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DEPT. OF HEALTH AND HUMAN SERVICES

Jim Pillen, Governor

Nebraska State Stroke Task Force Meeting Agenda

Date: January 23rd, 2025

Time:
5:00-7:00 p.m.

Location:
Zoom

For Information Contact:
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Tonja.Bohling@nebraska.gov

All items known at the time of distribution of this agenda are listed. A current agenda is available at the Department of Health and Human Services, Division of Public Health Office of Emergency Health Systems. If auxiliary aids or reasonable accommodations are needed for attendance at a meeting, please call Tonja Bohling at (402) 471-8129 (voice), or for persons who are deaf or hard of hearing, please call the Nebraska Relay System at 711 (TDD), prior to the meeting date. Advance notice of seven days is needed when requesting an interpreter.

2025 Board Meeting Dates:

TBD

Note: Dates are subject to change

1) Call to Order, Roll Call, and Declaration of a Quorum
   Announcement: "This is a public meeting, and the open meetings law is posted."
2) Adoption of Agenda
3) Approval of Minutes:
   a) October 15, 2024 Minutes
4) Strategic planning
5) Future Meeting Dates/Postings Locations
6) Public Comment
7) Call to Adjourn

JOIN ZOOM MEETING LINK:
https://us06web.zoom.us/j/84375524536?pwd=9aNqHeaXZkjS7mYDDXmxIwqaIQhoY9.1

Meeting ID: 843 7552 4536
Passcode: 106980

Nebraska State Stroke Task Force
CY2025 Planning Meeting
Thursday January 23rd
5:00 p.m. -7:00 p.m.

Agenda

- 5:00 – 5:20 SWOT analysis review
- 5:20 – 6:00 State Statute Discussion/Gap analysis of State Stroke Task Force Activity
- 6:00 – 7:00 Identification of Task Force goals/objectives for calendar year 2025
- 7:00 Adjourn

Pre-Meeting Documents

- NE State Stroke Task Force Planning PPT
- Nebraska Stroke Statutes
- Recommendations for Regional Stoke Destination Plans in Rural, Suburban, and Urban Communities from the Prehospital Stroke System of Care *Stroke.* 2021;52:e133–e152. DOI: 10.1161/STROKEAHA.120.033228
- Planning Questions

Support Materials – attached in email

- Recommendations for Regional Stoke Destination Plans in Rural, Suburban, and Urban Communities From the Prehospital Stroke System of Care
- 2023 Heart Disease Fact Sheet Nebraska
- EMS Regional Specialist Map
- Get With the Guidelines Reporting Measures – Includes measure definitions for thrombolysis therapy metrics and time goals
- EMS Mission Lifeline Stroke Measures – includes all prehospital (EMS) measures
- State of Nebraska EMS Guidelines
- EMS Stroke Screening tool utilization data – Q1-2 2024

MINUTES OF THE MEETING
of the NEBRASKA
STROKE TASK FORCE
BOARD

October 15, 2024

CALL TO ORDER

The meeting of the Nebraska State Stroke Task Force Meeting was called to order by Denise Gorski, Board Co-Chairperson, at 5:30pm, Tuesday, October 15, 2024. This meeting was held in the Dodge Room at Madonna Rehabilitation Hospital 17500 Burke Street, Omaha, NE. Copies of the agenda were emailed in advance to the Task Force Board members, interested parties, and posted on the Department of Health and Human Services website.

ROLL CALL

The following board members were present to answer roll call:

- Hanne Beldin
- Amy Goldman
- Denise Gorski
- Mary Ellen Hook
- Dr. Vishal Jani
- Becka Neumiller
- Kristy Weissling

The following Board members were absent: Noah Bernhardson, Brianna Cochran, Nancy Jo Hansen, and Brenda Rhembrandt.

The following staff members from the Department were also present during all or part of the meeting:

- Tonja Bohling
- Tim Wilson

A quorum was present, and the meeting convened. Gorski announced that this is a public meeting and the open public meeting notice had been posted. Due to several new members joining the Task Force, Gorski had each member of the Stroke Task Force gave an introduction telling their name and what agency they represented and how long they had worked in stroke related programs.

ADOPTION OF THE AGENDA

MOTION: Weissling made the motion, seconded by Gorski, to adopt the agenda for the October 15, 2024, State Stroke Task Force meeting.

Voting Yes: Hanne Beldin, Amy Goldman, Denise Gorski, Mary Ellen Hook, Dr. Vishal Jani, Becka Neumiller, Kristy Weissling. Voting No: None. Abstain: None. Absent: Noah Bernhardson, Brianna Cochran, Nancy Jo Hansen, and Brenda Rhembrandt.

Motion carried.

APPROVAL OF THE MINUTES

MOTION: Hook made the motion, seconded by Weissling, to approve the minutes from the July 25, 2024, State Stroke Task Force meeting.

DRAFT

Voting Yes: Hanne Beldin, Amy Goldman, Denise Gorski, Mary Ellen Hook, Dr. Vishal Jani, Becka Neumiller, Kristy Weissling. Voting No: None. Abstain: None. Absent: Noah Bernhardson, Brianna Cochran, Nancy Jo Hansen, and Brenda Rhembrandt.

Motion carried.

AGENDA ITEM: OLD BUSINESS – DHHS FUNDING FOR CRITICAL ACCESS HOSPITAL (CAH) PARTICIPATION IN GWTG STROKE REGISTRY SUSTAINABILITY

Wilson gave an update. The proposal has been sent to Ryan Daly, DHHS Finance, for review.

During the review they will be comparing the cost of using the stroke registry through GWTG vs. using a registry system that already has stroke built into it (ImageTrend).

One main issue with GWTG is that Statute requires hospitals enter data into the registry determined by the State. Thus, this becomes a requirement that the State must enforce. Any facility that is State designated is required to enter data into the registry and if they are not, they risk losing their designation. Non-designated facilities data entered into the registry is the above and beyond data.

Two scenarios: a) if everyone participated = $216,000 and b) sustain what is current = $170,000

The data going into the registry is very robust and Neumiller would have access to the data.

Wilson will follow up with Ryan Daly and follow up with the deputy director letting them know this proposal needs to be approved right away. Next meeting Wilson will have an update.

AGENDA ITEM: AHA/NE DOH CAH Participation in Get With The Guidelines

Tabled to the next meeting.

AGENDA ITEM: Data Measure Reporting/DHHS Data Extraction

Hanne Beldin gave a report on dashboard data (See attachment in agenda packet). The question was asked, what information does the Task Force need? What data do the other committees need to do the work driven by the Task Force? Discussion was held about data collection of volumes, social determinants/demographics, cardiovascular burden, access to post-acute care, door in/door out times, interventional rates, level of care, and discharge disposition (this will be looked at further for the next meeting). Collecting data via regions and defining region areas were discussion points. Collection of data via trauma regions has most benefits. Data should be gathered on a quarterly basis. Data elements to look at for the next meeting are, volumes, ischemic, hemorrhagic, interventional rates, disposition, transfer to higher-level-care data, possibly demographics, and cardiovascular burden. Becoming a Coverdale state was suggested.

AGENDA ITEM: DHHS iEXCEL Collaboration

The Board discussed collaboration and the creation of an online database/repository for the dissemination of training content. Resources would be linked to the DHHS website for wide access to a variety of users, while using the iEXCEL team for streaming, hosting, data capture and management of the system. The last dollar quote given, which was old, was over $20,000 annually to keep that repository. DHHS and the iEXCEL group will hold added discussions and they will put together another proposal to present to the Stroke Task Force in the future.

AGENDA ITEM: PHHS Grant Activities

Neumiller reported on PHHS Grant activities. This year's focus was on women and stroke. All grant monies for the grant cycle were spent. The iEXCEL contract for the 2023-2024 year has built into it two 1-year extensions of $41,000 for each year.

Next year (2024-2025) the focus will be on addressing deficiencies/gaps in training. Approval is for $65,000 and will run from October 1, 2024, through September 30, 2025. $3,000 is earmarked for the National

Stoke Conference. IEXCEL and Evergreen Projects and other conferences are areas being looked at for budget expenditures. She is also looking at spending funding on EMS.

Goldman gave a summary of the Women & Stroke Conference. Total attendance was around 120-130 attendees. They did not have enough registered at the Scottsbluff site, so ended up canceling the session there and offered to have those registered at Scottsbluff attend at Kearney. Many attendees gave positive reviews of the conference. It was very engaging, interactive, and three-dimensional. It was suggested to have more breakout sessions next year.

AGENDA ITEM: Committee Reports

I. Clinical Committee – Gorski gave an update on this committee (see attachment in agenda packet). The Rural Accelerator is being looked at to subsidize smaller centers. This committee has been working on the Door-In/Door-Out Survey. There was a poor response for this survey. The survey will be sent out again in an attempt to get a better response rate. It will go out to all hospitals. The Clinical Committee will make recommendations to the State Task Force on required fields as a state. Neumiller has what she needs to send the survey to all the hospitals.

   Gorski also presented a dashboard with goal percentages data. These goals are established by GWTG benchmarks and reporting measures. The top two areas are the receiving facility (bed availability and capacity at higher levels of care) and transportation. "Wall time" was discussed.

II. Rehab Committee – Goldman gave an update on this committee (see attachment in agenda packet).

Discussion was held about the Shared Folder. Information from the committees needing to go into the shared folder needs to be sent to Wilson. Also, non-board-member committee member names for Rehabilitation Committee and Clinical Committee need to be sent to Tonja Bohling so she can get them added onto the Shared Folder. The EMS Committee will be done by Neumiller.

Also discussed was Committees getting direction from the Task Force and the need to schedule a Task Force Strategic Planning Meeting (see Agenda Item below).

AGENDA ITEM: Task Force Membership

I. Task Force Vacancies are:
   a. EMS Representative
   b. Physician Representative

II. Vacancies Process – positions are appointed by the Department. The Department will post the vacancies in their newsletter and send it to the hospital list. The application is now on the website. NE DHHS (Wilson) will review and appoint from those applications submitted. The goal is for these positions to be filled by the next Task Force meeting in January.

AGENDA ITEM: Executive Committee

Vice Chair Election – No discussion held.

AGENDA ITEM: Strategic Planning Meeting

A Task Force Strategic Planning Meeting was proposed to address policy, public awareness/education, advocacy, rehab, EMS, procedure, committee structure, etc. It was determined to hold the strategic planning meeting in addition to the quarterly Task Force meetings, preferably before the January Task Force meeting. Discussion was held regarding Date/Time/Location, Virtual/In-Person, and whether or not to have a moderator. Participants at the Planning Meeting can include other Committee members or anyone else who may be a partner and able to help plan and give ideas. Official votes at the meeting will only be from Stroke Task Force members.

It was determined Task Force members will work on information gathering and preparation (getting data), then plan for an in-person meeting. A proposed meeting place is Madonna in Lincoln. Gorski and Beldin will gather data and send out a packet with some questions around it.

AGENDA ITEM: Future Meeting Dates/Locations (Proposed, may change during meeting)

The following proposed 2025 meeting dates were submitted to the Stroke Task Force in the Agenda Packet.

January 23, 2025 – Virtual

April 24, 2025 – In-Person

July 24, 2025 – Virtual

October 9, 2025 – In-Person

Next meeting date and time is Thursday, January 23, 2025, from 5:00pm-7:00pm. This will be a virtual meeting.

AGENDA ITEM: Posting of Meeting Notifications

No discussion held.

AGENDA ITEM: Public Comment

None.

CALL TO ADJOURN

There being no further business, the meeting adjourned at approximately 6:57 pm.

Respectfully submitted,

Tonja Bohling
OEHS Administrative Technician

Questions for planning session

Reflecting on the materials shared reflect on the following questions:

1. What drives success or failure for the State Stroke Task Force

2. Does the current (committee) structure of the Task Force aide or hinder the ability to achieve goals? Why?

3. What capabilities or limitations does the Task Force have in its ability to improve stroke systems of care? Be specific and include examples.

4. Using the "Integration of Regional EMS into SSOC" (Jausch et al, p. 9) as a best practice reference to integration of EMS systems, how does Nebraska compare? Where do we excel?

5. How might the Stroke Task force and/or committee structure support improvement in this area?

6. What opportunities exist with rural SSOC (Jausch et al, p. 12-13) and how can the Task Force and/or committee structure support those efforts?

7. Additional thoughts on urban SSOCs?

8. Looking forward into the future, what has the Task Force accomplished and how does the Task Force support the SSOC activities across the state?

Check for updates

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

Edward C. Jauch, MD; Lee H. Schwamm, MD; Peter D. Panagos, MD; Jolene Barbazzeni, RN; Robert Dickson, MD; Robert Dunne, MD; Jenevra Foley, MSL, RHIA, CCP; Justin F. Fraser, MD; Geoffrey Lassers, PMD, AAS; Christian Martin-Gill, MD; Suzanne O'Brien, MSN, BSN, RN; Mark Pinchalk, MS; Shyam Prabhakaran, MD; Christopher T. Richards, MD; Peter Taillac, MD; Albert W. Tsai, PhD; Anil Yallapragada, MD; on behalf of the Prehospital Stroke System of Care Consensus Conference

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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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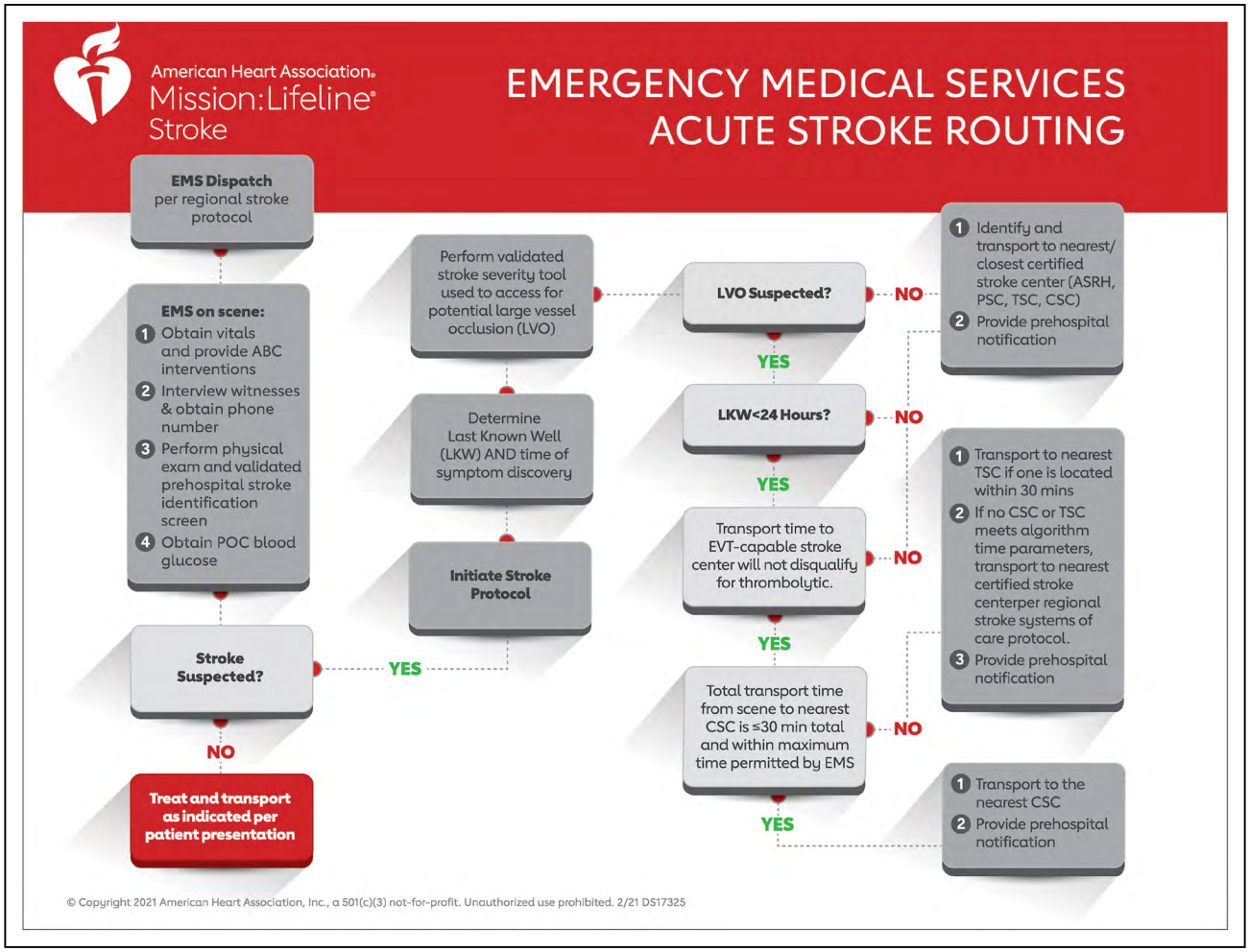

Figure 1. Mission: Lifeline Stroke Emergency Medical Services (EMS) Acute Stroke Routing Algorithm.
ABC indicates airway, breathing and circulation; ASRH, acute stroke-ready hospital; CSC, comprehensive stroke center; EVT, endovascular therapy; LKW, last known well; LVO, large vessel occlusion; POC, 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.

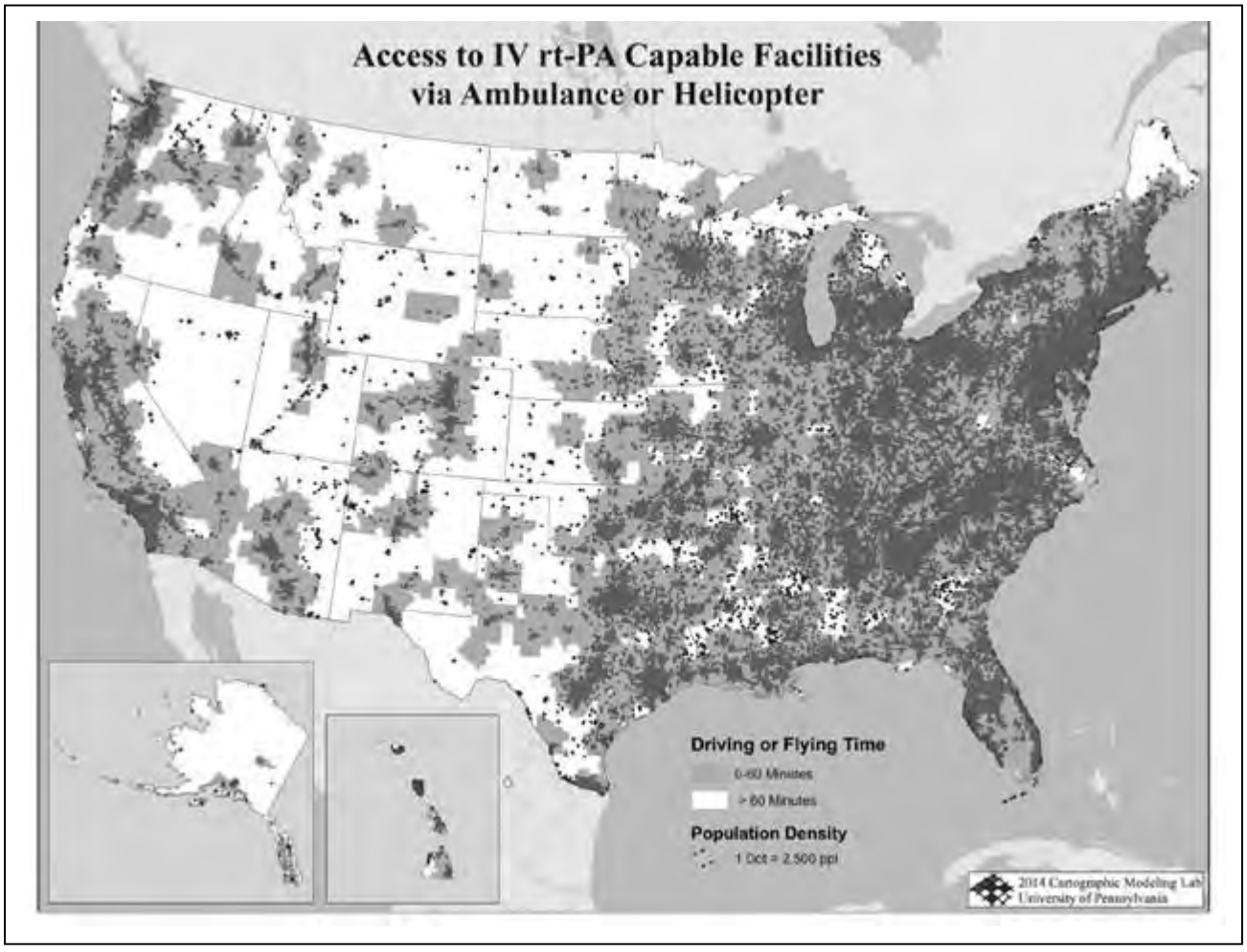

Figure 2. Access to thrombolysis-capable hospitals by ground or air medical transport.
Access by ground or air to intravenous recombinant tissue-type plasminogen activator (IV r-tPA)-capable hospitals within 60 minutes. Reprinted from Adeoye et al19 with permission. Copyright ©2014, the American Heart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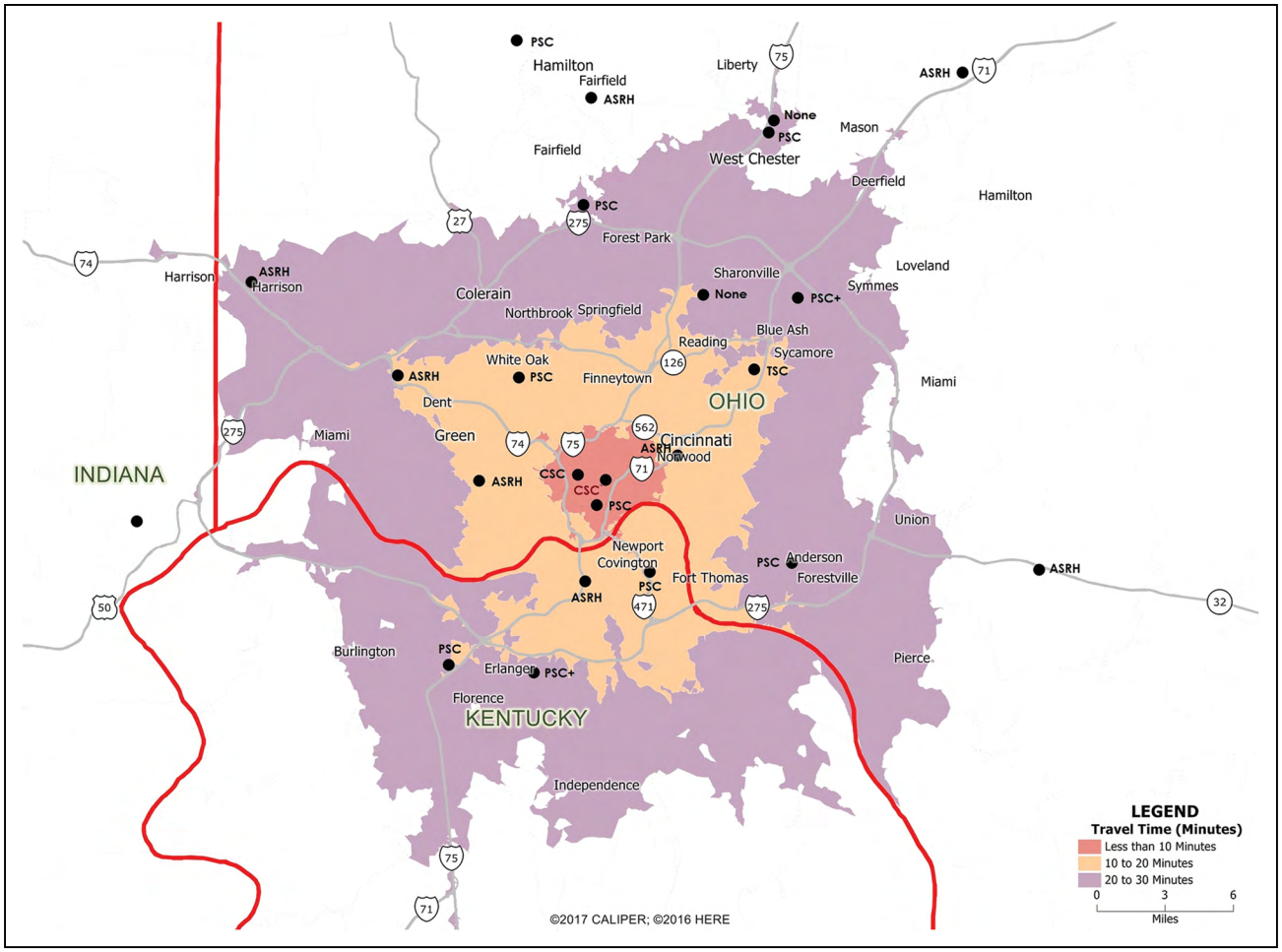

Figure 3. Example of a current regional stroke system of care showing the density and distribution of endovascular therapy–capable centers (comprehensive stroke center [CSC] and thrombectomy-capable stroke center [TSC]) in adjacent urban and suburban areas.

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.

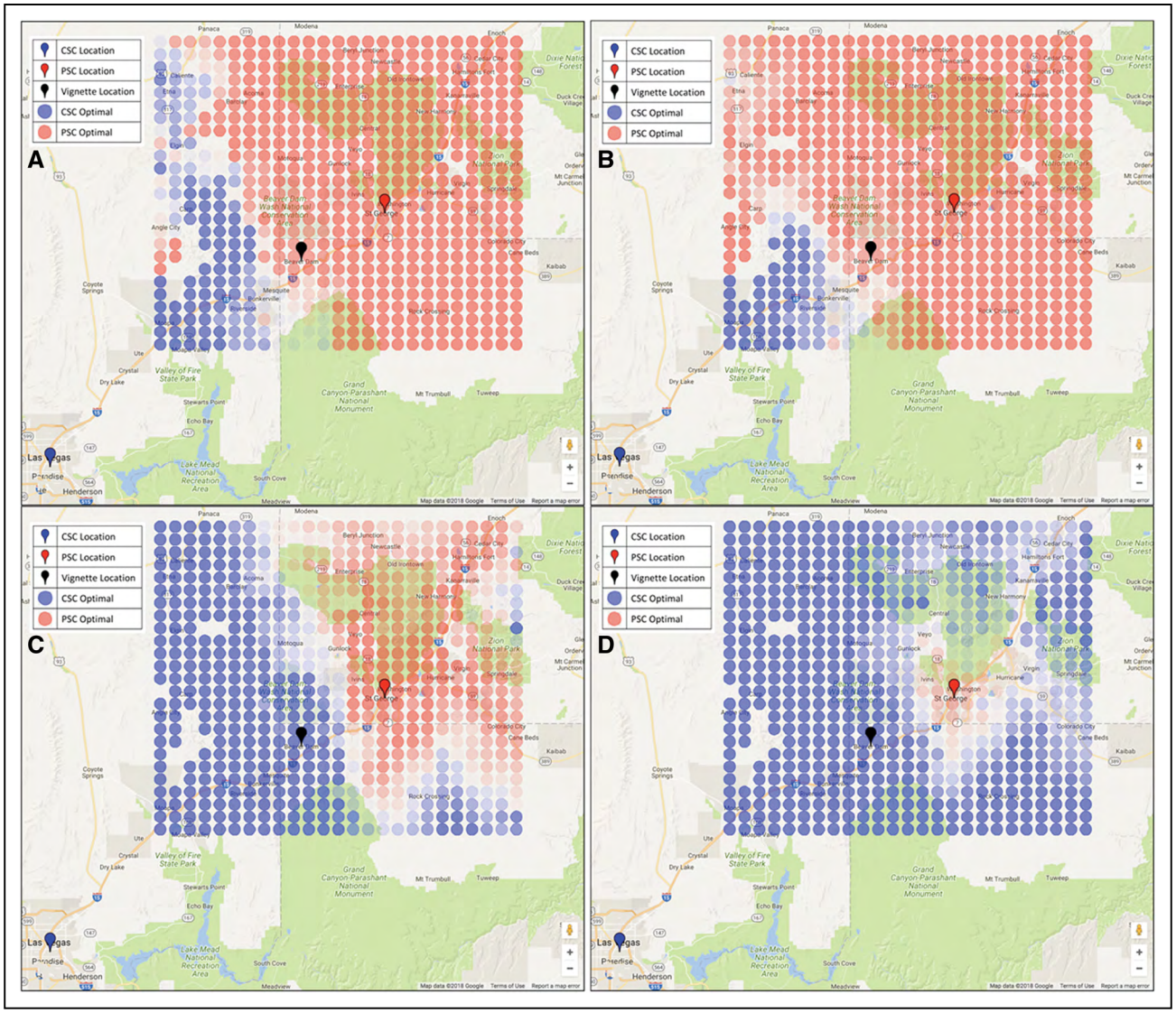

Figure 5. Simulation and decision modeling demonstrate that variation in the optimal destination in adjacent urban and suburban stroke systems of care is highly dependent on patient characteristics and traffic congestion.
Optimal triage strategies for a 65-y-old woman 10 min from symptom onset with rapid 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.

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CLINICAL AND POPULATION SCIENCES

Rural Hospital Performance in Guideline-Recommended Ischemic Stroke Thrombolysis, Secondary Prevention, and Outcomes

Shumei Man, MD, PhD; David Bruckman, MS; Ken Uchino, MD; Bing Yu Chen, MD; Jarrod E. Dalton, PhD; Gregg C. Fonarow, MD

BACKGROUND: Existing data suggested a rural-urban disparity in thrombolytic utilization for ischemic stroke. Here, we examined the use of guideline-recommended stroke care and outcomes in rural hospitals to identify targets for improvement.

METHODS: This retrospective cohort study included patients (aged ≥18 years) treated for acute ischemic stroke at Get With The Guidelines-Stroke hospitals from 2017 to 2019. Multivariable mixed-effect logistic regression was used to compare thrombolysis rates, speed of treatment, secondary stroke prevention metrics, and outcomes after adjusting for patient- and hospital-level characteristics and stroke severity.

RESULTS: Among the 1 127 607 patients admitted to Get With The Guidelines-Stroke hospitals in 2017 to 2019, 692 839 patients met the inclusion criteria. Patients who presented within 4.5 hours were less likely to receive thrombolysis in rural stroke centers compared with urban stroke centers (31.7% versus 43.5%; adjusted odds ratio [aOR], 0.72 [95% CI, 0.68–0.76]) but exceeded rural nonstroke centers (22.1%; aOR, 1.26 [95% CI, 1.15–1.37]). Rural stroke centers were less likely than urban stroke centers to achieve door-to-needle times of ≤45 minutes (33% versus 44.7%; aOR, 0.86 [95% CI, 0.76–0.96]) but more likely than rural nonstroke centers (aOR, 1.24 [95% CI, 1.04–1.49]). For secondary stroke prevention metrics, rural stroke centers were comparable to urban stroke centers but exceeded rural nonstroke centers (aOR of 1.66, 1.94, 2.44, 1.5, and 1.72, for antithrombotics within 48 hours of admission, antithrombotics at discharge, anticoagulation for atrial fibrillation/flutter, statin treatment, and smoking cessation, respectively). In-hospital mortality was similar between rural and urban stroke centers (aOR, 1.11 [95% CI, 0.99–1.24]) or nonstroke centers (aOR, 1.00 [95% CI, 0.84–1.18]).

CONCLUSIONS: Rural hospitals had lower thrombolysis utilization and slower treatment times than urban hospitals. Rural stroke centers provided comparable secondary stroke prevention treatment to urban stroke centers and exceeded rural nonstroke centers. These results reveal important opportunities and specific targets for rural health equity interventions.

GRAPHIC ABSTRACT: A graphic abstract is available for this article.

Key Words: health equity ■ ischemic stroke ■ quality of care ■ rural hospitals ■ thrombolytic therapy

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In the United States, 97% of land is rural, with a population of 66 million.[1] Stroke incidence is 23% to 30% higher in rural areas than in urban areas.[2] Despite the overall improvement in stroke care and decline in stroke mortality over the past decades, rural-urban gaps increased from 2008 to 2017.[2–4] Studies using administrative data have shown that rural patients with stroke, when compared with urban patients, receive less thrombolytic treatment and have higher case fatality.[3,4] The interpretation of administrative data is limited by the inability to account for the time of presentation or to examine modifiable process metrics that may affect

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Nonstandard Abbreviations and Acronyms

AHA	American Heart Association
aOR	adjusted odds ratio
DTN	door-to-needle times
EMS	emergency medical service
GWTG	Get With The Guidelines
NIHSS	National Institutes of Health Stroke Scale

outcomes. It remains unclear whether the rural-urban disparity in thrombolytic utilization was due to rural patients not presenting to the hospital before the 4.5-hour thrombolysis time window or to rural hospitals not providing treatment to eligible patients.

Intravenous thrombolysis improves the outcomes of acute ischemic stroke, but the benefit is time-dependent.[5–8] Door-to-needle (DTN) times are of particular interest for local and national quality initiatives because they are under complete control of the hospital care team. Shorter DTN times are associated with better functional outcomes and lower mortality.[7,8] The feasibility of improving DTN times has been demonstrated by Target: Stroke, an American Heart Association (AHA) national quality initiative; however, the participation among rural hospitals was low.[9–11] Thus, the status of rural-urban gaps in meeting the guideline-recommended DTN times and evidence-based secondary prevention metrics developed by the AHA, the Joint Commission, and Centers for Disease Control and Prevention remains unclear after implementing improvements in Target: Stroke participating hospitals.[9]

Rural hospitals make up 35% of acute care hospitals in the United States and are major contributors to the rural economy and community stability.[12,13] About 60% of rural hospitals are Critical Access Hospitals, which are typically small (≤25 inpatient beds) and distant.[14] Rural hospitals have low operating margins, with 52% showing negative margins.[15] In 2000, the Brain Attack Coalition recommended the establishment of stroke centers to provide evidence-based stroke care.[16] A stroke center is required to have an acute stroke team and neurologist available at all times, designated stroke beds, sufficient diagnostic services, the ability to provide thrombolytics, and requiring report performance measures.[17] While most rural hospitals are unable to meet the requirements for stroke center certification, they are the only resource for local residents to receive a timely acute stroke diagnosis and treatment. This study aimed to obtain a comprehensive understanding of the performances of rural stroke centers and nonstroke centers in providing thrombolytic treatment to eligible patients, DTN times, secondary stroke prevention, and in-hospital outcomes using the Get With The Guidelines (GWTG)-Stroke registry.[18,19]

METHODS

Data Availability

Given that GWTG data are collected for quality improvement rather than primarily for research, data-sharing agreements require an application process for other researchers to access the data. Researchers interested in utilizing GWTG data for research purposes, including validation, can submit proposals at https://www.heart.org/en/professional/quality-improvement/quality-research-and-publications/national-level-program-data-research-opportunities. For detailed information about data analysis, contact the corresponding author.

Data Source

This retrospective cohort study utilized the GWTG-Stroke database provided by the AHA Precision Medicine Platform.[20] GWTG-Stroke is an ongoing data collection launched by AHA to support continuous quality improvement of hospital systems of care.[18,19] Trained hospital personnel are instructed to collect data of consecutive patients treated for acute ischemic stroke by prospective clinical identification, retrospective identification using International Classification of Diseases Ninth Revision codes, or a combination.[18,19] Detailed descriptions of the data collection and quality auditing have been previously published.[18,19] De-identified data were collected and analyzed; cells with <11 values were suppressed to protect participants' confidentiality. Each participating hospital received either human research approval to enroll cases without individual patient consent under the common rule or a waiver of authorization and exemption from subsequent review by their institutional review board. Advarra, the institutional review board for the AHA, determined that this study is exempt from institutional review board oversight.

Rural hospitals are defined by the American Hospital Association as those not located within a metropolitan area designated by the US Office of Management and Budget and the Census Bureau. Patients were grouped by the rural or urban location of their hospital.[21] County-level data were obtained from the Institute for Health Metrics and Evaluation.

Study Population

This study included patients aged ≥18 years who were treated for acute ischemic stroke at GWTG-Stroke participating hospitals from January 1, 2017, to December 31, 2019. The inclusion and exclusion algorithms are provided in Figure 1. Patients transferred-in or with in-hospital stroke with missing onset, arrival, or thrombolysis treatment timeliness or from hospitals with missing rural or urban locations were excluded. This study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Outcomes

Primary outcomes were thrombolysis rates among patients arriving within 4.5 hours from the last known well and the proportion of patients receiving thrombolysis with DTN times within the guideline-recommended 30, 45, and 60 minutes.

Secondary outcomes were thrombolytic treatment by 3 hours among patients arriving by 2 hours without thrombolytic contraindications (arrival by 2 hours/treat by 3 hours), and

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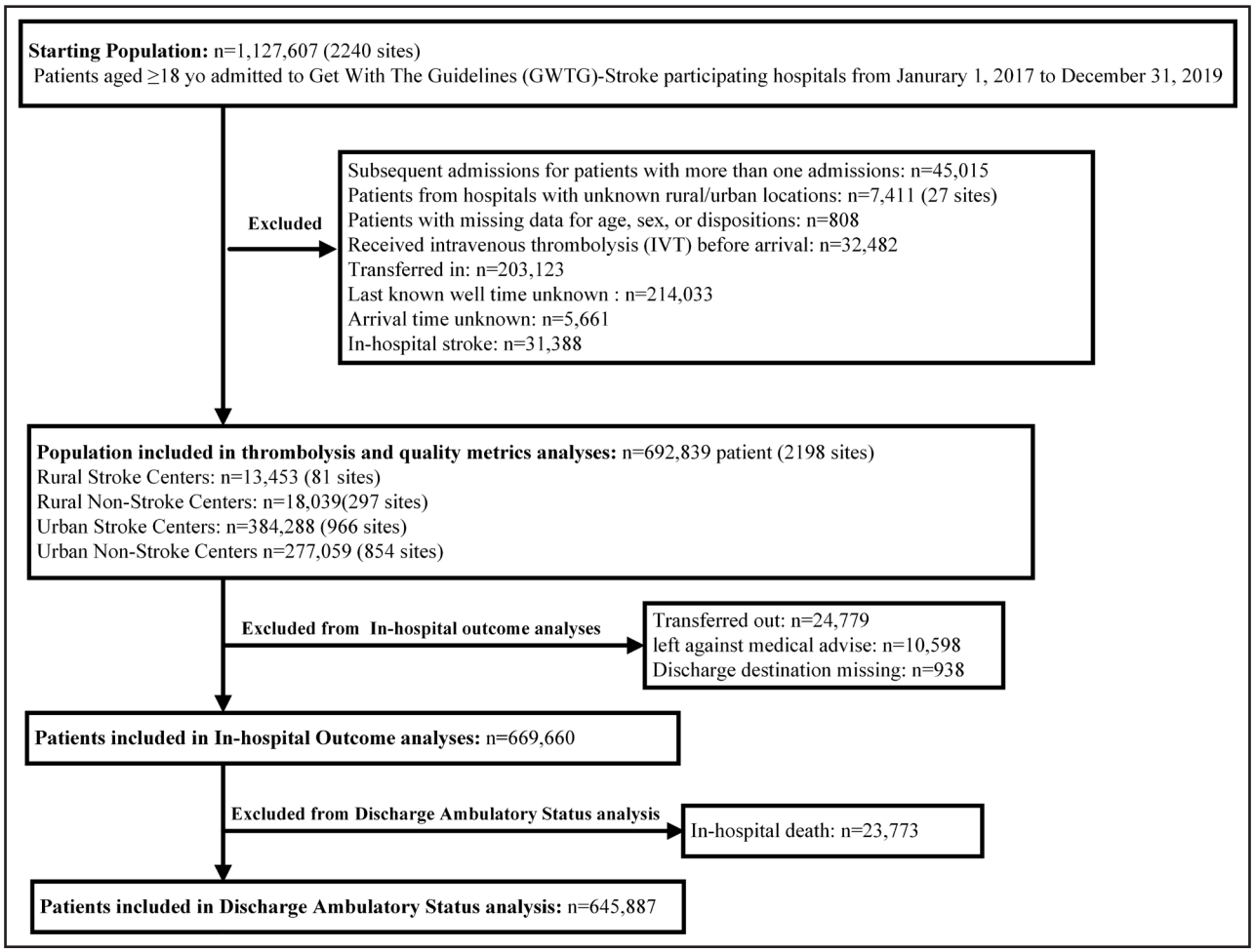

Figure 1. Study flow chart.

thrombolytic treatment by 4.5 hours among patients arriving by 3.5 hours without contraindications (arrival by 3.5 hours/treat by 4.5 hours). Safety and efficacy outcomes included in-hospital mortality, the combination of in-hospital mortality and discharge to hospice and palliative care, thrombolysis complications, and ambulatory at discharge among patients who were discharged alive. We also assessed the proportion of patients presenting within 4.5 hours from last known well, arrival by emergency medical service (EMS), EMS prenotification, thrombectomy rate, discharge destination, and adherence to the rest of the GWTG-Stroke performance measures during index stroke admission (antithrombotics within 48 hours of admission, venous thromboembolism prophylaxis, antithrombotics at discharge, anticoagulation for atrial fibrillation, statin treatment for low-density lipoprotein ≥100 mg/dL, and smoking cessation).[18,19] Defect-free care is a measure that summarizes the overall conformity with the 7 performance measures for each patient.[18,19]

Statistical Analysis

Patient and hospital characteristics and outcomes were compared between rural and urban hospitals. Standardized difference for a continuous variable was calculated using the difference in the mean between 2 groups divided by the SD.[22,23] The proportions were used in calculating the standardized difference in categorical variables as previously described.[22] Standardized difference >10% was considered a significant imbalance.

Multivariate logistic regression models were constructed to assess the differences in prespecified outcomes and adherence to GWTG-Stroke performance measures between overall rural versus urban hospitals, rural stroke centers versus urban stroke centers, and rural stroke centers versus rural nonstroke centers using hospital mixed effects to control for in-hospital clustering. Models adjusted for patient factors including age, sex, race/ethnicity, comorbidities (atrial fibrillation/flutter, previous stroke or transient ischemic attack, history of coronary artery disease/myocardial infarction, carotid stenosis, diabetes, peripheral artery disease, hypertension, dyslipidemia, and smoking), admission variables (arrival by EMS, onset-to-arrival time, arrival during off hours, antiplatelet or anticoagulant before admission, and stroke severity as measured by initial National Institutes of Health Stroke Scale [NIHSS]), and hospital characteristics including total bed number, annual ischemic stroke volume, annual thrombolysis volume, teaching status, stroke center certification, and census region. As exploratory analysis, we further adjusted for county-level covariates (median household income, unemployment rate, and proportion of residents with high school or bachelor degree). County-level covariates

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were not included in the primary analyses due to the high missing rates (≈18%).

Covariates with >5% missing data (ie, county-level data) were excluded from the primary analyses. For remaining covariates, the rates of missingness were low (Table S1). Missing race/ethnicity and comorbidities were not associated with the primary outcome (all $P<0.05$), and imputation of patient covariates was not necessary.[24] Primary analyses were conducted among patients with NIHSS reported. Sensitivity analysis was performed among all patients without adjusting for NIHSS.

Statistical analyses were performed using SAS software, version 9.4 (SAS Institute). All hypothesis tests were 2-sided, with $P<0.05$ considered statistically significant.

RESULTS

Patient and Hospital Characteristics

The inclusion and exclusion workflow are provided in Figure 1. A total of 1 127 607 patients aged ≥18 years were treated for acute ischemic stroke at GWTG-Stroke participating hospitals from 2017 to 2019. We excluded patients with missing data for age, sex, last known well or arrival time, transferred-in, in-hospital strokes, not first-time admissions, and from hospitals with unknown rural/urban locations. The final population consisted of 692 839 patients, among which 31 492 were admitted to 378 rural hospitals (81 stroke centers and 297 nonstroke centers) and 661 347 were admitted to 1820 urban hospitals (966 stroke centers and 854 nonstroke centers). Patient and hospital characteristics are shown in Table 1 and by stroke center certification in Table S2. Rural hospitals treated more White patients than urban hospitals (81.8% versus 65.9%, standardized difference 0.37) and fewer Asian (0.8% versus 3.3%), Black (13.2% versus 18.8%), and Hispanic patients (1.4% versus 8.2%). Compared with urban residents, rural residents used fewer EMS (52.5% versus 58.9%) and had longer onset-to-arrival times (median, 308 versus 240 minutes). Patients in rural and urban hospitals had comparable median NIHSS (3 versus 3; interquartile range [1, 7] versus [1, 8], standardized difference 0.08). More rural hospitals were small and nonteaching hospitals with lower annual ischemic stroke volume (median, 52 versus 168; standardized difference 0.68) and thrombolysis volume (median, 7 versus 17; standardized difference 1.03) compared with urban hospitals.

Rural Hospitals Underperformed Urban Hospitals in Key Thrombolysis and Quality Metrics

We compared the overall performance of rural hospitals with urban hospitals, adjusting for patient and hospital factors (Table 2). The proportion of patients arriving at the hospital within 4.5 hours of stroke onset was lower in rural hospitals than urban hospitals (46.6% versus 51.9%; adjusted odds ratio [aOR], 0.85 [95% CI, 0.83–0.88]) with less EMS utilization (52.5% versus 59.1%; aOR, 0.63 [95% CI, 0.59–0.67]). For patients presenting within 4.5 hours, the thrombolytic treatment rates were lower in rural hospitals than those at urban hospitals (26.5% versus 43.2%; aOR, 0.54 [95% CI, 0.52–0.57]). Among patients treated with thrombolytics, a DTN time of ≤60 minutes was achieved in 57.9% of patients in rural hospitals compared with 69.2% of those in urban hospitals (aOR, 0.81 [95% CI, 0.75–0.88]). Similar differences were observed in DTN ≤45 and ≤30 minutes. Only 0.5% of patients in rural hospitals received thrombectomy, compared with 6.0% in urban hospitals (aOR, 0.24). Rural patients were less likely to be discharged to inpatient rehabilitation facilities (aOR, 0.84 [95% CI, 0.81–0.86]) and more likely to be discharged to skilled nursing facilities (aOR, 1.19 [95% CI, 1.15–1.23]) and home (aOR, 1.04 [95% CI, 1.01–1.07]). In the stepwise analysis (Table S3), the unadjusted differences between rural and urban hospitals were slightly attenuated after adjusting for patient characteristics (model 1), drastically attenuated after also adjusting for hospital characteristics (model 2), and slightly attenuated by further adjustment for county-level factors (model 3). Compared with urban hospitals, in-hospital mortality was lower in rural hospitals after adjusting for patient characteristics (aOR, 0.89 [95% CI, 0.82–0.96]), but higher after adjusting for hospital characteristics (aOR, 1.12 [95% CI, 1.03–1.20]), while the difference dissipated after adjusting for county-level factors (aOR, 1.07 [95% CI, 0.99–1.17]).

Rural Stroke Centers Underperformed Urban Stroke Centers in Thrombolytic Treatment but Exceeded Rural Nonstroke Centers

We further compared quality metrics between rural stroke centers and urban stroke centers and between rural stroke centers and rural nonstroke centers. The numerical data are provided in Table S4. Hospital arrival times and thrombolysis care metrics are presented in Figure 2 with aORs after adjusting for patient and hospital characteristics. Patients who arrived at rural stroke centers within 4.5 hours from stroke onset had lower odds to receive thrombolysis than those arriving at urban stroke centers (aOR, 0.72 [95% CI, 0.68–0.76]), but higher odds than patients arriving at rural nonstroke centers (aOR, 1.26 [95% CI, 1.15–1.37]). Among patients treated with thrombolysis, rural stroke centers were less likely to achieve DTN ≤45 minutes when compared with urban stroke centers (33% versus 44.7%; aOR, 0.86 [95% CI, 0.76–0.96]) but exceeded rural nonstroke centers (28.9%; aOR, 1.24 [95% CI, 1.04–1.49]).

For guideline-recommended secondary stroke prevention treatment and venous thromboembolism

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Table 1. Patient and Hospital Characteristics

	Rural hospital	Urban hospital	Standardized difference
N	31 492	661 347	
Age, y, mean±SD	72±14	71±14	0.10
Female, %	15 772 (50.1)	328 387 (49.6)	0.01
Race/ethnicity			
Asian	247 (0.8)	21 647 (3.3)	0.18
Black	4158 (13.2)	124 584 (18.8)	0.15
Hispanic	441 (1.4)	54 263 (8.2)	−0.32
Native American	174 (0.6)	2118 (0.3)	0.04
Pacific Islander	156 (0.5)	1664 (0.2)	0.04
White	25 751 (81.8)	435 545 (65.9)	0.37
Other/unknown	565 (1.8)	21 526 (3.2)	0.09
Comorbidities			
Atrial fibrillation/flutter	5853 (18.6)	120 295 (18.2)	0.01
Heart failure	3188 (10.1)	62 101 (9.4)	0.02
Prosthetic heart valve	377 (1.2)	7944 (1.2)	0.02
Previous stroke/transient ischemic attack	8272 (26.3)	162 649 (24.6)	0.04
CAD/prior myocardial infarction	8043 (25.5)	141 346 (21.4)	0.10
Carotid stenosis	1103 (3.5)	20 765 (3.1)	0.02
Diabetes	11 383 (36.2)	224 892 (34.0)	0.04
Peripheral vascular disease	1469 (4.7)	25 778 (3.9)	0.04
Hypertension	24 615 (78.2)	489 129 (74.0)	0.10
Smoking	6413 (29.4)	118 468 (17.9)	0.06
Dyslipidemia	14 586 (46.3)	305 957 (46.3)	0.01
Arrival information			
Arrival via EMS	16 520 (52.5)	389 258 (58.9)	0.13
EMS prenotification	10 851 (34.5)	238 907 (36.1)	0.17
Arrival during off hours*	15 050 (47.8)	331 840 (50.2)	0.05
Onset to arrival, min	308 [90, 799]	240 [73, 742]	0.12
NIHSS	3 [1, 7]	3 [1, 8]	0.08
Hospital characteristics, n	378	1820	2198
Bed number			
0–100	219 (57.9)	217 (11.9)	1.10
101–300	144 (38.1)	949 (52.2)	0.29
≥301	15 (4.0)	654 (35.9)	0.87
Teaching hospitals	29 (7.7)	614 (33.7)	0.68
Annual ischemic stroke volume	52 [26, 98]	168 [97, 259]	1.39
Annual IVT volume	7 [4, 13]	17 [9, 30]	1.03
Region			
Northeast	36 (9.5)	367 (20.2)	0.3
Midwest	129 (34.1)	382 (21.0)	0.30
South	175 (46.3)	681 (37.4)	0.18
West	38 (10.1)	390 (21.4)	0.32

Data were expressed as n (%), mean±SD, or median [interquartile range]. Standardized difference was calculated using the difference in the mean of a variable between 2 groups divided by the SD. The proportions were used in calculating standardized difference in categorical variables. Standardized difference >10% was considered significant imbalance. CAD indicates coronary artery disease; EMS, emergency medical services; IVT, intravenous thrombolysis; and NIHSS, National Institutes of Health Stroke Scale.

*Off hours: Regular working hours are defined as 7 AM to 6 PM, Monday to Friday on nonholidays. Arriving outside of these hours are considered off hours.

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Table 2. Rural Versus Urban Hospital Performance

	Rural*	Urban*	Unadjusted		Adjusted	
	n (%)	n (%)	OR (95% CI)	*P* value	OR (95% CI)	*P* value
IVT care metrics						
IVT among patients arriving within 4.5 h	2814 (26.5)	109 860 (43.2)	0.49 (0.47–0.51)	<0.001	0.64 (0.61–0.66)	<0.001
DTN ≤30 min	273 (9.7)	18 281 (16.6)	0.54 (0.47–0.61)	<0.001	0.84 (0.73–0.95)	0.008
DTN ≤45 min	876 (31.1)	49 201 (44.8)	0.56 (0.51–0.60)	<0.001	0.78 (0.72–0.85)	<0.001
DTN ≤60 min	1629 (57.9)	76 010 (69.2)	0.61 (0.57–0.66)	<0.001	0.81 (0.75–0.88)	<0.001
DTN >60 min	1185 (42.1)	33 850 (30.8)	1.63 (1.51–1.76)	<0.001	1.23 (1.14–1.34)	<0.001
Arrive by 2 h/treat by 3 h	1964 (95.2)	79 210 (97.5)	0.50 (0.41–0.62)	<0.001	0.66 (0.53–0.82)	<0.001
Arrive by 3.5 h/treat by 4.5 h	2660 (99.3)	102 973 (99.6)	0.54 (0.34–0.87)	0.011	0.75 (0.45–1.26)	0.28
Thrombolytic complications	103 (3.9)	3755 (3.5)	0.85 (0.70–1.03)	0.10	1.06 (0.87–1.29)	0.58
Additional performance measures during index stroke admission						
Antithrombotics by 48 h	19 358 (96.5)	389 907 (97.3)	0.77 (0.71–0.83)	<0.001	0.82 (0.74–0.91)	<0.001
VTE prophylaxis	21 052 (98.5)	500 242 (99.2)	0.50 (0.44–0.56)	<0.001	0.59 (0.51–0.67)	<0.001
Antithrombotics at discharge	26 008 (98.3)	562 382 (99.3)	0.40 (0.36–0.44)	<0.001	0.54 (0.48–0.62)	<0.001
Anticoagulation for Afib/flutter	4118 (93.3)	91 700 (97.1)	0.41 (0.37–0.47)	<0.001	0.63 (0.54–0.73)	<0.001
Smoking cessation	5233 (95.0)	103 424 (97.9)	0.40 (0.36–0.46)	<0.001	0.52 (0.45–0.61)	<0.001
Statin for LDL ≥100	20 021 (95.6)	433 315 (98.2)	0.41 (0.38–0.43)	<0.001	0.58 (0.53–0.63)	<0.001
Door-to-CT ≤25 min	13 070 (51.0)	276 144 (52.5)	0.94 (0.92–0.97)	<0.001	0.96 (0.93–0.99)	<0.001
NIHSS documented	25 040 (85.9)	573 308 (93.1)	0.45 (0.44–0.47)	<0.001	0.21 (0.11–0.41)	<0.001
Defect-free care†	21 561 (70.4)	522 156 (80.4)	0.58 (0.56–0.59)	<0.001	0.71 (0.69–0.73)	<0.001
Thrombectomy rate	126 (0.5)	32 405 (6.0)	0.09 (0.08–0.11)	<0.001	0.24 (0.21–0.29)	<0.001
Arrival data						
Proportion of patients arrived within 4.5 h	10 548 (46.6)	252 864 (51.9)	0.81 (0.79–0.83)	<0.001	0.85 (0.83–0.88)	<0.001
Proportion of patients arrived within 24 h	29 249 (92.9)	619 710 (93.7)	0.88 (0.84–0.92)	<0.001	0.92 (0.87–0.96)	<0.001
Arrival by EMS	16 520 (52.5)	389 258 (59.1)	0.76 (0.74–0.78)	<0.001	0.63 (0.59–0.67)	<0.001
In-hospital outcomes‡	29 779	639 881				
In-hospital mortality	1002 (3.4)	22 771 (3.6)	0.94 (0.88–1.01)	0.08	1.12 (1.03–1.20)	0.005
In-hospital mortality and hospice/palliative care	2318 (7.8)	53 337 (8.3)	0.93 (0.89–0.97)	<0.001	0.89 (0.84–0.94)	<0.001
Discharge destination						
IRF	5044 (17.5)	130 991 (21.2)	0.79 (0.76–0.81)	<0.001	0.84 (0.81–0.86)	<0.001
SNF	6306 (21.9)	112 118 (18.2)	1.26 (1.23–1.30)	<0.001	1.19 (1.15–1.23)	<0.001
Home	15 598 (54.2)	334 837 (54.3)	1.00 (0.97–1.02)	0.85	1.04 (1.01–1.07)	0.014
Ambulatory at discharge§	14 265 (49.6)	308 759 (50.0)	0.98 (0.96–1.01)	0.13	1.01 (0.99–1.04)	0.33

Models adjusted for patient factors including age, sex, race/ethnicity, comorbidities (atrial fibrillation/flutter, previous stroke or transient ischemic attack, history of coronary artery disease/myocardial infarction, carotid stenosis, diabetes, peripheral artery disease, hypertension, dyslipidemia, and smoking), and admission variables (arrival by EMS, arrival during off hours, and initial NIHSS); and hospital characteristics including total bed number, annual ischemic stroke volume, annual thrombolytic volume, teaching status, stroke center certification, and census region. CT indicates computed tomography; DTN, door-to-needle times; EMS, emergency medical services; IRF, inpatient rehabilitation facility; IVT, intravenous thrombolysis; LDL, low-density lipoprotein; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; SNF, skilled nursing facility; and VTE, venous thromboembolism.

*Data are expressed as number of eligible patients (%).

†Defect-free care summarized the overall conformity with the 7 performance measures for each patient.

‡In-hospital outcome analyses excluded patients transferred-out, left against medical advice, and with unknown discharge disposition.

§Ambulatory at discharge were analyzed among patients who were discharged alive with ambulatory status documented.

prophylaxis (Figure 3), rural stroke centers showed comparable performances with urban stroke centers except for statin treatment for low-density lipoprotein ≥100 mg/dL. Rural stroke centers performed significantly better than rural nonstroke centers in providing antithrombotics within 48 hours of admission, antithrombotics at discharge, anticoagulation for atrial fibrillation/flutter, statin treatment, venous thromboembolism prophylaxis, and smoking cessation (aOR of 1.66, 1.94, 2.44, 1.50, 1.99, and 1.72, respectively). Rural stroke centers had lower NIHSS reporting and defect-free care when compared with urban stroke centers but exceeded rural nonstroke centers in both.

In-hospital outcomes are shown in Figure 4. The risk-adjusted in-hospital mortality did not significantly differ between rural stroke centers and urban stroke

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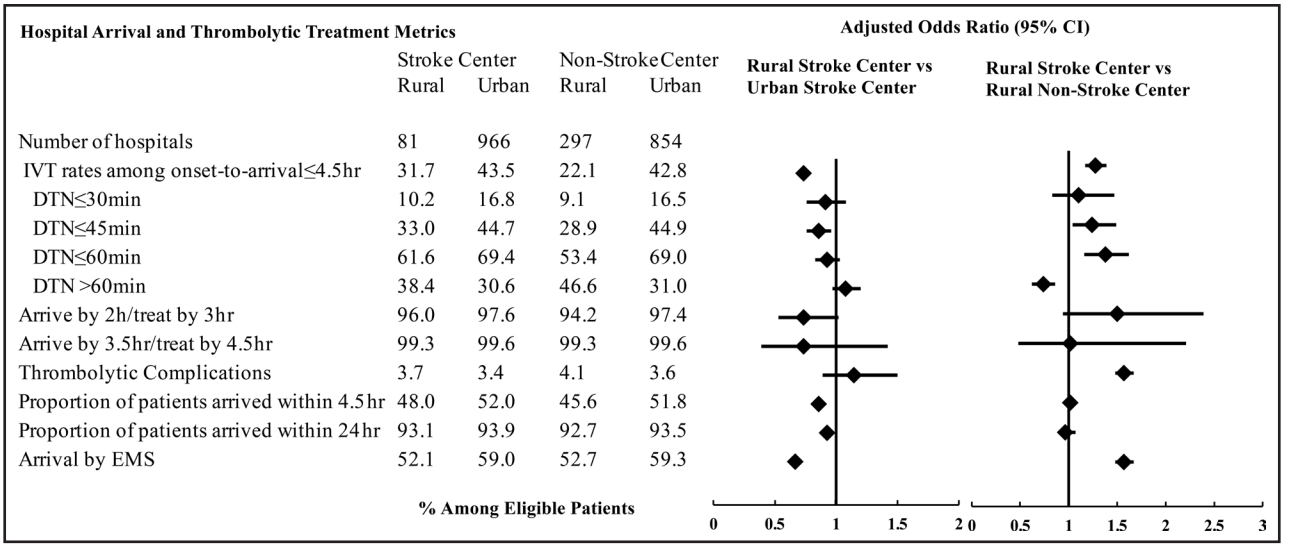

Figure 2. Hospital arrival and thrombolysis care metrics in rural stroke centers and nonstroke centers.
Models adjusted for: patient factors including age, sex, race/ethnicity, comorbidities (atrial fibrillation/flutter, previous stroke or transient ischemic attack, history of coronary artery disease/myocardial infarction, carotid stenosis, diabetes, peripheral artery disease, hypertension, dyslipidemia, and smoking), and admission variables (arrival by emergency medical service [EMS], arrival during off hours, and initial National Institutes of Health Stroke Scale); and hospital characteristics including total bed number, annual ischemic stroke volume, annual thrombolytic volume, teaching status, stroke center certification, and census region. DTN indicates DTN, door-to-needle; and IVT, intravenous thrombolytic treatment.

centers (aOR, 1.11 [95% CI, 0.99–1.24]) or between rural stroke centers and rural nonstroke centers (aOR, 1 [95% CI, 0.84–1.18]). Patients at rural stroke centers, similar to rural nonstroke centers, had lower odds of discharge to inpatient rehabilitation facilities (aOR, 0.81 [95% CI, 0.77–0.85]) and higher odds to skilled nursing facilities (aOR, 1.29 [95% CI, 1.23–1.36]) than urban stroke centers. More patients at rural stroke centers were ambulatory at discharge than at urban stroke centers (aOR, 1.17 [95% CI, 1.13–1.23]) or rural nonstroke centers (aOR, 1.37 [95% CI, 1.29–1.46]). The above directionalities were held in the sensitivity analysis without adjusting for NIHSS to include patients with missing NIHSS (Table S5).

DISCUSSION

The persistent rural-urban disparities in cardiovascular risk factors, access to care, and cardiovascular mortalities have led to a presidential advisory of call-to-action for the AHA and other stakeholders.[25] Our study provides the first comprehensive assessment of thrombolytic treatment, secondary stroke prevention, and other guideline-recommended stroke care metrics in rural hospitals. Our results demonstrated that rural stroke centers use less thrombolytic treatment for patients arriving within the 4.5-hour thrombolytic time window and have a slower speed of treatment than urban stroke centers but not rural nonstroke centers. In addition, rural nonstroke

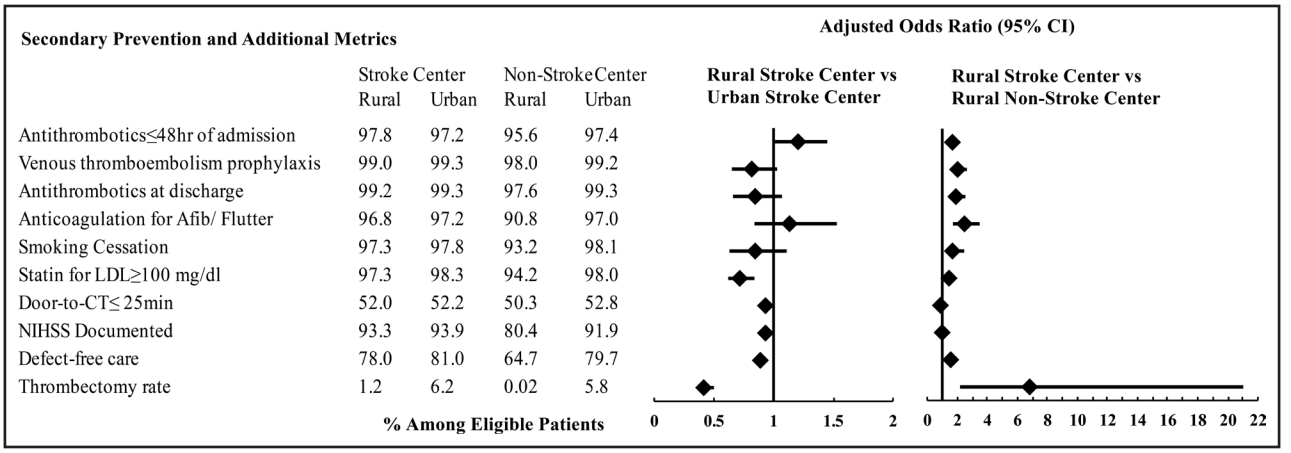

Figure 3. Adherence to guideline-recommended performance measures in rural stroke centers and nonstroke centers.
Defect-free care summarized the overall conformity with the performance measures for each patient. Afib indicates atrial fibrillation; CT, computed tomography; LDL, low-density lipoprotein; and NIHSS, National Institutes of Health Stroke Scale.

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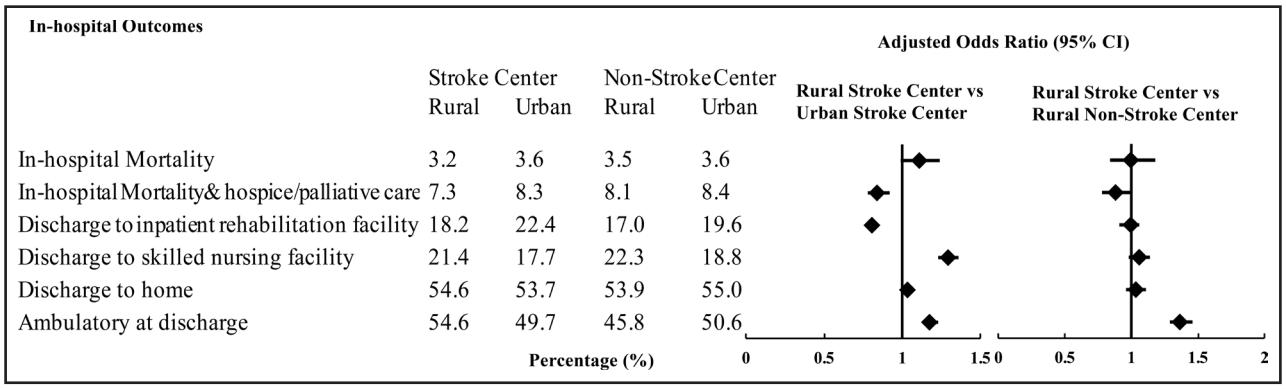

Figure 4. In-hospital outcomes in rural stroke centers and nonstroke centers.
In-hospital outcomes excluded patients who were transferred out, left against medical advice, and with unknown discharge disposition. Ambulatory at discharge included patients discharged alive with ambulatory status documented.

centers, relative to rural stroke centers, implemented less evidence-based secondary prevention treatments, including smoking cessation, statin, antithrombotics, and anticoagulation for eligible patients. Disparity in stroke care is a global theme across different health care systems, including those countries with a single health care payer.[26,27] Our findings reveal important opportunities and specific targets to further improve stroke care in rural areas in the United States, a country with a wide range of rurality, with indications to other countries of either single or multiple health care payers.

This study provides novel data on modifiable gaps in the stroke process of care between rural and urban hospitals and among different rural hospitals. Previous existing data do not identify any modifiable care processes leading to rural health inequity, including thrombolysis treatment disparity.[3,4] Our study measured care process differences between rural stroke centers and urban stroke centers and between rural stroke centers and rural nonstroke centers in providing thrombolytic treatment and secondary stroke prevention for potentially eligible patients. Missed treatment opportunities in timely thrombolysis, secondary stroke prevention, and inpatient rehabilitation may negatively affect functional outcomes, survival, and stroke recurrence in rural patients. These gaps can be eliminated by focused quality initiatives at local, regional, or national levels. The feasibility of continuous improvement in in-hospital thrombolysis rate and speed of treatment has been demonstrated among GWTG-Stroke participating hospitals in the Target: Stroke national quality initiatives.[9–11] Similar success using data monitoring and feedback approaches has been demonstrated in Denmark, Sweden, Australia, Canada, and the United Kingdom.[28,29] Unfortunately, rural hospitals were underrepresented in GWTG-Stroke, which has hindered quality improvement programs by not using data monitoring and feedback. A new 3-year Rural Initiative has been launched by the AHA to provide up to 700 rural hospitals with no-cost access to GWTG quality programs and to help rural hospitals and clinicians in providing consistent, timely, and appropriate evidence-based care.[30] Our study provides important data to guide the ongoing efforts in the United States and worldwide to improve rural stroke care and health equity.

Hospital characteristics, especially hospital size, had major impacts on hospital comparisons in the adjusted model. It is worth noting that among the 1800 rural hospitals in the United States,[12] this study represents only 378 hospitals and 81 stroke centers. A greater proportion of rural hospitals are small and nonteaching hospitals, compared with urban hospitals, which may explain the significant attenuation of rural-urban differences after adjusting for hospital characteristics. Rural hospitals that did not participate in GWTG-Stroke may have limited resources, but they are critical in providing acute stroke treatment for rural communities. Small rural hospitals may have a shortage of expertise to diagnose stroke, implement guideline-recommended treatment, and establish institutional protocols. Efforts should focus on implementing evidence-based stroke care and quality improvement programs derived from data feedback. Our study demonstrates that, compared with urban residents, rural patients were less likely to arrive at the hospital within 4.5 hours. Although late presentation could be due to delays in identifying stroke symptoms at home, calling 911, or not using EMS, lack of access to hospitals providing stroke treatment is a likely contributing factor.[31] A study using the 2000 census data of North Carolina, South Carolina, and Georgia showed that only 26% of rural residents resided within a 30-minute driving distance to a stroke center compared with 70% of urban residents having this resource.[32] A study using the 2010 Nielsen-Claritas census estimates showed that only 1% of the rural population lived within 60-minute driving distance of a stroke center.[33] Successful delivery of evidence-based stroke treatment in rural communities relies on innovative strategies (eg, telehealth[34]) to integrate existing rural hospitals into the regional and national stroke networks with policy, staffing, and financial support and to avoid unrealistic administrative burdens.

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This study has several limitations. First, participation in GWTG-Stroke is voluntary, and data are self-reported by participating hospitals. However, prior quality audits of GWTG-Stroke data have shown high concordance rates with source documentation.[19] Second, small rural hospitals are underrepresented in GWTG-Stroke, although their participation has increased over time. Rural hospitals that do not participate in GWTG-Stroke may have more limited resources and performances, but these hospitals were not included in this study. Third, data reporting in rural hospitals may not be complete, as indicated by the high data missing rates in NIHSS in rural hospitals. Fourth, although we adjusted for many patient and hospital characteristics, as well as stroke severity as measured by NIHSS, there may be residual measured or unmeasured confounding variables that influence the findings. Fifth, county-level data are missing in almost 20% of the patients in the linked database. With the concern that data missingness may not be random, the analyses adjusting for county-level socioeconomic factors were considered exploratory. Sixth, the use of Telestroke may affect hospital performances[34] and differ by stroke center status, but that data were not collected in GWTG-Stroke during the study period.

CONCLUSIONS

Patients arriving at rural hospitals within 4.5 hours from the last known well received intravenous thrombolytic treatment at only about half the rate of patients at urban hospitals. The speed of thrombolytic administration in rural stroke centers is slower than in urban stroke centers but faster than in rural nonstroke centers. In addition, rural nonstroke centers provide less secondary stroke prevention treatment than rural stroke centers. Risk-adjusted in-hospital mortality did not significantly differ between rural and urban stroke centers or among rural hospitals. These findings provide important opportunities and actionable targets for further regional and national rural initiatives to improve stroke care in rural hospitals.

ARTICLE INFORMATION

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Disclosures

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Supplemental Material

Tables S1–S5

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NE State Stroke Task Force

2025 Objective Planning Meeting

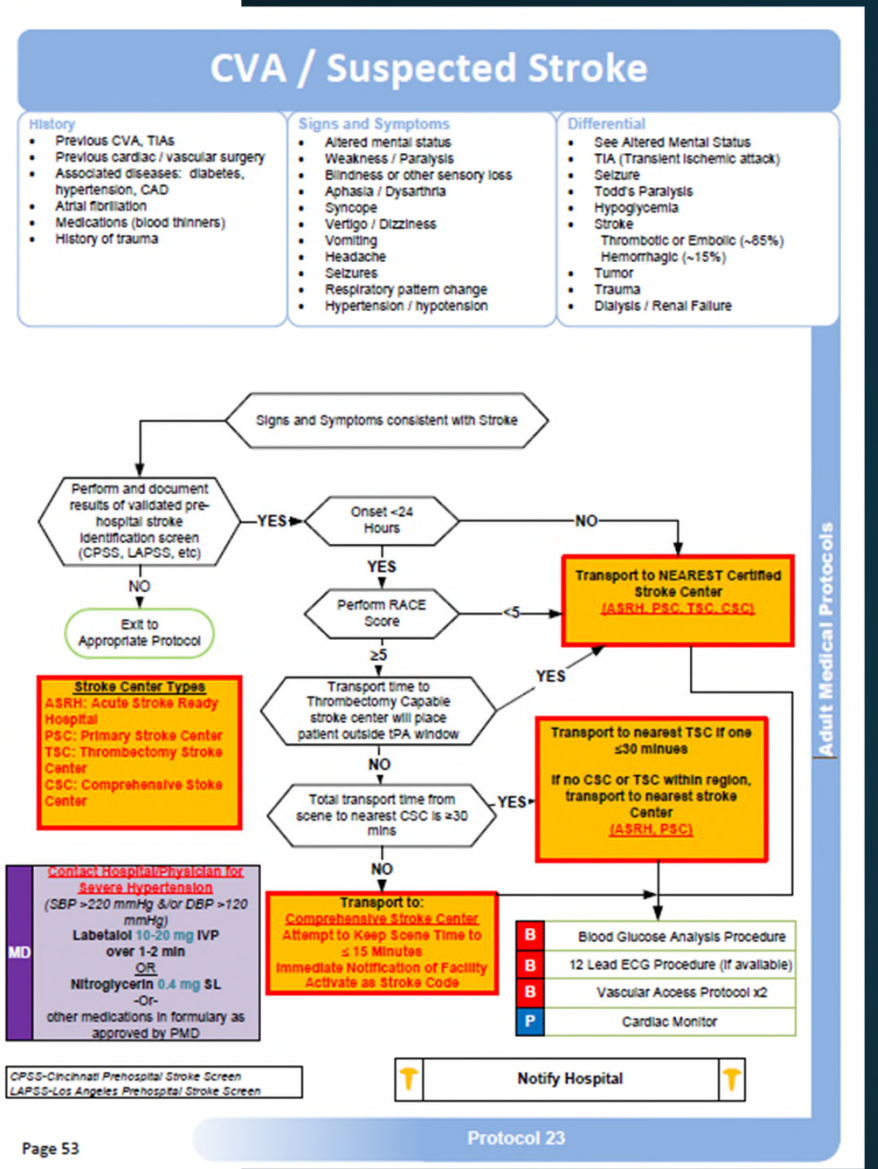
January 23, 2024

EMS

Measure Details

Benchmark Group	Measure Group	Measure	Time Period	Total Patients	Numerator	Denominator	Exception	% Patients
Mission: Lifeline Stroke Nebraska	Pre-hospital Care Measures	AHASTR184: Stroke Screen Performed and Reported	2024 Q1	1368	152	347	0	43.8%
			2024 Q2	1436	137	317	0	43.2%
NE CAH	Pre-hospital Care Measures	AHASTR184: Stroke Screen Performed and Reported	2024 Q1	81	4	24	0	16.7%
			2024 Q2	75	9	16	0	56.3%
NE STK, TSC, CSC	Pre-hospital Care Measures	AHASTR184: Stroke Screen Performed and Reported	2024 Q1	1234	141	303	0	46.5%
			2024 Q2	1309	125	283	0	44.2%

- [Visio-State of Nebraska 2023 EMS Guidelines.vsdx [dhhs.ne.gov]]

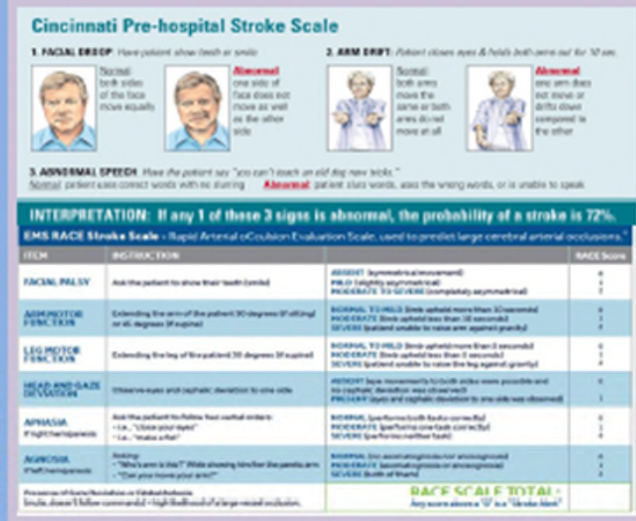


CVA / Suspected Stroke

Adult Medical Protocols

For further information on current recommendations regarding stroke care, including the rationale to treat or not treat hypertension in the setting of possible stroke, see the current version of: "Protocols for the Early Management of Patients With Acute Ischemic Stroke: A Protocol for Healthcare Professionals From the American Heart Association/American Stroke Association"

Available at: https://www.stroke.org/-/media/stroke-files/ems-resources/stroke-training-for-ems-professionals-ucm_488744.pdf?la=en



Cincinnati Pre-hospital Stroke Scale

1. FACIAL DROP: *Have patient show teeth or smile*
   - Normal: both sides of the face move equally
   - Abnormal: one side of face does not move as well as the other side
2. ARM DRIFT: *Patient closes eyes & holds both arms out for 10 sec.*
   - Normal: both arms move the same or both arms do not move at all
   - Abnormal: one arm does not move or drifts down compared to the other
3. ABNORMAL SPEECH: *Have the patient say "you can't teach an old dog new tricks."*
   - Normal: patient uses correct words with no slurring
   - Abnormal: patient slurs words, uses the wrong words, or is unable to speak

INTERPRETATION: If any 1 of these 3 signs is abnormal, the probability of a stroke is 72%.

EMS RACE Stroke Scale - Rapid Arterial oCclusion Evaluation Scale, used to predict large cerebral arterial occlusions.

ITEM	INSTRUCTION		RACE Score
FACIAL PALSY	Ask the patient to show their teeth (smile)	ABSENT (symmetrical movement) MILD (slightly asymmetrical) MODERATE TO SEVERE (completely asymmetrical)	0 1 2
ASSOCIATED FUNCTION	Extending the arm of the patient 90 degrees (if sitting) or 45 degrees (if supine)	NORMAL TO MILD: Stroke upheld more than 10 seconds) MODERATE: Stroke upheld less than 10 seconds) SEVERE (patient unable to raise arm against gravity)	0 1 2
LEG MOTOR FUNCTION	Extending the leg of the patient 30 degrees (if supine)	NORMAL TO MILD: Stroke upheld more than 5 seconds) MODERATE: Stroke upheld less than 5 seconds) SEVERE (patient unable to raise the leg against gravity)	0 1 2
HEAD AND GAZE DEVIATION	Observe eyes and cephalic deviation to one side	ABSENT (eye movement to both sides were possible and no cephalic deviation was observed) PRESENT (eyes and cephalic deviation to one side was observed)	0 1
APHASIA (Right hemisphere)	Ask the patient to follow two verbal orders: - I.e., "Close your eyes" - I.e., "make a fist"	NORMAL (performs both tasks correctly) MODERATE (performs one task correctly) SEVERE (performs neither task)	0 1 2
AGNOSIA (Left hemisphere)	Asking: - "Who's arm is this?" (While showing him/her the paretic arm. - "Can you move your arm?"	NORMAL (no asomatognosia nor anosognosia) MODERATE (asomatognosia or anosognosia) SEVERE (both of them)	0 1 2
Presence of Atrial Fibrillation or Carotid Bruit Stroke, Aware/Follow commands = high likelihood of a large vessel occlusion.		RACE SCALE TOTAL: Any score above a "0" is a "Stroke Alert"	

LOS ANGELES PREHOSPITAL STROKE SCREEN (LAPSS)

Patient Name: _____
Rater Name: _____
Date: _____

Screening Criteria	Yes	No
4. Age over 45 years	☐	☐
5. No prior history of seizure disorder	☐	☐
6. New onset of neurologic symptoms in last 24 hours	☐	☐
7. Patient was ambulatory prior to (prior to event)	☐	☐
8. Blood glucose between 60 and 400	☐	☐

9. Exam: look for obvious asymmetry

	Normal	Right	Left
Facial smile / grimace:	☐	☐ Droop	☐ Droop
Grip:	☐	☐ Weak Grip ☐ No Grip	☐ Weak Grip ☐ No Grip
Arm weakness:	☐	☐ Drifts Down ☐ Falls Rapidly	☐ Drifts Down ☐ Falls Rapidly

Based on exam, patient has only unilateral (and not bilateral) weakness: Yes☐ No☐

10. If Yes (or unknown) to all items above LAPSS screening criteria met: Yes☐ No☐

11. If LAPSS criteria for stroke met, call stroke log/hospital with "CODE STROKE". If not then return to the appropriate treatment protocol. (Note: the patient may still be experiencing a stroke if even if LAPSS criteria are not met.)

Pearls

- **Recommended Exam: Mental Status, HEENT, Heart, Lungs, Abdomen, Extremities, Neuro**
- **Acute Stroke care is evolving rapidly. Time of onset / last seen normal parameters may be changed at any time depending on the capabilities and resources of the Stroke Receiving Hospital.**
- **Time of Onset or Last Seen Normal: One of the most important items the pre-hospital provider can obtain, on which all treatment decisions are based. Be very precise in gathering data to establish the time of onset and report as an actual time (i.e. 13:47 NOT "about 45 minutes ago.") Without this information patient may not be able to receive thrombolytics at facility. For patients with "Woke up and noticed stroke," Time starts when patient went to sleep or was last awake and was last known normal (NOT the time they woke up).**
- **Scene times should be generally limited to ≤ 15 minutes and the patient should be transported to capable stroke receiving facility. In-field notification of receiving facility should be performed and transport times should be minimized.**
- The differential listed on the Altered Mental Status Protocol should also be considered.
- Be alert for airway problems (swallowing difficulty, vomiting/aspiration).
- Document the results of the pre-hospital stroke identification screen (CPSS, LAPSS, etc) in the ePCR.
- Elderly patients with UTIs may show stroke signs and symptoms, always error on the side of caution

State EMS Reporting - Aggregate

Incidents that Provider Primary or Secondary Impression is a stroke, and that the patient was treated and transported. Possibly reported in the narrative

80% of encounters with stroke screen not documented in discrete fields available

Report Criteria

Situation Provider Primary Impression Description Only (Esituation.11): Is In Hemorrhagic stroke (CVA), Ischemic stroke (CVA), Stroke

Situation Provider Secondary Impression Description Only List (Esituation.12): Contains stroke

Disposition Incident Patient Disposition (3.4=Edisposition.12/3.5=Itdisposition.112): Is Equal To Patient Treated, Transported by this EMS Unit

Agency is Demo Service: Is Equal To 0

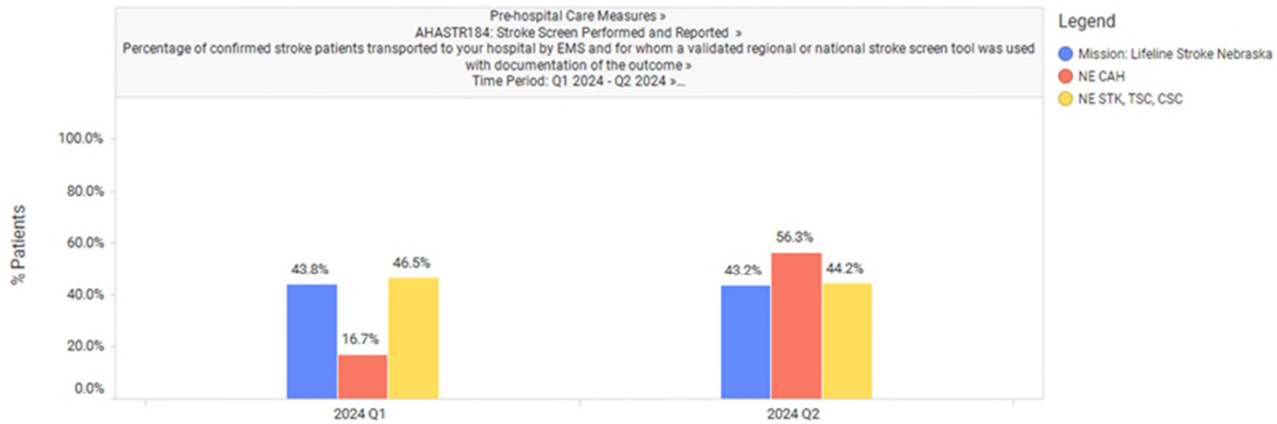
Average Scene Time	Average Positive Stroke Score to Stroke Alert Time in Minutes	Patient Initial Stroke Scale (eVitals.30)	Patient Last Stroke Scale (eVitals.30)	Count of Patient Stroke Scale Assessments per Incident (eVitals.30)	Total Number of Incidents
Patient Initial Stroke Scale Score (eVitals.29): (None)					
17 min	12 min	Blank	Blank	2	13
				1	139
				None	711
		Cincinnati	Cincinnati	2	4
				1	16
		F.A.S.T. Exam	F.A.S.T. Exam	1	3
		NIH	NIH	1	3
		Other Stroke Scale Type	Other Stroke Scale Type	1	3
		RACE (Rapid Arterial Occlusion Evaluation)	RACE (Rapid Arterial Occlusion Evaluation)	2	1
					Total: 893

9. Stroke Screen Performed and Reported

Percentage of confirmed stroke patients transported to your hospital by EMS and for whom a validated regional or national stroke screen tool was used with documentation of the outcome.

Initial Patient Population	Coding Instructions
Include:	
All patients age 18 years and older with a final clinical diagnosis of stroke transported to your hospital by EMS.	**Age:** ≥ 18 **AND** **How patient arrived at your hospital:** = Air Transport OR = EMS from home/scene OR = Mobile Stroke Unit OR = Transfer from outpatient facility **AND** **Final clinical diagnosis related to stroke:** = Ischemic Stroke OR = Subarachnoid Hemorrhage OR = Intracerebral Hemorrhagic OR = Stroke not otherwise specified
Denominator	
Include:	
All patients in the initial patient population.	**Same as initial patient population**
Exclusions: (Always remove from denominator)	
Stroke occurred after hospital arrival (in ED/Obs/Inpatient) Transferred patients from hospice or different hospital Elective Carotid Intervention Clinical Trial	**Patient location when stroke symptoms discovered:** = Stroke occurred after hospital arrival-In ED/Obs/Inpatient **OR** **How patient arrived at your hospital:** =Transfer from another hospital OR = Transfer from Hospice **OR** **Elective Carotid Intervention:** = Yes **OR** **Clinical Trial:** = Yes
Exceptions: (Remove from denominator if present and numerator is not met)	
None	N/A
Numerator	
Prehospital Screening tool used, and outcome documented	**Stroke screen used:** = screening tool selected (BE FAST, CPSS, DPSS, FAST, LAPSS, MEND, MASS, Med PACS, MEND, mLAPSS, OPSST, ROSIER, Stroke screen tool used, but tool used is unknown, or Other (text field is populated)) **AND** **Documentation of Outcome:** = Positive OR = Negative]

Measure Summary



Measure Details

Benchmark Group	Measure Group	Measure	Time Period	Total Patients	Numerator	Denominator	Exception	% Patients
Mission: Lifeline Stroke Nebraska	Pre-hospital Care Measures	AHASTR184: Stroke Screen Performed and Reported	2024 Q1	1368	152	347	0	43.8%
			2024 Q2	1436	137	317	0	43.2%
NE CAH	Pre-hospital Care Measures	AHASTR184: Stroke Screen Performed and Reported	2024 Q1	81	4	24	0	16.7%
			2024 Q2	75	9	16	0	56.3%
NE STK, TSC, CSC	Pre-hospital Care Measures	AHASTR184: Stroke Screen Performed and Reported	2024 Q1	1234	141	303	0	46.5%
			2024 Q2	1309	125	283	0	44.2%

Thrombolytic Therapies
2023 GWTG - NE

GWTG – Thrombolytic Therapies Measure

AHASTR47: Thrombolytic Therapies	
Patients with ischemic stroke grouped by type and location of thrombolytic therapy	
Initial Patient Population	
All patients age 18 years and older with a final clinical diagnosis of ischemic stroke	**Age** ≥ 18 **AND** **Final clinical diagnosis related to stroke** = (Ischemic Stroke)
Denominator	
Include:	
All patients in the Initial Patient Population	Same as initial patient population
Exclusions:	
• Clinical Trial • Elective Carotid Intervention	**During this hospital stay, was the patient enrolled in a clinical trial in which patients with the same condition as the measure set were being studied** = (Yes) **OR** **Was this patient admitted for the sole purpose of performanceof elective carotid intervention** = (Yes)
Exceptions:	
None	N/A
Numerator/Report	
Patients grouped by type and location of thrombolytic therapy: 1. IV thrombolytic initiated at this hospital for ED patients 2. IV thrombolytic initiated at this hospital for Inpatients 3. IV thrombolytic initiated at outside hospital and not initiated at this hospital 4. IA catheter-based treatment at this hospital for ED patients 5. IA catheter-based treatment at this hospital for Inpatients 6. IA catheter-based treatment at outside hospital 7. Any thrombolytic therapy	**Group 1:** **IV thrombolytic initiated at this hospital** = (Yes) **AND (Patient location when stroke symptoms discovered** is not (Stroke occurred after hospital arrival (in ED/Obs/Inpatient)) **OR Patient location when stroke symptoms discovered** is blank) **Group 2:** **IV thrombolytic initiated at this hospital** = (Yes) **AND Patient location when stroke symptoms discovered** = (Stroke occurred after hospital arrival (in ED/Obs/Inpatient) **Group 3:** **IV thrombolytic at an outside hospital** = (Yes) **AND IV thrombolytic initiated at this hospital** = (No)

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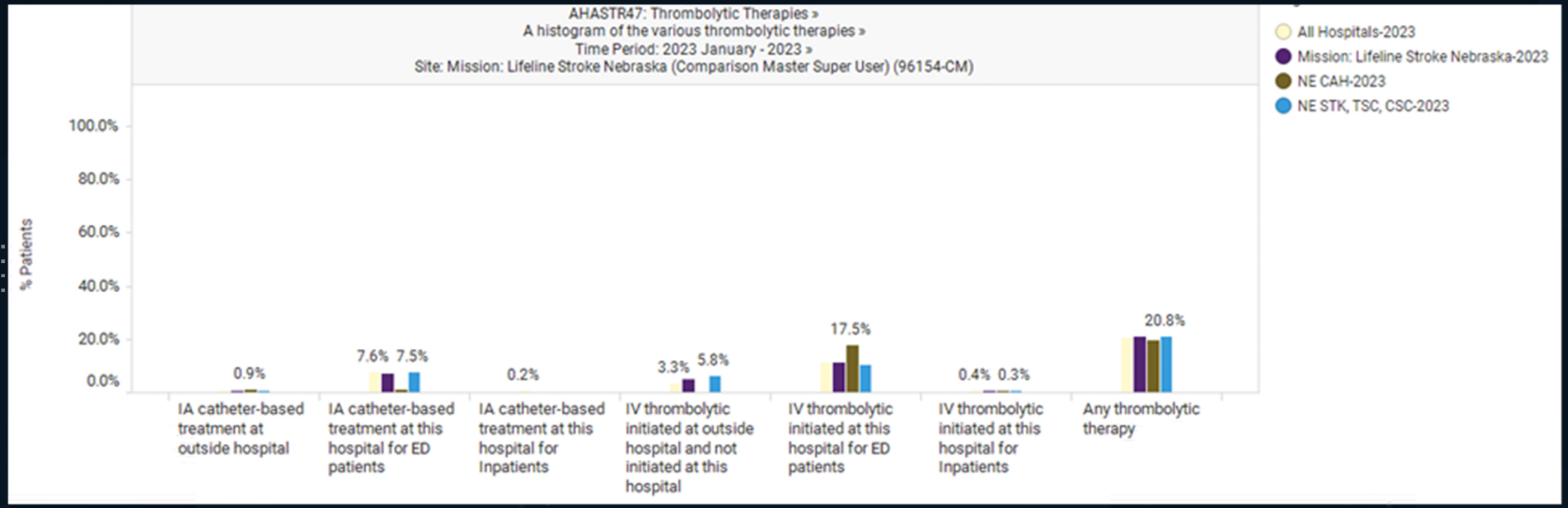
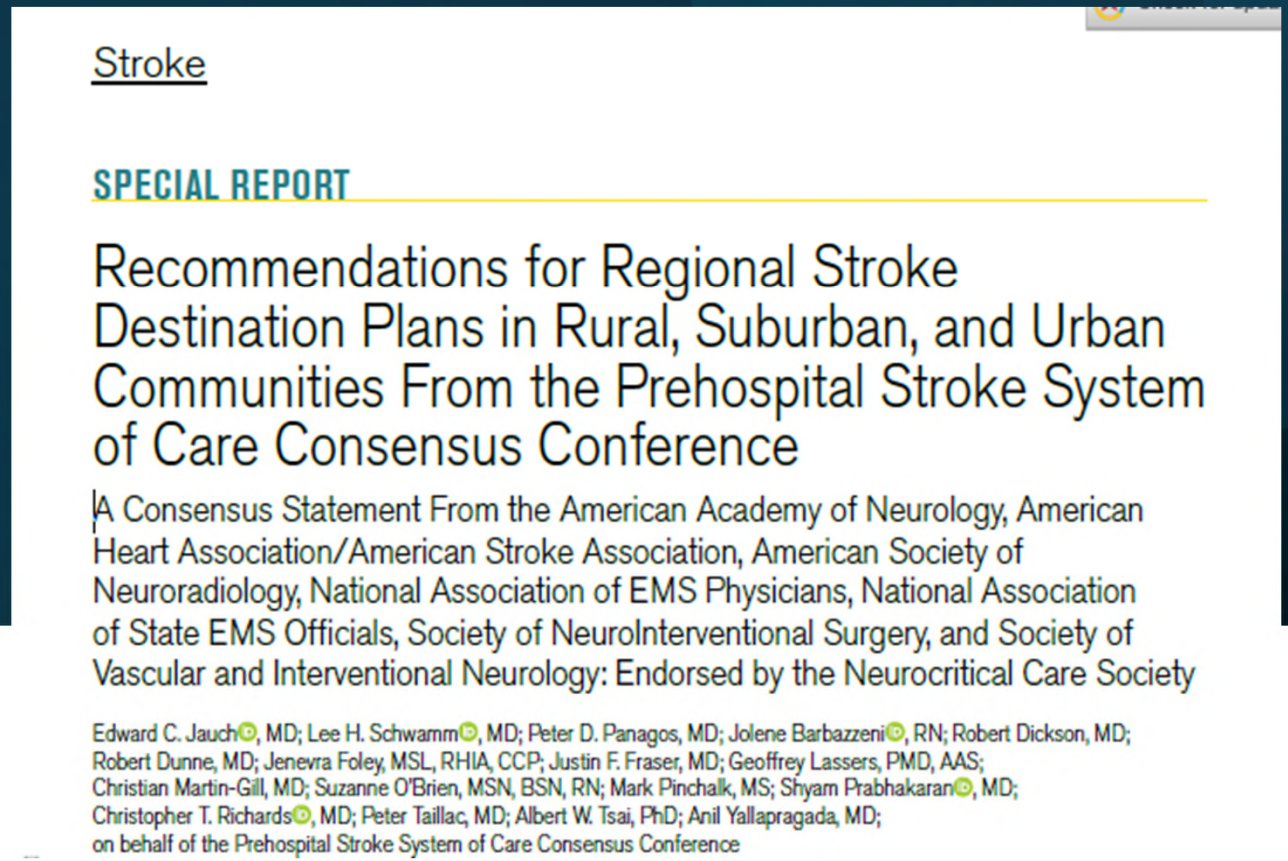

AHASTR47: Thrombolytic Therapies »
A histogram of the various thrombolytic therapies »
Time Period: 2023 January - 2023 »
Site: Mission: Lifeline Stroke Nebraska (Comparison Master Super User) (96154-CM)
All Hospitals-2023
Mission: Lifeline Stroke Nebraska-2023
NE CAH-2023
NE STK, TSC, CSC-2023
% Patients
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
0.9%
7.6%
7.5%
0.2%
3.3%
5.8%
17.5%
0.4%
0.3%
20.8%
IA catheter-based treatment at outside hospital
IA catheter-based treatment at this hospital for ED patients
IA catheter-based treatment at this hospital for Inpatients
IV thrombolytic initiated at outside hospital and not initiated at this hospital
IV thrombolytic initiated at this hospital for ED patients
IV thrombolytic initiated at this hospital for Inpatients
Any thrombolytic therapy

Measure Details

Benchmark Group	Time Period	Total Patients	IA catheter-based treatment at outside ...	IA catheter-based treatment at this hospital for...	IA catheter-based treatment at this hospital for...	IV thrombolytic initiated at outside hospital and ...	IV thrombolytic initiated at this hospital for ED patients	IV thrombolytic initiated at this hospital for Inpatients	Any thrombolytic therapy
			Values	Values	Values	Values	Values	Values	Values
All Hospit...	2023	538508	1738 (0.3%)	40694 (7.6%)	1165 (0.2%)	17869 (3.3%)	60896 (11.3%)	2362 (0.4%)	109617 (20.4%)
Mission: L...	2023	3122	13 (0.4%)	210 (6.7%)	(0.0%)	161 (5.2%)	341 (10.9%)	10 (0.3%)	645 (20.7%)
NE CAH	2023	228	2 (0.9%)	2 (0.9%)	(0.0%)	(0.0%)	40 (17.5%)	1 (0.4%)	44 (19.3%)
NE STK, T...	2023	2765	7 (0.3%)	208 (7.5%)	(0.0%)	161 (5.8%)	278 (10.1%)	8 (0.3%)	575 (20.8%)

2023 Thrombolysis Rates – NE GWTG for Reporting Hospitals

Use the following article to help inform thoughts on Stroke Systems of Care needs for Nebraska



Stroke

SPECIAL REPORT

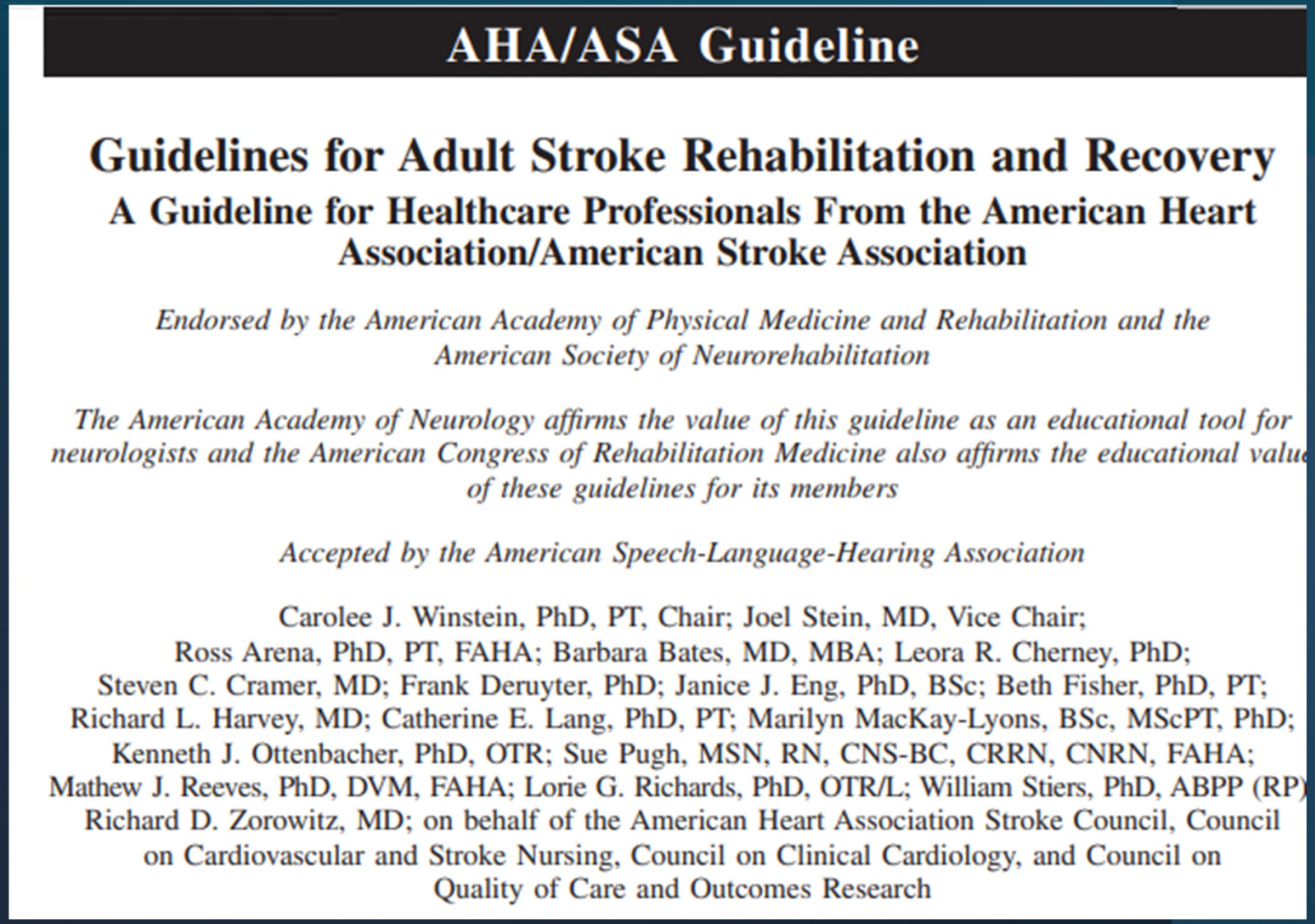
Recommendations for Regional Stroke Destination Plans in Rural, Suburban, and Urban Communities From the Prehospital Stroke System of Care Consensus Conference

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

Edward C. Jauch, MD; Lee H. Schwamm, MD; Peter D. Panagos, MD; Jolene Barbazzeni, RN; Robert Dickson, MD; Robert Dunne, MD; Jenevra Foley, MSL, RHIA, CCP; Justin F. Fraser, MD; Geoffrey Lassers, PMD, AAS; Christian Martin-Gill, MD; Suzanne O'Brien, MSN, BSN, RN; Mark Pinchalk, MS; Shyam Prabhakaran, MD; Christopher T. Richards, MD; Peter Taillac, MD; Albert W. Tsai, PhD; Anil Yallapragada, MD; on behalf of the Prehospital Stroke System of Care Consensus Conference

Stroke. 2021;52:e133–e152. DOI: 10.1161/STROKEAHA.120.033228

Use the following article to help inform thoughts on Stroke Systems of Care needs for Nebraska



AHA/ASA Guideline

Guidelines for Adult Stroke Rehabilitation and Recovery

A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association

Endorsed by the American Academy of Physical Medicine and Rehabilitation and the American Society of Neurorehabilitation

The American Academy of Neurology affirms the value of this guideline as an educational tool for neurologists and the American Congress of Rehabilitation Medicine also affirms the educational valu of these guidelines for its members

Accepted by the American Speech-Language-Hearing Association

Carolee J. Winstein, PhD, PT, Chair; Joel Stein, MD, Vice Chair;
Ross Arena, PhD, PT, FAHA; Barbara Bates, MD, MBA; Leora R. Cherney, PhD;
Steven C. Cramer, MD; Frank Deruyter, PhD; Janice J. Eng, PhD, BSc; Beth Fisher, PhD, PT;
Richard L. Harvey, MD; Catherine E. Lang, PhD, PT; Marilyn MacKay-Lyons, BSc, MScPT, PhD;
Kenneth J. Ottenbacher, PhD, OTR; Sue Pugh, MSN, RN, CNS-BC, CRRN, CNRN, FAHA;
Mathew J. Reeves, PhD, DVM, FAHA; Lorie G. Richards, PhD, OTR/L; William Stiers, PhD, ABPP (RP)
Richard D. Zorowitz, MD; on behalf of the American Heart Association Stroke Council, Council on Cardiovascular and Stroke Nursing, Council on Clinical Cardiology, and Council on Quality of Care and Outcomes Research

Use the following article to help inform thoughts on Stroke Systems of Care needs for Nebraska

Stroke

CLINICAL AND POPULATION SCIENCES

Rural Hospital Performance in Guideline-Recommended Ischemic Stroke Thrombolysis, Secondary Prevention, and Outcomes

Shumei Man, MD, PhD; David Bruckman, MS; Ken Uchino, MD; Bing Yu Chen, MD; Jarrod E. Dalton, PhD; Gregg C. Fonarow, MD

Reflecting on the materials shared reflect on the following questions:

1. What drives success or failure for the State Stroke Task Force
2. Does the current (committee) structure of the Task Force aide or hinder the ability to achieve goals? Why?
3. What capabilities or limitations does the Task Force have in its ability to improve stroke systems of care? Be specific and include examples.
4. Using the “Integration of Regional EMS into SSOC” (Jausch et al, p. 9) as a best practice reference to integration of EMS systems, how does Nebraska compare? Where do we excel?
5. How might the Stroke Task force and/or committee structure support improvement in this area?
6. Wha opportunities exist with rural SSOC (Jausch et al, p. 12-13) and how can the Task Force and/or committee structure support those efforts?
7. Additional thoughts on urban SSOCs?
8. Looking forward into the future, what has the Task Force accomplished and how does the Task Force support the SSOC activities across the state?
9. What are the most important priorities of the Task Force?

Check for updates

Guidelines for Adult Stroke Rehabilitation and Recovery

A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association

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Purpose—The aim of this guideline is to provide a synopsis of best clinical practices in the rehabilitative care of adults recovering from stroke.

Methods—Writing group members were nominated by the committee chair on the basis of their previous work in relevant topic areas and were approved by the American Heart Association (AHA) Stroke Council's Scientific Statement Oversight Committee and the AHA's Manuscript Oversight Committee. The panel reviewed relevant articles on adults using computerized searches of the medical literature through 2014. The evidence is organized within the context of the AHA framework and is classified according to the joint AHA/American College of Cardiology and supplementary AHA methods of classifying the level of certainty and the class and level of evidence. The document underwent extensive AHA internal and external peer review, Stroke Council Leadership review, and Scientific Statements Oversight Committee review before consideration and approval by the AHA Science Advisory and Coordinating Committee.

Results—Stroke rehabilitation requires a sustained and coordinated effort from a large team, including the patient and his or her goals, family and friends, other caregivers (eg, personal care attendants), physicians, nurses, physical and occupational therapists, speech-language pathologists, recreation therapists, psychologists, nutritionists, social workers, and others. Communication and coordination among these team members are paramount in maximizing the effectiveness

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This guideline was approved by the American Heart Association Science Advisory and Coordinating Committee on January 4, 2016, and the American Heart Association Executive Committee on February 23, 2016. A copy of the document is available at http://professional.heart.org/statements by using either "Search for Guidelines & Statements" or the "Browse by Topic" area. To purchase additional reprints, call 843-216-2533 or e-mail kelle.ramsay@wolterskluwer.com.

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and efficiency of rehabilitation and underlie this entire guideline. Without communication and coordination, isolated efforts to rehabilitate the stroke survivor are unlikely to achieve their full potential.

Conclusions—As systems of care evolve in response to healthcare reform efforts, postacute care and rehabilitation are often considered a costly area of care to be trimmed but without recognition of their clinical impact and ability to reduce the risk of downstream medical morbidity resulting from immobility, depression, loss of autonomy, and reduced functional independence. The provision of comprehensive rehabilitation programs with adequate resources, dose, and duration is an essential aspect of stroke care and should be a priority in these redesign efforts. **(*Stroke.* 2016;47:e98-e169. DOI: 10.1161/STR.0000000000000098.)**

Key Words: AHA Scientific Statements ■ exercise ■ paresis ■ recovery of function ■ rehabilitation ■ stroke

Between 2000 and 2010, the relative rate of stroke deaths dropped by 35.8% in the United States.[1] However, each year stroke affects nearly 800 000 individuals, with many survivors experiencing persistent difficulty with daily tasks as a direct consequence. More than two thirds of stroke survivors receive rehabilitation services after hospitalization.[2] Despite the development of stroke center designation and improved systems to recognize stroke symptoms and deliver care promptly, only a minority of patients with acute stroke receive thrombolytic therapy, and many of them remain with residual functional deficits. Thus, the need for effective stroke rehabilitation is likely to remain an essential part of the continuum of stroke care for the foreseeable future.

Despite the extensive resources devoted to stroke rehabilitation and aftercare, large-scale, rigorous, clinical trials in this field have been few and have been conducted only in the past decade or so. Thus, many gaps continue to be seen in the evidence base for stroke rehabilitation, for which smaller trials of less rigorous design provide the only available data, and in some cases, even these are not yet available. Certain aspects of stroke rehabilitation care are well established in clinical practice and constitute a standard of care that is unlikely to be directly tested in a randomized, clinical trial, for example, the provision of physical therapy (PT) to early stroke survivors with impaired walking ability. Thus, practice guidelines such as this one will likely rely on a mixture of evidence and consensus. It is hoped that the relative proportion of recommendations based on rigorous evidence will grow over time.

This guideline uses the framework established by the American Heart Association (AHA) concerning classes and levels of evidence for use in guidelines, as shown in Tables 1 and 2.

We have organized this guideline into 5 major sections: (1) The Rehabilitation Program, which includes system-level sections (eg, organization, levels of care); (2) Prevention and Medical Management of Comorbidities, in which reference is made to other published guidelines (eg, hypertension); (3) Assessment, focused on the body function/structure level of the *International Classification of Functioning, Disability, and Health* (*ICF*)[3]; (4) Sensorimotor Impairments and Activities (treatment/interventions), focused on the activity level of the *ICF*; and (5) Transitions in Care and Community Rehabilitation, focused primarily on the participation level of the *ICF*.

Published guidelines are, by their very nature, a reflection of clinical practice at a particular point in time and the evidence base available. As new information becomes available, best practice can change quickly, and it is incumbent on the users of these guidelines to keep the ever-changing nature of clinical knowledge in mind. Equally important, no guideline can substitute for the careful evaluation of the individual patient by an experienced clinician, in which the art and science of medicine intersect. Guidelines that are correct in the aggregate may not represent the best care for any specific individual, and careful individualization is needed at the point of care.

We have benefited from the published Veterans Affairs/Department of Defense stroke rehabilitation guidelines[4] and several of the prior AHA stroke-related guidelines.[4a] Although the current guideline is a fundamentally new work, it certainly reflects the insights and judgments of these prior guidelines.

Because stroke is fundamentally a chronic condition, we have attempted to span the entire course of rehabilitation, from the early actions taken in the acute care hospital through reintegration into the community. The end of formal rehabilitation (commonly by 3–4 months after stroke) should not mean the end of the restorative process. In many respects, stroke has been managed medically as a temporary or transient condition instead of a chronic condition that warrants monitoring after the acute event. Currently, unmet needs persist in many domains, including social reintegration, health-related quality of life, maintenance of activity, and self-efficacy (ie, belief in one's capability to carry out a behavior). Apathy is manifested in >50% of survivors at 1 year after stroke[5]; fatigue is a common and debilitating symptom in chronic stroke[6]; daily physical activity of community-living stroke survivors is low[7]; and depressive symptomology is high.[8] By 4 years after onset, >30% of stroke survivors report persistent participation restrictions (eg, difficulty with autonomy, engagement, or fulfilling societal roles).[9]

The Rehabilitation Program

Organization of Poststroke Rehabilitation Care (Levels of Care)

Rehabilitation services are the primary mechanism by which functional recovery and the achievement of independence are promoted in patients with acute stroke. The array of rehabilitation services delivered to stroke patients in the United States is broad and highly heterogeneous, varying in the type of care settings used; in the duration, intensity, and type of interventions delivered; and in the degree of involvement of specific medical, nursing, and other rehabilitation specialists. The nature and organization of rehabilitation stroke services in the United States have changed considerably over time in response to various forces, including the increasing integration of hospital and outpatient care delivery systems (at both local and regional levels), the organization of medical and other specialty rehabilitation groups, and most important, repeated changes to the federal reimbursement fee structure (specifically, Centers for Medicare & Medicaid Services), which is

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Table 1. Applying Classification of Recommendations and Level of Evidence

ESTIMATE OF CERTAINTY (PRECISION) OF TREATMENT EFFECT	SIZE OF TREATMENT EFFECT: CLASS I *Benefit >>> Risk* Procedure/Treatment **SHOULD** be performed/ administered	CLASS IIa *Benefit >> Risk* *Additional studies with focused objectives needed* **IT IS REASONABLE** to perform procedure/administer treatment	CLASS IIb *Benefit ≥ Risk* *Additional studies with broad objectives needed; additional registry data would be helpful* Procedure/Treatment **MAY BE CONSIDERED**	CLASS III *No Benefit* or CLASS III *Harm* Procedure/Test / Treatment COR III: No benefit — Not Helpful / No Proven Benefit COR III: Harm — Excess Cost w/o Benefit or Harmful / Harmful to Patients
LEVEL A Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses	■ Recommendation that procedure or treatment is useful/effective ■ Sufficient evidence from multiple randomized trials or meta-analyses	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Sufficient evidence from multiple randomized trials or meta-analyses
LEVEL B Limited populations evaluated* Data derived from a single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is useful/effective ■ Evidence from single randomized trial or nonrandomized studies	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Evidence from single randomized trial or nonrandomized studies
LEVEL C Very limited populations evaluated* Only consensus opinion of experts, case studies, or standard of care	■ Recommendation that procedure or treatment is useful/effective ■ Only expert opinion, case studies, or standard of care	■ Recommendation in favor of treatment or procedure being useful/effective ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation's usefulness/efficacy less well established ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Only expert opinion, case studies, or standard of care
Suggested phrases for writing recommendations	should is recommended is indicated is useful/effective/beneficial	is reasonable can be useful/effective/beneficial is probably recommended or indicated	may/might be considered may/might be reasonable usefulness/effectiveness is unknown/unclear/uncertain or not well established	COR III: No Benefit: is not recommended; is not indicated; should not be performed/ administered/ other; is not useful/ beneficial/ effective COR III: Harm: potentially harmful; causes harm; associated with excess morbidity/mortality; should not be performed/ administered/ other
Comparative effectiveness phrases†	treatment/strategy A is recommended/indicated in preference to treatment B treatment A should be chosen over treatment B	treatment/strategy A is probably recommended/indicated in preference to treatment B it is reasonable to choose treatment A over treatment B		

A recommendation with Level of Evidence B or C does not imply that the recommendation is weak. Many important clinical questions addressed in the guidelines do not lend themselves to clinical trials. Although randomized trials are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as sex, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use.

†For comparative effectiveness recommendations (Class I and IIa; Level of Evidence A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

the central driver of much of the system's organization and structure. Further systems-level changes are inevitable, given the ongoing federal changes to the healthcare system and the recent focus on "episodes of care," which promises to result in wholesale changes to the organization of medical care delivery in the United States.[10]

The highly heterogeneous organizational structure of stroke rehabilitation care in the United States brings with it challenges in terms of determining the quality of care delivered by the system (ie, timeliness, effectiveness, efficiency, safety, fairness, and patient-centeredness). The unique and somewhat idiosyncratic nature of the stroke rehabilitation system in the United States also presents challenges in terms of assessment of which research findings, among the expanding evidence base of stroke rehabilitation care, are applicable to the system. For example, much of the research documenting the benefits of stroke units and other aspects of organized integrated interprofessional models of stroke care was developed in Europe and elsewhere, and the degree to which these findings are directly applicable to the US system of stroke care is often debated.

Organization of Acute and Postacute Rehabilitation Care in the United States

An excellent review of the current organizational structure of stroke rehabilitation care in the United States can be found in

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Table 2. Definition of Classes and Levels of Evidence Used in AHA/ASA Recommendations

Class I	Conditions for which there is evidence for and/or general agreement that the procedure or treatment is useful and effective
Class II	Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of a procedure or treatment
Class IIa	The weight of evidence or opinion is in favor of the procedure or treatment
Class IIb	Usefulness/efficacy is less well established by evidence or opinion
Class III	Conditions for which there is evidence and/or general agreement that the procedure or treatment is not useful/effective and in some cases may be harmful
Therapeutic recommendations	
Level of Evidence A	Data derived from multiple randomized, clinical trials or meta-analyses
Level of Evidence B	Data derived from a single randomized trial or nonrandomized studies
Level of Evidence C	Consensus opinion of experts, case studies, or standard of care
Diagnostic recommendations	
Level of Evidence A	Data derived from multiple prospective cohort studies using a reference standard applied by a masked evaluator
Level of Evidence B	Data derived from a single grade A study, ≥1 case-control studies, or studies using a reference standard applied by an unmasked evaluator
Level of Evidence C	Consensus opinion of experts

AHA/ASA indicates American Heart Association/American Stroke Association.

the 2010 AHA scientific statement "Comprehensive Overview of Nursing and Interdisciplinary Rehabilitation Care of the Stroke Patient."[11] We briefly review the different stroke neurology, rehabilitation care settings that are essential components of this system (Appendix 1).

Ideally, rehabilitation services are delivered by a multidisciplinary team of healthcare providers with training in neurology, rehabilitation nursing, occupational therapy (OT), PT, and speech and language therapy (SLT). Such teams are directed under the leadership of physicians trained in physical medicine and rehabilitation (physiatrist) or by neurologists who have specialized training or board certification in rehabilitation medicine. Other health professionals who play an essential role in the process include social workers, psychologists, psychiatrists, and counselors.[11]

Health care provided during the acute hospital stay is focused primarily on the acute stabilization of the patient, the delivery of acute stroke treatments, and the initiation of prophylactic and preventive measures. Although the delivery of rehabilitation therapies (OT/PT/SLT) is generally not the first priority, data strongly suggest that there are benefits to starting rehabilitation as soon as the patient is ready and can tolerate it.[11] The cardinal feature of acute inpatient care for stroke patients in the United States is its brevity; the median length of stay for patients with ischemic stroke in only 4 days. Regardless of whether rehabilitation is started during the inpatient stay, all patients should undergo a formal assessment (often conducted by the OT/PT/SLT services) of the patient's rehabilitation needs before discharge.[12] The discharge process may also involve rehabilitation nursing case managers and social workers who can assess psychosocial issues that may influence the transition.

Healthcare services provided after hospital discharge are referred to as postacute care services and are designed to support patients in their transition from the hospital to home and in their pursuit of achieving the highest level of functioning possible. In addition to the rehabilitation care provided by OT/PT/SLT, care may include physiatrists or other physicians, rehabilitation nurses, and nursing aides. The intensity of rehabilitation care varies widely, depending on the setting, with the most intensive rehabilitation care provided in inpatient rehabilitation facilities (IRFs), followed by skilled nursing facilities (SNFs), which provide "subacute" rehabilitation.

IRFs provide hospital-level care to stroke survivors who need intensive, 24-hour-a-day, interdisciplinary rehabilitation care that is provided under the direct supervision of a physician. Medicare (Centers for Medicare & Medicaid Services) regulations specify that admission to IRFs should be limited to patients for whom significant improvement is expected within a reasonable length of time and who are likely to return to a community setting (rather than being transferred to another setting such as a SNF or long-term care facility). Medicare regulations also generally dictate that IRFs provide at least 3 hours of rehabilitation therapy (defined as PT, OT, and SLT) per day for at least 5 d/wk.[11] Physicians are expected to have training or experience in rehabilitation, and daily physician visits are typical. Registered nurses are present on a continuous basis and commonly have specialty certification in rehabilitation nursing. An IRF can be located as a geographically distinct unit within an acute care hospital or as a free-standing facility.

SNFs (also known as subacute rehabilitation) provide rehabilitation care to stroke survivors who need daily skilled nursing or rehabilitation services. Admission to SNFs may be requested for patients who the rehabilitation team determines may not reach full or partial recovery or if skilled nursing services are required to maintain or prevent deterioration of the patient. SNFs are required to have rehabilitation nursing on site for a minimum of 8 h/d, and care must still follow a physician's plan, although there is no requirement for direct daily supervision by a physician.[13] SNFs can be stand-alone facilities, but when located within an existing nursing home or hospital, they must be physically distinguishable from the larger institution (eg, a separate designated wing, ward, or building).

Nursing homes provide long-term residential care for individuals who are unable to live in the community. Many individuals who reside in nursing homes initially enter the facility under their Medicare short-term SNF benefit and then transition to long-term care once the needs for skilled nursing are no longer present. Medicare will provide insurance coverage for up to 100 days in an SNF but does not cover long-term nursing home care, which is generally paid out of pocket, by long-term care insurance, or through the Medicaid program.

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Long-term acute care hospitals are another inpatient setting that delivers postacute rehabilitation care. Long-term acute care hospitals provide extended medical and rehabilitative care to stroke patients with complex medical needs resulting from a combination of acute and chronic conditions (eg, ventilator-dependent care, pain management). As a consequence of this high-needs patient population, facilities must demonstrate an average length of stay of at least 25 days.[14,15] Because of these requirements, long-term acute care hospitals provide care to a relatively small but growing minority of stroke patients.[14]

For stroke patients who go home after an acute hospitalization, rehabilitation care can be provided in the community either by a home healthcare agency (HHCA) or through outpatient offices and clinics. The intensity of rehabilitation care can vary tremendously across these 2 settings. For patients in the Medicare program to be eligible for HHCA services, they must be certified as being homebound by a physician (defined by the Centers for Medicare & Medicaid Services as unable to leave the home except to receive medical care or to have occasional nonmedical trips). HHCAs focus on delivering skilled nursing care and rehabilitation therapy (eg, OT, PT, SLT), as well as some limited assistance with daily tasks provided by home health aides supervised by nurses. Care encompasses medical and social needs and services that are designed to assist the patient in living in his or her own home.[13] Currently, home healthcare services are reimbursed under a prospective payment system that covers up to 60 days of services. These services may be extended if they can be clinically justified. Home healthcare services may also be performed in assisted living facilities or other group homes but are not reimbursed if the services are duplicative of the services of another facility or agency.

Appropriateness of Early Supported Discharge Rehabilitation Services

For selected stroke patients, early discharge to a community setting for ongoing rehabilitation may provide outcomes similar to those achieved in an inpatient rehabilitation unit. This early supported discharge (ESD) model of care links inpatient care with community services and allows certain patients to be discharged home sooner with support of the rehabilitation team.

The efficacy of ESD for patients with acute stroke was evaluated in the ESD Trialists' systematic review.[16] This 2012 review concluded that "appropriately resourced ESD services provided for a selected group of stroke patients can reduce long-term dependency and admission to institutional care as well as reducing the length of hospital stay." No adverse impacts were identified on either mood or the subjective health status of patients or caregivers with ESD. ESD has been studied primarily in Europe and Australia/New Zealand, where systems of care are different than in the United States and where the average acute care hospitalization length of stay for stroke is longer than in the United States. Extrapolation of these results to the United States should take these distinctions into account.

A meta-analysis conducted by Langhorne et al[17] and updated by Langhorne and Holmqvist[18] found that ESD services reduce inpatient length of stay and adverse events (eg, readmission rates) while increasing the likelihood of independence and living at home. Several recent systematic reviews have also reported that ESD after stroke was associated with shorter hospital lengths of stay, lower overall costs of care, lower risk of institutionalization, and no adverse effects on functional recovery.[19–21]

To be effective, ESD should be considered for patients with mild to moderate stroke when adequate community services for both rehabilitation and caregiver support are available and can provide the level of intensity of rehabilitation service needed.[22] Patients should remain in an inpatient setting for their rehabilitation care if they are in need of skilled nursing services, regular contact by a physician, and multiple therapeutic interventions.

Examples for need of skilled nursing services include (but are not limited to) the following:

- Bowel and bladder impairment
- Skin breakdown or high risk for skin breakdown
- Impaired bed mobility
- Dependence for activities of daily living (ADLs)
- Inability to manage medications
- High risk for nutritional deficits

Examples for need of regular contact by a physician include (but are not limited to) the following:

- Medical comorbidities not optimally managed (eg, diabetes mellitus and hypertension)
- Complex rehabilitation issues (eg, orthotics, spasticity, and bowel/bladder)
- Acute illness (but not severe enough to prevent rehabilitation care)
- Pain management issues

Examples for need of multiple therapeutic interventions include (but are not limited to) the following:

- Moderate to severe motor/sensory deficits, and/or
- Cognitive deficits, and/or
- Communication deficits

Outpatient therapies require patients to travel from their home to obtain care at hospital-based or free-standing facilities. All outpatient OT, PT, and SLT services must be certified by a physician who is responsible for establishing a planned set of therapy services. These therapies must be complex enough that they can be performed only by a qualified healthcare professional. Treatment plans need to be reviewed and recertified every 30 days.

Multiple transitions in care are typical for individuals recovering from stroke and pose particular challenges for healthcare providers, stroke survivors, and their caregivers in terms of maintaining continuity of care and avoiding undesirable lapses in the rehabilitation program of care. Moreover, stroke survivors need to navigate the transition from a medical model of treatment to a more community-based model that includes return to work (for some), leisure activities, and exercise for fitness. The Transitions in Care and Community Rehabilitation section addresses transitions to the community after discharge.

Trends in the Use of Acute and Postacute Stroke Rehabilitation in the United States

The organization of rehabilitation stroke services in the United States has changed considerably over time in response to the frequent changes to the federal reimbursement fee structure for both acute (inpatient) and postacute

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care. Currently, ≈70% of Medicare beneficiaries discharged for acute stroke use Medicare-covered postacute care,[23] with most receiving rehabilitation care from multiple providers in several different settings.[24,25] Considering the first setting after the acute hospitalization, the largest proportion of stroke patients are referred for rehabilitation to an SNF (32%), followed by an IRF (22%) and then HHCA (15%).[26] Major changes in the Medicare postacute care reimbursement policies starting in the 1990s dramatically affected use patterns,[26] particularly for HHCAs, after the introduction of an interim payment system in 1997 with extensive changes to its rules and regulations in 2000. The introduction of prospective payment systems for SNFs (1998), IRFs (2002), and long-term acute care hospitals (2002) also affected their use.[13,27] Between 1996 and 2003, the proportion of Medicare stroke patients who received care from HHCAs declined by >25% during this period (from 20% to 15%),[26] whereas the proportion who received SNF or IRF care remained relatively unchanged. However, the proportion of stroke patients not referred to any postacute care increased from 26% to 31% during this period,[26] and an analysis of 2006 Medicare data found that this proportion had increased to 42%.[28] Although legislated payment changes have had major influences on where rehabilitation services are provided, several other nonclinical factors affect the use of postacute care rehabilitation services. There is considerable geographic variability in the use of these services in the United States,[29] which is driven in part by local differences in the availability of postacute care settings and regulatory practices.[29–33] Factors such as the daily census, case mix, teaching status, ownership, and urbanicity of the hospital and the percentage of patients served by Medicare have been shown to influence use patterns of postacute services.[30,34,35] At the patient level, sociodemographic factors such as age, income, race, and living circumstances have also been shown to affect the use and type of rehabilitation services provided.[30–33,36–38]

Of central interest to researchers and policy makers is the need for a better understanding of the impact of rehabilitation care at these different rehabilitation settings on patient outcomes, especially relative to resource use and costs. The studies that have compared outcomes in hospitalized stroke patients first discharged to an IRF, an SNF, or a nursing home have generally shown that IRF patients have higher rates of return to community living[39,40] and greater functional recovery,[39–42] whereas patients discharged to an SNF or a nursing home have higher rehospitalization rates[43] and substantially poorer survival.[44,45] However, all of these studies have limitations resulting from their observational designs, which rely on administrative data[39–41] or data from a limited number of facilities.[42] Importantly, most of these studies demonstrate substantial baseline differences in patient case mix between settings, with IRF patients having a more favorable prognostic outlook because of their younger age, lower prestroke disability, fewer comorbidities, and greater caregiver/family support and because they have been selected for their potential to return to the community.[39–41,45] These differences serve to illustrate that the decision to refer a stroke patient to a particular setting after discharge is dictated by a complex set of demographic, clinical, and nonclinical factors that are also inevitably related to patient outcomes. This inherent confounding or channeling bias[46] has been addressed by these studies through the application of complex statistical methods.[39–41] However, uncertainty remains about how much of the final difference in outcome is attributable to residual confounding resulting from unmeasured factors (particularly stroke severity and prestroke disability). Despite these concerns, the consistency of the findings in favor of IRF referral suggests that stroke survivors who qualify for IRF services should receive this care in preference to SNF-based care.

Recommendations: Organization of Poststroke Rehabilitation Care (Levels of Care)	Class	Level of Evidence
It is recommended that stroke patients who are candidates for postacute rehabilitation receive organized, coordinated, interprofessional care.	I	A
It is recommended that stroke survivors who qualify for and have access to IRF care receive treatment in an IRF in preference to a SNF.	I	B
Organized community-based and coordinated interprofessional rehabilitation care is recommended in the outpatient or home-based settings.	I	C
ESD services may be reasonable for people with mild to moderate disability.	IIb	B

Rehabilitation Interventions in the Inpatient Hospital Setting

There is strong evidence that organized, interprofessional stroke care not only reduces mortality rates and the likelihood of institutional care and long-term disability but also enhances recovery and increases independence in ADLs.[47–50] Although many small, randomized, clinical trials have studied interventions in the acute rehabilitation phase, the only large, randomized, clinical trials in stroke recovery and rehabilitation have focused on the chronic recovery phase.[51,52] This section updates the scientific statement on the comprehensive overview of nursing and interprofessional rehabilitation care of the stroke patient and previously summarized recommendations for care of the stroke survivor in the inpatient rehabilitation phase.[11]

Although acute stroke units have higher levels of nurse staffing, earlier assessments of stroke type and treatment, and more intensive physiological monitoring, rehabilitation units (including comprehensive stroke units in Europe) emphasize recovery and rehabilitation, involving rehabilitation physicians and allied health professionals, increased interprofessional staff education and training, greater patient and caregiver participation in rehabilitation, and early mobilization protocols.[53] Age, cognition, functional level after stroke, and to a lesser extent continence have shown consistent associations with poststroke outcomes, and stroke severity is associated with acute discharge disposition, final discharge disposition, and functional level.[54] In recent years, lengths of stay in IRFs have decreased significantly, but in survivors with mild to moderate stroke, patient satisfaction does not appear to be diminished, and recovery actually may be faster.[55] In the United States, data after the initiation of prospective payment for rehabilitation in 2002 suggest that discharges from IRFs to institutional settings have increased.[56]

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Timing and intensity of acute rehabilitation also are important issues in poststroke functional outcomes but remain controversial. Overall, a 2009 meta-analysis demonstrated insufficient evidence to support or refute the efficacy of routine very early mobilization after stroke compared with conventional care.[57] In the recently completed randomized, controlled trial (RCT) of the efficacy and safety of very early mobilization within 24 hours of stroke onset (A Very Early Rehabilitation Trial [AVERT]), the high-dose, very early mobilization protocol was associated with a reduction in the odds of a favorable outcome at 3 months.[58] Early mobilization after stroke is recommended in many clinical practice guidelines worldwide. The AVERT findings should affect clinical practice by refining present guidelines, but clinical recommendations should be informed by future analyses of dose-response associations.

The only evidence assessing the intensity of stroke rehabilitation comes from literature comparing IRFs with subacute rehabilitation. In a study of 222 subjects, Chan et al[59] reported that subjects whose care included an IRF stay experienced functional scores at least 8 points higher (twice the minimally detectable change) on the Activity Measure for Post-Acute Care than those who went to SNFs or received home health/outpatient care. A retrospective cohort study of 360 subjects demonstrated that subjects who received >3.0 hours of therapy daily made significantly more functional gains than those receiving <3.0 hours daily, although hemorrhagic stroke, left-sided brain injury, earlier IRF admission, and longer IRF stay also were associated with total functional improvement.[60]

Finally, the efficacy of complementary medicine techniques has been studied in the IRF environment. In a randomized, clinical trial of 274 subjects receiving acupuncture, PT, or both, no synergistic effect was found when acupuncture was added to PT, although all subjects exhibited functional gains.[61] An RCT of 53 subjects receiving whole-body somatosensory stimulation or exercise therapy in addition to conventional rehabilitation demonstrated no significant increases in the recovery of balance and ADLs.[62]

For evidence pertaining to dysphagia; interventions for upper limb rehabilitation, including upper extremity activities (ie, ADLs, instrumental ADLs [IADLs]), touch, and proprioception; lower extremity rehabilitation, including mobility (eg, locomotion) and balance/vestibular rehabilitation; and therapies for cognitive impairments and hemi-spatial neglect, the reader is directed to those subsections in The Rehabilitation Program section.

Recommendations: Rehabilitation Interventions in the Inpatient Hospital Setting	Class	Level of Evidence
It is recommended that early rehabilitation for hospitalized stroke patients be provided in environments with organized, interprofessional stroke care.	I	A
It is recommended that stroke survivors receive rehabilitation at an intensity commensurate with anticipated benefit and tolerance.	I	B
High-dose, very early mobilization within 24 hours of stroke onset can reduce the odds of a favorable outcome at 3 months and is not recommended.	III	A

Prevention and Medical Management of Comorbidities

Prevention of Skin Breakdown and Contractures

Hemiparesis, sensory changes, and altered levels of consciousness place the patient with stroke at risk for joint and muscle contractures and skin breakdown. Pressure ulcers are also associated with impaired circulation, older age, and incontinence. Regular assessment of skin and the use of objective scales of risk such as the Braden scale are valuable in the prevention of skin injury and should be followed by regular skin inspection with documentation.[63] Agency for Healthcare Research and Quality (AHRQ) guidelines recommend minimizing or eliminating friction, minimizing pressure, providing appropriate support surfaces, avoiding excessive moisture, and maintaining adequate nutrition and hydration.[63] Specific measures include regular turning (at least every 2 hours), good hygiene, and the use of special mattresses and proper wheelchair seating to prevent skin injury.[11]

After stroke with hemiparesis, 60% of patients will develop joint contracture on the affected side within the first year, with wrist contractures occurring most commonly in patients who do not recover functional hand use.[65,66] The occurrence of elbow contractures within the first year after stroke is associated with the presence of spasticity within the first 4 months.[67] These contractures can cause pain and make self-care, including dressing and hygiene, difficult. Many clinicians recommend daily stretching of the hemiplegic limbs to avoid contractures, and patients and families should be taught proper stretching techniques to avoid injury and to maximize effectiveness. Resting hand splints are often applied to prevent contractures in hemiplegic wrist and fingers, but their effectiveness is not well established.[68,69] There is controversy over the benefit of resting hand splints such that the Royal College of Physicians National Institute for Clinical Excellence guidelines recommend against the use of resting hand splints but the Veterans Affairs/Department of Defense clinical practice guidelines recommend their use.[4,70,71] Application of resting hand splints combined with other treatments, including early botulinum toxin injection to wrist and finger flexors, may be beneficial.[72] Early after stroke, positioning of the hemiplegic shoulder in maximum external rotation for 30 minutes each day either in bed or in a chair can be useful for preventing shoulder contracture.[73,74] Applying serial casting or static adjustable splints may be beneficial in preventing elbow or wrist contractures, although data are conflicting.[4,72,75,76] Surgical release of the brachialis, brachioradialis, and biceps muscles is a reasonable option to treat pain and range-of-motion limitations in patients with substantial established elbow flexor contractures.[77]

Ankle plantarflexion contractures after stroke can affect gait quality and safety. The use of an ankle-foot orthosis (AFO) can improve gait in patients with active plantarflexion during the swing phase of gait but also may be beneficial in preventing ankle contracture.[78] For nonambulatory patients, the use of a resting ankle splint at night, set in the plantigrade position (ankle at 90° and subtalar neutral), or

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standing on a tilt table for 30 min/d is probably useful in preventing contracture.[78]

Recommendations: Prevention of Skin Breakdown and Contractures	Class	Level of Evidence
During hospitalization and inpatient rehabilitation, regular skin assessments are recommended with objective scales of risk such as the Braden scale.	I	C
It is recommended to minimize or eliminate skin friction, to minimize skin pressure, to provide appropriate support surfaces, to avoid excessive moisture, and to maintain adequate nutrition and hydration to prevent skin breakdown. Regular turning, good skin hygiene, and use of specialized mattresses, wheelchair cushions, and seating are recommended until mobility returns.	I	C
Patients, staff, and caregivers should be educated about the prevention of skin breakdown.	I	C
Positioning of hemiplegic shoulder in maximum external rotation while the patient is either sitting or in bed for 30 minutes daily is probably indicated.	IIa	B
Resting hand/wrist splints, along with regular stretching and spasticity management in patients lacking active hand movement, may be considered.	IIb	C
Use of serial casting or static adjustable splints may be considered to reduce mild to moderate elbow and wrist contractures.	IIb	C
Surgical release of brachialis, brachioradialis, and biceps muscles may be considered for substantial elbow contractures and associated pain.	IIb	B
Resting ankle splints used at night and during assisted standing may be considered for prevention of ankle contracture in the hemiplegic limb.	IIb	B

Prevention of Deep Venous Thrombosis

Survivors of acute stroke are at high risk of deep venous thrombosis (DVT) and pulmonary embolism (PE) as a result of a combination of limb immobility and reduced activity level.[79] Prevention of DVT and PE can be divided into pharmacological and mechanical methods in both ischemic and hemorrhage strokes. Prophylactic treatment is initiated depending on the type of stroke and use of thrombolytic therapy. Therapy usually is continued throughout the rehabilitation stay or until the stroke survivor regains mobility, with few studies examining the optimal duration of prophylaxis. For patients with mild motor impairments who are discharged directly home from the hospital, DVT prophylaxis may not be needed. For patients discharged to an SNF with a stay that extends beyond the active rehabilitation program, the duration of prophylactic treatment remains at the discretion of the treating physician.

Recommendations for the prevention of DVT and PE in ischemic stroke are delineated in great detail in the American College of Chest Physicians' "Antithrombotic Therapy and Prevention of Thrombosis, 9th edition."[80] One meta-analysis of 16 trials involving 23 043 patients with acute ischemic stroke compared stroke survivors receiving varying amounts of unfractionated heparin (UFH) with control subjects.[81] The use of high-dose UFH (>15 000 U/d) was associated with a reduction in PE (odds ratio [OR], 0.49; 95% confidence interval [CI], 0.29–0.83) but also with an increased risk of intracerebral hemorrhage (ICH; OR, 3.86; 95% CI, 2.41–6.19) and extracerebral hemorrhage (ECH; OR, 4.74; 95% CI, 2.88–7.78). Low-dose UFH (<15 000 U/D) decreased the thrombosis risk (OR, 0.17; 95% CI, 0.11–0.26) but had no influence on the risk of PE (OR, 0.83; 95% CI, 0.53–1.31). The risk of ICH or ECH was not significantly increased (OR, 1.67; 95% CI, 0.97–2.87 for ICH; OR, 1.58; 95% CI, 0.89–2.81 for ECH) with prophylactic-dose UFH.

Adjusted-dose low-molecular-weight heparin (LMWH) decreased the risk of both DVT (OR, 0.07; 95% CI, 0.02–0.29) and PE (0.44; 95% CI, 0.18–1.11), but this benefit was offset by an increased risk of ICH (OR, 2.01; 95% CI, 1.02–3.96) and ECH (OR, 1.78; 95% CI, 0.99–3.17). Prophylactic-dose LMWH (defined as 3000–6000 IU/d) reduced the incidence of both DVT (OR, 0.34; 95% CI, 0.19–0.59) and PE (OR, 0.36; 95% CI, 0.15–0.87) without an increased risk of ICH (OR, 1.39; 95% CI, 0.53–3.67) or ECH (OR, 1.44; 95% CI, 0.13–16). For prophylactic-dose LMWH, the number needed to treat to avoid 1 event was 7 for DVT and 38 for PE.

Overall, the guidelines of the American College of Chest Physicians (9th edition) found an estimated reduction in overall mortality of 12 deaths per 1000 individuals receiving either UFH or LMWH compared with no anticoagulation[80]; no form of prophylaxis is 100% effective in preventing venous thromboembolism in this population, however.

A meta-analysis[82] and a Cochrane systematic review of 9 trials involving 3137 subjects confirmed the superiority of LMWH over UFH.[83] Only 1 high-quality cost-effectiveness analysis comparing LMWH with UFH in acutely ill medical subjects (not stroke) demonstrated fewer complications with LMWH at a lower overall cost.[84]

Intermittent pneumatic compression or sequential compression devices are designed to spur blood flow by intermittently applying pressure on the calf muscles and vasculature. One Cochrane systematic review of 2 small studies including 177 subjects demonstrated a nonsignificant trend toward a lower risk of DVT (OR, 0.45; 95% CI, 0.19–1.10) with no significant effect on mortality (OR, 1.04; 95% CI, 0.37–2.89).[85]

Elastic compression stockings, also referred to as graduated compression stockings, are designed to promote venous blood flow by applying a pressure gradient from the ankle more proximally. One large, randomized, clinical trial involving 2518 subjects failed to demonstrate a positive or negative effect on the occurrence of symptomatic proximal DVT or PE.[86] However, subjects using elastic compression stockings had an increase in skin complications (relative risk [RR], 4.18; 95% CI, 2.4–7.3). One Cochrane systematic review of 2 trials including 2615 subjects demonstrated no significant reduction in DVT (OR, 0.88; 95% CI, 0.72–1.08) or death (OR, 1.13; 95% CI, 0.87–1.47).[85]

The addition of elastic compression stockings to intermittent pneumatic compression has been studied in a few small studies but has failed to demonstrate a positive or negative effect.[87] Studies in other patient populations have demonstrated

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that the combination of elastic compression stockings and pharmacological prophylaxis significantly reduced the incidence of symptomatic or asymptomatic DVT (OR, 0.40; 95% CI, 0.25–0.65). However, the benefit of treatment should be weighed against the increase in skin complications observed with the use of elastic compression stockings.[88]

With respect to hemorrhagic stroke, prophylactic-dose heparin does not increase the risk of recurrent intracranial bleeding significantly, although the overall quality of the evidence is low.[80] In 1 small study comparing the initiation of prophylactic heparin on the second and fourth hospital days, there were no harmful or beneficial effects on any outcomes.[89] This study provides very low-quality evidence that early use of prophylactic-dose heparin is safe in stroke survivors with primary ICH.

Comparisons of the effects between UFH and LMWH and the effects of intermittent pneumatic compression and elastic compression stockings have not been done in stroke survivors with primary ICH. Therefore, recommendations are consistent with those of ischemic stroke.[80]

Recommendations: Prevention of DVT	Class	Level of Evidence
In ischemic stroke, prophylactic-dose subcutaneous heparin (UFH or LMWH) should be used for the duration of the acute and rehabilitation hospital stay or until the stroke survivor regains mobility.	I	A
In ischemic stroke, it is reasonable to use prophylactic-dose LMWH over prophylactic-dose UFH for prevention of DVT.	IIa	A
In ischemic stroke, it may be reasonable to use intermittent pneumatic compression over no prophylaxis during the acute hospitalization.	IIb	B
In ICH, it may be reasonable to use prophylactic-dose subcutaneous heparin (UFH or LMWH) started between days 2 and 4 over no prophylaxis.	IIb	C
In ICH, it may be reasonable to use prophylactic-dose LMWH over prophylactic-dose UFH.	IIb	C
In ICH, it may be reasonable to use intermittent pneumatic compression devices over no prophylaxis.	IIb	C
In ischemic stroke, it is not useful to use elastic compression stockings.	III	B
In ICH, it is not useful to use elastic compression stockings.	III	C

Treatment of Bowel and Bladder Incontinence

Urinary incontinence and fecal incontinence are common problems after stroke. Approximately 40% to 60% of stroke patients have urinary incontinence during their acute admission for stroke, falling to 25% by hospital discharge. At 1 year, 15% will remain incontinent of urine.[90] Age, cognition, and motor impairments are risk factors for bladder incontinence. Fecal incontinence prevalence is ≈40% acutely but diminishes to 20% by discharge from rehabilitation. Age and functional impairment are risk factors for fecal incontinence on admission for stroke.[91] Impaired awareness of urinary incontinence is correlated with mortality[92] and the need for nursing home care 3 months after stroke.[93] On a positive note, many patients recover continence after stroke. Because of the risk of skin breakdown, the social stigma, and the burden of care associated with incontinence, management of bowel and bladder continence is an essential part of the rehabilitation process.

Although considerable data on the rate of urinary incontinence exist, there is a paucity of published studies on therapeutic interventions to improve rates of continence. The recommendation to remove indwelling urinary catheters within 24 hours is based on the Centers for Disease Control and Prevention recommendations for all hospitalized patients to prevent catheter-associated urinary tract infections and is not specific to stroke.[94]

The studies reported by Pettersen et al[92] and Myint et al[95] combined multiple recommendations representing "best practice" for bladder management and applied them to a modest-sized population of stroke patients. Their studies showed success but limited generalizability because of study design. It is impossible to ascertain which of the multiple interventions were responsible for the improvements seen.

Cognitive awareness plays a role in continence and ultimately in overall stroke outcome. There are many types and causes of incontinence, ranging from impaired awareness of the need to void to difficulty with mobility in reaching the bathroom to communication difficulties resulting from aphasia.

We were unable to identify any high-quality studies of treatment for fecal incontinence after stroke, and recommendations are based on the general population of adults.[96]

Recommendations: Treatment of Bowel and Bladder Incontinence	Class	Level of Evidence
Assessment of bladder function in acutely hospitalized stroke patients is recommended.		
A history of urological issues before stroke should be obtained.	I	B
Assessment of urinary retention through bladder scanning or intermittent catheterizations after voiding while recording volumes is recommended for patients with urinary incontinence or retention.	I	B
Assessment of cognitive awareness of need to void or having voided is reasonable.	IIa	B
Removal of the Foley catheter (if any) within 24 hours after admission for acute stroke is recommended.	I	B
It is reasonable to use the following treatment interventions to improve bladder incontinence in stroke patients:	IIa	B
Prompted voiding		
Pelvic floor muscle training (after discharge home)		
It may be reasonable to assess prior bowel function in acutely hospitalized stroke patients and include the following:	IIb	C
Stool consistency, frequency, and timing (before stroke)		
Bowel care practices before stroke		

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Assessment, Prevention, and Treatment of Hemiplegic Shoulder Pain

Shoulder pain is common after stroke, with an incidence during the first year of 1% to 22%.[97,98] The reported prevalence of shoulder pain varies between 5% and 84%, depending on the acuity and definition of shoulder pain used.[99] The development of shoulder pain after stroke is associated with shoulder subluxation and motor weakness. Importantly, these 2 factors have strong covariance, suggesting that motor impairment may be the more important predictive factor.[100] However, motor weakness is not predictive of pain severity in the hemiplegic shoulder. Spasticity is believed to contribute to the genesis of shoulder pain in some patients, although a causal relationship has not been confirmed. Other predictors of shoulder pain include older age, left hemiplegia, the presence of tactile extinction and reduced proprioception in the painful limb, early complaints of pain, reduced passive shoulder abduction and external rotation of glenohumeral joint, a positive Neer impingement sign (shoulder pain with passive abduction of the internally rotated arm), and tenderness to palpation over the biceps tendon and supraspinatus.[101–105]

Hemiplegic shoulder pain is multifactorial. Pain is associated with shoulder tissue injury, abnormal joint mechanics, and central nociceptive hypersensitivity. About one third of patients with acute stroke have abnormal ultrasound findings in the hemiplegic shoulder when studied at the time of admission to acute inpatient rehabilitation, including effusion in biceps tendon or subacromial bursa; tendinopathy of biceps, supraspinatus, or subscapularis; and rotator cuff tear.[106,107] Such findings are more prevalent in the hemiplegic shoulder than in the nonhemiplegic shoulder and in those with more severe hemiplegia, subluxation, spasticity, limited joint range, and shoulder pain.[106] The frequency of abnormal ultrasound findings in the hemiplegic shoulder increases over the course of rehabilitation in patients with more severe motor impairment.[106,107] Although there is an association between abnormal findings on shoulder ultrasound and hemiplegic shoulder pain in patients with acute stroke, a causal association has not been established. Among patients with acute and chronic stroke with hemiplegic shoulder pain, the presence of shoulder tissue injury on imaging is not associated with the severity of pain.[108,109]

Patients with stroke-related hemiplegia demonstrate altered movement patterns at certain stages of recovery. In the acute phase of stroke, shoulder subluxation is associated with pain. In those with chronic stroke and hemiplegic shoulder pain, there is capsular stiffness and altered resting position of the scapula in lateral rotation.[103,110] Compared with those without voluntary movement, patients with some movement in the painful hemiparetic shoulder have a higher rate of shoulder joint tissue injury on magnetic resonance imaging, suggesting that more physical activity promotes injury.[109] However, the relationship between altered kinematics and pain in the hemiparetic shoulder has not been established. For example, shoulder joint kinematics are altered with spasticity, yet there are no clear correlations between reductions in Ashworth and pain scores or reductions in subluxation and pain.[111] Thus, the exclusive role of peripheral nociceptive pain in the mechanically altered hemiplegic shoulder has been questioned.[112]

There is recent evidence supporting both a peripheral and a central neuropathic role for shoulder pain.[112–114] Patients with hemiplegic shoulder pain have a higher prevalence of altered somatosensory function with reduced sensory thresholds and decreased kinesthesia than patients without pain and normal control subjects.[105,115–117] In addition, patients with shoulder pain have higher rates of allodynia and hyperpathia on both the affected and less affected sides than stroke patients without pain.[116,117] Patients with painful shoulders also have higher heat pain thresholds and lower pain pressure thresholds.[117,118] Soo Hoo and colleagues[118] found lower pain pressure thresholds on the affected and less affected sides in patients with shoulder pain. Somatosensory evoked responses from the affected upper limb differ between stroke patients with and those without shoulder pain.[119] Although diagnostically distinct from hemiplegic shoulder pain, complex regional pain syndrome (also called shoulder-hand syndrome) is characterized by allodynia and hyperpathia and includes shoulder pain as a key component. Thus, there is growing recognition that hemiplegic shoulder pain is a syndrome with biomechanical and central nervous system components and overlaps with complex regional pain syndrome.

Interventions to prevent the onset of and to treat shoulder pain in patients with stroke-related hemiplegia include proper positioning, maintenance of shoulder range of motion, and motor retraining. For people in wheelchairs, lap trays and arm troughs might be useful positioning devices to reduce shoulder pain and subluxation. Some suggest that consistent performance of aggressive passive range-of-motion exercises may reduce or prevent later shoulder problems, but the evidence in support of or against this suggestion is missing. Aggressive range of motion of the complex shoulder joint, if done improperly, could do more harm than good. The use of slings, especially during ambulation training to protect the shoulder from traction injury, may be considered, and the use of overhead pulley exercises should be avoided.[70,120] Research has focused on several adjuvant treatments, including strapping, acupuncture, and neuromuscular electrical stimulation (NMES). There are a few RCTs with mixed results on shoulder strapping for the prevention of shoulder pain after acute stroke.[121–123] Each study used different strapping (or taping) techniques and measured different pain outcomes. In the largest of these, Pandian and others[123] randomized 162 patients with acute stroke to either shoulder taping or sham taping. There was a trend toward a difference in visual analog pain scale and pain-related disability scores over 30 days, but these differences were not statistically or clinically significant. Currently, there is insufficient evidence to support or refute the efficacy of shoulder strapping (taping) for the prevention of hemiplegic shoulder pain.

Acupuncture in combination with standard therapeutic exercise may be a safe and effective adjuvant for the treatment of hemiplegic shoulder pain. This was suggested by Lee and colleagues[124] in a recent systematic review of this topic. They found 7 RCTs, all showing positive effects. However, they could not recommend concrete conclusions because of the limited number of available trials.

Various types of skin surface electrical stimulation have been evaluated for the treatment of hemiplegic shoulder pain, including transcutaneous electrical nerve stimulation (TENS) and NMES. These modalities have not been evaluated sufficiently, and their efficacy for pain prevention and treatment

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remains inconclusive.[125] The largest RCT to date testing surface NMES to a hemiplegic shoulder showed no effect on pain prevention in patients with acute stroke; however, pain was not a primary outcome measure in this study.[126] Compliance with the use of surface NMES has been variable in these studies, and surface NMES has been shown to be less well tolerated than intramuscular NMES.[126–128] Intramuscular NMES for 6 h/d over 6 weeks with 4 implanted electrodes showed efficacy in 2 open-label trials.[129,130] Pain differences between treatment and control groups remained significant 12 months after treatment, and NMES was more effective in patients with less chronic stroke (defined as <77 months after stroke in this study).[131,132] Although fully implanted intramuscular stimulators for hemiplegic shoulder have been developed, there are insufficient data to support efficacy to date.[133]

Corticosteroid injection into glenohumeral joint or subacromial space is commonly used to treat shoulder pain. There are limited studies on the use of steroid injection in the painful hemiplegic shoulder. Observational studies have shown a significant reduction in hemiplegic shoulder pain after either glenohumeral or subacromial injection, but the long-term pain reduction has not been verified.[134,135] These injections result in superior short-term pain reduction compared with standard care.[136] There are only 2 randomized trials of shoulder joint injections for pain. Snels and colleagues[137] showed no significant effect on pain reduction after glenohumeral injection. In contrast, Rah and others[138] showed a significant reduction in pain after corticosteroid injection compared with placebo. In the latter study, Rah et al selected only patients with shoulder joint pathology that was verified by ultrasonography.

Botulinum toxin injections into the shoulder musculature have shown mixed results in the management of shoulder pain. de Boer and colleagues[139] showed no impact of botulinum toxin injection into the subscapularis of painful hemiplegic shoulders, whereas Yelnick and colleagues[140] showed significant reductions in pain scores in patients treated for shoulder spasticity. Some investigators have noted reduced pain with shoulder movement after botulinum toxin injections to the pectoralis major and biceps brachii, but others found no change in reported pain scores after pectoralis major injection.[141–143] Lim et al[144] found botulinum toxin injections to the pectoralis major, infraspinatus, and subscapularis muscles superior to glenohumeral steroid injection. Botulinum toxin injections may decrease shoulder spasticity and pain associated with spasticity-related joint mobility restrictions but are not sufficient to reduce shoulder pain in general.

Suprascapular nerve blocks may be effective in reducing shoulder pain through a reduction of both nociceptive and neuropathic pain mechanisms. A recent randomized, clinical trial showed that suprascapular nerve blocks were superior to placebo injections in reducing hemiplegic shoulder pain for up to 12 weeks after treatment.[145,146] In another small, comparison study of patients with nonneuropathic hemiplegic shoulder pain, suprascapular nerve blocks were as effective as glenohumeral triamcinolone injections.[147]

Surgical tenotomy of the pectoralis major, lattisimus dorsi, teres major, and subscapularis muscles may reduce pain in patients with severe hemiplegia and restrictions in shoulder range of motion.[148] In patients with clinical evidence of a central pain component associated with sensory changes, allodynia, and hyperpathia, medication management with neuromodulating medications may be considered.[70,120,149]

Recommendations: Assessment, Prevention, and Treatment of Hemiplegic Shoulder Pain	Class	Level of Evidence
Patient and family education (ie, range of motion, positioning) is recommended for shoulder pain and shoulder care after stroke, particularly before discharge or transitions in care.	I	C
Botulinum toxin injection can be useful to reduce severe hypertonicity in hemiplegic shoulder muscles.	IIa	A
A trial of neuromodulating pain medications is reasonable for patients with hemiplegic shoulder pain who have clinical signs and symptoms of neuropathic pain manifested as sensory change in the shoulder region, allodynia, or hyperpathia.	IIa	A
It is reasonable to consider positioning and use of supportive devices and slings for shoulder subluxation.	IIa	C
A clinical assessment can be useful, including:		
Musculoskeletal evaluation	IIa	C
Evaluation of spasticity	IIa	C
Identification of any subluxation	IIa	C
Testing for regional sensory changes	IIa	C
NMES may be considered (surface or intramuscular) for shoulder pain.	IIb	A
Ultrasound may be considered as a diagnostic tool for shoulder soft tissue injury.	IIb	B
Usefulness of acupuncture as an adjuvant treatment for hemiplegic shoulder pain is of uncertain value.	IIb	B
Usefulness of subacromial or glenohumeral corticosteroid injection for patients with inflammation in these locations is not well established.	IIb	B
Suprascapular nerve block may be considered as an adjunctive treatment for hemiplegic shoulder pain.	IIb	B
Surgical tenotomy of pectoralis major, lattisimus dorsi, teres major, or subscapularis may be considered for patients with severe hemiplegia and restrictions in shoulder range of motion.	IIb	C
The use of overhead pulley exercises is not recommended.	III	C

Central Pain After Stroke

Central poststroke pain is pain that results from a lesion in the somatosensory system rather than from a peripheral nociceptive or psychogenic cause.[150,151] Diagnostic criteria include requirements that the pain occur after stroke, be located in an area of the body that corresponds to the lesion in the central nervous system, and not be accounted for by nociceptive or peripheral neuropathic pain.[100] Central pain is classically associated with thalamic stroke (Dejerine-Roussy syndrome) but can result from a lesion anywhere along the spinothalamic and thalamocortical tracts within the central nervous system.[150] Central pain symptoms are usually described as burning or aching and often include

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allodynia associated with touch, cold, or movement.[152–155] Use of diagnostic criteria for central poststroke pain such as those proposed by Klit et al[151] can be helpful. The incidence of central poststroke pain is estimated at 7% to 8%, and it typically begins within a few days after stroke, with the majority of patients becoming symptomatic within the first month.[152,154]

There is limited evidence on the efficacy of proposed treatments for central poststroke pain. Pharmacotherapy combined with therapeutic exercise and psychosocial support is a reasonable approach.[156] Response to treatment is best assessed with standardized serial measurements such as pain diaries, visual analog scales, or pain questionnaires.[157] Pharmacotherapy has relied primarily on antidepressant medications and anticonvulsants. Amitriptyline 75 mg at bedtime has been shown to lower daily pain ratings and to improve global functioning.[158] Lamotrigine can reduce daily pain ratings and cold-induced pain, but only 44% of patients given this medication have a good clinical response.[159] Results for pregabalin have been mixed, with 2 clinical trials finding that daily pain reporting with pregabalin was not significantly better than with placebo.[160,161] Sleep and anxiety were improved with pregabalin, however. Gabapentin has not been well studied for poststroke central pain but has been effective in other forms of neuropathic pain.[162,163] Other options for central pain management include carbamazepine and phenytoin, but their usefulness is not well established.[158,164]

There are few nonpharmacological options for the management of central poststroke pain. TENS was shown to be ineffective in a small trial.[165] Motor cortex stimulation can be given with a surgically implanted dural electrode overlying the motor cortex that is connected to a subcutaneous pulse generator. In several case series, pain reductions of >50% on the visual analog scale were achieved in 50% to 83% of patients, with effectiveness for up to 2 years after implantation.[166–169] However, cortical stimulator implantation is associated with several complications, including infection, hardware failure, postoperative seizures, and long-term epilepsy. Motor cortex stimulation may be an option for intractable central poststroke pain. Deep brain stimulation has conflicting evidence for the management of central pain and currently cannot be recommended.[170,171]

Recommendations: Central Pain After Stroke	Class	Level of Evidence
The diagnosis of central poststroke pain should be based on established diagnostic criteria after other causes of pain have been excluded.	I	C
The choice of pharmacological agent for the treatment of central poststroke pain should be individualized to the patient's needs and response to therapy and any side effects.	I	C
Amitriptyline and lamotrigine are reasonable first-line pharmacological treatments.	IIa	B
Interprofessional pain management is probably useful in conjunction with pharmacotherapy.	IIa	C
Standardized measures may be useful to monitor response to treatment.	IIb	C
Pregabalin, gabapentin, carbamazepine, or phenytoin may be considered as second-line treatments.	IIb	B
TENS has not been established as an effective treatment.	III	B
Motor cortex stimulation might be reasonable for the treatment of intractable central poststroke pain that is not responsive to other treatments in carefully selected patients.	IIb	B
Deep brain stimulation has not been established as an effective treatment.	III	B

Prevention of Falls

A great deal of research literature exists on the epidemiology, risk factors, and development of prevention programs for falls in the general population of older adults.[172] Less information is available for individuals with stroke. Falls and their prevention in individuals with stroke require special considerations.[173] Risk factors, interventions, and prevention programs developed for the community-living older population will not necessarily translate to the population of individuals with stroke. The Balance and Ataxia section provides more discussion.

Up to 70% of individuals with a stroke fall during the first 6 months after discharge from the hospital or rehabilitation facility.[174] Individuals with stroke are also at risk to be repeat fallers and to experience an injury associated with a fall.[175] A larger portion of fractures occurring in individuals with stroke (27%) involve the hip or pelvis compared with <10% of the general population of older adults who fall.[176] The loss of bone mineral density (BMD) associated with stroke may contribute to the higher hip fracture rate for individuals with stroke.[177]

In addition to the physical consequences associated with fractures and related injuries, falls have psychological and social consequences. The impairments in balance, gait, motor control, perception, and vision contribute to a heightened fear of falling in individuals with stroke. Studies indicate that 30% to 80% of individuals with stroke report various levels of fear associated with falling and mobility.[178] Fear of falling can lead to reduced levels of physical activity and deconditioning, creating a cascade that may result in greater declines in physical activity, a decrease in ADLs, a loss of independence, fewer community interactions, social isolation, and depression. Ironically, the reduction in physical activity resulting from fear of falling can itself contribute to an increased risk of falls.[179]

Risk Factors and Assessment

Evaluation of risk factors is widely recognized as the first step in preventing falls. A systematic review[180] of factors contributing independently to falls in the general older population identified previous falls, low muscle strength, impaired gait, poor balance, and use of specific and multiple medications as the strongest risk factors for falls. Research suggests that risk factors in the stroke population are similar overall but with some differences.[173] For example, a history of falls before a stroke does not appear to be as strong a risk factor as it is in the general older population.[173]

The probability of falling also increases with the number of risk factors. Tinetti and others[181] reported that the 1-year risk of falling among the general elderly population increased from a range of 8% to 19% for individuals with no risk factors to >70% for individuals with ≥4 risk factors.

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The assessment of risk factors varies across settings and circumstances. For example, a majority of falls for individuals with stroke that occur during hospitalization are associated with transfers and attempting activities without supervision, whereas the majority of falls for individuals with stroke living in the community are associated with walking.[182]

Numerous fall risk assessment tools are available. A recent systematic review[183] identified 8 commonly used fall risk assessment tools with existing reliability and validity. The most commonly used assessment instrument in the 43 prevention studies reviewed was the Morse Fall Scale.[184] The Berg Balance Scale has demonstrated good sensitivity and specificity in predicting falls in individuals with stroke.[185] Several federal and professional associations have developed fall prevention toolkits that include risk assessment instruments and protocols (eg, the National Center of Patient Safety Falls Toolkit, the Centers for Disease Control and Prevention Stopping Elderly Accidents, Deaths and Injuries Toolkit, the AHRQ Preventing Falls in Hospitals–A Toolkit for Improving Quality Care, and the AHRQ Step-Up to Stop Falls Toolkit).

Prevention Programs

The most comprehensive assessment of preventing falls in the general population of older adults is the recent Cochrane database review.[172] The evidence specific for fall prevention in individuals with stroke is limited. A recent randomized trial of a multifactorial falls prevention program for individuals with stroke[186] reported no benefit for this intervention compared with usual care among 156 participants. Tai Chi has been found to be more effective than strength and range-of-movement exercises in a clinical trial.[187] A nonrandomized, small-scale, controlled study found a community-based progressive group exercise program that included walking and strength and balance training for 1 hour 3 times a week for participants with mild to moderate hemiparesis to be safe, feasible, and efficacious in a community setting.[188]

Recommendations: Prevention of Falls	Class	Level of Evidence
It is recommended that individuals with stroke discharged to the community participate in exercise programs with balance training to reduce falls.	I	B
It is recommended that individuals with stroke be provided a formal fall prevention program during hospitalization.	I	A
It is reasonable that individuals with stroke be evaluated for fall risk annually with an established instrument appropriate to the setting.	IIa	B
It is reasonable that individuals with stroke and their caregivers receive information targeted to home and environmental modifications designed to reduce falls.	IIa	B
Tai Chi training may be reasonable for fall prevention.	IIb	B

Seizure Prophylaxis

A new seizure diagnosis after stroke can be classified as early (beginning within the first few days of stroke) or late. A seizure is most likely to arise during the first 24 hours after stroke onset, is usually partial at onset, and has a variable tendency to secondarily generalize. A poststroke seizure is more common with ICH[189] or when the stroke involves cerebral cortex[190]; seizures in patients with lacunar stroke are rare.[191] Estimates of the percentage of patients having a seizure during the first few days after a stroke range from 2% to 23% in various studies, with the true risk toward the lower end of this range.[191,192] A minority of such patients will have a recurrent seizure, and status epilepticus is uncommon.[193]

Estimates for the incidence of a seizure developing late after stroke are even more variable, ranging from 3% to 67%.[192] One study found a 1.5% rate of seizures specifically during inpatient admission for stroke rehabilitation.[194] The probability of a late seizure is higher in patients with preexisting dementia.[195] Seizures with onset within 2 weeks of stroke are usually easy to control medically.[196]

No data are available to guide the utility of prophylactic administration of antiepileptic drugs after stroke, and limited data are available on the efficacy of antiepileptic drugs in the treatment of stroke patients who have experienced a seizure. Any patient who develops a seizure should be treated with standard management approaches, including a search for reversible causes of seizure and any potential antiepileptic drugs. Subclinical seizures can be difficult to detect unless suspected, so the treating physician might consider pursuing this diagnosis in a patient with otherwise unexplained rapidly shifting sensorium or other deficits or transient fluctuations in vital signs.

Prophylactic administration of antiepileptic drugs to prevent a seizure is not recommended for patients with stroke,[192] including patients with ICH.[197] RCTs are also lacking for the prevention or treatment of seizures in patients with subarachnoid hemorrhage.[198] However, prophylactic therapy with antiepileptic drugs is advocated by some on the basis of theoretical concerns such as an association of increased rate of seizures among subgroups of patients with subarachnoid hemorrhage with selected features such as thicker clot or rebleeding.[198]

In all cases, it must be understood that prescribing a new antiepileptic drug carries a significant risk of side effects.[199,200] Furthermore, some data suggest that prophylactic use of antiepileptic drug therapy may be associated with poorer outcome.[199–202] The risk-benefit analysis of antiepileptic drug use after a recent stroke includes an important concern that does not pertain to many neurological settings. Evidence suggests that many of the medicines used to treat seizures, including phenytoin and benzodiazepines, dampen some mechanisms of neural plasticity that contribute to behavioral recovery after stroke.[203–205]

Recommendations: Seizures	Class	Level of Evidence
Any patient who develops a seizure should be treated with standard management approaches, including a search for reversible causes of seizure in addition to potential use of antiepileptic drugs.	I	C
Routine seizure prophylaxis for patients with ischemic or hemorrhagic stroke is not recommended.	III	C

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Secondary Stroke Prevention

Stroke shares many risk factors with other forms of cardiovascular disease such as hypertension, smoking, hyperlipidemia, and inactivity.[206] With hospitalization for acute stroke brief, it is particularly important to address the secondary prevention of stroke and other cardiovascular diseases during the postacute rehabilitation phase of care. Readers are directed to the most recent AHA/American Stroke Association (ASA) secondary stroke prevention guideline for further information.[206]

Poststroke Depression, Including Emotional and Behavioral State

In the United States and globally, depression and anxiety are common after stroke and are associated with increased mortality and poor functional outcomes.[207–214] There is evidence that the likelihood of depression increases with stroke severity,[215] but the mechanisms of poststroke depression are incompletely understood. Depression has been reported in up to 33% of stroke survivors compared with 13% of age- and sex-matched control subjects,[216] but reliable estimates of the incidence and prevalence of depression in a stroke cohort are limited.[217] Predictors of poststroke depression include a history of depression, severe disability, cognitive impairment, previous stroke, a positive family history of psychiatric disorder, and female sex.[216–220] As poststroke psychosocial issues are studied, greater understanding of the complexity of the problem is obtained. For example, Vickery et al[214] analyzed how the stability of self-esteem plays a role in the rate of depressive symptoms. The depression and emotionalism section of the 2005 stroke rehabilitation clinical practice guidelines does an excellent job of describing the incidence of poststroke depression and pseudo-bulbar affect.[149] What is clear from the literature is that these issues are real and warrant assessment and treatment as early as possible and on an ongoing basis. The section on poststroke depression in the AHA/ASA "Palliative and End-of-Life Care in Stroke"[221] scientific statement gives highlights of prevention, assessment, and treatment. Here, we highlight how poststroke depression affects stroke rehabilitation and recovery and, vice versa, how rehabilitation and exercise affect depression.

Although data are inconclusive as to whether improvement of poststroke depression is independently associated with functional improvement,[222] depression can negatively affect a patient's ability to actively participate in rehabilitation therapies.[223] It is important to address symptoms early in the rehabilitation process, especially given the recent trend for less time in rehabilitation. Depression frequently coexists with other psychiatric symptoms. Anxiety in particular is found to coexist with depression in the poststroke patient population but frequently goes undiagnosed.[224] Anxiety can create uncomfortable or disabling feelings of worry/fear accompanied by physical symptoms that make participation in therapy more difficult. Shimoda and Robinson[225] reported that generalized anxiety disorder accompanied by poststroke depression delayed recovery from depression, delayed ADL recovery, and reduced overall social functioning. Unfortunately, few studies have been conducted to address the treatment of and recovery from poststroke generalized anxiety disorder.[226] Anxiety symptoms in poststroke patients should be assessed and treated, particularly in those patients with a diagnosed depressive disorder. Any patient diagnosed with 1 form of mood disorder should be assessed for others.

A review of intervention trials for treatment of poststroke depression yielded no evidence of benefits of psychotherapy in treating depression after stroke.[227] de Man-van Ginkel et al[228] identified additional nursing practices that had a positive impact on reducing depression symptoms, including life review therapy, motivational interviewing, nursing support programs, and physical exercise.

Rehabilitation, Exercise, and Recovery

A study with 49 depressed patients (24 treated for depression and 25 not treated as determined by physician preference) was conducted to evaluate the effects of poststroke depression and antidepressant therapy on the improvement of motor scores and disability.[229] Poststroke depression was found to have negative effects on functional recovery, and the pharmacological treatment of depression was found to counterbalance this effect. Similarly, a study with 55 patients with poststroke major or minor depression found that remission of poststroke depression over the first few months after stroke is associated with greater recovery of ADL function than continued depression.[230] Early effective treatment of depression may have a positive effect on the rehabilitation outcome. No larger-scale studies following up on this line of research were found.

Physical exercise may provide a complementary treatment for depression. Exercise may affect depressive symptoms through a number of mechanisms. For example, the hypothalamic-pituitary-adrenal axis may be dysregulated in depression, resulting in elevated cortisol levels. Exercise can improve regulation of hypothalamic-pituitary-adrenal responses.[231] Depression also has direct and indirect consequences on immune function,[232] and regular exercise may serve as a nonpharmacological stimulus for enhancing immune function.[233] Furthermore, social contact through group exercise may be beneficial for individuals with depression.

Meta-analyses in adults with depression (but without stroke) have shown positive effects of exercise on depressive symptoms. A Cochrane review reported a large clinical effect with a standardized mean difference of −0.82 of physical exercise on depressive symptoms.[234] A systematic review suggested that physical exercise was effective in treating depression, especially in individuals with high baseline levels of depression.[235]

In a meta-analysis of 13 studies (n=1022 patients), Eng and Reime[236] found that depressive symptoms after stroke were lower immediately after ≥4 weeks of exercise (standardized mean difference=−0.13 [95% CI, −0.26 to −0.01]). Exercise appeared to have a small beneficial effect on depressive symptoms across both the subacute and chronic stages of stroke recovery, but these effects were not retained after the exercise was terminated. Saunders et al[237] reviewed

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8 exercise studies that included a depression outcome in a stroke population and meta-analyzed 3 of these studies. They concluded that the results were inconsistent among the trials. A major criticism is that the majority of the stroke studies used depressive symptoms as a secondary outcome, and as a result, the levels of depressive symptoms varied widely in these studies. Given the strong evidence in nonstroke populations with depression, coupled with the preliminary evidence in stroke populations, exercise may be useful as a potential treatment to reduce depressive symptoms in individuals with stroke.

Depression and other psychological disorders, specifically anxiety, can occur at any time after stroke. Healthcare providers should evaluate these issues during poststroke follow-up visits. One study compared different diagnostic tools to determine whether one was superior over another. Bergersen et al[238] reported that patients and their caregivers fail to discuss psychosocial issues or symptomology with their providers. There are cultural differences in reporting psychosocial issues, resulting in part from perceived cultural morays discouraging personal feelings.[209] Varying poststroke assessments on the basis of cultural background is an important consideration specifically in poststroke depression. Nonpharmacological treatment options can provide some successful outcomes. Unfortunately, there are no well-designed RCTs in which various treatment interventions are compared to determine superiority. Because of the complexity of the psychosocial diseases and limited understanding, a number of treatment options should be tried to determine patient-specific effectiveness. This supports the need for ongoing monitoring after treatment.

Medication

Poststroke depression is treatable with a variety of antidepressant medications, with selective serotonin reuptake inhibitors (SSRIs) and tricyclic antidepressants being the most widely studied.[223,239] Treatment with heterocyclic antidepressant medications and SSRIs appears to be a viable option for poststroke depression, but their absolute or relative efficacy has yet to be fully established.[240] In 1 study of 870 veterans with poststroke depression, poststroke SSRI treatment was associated with longer survival. The authors concluded that after a stroke, SSRI initiation or resumption of treatment should be considered as part of a medication therapy management service, especially if the patient has a history of depression or was taking an SSRI before the stroke.[241] A 2008 Cochrane review analyzing data for 13 pharmaceutical agents, including tricyclic antidepressants, SSRIs, and monoamine oxidase inhibitors, found some benefit of pharmacotherapy in terms of a complete remission of depression and improvement in scores on depression rating scales, but there was also an associated increase in adverse events.[227] The analyses were complicated by a lack of standardized diagnostic and outcome criteria and differing analytic methods. To the best of our knowledge, there have been no studies on the effectiveness of a combined drug intervention (eg, SSRIs) and rehabilitation intervention on recovery outcomes after stroke.

Recommendations: Poststroke Depression, Including Emotional and Behavioral State	Class	Level of Evidence
Administration of a structured depression inventory such as the Patient Health Questionnaire-2 is recommended to routinely screen for poststroke depression.	I	B
Patient education about stroke is recommended. Patients should be provided with information, advice, and the opportunity to talk about the impact of the illness on their lives.	I	B
Patients diagnosed with poststroke depression should be treated with antidepressants in the absence of contraindications and closely monitored to verify effectiveness.	I	B
A therapeutic trial of an SSRI or dextromethorphan/quinidine is reasonable for patients with emotional lability or pseudobulbar affect causing emotional distress.	IIa	A
Periodic reassessment of depression, anxiety, and other psychiatric symptoms may be useful in the care of stroke survivors.	IIa	B
Consultation by a qualified psychiatrist or psychologist for stroke survivors with mood disorders causing persistent distress or worsening disability can be useful.	IIa	C
The usefulness of routine use of prophylactic antidepressant medications is unclear.	IIb	A
Combining pharmacological and nonpharmacological treatments of poststroke depression may be considered.	IIb	A
The efficacy of individual psychotherapy alone in the treatment of poststroke depression is unclear.	IIb	B
Patient education, counseling, and social support may be considered as components of treatment for poststroke depression.	IIb	B
An exercise program of at least 4 weeks duration may be considered as a complementary treatment for poststroke depression.	IIb	B
Early effective treatment of depression may have a positive effect on the rehabilitation outcome.	IIb	B
No recommendation for the use of any particular class of antidepressants is made. SSRIs are commonly used and generally well tolerated in this patient population.	III	A

Poststroke Osteoporosis

BMD and lean tissue mass commonly decline after stroke.[242–244] Although declines in BMD and lean tissue mass can occur in both limbs, changes on the paretic side are more profound. BMD can decrease by >10% in <1 year in the paretic lower limb.[242] Moreover, the decline in BMD, coupled with balance deficits resulting from stroke, increases fracture risk.[245] Changes in BMD after stroke are correlated with functional deficits in the paretic limb(s). Jørgensen et al[246] assessed 40 patients at 6 days, 7 months, and 1 year after stroke. Seventeen patients were

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initially nonambulatory, and 23 were ambulatory. Ambulatory status was predictive of changes in BMD 1 year after stroke. The nonambulatory patients had a 10% reduction in BMD in the paretic lower limb compared with a 3% reduction in BMD in ambulatory patients. Moreover, among the 17 patients who were initially nonambulatory, 12 regained walking ability with assistance 2 months after stroke. Those patients who regained ambulation ability had an 8% reduction in BMD in the paretic lower limb compared with a 13% reduction in those who remained nonambulatory. Pang et al[247] found that femur BMD and lean mass were significantly lower and fat mass was significantly higher on the paretic side compared with the nonparetic side in ambulatory men and women who suffered a stroke >1 year earlier. However, the degree to which BMD was preserved in the paretic lower extremity was significantly correlated with 6-minute walk test distance, peak oxygen consumption ($\dot{V}o_2$), and handheld dynamometry. Multiple regression analysis revealed that peak $\dot{V}o_2$ was a significant predictor of paretic limb BMD and lean tissue mass. Paretic upper limbs also demonstrate significant declines in BMD and lean mass after stroke. The decline in BMD and lean mass is associated with paretic upper limb strength assessed by handheld dynamometry.[248]

The US Preventive Services Task Force[249] recommends osteoporosis screening in all women ≥65 years of age; women <65 years of age whose fracture risk is greater than or equal to that of older white women with no additional risk factors should also undergo osteoporosis screening. The US Preventive Services Task Force concludes that there is inconclusive evidence to make any osteoporosis screening recommendations for men. Individuals with stroke have an increased risk for osteoporosis, particularly on the paretic side.[250] The risk of fracture is also increased in patients with stroke.[251] In men with stroke, although osteoporosis and fracture risks are higher, no clear guidance on screening can be provided at this time.[252] The current US Preventive Services Task Force recommendations are appropriate in the stroke population.

Limited research indicates that increased levels of physical activity such as ambulation and resistance training attenuate the decline in, maintain, or increase BMD and lean tissue mass after stroke.[245,246,253–257]

Recommendations: Poststroke Osteoporosis	Class	Level of Evidence
It is recommended that individuals with stroke residing in long-term care facilities be evaluated for calcium and vitamin D supplementation.	I	A
It is recommended that US Preventive Services Task Force osteoporosis screening recommendations be followed in women with stroke.	I	B
Increased levels of physical activity are probably indicated to reduce the risk and severity of poststroke osteoporosis.	IIa	B

Assessment

Level of Disability

Stroke can affect numerous aspects of neural function and structure. Clinically, this most often manifests as weakness, with other common impairments being aphasia, neglect, visual field deficit, cognitive changes such as executive dysfunction or memory loss, major depression, sensory deficits, dysarthria, and problems with coordination.[11,258,259]

Measures of body function tend to be more objective, easier to define, and easier to measure compared with other levels of the World Health Organization's *ICF* but may have less relevance to a patient's function and independence. Limited correlation exists across *ICF* dimensions.[11,260] The reason is that numerous factors have a greater influence on outcome as one moves from body function/structure to activity limitations, participation restrictions, and quality of life.[261] During acute stroke management, the focus tends to be more on measures of body function, whereas toward the more chronic phases, the emphasis shifts to activities and participation.[11] Regardless of *ICF* dimension, formal standardized and validated measures should be used to the extent possible.

Many methods are available to measure loss of body function/structure. Chief among these is the physical examination. Many scales have been devised.[262] Some are global scales that aim to capture all major deficits and to combine the assessment into a single score, whereas others are modality specific. In the United States, the most widely used global assessment of impairment is the National Institutes of Health Stroke Scale, which ranges from 0 to 42, with higher scores indicating more severe loss of body function/structure. Training and formal certification on National Institutes of Health Stroke Scale scoring are widely available, increasing the precision of this measure and permitting the use of this tool by a variety of disciplines. The National Institutes of Health Stroke Scale is a good predictor of short-term and long-term morbidity and mortality[263] and has been found to be sensitive to change in numerous studies. Limitations of the National Institutes of Health Stroke Scale include low granularity for defining differences in level of impairment and insensitivity to many common poststroke deficits such as depression, hand-motor deficits, swallowing, or memory loss.

Many modality-specific measures have been constructed for measuring loss of body function/structure across the many brain neural systems. Common examples include the upper limb motor section of the Fugl-Meyer scale or the Box and Block Test for measuring arm motor deficits; the leg motor section of the Fugl-Meyer scale or gait velocity for measuring leg motor deficits; the Western Aphasia Battery or the Boston Naming Test for language deficits; the Behavioral Inattention Test or The Line Cancellation test for measuring neglect; the Nottingham Sensory Assessment or the sensory section of the Fugl-Meyer scale for measuring somatosensory deficits; the Hamilton Depression Scale or the Beck Depression Inventory II for measuring severity of depression symptoms; and the Mini-Mental Status Exam or Trail Making Tests (A and B) for cognitive deficits. More complete lists of such tests have been compiled.[11,258] In addition, the National Institute of Neurological Disorders and Stroke has compiled a set of common data elements for each dimension of the *ICF*,[3] including the 3 major dimensions of body structures/body functions (impairments), activities (activity limitations), and participation (participation restrictions).

Some scales focus on measures that require specific equipment such as a dynamometer for measuring hand grip strength, various perimetry devices (eg, Humphrey or octopus) for measuring visual field loss, an electric goniometer for measuring

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range of motion, or von Frey filaments for measuring tactile sensory deficits. Robotic devices are receiving increasing attention for their ability to quantify loss of body function/structure,[264] in some cases generating data that cannot be obtained by a human examiner.[265] Telemedicine may be used by examiners in remote locations to measure level of disability.[266]

The assessment of body function/structure in a patient recovering from stroke may be performed to predict outcome, to monitor recovery, to monitor response to a new therapy, to guide new treatment decisions, to document clinical status as part of reimbursement, to inform patient stratification such as in selecting postdischarge setting, in the context of a clinical trial, as part of stroke center or rehabilitation ward certification requirements, or in compliance with a stroke care plan protocol. Valid reliable measures have been defined for each of these purposes. Similar considerations apply to choosing the frequency with which impairments are measured.

Assessing Overall Rehabilitation Needs

After acute hospital admission for stroke, patients should have comprehensive assessments of body structures and function, activity limitations, and participation restrictions according to the *ICF*.[11,267,268] These assessments can be performed concurrently with diagnostic testing as soon as 24 hours after admission, as the patient's medical stability allows. Evaluation of a stroke survivor's rehabilitation needs is best performed by an interprofessional team that can include a physician with expertise in rehabilitation, nurses, physical therapists, occupational therapists, speech/language therapists, psychologists, and orthotists.[4,149,258] Prvu Bettger and colleagues[12] noted that among acute hospitals participating in the AHA's Get With The Guidelines program, 90% of patients have an assessment for postacute rehabilitation services documented, but little information is available about the nature or reliability of these assessments. If clinically indicated, appropriate postacute rehabilitation settings include outpatient rehabilitation or day rehabilitation programs, skilled nursing–level rehabilitation, long-term acute care hospitals, and acute rehabilitation hospitals.

Selection of the most appropriate level of care requires consideration of many factors, including the severity of residual neurological deficits, resulting activity limitations, cognitive and communicative ability, psychological status, swallowing ability, premorbid functional ability, medical comorbidities, level of family/caregiver support, likelihood of returning to community living, and ability to participate in a rehabilitation program.[70,269,270] Certain factors such as older age, impaired cognition, lower functional level after stroke, and urinary incontinence are predictors of the need for inpatient rehabilitation care.[54,271] The presence of neglect syndrome can predict a longer rehabilitation stay and lower functional status at discharge.[272] Among patients with less neurological impairment, assessment of balance ability with standardized measures such as the Berg Balance Scale or the Postural Assessment Scale for Stroke can help determine the risk of fall and need for inpatient rehabilitation rather than discharge home with outpatient services[273–275] (The Prevention of Falls section provides more information). For patients who can walk, assessment of gait speed with the 10-m walk test can help determine functional ambulatory ability.[276,277] Risk of fall with ambulation is important for counseling patient and family on safety.

A comprehensive determination of functional abilities appears to be useful before acute hospital discharge with standardized assessments such as the Barthel Index or the Functional Independence Measure (FIM). Both the Barthel Index and the FIM are strong predictors of discharge functional status, discharge destination after inpatient rehabilitation, and length of rehabilitation stay.[278–281] The FIM is the most commonly used functional measure in the United States because it is tied to the prospective payment system of the Centers for Medicare & Medicaid Services.

There currently is no single functional assessment with measurement properties that is used throughout the entire clinical course of stroke care (acute hospital, inpatient rehabilitation, and outpatient care) for tracking stroke rehabilitation outcome. A computerized questionnaire called the Activity Measure for Post-Acute Care is not specific to stroke but has demonstrated feasibility as such a tool in stroke populations.[282] Although it requires cognitive and language ability to complete, proxy responses to the Activity Measure for Post-Acute Care are well correlated with patient responses.[283] Thus, the Activity Measure for Post-Acute Care may prove to be a suitable longitudinal outcome measure for stroke patients, including those with cognitive deficits and aphasia.

ADLs, IADLs, and Disability Measurement

The term ADLs typically refers to routine self-care tasks that people perform as part of their everyday life.[284] ADLs are generally subdivided into those associated with personal self-care and fundamental mobility, often referred to as basic ADLs, and tasks involving more complex domestic, community, and leisure activities, referred to as IADLs.[285]

An evidence-based consensus conference on improving measurement of disability sponsored by the AHRQ concluded that a single consensus definition of disability is not feasible or desirable.[286] The AHRQ report contends that the meaning of disability is dependent on context and the purpose for which the definition will be used. The *ICF* uses disability as a generic term that includes aspects of body functions and structure, activity, and participation within the context of the environment and personal/social factors.[3,287] The recommendations below for ADLs, IADLs, and disability are based on the conceptual approach to disability endorsed by the World Health Organization.[3]

In the 2005 stroke rehabilitation clinical practice guidelines, there were 2 recommendations on the assessment of function. The first was that a standardized assessment tool be used to evaluate functional status in individuals with stroke. The second recommendation was to consider using the FIM as the standardized assessment for function in individuals with stroke.[149]

Over the past decade, there has been substantial progress in 2 general areas pertaining to measurement of function and disability, including ADLs and IADLs. The first is more sophisticated methodological approaches to assessment, specifically the development of methods based on item response theory and computer-adapted testing.[288] The second is the recent attention to patient-centered and patient-reported outcome measures. The emphasis on patient-centered and patient-reported measures is related to healthcare reform and the implementation of the Patient Protection and Affordable Care Act.[289]

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New tools for assessment include the Patient-Reported Outcomes Measurement Information System[290] and the NIH Toolbox.[291] Both the Patient-Reported Outcomes Measurement Information System and the NIH Toolbox are designed to help clinicians and healthcare consumers by providing a common platform based on procedures and metrics that will generate outcomes comparable across large populations, including individuals with stroke.

The largest and most comprehensive source of evidence-based reviews and reports focused on stroke rehabilitation is available from the Evidence-Based Review of Stroke Rehabilitation (EBRSR) program supported by the Canadian Stroke Network.[270,292] Information and the evidence-based reports from EBRSR are available online.[292a]

Specific to the assessment of ADLs and IADLs (disability), the EBRSR has produced an evidence-based report titled "Outcome Measures in Stroke Rehabilitation."[292b] All reviewed assessments are classified according to the World Health Organization's *ICF* conceptual framework. The frequently used modified Rankin Scale is included within the Activity/Disability Outcome Measures section. With the use of the *ICF*, each assessment is categorized as providing information at the level of body functions and structure, activities, or participation. All assessment instruments in the EBRSR report are evaluated with 8 criteria. The criteria were derived from a comprehensive review of 413 articles on measurement methodology by the Health Technology Assessment Program.[293] The criteria include operationally defined ratings for appropriateness, reliability, validity, responsiveness, precision, interpretability, acceptability, and feasibility. Appendix 2 includes measures reviewed in the EBRSR report as of November 2012.

Assessment Challenges

The instruments included in Appendix 2 and the evidence-based reviews in the EBRSR are based on traditional measurement models. As noted above, new assessments are being developed with the use of item response theory and computer-adapted testing. These assessments are difficult to evaluate with the traditional criteria such as validity and reliability normally used in evidence-based reviews. For example, Hsueh and colleagues[329] reported the development of a computer-adapted test for evaluating ADLs in individuals with stroke referred to as the ADL-CAT (computer-adapted test). The authors report the ADL-CAT produced scores that were highly correlated with traditional ADL measures such as the Barthel Index but could be completed in one-fifth the time required to administer the Barthel Index.[329] New or refined criteria consistent with advances in measurement approaches need to be developed and incorporated into existing levels of evidence hierarchies to accommodate the evaluation and evidence-based reviews of assessments.

Another challenge in establishing functional assessment guidelines is how to incorporate the growing emphasis on patient reported and patient-centered measures within the assessment of ADLs, IADLs, and other disability measures. The solution to this challenge extends beyond simply asking patients or consumers to respond to traditional ADL questions such as "Can you put on an article of clothing?" Rather, it requires patients and other stakeholders to be active partners in the assessment process and to help identify the items and outcomes that should be measured. Until computer-adapted tests (eg, ADL-CAT) for ADLs and IADLs become routine in practice, a combination of assessments such as a basic ADL measure (eg, the 10-item Barthel Index)[330] or the FIM and an IADL measure (eg, the 15-item Frenchay Activity Index)[331] is recommended to capture the broad spectrum of ADL function. Recently, a Rasch analysis was used to validate a combined measure of basic and extended daily life functioning after stroke.[332] Even those recovering from mild stroke or transient ischemic attack (eg, those scoring 100 on the Barthel Index) continue to demonstrate deficits in health status. Although basic ADL measures may not be sufficiently sensitive to change among the least impaired stroke survivors, the IADL assessment tool will likely be more sensitive to these more subtle deficits at discharge and provide useful information for discharge planning.

Recommendations: Assessment of Disability and Rehabilitation Needs	Class	Level of Evidence
It is recommended that all individuals with stroke be provided a formal assessment of their ADLs and IADLs, communication abilities, and functional mobility before discharge from acute care hospitalization and the findings be incorporated into the care transition and the discharge planning process.	I	B
It is recommended that all individuals with stroke discharged to independent community living from postacute rehabilitation or SNFs receive ADL and IADL assessment directly related to their discharge living setting.	I	B
A functional assessment by a clinician with expertise in rehabilitation is recommended for patients with an acute stroke with residual functional deficits.	I	C
Determination of postacute rehabilitation needs should be based on assessments of residual neurological deficits; activity limitations; cognitive, communicative, and psychological status; swallowing ability; determination of previous functional ability and medical comorbidities; level of family/caregiver support; capacity of family/caregiver to meet the care needs of the stroke survivor; likelihood of returning to community living; and ability to participate in rehabilitation.	I	C
It is reasonable that individuals with stroke discharged from acute and postacute hospitals/centers receive formal follow-up on their ADL and IADL status, communication abilities, and functional mobility within 30 days of discharge.	IIa	B
The routine administration of standardized measures can be useful to document the severity of stroke and resulting disability, starting in the acute phase and progressing over the course of recovery and rehabilitation.	IIa	C
A standardized measure of balance and gait speed (for those who can walk) may be considered for planning postacute rehabilitation care and for safety counseling with the patient and family.	IIb	B

Assessment of Motor Impairment, Activity, and Mobility

Motor impairments are common after stroke and occur when the stroke lesion includes the corticospinal system, that is, the motor cortical areas and the corticospinal tract.[333] Indeed, the

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extent of damage to the corticospinal system is predictive of motor outcomes and response to treatment.[334–336] Assessment of motor impairments enables the clinician to understand which aspects of movement and motor control are disrupted after stroke. Assessment of activity such as upper extremity function, balance, and mobility is used to quantify the functional consequences of the motor impairments. Accurate assessment provides prognostic information[337–341] and guides the selection of motor interventions and the tailoring of these interventions to each individual.[294]

Assessment of motor impairments and activity is critical for delivering efficient, high-quality rehabilitation services to individuals with stroke. Assessment results are used to determine who needs further services, what types of services are required, what is the most appropriate setting for those services, which interventions to select, how to tailor the interventions to individual patients, and whether the rehabilitation services are achieving the desired outcomes.[342–344] When standardized assessments are implemented within and across facilities, measures that are familiar and clinician friendly and meet the clinical needs of the service are generally implemented most easily.[345–347]

Technology to objectively measure real-world activity has been emerging over the past decades. Alternatively, clinicians have relied on self-report measures to gain insight into what a person is doing in daily life. The assumption that clinic performance is equivalent to outside-of-clinic performance may not be true.[321] Whereas patient-reported outcomes allow a more patient-centered approach, some self-report measures are prone to reporting biases.[348,349] Commercially available devices to measure movement when people are outside the rehabilitation clinic are now readily available and becoming more user friendly. These devices include wrist-worn accelerometers,[294,326] ankle-worn accelerometers,[325] step-activity monitors,[328,350] and the more economical alternative, pedometers.[327] Recording movements allow the clinician to measure the quantity and sometimes the types of movements occurring in everyday life.

Recommendations: Assessment of Motor Impairment, Activity, and Mobility	Class	Level of Evidence
Motor impairment assessments (paresis/muscle strength, tone, individuated finger movements, coordination) with standardized tools may be useful.	IIb	C
Upper extremity activity/function assessment with a standardized tool may be useful.	IIb	C
Balance assessment with a standardized tool may be useful.	IIb	C
Mobility assessment with a standardized tool may be useful.	IIb	C
The use of standardized questionnaires to assess stroke survivor perception of motor impairments, activity limitations, and participation may be considered.	IIb	C
The use of technology (accelerometers, step-activity monitors, pedometers) as an objective means of assessing real-world activity and participation may be considered.	IIb	C
Periodic assessments with the same standardized tools to document progress in rehabilitation may be useful.	IIb	C

Assessment of Communication Impairment

Communication is a vital aspect of daily functioning, and stroke frequently results in communication impairment. One million people in the United States are estimated to have aphasia, commonly as a result of stroke.[351] Communication impairment can negatively affect participation in life activities immediately after the stroke and can result in long-term deficits. It is important to identify problems early with a thorough and holistic assessment. It is equally important to identify strengths and compensatory strategies that can enable the patient to maximize independence and to reenter life activities with as much competency and confidence as possible.

In recent years, more attention has been given to incorporating the *ICF* framework and principles into the assessment of communication. Communication is required for most daily activities, so everyday life can be significantly affected by impairment. In previous years, assessment focused on disability; now attention is focused on maximizing quality of life and participating in daily activities. Additionally, caregivers are increasingly included in the evaluation process because their skill and attitude have a significant impact on creating successful communication exchanges.

Telerehabilitation is becoming an accepted alternative to face-to-face communication assessment for people with communication impairment; however, telerehabilitation requires adequate technology. Multiple studies have demonstrated that telepractice for communication assessment is feasible and effective.[352–354]

Recommendations: Assessment of Communication Impairment	Class	Level of Evidence
Communication assessment should consist of interview, conversation, observation, standardized tests, or nonstandardized items; assess speech, language, cognitive-communication, pragmatics, reading, and writing; identify communicative strengths and weaknesses; and identify helpful compensatory strategies.	I	B
Telerehabilitation is reasonable when face-to-face assessment is impossible or impractical.	IIa	A
Communication assessment may consider the individual's unique priorities using the *ICF* framework, including quality of life.	IIb	C

Assessment of Cognition and Memory

Cognitive impairment is found in a substantial portion of stroke survivors, affecting more than one third of stroke survivors at 3 and 12 months after stroke.[355] These impairments persist in many individuals for years[356,357] and are associated with poor long-term survival, higher disability, and greater institutionalization rates. Tatemichi et al[358] found that the RR for dependent living associated with cognitive impairment was 2.4 at 3 months after stroke after adjustment for age and physical impairment. Another study found the RR of death associated with dementia 5 years after stroke was 3.11 (95% CI, 1.79–5.41) after adjustment for the effects of demographic factors, cardiac disease, severity of stroke, stroke type, and recurrent stroke.[359] The cognitive domains most likely to be defective in patients with stroke compared with

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control subjects were memory, orientation, language, and attention. Because physical and cognitive impairments after stroke have independent prognostic implications, evaluation of both domains should be routine in the clinical care of stroke patients. Prospective studies have shown that cognitive status is an important determinant of poststroke success. The Neurobehavioral Cognitive Status Examination is a brief screening tool that assesses cognition in the ability areas of language, constructions, memory, calculation, and reasoning. A small prospective study found that the Neurobehavioral Cognitive Status Examination both provides a rapid and sensitive measure of cognitive function and appears to predict functional status change as a result of inpatient stroke rehabilitation.[360] A formal neuropsychological examination (including assessment of language, neglect, praxis, memory, emotional responses, and specific cognitive syndromes) may be helpful after the detection of cognitive impairment with a screening instrument. Neuropsychological protocols must be sensitive to a wide range of abilities, especially the assessment of executive and attentional functions. Brief mental status scales inadequately assess executive skills and other higher-level cognitive functions. Specific areas that should be included in this type of assessment include the following:

- Processing speed
- Simple attention and complex attention ("working memory")
- Receptive, expressive, and repetition language abilities
- Praxis (performing skilled actions such as using a tool)
- Perceptual and constructional visual-spatial abilities, including issues related to visual fields and neglect
- Memory, including language-based memory and visual-spatial memory, and differentiating learning, recall, recognition, and forced-choice memory
- Executive functioning, including awareness of strengths and weaknesses, organization and prioritization of tasks, task maintenance and switching, reasoning and problem solving, error awareness and safety judgment, and emotional regulation

Recommendations: Assessment of Cognition and Memory	Class	Level of Evidence
Screening for cognitive deficits is recommended for all stroke patients before discharge home.	I	B
When screening reveals cognitive deficits, a more detailed neuropsychological evaluation to identify areas of cognitive strength and weakness may be beneficial.	IIa	C

Sensory Impairments, Including Touch, Vision and Hearing

Stroke may result in a variety of different types of sensory impairment such as loss of vision, touch, proprioception, hearing, and others. Sensory impairments are often assessed through physical examination, although methods exist for more precise measurement of certain sensory deficits such as automated perimetry for visual field loss or audiometry for hearing loss. Although these are not routinely used, such testing may be useful when a detailed understanding of sensory impairment is needed.

Various forms of sensory deficit are commonly seen after stroke. For example, somatosensory deficits are present in 45%[259] to 80%[362] of patients, and visual field loss occurs in roughly 30%[363] (estimates range from 15%[259]–52%[364]) of patients. The high degree of connectivity[365] in the human brain not only results in loss of function directly in the affected sensory modality but also affects complex behaviors that require distributed multimodal processing such as fine motor control.[362,366] As a result, sensory impairments are directly linked to activity limitations and participation restrictions after stroke[367] and can improve with therapeutic intervention,[368] particularly those based on multimodal interventions such as virtual reality[369] and augmented reality.[370]

Somatosensory Impairments

Somatosensory impairments include tactile, pain, temperature, pressure, vibration, proprioception, stereognosis, and graphesthesia. Tactile deficits may be the most common form of sensory deficit after stroke.[367] In the months after a stroke, patients show substantial but variable somatosensory recovery, especially for proprioception.[371] Studies of experimental stroke in primates[372,373] and rats[374] describe the neurobiological basis of sensory recovery after stroke, with overall similar findings in human subjects scanned with functional magnetic resonance imaging.[375,376] Assessment of sensory deficits remains largely a matter of bedside examination[377]; however, sensory scales are under study,[378,379] and new devices can quantify deficits.[380,381]

Visual Impairments

The most common visual impairment after stroke is visual field loss, affecting ≈30% of stroke survivors.[363] Vision plays a central role in many human functions, so a reduction in vision can affect many roles, quality of life, motivation, and social behaviors.[382] Although assessment of visual field loss is most often obtained with confrontation methods at the bedside, automated perimetry methods are more sensitive and precise and thus may be preferred in settings where such clarity is deemed important such as evaluation for driving.[364] Some degree of spontaneous restoration of visual fields generally occurs after stroke. However, the percentage of patients who achieve significant recovery is uncertain, with estimates ranging from 7% to 85%,[383] and the degree of recovery is variable.[364] As with many features of spontaneous behavioral recovery after stroke, gains are highest early after the injury, with the maximum period of spontaneous recovery of visual fields being reported to be in the first 2 to 10 days,[384] the first month,[385] or the first 3 months.[363] Numerous other forms of visual impairment may be seen after stroke such as abnormal eye movements, reduced visual acuity, diplopia, impaired color vision, difficulty with reading, and deficits in higher-order visual processing.

Hearing Impairments

Stroke can also result in acute hearing loss. This may be present in as many as 21% of patients with posterior circulation ischemia,[386] often resulting from ischemia in the distribution of the anterior inferior cerebellar artery, and in most cases is attributable to infarction in the inner ear. As a result, stroke-related hearing loss is usually accompanied by vertigo and often with additional deficits related to brainstem/cerebellar infarction.[387] Audiometry

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is more sensitive than bedside assessment of hearing loss. Neurootologic testing may provide insights by characterizing and measuring associated forms of vestibular dysfunction. Most patients show partial or complete recovery by 1 year after stroke.[388]

Recommendation: Sensory Impairments, Including Touch, Vision, and Hearing	Class	Level of Evidence
Evaluation of stroke patients for sensory impairments, including touch, vision, and hearing, is probably indicated.	IIa	B

Sensorimotor Impairments and Activities

Dysphagia Screening, Management, and Nutritional Support

Dysphagia is common after stroke, affecting 42% to 67% of patients within 3 days after stroke. Of these patients, about half aspirate, and one third of those patients develop pneumonia.[389] Dysphagia or aspiration can lead to pneumonia, malnutrition, dehydration, weight loss, and overall decreased quality of life. Aspiration may be "silent" or "occult" and not clinically obvious. Early identification through screening can reduce the risk of developing these adverse health consequences.[389] Additionally, observational studies suggest that dysphagia screening reduces the risk of pneumonia.[390]

A systematic review of 8 studies demonstrated that the odds of being malnourished were increased if dysphagia was present after stroke.[391] Despite the potential consequences of dysphagia, a review of nursing nutritional care concluded that a functional, supportive, and educational nursing nutritional role was essential, but little evidence was of sufficient quality to support policy and practice development or to inform education.[392]

In 2012, a group of dysphagia experts came to the consensus that early dysphagia screening should be conducted and that although no one screening tool can be recommended, a valid tool should be used.[393] Additional systematic reviews and studies also support early screening for dysphagia. However, because dysphagia screening has not been well standardized and its utility has not been established rigorously in RCTs, it has been removed from The Joint Commission performance standards and from Get With The Guidelines–Stroke performance measures. Nonetheless, it remains an important component of clinical care. Therefore, we include the same recommendation that appears in the most recent "Guidelines for the Early Management of Patients With Acute Ischemic Stroke."[394]

Once dysphagia or aspiration risk has been identified, a clinical bedside evaluation can provide valuable diagnostic information about the swallow mechanism and how to proceed with managing the patient. However, a bedside evaluation alone cannot predict the presence or absence of aspiration because patients can aspirate without overt clinical signs or symptoms.[395]

Instrumental evaluation (videofluoroscopy, fiberoptic endoscopic evaluation of swallowing, or fiberoptic endoscopic evaluation of swallowing with sensory testing) allows the clinician to visualize swallow physiology, thus determining the presence or absence of aspiration, the quantity of aspiration, and the physiological or structural causes for dysphagia. This information is necessary for forming an appropriate and effective treatment plan, which can include swallow therapy and diet recommendations.[396–398] There is no consensus in the literature on a preferred instrumental study. Both videofluoroscopy and fiberoptic endoscopic evaluation of swallowing can be used to evaluate the swallow mechanism.

Additionally, a large cohort study was completed, showing that fiberoptic endoscopic evaluation of swallowing with sensory testing is a relatively safe procedure for evaluating the sensory and motor aspects of dysphagia. Clinical judgment should be used to weigh the advantages and disadvantages of each study for each individual patient.[399]

Multiple systematic reviews showed that behavioral interventions, including "swallowing exercises, environmental modifications such as upright positioning for feeding, safe swallowing advice, and appropriate dietary modifications,"[400] should be considered for the management and treatment of dysphagia.[400,401] A group of dysphagia and swallow rehabilitation experts reviewed 10 principles of neural plasticity and discussed how they should be incorporated into dysphagia rehabilitation strategies and interventions to promote evidence-based practice.[402] Other therapies considered in systematic reviews, including drug therapy, NMES, pharyngeal electric stimulation, physical stimulation, transcranial direct current stimulation (tDCS), and transcranial magnetic stimulation, have no conclusive evidence supporting their use in dysphagia treatment.[400] Additionally, acupuncture may be a beneficial alternative treatment of dysphagia.[403] Cohort studies have shown that oral hygiene protocols may help reduce aspiration pneumonia after stroke.[404,405]

Recently, there have been a series of clinical trials called the Feed or Ordinary Diet (FOOD) trials, which are large, well-designed RCTs that address when and how to feed patients after stroke.[406–408] As a result of underrecruitment, definitive conclusions cannot be made; however, these studies and a Cochrane review[400] offer much information.

Nutritional supplements are recommended only for patients with malnutrition or those at risk of malnutrition. Routine oral nutritional supplements are not associated with improved functional outcome at 6 months after stroke. This clinical trial has found that few participants (8%) were malnourished at baseline and that supplements may contribute to hyperglycemia if the patient is not malnourished.[408]

Early tube feeding (started within 7 days) may increase the survival of dysphagic patients who cannot safely eat by mouth; however, this may keep patients alive "in a severely disabled state when they otherwise would have died."[407] Therefore, to reduce case fatality, providers should initiate early tube feeds; however, they can wait up to 7 days after a stroke to initiate tube feeds, especially when conversations about the goals of care are needed. Tube feeds via nasogastric route are reasonable for the first 2 to 3 weeks after stroke unless there is a strong reason to opt for percutaneous endoscopic gastrostomy placement (eg, cannot pass a nasogastric tube).[407]

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Early percutaneous endoscopic gastrostomy placement is not supported for stroke patients.[406] After this time period, percutaneous endoscopic gastrostomy placement is recommended because it is associated with fewer treatment failures, higher feed delivery, and improved albumin concentration.[400]

Recommendations: Dysphagia Screening, Management, and Nutritional Support	Class	Level of Evidence
Early dysphagia screening is recommended for acute stroke patients to identify dysphagia or aspiration, which can lead to pneumonia, malnutrition, dehydration, and other complications.	I	B
Dysphagia screening is reasonable by a speech-language pathologist or other trained healthcare provider.	IIa	C
Assessment of swallowing before the patient begins eating, drinking, or receiving oral medications is recommended.	I	B
An instrumental evaluation is probably indicated for those patients suspected of aspiration to verify the presence/absence of aspiration and to determine the physiological reasons for the dysphagia to guide the treatment plan.	IIa	B
Selection of instrumental study (fiberoptic endoscopic evaluation of swallowing, videofluoroscopy, fiberoptic endoscopic evaluation of swallowing with sensory testing) may be based on availability or other considerations.	IIb	C
Oral hygiene protocols should be implemented to reduce the risk of aspiration pneumonia after stroke.	I	B
Enteral feedings (tube feedings) should be initiated within 7 days after stroke for patients who cannot safely swallow.	I	A
Nasogastric tube feeding should be used for short term (2–3 weeks) nutritional support for patients who cannot swallow safely.	I	B
Percutaneous gastrostomy tubes should be placed in patients with chronic inability to swallow safely.	I	B
Nutritional supplements are reasonable to consider for patients who are malnourished or at risk of malnourishment.	IIa	B
Incorporating principles of neuroplasticity into dysphagia rehabilitation strategies/interventions is reasonable.	IIa	C
Behavioral interventions may be considered as a component of dysphagia treatment.	IIb	A
Acupuncture may be considered as a adjunctive treatment for dysphagia.	IIb	B
Drug therapy, NMES, pharyngeal electrical stimulation, physical stimulation, tDCS, and transcranial magnetic stimulation are of uncertain benefit and not currently recommended.	III	A

Nondrug Therapies for Cognitive Impairment, Including Memory

Impairments in multiple domains of cognition, including attention, processing speed, executive function, verbal and visual memory, language, and perception, occur frequently after stroke. Stroke doubles an individual's risk for dementia (including Alzheimer disease).[409]

Cognitive rehabilitation has been the traditional nonpharmacological method to treat cognitive impairment and has been defined as a "systematic, functionally-oriented service of therapeutic cognitive activities, based on an assessment and understanding of the person's brain-behavior deficits."[410] These treatments are directed at the restoration or reestablishment of cognitive activity, the acquisition of strategies to compensate for impaired cognitive function, and the use of adaptive technique or equipment for increasing independence. Few studies have assessed interventions for cognitive deficits in the IRF environment. An RCT (n=83 at >4 months after stroke) compared a multicomponent cognitive therapy and graded activity training with cognitive therapy alone over 12 weeks and demonstrated that the multicomponent therapy exceeded the cognitive therapy in fatigue reduction and improved physical endurance.[411] A systematic review[412] published in 2011 of cognitive rehabilitation in stroke that searched guidelines in stroke management, other systematic reviews, and clinical RCTs concluded that compensatory strategies can be used to improve memory outcomes. However, use of an external memory aid is in itself a memory task, so those with the greatest need also have the greatest problems using them. One solution to this problem has been the development of a paging system whereby a paging service with a customized set of reminders and appropriate date and time sends out reminders to the individual pager that is carried by the person who needs to be reminded. Recently, this idea has been modernized by the use of text message reminders to one's mobile device. The use of a paging system can significantly reduce everyday failures of memory and planning in stroke survivors. However, there was not enough evidence from RCTs to determine whether cognitive rehabilitation for memory problems after stroke is helpful.

Recently, attention has focused on the application of physical activity and exercise to improve cognitive function after stroke. Meta-analysis suggests that physical activity has a protective effect against cognitive decline[413] and may improve cognitive function in older adults without cognitive impairment.[414] A number of mechanisms have been suggested to explain the effects of exercise on cognition after stroke, including the increase in cerebral blood volume, increased expression of growth factors such as brain-derived neurotrophic factor, and a positive effect on depressive symptoms, which may mediate an improvement in cognitive performance.[415]

In animal models, a stimulating and enriched environment has been shown to improve neurobehavioral function and learning after stroke.[416] Although it is not yet known exactly what type of environment might provide optimal stimulation for a person who has had a stroke, it has been suggested that the setting should be conducive to participating in physical activity and cognitive and social activities.[417]

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Cognitive Rehabilitation

Systematic reviews that include people with both traumatic brain injury and stroke are generally more positive on the benefits of cognitive rehabilitation[418] than those involving people with stroke alone.[419–421] This may be due in part to the smaller number of stroke-only studies and the confounding factors of age and vascular involvement with stroke. A Cochrane review of 6 RCTs found a benefit of cognitive rehabilitation after stroke on some aspects of attention deficits at the end of the treatment period.[420] Not all aspects of attention are similarly affected; attention training had a positive effect on divided attention immediately after the intervention (4 studies) but no effect on selective attention (6 studies), alertness (4 studies), or sustained attention (4 studies).[420] Two cognitive rehabilitation RCTs found improvements in subjective measures of attention[422] and mental slowness[423] after stroke immediately after treatment and at follow-up.

The European Federation of Neurological Societies guidelines on cognitive rehabilitation[424] summarized a number of publications related to memory rehabilitation interventions without external memory aids, rehabilitation interventions with nonelectronic external memory aids, and rehabilitation interventions with assistive electronic technologies (the specific number of studies identified and reviewed was not given).

They concluded the following:

- That memory strategies without electronic aids are possibly effective (Level C recommendation)
- That specific learning strategies such as errorless learning are probably effective (Level B recommendation)
- That nonelectronic external memory aids such as diary or notebook keeping are possibly effective (Level C recommendation)
- That electronic external memory devices such as computers, paging systems, and portable voice organizers are probably effective (Level B recommendation)
- That the use of virtual environments has shown positive effects on verbal, visual, and spatial learning and that memory training in virtual environments is rated as possibly effective (Level C recommendation)
- That a direct comparison of memory training in virtual environments versus nonvirtual environments is still lacking and no recommendation can be made as to the specificity of the technique

An updated review of the literature (2003–2008)[418] concluded that (1) for individuals with mild memory impairments, memory strategy training, including the use of internalized strategies (eg, visual imagery) and external memory compensations (eg, notebooks), is recommended as a practice standard; (2) for individuals with severe memory deficits, the use of external compensations, including assistive technology, with direct application to functional activities is recommended as a practice guideline; and (3) for individuals with severe memory impairments, errorless learning techniques may be effective for learning specific skills or knowledge, although with limited transfer to novel tasks or reduction in overall functional memory problems

However, a recent Cochrane meta-analysis[425] with 13 cognitive rehabilitation RCTs reported no benefit to executive functioning after stroke, whereas other systematic reviews using a broader range of evidence have suggested some limited evidence.[426,427] Current studies are small and have highly varied content, making comparisons difficult. Notably, an RCT delivered strategies focused on problem solving by 3 methods (face to face, online, and computer training) and found that although all improved problem-solving and IADL abilities, the face-to-face training group resulted in the most improvement in problem-solving self-efficacy.[428] Another RCT[429] found that using a pager was effective in increasing goal attainment (ie, medication and appointments) but that stroke participants' performance returned to baseline levels when the pager was discontinued. In contrast, specific aspects of memory (eg, visual-spatial recall, subjective memory experience, verbal and prospective memory, working memory, and attention) have been shown to improve after stroke in 6 different controlled trials that used very diverse cognitive training strategies.[430–435]

A systematic review of the literature (1995–2011) focused specifically on information and communication technology tools for individuals with acquired brain injury, including stroke,[436] reviewed 5 studies that addressed memory problems. The quality of the studies was so low that it was not possible to determine whether the tools were beneficial.

Only 2 studies have examined the effects of tDCS on attention in stroke patients.[437,438] The first study[438] found that anodal tDCS over the left dorsolateral prefrontal cortex was associated with enhanced complex attention (working memory) performance. The second study[437] found that noninvasive anodal tDCS applied to the left dorsolateral prefrontal cortex improved attention compared with sham stimulation. Although improved attention may result in improved memory because people are better able to initially register information, neither addressed whether the performance benefits resulted in improved memory learning and retention.

In summary, most cognitive rehabilitation programs use a variety of activities, including practice requiring attention, planning or working memory with pencil and paper or computerized activities, and teaching of compensatory strategies. Although a growing number of RCTs have addressed immediate effects on standardized psychobehavioral tests, few studies have assessed the durability of treatment effects or relevance to everyday functioning.

Exercise

Cumming et al[415] performed a systematic review through 2011 and found 12 RCTs and controlled, clinical trials that studied the effects of a physical activity or exercise-based intervention on cognitive function in stroke. They concluded that there are reasonably consistent and relatively small positive effects of exercise on cognition, with some studies finding specific positive effects on memory. However, the pool of studies identified was small, and methodological shortcomings were widespread.

Because most studies measured cognition or memory as a secondary outcome, there was a wide range of baseline cognitive abilities, including those without cognitive impairment. The dose and content of the exercise protocols have

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been highly diverse,[415,440,441] preventing recommendations on the optimal intensity or timing. Although no longitudinal exercise or physical activity studies have been undertaken to prevent cognitive impairment or dementia after stroke, it would seem reasonable to extend the results of studies in older adults that suggest a protective effect of exercise on cognitive decline.[413]

Enriched Environment

An RCT that modified the stroke rehabilitation environment with the provision of a computer with Internet, books, games, virtual reality gaming technology, and encouragement from staff to use the activities increased the engagement of patients with cognitive activities and reduced time spent inactive and alone.[417] Särkämö et al[442] performed a single-blind RCT to determine whether listening to music everyday can facilitate the recovery of cognitive functions after stroke. Two months of daily listening (95 minutes daily) to self-selected music after acute stroke improved verbal memory, focused attention, and depressive symptoms compared with listening to an audio book or not listening to music.[442]

Four weeks of playing virtual reality games for 30-minute sessions 3 times weekly improved visual attention and short-term visuospatial memory in a very small RCT of patients early after stroke.[443] These games required primarily paretic arm movements (eg, raise a hand to stop soccer balls from entering the goal).

Recommendations: Nondrug Therapies for Cognitive Impairment, Including Memory	Class	Level of Evidence
Enriched environments to increase engagement with cognitive activities are recommended.	I	A
Use of cognitive rehabilitation to improve attention, memory, visual neglect, and executive functioning is reasonable.	IIa	B
Use of cognitive training strategies that consider practice, compensation, and adaptive techniques for increasing independence is reasonable.	IIa	B
Compensatory strategies may be considered to improve memory functions, including the use of internalized strategies (eg, visual imagery, semantic organization, spaced practice) and external memory assistive technology (eg, notebooks, paging systems, computers, other prompting devices).	IIb	A
Some type of specific memory training is reasonable such as promoting global processing in visual-spatial memory and constructing a semantic framework for language-based memory.	IIb	B
Errorless learning techniques may be effective for individuals with severe memory impairments for learning specific skills or knowledge, although there is limited transfer to novel tasks or reduction in overall functional memory problems.	IIb	B
Music therapy may be reasonable for improving verbal memory.	IIb	B
Exercise may be considered as adjunctive therapy to improve cognition and memory after stroke.	IIb	C
Virtual reality training may be considered for verbal, visual, and spatial learning, but its efficacy is not well established.	IIb	C
Anodal tDCS over the left dorsolateral prefrontal cortex to improve language-based complex attention (working memory) remains experimental.	III	B

Use of Drugs to Improve Cognitive Impairments, Including Attention

Several medications are used to treat general cognitive disorders, but little literature addresses their use for poststroke cognitive deficits. Dextroamphetamine has been studied for poststroke motor recovery,[444] but no studies have substantiated its use for cognitive disorders. Although the effect of methylphenidate in 1 small trial might rely partly on an improvement in attention and effort through cingulum modulation,[445] no studies have assessed its use in cognitive rehabilitation after stroke. Modafinil has been studied for the treatment of poststroke depression[446] and fatigue[447] but not cognitive recovery. Atomoxetine also has been studied for the treatment of poststroke depression but not cognitive deficits.

Donepezil has been studied in a small, randomized, clinical trial.[448] Ten right-hemispheric stroke survivors were randomized to receive either 5 mg donepezil or placebo. The donepezil group demonstrated significant improvements on the Mini-Mental Status Examination 1 month after completion of treatment, and functional magnetic resonance imaging showed increased activation in both prefrontal areas, both inferior frontal lobes, and the left inferior parietal lobe.

A pilot study randomized 50 subjects to receive either rivastigmine or placebo.[449] Subjects receiving rivastigmine demonstrated statistically significant improvement (1.70 versus 0.13; P=0.02) on the animal subtask of the verbal fluency measure compared with those on placebo, but a nonsignificant trend toward improvement was observed in the Color Trails II test, described as a culture-fair test of visual attention, graphomotor sequencing, and effortful executive processing abilities.

A study of 47 subjects at least 6 months after stroke were randomized to receive fluoxetine, nortriptyline, or placebo.[450] Although no significant group effect was found at the end of treatment, the placebo group exhibited deterioration in executive functioning 21 months after treatment, whereas the groups who received fluoxetine or nortriptyline significantly improved, independently of depressive symptoms (F=12.1 df=1, 45; P=0.001). The improvement was attributed to possible reorganization of neuronal networks associated with prefrontal functions based on modulation of monoaminergic neurotransmission and the activity of neurotrophins.

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Recommendations: Use of Drugs to Improve Cognitive Impairments, Including Attention	Class	Level of Evidence
The usefulness of donepezil in the treatment of poststroke cognitive deficits is not well established.	IIb	B
The usefulness of rivastigmine in the treatment of poststroke cognitive deficits is not well established.	IIb	B
The usefulness of antidepressants in the treatment of poststroke cognitive deficits is not well established.	IIb	B
The usefulness of dextroamphetamine, methylphenidate, modafinil, and atomoxetine in the treatment of poststroke cognitive deficits is unclear.	IIb	C

Limb Apraxia

Limb apraxia is "a decrease or difficulty in performing purposeful, skilled movements" that cannot be attributed to hemiplegia or lack of effort.[451] It is more common after left hemispheric than right hemispheric stroke.[452] Although not traditionally believed to affect daily life function,[453,454] there is now evidence that apraxia is associated with reduced independence in daily life activities.[455–457] Despite its incidence and its impact on independent functioning, there is a paucity of research on therapeutic interventions for limb apraxia. Several systematic reviews have been conducted since 2005,[458–461] reviewing 5 small RCTs across the 4 reviews. Since these reviews, no additional RCTs and only 1 case study have been published.[462] Two reviews concluded that there was not enough information to determine whether interventions for apraxia were efficacious.[458,459] Some studies have found immediate postintervention improvements on apraxia tests or in daily life activities, but few have found lasting advantages for the trained groups.[459]

Recommendations: Limb Apraxia	Class	Level of Evidence
Strategy training or gesture training for apraxia may be considered.	IIb	B
Task practice for apraxia with and without mental rehearsal may be considered.	IIb	C

Hemispatial Neglect or Hemi-Inattention

Hemispatial neglect, also called hemiagnosia, hemineglect, unilateral neglect, spatial neglect, contralateral neglect, unilateral visual inattention, hemi-inattention, neglect syndrome, or contralateral hemispatialagnosia, is a neuropsychological condition in which, after damage to a part of 1 hemisphere of the brain is sustained, a deficit in attention to and awareness of 1 side of space is observed. These symptoms are not attributable to a primary sensory (eg, visual) or motor deficit; they are typically contralateral to the lesion. Hemispatial neglect is common after stroke[463] and significantly impairs the ability to participate effectively in rehabilitation.[464] Although neglect improves over time, neglect symptoms continue to interfere with daily functioning long after stroke.[465–467] The interventions developed for neglect fall into 2 general categories: bottom-up approaches, designed to remediate attention processes for the left hemispace and internal representations of space, and top-down approaches, aimed at teaching the person strategies for compensating for neglect.[468] Most studies of neglect have been plagued by low-quality methods and small sample sizes.

Three systematic reviews have been completed since 2005,[468–470] reviewing 24 unique randomized, clinical trials and 14 additional studies with weaker designs. The interventions studied and outcome measures varied widely in these reviews. Fifteen additional RCTs investigating neglect were found that were not included in those reviews (prism adaptation, 2; virtual reality, 2; limb activation, 2; neck vibration with prism adaptation, 1; visual scanning with limb activation, 1; mental practice, 1; repetitive transcranial magnetic stimulation, 4; and optokinetic stimulation, 2).[471–483] There is evidence for the efficacy of several top-down and bottom-up approaches in improving both immediate performance and long-term performance on standard neglect tests such as cancellation tests and line bisection tests.* These include half-field eye patching, visual scanning training, prism adaptation, limb activation, optokinetic stimulation, mental imagery (but see the work by Welfringer and colleagues[482]), and brain stimulation with repetitive transcranial magnetic stimulation, theta burst transcranial magnetic stimulation, or tDCS. Two randomized, clinical trials of eye patching for unilateral neglect in 35 subjects[487] and 60 subjects[488] did not demonstrate any significant functional improvement. None of these treatments resulted in improvement on all neglect tests.

Few studies have examined the efficacy of these interventions on daily life functioning. Several have used the behavioral tests from the Behavioral Inattention Test[489]or the Baking Tray Test,[490] which are simulated real-life activities. Some studies have examined functional outcomes with the Catherine Bergego Scale,[491] which measures neglect symptoms during everyday activities or paragraph reading tasks. Others have used the less sensitive, general tests of functioning in ADLs such as the Barthel Index[330] and the FIM.[492] There is limited evidence to date that these interventions increase daily life functioning, even when performance on neglect tests has improved,[468,470] although some individual RCTs have found positive results on daily function.[469,471,475,481,484]

Cognitive rehabilitation may have immediate benefits on tests of neglect, as supported by a meta-analysis of 23 RCTs, but it is uncertain whether disability associated with neglect was altered.[419] Finally, a meta-analysis[493] found that compensatory scanning training improved reading and visual scanning in people with visual field defects (and possibly coexisting visual neglect).

It is important to note that in many of the studies, the target intervention was provided in addition to regular therapy or scanning training. Therefore, there is not sufficient evidence to ascertain whether neglect interventions are effective when provided in isolation. In addition, several issues in understanding how to treat neglect exist. These include understanding the heterogeneous response to treatment across clients, the heterogeneous response to treatment across measured tasks, the parameters of treatment (dosing, type of practice activity during or after treatment), and the relative efficacy of the various interventions, either alone or in combination.

*References 469–471, 473, 475, 476, 478, 480, 481, 484–486

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Recommendations: Hemispatial Neglect or Hemi-Inattention	Class	Level of Evidence
It is reasonable to provide repeated top-down and bottom-up interventions such as prism adaptation, visual scanning training, optokinetic stimulation, virtual reality, limb activation, mental imagery, and neck vibration combined with prism adaptation to improve neglect symptoms.	IIa	A
Right visual field testing may be considered.	IIb	B
Repetitive transcranial magnetic stimulation of various forms may be considered to ameliorate neglect symptoms.	IIb	B

Communication Disorders

Disorders of communication and related cognitive impairments are common after stroke and include aphasia, cognitive-communication disorders, dysarthria, and apraxia of speech. Communication disorders may affect speaking, listening, reading, writing, gestures, and pragmatics. The presence of a communication disorder may negatively affect social participation, psychosocial well-being, and quality of life.

A certified speech and language pathologist normally performs the evaluation and treatment of communication disorders. The overall goals of speech and language treatment are to facilitate the recovery of communication, to assist patients in developing strategies to compensate for communication disorders, and to counsel and educate people in the patient's environment on assistive communication supports to facilitate communication, to decrease isolation, and to meet the patient's wants and needs. Compensatory and assistive communication supports may range from low-tech strategies such as paper/pencil and communication boards/books to high-tech devices that include smart phones and speech-generating devices.

Cognitive-Communication Disorders

There is great diversity in the presentation of cognitive-communication problems after stroke.[494] A systematic review of cognitive-communication disorders after right hemispheric stroke suggested that many individuals at both the chronic and acute phases of recovery benefit from sentence- or discourse-level communication treatments.[495]

Several reviews summarize research evidence for treatments of attention, visual neglect, memory training, and other cognitive treatments for individuals with acquired brain injuries, including right hemispheric stroke. Although RCTs are lacking,[419,420,425] a systematic review concludes that there is now sufficient information to support evidence-based protocols to implement empirically supported treatments for cognitive and communication disability after stroke.[418] The Nondrug Therapies for Cognitive Impairment, Including Memory section above provides more information on nonpharmacological treatments for cognitive disorders after stroke.

Aphasia

An RCT indicated that daily aphasia therapy in very early stroke recovery (starting at 3 days) improved communication outcomes in people with moderate to severe aphasia.[496] One systematic review of treatment in patients at >6 months after stroke concluded that aphasia therapy continued to be efficacious in the chronic stages,[497] whereas another concluded that there was no significant relationship between time after onset and response to treatment.[498] Insufficient evidence exists to know when treatment should start or how long it should continue.

Several systematic reviews have indicated that intensive treatment is favored,[499–501] but there is no consensus on the optimum amount, intensity, distribution, or duration of treatment.[353] For subacute aphasia, 1 RCT has shown that a short duration (3 weeks) of intensive therapy is efficacious,[502] whereas another RCT indicated that intensive treatment over a longer duration (12 weeks) may not always be feasible.[503] Therefore, intensive therapy should be provided as tolerated and feasible.

A variety of different treatment approaches for aphasia have been developed. Small-group and single-subject studies support their efficacy.[497] A systematic review of RCTs of aphasia treatment stated that no conclusions can be made about the effectiveness of one treatment over another.[499]

Three RCTs evaluated computer-based therapy, with 1 RCT comparing it with no treatment, 1 comparing it with the same treatment provided by a speech and language therapist, and the third comparing it with the same amount of nonlinguistic computer training.[504–506] These 3 trials concluded that computer-based therapy is feasible and efficacious. Therefore, computerized treatment is beneficial and can be used to supplement treatment provided by a speech-language pathologist.

A systematic review concluded that communication partner training is effective in improving communication activities or the participation of the communication partner. It is also probably effective in improving communication activities or the participation of individuals with chronic aphasia when they are interacting with trained communication partners.[507] Communication partners may include family members and caregivers, healthcare professionals, and others in the community or organization. Further studies are needed to examine the impact of communication partner training with individuals with acute aphasia.[507]

Two systematic reviews have addressed group therapy.[499,508] Group treatments for people with aphasia occur across the continuum of care.[508] Overall, results indicate that group participation can improve specific linguistic processes with no significant difference in outcomes between individual one-on-one therapy and group therapy. There is also some evidence that outpatient and community-based group participation can benefit social networks and community access.[508]

Several small RCTs have shown that drug therapy appears to be beneficial in conjunction with SLT, whereas other studies have failed to show a benefit. Drugs showing promise include donepezil,[509] memantine,[510] and galantamine.[511] Bromocriptine[512] and piracetam[513] do not appear beneficial. More extensive studies of pharmacotherapy for aphasia are needed before the routine use of any medication can be

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recommended. Further research on the dose and timing of administration is needed.

Brain stimulation techniques, including epidural cortical stimulation, repetitive transcranial magnetic stimulation, and tDCS, have been used to modulate cortical excitability during poststroke language recovery. Small studies have shown therapeutic benefits when brain stimulation techniques are used, typically in combination with behavioral language therapy.[504,514–516] Most studies are small-group or single-subject studies and have been conducted in patients with chronic aphasia. Two RCTs investigating repetitive transcranial magnetic stimulation in acute and subacute aphasia[517,518] found mixed results. Brain stimulation combined with speech language therapy may benefit selected patients, but more information on the site of stimulation and stimulation parameters is needed before it can be used in routine clinical practice.[437,438,516]

Recommendation: Cognitive Communication Disorders	Class	Level of Evidence
Interventions for cognitive-communication disorders are reasonable to consider if they are individually tailored and target:	IIa	B
The overt communication deficit affecting prosody, comprehension, expression of discourse, and pragmatics		
The cognitive deficits that accompany or underlie the communication deficit, including attention, memory, and executive functions		

Recommendations: Aphasia	Class	Level of Evidence
Speech and language therapy is recommended for individuals with aphasia.	I	A
Treatment for aphasia should include communication partner training.	I	B
Intensive treatment is probably indicated, but there is no definitive agreement on the optimum amount, timing, intensity, distribution, or duration of treatment.	IIa	A
Computerized treatment may be considered to supplement treatment provided by a speech-language pathologist.	IIb	A
A variety of different treatment approaches for aphasia may be useful, but their relative effectiveness is not known.	IIb	B
Group treatment may be useful across the continuum of care, including the use of community-based aphasia groups.	IIb	B
Pharmacotherapy for aphasia may be considered on a case-by-case basis in conjunction with speech and language therapy, but no specific regimen is recommended for routine use at this time.	IIb	B
Brain stimulation techniques as adjuncts to behavioral speech and language therapy are considered experimental and therefore are not currently recommended for routine use.	III	B

Motor Speech Disorders: Dysarthria and Apraxia of Speech

Dysarthria is a collective term for a group of speech disorders that result from paralysis, weakness, or incoordination of the speech musculature after neurological damage. Dysarthria can affect, singly or in combination, any of the subsystems underlying speech production: the respiratory, laryngeal, velopharyngeal, and oral-articulatory subsystems. It is estimated that 20% of stroke patients present with dysarthria,[519] although the type of dysarthria and its specific characteristics vary, depending on factors such as lesion site and severity.

Apraxia of speech is a disorder of motor planning or programming resulting in difficulty in volitionally producing the correct sounds of speech. In addition to articulatory disturbances, prosodic deficits such as slow rate of speech and restricted variations in pitch and loudness may be present. Apraxia of speech typically co-occurs with nonfluent aphasia, and the existence of a pure apraxia of speech without aphasia is debatable.

Motor speech disorders affect the intelligibility, naturalness, and efficiency of communication. The presence of a motor speech disorder may negatively affect social participation, psychosocial well-being, and quality of life.

Speech and language therapists use a range of behavioral treatments to address motor speech disorders in individuals after stroke.[520–523] Behavioral treatments for motor speech disorders are diverse in their focus and theoretical underpinnings and should be tailored to the individual's unique strengths, deficits, goals, priorities, and circumstances. Behavioral treatments may focus on improving the physiological support for speech and target impairments in respiration, phonation, articulation, and resonance. Behavioral treatments may also include strategies to increase the precision of articulation, to modify the rate and loudness of speech, and to improve prosody. To date, no randomized, clinical trials have addressed the efficacy of these approaches,[524,525] but small, nonrandomized group studies and carefully designed, single-subject, experimental studies have demonstrated positive results.[521,526–528] Individuals with motor speech disorders may improve as a result of treatment, even when the condition is chronic.[521,522,528,529] There is no consensus on the optimum amount, distribution, or variability of practice or the best type, frequency, and timing of treatment.

Patients with motor speech disorders may benefit from using augmentative and alternative communication devices to supplement their communication. Augmentative and alternative communication devices range from simple picture boards or spelling boards to portable amplification systems and high-tech electronic devices with eye-tracking capability.[522,530] Supplemental strategies such as gesture or writing can be used to enhance communication attempts. Two systematic reviews have concluded that augmentative and alternative communication and speech supplementation techniques may be useful for individuals with motor speech disorders, when speech is insufficient to meet the individual's communication needs.[527,531]

The effects of motor speech disorders after stroke extend beyond the physiological characteristics of the impairment. Studies have shown that the resulting communication difficulties affect social participation and quality of life[532,533] and that the psychosocial impact of a motor speech disorder is disproportionate to the severity of the physiological impairment.[532,533]

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Behavioral management of motor speech disorders includes support and counseling. Interventions addressing the broad life implications of motor speech disorders are being developed, and pilot studies are underway.[534]

Addressing environmental factors during rehabilitation is consistent with the *ICF* and warrants consideration.[535–537] For individuals with motor speech disorders, this may include providing education that addresses the knowledge and attitudes of communication partners or modifying the characteristics of the physical environment such as reducing noise levels.[535–537]

Telerehabilitation may be used to overcome barriers of access to services.[538] The quality of telerehabilitation services must be consistent with the quality of services delivered face to face.[538] Studies demonstrating the feasibility of telerehabilitation in the management of dysarthria are emerging.[353]

Recommendations: Motor Speech Disorders: Dysarthria and Apraxia of Speech	Class	Level of Evidence
Interventions for motor speech disorders should be individually tailored and can include behavioral techniques and strategies that target:	I	B
Physiological support for speech, including respiration, phonation, articulation, and resonance		
Global aspects of speech production such as loudness, rate, and prosody		
Augmentative and alternative communication devices and modalities should be used to supplement speech.	I	C
Telerehabilitation may be useful when face-to-face treatment is impossible or impractical.	IIa	C
Environmental modifications, including listener education, may be considered to improve communication effectiveness.	IIb	C
Activities to facilitate social participation and promote psychosocial well-being may be considered.	IIb	C

Spasticity

Spasticity, classically defined as a velocity-dependent resistance to stretch of a muscle, is a component of the upper motor neuron syndrome. Poststroke spasticity may have dystonic features, including involuntary muscle activity and limb positioning. Spasticity is correlated with activity limitations associated with hygiene, dressing, and pain. These activity limitations increase caregiver burden and reduce quality of life as measured by the EuroQol-5.[539]

When spasticity is present, the cost of care is 4 times higher than when spasticity is absent; however, because spasticity is strongly associated with stroke severity, the independent impact of spasticity on costs is not known.[540] Thus, the cost of treating spasticity may not reduce the overall cost of stroke-related care. For example, in 1 study, the use of botulinum toxin injections for upper limb spasticity combined with therapy was not found to be cost-effective compared with therapy alone.[541]

The prevalence of poststroke spasticity in any limb is in the range of 25% to 43% over the first year after stroke.[542–545] For patients who require acute rehabilitation after stroke, the prevalence of spasticity in any limb is 42%.[546] The incidence of upper limb spasticity over the first 3 months in patients admitted to rehabilitation is 33%.[9] The strongest predictor of moderate to severe spasticity (Ashworth scale score ≥2) is severe proximal and distal limb weakness on acute hospital or rehabilitation admission.[543,547]

The use of resting hand splints is not effective for reducing wrist and finger spasticity, and the use of such splints is controversial for the prevention of contracture in the setting of spasticity.[75] For ankle plantarflexor spasticity, a short course of ankle casting may facilitate spasticity reduction after injection of botulinum toxin. Taping, however, has no effect on spasticity after lower limb botulinum toxin injection and is not recommended.[548,549]

NMES combined with therapy may improve spasticity, but there is insufficient evidence that the addition of NMES improves functional gait or hand use.[550] Vibration applied to spastic muscle groups might be considered to reduce spasticity transiently, but it is not effective for long-term reduction of spastic hypertonia.[551–553]

Injection of botulinum toxin is used commonly to treat upper limb spasticity in patients with stroke and is recommended in several recent review articles and previously published guidelines as an important tool in the comprehensive management of poststroke spastic hypertonia.[149,554–557] Injections of botulinum toxin A can reduce spasticity significantly as measured by the Ashworth scale. In a meta-analysis, botulinum toxin was shown to have a small but statistically significant effect on activity as measured by the Disability Assessment Scale after injection into the upper limb.[558] However, improvements were attributable to the lowered resistance to muscle stretch during passive repositioning of the upper limb rather than to the actual skilled functional use of the arm and hand. Thus, there is no evidence to suggest that botulinum toxin injections will improve functional upper limb use, but it may improve limb active or passive limb positioning for activities such as dressing and hygiene.[559,560] Although botulinum toxins are clinically recommended for spasticity reduction, it is not clear that they are a cost-effective means to manage spastic hypertonia compared with physical or occupational therapies alone.[541] However, if a reduction in caregiver burden is taken into account, the use of botulinum toxins with therapy may be cost-effective.[561] The early injection of botulinum toxins as soon as hypertonia appears may be effective in preventing later spasticity, but this needs further study.[562,563]

Botulinum toxins injected into the ankle plantarflexor and inverter muscles significantly reduce lower limb spasticity as measured by the Ashworth scale.[564–566] Injections may also improve gait speed, although only slightly.[567] Botulinum toxin injections into the rectus femoris muscle may improve tonic knee extension during the swing phase of gait in stroke, but further study is needed.[568] Although botulinum toxins have been used to improve orthotic fit, no studies of this application have been reported.

Oral antispasticity agents, including baclofen, dantrolene sodium, and tizanidine, have a marginal effect on reducing generalized spasticity, but dose-limiting side effects such as tiredness and lethargy are common.[569–577] Intrathecal baclofen therapy is effective in reducing generalized spastic

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hypertonia in patients with stroke.[570,578–582] A consensus panel in 2006 recommended that intrathecal baclofen therapy is appropriate in those patients with spasticity who do not respond well to other interventions or in patients who experience adverse effects from other treatments. They also concluded that intrathecal baclofen therapy can be considered as early as 3 to 6 months after stroke for patients refractory to other treatments.[583]

Recommendations: Spasticity	Class	Level of Evidence
Targeted injection of botulinum toxin into localized upper limb muscles is recommended to reduce spasticity, to improve passive or active range of motion, and to improve dressing, hygiene, and limb positioning.	I	A
Targeted injection of botulinum toxin into lower limb muscles is recommended to reduce spasticity that interferes with gait function.	I	A
Oral antispasticity agents can be useful for generalized spastic dystonia but may result in dose-limiting sedation or other side effects.	IIa	A
Physical modalities such as NMES or vibration applied to spastic muscles may be reasonable to improve spasticity temporarily as an adjunct to rehabilitation therapy.	IIb	A
Intrathecal baclofen therapy may be useful for severe spastic hypertonia that does not respond to other interventions.	IIb	A
Postural training and task-oriented therapy may be considered for rehabilitation of ataxia.	IIb	C
The use of splints and taping are not recommended for prevention of wrist and finger spasticity after stroke.	III	B

Balance and Ataxia

Balance depends on sensory inputs from the visual, vestibular, and somatosensory systems. These sensory inputs are integrated and used to control anticipatory and reactive motor output to postural disturbances. Balance impairment (inclusive of postural control impairment) is common after stroke[182,584,585] because stroke can affect 1 or more of the sensory and motor networks. Impaired balance makes it difficult to safely complete ADLs, to move about the home and community, and to live independently. A large percentage of people report falling at least once in the first 6 months after stroke.[182,585] People with stroke who fall are twice as likely to sustain a hip fracture compared with those who fall but do not have a stroke.[586] Balance impairments can result in low balance confidence, which in turn may further reduce activity.[587] If left undetected or untreated, balance impairments can result in a cascade of serious, undesirable, and expensive events.[175,245]

Evaluation of balance abilities is considered part of routine clinical practice in individuals with stroke.[308,588,589] Standardized tests of balance challenge different aspects of postural control such as anticipatory postural reactions during a variety of functional behaviors. Specific balance limitations identified during the evaluation will help determine the risk of falling and guide the selection and tailoring of balance-specific interventions.[308,591]

Although balance training programs have been shown to be beneficial after stroke, no specific approach or program has been demonstrated to be superior, nor is the optimal timing clear. Balance training has been successfully implemented as group and one-on-one sessions, circuit training, and hospital- versus home- versus community-based programs. Content of the training typically includes balance-specific activities, (eg, practice responding to challenges in standing) and more general activities (eg, strengthening exercises, gait activities).[592] Shorter, more time-intensive programs appear comparable to longer, less time-intensive programs.[592] Progression to more challenging training activities over the course of training is important. The one type of training that has not been shown to be beneficial for balance is water-based programs.[593]

Studies of balance training have generally been small, typically 10 to 60 subjects. Subjects typically have been able to ambulate independently (with or without an assistive device) and be relatively cognitively intact. Four systematic reviews and meta-analyses have reviewed the effects of various interventions on balance after stroke, with the latest one published in 2013. Findings across these reviews show inconsistent effects on balance outcomes. Subsequent published RCTs have tested a variety of types of balance training devices (sliding board, trunk exercises on a physioball, shoe wedge) or programs (yoga, Tai Chi,[187] gait training, motor imagery). The later studies have similar methodological challenges (8–40 subjects per group) and lead to similar, inconsistent conclusions about the superiority of any 1 specific treatment.[594–604] Likewise, a systematic review of fall prevention after stroke has shown that inconsistencies in outcome measures, intervention type, and implementation in previous research make it difficult to determine the effectiveness of fall prevention programs after stroke.[174] The Prevention of Falls section provides more discussion.

Use of devices and orthotics (eg, cane, AFO) also improves balance.[605] Finally, it should be noted that improving balance alone may not be sufficient for preventing falls because falls may have multiple contributing causes.

Ataxia is a disorder of coordinated muscle activity during voluntary movement associated with injury to the cerebellum, cerebellar peduncles, and brainstem cerebellar tracts. Patients with ataxia have delayed movement initiation, timing errors, abnormal limb trajectories, and dysmetria.[606,607] Ataxia is present in 68% to 86% of patients with brainstem stroke. Ataxia typically improves during acute rehabilitation.[608,609] Ataxia without concurrent hemiparesis has a better prognosis for functional recovery in acute rehabilitation.[610] However, the presence of ataxia with or without weakness does not affect general functional recovery negatively.[608,609] Ataxia can affect the quality of use of the functional hand negatively because patients with cerebellar lesions can have impaired motor learning (eg, reduced skill improvement on a pursuit rotor task or ability to learn a finger sequence).[611,612] Despite this, case studies indicate that intensive task-oriented therapy may improve motor performance and actual use of ataxic limbs in patients with stroke-related ataxia.

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After participating in a task-oriented training program, patients improved reaching speed and had reduced trunk motion during reaching.[613] Stoykov and others[606] noted that postural training and provision of trunk support could have a positive impact on upper limb motor control and dexterity in a patient with upper limb ataxia. There is a paucity of research on rehabilitation approaches to limb ataxia, but at present, postural training and task-oriented upper limb training are recommended.

Recommendations: Balance and Ataxia	Class	Level of Evidence
Individuals with stroke who have poor balance, low balance confidence, and fear of falls or are at risk for falls should be provided with a balance training program.	I	A
Individuals with stroke should be prescribed and fit with an assistive device or orthosis if appropriate to improve balance.	I	A
Individuals with stroke should be evaluated for balance, balance confidence, and fall risk.	I	C
Postural training and task-oriented therapy may be considered for rehabilitation of ataxia.	IIb	C

Mobility

The loss or difficulty with ambulation is one of the most devastating sequelae of stroke, and restoration of gait is often one of the primary goals of rehabilitation. Gait-related activities include such tasks as mobility during rising to stand, sitting down, stair climbing, turning, transferring (eg, wheelchair to bed or bed to chair), using a wheelchair after stroke, walking quickly, and walking for specified distances.[614] Limitations in gait and gait-related activities are associated with an increase in fall risk. A number of systematic reviews have demonstrated enhanced outcomes of gait, gait-related activities, and ADLs[615] after intensive, repetitive task training.[616–618] The role of treadmill training and electromechanics-assisted gait training remains under study.[619]

Key training parameters for improving mobility after stroke are activity-specific and functional task practice; practice that is progressively more difficult and challenging; practice that is of sufficient intensity, frequency, and duration; and practice that is at an appropriate time relative to stroke onset.[616,620] These parameters pertain to treadmill training with or without body weight support, circuit training, mobility training, and electromechanics-assisted training.[616]

Dickstein[621] reviewed a variety of mobility training techniques and found that gains were comparable across treatments but generally insufficient for patients to advance to a higher functional walking category on the basis of the categories defined by Perry et al.[277] No benefit was seen for more complex methods such as treadmill and robotic-based interventions compared with more traditional approaches.

Circuit class therapy is a form of group treatment with exercises focused on repetitive practice of functional tasks.[622–624] A 2009 meta-analysis and recent systematic review concluded that circuit class therapy was a safe and effective method for improving mobility after stroke.[623,625]

Treadmill training in the context of task-specific training may be used with or without body weight support or therapists to assist the paretic lower extremity in stepping. A recent systematic review concluded that compared with no intervention or with an intervention with no walking component, treadmill training without body weight support improved walking speed and distance among ambulatory people after stroke. Although these benefits were maintained beyond the intervention period, it is not yet known whether treadmill training is superior to overground walking training.[621,626] Recently, it was demonstrated that treadmill training with body weight support and traditional gait training were equally effective in improving walking and transfers in patients dependent on walking assistance after stroke.[51,627] A recent systematic review, including those <3 months after stroke and unable to walk, reported that those individuals who are earlier after stroke and more severe are more likely to have a better gait recovery outcome with mechanically assisted training compared with overground training and by using a harness in conjunction with the mechanical device. Mechanically assisted walking (eg, treadmill, electromechanical gait trainer, robotic device, servo-motor) with body weight support was found to be more effective than overground walking at increasing independent walking in nonambulatory patients early after stroke.[628]

Lower Extremity Strengthening

A 2007 review concluded that graded strength training improves the ability to generate force but does not transfer to improvements in walking.[618] However, a more recent meta-analysis demonstrated that providing lower limb resistance training to community-dwelling individuals who are 6 months after stroke has the capacity to improve comfortable gait speed and total distance walked.[629] Similarly, a 2008 review concluded that despite limited long-term follow-up data, there is evidence that resistance training produces increased strength, gait speed, and functional outcomes, as well as improved quality of life.[630]

NMES has been used to stimulate the ankle dorsiflexors during the swing phase of the gait cycle. A recent systematic review revealed a small but significant treatment effect of NMES on gait capacity in individuals in the chronic phase after stroke.[631] Similarly, a meta-analysis revealed the effectiveness of NMES at improving gait speed in subjects after stroke.[632] Several RCTs have observed improved recovery of gait function after stroke in the chronic[550,633–635] and acute phases[636,637] when NMES was applied in conjunction with a conventional rehabilitation program. Studies comparing the use of an AFO to NMES in controlling foot drop during walking have found similar results.[638,639] Although subjects preferred the foot drop stimulator used in 2 multisite RCTs, both the stimulator and a conventional AFO produced equivalent functional gains.[638,640,641] Similar results were obtained in a comparison of surface peroneal nerve stimulation and use of an AFO.[642,643] Significant improvements in functional mobility were found with both peroneal nerve stimulation and AFO during the treatment period and were maintained at the 6-month follow-up.

Medications for Motor Recovery

Several medications have been studied as potential contributors to stroke recovery in general and to motor recovery in

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particular, including dextroamphetamine, methylphenidate, levodopa, and SSRIs. Fluoxetine was found to be helpful for motor recovery in a double-blind, placebo-controlled trial,[644] and several smaller studies of SSRIs were also suggestive of benefit.[645–648] A systematic review and meta-analysis found evidence of benefit for SSRIs in overall disability after stroke.[649] The overall quality of these studies was not sufficient, however, to make a definitive recommendation, and larger, well-controlled trials are in progress. A randomized, double-blind, placebo-controlled trial of dextroamphetamine in 71 subjects was negative,[444] and a subsequent systematic review of the use of amphetamines for improving motor recovery after stroke found inconsistent findings,[650] and these carry a risk of adverse cardiovascular effects. A randomized, double-blind, placebo-controlled trial of levodopa found short-term benefit of this therapy compared with placebo for motor function but was limited by relatively small size (47 subjects analyzed), baseline differences in stroke severity and patient age between the 2 treatment groups, and the short-term follow-up of only 3 weeks after the completion of therapy.[651]

Acupuncture

The Ottawa Panel recommends that there is good scientific evidence to consider including acupuncture as an adjunct to standard stroke rehabilitation to improve walking mobility.[639] Shiflett[652] reviewed a number of RCTs of acupuncture for stroke recovery and performed a reanalysis suggesting that acupuncture may be effective as an adjunctive treatment for improving walking speed.

Transcutaneous Electrical Nerve Stimulation

TENS provides electrically induced sensory input to the lower limb. A meta-analysis revealed that there was insufficient research to make conclusions about the effectiveness of TENS in improving gait and gait-related activities.[632] Three subsequent RCTs provided evidence of a potential benefit of TENS on physical function after stroke, particularly when combined with task-related activity.[653–655]

Rhythmic Auditory Cueing

Rhythmic auditory cueing is a therapy approach in which overground walking is synchronized to a rhythmic auditory cue to improve temporal and spatial gait measures. An evidence synthesis found moderate evidence of improved velocity and stride length in people with stroke after gait training with rhythmic music. Synchronizing walking to rhythmic auditory cues can result in short-term improvement in gait measures of people with stroke. Further high-quality studies are needed before recommendations for clinical practice can be made.[656]

Use of AFOs

Use of AFOs is an effective method of compensating for motor impairments in the lower limb after stroke.[657–660] The reader is referred to the section below on adaptive equipment for details.

Robotic and Electromechanics-Assisted Training Devices

Robots and electromechanics-assisted training devices have been used in an effort to promote gait recovery after stroke. Most of these devices incorporate body weight support along with treadmills or foot platform pedals analogous to an elliptical trainer. Their main advantage over conventional gait training is that they reduce the need for intensive therapist support. These devices include the Lokomat, the Gait Trainer GT 1, and the AutoAmbulator. A Cochrane systematic review updated in 2013 concluded that patients with stroke who received electromechanics-assisted gait training in combination with PT were more likely to achieve independent walking than patients receiving gait training without these devices, but it did not find an increase in gait velocity.[661] The review concluded that the individuals most likely to benefit from this therapy appear to be those who are within the first 3 months after stroke and those who are unable to walk. In contrast, a study by Hornby et al[662] demonstrated greater improvement in gait velocity and single limb support time on the paretic limb after therapist-assisted locomotor training compared with robotic-assisted locomotor training.[662] A systematic review found improved balance for stroke survivors receiving robotic gait training, but there was insufficient evidence comparing robotic gait training with conventional gait training to determine whether these therapies are similar in this regard.[663]

Exoskeletal wearable lower limb robotic devices are also available for gait training after stroke and allow overground walking with the device. Most of these devices (eg, Ekso, Ekso Bionics, Richmond, CA; Indego, Parker-Hannifin; and ReWalk, Marlborough, MA) are bilateral in design, although unilateral exoskeletal wearable devices have also been developed (eg, Bionic Leg, AlterG, Fremont, CA). Although a pilot study of a unilateral device did not demonstrate benefit compared with conventional exercise therapy,[664] most of the devices in this class have not yet been examined in controlled trials for stroke survivors. Overall, although robotic therapy remains a promising therapy as an adjunct to conventional gait training, further studies are needed to clarify the optimal device type, training protocols, and patient selection to maximize benefits.

Electromyographic Biofeedback

Electromyographic biofeedback is a technique that uses visual or audio signals to provide the patient with feedback on his/her muscle activity. The literature on the use of electromyographic biofeedback plus conventional rehabilitation includes some studies suggesting improved motor power, functional recovery, and gait quality compared with conventional rehabilitation alone. However, a 2007 Cochrane database systematic review did not find a treatment benefit. The results of the systematic review are limited because the trials were small, were generally poorly designed, and used varying outcome measures, making it difficult to compare across studies.[665]

Virtual Reality

Virtual reality is the use of computerized technology to allow patients to engage in specific task practice within a computer-generated visual environment in a naturalistic fashion. An environment that may be more interesting to a subject may enhance motivation to practice. In 2011, the Cochrane Stroke Group concluded that there was insufficient evidence to reach conclusions about the effect of virtual reality and interactive video gaming on gait speed.[666] However, a recent systematic

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review[667] suggests that virtual reality promotes changes in gait parameters despite diversity of protocols, participant characteristics, and number of subjects included.

Traditional Physiotherapeutic Approaches (Neurodevelopmental Therapy/Bobath, Brunnstrum, Proprioceptive Neuromuscular Facilitation)

A recent systematic review conducted by Langhammer and Stanghelle[668] assessed the efficacy of the traditional physiotherapeutic approaches. Although improvements in motor function were demonstrated, no trial showed that these approaches were superior to the respective comparison therapies.[668] Similarly, it was concluded that neurodevelopmental approaches were equivalent or inferior to other approaches in improving walking ability in a 2007 systematic review.[618]

Water-Based Exercises

The conclusions drawn in a 2012 Cochrane systematic review revealed that the evidence from RCTs to date does not confirm or refute that water-based exercises after stroke might help to improve gait and gait-related activities.[593]

Recommendations: Mobility	Class	Level of Evidence
Intensive, repetitive, mobility- task training is recommended for all individuals with gait limitations after stroke.	I	A
An AFO after stroke is recommended in individuals with remediable gait impairments (eg, foot drop) to compensate for foot drop and to improve mobility and paretic ankle and knee kinematics, kinetics, and energy cost of walking.	I	A
Group therapy with circuit training is a reasonable approach to improve walking.	IIa	A
Incorporating cardiovascular exercise and strengthening interventions is reasonable to consider for recovery of gait capacity and gait-related mobility tasks.	IIa	A
NMES is reasonable to consider as an alternative to an AFO for foot drop.	IIa	A
Practice walking with either a treadmill (with or without body-weight support) or overground walking exercise training combined with conventional rehabilitation may be reasonable for recovery of walking function.	IIb	A
Robot-assisted movement training to improve motor function and mobility after stroke in combination with conventional therapy may be considered.	IIb	A
Mechanically assisted walking (treadmill, electromechanical gait trainer, robotic device, servo-motor) with body weight support may be considered for patients who are nonambulatory or have low ambulatory ability early after stroke.	IIb	A
There is insufficient evidence to recommend acupuncture for facilitating motor recovery and walking mobility.	IIb	B
The effectiveness of TENS in conjunction with everyday activities for improving mobility, lower extremity strength, and gait speed is uncertain.	IIb	B
The effectiveness of rhythmic auditory cueing to improve walking speed and coordination is uncertain.	IIb	B
The usefulness of electromyography biofeedback during gait training in patients after stroke is uncertain.	IIb	B
Virtual reality may be beneficial for the improvement of gait.	IIb	B
The effectiveness of neurophysiological approaches (ie, neurodevelopmental therapy, proprioceptive neuromuscular facilitation) compared with other treatment approaches for motor retraining after an acute stroke has not been established.	IIb	B
The effectiveness of water-based exercise for motor recovery after an acute stroke is unclear.	IIb	B
The effectiveness of fluoxetine or other SSRIs to enhance motor recovery is not well established.	IIb	B
The effectiveness of levodopa to enhance motor recovery is not well established.	IIb	B
The use of dextroamphetamine or methylphenidate to facilitate motor recovery is not recommended.	III	B

Upper Extremity Activity (Includes ADLs, IADLs, Touch, Proprioception)

The majority of individuals with stroke experience problems with the upper extremity, most commonly paresis,[670,671] which is the key impairment in most cases.[333,337,341,672,673] Only a small portion of people fully recover from upper limb paresis after a stroke, with the remainder left with lingering upper extremity impairments, activity limitations, and participation restrictions.[338,674] An inability to use the upper extremity in daily life can lead to loss of independence with ADLs and of important occupations (eg, work, driving) and can even contribute to institutionalization.

Task-specific training, or functional task practice, is based on the premise that practice of an action results in improved performance of that action and is focused on learning or relearning a motor skill.[675,676] Task-specific practice is an element of or used in combination with many upper extremity interventions such as constraint-induced movement therapy (CIMT) and NMES. Across a large number of studies, the key elements of task-specific training are repeated, challenging practice of functional, goal-oriented activities. Trunk restraint during task-specific training is beneficial in reducing compensatory trunk movements and promoting proximal movement control.[677,678] Strengthening upper extremity muscles may be beneficial as an adjunct to task-specific training,[679,680] when therapy time permits, or when the strengthening activities can be performed outside formal therapy sessions.

CIMT has been demonstrated to improve upper extremity activity, participation, and quality of life in individuals with baseline ability to control wrist and finger extension compared with usual care.[52,678,681–685] It is less clear whether CIMT has

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any advantage over dose-matched conventional upper limb therapy.[686,687] CIMT can be delivered in its original form 3 to 6 h/d for 5 d/wk for 2 weeks or in a modified version 1 h/d for 3 d/wk for 10 weeks. The modified CIMT intervention appears to result in improvements that are comparable to the original version, although it has not been as extensively tested.[688–694]

Bilateral upper limb training has not been as well studied as CIMT. Two meta-analyses and more recent trials suggest that there is a small but measurable benefit compared with no intervention, but no consistent evidence of superiority over other task-specific training interventions has been shown.[695–699] Recent trials comparing bilateral training with CIMT or modified CIMT indicate that they may have similar efficacy for individuals with preserved isolated wrist and finger movement.[700–702]

For individuals with more severe paresis, the potential for recovery of upper extremity function is greatly reduced, particularly later after stroke.[674] Robotic therapy can deliver larger amounts of upper extremity movement practice for these individuals. There are a variety of types of upper extremity robots, consisting primarily of workstation devices used in a rehabilitation facility but also including some wearable exoskeletal devices that can be used in a home environment. A Cochrane review updated in 2012 found that upper limb robotic therapy provided benefit with regard to ADLs and arm function but not arm muscle strength.[703] The variation within the trials with regard to duration and amount of training, the specific devices used, and patient populations studied limits the interpretation of these results. Moreover, many of the studies performed with robot-aided therapy have compared it with usual care rather than dose-matched conventional upper limb exercise therapy. Those studies incorporating dose-matched exercise as a comparison treatment show minimal or no differences in the efficacy between these 2 treatments.[704,705] Overall, robotic therapy appears to provide some benefit for upper extremity motor abilities and participation but is of uncertain utility compared with dose-matched conventional upper limb exercise therapies.[706–713]

NMES can be used for those with minimal ability for volitional muscle activation. It may be beneficial for improving upper extremity activity if used in combination with task-specific training, particularly when applied to the wrist and hand muscles.[714–716] Alternatively, it is beneficial in preventing or correcting shoulder subluxation.[125,132,717]

Mental practice, or mental imagery, may be useful as an adjunct to upper extremity exercise therapies.[718–722] Initial training in mental practice occurs within a therapy session, but additional practice can happen outside formal therapy time. It is feasible to integrate mental practice with physical practice.[723] Longer durations of mental practice appear to produce more benefit.[724]

Virtual reality and video gaming have the potential to increase participant engagement and the amount of upper extremity movement practice. Computer-based video games are widely available for recreational purposes for the general public, including those with handheld controllers (eg, Wii) and motion capture systems (Xbox Kinect, Microsoft, Inc). In addition, these systems can be used as remotely monitored telerehabilitation systems.[725] To date, most studies of efficacy have been small and have used a variety of technologies and training programs, making generalization difficult. A Cochrane review[666] found benefit in terms of upper limb function and ADLs but no improvements in upper limb strength. The studies were of low quality in many cases, reducing confidence in this finding. Efficacy of Virtual Reality Exercises in STroke rehabilitation (EVREST),[727] a multicenter, randomized, clinical trial, is under way that may provide more definitive evidence. At present, virtual reality and video gaming are reasonable alternative methods to engage individuals with stroke in the rehabilitation process and to increase the amount of movement practice.[666,728,729,731–733]

A variety of interventions have been the focus of ≥1 studies but have not yet been shown to be consistently beneficial for upper limb motor rehabilitation. These include somatosensory stimulation[734–738] and noninvasive brain stimulation (transcranial magnetic stimulation or tDCS) in combination with upper extremity exercise therapy,[739–746] interventions targeting motor apraxia,[458] and manual therapy approaches such as stretching, passive exercise, and mobilization,[748] although these approaches are a routine part of practice for individuals with more severely affected upper extremities to prevent contractures and to manage spasticity.

Finally, upper extremity rehabilitation programs can be delivered in a variety of settings such as inpatient hospitals and outpatient clinics and within the home. A recent systematic review and subsequent RCT indicate that both outpatient and home service delivery models produce similar results on upper extremity activity, including the ability to perform ADLs.[749,750]

Recommendations: Upper Extremity Activity, Including ADLs, IADLs, Touch, and Proprioception	Class	Level of Evidence
Functional tasks should be practiced; that is, task-specific training, in which the tasks are graded to challenge individual capabilities, practiced repeatedly, and progressed in difficulty on a frequent basis.	I	A
All individuals with stroke should receive ADL training tailored to individual needs and eventual discharge setting.	I	A
All individuals with stroke should receive IADL training tailored to individual needs and eventual discharge setting.	I	B
CIMT or its modified version is reasonable to consider for eligible stroke survivors.	IIa	A
Robotic therapy is reasonable to consider to deliver more intensive practice for individuals with moderate to severe upper limb paresis.	IIa	A
NMES is reasonable to consider for individuals with minimal volitional movement within the first few months after stroke or for individuals with shoulder subluxation.	IIa	A
Mental practice is reasonable to consider as an adjunct to upper extremity rehabilitation services.	IIa	A
Strengthening exercises are reasonable to consider as an adjunct to functional task practice.	IIa	B
Virtual reality is reasonable to consider as a method for delivering upper extremity movement practice.	IIa	B

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Recommendations: Upper Extremity Activity, Including ADLs, IADLs, Touch, and Proprioception (Continued)	Class	Level of Evidence
Somatosensory retraining to improve sensory discrimination may be considered for stroke survivors with somatosensory loss.	IIb	B
Bilateral training paradigms may be useful for upper limb therapy.	IIb	A
Acupuncture is not recommended for the improvement of ADLs and upper extremity activity.	III	A

Adaptive Equipment, Durable Medical Devices, Orthotics, and Wheelchairs

Many patients require assistive devices, adaptive equipment, mobility aids, wheelchairs, and orthoses to maximize independent functioning after stroke. Many types of adaptive devices and equipment are available. Type and level of functional deficit, degree of achieved adaptation, and the structural characteristics of the living environment determine the need for a particular item.

A vast array of adaptive devices are available, including devices to make eating, bathing, grooming, and dressing easier for patients with functional limitations. The Convention on the Rights of Persons With Disabilities supports facilitating access by individuals with disabilities to quality mobility aids, devices, and assistive technologies by making them available at affordable cost.[751] Many patients may need to use adaptive devices early during rehabilitation but will not require long-term use. This should be taken into account when the provision of a device is considered. Examples of adaptive devices include (but are not limited to) eating utensils with built-up handles, rocker knives, plate guards, nonskid placemats, long-handled sponges for bathing, handheld showers, tub and shower chairs, grab bars for bathrooms, and elevated toilet seats. A meta-analysis found that OT increased independence in ADLs.[752] The protocols in these studies focused on improving personal ADLs, including the provision and training in the use of adaptive equipment.

Stroke can cause a number of gait impairments; consequently, stroke patients often have an unstable, inefficient walking pattern and a high risk for falls (see the sections Prevention of Falls and Mobility). More than half of stroke patients require an assistive device (cane, walker, wheelchair) to assist mobility, most frequently a cane.[753] Studies that have assessed the immediate effects of different assistive devices provided in random order have shown that ambulatory function (speed, step length, functional ambulation category) was improved with a cane after stroke.[754,755] Patients felt that their walking, walking confidence, and walking safety improved and said they would rather walk with an assistive device than delay walking to achieve a normal gait pattern.[755] Walking devices increase the base of support around a patient's center of gravity and reduce the balance and effort needed to walk. Walking aids include (but are not limited to) the following:

- Single-point cane: a conventional cane that provides 1 point of contact and limited improvement in balance and stability.
- Tripod and quad cane: canes that have 3 or 4 points of contact and offer more stability than a single-point cane but are heavier, bulkier, and more awkward to use. A quad cane has been shown to reduce postural sway more than a single-point cane in patients with stroke.[756]
- Two-wheeled walkers, 4-wheeled walkers, or rollators (ie, 4-wheeled walker with a seat): devices that require the use of both arms and legs. They support more body weight than a cane and are more energy efficient but cannot be used on stairs. They should be lightweight and foldable for use outside the home. Four-wheeled walkers may require hand-motor coordination to manage handbrakes on a downhill slope.

For individuals with stroke who cannot ambulate safely, a wheelchair can enhance mobility. Up to 40% of stroke patients have been reported to use a manual wheelchair at rehabilitation discharge.[757] A wheelchair may be required when a patient is unable to ambulate or when there is concern about his/her ability to ambulate safely or functionally.[758] The patient often propels the chair by using the less affected hand on 1 wheel and foot on the floor. Self-propulsion in a wheelchair early after a stroke has not been shown to be detrimental to muscle tone or functional outcomes.[759] Many stroke survivors also use manual wheelchairs for longer-distance travel such as shopping or physician appointments although they are capable of short-distance ambulation within the home. In these situations, the wheelchair is typically propelled by a caregiver.

Although powered wheelchairs are less commonly used after stroke, many stroke patients can learn to use powered wheelchairs safely with appropriate training.[760] Wheelchair designs vary greatly, and a wheelchair prescription should be specific to the patient's needs and environment and patient and family/caregiver preferences. The prescription of a wheelchair (manual or powered) in the community can increase participation and improve quality of life.[761,762]

A common approach to managing the lower limb motor impairments resulting from a stroke is to use an orthotic device (an orthosis), most commonly an AFO. Meta-analyses have shown a favorable impact of lower limb orthoses on walking disability (speed), walking impairment (step/stride length), and balance (weight distribution in standing).[659,605] However, the included studies examined only the immediate effects while the orthosis was worn.[659] A recent meta-analysis and systematic review suggested the potential mechanism(s) associated with the above effects by demonstrating a positive effect of an AFO on ankle kinematics, knee kinematics in stance phase, kinetics, and energy cost.[658] Two RCTs[763,764] showed that after 3 months of AFO use, AFO users had better mobility while wearing the AFO. One small RCT[764] found that although a dynamic hinged AFO improved ambulatory function over a standard AFO, it induced some dependence; the standard AFO group performed better after 3 months of use when walking without any orthosis. With respect to the patient's perspective, it is important to determine whether an individual is willing to wear an AFO regularly. Considerations to improve compliance with using an AFO

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include verification that it fits correctly and comfortably and is acceptable in appearance.

Recommendations: Adaptive Equipment, Durable Medical Devices, Orthotics, and Wheelchairs	Class	Level of Evidence
Ambulatory assistive devices (eg, cane, walker) should be used to help with gait and balance impairments, as well as mobility efficiency and safety, when needed.	I	B
AFOs should be used for ankle instability or dorsiflexor weakness.	I	B
Wheelchairs should be used for nonambulatory individuals or those with limited walking ability.	I	C
Adaptive and assistive devices should be used for safety and function if other methods of performing the task/activity are not available or cannot be learned or if the patient's safety is a concern.	I	C

Motor Impairment and Recovery: Deconditioning and Fitness After Stroke

People having sustained a stroke present with varying degrees of compromised cardiorespiratory fitness, as reflected in peak $\dot{V}o_2$ levels of 8 to 22 mL $O_2 \cdot kg^{-1} \cdot min^{-1}$ (an average of ≈53% of age- and sex-matched normative values).[765] Given that 15 to 18 mL $O_2 \cdot kg^{-1} \cdot min^{-1}$ is deemed necessary for independent living, the state of fitness after stroke is a significant health, functional, and quality-of-life issue.[766] Multiple factors before stroke, at the time of stroke, and after stroke help explain this state. The result is often a profound and persistent deconditioned state that leads to further physical inactivity, reduced socialization, and heightened risk of further vascular events, including a second stroke.

The lifetime risk of stroke recurrence among people with stroke is ≈30%, and the risk of either nonstroke vascular death or myocardial infarction is ≈2%/y.[767] Recurrence of stroke has been found to vary by sex: 24% of women and 42% of men experience a recurrence within 5 years of onset.[768,769] The reported rates of vascular risks are high among people who have a recurrence: The prevalence of hypertension (75%), ischemic heart disease (37%), hyperlipidemia (56%), atrial fibrillation (29%), and diabetes mellitus (24%) is significant in individuals who sustain a second stroke.[770] For a comprehensive and timely set of evidence-based recommendations for all clinicians who manage secondary prevention, the reader is directed to the AHA/ASA guidelines for the prevention of stroke in patients with stroke and transient ischemic attack.[206]

Activity level after stroke is an independent predictor of life satisfaction, after controlling for demographic variables and depression.[771] Low levels of physical activity have been documented across the continuum of stroke severity and care, even among people who have had what is considered a mild stroke.[772] A behavioral mapping study revealed that activity out of bed during acute stroke care (ie, <14 days after the onset of stroke) varied widely among the European countries studied, ranging between 2% and 56% of the total time of the observation periods.[773] Stroke rehabilitation sessions have been reported to be of inadequate intensity to induce a cardiovascular training effect,[774,775] with an average of 17 minutes spent in standing and walking per session.[776] Daily ambulatory activity of community-dwelling stroke survivors has been reported to be 50%[777] to 61%[778] of that of nondisabled control subjects, less than that of older adults with other chronic health conditions of the musculoskeletal or cardiovascular system.[779] At the same time, self-reports of physical activity among people with chronic stroke tend to be highly inflated.[780]

Sedentary behavior is defined as a waking behavior such as sitting or lying that involves an energy expenditure of <1.5 metabolic equivalents (METs; 1 MET is the amount of oxygen consumed while sitting at rest and is ≈3.5 mL $O_2 \cdot kg^{-1} \cdot min^{-1}$). Less sedentary behavior has been found to be an independent predictor of successful aging among individuals ≥45 years of age.[781] Moreover, prolonged bouts of sedentary behavior and total amount of physical inactivity appear to be independently related to risk factors associated with metabolic syndrome (eg, increased waist circumference, body mass index, triglycerides, and plasma glucose).[782] To date, little research has been conducted on patterns of sedentary behavior after stroke. A cohort study reported that people after stroke (n=25) spent less time being physically active and had fewer breaks in sedentary behavior at 1 week, 3 months, and 6 months after stroke compared with nondisabled control subjects matched by age, sex, and body mass index.[781]

Intervention strategies are needed to break the relentless poststroke cycle of reduced physical activity leading to further reductions in functional capacity and heightened risk of secondary complications. The central role that aerobic exercise plays in improving cardiorespiratory fitness is well known and strongly supported by evidence.[783] It is now clear that people with mild or moderate stroke are capable of improving their exercise capacity through exercise or structured physical activity.[784–786] Enhanced fitness enables individuals to engage in daily physical activities at a lower percentage of their maximal capacity and hence with a lower physiological burden.[787] Exercise-induced gains in peak $\dot{V}o_2$ have been relatively modest, with the magnitude of improvement ranging from 0.3 METs[788] to 1.2 METs[789] in trials of individuals in the subacute poststroke period and averaging ≈0.5 METs in trials of individuals with chronic stroke. However, even modest improvements in exercise capacity are associated with reduced cardiac complications in people with coronary artery disease[790] and increased survival (10%–25% reduction in mortality for every 1-MET increase in exercise capacity).[791]

Emerging research suggests that aerobic exercise after stroke confers clinically meaningful health benefits in numerous physical and psychosocial domains that extend well beyond the cardiorespiratory system. At the impairment level, some evidence exists that exercise positively affect bone health[792] (but not risk of fracture[253]), fatigue,[411] executive functioning and memory, depressive symptoms,[794,795] and emotional well-being[188] (see the earlier section on the benefits of exercise for poststroke depression). At the activity level, improvements have been noted in walking ability[796] (endurance more than speed[797]) and upper extremity muscle strength.[680] At the participation level, preliminary evidence has reported an association between exercise training after

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stroke and social participation,[188] as well as return to work.[799] Finally, a meta-analysis reported that exercise interventions for community-based stroke survivors have significant effects on health-related quality of life, which is arguably the ultimate goal of stroke rehabilitation.[800]

The role of exercise in preventing further vascular events after stroke, including a second stroke, myocardial infarction, and vascular death, has not been firmly established.[786] There is evidence that aerobic exercise as a stand-alone intervention after stroke improves certain vascular risk factors, including glucose intolerance,[801] vascular stiffness,[802] high resting blood pressure,[803,804] and elevated total cholesterol.[803] A multifaceted approach that combines nonpharmacological interventions (ie, exercise, dietary advice, lifestyle counseling, and patient education) and appropriate pharmacological therapy has been encouraged,[805] but the effectiveness of specific nonpharmacological components remains to be investigated.[806] Pilot studies of second stroke prevention using a cardiac rehabilitation approach have demonstrated a reduction in cardiac risk scores[807] and improvements in total cholesterol, body composition, and resting blood pressure,[808] but these results must be confirmed in larger, controlled trials. Despite a lack of robust evidence, exercise and physical activity are regarded as key components of comprehensive stroke risk-reduction efforts.[206]

Individually Tailored Exercise Program Prescription

Active participation in exercise should be initiated early after stroke for several reasons: to minimize the detrimental effects of bedrest and inactivity, to capitalize on heightened neuroplasticity present in the early poststroke period, and to begin the important process of fostering exercise self-efficacy and self-monitoring. Mobilization within 24 hours after stroke has been shown in a phase II trial to accelerate recovery of walking and functional ability[809]; however, a recent study reported possible detrimental effects with such early activity.[810] In the recently completed AVERT RCT, the high-dose, very early mobilization protocol was associated with a reduction in the odds of a favorable outcome at 3 months.[58] In contrast to very early mobilization, there is growing evidence that the initiation of aerobic exercise in the subacute period (ie, a mean of 11–78 days after stroke) is safe and effective in improving exercise capacity and walking endurance.[784,789] Specific recommendations for graded exercise testing can be found in the AHA guideline on stable ischemic heart disease.[811,812] The ASH/ASA scientific statement "Physical Activity and Exercise Recommendations for Stroke Survivors"[813] provides more details on the pre-exercise evaluation.

As with all aspects of stroke rehabilitation, the training regimen should emphasize repetition, gradually progressive task difficulty, and functional practice.[814] The standard parameters of exercise prescription, that is, mode, frequency, duration, and intensity, require careful consideration to ensure a safe intervention that accommodates the individual's functional limitations, comorbidities, motivation, and goals. Because the optimal training parameters have not been determined specifically for the stroke population,[815] current recommendations are based on general exercise guidelines[816] and on protocols shown to be effective in training studies involving people after stroke.[796] A wide range of exercise modes (eg, treadmill, body weight–supported treadmill, recumbent bicycle, cycle ergometer, stepper, aqua aerobics) have been used effectively in training studies.[796] Because overground walking at self-selected speeds after stroke elicits oxidative stress in the range of 2.6 METs[818] to 3.4 METs,[819] it may be an appropriate aerobic modality for people who are moderately unfit. Preliminary evidence also suggests that participants in the chronic poststroke period can achieve low to moderate exercise intensities when playing an active video game (Nintendo Wii Sports).[820] Furthermore, a recent trial involving people with subacute stroke demonstrated greater gains in peak $\dot{V}o_2$ with a combination of robot-assisted gait training and conventional PT than conventional therapy alone.[821]

There is some evidence that the combination of aerobic and strengthening exercises in nonstroke populations enhances health outcomes (eg, reducing resting blood pressure[822] and metabolic syndrome risk factors[823]). However, conclusions from a meta-analysis indicated the need for further investigation to determine whether combining aerobic and strengthening exercises bestows similar advantages in the stroke population.[785] Since then, a small, single-cohort study involving individuals with chronic stroke reported improved muscle strength and walking endurance but no change in peak $\dot{V}o_2$ after an 8-week program of lower extremity strength training at 85% to 95% of 1-repetition maximum.[825]

Benefits derived from aerobic training are dose dependent. The appropriate total volume of exercise, achieved through various combinations of frequency, duration, and intensity, is key to attaining and maintaining cardiorespiratory fitness. Nevertheless, there appears to be a minimal threshold for each parameter to achieve the most favorable outcomes. The frequency of structured aerobic exercise should be at least 3 d/wk for a minimum of 8 weeks, with lighter forms of physical activity (eg, brisk walking, stair climbing) promoted on the other days of the week. The duration of each session should be a minimum of 20 minutes in the training zone in addition to 3- to 5-minute periods of low-intensity warm-up and cool-down. For very deconditioned individuals, including many people after stroke, exercise may be delivered in multiple bouts of ≤5 minutes in a single session or throughout the day.[783]

Exercise intensity is the most challenging parameter to determine but also the most critical to ensure that a dose that is safe, attainable, and adequate to elicit a training effect. Factors that affect intensity are baseline fitness level, neurological and cardiac status, comorbidities, motivation, and goals of the program. Heart rate is typically used to establish and monitor training intensity, with resting rate measured after a minimum of 5 minutes of quiet sitting and exercise heart rate measured with an electronic device. It is important to note that β-blocker medication depresses the heart rate response to exercise and that atrial fibrillation (common after stroke) yields a chronically irregular ventricular rate, thus posing challenges in the prescription of exercise intensity.[826] Various recommendations have been made on the appropriate exercise intensity for patients after stroke, including "moderate training intensities,"[206] 40% to 70% of heart rate reserve (maximal heart rate minus resting heart rate),[827] and 50% to 80% of maximal heart rate.[785] A meta-analysis concluded that for extremely unfit individuals, intensities as low as 30% of heart rate reserve can induce a cardiovascular training

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effect.[828] At the other end of the spectrum, 2 pilot exercise studies provided early evidence supporting the safe and effective use, at least in the chronic stroke population, of high-intensity exercise (ie, 60%–80% of heart rate reserve,[829] 85%–95% of peak heart rate[830]). The recent AHA/ASA scientific statement "Physical Activity and Exercise Recommendations for Stroke Survivors"[813] gives more details on exercise/physical activity recommendations for stroke survivors.

Chronic Care Management: Home- and Community-Based Participation

Because exercise confers health benefits even years after stroke, participation in physical activity should be encouraged regardless of how much time has elapsed since stroke onset. The effectiveness of exercise training in the chronic stages of stroke is no longer in question; in fact, the vast majority of fitness trials have involved people at this stage of stroke chronicity.[796] Moreover, it has long been recognized that benefits of training decline significantly without ongoing participation in physical activity.[831] Thus, physical activity designed to promote cardiovascular fitness should be an important aspect of community reintegration after stroke. However, adherence to regular physical activity is influenced by a host of individual factors (eg, stroke severity, preexisting/comorbid conditions, motivation, health beliefs, exercise history, fatigue, depression, adaptability, coping skills, cognition), social/cultural factors (eg, family support, social policies, professionals' attitudes about exercise, social norms and stigmas), and environmental factors (eg, program costs, access to transportation, fitness facilities and equipment).[832,833] These factors must be systematically addressed to achieve the goal of long-term commitment to healthy, active living behaviors among stroke survivors.

Strategies to instill long-term commitment to a physically active lifestyle should be initiated during formal stroke rehabilitation, but evidence to guide intervention is lacking.[834] Considering the high likelihood of a prestroke history of sedentary behavior, fostering exercise self-efficacy is particularly important to ease the transition from structured, institution-based aerobic training to home- and community-based physical activity.[834] Incorporating principles of adult learning (eg, observation, practice, repetition, relevance) and self-management (eg, problem solving, goal setting, making choices, taking action, using available resources) is essential.[835,836] Early participation in fitness training and education on lifestyle choices, risk factor reduction, and secondary prevention may facilitate uptake of healthy behaviors. Myths about exercise (exercise is unsafe, causes second stroke, increases fatigability)[833,837,838] need to be dispelled in the process of rehabilitation. Most important, patients' preferences concerning exercise must be sought out and respected.[839] Finally, stroke survivors who are unable to exercise will need alternative solutions to maintain an active and engaged lifestyle.

The fitness program should be customized on the basis of the participant's functional limitations, long-term health-related goals, and social and environmental factors. Periodic monitoring of the intensity of the program and the participant's fitness level and adherence may be reasonable. Investigations of the effectiveness of predischarge counseling in increasing long-term adherence to activity after stroke have yielded mixed results.[840,841] In addition, a self-guided stroke workbook did not elicit demonstrable changes in physical activity.[842] It appears that passive approaches (professional advice, written material) alone are not adequate to increase physical activity after stroke.[841] Given that the most common motivator to physical activity after stroke is the opportunity to meet other stroke survivors,[833] together with the findings that stroke survivors report greater preferences for exercising in groups and at fitness centers,[839] it is prudent to direct resources to facilitating participation in physical activity in community settings. Developing partnerships between healthcare professionals and fitness centers or community exercise programs could help to address a concern expressed by patients after stroke that exercise instructors must be suitably trained and knowledgeable about stroke.[837] Integrated care models that include periodic liaison between care providers and patients after stroke via telephone or electronic follow-up may be the solution to providing ongoing support for physical activity.[843]

Recommendations: Chronic Care Management: Home- and Community-Based Participation	Class	Level of Evidence
After successful screening, an individually tailored exercise program is indicated to enhance cardiorespiratory fitness and to reduce the risk of stroke recurrence.	I	A (for improved fitness); B (for reduction of stroke risk)
After completion of formal stroke rehabilitation, participation in a program of exercise or physical activity at home or in the community is recommended.	I	A

Treatments/Interventions for Visual Impairments

Treatments and interventions for visual impairments after stroke focus on 3 areas: deficits in eye movements, deficits in visual fields, and deficits in visual-spatial or perceptual deficits. There have been 7 systematic reviews of treatments for visual impairments after stroke.[382,418,493,737,844,846,847] These systematic reviews covered reports up to 2011. The literature is generally limited in this area, and the methodological quality was poor in general or poorly reported, providing insufficient high-quality evidence on which to reach generalizable conclusions. However, limited evidence suggested that compensatory scanning training is effective at improving scanning and reading outcomes but not improving visual field deficits. There was insufficient evidence of the impact of compensatory scanning training on ADLs. There was also insufficient evidence about the benefits of vision restoration therapy (restitutive intervention) after stroke. Across these systematic reviews, 2 studies targeted eye movement deficits, 2 case studies and 1 nonrandomized prospective study assessed interventions for visual field cuts, and 3 studies dealt with perceptual deficits. In general, there was insufficient evidence to reach conclusions about the effectiveness of interventions for patients with any of these visual deficits after stroke. Barrett[844] reviewed the behavioral optometry literature. Behavioral optometry proposes that eye and visual function can be improved through various vision therapy methods, including

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eye exercises and the use of lenses, prisms, filters, occluders, specialized instruments, and computer programs to improve vision skills such as eye movement control, eye focusing, and coordination. Barrett concluded that there is a paucity of controlled trials in the literature to support behavioral optometry approaches and that a large majority of behavioral management approaches are not evidence based. However, there was evidence supporting the use of eye exercises for treatment of convergence insufficiency, the use of yoked prisms in stroke patients with visual field cuts, and the use of vision rehabilitation of visual field defects (selecting areas of residual vision that are then stimulated during computer-assisted training to achieve visual field enlargement).

A number of studies included as part of a broader review dealing with rehabilitation of cognitive deficits[418] focused on visual neglect, which is addressed elsewhere in this guideline. However, with regard to other forms of visual deficits, those studies concluded that systematic training of visual organization skills may be considered for individuals with visual perceptual deficits, without visual neglect, and after right hemispheric stroke as part of acute rehabilitation and that computer-based interventions intended to produce extension of damaged visual fields may be considered for people with traumatic brain injury or stroke.

In addition to those covered by the 7 systematic reviews, 3 studies dealt with treatments for visual impairments after stroke.[848–850] Mödden et al[850] concluded that computer-based compensatory therapy improved functional deficits after visual field loss compared with compensation strategies training (ie, standard OT). A 2010 study[848] concluded that multimodal audiovisual exploration training is more effective than exploration training alone. Finally, a 2012 study[849] reported that a virtual reality training group showed a significant difference in all Motor-Free Visual Perception Test raw scores and response times, with improvements in recognizing shapes, solving pictorial puzzles, and object perception.

Recommendations: Treatments/Interventions for Visual Impairments	Class	Level of Evidence
For deficits in eye movements:		
Eye exercises for treatment of convergence insufficiency are recommended.	I	A
Compensatory scanning training may be considered for improving functional ADLs.	IIb	B
Compensatory scanning training may be considered for improving scanning and reading outcomes.	IIb	C
For deficits in visual fields:		
Yoked prisms may be useful to help patients compensate for visual field cuts.	IIb	B
Compensatory scanning training may be considered for improving functional deficits after visual field loss but is not effective at reducing visual field deficits.	IIb	B
Computerized vision restoration training may be considered to expand visual fields, but evidence of its usefulness is lacking.	IIb	C
For visual-spatial/perceptual deficits:		
Multimodal audiovisual spatial exploration training appears to be more effective than visual spatial exploration training alone and is recommended to improve visual scanning	I	B
There is insufficient evidence to support or refute any specific intervention as effective at reducing the impact of impaired perceptual functioning.	IIb	B
The use of virtual reality environments to improve visual-spatial/perceptual functioning may be considered.	IIb	B
The use of behavioral optometry approaches involving eye exercises and the use of lenses and colored filters to improve eye movement control, eye focusing, and eye coordination is not recommended.	III	B

Hearing Loss

The healthcare provider's ability to effectively communicate with a patient who has had a stroke is essential to provide adequate patient care. Unfortunately, hearing impairment is common among stroke patients, and this may significantly affect communication. This impairment must be considered when communicating with patients to provide effective patient-centered care.

Hearing impairment is commonly associated with aging, and the associated communication difficulties are only further exacerbated after stroke. It has been reported that the most common type of communication impairment within an acute hospital stroke unit is a hearing impairment, with estimates that 67% to 90% of these patients have a mild or greater hearing impairment.[851] Although a sudden onset of hearing loss resulting from a stroke is uncommon, stroke patients often have a preexisting or an undiagnosed hearing loss. In some instances, difficulty hearing may simply be caused by cerumen impaction or may be attributable to age-related hearing loss.[851] Stroke patients with communication or cognitive impairments may be unable to relay information about their hearing history. Reports from family or significant others often give healthcare providers some indication of the patient's hearing abilities before the stroke. It is recommended that any noticeable hearing impairment be assessed and documented to improve patient care. Edwards et al[852] reported that 86% of stroke patients in acute care facilities had a hearing impairment that was not documented in their chart.

Amplification can often help patients who have had a stroke to overcome the barrier of a hearing impairment. One study reported that of 52 patients who had suffered a stroke and had a hearing impairment, 11 (21%) owned hearing aids.[851] By verifying that the hearing aids or amplification devices are working and reminding the patients to wear them, healthcare providers will be able to better communicate with these patients. Unfortunately, not all patients with a hearing impairment have hearing aids. In this case, it is important to incorporate communication strategies such as looking at the

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patient when talking to him/her and minimizing the level of background noise.

Recommendations: Hearing Loss	Class	Level of Evidence
If a patient is suspected of a hearing impairment, it is reasonable to refer to an audiologist for audiometric testing.	IIa	C
It is reasonable to use some form of amplification (eg, hearing aids).	IIa	C
It is reasonable to use communication strategies such as looking at the patient when speaking.	IIa	C
It is reasonable to minimize the level of background noise in the patient's environment.	IIa	C

Transitions in Care and Community Rehabilitation

Ensuring Medical and Rehabilitation Continuity Through the Rehabilitation Process and Into the Community

The transition from inpatient care to home after a stroke can be difficult for patients and caregivers. Those patients who require ongoing rehabilitation after discharge should continue to be followed up by a care team with expertise in stroke rehabilitation whenever possible. Patients who do not require additional rehabilitation services and are discharged to home or who are profoundly and permanently disabled and discharged to a long-term care setting can be managed by a primary care provider.

One recent systematic review of 9 RCTs looked at the effectiveness of various models of primary care–based follow-up after stroke. The studies included interventions using stroke support workers, care coordinators, or case managers. As a result of the wide variability of the methodological quality of the studies, interpretation was limited. The authors noted that although patients and caregivers receiving follow-up were generally more satisfied with some aspects of communication and had a greater knowledge of stroke, there did not appear to be any gains in physical function, mood, or quality of life compared with those who did not.[853] Another systematic review examining transitional care models after stroke or myocardial infarction showed that hospital-initiated transitional care could improve some outcomes in adults hospitalized for stroke or myocardial infarction.[854]

Although not specific to stroke, a 2012 Cochrane study to determine the effectiveness of discharge planning for patients moving from an acute hospital stay to a home setting evaluated the results of 24 RCTs comparing individualized discharge plans with routine discharge care that was not tailored to the individual patient. Using data from 8098 patients, the investigators found that hospital length of stay and hospital readmissions were "statistically significantly reduced for patients admitted to hospital with a medical diagnosis and who were allocated to discharge planning (mean difference length of stay −0.91, 95% CI −1.55 to −0.27, 10 trials; readmission rates RR 0.82, 95% CI 0.73 to 0.92, 12 trials)." For elderly patients with a medical condition, they found no significant difference between groups with respect to mortality (RR, 0.99; 95% CI, 0.78–1.25, 5 trials) or being discharged from hospital to home (RR, 1.03; 95% CI, 0.93–1.14, 2 trials). The authors concluded that a "discharge plan tailored to the individual patient probably brings about reductions in hospital length of stay and readmission rates for older people admitted to hospital with a medical condition" but that the impact of discharge planning on mortality, health outcomes, and cost remained unclear.[855] For patients who have suffered a stroke and are being discharged from acute care, the discharge planning should include rehabilitation professionals who can identify long-term needs and help organize provision of those services.

Alternative methods of communication and support such as telephone visits, telehealth, or Web-based support are newer options that should be considered, particularly for patients in rural settings who may have difficulty traveling for medical care once they are discharged from formal rehabilitation services.[856] These technologies can be used for long-distance counseling, problem solving, and educational sessions, as well as for transmitting critical data such as blood pressure readings, weight, or laboratory results.

Recommendation: Ensuring Medical and Rehabilitation Continuity Through the Rehabilitation Process and Into the Community	Class	Level of Evidence
It is reasonable to consider individualized discharge planning in the transition from hospital to home.	IIa	B
It is reasonable to consider alternative methods of communication and support (eg, telephone visits, telehealth, or Web-based support), particularly for patients in rural settings.	IIa	B

Social and Family Caregiver Support

As a result of the complexity of the disease, the deficits and disability, and the change in family and significant other dynamics, the caregiver and family are integral to the post-stroke treatment plan. A major challenge is that 12% to 55% of caregivers suffer from some emotional distress,[209] most commonly depression.[238] A growing body of research is focused on the caregiver's quality of life and on treatment strategies to benefit both the caregiver and the stroke survivor.

Families and caregivers of stroke survivors sustain a significant impact on their psychosocial health. Worldwide, depression is observed not only in the patient but also in the caregiver. Untreated depression is associated with a lower quality of life and increased burden for the caregiver and survivor.[857] In Korea, increased burden was related to increased patient depression and insufficient support. In contrast, an American study found that increased caregiver burden is more closely correlated with lack of time for self.[858] Smith and colleagues[859] found that the caregiver needs varied as a function of age. Younger caregivers want information and training and are more inclined to criticize the healthcare system, whereas older caregivers need support to maintain a positive outlook and are less inclined to criticize the healthcare system.

Since the previous guidelines published in 2005, many researchers have investigated the caregiver perspective and better understand the interventions most likely to improve quality of life and to decrease burden. The Cochrane Collaboration

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found that information improved the patient's and caregiver's knowledge while also slightly decreasing patient depression. The most effective educational programs included active involvement and follow-up by the educator. Education programs for caregiver and stroke participant should include supportive problem solving and skill development,[860] "how to's" of physical care needs and financial assistance,[861] medications,[862] respite, domestic assistance, and reassurance.[863] Ongoing support for the caregiver favorably affects the stroke survivor and caregiver. This support comes in many different actions. Steiner et al[864] studied physical and emotional support, whereas Campos de Oliveira[865] more clearly defined the support as a needed support structure. The caregivers need either family or friends to provide emotional and physical assistance, and the caregivers need the healthcare providers to help them establish and maintain this over time.[866] Counseling can also be a helpful intervention.[867] In summary, healthcare professionals need to consider the patient, along with a diverse set of support options and treatments for the family and primary caregiver.

Recommendations: Social and Family Caregiver Support	Class	Level of Evidence
It may be useful for the family/caregiver to be an integral component of stroke rehabilitation.	IIb	A
It may be reasonable that family/caregiver support include some or all of the following on a regular basis:	IIb	A
Education		
Training		
Counseling		
Development of a support structure		
Financial assistance		
It may be useful to have the family/caregiver involved in decision making and treatment planning as early as possible and throughout the duration of the rehabilitation process.	IIb	B

Referral to Community Resources

Successful transition to the community requires careful assessment of the match between patient needs and the availability of formal and informal resources. Referral to appropriate local community resources can help to support the needs and priorities of the patient and the family or caregiver. Some services can be organized and in place before hospital discharge, whereas referral to some community resources may be provided on transition to the community. A range of community resources are available that patients and their families/caregivers may desire to access immediately or in the future as their needs change.

Formal referral may be required for services such as vocational counseling, psychological services, social services, sexual health counseling, driver evaluation, or home environment assessment. Referral to a day service program may be appropriate for a patient who may benefit from a structured program and for caregivers who need respite time.

Multiple potential resources may assist stroke patients and their families/caregivers in the management of the long-term effects of stroke such as local stroke survivor and caregiver support groups, leisure and exercise programs, respite care, self-management programs, and home support (eg, Meals on Wheels).

More than 50% of stroke survivors require support with IADLs.[868] A high proportion of stroke survivors 1 to 5 years after injury use community services, with the most frequently accessed being household services (housework, lawn/garden care, and Meals on Wheels) and then therapy services (eg, PT).[868]

Caregivers have identified that it is important to know what resources are available and to be able to access them.[869] Stroke patients and their caregivers can be active in managing their chronic condition if they have appropriate information and resources. If stroke survivors and caregivers are to be active in their decision making and the management of the long-term effects of stroke, appropriate information delivered in a timely and effective format is necessary. It is critical that the process involve assessment of an individual's needs, education about available resources, linking of patient and resources, referrals, and follow-up to ensure the individual receives the necessary services. Health providers may wish to use a checklist to identify whether referral to other services is warranted.[870] A meta-analysis of 21 trials showed that the provision of information (including local resources) to patients and their caregivers may improve aspects of patient satisfaction, improve knowledge of stroke, and reduce patient depression scores.[871]

A systematic review[872] and meta-analysis[873] demonstrated the growing recognition that functional outcomes (including motor, cognitive, and psychosocial function) can be improved or at least maintained in chronic stroke with community interventions. In addition, a meta-analysis of 17 RCTs showed that lifestyle interventions (eg, health promotion or education, lifestyle counseling) may reduce the risks leading to another stroke or cardiovascular event.[874] A meta-analysis of 8 RCTs showed that exercise referral schemes that provide a clear referral by primary care professionals to third-party professionals to increase exercise or physical activity can increase the number of participants who achieve 90 to 150 min/wk of moderate physical activity and reduce depressive symptoms in sedentary individuals with or without a medical diagnosis (obesity, hypertension, depression, diabetes mellitus).[875] In a qualitative study, stroke survivors described great physical and psychological well-being after participation in an exercise referral scheme.[876]

Recommendations: Referral to Community Resources	Class	Level of Evidence
It is recommended that acute care hospitals and rehabilitation facilities maintain up-to-date inventories of community resources.	I	C
Patient and family/caregiver preferences for resources should be considered.	I	C
It is recommended that information about local resources be provided to the patient and family.	I	C
It is recommended that contact with community resources be offered through formal or informal referral.	I	C
Follow-up is recommended to ensure that the patient and family receive the necessary services.	I	C

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Rehabilitation in the Community

The Centers for Medicare & Medicaid Services define community as one of the following settings: home, board and care, transitional living, intermediate care, or assisted living residence. More than 80% of the >6 million survivors of stroke in the United States live in the community, most of them at home, and the majority with some residual functional limitations. Studies have documented that 35% to 40% of individuals have limitations in basic ADLs 6 months after a stroke. More than 50% have limitations in ≥1 IADLs.[794,877]

There is substantial evidence that rehabilitation services, particularly exercise-based programs, provided in the community after discharge from acute or institutional care can improve cardiovascular health and decrease the risk of cardiovascular events, leading to increased short-term survival rates for individuals who have experienced a stroke.[878,879] Other community-based intervention trials have demonstrated enhanced ambulation and mobility, better self-care, and greater functional independence.[880]

Benefits associated with community- and home-based rehabilitation programs have been reported for a variety of outcomes, including reduced costs, decreased length of stay in hospitals or institutional settings, more opportunity for patient and family involvement in the treatment process, and less stress on caregivers and family members.[881,882]

It has also been consistently reported that individuals recovering from a stroke and their family members or caregivers prefer home- or community-based rehabilitation programs over center- or institutionally located rehabilitation services for a variety of practical and personal reasons.[881] Patient satisfaction with home-based rehabilitation programs is generally higher than for institutionally based alternatives.[882] Because the potential for recovery exists regardless of age and time after stroke and because fewer financial resources appear to be dedicated to providing optimal care during the later phases of stroke recovery, family caregiver education and support are recommended. Intervention, referrals, and follow-up care based on detailed caregiver assessments conducted during the survivor's inpatient stay are likely to smooth the transition of care to the home setting.[11] There is growing evidence for the effectiveness of stroke family caregiver and dyad (caregiver and patient) interventions.[883] Among the Class I, Level of Evidence A recommendations about caregiver and dyad interventions were the following: (1) Interventions that combine skill building with psycho-educational strategies should be chosen over interventions that only use psycho-educational strategies; (2) interventions that are tailored or individualized on the basis of the needs of stroke caregivers should be chosen over nontailored, one-size-fits-all interventions; (3) postdischarge assessments with tailored interventions based on changing needs should be performed to improve caregiver outcomes; (4) interventions that are delivered face to face or by telephone are recommended; and (5) interventions consisting of 5 to 9 sessions are recommended.

The ability to translate these findings into targeted intervention programs and guidelines for the care of individuals with stroke is complicated by several factors.[884,885] There is substantial variability in the timing of the initiation of home-based treatment programs. Home-based rehabilitation may not be appropriate for all individuals with stroke, depending on level of severity, comorbidities, or the need for specialized treatment or equipment. Existing studies comparing community- and home-based rehabilitation vary substantially in the duration and intensity of the intervention and in the nature and complexity of the treatment programs provided.[881] For example, some treatment programs are single interventions such as exercise; other programs involve multiple components requiring levels of specialized expertise.

Issues related to the fidelity and integrity of the treatment, patient safety, and the lack of equipment and capacity to provide selected interventions in a home or community setting have been identified as concerns associated with home-based rehabilitation.[886] Research-based evidence on potential adverse effects associated with rehabilitation programs conducted in the home and community is limited.

The majority of trials and reviews of community-based rehabilitation programs have compared home-based intervention programs with programs provided in centers or hospital/clinic-based outpatient programs.[881] Several studies published since the 2005 stroke rehabilitation clinical practice guidelines have examined a combination of ESD programs and community rehabilitation and compared these programs with standard inpatient and outpatient rehabilitation services. Langhorne and colleagues[17,18] found that the combination of ESD and community rehabilitation reduced inpatient length of stay and hospital readmission rates and increased functional independence and the ability of patients to live at home and participate in the community.

A systematic review by Hillier and Inglis-Jassiem[881] examined data comparing the benefits of home-based programs and programs in rehabilitation centers for individuals with stroke living in the community. Eleven trials met the inclusion criteria. Functional outcome data were pooled for the Barthel Index across the majority of the trials. Functional status was significantly improved for the home-based cohort at 6 weeks and 3 to 6 months. The difference between home-based and rehabilitation center groups was less clear after 6 months. Cost benefits and caregiver satisfaction were secondary measures and favored the home-based intervention trials.

A widely cited Cochrane Collaboration review[887,888] examined therapy-based rehabilitation services for stroke patients at home (Outpatient Service Trialists). The review examined trials meeting the Cochrane Collaboration criteria and compared home-based therapy with conventional care or no care within 1 year of hospital discharge for individuals with stroke. The primary outcomes were adverse events, deterioration in ability to perform ADLs, and level of improvement in ADL outcomes. The authors concluded that home-based therapy reduced the odds of a poor outcome, that is, death or deterioration in the ability to perform ADLs. Patients in the home-based therapy program also demonstrated improved ADL abilities compared with individuals in the usual or no treatment groups.[887,888]

The majority of trials and reviews examining community- and home-based rehabilitation programs in individuals with stroke have focused on functional, mobility, or motor outcomes. A recent meta-analysis by Graven and others[794] examined the impact of community-based rehabilitation on reducing

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depression and increasing participation and health-related quality of life in individuals with stroke. The 54 studies included in the review were divided into 9 intervention categories. Analyses revealed significant reductions in depressive symptoms. The reduction in depressive symptoms was associated with exercise interventions. Treatments involving leisure and recreational activities showed moderate effects for the outcomes of participation and health-related quality of life. Comprehensive, multifactorial rehabilitation interventions demonstrated limited evidence for depression and participation but showed strong evidence for health-related quality-of-life outcomes.[794]

Recommendations: Rehabilitation in the Community	Class	Level of Evidence
Patients with stroke receiving comprehensive ADL, IADL, and mobility assessments, including evaluation of the discharge living setting, should be considered candidates for community- or home-based rehabilitation when feasible. Exclusions include individuals with stroke who require daily nursing services, regular medical interventions, specialized equipment, or interprofessional expertise.	I	A
It is reasonable that caregivers, including family members, be involved in training and education related directly to home-based rehabilitation programs and be included as active partners in the planning and implementation or treatment activities under the supervision of professionals.	IIa	B
A formal plan for monitoring compliance and participation in treatment activities may be useful for individuals with stroke referred for home- or community-based rehabilitation services. A case manager or professional staff person should be assigned to oversee implementation of the plan.	IIb	B

Sexual Function

Sexuality is an important aspect of poststroke quality of life for both patients and their significant others. Although there is substantial individual variation, overall stroke survivors tend to experience a high prevalence of sexual dysfunction. Comorbid medical conditions (eg, diabetes mellitus, hypertension, depression), medication side effects, stroke-related physical and functional deficits, lack of knowledge, and concerns about safety, role changes, and change in libido can affect the patient's sexual function. Healthcare workers need to help the patient and significant other navigate through the issues surrounding sexual function.

Multiple studies indicate that stroke survivors and their significant others have concerns about sexuality but are frequently reluctant to ask their healthcare providers about these concerns.[889] This reluctance may stem from the patient's embarrassment or other cultural barriers, as well as a lack of knowledge on the part of the healthcare provider. The greater the patient's disability is, the greater is the likelihood of sexual dysfunction and decreased sexual life satisfaction.[890] Stroke survivors report a desire for more information about sexuality from healthcare providers, physicians in particular.[891] It is important for the patient and significant other to know that sex is not contraindicated after stroke. The most common sexual dysfunctions after stroke are decreased libido, erection and ejaculation disorders in men, lubrication and orgasm in women, and self-image and role changes for both men and women. Interventions and education about sexuality that address these concerns such as positioning, timing, open communication, and functional treatments can be helpful. Additional training for healthcare providers on this topic, including methods of appropriately approaching patients and their partners to discuss sexuality, may be needed.[892]

Recommendation: Sexual Function	Class	Level of Evidence
An offer to patients and their partners to discuss sexual issues may be useful before discharge home and again after transition to the community. Discussion topics may include safety concerns, changes in libido, physical limitations resulting from stroke, and emotional consequences of stroke.	IIb	B

Recreational and Leisure Activity

Engagement in leisure and recreational pursuits is important to health.[893–896] Active leisure and recreational activities have been targeted as particularly important.[894,895,897] However, individuals with stroke are limited in their ability to engage in leisure and recreational activities, particularly active ones.[779,898–900]

In general, poststroke rehabilitation in the United States provides little attention to leisure and recreation.[902] Individuals with stroke report that they engage in significantly fewer leisure and recreation activities than they did before the stroke.[898,899] In addition, the leisure activities in which they do engage have shifted from active to sedentary activities such as television watching and reading.[898] Limited research examines the efficacy of rehabilitation for increasing participation in leisure and recreation activities. However, several studies (1 qualitative study, 2 RCTs, and 2 systematic reviews) suggest that therapy targeted at leisure/recreation and the provision of some adaptive equipment may facilitate increased engagement in leisure or recreation activities.[794,903,904,906] Although therapy was variable across the studies, in several, the therapy consisted of education about the importance of being physically active, education on community resources, and training in problem solving around barriers to being physically active.[794,903] One study that showed that such programming facilitated long-term increased physical activity engagement offered this kind of programming during rehabilitation, suggesting that such programming could begin early during rehabilitation.[908,909] It must be noted, however, that this study took place in Europe, involved much longer durations of rehabilitation than individuals experience in the United States, and involved individuals with a variety of disabling conditions (only 26% were individuals with stroke); in addition, results were not broken down by disability condition. The provision of a wheelchair may be critical because many individuals with stroke who are able to ambulate do not have the endurance to ambulate for long periods in the community.[906]

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Recommendations: Recreational and Leisure Activity	Class	Level of Evidence
It is reasonable to promote engagement in leisure and recreational pursuits, particularly through the provision of information on the importance of maintaining an active and healthy lifestyle.	IIa	B
It is reasonable to foster the development of self-management skills for problem solving for overcoming barriers to engagement in active activities.	IIa	B
It is reasonable to start education and self-management skill development about leisure/recreation activities during and in conjunction with in-patient rehabilitation.	IIa	B

Return to Work

In the United States, ≈20% of strokes occur in individuals who are of vocational age.[910] Vocational roles provide a social identity and contribute to increased self-esteem and life satisfaction.[911] It is estimated that about one third of the economic burden of stroke through the year 2050 will be attributable to lost earnings after stroke.[912]

The percentage of individuals who were working before their stroke who return to work after stroke varies widely across studies, from 20%[913] to 66%.[914] This stems from large differences in sample characteristics, healthcare and social system differences in different countries, various definitions of work, and variable follow-up periods. It is clear, however, that a large percentage of individuals with stroke who are of vocational age do not return to work. It is estimated that one third of the $1.75 trillion in annual costs[1] associated with stroke are attributable to lost earnings in the United States alone.[912] The factors associated with return to work have also varied across different studies. Factors most frequently found to be associated with return to work are younger age, less severe impairments, independence in ADLs, good communication skills, good higher-level cognitive skills and processing speed, and a white collar profession.[915–921] Some of those who do return to work have been able to return full-time to their previous jobs; some have required job modifications or alternative jobs; and others were able to return only part-time.[890,917,919] The ability to resume driving may also be an important factor in being able to return to employment.[915]

Because several of the variables presenting barriers to return to work are modifiable, therapy targeted at vocational goals has the potential to increase return-to-work rates for individuals with stroke. However, no controlled trials have examined the efficacy or effectiveness of therapy targeted at vocational goals or vocational rehabilitation programs, and a structured review found insufficient evidence to support or refute the efficacy of any specific vocational rehabilitation program.[922] Several case studies suggest that for some individuals, therapy targeted at vocational goals can result in successful return to work.[923,924] Chan and colleagues[925] reported that their vocational rehabilitation program facilitates 55% of their enrollees to return to work. However, the lack of enrollee description makes it unclear how to interpret their success rate because several studies have found similar return-to-work rates without formal vocational rehabilitation. Although evidence is limited, many clinicians advise that for individuals considering return to work, an assessment of cognitive, perception, physical, and motor abilities be performed to determine readiness and the needed accommodations to return to work. This assessment should be tailored to the individual's needs and capabilities for the specified job situation and may include executive functions, high-level oral and written communication, and fatigue. Once performance under the best conditions has been assessed, further assessment under conditions of fatigue and stress may be useful to mimic potential job situations.

Discrimination against individuals with disabilities remains common in the workplace and may not be identified by the prospective employer as a reason for denying a disabled candidate employment. Familiarity with the provisions of the Americans With Disabilities Act and its requirements for "reasonable accommodation" is important for individuals seeking to return to a job after stroke or seeking a new position. Rehabilitation professionals can serve as a resource for motivated employers to help overcome workplace barriers for employees with disabilities.

Recommendations: Return to Work	Class	Level of Evidence
Vocationally targeted therapy or vocational rehabilitation is reasonable for individuals with stroke considering a return to work.	IIa	C
An assessment of cognitive, perception, physical, and motor abilities may be considered for stroke survivors considering a return to work.	IIb	C

Return to Driving

Driving is an essential IADL for many individuals in that it has a major impact on participation in activities outside the home.[926] Between one third and two thirds of individuals after stroke resume driving after 1 year.[927,928] However, because driving is a highly complex activity that requires skills in cognition, perception, emotional control, and motor control,[929] the ability to drive is often affected by stroke.[928] State law determines whether someone with a stroke is eligible to drive. The law concerning this topic varies by state. For example, in some states, individuals who have a neurological condition (stroke, traumatic brain injury, Parkinson disease, multiple sclerosis), among other non-neurological health conditions, are required to report their health condition to the appropriate state agency (eg, Department of Transportation or Department of Public Safety). After this reporting, the physician should assess patients' physical or mental impairments that might adversely affect driving abilities. Each case must be evaluated individually because not all impairments may give rise to an obligation on the part of the physician. In other states without self-reporting, physicians must take several initial steps before reporting: have a tactful but candid discussion with the patient and family about the risks of driving, suggest to the patient that he or she seek further treatment such as substance abuse treatment or OT, and encourage the patient and the family to decide on a restricted driving schedule. Efforts made by physicians to inform patients and families, to advise them of their options, and to negotiate a workable plan may render reporting unnecessary. Physicians should use their best judgment

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when determining when to report impairments that could limit a patient's ability to drive safely. The physician's role is to report medical conditions that would impair safe driving as dictated by his or her state's mandatory reporting laws and standards of medical practice. Physicians should disclose and explain to their patients this responsibility to report. Physicians should protect patient confidentiality by ensuring that only the minimal amount of information is reported and that reasonable security measures are used in handling that information. Physicians should work with their state medical societies to create statues that uphold the best interests of patients and community and that safeguard physicians from liability when reporting in good faith.[930] The appropriate state agency determines whether the individual is allowed to keep his/her license or obtain a restricted license or whether another option is necessary. However, the decision about return to driving should happen with the physiatrist or primary care provider, patient with stroke, and family. If necessary, a driving rehabilitation specialist can perform a formal driving evaluation. The ASA Driving after Stroke Web site provides information on life after stroke.[930a]

The majority of individuals who sustain a stroke want to and do return to driving within a year after stroke.[927,928,931] Despite a significant number of individuals in whom driving ability is reduced[928,932] and the incidence of reduced self-awareness of driving difficulties after stroke,[933] very few individuals are ever formally assessed for driving, nor is return to driving discussed with them.[72,928,934] This is clearly a neglected area in the current healthcare system surrounding rehabilitation services after stroke.

There are no standardized driving assessment batteries. Many assessments contain both neuropsychological tests and on-the-road testing. There is no clear consensus on whether neuropsychological tests adequately predict the ability to drive. Two recent reviews (1 systematic review,[936] 1 meta-analysis[937]) examined the ability of neuropsychological tests to predict on-the-road driving test performance or voluntary cessation of driving across 37 studies (8 overlapping studies). The only neuropsychological test that was a significant predictor of fitness to drive in both reviews was the Trail Making Test B. There is great variation across studies in sample selection and in which neuropsychological tests were used to predict fitness to drive. For example, finding no effect for vision is likely the result of a biased sample excluding subjects with visual impairments consistent with state laws restricting such individuals from driving.[937] Driving simulators offer the ability to test an individual for fitness to drive in dynamic environments that are safer than on-the-road tests.[938] One cautionary note is that currently few studies have tested to what degree (if any) driving simulator performance is a sufficient predictor of on-the-road driving to determine the safety of return to driving. One study of 23 participants[939] showed that the simulator performance variables of complex reaction time and distance to collision were able to correctly classify 85% of the participants as fit to drive or not. Because there is no single set of neuropsychological tests that can accurately predict fitness to drive, an on-the-road driving test should also be strongly considered, especially for individuals who possess the cognitive ability and are eligible on the basis of local laws.

Several studies have shown that some individuals with stroke who are unable to pass fitness-to-drive tests can do so after intervention.[938,940–942] Intervention programs may involve adaptive equipment and training for the specific impairments interfering with driving (eg, infrared controls for 1-handed driving, cognitive training, vision training) or simulator training, on-road training, or their combination. Although few studies have tested the efficacy of driving training on driving ability, 2 studies have found simulator training to be superior to traditional cognitive training.[938,941] One study showed that visual training with the Dynavision system (Dynavision LLC, West Chester, OH) did not result in increased driving ability.[943] Unfortunately, other studies that investigated vision training and showed improved driving-related visual skills did not include measures of actual driving ability.[944] Thus, the evidence is insufficient to determine whether visual training improves driving performance in those individuals with insufficient visual skills. In general, studies examining the efficacy of driver training suffer from small, heterogeneous samples. In addition, intervention programs in these studies do not appear to be specific to the impairments of the participants.

Recommendations: Return to Driving	Class	Level of Evidence
Individuals who appear to be ready to return to driving, as demonstrated by successful performance on fitness-to-drive tests, should have an on-the-road test administered by an authorized person.	I	C
It is reasonable that individuals be assessed for cognitive, perception, physical, and motor abilities to ascertain readiness to return to driving according to safety and local laws.	IIa	B
It is reasonable that individuals who do not pass an on-the-road driving test be referred to a driver rehabilitation program for training.	IIa	B
A driving simulation assessment may be considered for predicting fitness to drive.	IIb	C

Conclusions

Stroke rehabilitation requires a sustained and coordinated effort from a large team, including the patient and his or her goals, family and friends, other caregivers (eg, personal care attendants), physicians, nurses, physical and occupational therapists, speech-language pathologists, recreation therapists, psychologists, nutritionists, social workers, and others. Communication and coordination among these team members are paramount in maximizing the effectiveness and efficiency of rehabilitation and underlie this entire guideline. Without communication and coordination, isolated efforts to rehabilitate the stroke survivor are unlikely to achieve their full potential.

The evidence base on specific stroke rehabilitation interventions has expanded considerably in recent years, although many gaps remain. In addition to summarizing the current evidence base, this document serves to highlight areas where additional research is needed to clarify the most effective treatment strategies.

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Treatment gaps and future research directions identified include the following:

- Investigate multimodal interventions (eg, drug and therapy, brain stimulation, and therapy)
- Consider including multiple outcomes such as patient-centered, self-report outcomes in future intervention effectiveness trials (Patient Reported Outcomes Measurement Information System [PROMIS[290]])
- Consider computer-adapted assessments for personalized and tailored interventions
- Explore effective models of care that consider stroke as a chronic condition rather than simply a single acute event
- Capitalize on newer technologies such as virtual reality, body-worn sensors, and communication resources, including social media
- Develop interventions for individuals with severe stroke
- Develop better predictor models to identify responders and nonresponders to different therapies

As systems of care evolve in response to healthcare reform efforts, postacute care and rehabilitation are often considered a costly area of care to be trimmed, but without recognition of their clinical impact and their ability to reduce the risk of downstream medical morbidity caused by immobility, depression, loss of autonomy, and reduced functional independence. The provision of comprehensive rehabilitation programs with adequate resources, dose, and duration is an essential aspect of stroke care and should be a priority in these redesign efforts. We hope that these guidelines help inform these efforts.

Appendix 1. Structure and Organization of Stroke Rehabilitation Care in the United States

Setting	Admission	Median Length of Stay	Specialist Involvement
Acute inpatient facility (hospital)	Near onset	4 d for ischemic stroke 7 d for hemorrhagic stroke	Major: MD, RN More limited: OT, PT, SLT, SW
IRF	5–7 d	15 d (range, 8–30 d)	Major: MD, RN, OT, PT, SLT More limited: SW
SNF	5–7 d	Highly variable (maximum, 100 d)	Major: LPN/LVN, NA, OT, PT, SLT More limited: MD, RN
Long-term care (nursing home)	Highly variable	Prolonged and highly variable	Major: LPN/LVN, NA More limited: RN, OT, PT, SLT, MD
Long-term care hospital	Variable	25-d average (required)	Major: RN, MD More limited: OT, PT, SLT
HHCA	Variable (typically 5–30 d)	Maximum 60-d episode	Major: NA, RN More limited: OT, PT, SLT, MD
Outpatient office	Variable (typically 5–30 d)	Variable	Major: OT, PT, SLT, MD

HHCA indicates home healthcare agency; IRF, inpatient rehabilitation facility; LPN/LVN, licensed practical or vocational nurse; MD, medical doctor; NA, nurse assistant; OT, occupational therapist; PT, physical therapist; RN, registered nurse (preferably with training in rehabilitation); SLT, speech-language therapist; SNF, skilled nursing facility; and SW, social worker. Modifed from Miller et al.[11] Copyright © 2010, American Heart Association, Inc.

Appendix 2. Recommended* Measures Table

Construct/Measure	Comments	Approximate Time to Administer, min	References for Further Information
Impairment			
Paresis/strength			
Motricity Index	Consists of strength testing via manual muscle testing at 3 key UE segments and 3 key LE segments; yields a score from 0–100 indicating strength of each limb	<5 for UEs; <5 for LEs	294–299
Muscle strength	Via manual muscle testing, graded on a 0–5 scale or handheld dynamometry	<5	
Grip, pinch dynamometry	Grip and pinch dynamometers are available in most rehabilitation clinics and hospitals; normative data are available for comparison	<5	
Tone			
Modified Ashworth scale	Quantifies spasticity on a scale measuring resistance to passive movement from 0–4, with higher numbers indicating greater severity; can assess at all joints or only a few	10	294, 298, 299

(*Continued*)

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Appendix 2. Continued

Construct/Measure	Comments	Approximate Time to Administer, min	References for Further Information
Sensorimotor impairment measures			
Fugl-Meyer	Quantifies sensorimotor impairment of the UE (0–66 points) and LE (0–34 points) on separate subscales; items are rated on ability to move out of abnormal synergies	25	298–302
Chedoke McMaster Stroke Assessment, impairment inventory	Quantifies impairments in 6 dimensions of shoulder pain, postural control, arm, hand, leg, and foot, each on a 7-point scale, with higher scores equalling less impairment	45	
Activity			
UE function			
Action Research Arm Test	Criteria based with 19 items; scores are from 0–57, with normal=57; allows observation of multiple grasps, grips, and pinches	10	294, 298–300, 302–306
Box and Block Test	Score is the number of blocks moved in 1 min; higher scores equal better performance; normative data are available for comparison	<5	
Chedoke Arm and Hand Activity Index	Criterion based with functional items requiring bilateral UE movement; available in 7-, 8-, 9-, and 13-item versions	25	
Wolf Motor Function Test	Time- and criterion-based scores on 15 items; contains some isolated joint movements and some functional tasks	15	
Balance			
Berg Balance Scale	Criterion-based assessment of static and dynamic balance; widely used in multiple settings	15	307–311
Functional Reach Test	A single-item test that measures how far one can reach in standing; normative data are available for comparison	<5	
Mobility			
Walking speed†	Brief and widely used; categories based on speed are: <0.4 m/s=household ambulation 0.4–0.8 m/s=limited community ambulation >0.8 m/s=community ambulation; normative data available for comparison	<5	307, 308, 312–314
Timed Up and Go	Quantifies more than straight walking, including sit/stand and a turn; scored by time to complete; criterion values available for comparison	<5	
6-Min walk test	Quantifies walking endurance; normative and criterion values for community ambulation distances available	<10	
Functional ambulation category	Classification made after observation or self-report of walking ability; 6-point scale with higher equals better walking ability; this tool allows assessment of walking ability in people who are not independent ambulators	<5	
Observational gait analysis	Commonly used in many clinics to plan treatment programs; several standardized formats are available; appropriate to use in conjunction with one of the above more quantifiable measures	5	
Participation			
Self-reported impairments, limitations, and restrictions			
Stroke Impact Scale: Strength, Mobility, ADL, and Hand Function subscales	These 4 subscales measure different aspects of physical performance; people rate their perceived ability to do different items; each subscale ranges from 0–100, with higher scores indicating better abilities	5 per subscale	294, 304, 307, 315
Motor Activity Log	14 or 28 questions about how the affected UE is used in daily life; scores range from 0–5, with 5 equal to similar to before the stroke	20	
Activities-specific Balance Confidence Scale	16 questions in which people with stroke rate their balance confidence during routine activities; scores range from 0–100, with higher scores indicating more confidence	20	316–319

(*Continued*)

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Appendix 2. Continued

Construct/Measure	Comments	Approximate Time to Administer, min	References for Further Information
Technology for monitoring activity and participation			
Accelerometers, step activity monitors, pedometers	Numerous commercially available options; issues to consider when purchasing: cost, expected wear and tear, accompanying software, ease of use, wearing comfort; pedometers are the most economic option but need to be checked for ability to register steps of individuals with slow walking speeds	<5 to don/doff; additional processing time	7, 294, 321–328, 350

ADL indicates activity of daily living; LE, lower extremity; and UE, upper extremity.
*Note that it is recommended that clinicians select a single measure for each construct; it is often unnecessary to use >1 measure.
†Generally tested on 5- or 10-m walkways.

Disclosures

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Catherine E. Lang	Washington University School of Medicine (St. Louis)	NIH (grant to test interventions for individuals with stroke)†; NIH (coinvestigator on grant investigating brain connectivity after stroke)*; Barnes Jewish Hospital Foundation*; NIH (coinvestigator on grant to investigate postacute rehabilitation for general medical population)*	None	None	None	None	Neurolutions, Inc*; Rehabilitation Institute of Chicago's NIDRR National Center for Rehabilitation Robotics*; Centers of Excellence in Stroke Collaborative Research for Regeneration, Resilience, and Secondary Prevention*; American Heart/American Stroke Association*; Bugher Foundation*	Royalties for book, AOTA Press Inc*

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*Modest.

†Significant.

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*Modest.

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