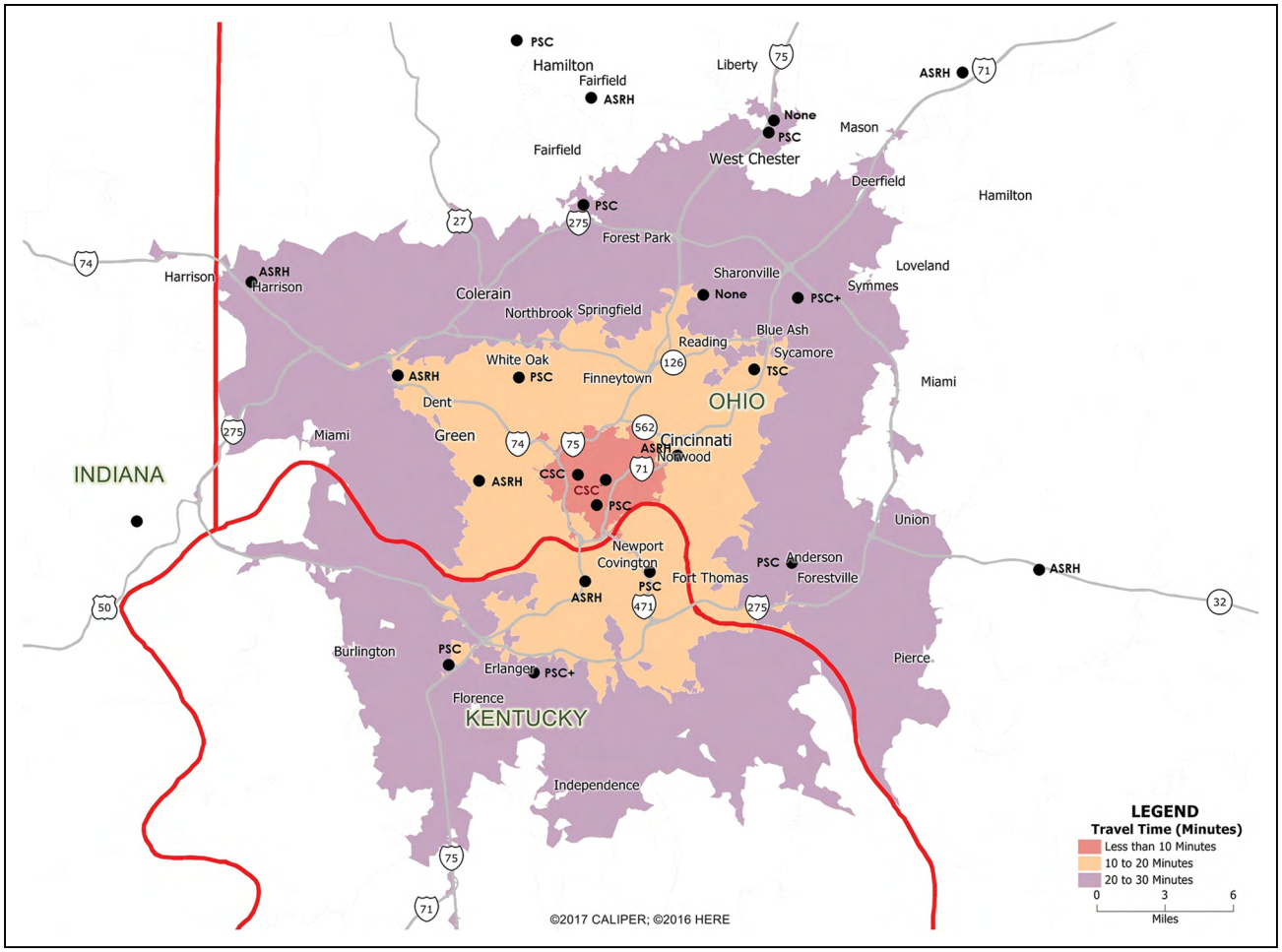

Figure 3. Example of a current regional stroke system of care showing the density and distribution of endovascular therapy–capable centers (comprehensive stroke center [CSC] and thrombectomy-capable stroke center [TSC]) in adjacent urban and suburban areas.

ASRH indicates acute stroke-ready hospital; and PSC, primary stroke center.

minutes and the maximum total transport time from scene to a TSC does not exceed 45 minutes. If no CSC or TSC exists within 45 minutes of total travel time, then EMS should go to the nearest ASRH or PSC. If patients are medically unstable or unsafe for prolonged transport, EMS should follow local protocols to determine the most appropriate destination. Triage algorithms should include in parallel simultaneous notification of a CSC/TSC that collaborates with the hospital, and activation of the EMS agency that will provide interfacility transport.

2. All suburban hospitals should have established protocols in place to rapidly and efficiently care for stroke patients, whether or not they chose to seek certification. This should include the administration of thrombolysis when indicated and the rapid assessment and transfer of patients eligible for EVT to CSCs or TCSs when indicated if not locally available.
3. If the suburban hospital is a certified PSC, then it is appropriate for most stroke patients to be admitted for poststroke care. Inpatient management of some complex stroke patients may require transfer to a CSC or TSC based on the stroke type and severity and availability of specialist consultation. Protocols for rapid transfer of patients requiring a higher level of care should be established within the regional SSOC. All hospitals should participate in a national stroke QI program.
4. Hospitals should have recurring stroke education for their staff and QI programs to optimize patient care processes, especially the ability to minimize DIDO time for patients needing transfer for EVT.
5. EMS providers in suburban areas without access to EVT centers within 45 minutes of transport time should transport suspected stroke patients to the nearest ASRH or PSC, especially for patients within the IV thrombolysis treatment window since many patients with suspected stroke due to LVO may not be candidates for EVT after evaluation. All suburban hospitals should have an identified regional partner for advanced stroke care and a

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predetermined plan for rapid escalation of care, early notification of the regional partner, and rapid interfacility transfer when needed. Algorithms should include in parallel simultaneous notification of the CSC/TSC that operates in partnership with the suburban hospital and activation of the EMS agency that will provide interfacility transport. If >1 local destination option exists, EMS should preferentially transport patients to the nearest local hospital that has these protocols in place.

6. EMS destination protocols should prioritize suburban hospitals that participate in a regional stroke QI program. Delays to definitive care should be carefully examined. All providers in the SSOC should provide feedback to each other about the acute stroke triage and transport process including EMS, rural hospital, and regional hospital staff. The process improvement should be patient centered and include all steps in the chain of acute stroke care.
7. PSCs, TSCs, and CSCs in suburban areas should seek to partner with their regional CSC to provide access to stroke research and QI opportunities when feasible and commensurate with their capabilities.

Urban Challenges

Prehospital Care

Urban areas represent the most densely populated areas of the country. The borough of Manhattan in New York City alone has a population density of over 72 000 people per square mile. The challenge in the United States and globally is the increasing proportion of the population living in dense urban areas; over 80% of the US population now inhabits urban areas, and this percentage continues to grow. In urban areas, prehospital care services are provided by local municipalities and private EMS services owned and operated directly by health care systems. Urban health care settings provide access to the entire spectrum of specialists and services. In large cities, several large, tertiary care health care facilities with CSC certification serve the local population, often within miles of one another and in direct competition, while other areas of the urban core may be left without ready access to EVT services (Figure 4).[60]

Prehospital providers serving urban areas face many unique challenges. Urban areas often have large, diverse ethnic populations where language and cultural barriers may interfere with the timely use of 911 services, delay access to EMS, and the early diagnosis of stroke.[61] The logistics of effective triage and transportation within a crowded urban environment that includes vertical housing structures and massive traffic congestion are significant barriers for EMS access and transport of stroke patients. Further complicating urban triage is the emergence of mobile stroke units (MSUs), often owned and operated by private health care systems rather than EMS agencies. First introduced in Germany and later in the United States, the typical MSU is simultaneously dispatched to the scene of a potential stroke or meets EMS transports midway.[62] An MSU is equipped with all the necessary infrastructure and personnel necessary for diagnosing acute ischemic or hemorrhagic strokes and initiating IV thrombolysis. Definitive data do not yet exist for demonstrating cost-effectiveness or improved patient outcomes with the use of MSU, and the impact on the SSOC is not well understood. Depending on the diagnosis, the MSU or another EMS service can triage and transport to the most appropriate facility.

Health Care Facilities

As of 2019, there are ≈250 CSCs and 50 TSCs certified in the United States, with most of these situated in urban metropolitan locations. Geographic information system visualizations of CSC and TSC locations are available from third-party organizations. Additionally, ≈33% of PSCs self-report performing some EVT annually and currently in the United States, ≈56% and 85% of patients having access to an endovascular-capable hospital within 60 minutes, by ground or air, respectively.[19] As certified CSCs and TSCs continue to expand in urban centers and PSCs enhance their EVT capabilities, the availability of advanced ischemic stroke care is increasing. However, geographic oversaturation of facilities in a defined region may dilute patient volumes and reduce operator competency, while oversaturation of low complexity stroke patients at CSCs can create overcrowding, increased cost, and decreased access for complex cases truly requiring CSC resources. It is worth noting that a concern expressed with the creation of the TSC certification was the development of TSCs within close proximity of established CSCs. As articulated by the JC and AHA in a joint statement, this was not the intent of the new certification program. "In areas without rapid access to a CSC, the TSC certification program provides an important option that EMS providers and state agencies can use to design prehospital triage algorithms and SSOC to optimize access to thrombectomy for patients with suspected LVO." Where available, CSCs remain the destination of choice for patients with suspected LVO. Therefore, prehospital destination plans must strive to route patients to the most appropriate level of care.[5,6]

Specific Recommendations for Urban SSOCs

1. EMS agencies should implement simplified and actionable destination plans that prioritize CSCs over other nearby centers for patients with suspected LVO within 24 hours of last known well.
2. In urban communities with >1 destination option, patients with suspected LVO should be triaged directly to a CSC if the total transport time from scene to CSC does not exceed 30 minutes. If no CSC is within a 30-minute transport time, then EMS should go directly to a TSC if the total transport time from scene to a TSC does not exceed

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Figure 4. Geographic overview of the urban stroke systems of care in Los Angeles County in February 2018 that highlighted several densely populated areas of need that did not have ready access to endovascular therapy from the available comprehensive stroke centers before the implementation of thrombectomy-capable stroke center certification.
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30 minutes. If no TSC or CSC exists within a 30-minute total travel time, then EMS should go to the nearest PSC or ASRH. If patients are medically unstable or unsafe for prolonged transport, EMS should follow local protocols to determine the most appropriate destination. Triage algorithms should include in parallel simultaneous notification of the CSC/TSC that operates in partnership with the destination hospital and activation of the EMS agency that will provide interfacility transport.

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3. Urban communities that have limited health care resources and no CSCs or TSCs within 45 minutes of the majority of scene departures should consider adopting the recommendations for suburban communities.
4. Urban areas are often served by multiple EMS agencies and vehicles, including MSUs, so the integration of all these services into a cohesive SSOC is essential. Triage algorithms and destination plans should follow patient-centric protocols and not be dictated by EMS or MSU ownership affiliations.
5. Urban tertiary care facilities within an SSOC should serve as a source for exporting best practices, assist referring hospitals with in-house and transfer protocols, and provide overall continuing education opportunities for regional partners.
6. Urban tertiary care facilities within an SSOC should provide patient-specific and systems-level feedback to patient referral sites as part of ongoing QI projects.
7. Stroke experts, typically found at CSCs in urban areas, should be included in local/state departments of health and governmental organization efforts to create legislative or regulatory priorities for stroke care and the enabling regulations for tiered SSOC.
8. PSCs, TSCs, and CSCs in urban centers should provide access to clinical trial opportunities for patients with stroke commensurate with their capabilities.

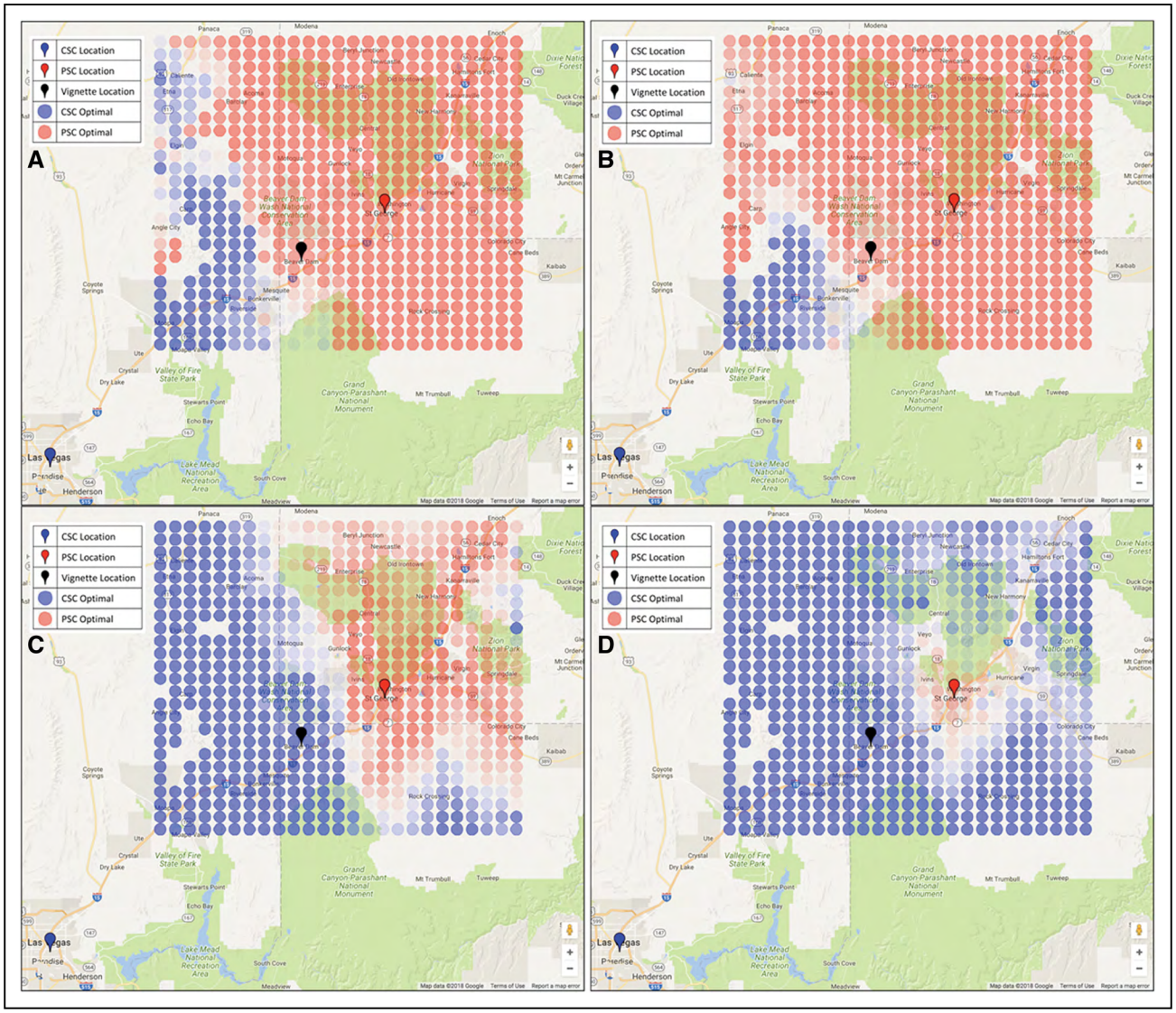

Figure 5. Simulation and decision modeling demonstrate that variation in the optimal destination in adjacent urban and suburban stroke systems of care is highly dependent on patient characteristics and traffic congestion.
Optimal triage strategies for a 65-y-old woman 10 min from symptom onset with rapid arterial occlusion evaluation (RACE) 3 (**A**) and RACE 8 (**C**) and 70 min from symptom onset with RACE 3 (**B**) and RACE 8 (**D**). Red circles indicate primary stroke center (PSC) is optimal, and blue circles indicate comprehensive stroke center (CSC) is optimal. More lightly shaded locations indicate less certainty in the optimal destination. Map data are provided by Google. Reprinted from Ali et al[65] with permission. Copyright ©2018, the American Heart Association.

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Limitations

Due to the expediency of the conference organization, there were some limitations to the process. Given the multitude of important stakeholders in SSOCs, further discussions and engagement should include additional national and regional partners as appropriate (eg, National Highway Traffic Safety Administration, Health Resources and Services Administration Federal Office of Rural Health Policy, and Trauma/EMS Systems). While this conference occurred at the International Stroke Conference, attendees were solely from the United States. Given the global importance of stroke, and the commonality of issues related to SSOCs, the considerations noted in this article are applicable broadly, and future conferences should include global partners.[63]

A formal systematic literature search was not performed before the meeting due to the lack of high-quality evidence to guide modifications in suburban and rural environments. Meta-analyses and statistical analyses were not applied to the limited available data. A formal definition of consensus was not established a priori; however, all participants had multiple opportunities to review all materials in development and provide feedback and criticism. Similarly, every endorsing organization had the opportunity to review and approve the recommendations. Nearly all participating organizations provided final endorsement or support of this article.

CONCLUSIONS

Patients with AIS now have opportunities for emergent reperfusion treatments never before available. SSOCs play a pivotal role in maximizing the opportunities for patients with AIS to receive this optimal care. Stakeholders in each region/state should work together to develop a local SSOC that integrates the various health care resources into the most effective system of care possible. Early stroke recognition, effective triage and transport, and timely and effective hospital- and provider-based stroke treatment are each a critical link in an effective SSOC. Stakeholder collaboration to form an SSOC should be driven by the singular purpose of maximizing stroke outcomes for our patients. In recent years, substantial effort has been invested in prehospital simulation modeling of optimal prehospital triage destinations using decision science, machine learning, and other computational tools (Figure 5).[6,48,64–67] This work, in addition to ongoing clinical trials, will likely provide additional evidence to further refine these tools and point-of-care decision support algorithms to support better evidence-based prehospital triage in the coming years. As new research identifies evidence on which paradigms are most effective for stroke patient care and professional societies endorse these in evidence-based guidelines, these recommendations should be considered a living document and be revised and updated accordingly.

ARTICLE INFORMATION

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REFERENCES

1. Schwamm LH, Pancioli A, Acker JE 3rd, Goldstein LB, Zorowitz RD, Shephard TJ, Moyer P, Gorman M, Johnston SC, Duncan PW, et al; American Stroke Association's Task Force on the Development of Stroke Systems. Recommendations for the establishment of stroke systems of care: recommendations from the American Stroke Association's Task Force on the Development of Stroke Systems. *Circulation*. 2005;111:1078–1091. doi: 10.1161/01.CIR.0000154252.62394.1E
2. Powers WJ, Derdeyn CP, Biller J, Coffey CS, Hoh BL, Jauch EC, Johnston KC, Johnston SC, Khalessi AA, Kidwell CS, et al; American Heart Association Stroke Council. 2015 American Heart Association/American Stroke Association focused update of the 2013 guidelines for the early management of patients with acute ischemic stroke regarding endovascular treatment: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2015;46:3020–3035. doi: 10.1161/STR.0000000000000074
3. Goyal M, Menon BK, van Zwam WH, Dippel DW, Mitchell PJ, Demchuk AM, Dávalos A, Majoie CB, van der Lugt A, de Miquel MA, et al; HERMES Collaborators. Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. *Lancet*. 2016;387:1723–1731. doi: 10.1016/S0140-6736(16)00163-X

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4. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2019;50:e344–e418. doi: 10.1161/STR.0000000000000211
5. Adeoye O, Nyström KV, Yavagal DR, Luciano J, Nogueira RG, Zorowitz RD, Khalessi AA, Bushnell C, Barsan WG, Panagos P, et al. Recommendations for the establishment of stroke systems of care: a 2019 update. *Stroke*. 2019;50:e187–e210. doi: 10.1161/STR.0000000000000173
6. Harrington RA. Prehospital phase of acute stroke care: guideline and policy considerations as science and evidence rapidly evolve. *Stroke*. 2019;50:1637–1639. doi: 10.1161/STROKEAHA.119.025584
7. Jauch EC, Cucchiara B, Adeoye O, Meurer W, Brice J, Chan YYF, Gentile N, Hazinski MF. Part 11: adult stroke: 2010 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*. 2010;122:S818–828.
8. Alberts MJ, Hademenos G, Latchaw RE, Jagoda A, Marler JR, Mayberg MR, Starke RD, Todd HW, Viste KM, Girgus M, et al. Recommendations for the establishment of primary stroke centers. Brain Attack Coalition. *JAMA*. 2000;283:3102–3109. doi: 10.1001/jama.283.23.3102
9. Proceedings of a National Symposium on Improving the Chain of Recovery for Acute Stroke in Your Community. National Institute of Neurological Disorders and Stroke. September 2003, NIH Publication No. 03-5348.
10. Higashida R, Alberts MJ, Alexander DN, Crocco TJ, Demaerschalk BM, Derdeyn CP, Goldstein LB, Jauch EC, Mayer SA, Meltzer NM, et al; American Heart Association Advocacy Coordinating Committee. Interactions within stroke systems of care: a policy statement from the American Heart Association/American Stroke Association. *Stroke*. 2013;44:2961–2984. doi: 10.1161/STR.0b013e3182a6d2b2
11. Alberts MJ, Wechsler LR, Jensen ME, Latchaw RE, Crocco TJ, George MG, Baranski J, Bass RR, Ruff RL, Huang J, et al. Formation and function of acute stroke-ready hospitals within a stroke system of care recommendations from the brain attack coalition. *Stroke*. 2013;44:3382–3393. doi: 10.1161/STROKEAHA.113.002285
12. The Joint Commission. Joint Commission Thrombectomy-Capable Stroke Center Certification. 2017. Accessed December 21, 2020. https://www.jointcommission.org/accreditation-and-certification/certification/certifications-by-setting/hospital-certifications/stroke-certification/advanced-stroke/thrombectomy-capable-stroke-center/
13. Alberts MJ, Latchaw RE, Selman WR, Shephard T, Hadley MN, Brass LM, Koroshetz W, Marler JR, Booss J, Zorowitz RD, et al; Brain Attack Coalition. Recommendations for comprehensive stroke centers: a consensus statement from the Brain Attack Coalition. *Stroke*. 2005;36:1597–1616. doi: 10.1161/01.STR.0000170622.07210.b4
14. Leifer D, Bravata DM, Connors JJ 3rd, Hinchey JA, Jauch EC, Johnston SC, Latchaw R, Likosky W, Ogilvy C, Qureshi AI, et al; American Heart Association Special Writing Group of the Stroke Council; Atherosclerotic Peripheral Vascular Disease Working Group; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular Nursing. Metrics for measuring quality of care in comprehensive stroke centers: detailed follow-up to Brain Attack Coalition comprehensive stroke center recommendations: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2011;42:849–877. doi: 10.1161/STR.0b013e318208eb99
15. Gupta R, Horev A, Nguyen T, Gandhi D, Wisco D, Glenn BA, Tayal AH, Ludwig B, Terry JB, Gershon RY, et al. Higher volume endovascular stroke centers have faster times to treatment, higher reperfusion rates and higher rates of good clinical outcomes. *J Neurointerv Surg*. 2013;5:294–297. doi: 10.1136/neurintsurg-2011-010245
16. Kim BM, Baek JH, Heo JH, Kim DJ, Nam HS, Kim YD. Effect of cumulative case volume on procedural and clinical outcomes in endovascular thrombectomy. *Stroke*. 2019;50:1178–1183. doi: 10.1161/STROKEAHA.119.024986
17. Fonarow GC, Zhao X, Smith EE, Saver JL, Reeves MJ, Bhatt DL, Xian Y, Hernandez AF, Peterson ED, Schwamm LH. Door-to-needle times for tissue plasminogen activator administration and clinical outcomes in acute ischemic stroke before and after a quality improvement initiative. *JAMA*. 2014;311:1632–1640. doi: 10.1001/jama.2014.3203
18. Tong X, Wiltz JL, George MG, Odom EC, Coleman King SM, Chang T, Yin X, Merritt RK; Paul Coverdell National Acute Stroke Program Team. A decade of improvement in door-to-needle time among acute ischemic stroke patients, 2008 to 2017. *Circ Cardiovasc Qual Outcomes*. 2018;11:e004981. doi: 10.1161/CIRCOUTCOMES.118.004981
19. Adeoye O, Albright KC, Carr BG, Wolff C, Mullen MT, Abruzzo T, Ringer A, Khatri P, Branas C, Kleindorfer D. Geographic access to acute stroke care in the United States. *Stroke*. 2014;45:3019–3024. doi: 10.1161/STROKEAHA.114.006293
20. Grigoryan M, Chaudhry SA, Hassan AE, Suri FK, Qureshi AI. Neurointerventional procedural volume per hospital in United States: implications for comprehensive stroke center designation. *Stroke*. 2012;43:1309–1314. doi: 10.1161/STROKEAHA.111.636076
21. Designated Trauma Centers. North Carolina Division of Health Service Regulation. Office of Emergency Medical Services. Accessed December 24, 2020. https://info.ncdhhs.gov/dhsr/ems/trauma/traumacenter.html
22. Gropen TI, Gagliano PJ, Blake CA, Sacco RL, Kwiatkowski T, Richmond NJ, Leifer D, Libman R, Azhar S, Daley MB; NYSDOH Stroke Center Designation Project Workgroup. Quality improvement in acute stroke: the New York State Stroke Center Designation Project. *Neurology*. 2006;67:88–93. doi: 10.1212/01.wnl.0000223622.13641.6d
23. Smith EE, Dreyer P, Prvu-Bettger J, Abdullah AR, Palmeri G, Goyette L, McElligott C, Schwamm LH. Stroke center designation can be achieved by small hospitals: the Massachusetts experience. *Crit Pathw Cardiol*. 2008;7:173–177. doi: 10.1097/HPC.0b013e318184e2bc
24. Ting HH, Rihal CS, Gersh BJ, Haro LH, Bjerke CM, Lennon RJ, Lim CC, Bresnahan JF, Jaffe AS, Holmes DR, et al. Regional systems of care to optimize timeliness of reperfusion therapy for ST-elevation myocardial infarction: the Mayo Clinic STEMI Protocol. *Circulation*. 2007;116:729–736. doi: 10.1161/CIRCULATIONAHA.107.699934
25. Holmes DR Jr, Bell MR, Gersh BJ, Rihal CS, Haro LH, Bjerke CM, Lennon RJ, Lim CC, Ting HH. Systems of care to improve timeliness of reperfusion therapy for ST-segment elevation myocardial infarction during off hours: the Mayo Clinic STEMI protocol. *JACC Cardiovasc Interv*. 2008;1:88–96. doi: 10.1016/j.jcin.2007.10.002
26. Grossman MD, Yelon JA, Szydiak L. Effect of American College of Surgeons Trauma Center Designation on outcomes: measurable benefit at the extremes of age and injury. *J Am Coll Surg*. 2017;225:194–199. doi: 10.1016/j.jamcollsurg.2017.04.034
27. Nathens AB, Jurkovich GJ, Maier RV, Grossman DC, MacKenzie EJ, Moore M, Rivara FP. Relationship between trauma center volume and outcomes. *JAMA*. 2001;285:1164–1171. doi: 10.1001/jama.285.9.1164
28. Brown JB, Rosengart MR, Kahn JM, Mohan D, Zuckerbraun BS, Billiar TR, Peitzman AB, Angus DC, Sperry JL. Impact of volume change over time on trauma mortality in the United States. *Ann Surg*. 2017;266:173–178. doi: 10.1097/SLA.0000000000001838
29. Kumbhani DJ, Cannon CP, Fonarow GC, Liang L, Askari AT, Peacock WF, Peterson ED, Bhatt DL; Get With the Guidelines Steering Committee and Investigators. Association of hospital primary angioplasty volume in ST-segment elevation myocardial infarction with quality and outcomes. *JAMA*. 2009;302:2207–2213. doi: 10.1001/jama.2009.1715
30. Centers for Disease Control and Prevention. Stroke Systems of Care: Policy Evidence Assessment Reports (PEARs). Accessed December 24, 2020. https://www.cdc.gov/dhdsp/pubs/stroke_pear.htm
31. Waggoner J, Carline JD, Durning SJ. Is there a consensus on consensus methodology? Descriptions and recommendations for future consensus research. *Acad Med*. 2016;91:663–668. doi: 10.1097/ACM.0000000000001092
32. United States Department of Agriculture. 2010 Rural-Urban Commuting Area (RUCA) Codes. Accessed December 24, 2020. https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes.aspx
33. Rui P, Kang K. National Hospital Ambulatory Medical Care Survey: 2015 Emergency Department Summary Tables. http://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2015_ed_web_tables.pdf.
34. Saver JL, Goyal M, van der Lugt A, Menon BK, Majoie CB, Dippel DW, Campbell BC, Nogueira RG, Demchuk AM, Tomasello A, et al; HERMES Collaborators. Time to treatment with endovascular thrombectomy and outcomes from ischemic stroke: a meta-analysis. *JAMA*. 2016;316:1279–1288. doi: 10.1001/jama.2016.13647
35. Nor AM, McAllister C, Louw SJ, Dyker AG, Davis M, Jenkinson D, Ford GA. Agreement between ambulance paramedic- and physician-recorded neurological signs with Face Arm Speech Test (FAST) in acute stroke patients. *Stroke*. 2004;35:1355–1359. doi: 10.1161/01.STR.0000128529.63156.c5
36. Aroor S, Singh R, Goldstein LB. BE-FAST (Balance, Eyes, Face, Arm, Speech, Time): reducing the proportion of strokes missed using the FAST mnemonic. *Stroke*. 2017;48:479–481. doi: 10.1161/STROKEAHA.116.015169
37. Buck BH, Starkman S, Eckstein M, Kidwell CS, Haines J, Huang R, Colby D, Saver JL. Dispatcher recognition of stroke using the National Academy Medical Priority Dispatch System. *Stroke*. 2009;40:2027–2030. doi: 10.1161/STROKEAHA.108.545574

Downloaded from http://ahajournals.org by on June 20, 2024

38. Oostema JA, Carle T, Talia N, Reeves M. Dispatcher stroke recognition using a stroke screening tool: a systematic review. *Cerebrovasc Dis*. 2016;42:370–377. doi: 10.1159/000447459
39. Krebes S, Ebinger M, Baumann AM, Kellner PA, Rozanski M, Doepp F, Sobesky J, Gensecke T, Leidel BA, Malzahn U, et al. Development and validation of a dispatcher identification algorithm for stroke emergencies. *Stroke*. 2012;43:776–781. doi: 10.1161/STROKEAHA.111.634980
40. Vidale S, Agostoni E. Prehospital stroke scales and large vessel occlusion: a systematic review. *Acta Neurol Scand*. 2018;138:24–31. doi: 10.1111/ane.12908
41. Krebs W, Sharkey-Toppen TP, Cheek F, Cortez E, Larrimore A, Keseg D, Panchal AR. Prehospital stroke assessment for large vessel occlusions: a systematic review. *Prehosp Emerg Care*. 2018;22:180–188. doi: 10.1080/10903127.2017.1371263
42. Zhou MH, Kansagra AP. Effect of routing paradigm on patient-centered outcomes in acute ischemic stroke. *J Neurointerv*. 2019;11:762–767.
43. Froehler MT, Saver JL, Zaidat OO, Jahan R, Aziz-Sultan MA, Klucznik RP, Haussen DC, Hellinger FR Jr, Yavagal DR, Yao TL, et al; STRATIS Investigators. Interhospital transfer before thrombectomy is associated with delayed treatment and worse outcome in the STRATIS Registry (Systematic Evaluation of Patients Treated With Neurothrombectomy Devices for Acute Ischemic Stroke). *Circulation*. 2017;136:2311–2321. doi: 10.1161/CIRCULATIONAHA.117.028920
44. Seker F, Bonekamp S, Rode S, Hyrenbach S, Bendszus M, Möhlenbruch MA. Direct admission vs. secondary transfer to a comprehensive stroke center for thrombectomy: retrospective analysis of a regional stroke registry with 2797 patients. *Clin Neuroradiol*. 2020;30:795–800. doi: 10.1007/s00062-019-00842-9
45. Weisenburger-Lile D, Blanc R, Kyheng M, Desilles JP, Labreuche J, Piotin M, Mazighi M, Consoli A, Lapergue B, Gory B; on behalf of the Endovascular Treatment in Ischemic Stroke Investigators. Direct admission versus secondary transfer for acute stroke patients treated with intravenous thrombolysis and thrombectomy: insights from the endovascular treatment in ischemic stroke registry. *Cerebrovasc Dis*. 2019;47:112–120. doi: 10.1159/000499112
46. US Department of Health and Human Services. Permitted Uses and Disclosures: Exchange for Health Care Operations. Accessed December 24, 2020. https://www.healthit.gov/sites/default/files/exchange_health_care_ops.pdf
47. Mission: Lifeline Stroke. American Heart Association. Severity-Based Stroke Triage Algorithm for EMS 2019. Accessed December 24, 2020. https://www.heart.org/en/professional/quality-improvement/mission-lifeline/mission-lifeline-stroke
48. Holodinsky JK, Williamson TS, Demchuk AM, Zhao H, Zhu L, Francis MJ, Goyal M, Hill MD, Kamal N. Modeling stroke patient transport for all patients with suspected large-vessel occlusion. *JAMA Neurol*. 2018;75:1477–1486. doi: 10.1001/jamaneurol.2018.2424
49. Freeman VK, Patterson D, Slifkin RT. Issues in Staffing Emergency Medical Services: A National Survey of Local Rural and Urban EMS Directors. 2008.
50. Bergrath S, Reich A, Rossaint R, Rörtgen D, Gerber J, Fischermann H, Beckers SK, Brokmann JC, Schulz JB, Leber C, et al. Feasibility of prehospital teleconsultation in acute stroke–a pilot study in clinical routine. *PLoS One*. 2012;7:e36796. doi: 10.1371/journal.pone.0036796
51. Kaufman BG, Thomas SR, Randolph RK, Perry JR, Thompson KW, Holmes GM, Pink GH. The rising rate of Rural Hospital Closures. *J Rural Health*. 2016;32:35–43. doi: 10.1111/jrh.12128
52. Shen YC, Hsia RY. Association between emergency department closure and treatment, access, and health outcomes among patients with acute myocardial infarction. *Circulation*. 2016;134:1595–1597. doi: 10.1161/CIRCULATIONAHA.116.025057
53. Menon BK, Campbell BC, Levi C, Goyal M. Role of imaging in current acute ischemic stroke workflow for endovascular therapy. *Stroke*. 2015;46:1453–1461. doi: 10.1161/STROKEAHA.115.009160
54. Al Kasab S, Almallouhi E, Harvey J, Turner N, Debenham E, Caudill J, Holmstedt CA, Switzer JA. Door in door out and transportation times in 2 telestroke networks. *Neurol Clin Pract*. 2019;9:41–47. doi: 10.1212/CPJ.0000000000000570
55. Boulouis G, Siddiqui KA, Lauer A, Charidimou A, Regenhardt RW, Viswanathan A, Leslie-Mazwi TM, Rost N, Schwamm LH. Immediate vascular imaging needed for efficient triage of patients with acute ischemic stroke initially admitted to Nonthrombectomy Centers. *Stroke*. 2017;48:2297–2300. doi: 10.1161/STROKEAHA.117.017607
56. Boulouis G, Lauer A, Siddiqui AK, Charidimou A, Regenhardt RW, Viswanathan A, Rost N, Leslie-Mazwi TM, Schwamm LH. Clinical imaging factors associated with infarct progression in patients with ischemic stroke during transfer for mechanical thrombectomy. *JAMA Neurol*. 2017;74:1361–1367. doi: 10.1001/jamaneurol.2017.2149
57. Man S, Zhao X, Uchino K, Hussain MS, Smith EE, Bhatt DL, Xian Y, Schwamm LH, Shah S, Khan Y, et al. Comparison of acute ischemic stroke care and outcomes between Comprehensive Stroke Centers and Primary Stroke Centers in the United States. *Circ Cardiovasc Qual Outcomes*. 2018;11:e004512. doi: 10.1161/CIRCOUTCOMES.117.004512
58. Saber H, Navi BB, Grotta JC, Kamel H, Bambhroliya A, Vahidy FS, Chen PR, Blackburn S, Savitz SI, McCullough L, et al. Real-world treatment trends in endovascular stroke therapy. *Stroke*. 2019;50:683–689. doi: 10.1161/STROKEAHA.118.023967
59. Foley N, Salter K, Teasell R. Specialized stroke services: a meta-analysis comparing three models of care. *Cerebrovasc Dis*. 2007;23:194–202. doi: 10.1159/000097641
60. The Joint Commission. Expanded Stroke Certification in Los Angeles County Helps Eliminate Geographic Disparities. Accessed December 24, 2020. https://www.jointcommission.org/resources/news-and-multimedia/blogs/leading-hospital-improvement/2018/03/expanded-stroke-certification-in-los-angeles-county-helps-eliminate-geographic-disparities/
61. Eisenstein AR, Song S, Mason M, Kandula NR, Richards C, Aggarwal NT, Prabhakaran SK. A community-partnered approach to inform a culturally relevant health promotion intervention for stroke. *Health Educ Behav*. 2018;45:697–705. doi: 10.1177/1090198117752787
62. Parker SA, Bowry R, Wu TC, Noser EA, Jackson K, Richardson L, Persse D, Grotta JC. Establishing the first mobile stroke unit in the United States. *Stroke*. 2015;46:1384–1391. doi: 10.1161/STROKEAHA.114.007993
63. Rudd AG, Bladin C, Carli P, De Silva DA, Field TS, Jauch EC, Kudenchuk P, Kurz MW, Lærdal T, Ong M, et al. Utstein recommendation for emergency stroke care. *Int J Stroke*. 2020;15:555–564. doi: 10.1177/1747493020915135
64. Bogle BM, Asimos AW, Rosamond WD. Regional evaluation of the severity-based stroke triage algorithm for emergency medical services using discrete event simulation. *Stroke*. 2017;48:2827–2835. doi: 10.1161/STROKEAHA.117.017905
65. Ali A, Zachrison KS, Eschenfeldt PC, Schwamm LH, Hur C. Optimization of prehospital triage of patients with suspected ischemic stroke. *Stroke*. 2018;49:2532–2535. doi: 10.1161/STROKEAHA.118.022041
66. Xu Y, Parikh NS, Jiao B, Willey JZ, Boehme AK, Elkind MSV. Decision analysis model for prehospital triage of patients with acute stroke. *Stroke*. 2019;50:970–977. doi: 10.1161/STROKEAHA.118.023272
67. Schlemm E, Ebinger M, Nolte CH, Endres M, Schlemm L. Optimal transport destination for ischemic stroke patients with unknown vessel status: use of prehospital triage scores. *Stroke*. 2017;48:2184–2191. doi: 10.1161/STROKEAHA.117.017281

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