

# UCLA

## UCLA Previously Published Works

### Title

The American Heart Association's Get With the Guidelines (GWTG)-Stroke development and impact on stroke care

### Permalink

<https://escholarship.org/uc/item/6s8856r6>

### Journal

Stroke and Vascular Neurology, 2(2)

### ISSN

2059-8688

### Authors

Ormseth, Cora H  
Sheth, Kevin N  
Saver, Jeffrey L  
et al.

### Publication Date

2017-06-01

### DOI

10.1136/svn-2017-000092

Peer reviewed

# The American Heart Association's Get With the Guidelines (GWTG)-Stroke development and impact on stroke care

Cora H Ormseth,<sup>1</sup> Kevin N Sheth,<sup>1</sup> Jeffrey L Saver,<sup>2</sup> Gregg C Fonarow,<sup>3</sup> Lee H Schwamm<sup>4</sup>

**To cite:** Ormseth CH, Sheth KN, Saver JL, *et al.* The American Heart Association's Get With the Guidelines (GWTG)-Stroke development and impact on stroke care. *Stroke and Vascular Neurology* 2017;**2**:e000092. doi:10.1136/svn-2017-000092

Received 22 April 2017  
Accepted 26 April 2017  
Published Online First  
29 May 2017

## ABSTRACT

The American Heart Association's Get With the Guidelines (GWTG)-Stroke programme has changed stroke care delivery in the USA since its establishment in 2003. GWTG is a voluntary registry and continuous quality improvement initiative that collects data on patient characteristics, hospital adherence to guidelines and inpatient outcomes. Implementation of the programme saw increased provision of evidence-based care and improved patient outcomes. This review will describe the development of the programme and discuss the impact on stroke outcomes and transformation of stroke care delivery that followed its implementation.

## BACKGROUND

The American Heart Association (AHA) is a scientific society that supports evidence development through research and publishes evidence-based guidelines for healthcare providers to improve the prevention and treatment of cardiovascular disease and stroke. However, the publication of evidence-based guidelines alone is not enough to improve clinical practice. Barriers to adherence included lack of familiarity or awareness of the guidelines, lack of motivation and outcome expectancy, lack of time and resources, organisational constraints and perceived malpractice liability.<sup>1,2</sup> The AHA has several mechanisms for measuring processes of care and outcomes through which it promotes improved quality of care. In collaboration with the American College of Cardiology, it has a formal mechanism for the development and promulgation of performance measures that are evidence-based recommendations supported by the highest level of evidence and suitable for public reporting by federal agencies.<sup>3</sup> Within the AHA suite of quality programmes, the Get With the Guidelines (GWTG) programmes include achievement and quality measures that have been developed by expert review and consensus from available evidence and that have sufficient evidence that failure to provide the recommended care is likely to

result in poor patient outcomes.<sup>4</sup> Performance measures are formally evaluated for validity, feasibility and impact on outcomes and are usually submitted to the National Quality Forum for formal review and endorsement by an independent agency. For the purposes of this review, we will use the term 'performance measures' more generally to encompass both formal performance measures and other measures of quality used within the GWTG programmes.

In the late 1990s, stroke care in the USA was fragmented, and rates of stroke incidence and mortality were high.<sup>5</sup> Despite its approval by the US Food and Drug Administration in 1996, intravenous tissue plasminogen activator (IV tPA) was underutilised in the acute treatment of stroke.<sup>6</sup> The AHA established the American Stroke Association (ASA) in 1998, and one of its first missions was to help bridge the gap between evidence and practice. The ASA formed the Metro Stroke Task Force to increase stroke awareness and improve the stroke system of care with an emphasis on hospital access and emergency response to stroke. The programme evolved into Operation Stroke, a community-based public awareness programme for stroke prevention and treatment. Operation Stroke ran through 2004 and was associated with improvements in stroke screenings and hospital infrastructure. In 2001, Senator Edward M. Kennedy worked with Massachusetts ASA volunteer Dr Lee Schwamm to craft a bill to fund the development of a stroke system of care. Together with Senator Bill Frist, MD, he introduced Senate Bill 1274 'The Stroke Treatment and Ongoing Prevention (STOP Stroke) Act of 2001', which appropriated \$40 million for stroke prevention, treatment and rehabilitation.<sup>7</sup> Though the bill passed the Senate in 2001 and was reintroduced for several subsequent years, it was never successfully passed by both houses of Congress and into law. However, it was clear



<sup>1</sup>Neurology, Yale University School of Medicine, New Haven, Connecticut, USA

<sup>2</sup>Department of Neurology, UCLA Medical Center, Los Angeles, California, USA

<sup>3</sup>Department of Cardiology, UCLA Medical Center, Los Angeles, California, USA

<sup>4</sup>Department of Neurology, Massachusetts General Hospital, Boston, Massachusetts, USA

## Correspondence to

Miss Cora H Ormseth;  
cora.ormseth@yale.edu

that hospital-level change was required to effect a reduction in stroke risk and improvement in patient outcomes, and efforts were initiated in parallel to the legislative actions to impact stroke care delivery.

In 2001, the Centers for Disease Control and Prevention (CDC) funded four Paul Coverdell National Acute Stroke Registry (PCNASR) prototypes to monitor stroke care and guide quality improvement.<sup>5</sup> The registry, named for Senator Paul Coverdell who suffered a fatal stroke due to cortical venous sinus thrombosis, served the dual purpose of disease registry and quality improvement initiative. Representatives from the CDC, Brain Attack Coalition (BAC), National Institute for Neurological Disorders and Stroke, Centers for Medicare & Medicaid Services (CMS) and Veterans Association developed an initial set of proposed data elements that would be collected from prehospital transport through postdischarge follow-up. These data elements were reviewed and refined collaboratively by the PCNASR prototype investigators from four states to develop a working pilot registry in the 2001–2005 cycle.

The Massachusetts prototype funded the development of the GWTG-Stroke alpha pilot. Patients admitted for new onset acute stroke or transient ischaemic attack (TIA) with symptoms present on hospital arrival were entered in the registry. The infrastructure of the programme was modelled on the GWTG-Coronary Artery Disease (GWTG-CAD, now ACTION Registry-GWTG) pilot launched in 2000. Data collection included measures from the acute treatment phase through hospital-based secondary prevention measures at discharge. The Research Triangle Institute, independent auditor to the CDC, evaluated the prototypes.<sup>9</sup> Analysis of the 6867 admissions from 2001 to 2002 found low adherence to established treatment guidelines, reaffirming the need for hospital-level interventions in stroke care. In 2003, GWTG-Stroke launched nationally and became available to all US hospitals on a voluntary basis.

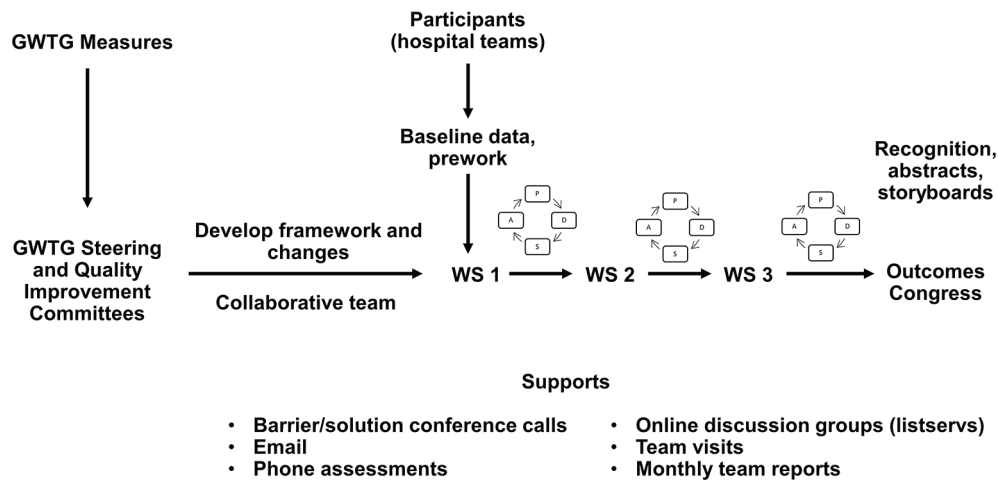
## ORGANISATION AND IMPLEMENTATION

The GWTG programme was developed as a systems-based rather than practitioner-focused intervention to address the gap between knowledge of guidelines and translation to clinical practice.<sup>10</sup> GWTG was based in part on similar efforts including the Cardiac Hospitalisation Atherosclerosis Management Program.<sup>11</sup> Guidelines were integrated in a Patient Management Tool (PMT) to maintain adherence, with hospitals able to run reports comparing themselves to other peer hospitals. Results from 24 Massachusetts hospitals participating in the 1-year GWTG-CAD pilot showed clinically and statistically significant increases in adherence to guidelines and provided proof of concept for active interventions to improve patient outcomes.<sup>12</sup> Based on these promising results, the AHA was emboldened to publicly announce its intention of reducing coronary heart disease, stroke and risk by 25% by 2010, with the GWTG suite of programmes at the heart of its efforts.<sup>13</sup>

GWTG-Stroke operates at the national and local levels and involves a series of quality improvement cycles and collaborative workshops to refine and develop hospital protocols and processes. At the core of GWTG-Stroke are the stroke performance measures, which were developed through the PCNASR process and subsequently harmonised with other similar efforts by other societies in a 2-day consensus conference attended by representatives of the AHA, CDC and the Joint Commission (JC). At the national level, Steering and Quality Improvement Committees recruit experts in registries, data acquisition and quality improvement to oversee the programme, review new evidence, recommend changes to the programme and disseminate guidelines to practitioners. The committees hold organisational stakeholder and opinion leader meetings, recruit and recognise hospitals for high performance, host collaborative learning sessions, develop hospital tool kits and drive legislative change.<sup>2</sup>

The PMT (Quintiles, Cambridge, MA) is crucial to the operation of GWTG. The PMT is an electronic case report form that serves the dual purpose of quality assurance and data collection. The PMT is integrated with electronic medical records and allows users to enter individual patient data at the point of care or during retrospective chart abstraction. Drop-down reminders ensure assessments and interventions are completed, and real-time data checks identify inconsistent entries or values that are out of range, eliminating delays in performance feedback on the individual level. Referral notes, patient letters and patient education materials are built into the tool for use at discharge if desired. Quintiles serves as the data collection and coordination centre, and the Duke Clinical Research Institute serves as the data analysis centre. The AHA works with government agencies to ensure that hospitals can report their data to State Health Departments when required for state-based stroke centre certification programmes and that hospital emergency departments have protocols for acute stroke treatment.

Participation in GWTG is voluntary. In the early stages, hospitals were recruited by AHA staff and volunteers based on interest, senior leadership commitment and geographic, ethnic and socioeconomic diversity of sites. An initial regional learning session was held to bring together stakeholders from all the participating hospitals, and 30 records were entered in the PMT at hospital enrolment to assess baseline performance. At the local level, hospitals define focused goals for improvement in adherence to achievement and quality measures. Reports generated by the PMT provide instant feedback to allow sites to problem-solve barriers to adherence and change protocols and order sets in their site if needed. Multidisciplinary teams in each hospital convene to review the data and develop strategies to further refine protocols in Plan Do Study Act (PDSA) cycles. The rapid cycles afforded by the continuous quality improvement (CQI) framework of the PDSA system allow for testing on a small scale and encourage rapid, innovative changes (figure 1).



**Figure 1** GWTG quality improvement framework. Foundation of the GWTG quality improvement programme. Adapted from Current Treatment Options in Cardiovascular Medicine. 2005;7:253–258. GWTG, Get With the Guidelines; WS, workshop.

At initial implementation, collaborative learning sessions are held every quarter and bring together multidisciplinary teams from different hospitals to address barriers to care. Hospital teams report on the success of different tools they have implemented, fostering a sense of community and accelerating improvement. Findings from clinical trials are presented, and guidelines for acute care and secondary prevention are disseminated. In between learning sessions, collaboration is continued with monthly conference calls, webinars, online discussion groups and email exchanges. Over time, as the majority of large US hospitals within communities have joined GWTG-Stroke, new learning sessions are not held in person but ongoing continuing stroke education and problem solving are shared via national webinars featuring senior volunteers.

Hospital recognition awards encourage progress and provide publicity. The Performance Achievement Award (PAA) recognises hospitals with a multidisciplinary team, a physician champion, orders or protocols that include GWTG measures, submission of data for 1 year of stroke discharges, commitment to ongoing data collection and CQI and adherence to the seven achievement measures

in 85% of all eligible patients (ie, those without any documented contraindication to treatment).

There are considerable financial and human resource costs associated with the development and implementation of GWTG. A sustainable national registry that serves a CQI function ideally requires a single set of data elements and performance measures, funding for data collection, improved electronic data collection, access to patient information while hospitalised and a commitment to ongoing improvement.<sup>14</sup> Additional costs include education, system re-engineering, executive-level sponsorship and local staffing. Recommended hospital staff include a stroke coordinator who manages the site and does data abstraction, a physician champion, actively engaged physicians and nurses and an effective multidisciplinary team of health professionals committed to achieving the programme goals.

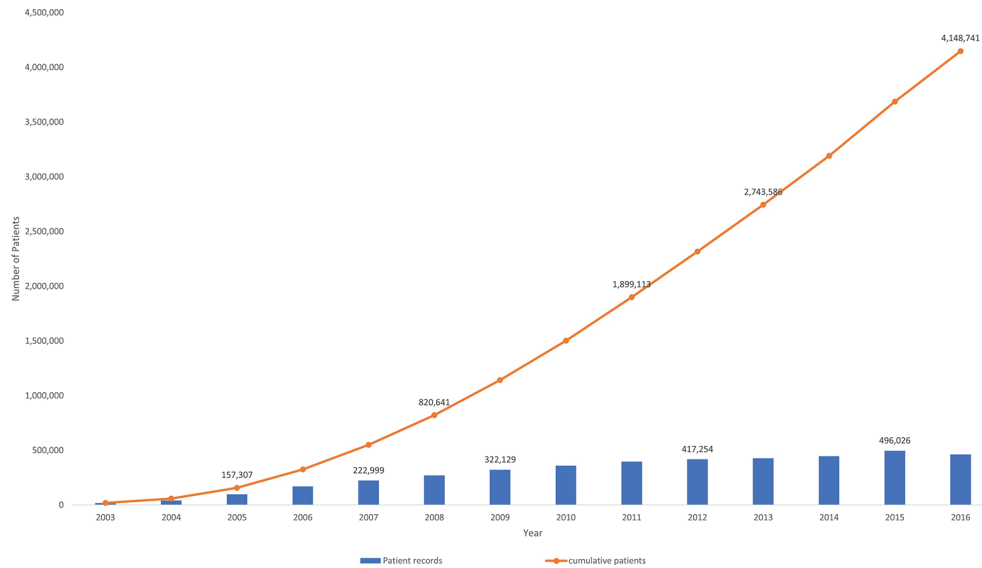
## ACHIEVEMENT MEASURES

Seven GWTG achievement measures, including four acute and three discharge measures, were developed from a consensus of stroke experts (table 1).<sup>15</sup> Composite and defect-free measures are included to

**Table 1** GWTG-Stroke achievement measures

IV tPA arrive by 2 hours, treat by 3 hours	IV tPA in patients who arrive <2 hours after symptom onset and treated within 3 hours of symptom onset
Early antithrombotics	Antithrombotic medication prescribed within 48 hours of admission
Deep venous thrombosis (DVT) prophylaxis	DVT prophylaxis within 48 hours of admission in patients at risk for DVT
Discharge antithrombotics	Antithrombotic medication prescribed at discharge
Anticoagulation for atrial fibrillation	Anticoagulation prescribed at discharge in patients with documented atrial fibrillation
Low-density lipoprotein (LDL) 100	Lipid-lowering medication prescribed at discharge if LDL $\geq$ 100 mg/dL, if patient treated with lipid-lowering agent before admission or LDL not documented
Smoking cessation	Smoking cessation intervention at discharge for current or recent smokers

GWTG, Get With the Guidelines; IV tPA, intravenous tissue plasminogen activator.



**Figure 2** Enrolment in GWTG-Stroke from 2003 to 2016. Yearly and cumulative enrolment in GWTG-Stroke from 2003 to 2016. Used with permission from the American Heart Association. GWTG, Get With the Guidelines.

assess hospital performance in providing all the appropriate interventions for each patient. Hospitals report the proportion of eligible patients receiving the measure divided by the total number of eligible patients without contraindications.

Additional measures of quality that are not yet supported at the highest levels of evidence include dysphagia screening before any oral intake, door-to-CT time  $\leq 25$  min in patients presenting with stroke symptoms  $< 3$  hours duration, stroke education at discharge and assessment for stroke rehabilitation services. Additional quality measures were subsequently added to include IV tPA in patients arriving within 3.5 hours of symptom onset and treated within 4.5 hours of symptom onset, time to IV tPA  $\leq 60$  min, National Institutes of Health Stroke Scale (NIHSS) documented, LDL documented and intensive statin therapy for ischaemic stroke patients with evidence of atherosclerosis prescribed at discharge.<sup>16</sup> Reporting measures include patient demographics and treatment time intervals throughout the hospitalisation.

## ENROLMENT AND REPORTING

In 2003, GWTG-Stroke was launched in eight additional states with a national launch later that year. There are currently over 4.5 million patients enrolled in GWTG-Stroke in over 2000 hospitals across the country, admitting  $\sim 50\%$  of index stroke hospitalisations annually (figure 2).<sup>17</sup> GWTG hospitals comprise a mix of JC-certified stroke centres, PCNASR hospitals and small and large hospitals in urban and rural settings across the USA and Puerto Rico. Comparison with statistics from the 2000 US Census shows the population of patients enrolled in GWTG is similar in age and racial makeup to the US population.<sup>18</sup> Medicare beneficiaries linked to the GWTG registry are similar in demographics, comorbidities and in-hospital outcomes compared with Medicare

beneficiaries who are not linked.<sup>19</sup> GWTG hospitals are more likely to be larger academic institutions located in urban areas in the Northwest and South, which is also where the majority of stroke patients in the USA are admitted.

The GWTG Steering Committee conducted a national data validation audit in 2012 that showed high accuracy and reliability across sites.<sup>20</sup> An improvement in quality of care may reflect a greater number of treated patients (increase in the numerator) or a greater number of patients excluded from the target population (decrease in the denominator). An analysis was performed to test the assumption that the improvement in performance measure compliance was an indication of better patient care.<sup>21</sup> The size of the target population did not change over time, and the improved performance reflected a higher proportion of patients receiving guideline-based treatment rather than a reduction in size of the target population or increased documentation of contraindications.

## OUTCOMES

Early analyses of GWTG data saw marked improvement in adherence to measures.<sup>22 23</sup> Quality measures improved after 6 months of programme initiation, not immediately, suggesting that the increased compliance with measures was the result of effective hospital interventions and not changes to data documentation. Analysis of 790 GWTG hospitals enrolled from April 2003 to July 2007 found clinically meaningful and statistically significant improvement in the seven achievement measures and a composite measure after 5 years of programme implementation.<sup>18</sup> Results showed a 30.8% increase in IV tPA use for patients arriving within 2 hours of symptom onset, 15.8% increase in deep venous thrombosis (DVT) prophylaxis, 14.7% increase in lipid-lowering drugs for elevated LDL and



28.4% increase in smoking cessation, while smaller but significant gains were seen in measures with high baseline performance. After controlling for secular trends, GWTG was associated with a 1.18-fold annual increase in the odds of receiving guideline-recommended care. This effect was observed across different sizes and geographic distribution of hospitals, though larger hospitals and teaching hospitals saw the greatest improvement.

Analysis of the first 1 million GWTG-Stroke patients provided further evidence of improvements in achievement measures and patient outcomes.<sup>15</sup> Admissions from 1419 hospitals from April 2003 to August 2009 showed 4.3% increase in discharge antithrombotics, 41.9% increase in IV tPA use in eligible patients, 51.0% increase in smoking cessation education, 20.8% increase in the composite score and 40.3% increase in the defect-free care measure. There was a 9.4-fold increase in odds of receiving guideline-recommended all-or-none care that was independent of patient and hospital characteristics. Temporal trends showed the proportion of patients discharged home increased, while hospital length of stay and in-hospital mortality decreased.

Subsequent studies show continued compliance across achievement measures and improved patient outcomes.<sup>24–30</sup> Compared with control hospitals matched for teaching status, region, ischaemic stroke volume and mortality rates, GWTG Medicare beneficiaries showed an increased proportion of patients discharged home as well as decreased 30-day and 1-year mortality rates.<sup>31</sup>

## LIMITATIONS

Quality improvement measures focus on reducing long-term disability and secondary prevention. A major limitation of the registry is the lack of postdischarge outcomes, without which the effect on long-term outcomes is challenging to measure. However, the resources required to collect long-term outcomes could prove a barrier to participation in and sustainability of the programme. In addition, linkage to large claims databases such as the Medicare Fee for Service dataset have allowed for longitudinal follow-up of outcomes such as death, rehospitalisation and time spent free of institutional living.<sup>32</sup> Several clinical trials or observational studies have been performed within the GWTG-Stroke hospital cohort. The Patient-Centered Research Into Outcomes Stroke Patients Prefer and Effectiveness Research study builds on the GWTG programme to collect patient feedback on their hospitalisation and postdischarge quality of life and outcomes.<sup>33</sup> Multiple analyses have linked cases with the Medicare Fee for Service database to analyse data on postdischarge resource utilisation and outcomes. Prospective studies such as the Adherence Evaluation After Ischemic Stroke Longitudinal registry analysed medication adherence and functional outcomes among GWTG patients after discharge.<sup>34,35</sup> Access to longitudinal data has allowed for comparison of rehospitalisation and mortality rates in TIA and stroke patients, correlation

between home-time and Modified Rankin Scale (mRS) score, outcomes among patients with atrial fibrillation treated with warfarin, incidence of depression and identification of predictors of discharge medication compliance 1-year post stroke.<sup>36–41</sup>

## MILESTONES IN STROKE QUALITY CARE

In 2005 the ASA endorsed the model of coordinated stroke systems of care.<sup>42</sup> At the time, stroke remained the third leading cause of death and a significant source of long-term disability in the USA. The Institute of Medicine (IOM) of the National Academy of Science concluded that the fragmentation of healthcare delivery resulted in failure to provide effective stroke care. Comprehensive, coordinated stroke systems of care were needed. Stroke systems of care are longitudinal systems that address all aspects of stroke care delivery, including primordial and primary prevention, community education, notification and response of emergency medical services, acute stroke treatment, subacute stroke treatment and secondary prevention, rehabilitation and CQI activities.

The ASA established the Task Force on the Development of Stroke Systems to define and provide recommendations for stroke care systems. The Task Force defined criteria for stroke systems: effective interaction and collaboration among agencies involved in patient care; a standardised approach to care in each facility; identification of performance measures for evaluation of effectiveness; tools and coordination of resources for stroke prevention, treatment and rehabilitation; prioritisation of patient-centred protocols; identification of obstacles to implementation, including political, legal and economic concerns; and customisation for optimal stroke care by each state or region. The Task Force determined CQI strategies are a critical function of stroke systems to optimise effectiveness and recommended ongoing evaluation of overall patient outcomes, linkages among system components and with other entities and obstacles and potential treatment gaps.

By 2006, many hospitals were participating in GWTG, PCNASR and JC Primary Stroke Center (PSC) programmes, each with different but overlapping performance measures. In May 2006, the ASA, CDC and JC harmonised 10 key performance measures that included (1) DVT prophylaxis for non-ambulatory patients by the end of hospital day 2, (2) antithrombotic therapy at discharge, (3) anticoagulation at discharge for patients with atrial fibrillation, (4) thrombolytic therapy administered within 3 hours of time last known well for patients with acute ischaemic stroke who arrive at the hospital within 2 hours of last known well, (5) antithrombotic therapy by the end of hospital day 2, (6) discharge on cholesterol-reducing medication for patients with LDL >100, or LDL not measured or on cholesterol-reducer before admission, (7) dysphagia screening, (8) stroke education, (9) smoking cessation and (10) assessment for rehabilitation.<sup>4</sup> The 10 performance measures were submitted formally by the JC in January 2008,

and the National Quality Forum endorsed eight of the measures. This single, standardised set of performance measures facilitates quality improvement across hospitals and reduces costs in implementing registries. Following this endorsement and substantial advocacy efforts led by AHA/ASA, CMS required the eight measures to be reported in the Medicare Reporting Hospital Quality Data for Annual Payment Update system, making these data available from almost all US hospitals. CMS also added a structural measure asking hospitals to report participation in a Systematic Clinical Database Registry for Stroke Care and endorsed measures for use in the Physician Quality Reporting Initiative programme.

The shift from fragmented to comprehensive stroke systems of care was a critical step in national stroke care delivery. Stroke systems can be improved through participation in stroke centre certification programmes or CQI programmes like GWTG.<sup>43</sup> Many states require GWTG as part of stroke centre designation, and the majority of PCNASR states use GWTG. Currently, 18 states and Washington, D.C. have statewide standards for the formal recognition of stroke facility designations and development of transport protocols, and 12 states and Washington, D.C. have standards for the development and utilisation of stroke registries.<sup>44</sup> GWTG serves as the data collection platform for many hospitals to transmit information to JC, CDC, CMS and state health departments or emergency medical services (EMS) agencies for analysis of performance.

Comparison of adherence to performance measures among GWTG PAA hospitals and JC PSC-certified hospitals showed that conformity with each performance measure was highest in PAA hospitals regardless of PSC certification.<sup>45</sup> PSC certification does not require evidence of achieving a certain level of performance to maintain recognition as the PAA does, suggesting a continuous quality monitoring system that requires explicit performance thresholds that could improve stroke care delivery. The BAC and ASA recommend that PSCs participate in CQI, which may account for the high uptake of GWTG.<sup>17</sup> Most primary stroke centres now participate in GWTG, and GWTG data have been used to compare PSC certification programmes by the JC, state based and other organisations.<sup>46</sup>

## TRANSFORMING CARE

GWTG has facilitated the dissemination of new findings in stroke research and has led to the rapid translation of new findings into clinical practice (table 2). After the 2008 European Cooperative Acute Stroke Study (ECASS) III demonstrated that IV tPA administration 3–4.5 hours after symptom onset improves outcome, the ASA released a science advisory to reflect the results of the trial.<sup>47</sup> Updated guidelines were disseminated to GWTG hospitals via learning sessions and national webinars, and this was associated with a rapid adoption of the expanded tPA window.<sup>48</sup> Similarly, after publication of the Management

of Atherothrombosis With Clopidogrel in High-Risk Patients trial results, GWTG hospitals saw a rapid reduction in prescription of dual antiplatelet therapy.<sup>49</sup>

GWTG studies have also led to new interventions. Hospitals had suboptimal rates of tPA administration within 60 min and had variation in timeliness of tPA initiation.<sup>50–59</sup> In 2010, the ASA launched Target: Stroke, a campaign to reduce door-to-needle (DTN) time modelled after similar successful efforts to reduce door-to-balloon time in primary percutaneous coronary interventions for acute myocardial infarction. Protocols and processes were analysed to establish the reasons for delayed DTN times.<sup>60–63</sup> GWTG toolkits were revised to include interventions such as the Stroke Rapid-Treatment Readiness Tool.<sup>64</sup> After the launch of Target: Stroke, median DTN time decreased from 74 to 59 min, and the percentage of patients treated within 60 min increased from 29.6% to 53.3% (figure 3).<sup>65</sup> Inpatient mortality and long-term disability were reduced in patients treated within 60 min. Absolute rates of tPA use within 3 hours of symptom onset among all ischaemic stroke patients admitted nearly doubled from 4.0% in 2003–2005 to 7.0% in 2010–2011 and expanded to include more patients who were older, non-white race/ethnicity and presented with mild deficits.<sup>66</sup> Despite this progress, delays and disparities still exist in administration of tPA, necessitating further iterations of interventions.<sup>67–73</sup>

GWTG studies have influenced expansion of the patient population eligible for tPA by studying the rates of adverse events in patients older than 80 or with other exclusions from the 3–4.5 hour treatment window recommendations based on the ECASS III trial. The additional tPA exclusion criteria of age >80 years, history of stroke and diabetes mellitus, oral anticoagulant treatment (regardless of international normalised ratio (INR)) and NIHSS >25 were analysed in GWTG-Stroke to detect any signals of lack of safety or efficacy.<sup>74</sup> Among the 31.5% of patients given tPA beyond 3 hours who met at least one exclusion criterion, no increased risk of symptomatic haemorrhage or of worsening outcomes was observed, suggesting that expansion of the inclusion criteria could be considered. Other studies have examined the risks and benefits of tPA in specific patient populations including patients taking novel oral anticoagulants or with hyperglycaemia, malignancy, leukoaraiosis, dementia, sickle cell disease or mild symptoms at presentation.<sup>75–82</sup> Given its prominent role in the patterns of care delivery with IV tPA, the ‘drip and ship’ method of tPA administration (ie, the treatment with tPA at an initial hospital followed by transfer to a stroke centre of higher capability for admission and further care) has been evaluated in GWTG and has been shown to be safe and efficacious while further increasing the proportion of patients who can receive tPA.<sup>83–86</sup>

GWTG studies led to the development of novel validated risk scores and mortality models for both ischaemic and haemorrhagic stroke, which have aided in prognostication and better understanding of case fatality rates.<sup>87–91</sup>

**Table 2** Topics and findings of selected major publications

Schwamm 2005 <sup>42</sup>	Recommendations from the ASA Task Force to establish stroke systems to improve patient outcomes in the prevention, treatment and rehabilitation of stroke in the USA.
Reeves 2005 <sup>9</sup>	Results from four PCNASR pilot prototypes showed a minority of acute stroke patients are treated according to established guidelines.
Schwamm 2006 <sup>14</sup>	Requirements for the design and implementation of a sustainable national registry for stroke quality improvement.
Schwamm 2009 <sup>18</sup>	Implementation of GWTG is associated with increased adherence to all stroke performance measures regardless of hospital size, geography and teaching status.
Schwamm 2010 <sup>5</sup>	A presidential advisory from the AHA/ASA reviewing a decade of efforts to reduce death and disability due to stroke.
Schwamm 2010 <sup>107</sup>	Quality of care improved for black, white and Hispanic patients in GWTG hospitals, though black patients still received fewer evidence-based care processes.
Fonarow 2010 <sup>15</sup>	Analysis of the first 1 million stroke and TIA admissions in GWTG showed improvements in quality of care, length of stay and in-hospital mortality over time.
Smith 2010 <sup>87</sup>	Development of a risk score for in-hospital ischaemic stroke mortality derived and validated within the GWTG programme.
Fonarow 2011 <sup>50</sup>	Fewer than one-third of patients treated with IV tPA had DTN times $\leq 60$ min. Provided some of the first evidence that shorter DTN times were associated with improved outcomes and greater safety, calling for a targeted initiative to improve timeliness of reperfusion.
Lewis 2011 <sup>25</sup>	Use of anticoagulation among stroke patients with atrial fibrillation increased to very high levels in GWTG hospitals.
Reeves 2011 <sup>21</sup>	Improvements in quality care associated with the GWTG programme were related to better care rather than better data documentation.
Reeves 2012 <sup>19</sup>	Comparison of patient and hospital characteristics among Medicare beneficiaries hospitalised with ischaemic stroke showed GWTG stroke admissions are representative of the national Medicare stroke population.
Messé 2012 <sup>48</sup>	Use of tPA between 3 and 4.5 hours increased after publication of the ECASS III in GWTG hospitals.
Fonarow 2012 <sup>89</sup>	Adding stroke severity as measured by the NIHSS improved model discrimination for hospital 30-day mortality.
Saver 2013 <sup>54</sup>	Earlier thrombolytic treatment was associated with reduced mortality and symptomatic intracranial haemorrhage and higher rates of independent ambulation at discharge and discharge to home.
Schwamm 2013 <sup>66</sup>	GWTG hospitals saw nearly doubled tPA administration from 2003 to 2011 with expansion to include more patients with mild symptoms, non-white race/ethnicity and older age.
Ellrod 2013 <sup>17</sup>	GWTG improves the value of care through rapid and sustained improvements in quality, narrowing the treatment gaps for women, younger and older patients and ethnic/racial minorities.
Fonarow 2014 <sup>65</sup>	DTN times for tPA administration and clinical outcomes after stroke improved significantly after implementation of the Target: Stroke quality improvement initiative.
Cronin 2014 <sup>74</sup>	Patients meeting ECASS III exclusion criteria are often treated in the 3–4.5 hour window without worse outcomes.
Xian 2015 <sup>39</sup>	Warfarin treatment was associated with improved clinical outcomes among stroke patients with atrial fibrillation.
Reeves 2015 <sup>30</sup>	Documentation of NIHSS has improved in GWTG hospitals but is higher for patients who are thrombolysis candidates.
Song 2016 <sup>31</sup>	Medicare beneficiaries in GWTG hospitals had improved functional outcomes at discharge and reduced postdischarge mortality compared with their matched counterparts in unaffiliated hospitals.

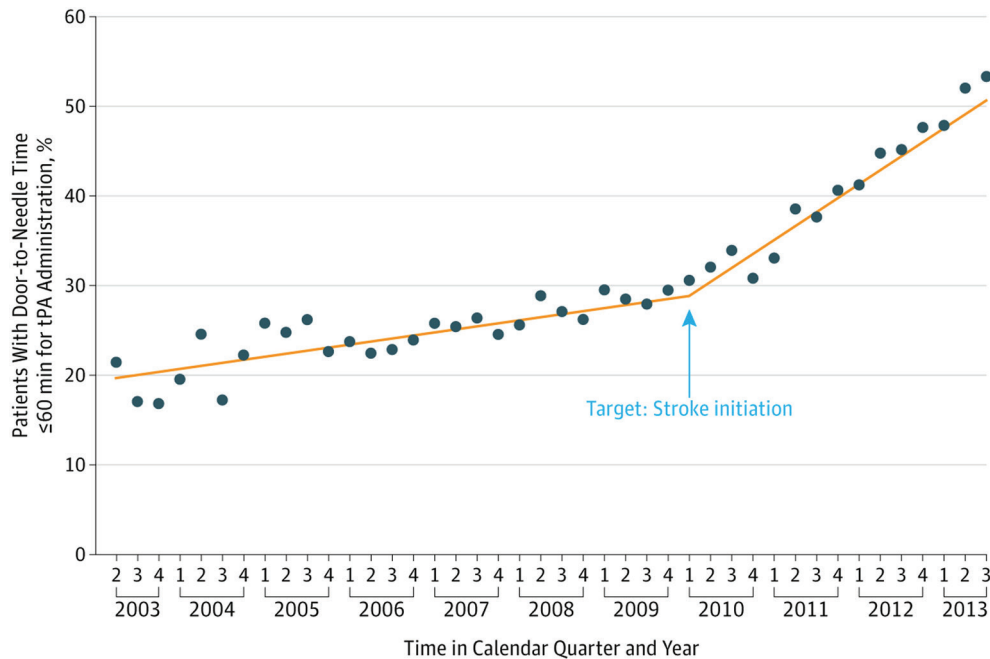
AHA/ASA, American Heart Association/American Stroke Association; DTN, door-to-needle; GWTG, Get With the Guidelines; IV TPA, intravenous tissue plasminogen activator; NIHSS, National Institutes of Health Stroke Scale; PCNASR, Paul Coverdell National Acute Stroke Registry.

The NIHSS was determined to be a strong discriminator of 30-day mortality risk and was instrumental in helping to revise a CMS stroke mortality measure that was lacking a measure of stroke severity.<sup>91</sup> Other studies have identified opportunities for improvement in hospital

prenotification and EMS diagnosis,<sup>92–97</sup> rates and risks of procedures and inpatient complications<sup>98–103</sup> and discharge processes.<sup>104–106</sup>

A priority in national healthcare is the reduction of racial/ethnic and socioeconomic disparities. Quality of





**Figure 3** Impact of the Target: Stroke quality improvement initiative. Time trend in the proportion of patients with door-to-needle times for tPA  $\leq 60$  min during the preintervention and postintervention periods of Target: Stroke. Reproduced with permission from JAMA. 2014; 311(16):1632–1640. Copyright ©2014 American Medical Association. All rights reserved. tPA, tissue plasminogen activator.

care improved across black, white and Hispanic patients after GWTG implementation, although black patients are still less likely than white or Hispanic patients to receive evidence-based care.<sup>107</sup> Several studies have examined persistent disparities in race/ethnicity, age, sex and socioeconomic status that must be addressed.<sup>108–116</sup> Studies have also found variation in care according to hospital region, time of presentation and stroke subtype.<sup>117–122</sup> A recent study found that despite the regional variability of healthcare resources available for acute stroke treatment, quality of care and in-hospital outcomes in GWTG hospitals did not differ by regional resource availability.<sup>123</sup>

## DISCUSSION

GWTG-Stroke has been recognised as a transformative force in stroke care improvement. The programme was awarded the 2002 CMS Common Knowledge Award from the US Department of Health and Human Services. Of the GWTG modules including Heart Failure, Atrial Fibrillation, Resuscitation and Cardiovascular Disease, Stroke is the largest, and its impact has been profound. GWTG significantly improves provision of evidence-based care and patient outcomes. It stands as a gold standard of CQI programmes and has guided the shift towards a stroke systems of care model in the USA.

The costs associated with implementation of the programme are offset by savings through improved stroke prevention and better outcomes after reperfusion therapy. GWTG identifies gaps in treatment, guides interventions, measures rates of change and facilitates new quality measures, lowering costs through improved

efficiency, decreased length of stay and readmission rates, secondary preventative measures and the facilitation of safe medical care.<sup>17</sup> Costs may be further offset by reimbursement in rates of thrombolytic administration.<sup>124</sup> The generalisability of GWTG to countries with lower healthcare expenditures was assessed in Taiwan and determined to be an applicable and feasible method of improving stroke care.<sup>125</sup>

GWTG could help alleviate the stroke care burden that has become a national priority in China.<sup>126</sup> Significant improvements in guideline adherence, hospital length of stay and inpatient mortality have been made in China since quality improvement initiatives were implemented.<sup>127</sup> Partnership with the existing China National Stroke Registry and the joint AHA and Care for Cardiovascular Disease in China project that has modelled GWTG-CAD could facilitate implementation of GWTG-Stroke.<sup>128 129</sup> Barriers to address include the critical follow-up built into GWTG for adherence to secondary stroke prevention measures, which may be difficult without comprehensive community health services.

The global stroke epidemic requires urgent measures to improve quality of stroke care. Assessment of the value of stroke care strategies requires a valid measure of patient outcomes. An international panel of stroke experts developed the International Consortium for Health Outcomes Measurement Stroke Standard Set for measuring the outcomes that matter most to patients with ischaemic stroke and ICH.<sup>130</sup> Outcome domains include survival, disease control, acute complications and long-term quality of life. Collection and analysis of these data

will prompt new strategies for stroke management and further the mission of GWTC of delivering effective, value-based stroke care to patients.

## CONCLUSIONS

GWTC is the AHA's flagship quality improvement programme to improve cardiovascular and stroke healthcare delivery. GWTC-Stroke was instituted at a time of medical urgency amidst legislation and collaboration among organisations to improve stroke risk and outcomes. GWTC transformed stroke care delivery by facilitating the translation of guidelines to clinical practice and implementing CQI strategies. The infrastructure of GWTC allows for economical scientific inquiry and rapid cycles of innovation that continue to refine stroke care delivery. The model is generalisable and applicable to other countries and could help to reduce the global burden of stroke.

**Contributors** CHO, KNS and LHS drafted and revised the paper. JLS and GCF revised the paper. All authors read and approved the final manuscript.

**Competing interests** None declared.

**Patient consent** Obtained.

**Provenance and peer review** Commissioned; internally peer reviewed.

**Open Access** This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

© Article author(s) (or their employer(s) unless otherwise stated in the text of the article) 2017. All rights reserved. No commercial use is permitted unless otherwise expressly granted.

## REFERENCES

- LaBresh KA, Gliklich R, Liljestrand J, et al. Using "get with the guidelines" to improve cardiovascular secondary prevention. *Jt Comm J Qual Saf* 2003;29:539–50.
- Hong Y, LaBresh KA. Overview of the American Heart Association "Get with the Guidelines" programs: coronary heart disease, stroke, and heart failure. *Crit Pathw Cardiol* 2006;5:179–86.
- Spertus JA, Eagle KA, Krumholz HM, et al. American College of Cardiology and American Heart Association methodology for the selection and creation of performance measures for quantifying the quality of cardiovascular care. *J Am Coll Cardiol* 2005;45:1147–56.
- Reeves MJ, Parker C, Fonarow GC, et al. Development of stroke performance measures: definitions, methods, and current measures. *Stroke* 2010;41:1573–8.
- Schwamm L, Fayad P, Acker JE. Association to reduce death and disability due to stroke: A presidential advisory from the American Heart Association/American Stroke Association. *Stroke; a journal of cerebral circulation*. *Stroke* 2010;41:1051–65.
- Tissue plasminogen activator for acute ischemic stroke. The National Institute of neurological disorders and stroke rt-PA stroke study group. *N Engl J Med* 1995;333:1581–7.
- Kennedy EM, Frist B. *Stroke Treatment and Ongoing Prevention Act of 2001: Report Together with Additional Views (to Accompany S. 1274)*. Washington, D.C: U.S. Government Printing Office, 2001;2:15116–8.
- Wattigney WA, Croft JB, Mensah GA, et al. Establishing data elements for the Paul Coverdell National Acute Stroke Registry: part 1. *Proceedings of an expert panel*. *Stroke* 2003;34:151–6.
- Reeves MJ, Arora S, Broderick JP, et al. Acute stroke care in the US: results from 4 pilot prototypes of the Paul Coverdell National Acute Stroke Registry. *Stroke* 2005;36:1232–40.
- LaBresh KA, Tyler PA. A collaborative model for hospital-based cardiovascular secondary prevention. *Qual Manag Health Care* 2003;12:20–7.
- Fonarow GC, Gawlinski A, Moughrabi S, et al. Improved treatment of coronary heart disease by implementation of a cardiac hospitalization Atherosclerosis Management Program (CHAMP). *Am J Cardiol* 2001;87:819–22.
- LaBresh KA, Ellrodt AG, Gliklich R, et al. Get with the guidelines for cardiovascular secondary prevention: pilot results. *Arch Intern Med* 2004;164:203–9.
- Smaha LA; American Heart Association. The American Heart Association get with the guidelines program. *Am Heart J* 2004;148:S46–S48.
- Schwamm L, Reeves MJ, Frankel M. Designing a sustainable national registry for stroke quality improvement. *Am J Prev Med* 2006;31:S251–S257.
- Fonarow GC, Reeves MJ, Smith EE, et al. Characteristics, performance measures, and in-hospital outcomes of the first one million stroke and transient ischemic attack admissions in get with the guidelines-stroke. *Circ Cardiovasc Qual Outcomes* 2010;3:291–302.
- Get with the Guidelines-Stroke: stroke fact sheet. *American Heart Association/American Stroke Association* 2015.
- Ellrodt AG, Fonarow GC, Schwamm LH, et al. Synthesizing lessons learned from get with the guidelines: the value of disease-based registries in improving quality and outcomes. *Circulation* 2013;128:2447–60.
- Schwamm LH, Fonarow GC, Reeves MJ, et al. Get with the Guidelines-Stroke is associated with sustained improvement in care for patients hospitalized with acute stroke or transient ischemic attack. *Circulation* 2009;119:107–15.
- Reeves MJ, Fonarow GC, Smith EE, et al. Representativeness of the get with the Guidelines-Stroke Registry: comparison of patient and hospital characteristics among Medicare beneficiaries hospitalized with ischemic stroke. *Stroke* 2012;43:44–9.
- Xian Y, Fonarow GC, Reeves MJ, et al. Data quality in the American Heart Association get with the Guidelines-Stroke (GWTC-Stroke): Results from a National Data Validation Audit. *Am Heart J*. In Press. 2012;163:392–8.
- Reeves MJ, Grau-Sepulveda MV, Fonarow GC, et al. Are quality improvements in the get with the guidelines: stroke program related to better care or better data documentation? *Circ Cardiovasc Qual Outcomes* 2011;4:503–11.
- LaBresh KA, Reeves MJ, Frankel MR, et al. Hospital treatment of patients with ischemic stroke or transient ischemic attack using the "Get With The Guidelines" program. *Arch Intern Med* 2008;168:411–7.
- Stoeckle-Roberts S, Reeves MJ, Jacobs BS, et al. Closing gaps between evidence-based stroke care guidelines and practices with a collaborative quality improvement project. *Jt Comm J Qual Patient Saf* 2006;32:517–27.
- Huang PH, Kim CX, Lerman A, et al. Trends in smoking cessation counseling: experience from American Heart Association-get with the guidelines. *Clin Cardiol* 2012;35:396–403.
- Lewis WR, Fonarow GC, Grau-Sepulveda MV, et al. Improvement in use of anticoagulation therapy in patients with ischemic stroke: results from get with the Guidelines-Stroke. *Am Heart J* 2011;162:692–9.
- Rost NS, Smith EE, Pervez MA, et al. Predictors of increased intravenous tissue plasminogen activator use among hospitals participating in the Massachusetts primary Stroke Service Program. *Circ Cardiovasc Qual Outcomes* 2012;5:314–20.
- Smith EE, Pan W, Olson D, et al. Frequency and determinants of lipid testing in ischemic stroke and transient ischemic attack: findings from get with the Guidelines-Stroke. *Stroke* 2010;41:232–8.
- Ovbiagele B, Schwamm LH, Smith EE, et al. Recent Nationwide Trends in Discharge Statin treatment of hospitalized patients with stroke. *Stroke* 2010;41:1508–13.
- O'Brien EC, Greiner MA, Xian Y, et al. Clinical effectiveness of statin therapy after Ischemic Stroke: primary results from the Statin Therapeutic area of the Patient-Centered Research Into Outcomes Stroke Patients Prefer and Effectiveness Research (PROSPER) Study. *Circulation* 2015;132:1404–13.
- Reeves MJ, Smith EE, Fonarow GC, et al. Variation and trends in the documentation of National Institutes of Health Stroke Scale in GWTC-Stroke Hospitals. *Circ Cardiovasc Qual Outcomes* 2015;8:S90–S98.
- Song S, Fonarow GC, Olson DM, et al. Association of get with the Guidelines-Stroke Program Participation and clinical outcomes for Medicare beneficiaries with ischemic stroke. *Stroke* 2016;47:1294–302.

32. O'Brien EC, Xian Y, Xu H, *et al.* Hospital variation in home-time after acute ischemic stroke: insights from the PROSPER study (Patient-Centered Research into Outcomes Stroke Patients Prefer and Effectiveness Research). *Stroke* 2016;47:2627–33.
33. Xian Y, O'Brien EC, Fonarow GC, *et al.* Patient-Centered Research into Outcomes Stroke Patients Prefer and Effectiveness Research: implementing the patient-driven research paradigm to aid decision making in stroke care. *Am Heart J* 2015;170:36–45.
34. Bushnell C, Zimmer L, Schwamm L, *et al.* The adherence eValuation after Ischemic Stroke Longitudinal (AVAIL) Registry: design, rationale, and baseline patient characteristics. *Am Heart J* 2009;157:428–35.
35. Bettger JP, Thomas L, Liang L, *et al.* Hospital variation in Functional Recovery after Stroke. *Circulation* 2017;10:e002391.
36. Bushnell CD, Olson DM, Zhao X, *et al.* Secondary preventive medication persistence and adherence 1 year after stroke. *Neurology* 2011;77:1182–90.
37. El Hussein N, Goldstein LB, Peterson ED, *et al.* Depression and antidepressant use after Stroke and transient ischemic attack. *Stroke* 2012;43:1609–16.
38. Fonarow GC, Liang L, Thomas L, *et al.* Assessment of home-time after acute ischemic stroke in Medicare beneficiaries. *Stroke* 2016;47:836–42.
39. Xian Y, Wu J, O'Brien EC, *et al.* Real world effectiveness of warfarin among ischemic stroke patients with atrial fibrillation: observational analysis from Patient-Centered Research into Outcomes Stroke Patients Prefer and Effectiveness Research (PROSPER) study. *BMJ* 2015;351:h3786.
40. Olson DM, Cox M, Pan W, *et al.* Death and rehospitalization after transient ischemic attack or acute ischemic stroke: one-year outcomes from the adherence evaluation of acute ischemic stroke-longitudinal registry. *J Stroke Cerebrovasc Dis* 2013;22:e181–e188.
41. Lopes RD, Shah BR, Olson DM, *et al.* Antithrombotic therapy use at Discharge and 1 year in patients with Atrial Fibrillation and acute stroke. *Stroke* 2011;42:3477–83.
42. Schwamm LH, *et al.* Recommendations for the Establishment of Stroke Systems of Care: Recommendations From the American Stroke Association's Task Force on the Development of Stroke Systems. *Circulation* 2005;111:1078–91.
43. Silva GS, Schwamm LH. Review of stroke center effectiveness and other get with the guidelines data. *Curr Atheroscler Rep* 2013;15:350.
44. Stroke facility designation and stroke registries. *American Heart Association/American Stroke Association* 2016.
45. Fonarow GC, Liang L, Smith EE, *et al.* Comparison of performance achievement award recognition with primary stroke center certification for acute ischemic stroke care. *J Am Heart Assoc* 2013;2:e000451.
46. Man S, Cox M, Patel P, *et al.* Differences in acute ischemic Stroke Quality of Care and outcomes by primary Stroke Center Certification Organization. *Stroke* 2017;48:412–9.
47. del Zoppo GJ, Saver JL, Jauch EC, *et al.* Expansion of the Time Window for treatment of acute ischemic stroke with intravenous tissue plasminogen activator: a Science Advisory from the American Heart Association/American Stroke Association. *Stroke* 2009;40:2945–8.
48. Messé SR, Fonarow GC, Smith EE, *et al.* Use of tissue-type plasminogen activator before and after publication of the European Cooperative Acute Stroke Study III in get with the Guidelines-Stroke. *Circ Cardiovasc Qual Outcomes* 2012;5:321–6.
49. Menon BK, Frankel MR, Liang L, *et al.* Rapid Change in Prescribing Behavior in Hospitals participating in get with the Guidelines-Stroke after Release of the management of Atherothrombosis with Clopidogrel in High-Risk patients (MATCH) Clinical Trial results. *Stroke* 2010;41:2094–7.
50. Fonarow GC, Smith EE, Saver JL, *et al.* Timeliness of tissue-type plasminogen activator therapy in acute ischemic stroke: patient characteristics, hospital factors, and outcomes associated with door-to-needle times within 60 minutes. *Circulation* 2011;123:750–8.
51. Tong D, Reeves MJ, Hernandez AF, *et al.* Times from Symptom Onset to Hospital Arrival in the get with the Guidelines-Stroke Program 2002 to 2009: temporal trends and implications. *Stroke* 2012;43:1912–7.
52. Rost NS, Masrur S, Pervez MA, *et al.* Unsuspected coagulopathy rarely prevents IV thrombolysis in acute ischemic stroke. *Neurology* 2009;73:1957–62.
53. Saver JL, Smith EE, Fonarow GC, *et al.* The "Golden Hour" and Acute Brain Ischemia: Presenting Features and Lytic Therapy in >30 000 Patients Arriving Within 60 Minutes of Stroke Onset. *Stroke* 2010;41:1431–9.
54. Saver JL, Fonarow GC, Smith EE, *et al.* Time to treatment with intravenous tissue plasminogen activator and outcome from acute ischemic stroke. *JAMA* 2013;309:2480–8.
55. Xian Y, Liang L, Smith EE, *et al.* Risks of intracranial hemorrhage among patients with acute ischemic stroke receiving warfarin and treated with intravenous tissue plasminogen activator. *JAMA* 2012;307:2600–8.
56. Desai JA, Smith EE. Prenotification and other factors involved in rapid tPA administration. *Curr Atheroscler Rep* 2013;15:337.
57. Lin CB, Cox M, Olson DM, *et al.* Perception Versus Actual Performance in Timely tissue plasminogen activation administration in the management of acute ischemic stroke. *J Am Heart Assoc* 2015;4:e001298.
58. Kim JT, Fonarow GC, Smith EE, *et al.* Treatment with tPA in the "golden hour" and the shape of the 4.5 hour time-benefit curve in the national US Get With the Guidelines-Stroke population. *Circulation* 2017;135:128–39.
59. Kelly AG, Hellkamp AS, Olson D, *et al.* Predictors of rapid brain Imaging in acute Stroke: analysis of the get with the Guidelines-Stroke Program. *Stroke* 2012;43:1279–84.
60. Olson DM, Constable M, Britz GW, *et al.* A qualitative assessment of practices associated with shorter door-to-needle time for thrombolytic therapy in acute ischemic stroke. *J Neurosci Nurs* 2011;43:329–36.
61. Xian Y, Smith EE, Zhao X, *et al.* Strategies used by hospitals to improve speed of Tissue-Type Plasminogen activator treatment in acute ischemic stroke. *Stroke* 2014;45:1387–95.
62. Zanichkowsky R, Nascimento JA, McCune M, *et al.* Where does the Time go? the effect of protocols for Stroke last known well documentation on intravenous recombinant tissue plasminogen activator delivery in the Northeast. *J Neurosci Nurs* 2016;48:71–4.
63. Bershad EM, Rao CP, Vuong KD, *et al.* Multidisciplinary protocol for rapid head computed tomography turnaround time in acute stroke patients. *J Stroke Cerebrovasc Dis* 2015;24:1256–61.
64. Olson DM, Cox M, Constable M, *et al.* Development and initial testing of the stroke rapid-treatment readiness tool. *J Neurosci Nurs* 2014;46:267–73.
65. Fonarow GC, Zhao X, Smith EE, *et al.* Door-to-needle times for tissue plasminogen activator administration and clinical outcomes in acute ischemic stroke before and after a quality improvement initiative. *JAMA* 2014;311:1632–40.
66. Schwamm LH, Ali SF, Reeves MJ, *et al.* Temporal trends in patient characteristics and treatment with intravenous thrombolysis among acute ischemic stroke patients at get with the Guidelines-Stroke hospitals. *Circ Cardiovasc Qual Outcomes* 2013;6:543–9.
67. Messé SR, Khatri P, Reeves MJ, *et al.* Why are acute ischemic stroke patients not receiving IV tPA? results from a national registry. *Neurology* 2016;87:1565–74.
68. Birnbaum LA, Rodriguez JS, Topel CH, *et al.* Older Stroke patients with High Stroke scores have delayed Door-To-Needle Times. *J Stroke Cerebrovasc Dis* 2016;25:2668–72.
69. Arora R, Salamon E, Katz JM, *et al.* Use and outcomes of intravenous thrombolysis for acute ischemic stroke in patients ≥90 years of Age. *Stroke* 2016;47:2347–54.
70. Ali SF, Siddiqui K, Ay H, *et al.* Baseline predictors of Poor Outcome in Patients Too good to treat with intravenous thrombolysis. *Stroke* 2016;47:2986–92.
71. Smith EE, Fonarow GC, Reeves MJ, *et al.* Outcomes in mild or rapidly improving Stroke not treated with intravenous recombinant Tissue-Type plasminogen activator: findings from get with the Guidelines-Stroke. *Stroke* 2011;42:3110–5.
72. Kamal N, Sheng S, Xian Y, *et al.* Delays in Door-to-Needle Times and their impact on treatment time and outcomes in get with the Guidelines-Stroke. *Stroke* 2017;48:946–54.
73. Xian Y, Xu H, Lytle B, *et al.* Use of strategies to improve Door-to-Needle Times with Tissue-Type Plasminogen activator in acute ischemic stroke in clinical practice. *Circulation* 2017;10:e003227.
74. Cronin CA, Sheth KN, Zhao X, *et al.* Adherence to third European Cooperative acute Stroke Study 3- to 4.5-hour exclusions and association with outcome: data from get with the Guidelines-Stroke. *Stroke* 2014;45:2745–9.
75. Giurgiutiu DV, Yoo AJ, Fitzpatrick K, *et al.* Severity of Leukoaraiosis, leptomeningeal collaterals, and clinical outcomes after intra-arterial therapy in patients with acute ischemic stroke. *J Neurointerv Surg* 2015;7:326–30.
76. Masrur S, Abdullah AR, Smith EE, *et al.* Risk of thrombolytic therapy for acute ischemic stroke in patients with current malignancy. *J Stroke Cerebrovasc Dis* 2011;20:124–30.
77. Busl KM, Nogueira RG, Yoo AJ, *et al.* Prestroke dementia is associated with poor outcomes after reperfusion therapy among elderly stroke patients. *J Stroke Cerebrovasc Dis* 2013;22:718–24.



78. Masrur S, Cox M, Bhatt DL, *et al.* Association of acute and chronic hyperglycemia with acute ischemic stroke outcomes Post-Thrombolysis: findings from get with the Guidelines-Stroke. *J Am Heart Assoc* 2015;4:e002193.
79. Romano JG, Smith EE, Liang L, *et al.* Outcomes in mild acute ischemic stroke treated with intravenous thrombolysis: a retrospective analysis of the get with the Guidelines-Stroke registry. *JAMA Neurol* 2015;72:423–31.
80. Romano JG, Smith EE, Liang L, *et al.* Distinct Short-Term Outcomes in Patients with Mild Versus rapidly improving Stroke not treated with thrombolytics. *Stroke* 2016;47:1278–85.
81. Adams RJ, Cox M, Ozark SD, *et al.* Coexistent sickle cell disease has no impact on the safety or outcome of lytic therapy in acute ischemic stroke: findings from get with the Guidelines-Stroke. *Stroke* 2017;48:686–91.
82. Xian Y, Federspiel JJ, Hernandez AF, *et al.* Use of intravenous recombinant tissue plasminogen activator in patients with acute ischemic Stroke who take Non-Vitamin K antagonist oral Anticoagulants before Stroke. *Circulation* 2017;135:1024–35.
83. Sheth KN, Smith EE, Grau-Sepulveda MV, *et al.* Drip and ship thrombolytic therapy for acute ischemic stroke: use, temporal trends, and outcomes. *Stroke* 2015;46:732–9.
84. Pervez MA, Silva G, Masrur S, *et al.* Remote Supervision of IV-tPA for acute ischemic stroke by Telemedicine or Telephone before transfer to a Regional Stroke Center is feasible and safe. *Stroke* 2010;41:e18–e24.
85. Ali SF, Singhal AB, Viswanathan A, *et al.* Characteristics and outcomes among patients transferred to a Regional Comprehensive Stroke Center for Tertiary Care. *Stroke* 2013;44:3148–53.
86. Milne MS, Holodinsky JK, Hill MD, *et al.* Drip 'n ship versus mothership for endovascular treatment: modeling the best transportation options for optimal outcomes. *Stroke* 2017;48:791–4.
87. Smith EE, Shobha N, Dai D, *et al.* Risk score for in-hospital ischemic stroke mortality derived and validated within the get with the Guidelines-Stroke Program. *Circulation* 2010;122:1496–504.
88. Menon BK, Saver JL, Prabhakaran S, *et al.* Risk score for intracranial hemorrhage in patients with acute ischemic stroke treated with intravenous Tissue-Type plasminogen activator. *Stroke* 2012;43:2293–9.
89. Fonarow GC, Pan W, Saver JL, *et al.* Comparison of 30-day mortality models for profiling hospital performance in acute ischemic stroke with vs without adjustment for stroke severity. *JAMA* 2012;308:257–64.
90. Smith EE, Shobha N, Dai D, *et al.* A risk score for in-hospital death in patients admitted with ischemic or hemorrhagic stroke. *J Am Heart Assoc* 2013;2:e005207.
91. Fonarow GC, Saver JL, Smith EE, *et al.* Relationship of national institutes of health stroke scale to 30-day mortality in medicare beneficiaries with acute ischemic stroke. *J Am Heart Assoc* 2012;1:42–50.
92. Brandler ES, Sharma M, McCullough F, *et al.* Prehospital Stroke identification: factors associated with diagnostic accuracy. *J Stroke Cerebrovasc Dis* 2015;24:2161–6.
93. Ekundayo OJ, Saver JL, Fonarow GC, *et al.* Patterns of emergency medical services use and its association with timely stroke treatment: findings from get with the Guidelines-Stroke. *Circ Cardiovasc Qual Outcomes* 2013;6:262–9.
94. Lin CB, Peterson ED, Smith EE, *et al.* Patterns, predictors, variations, and temporal trends in emergency medical service hospital prenotification for acute ischemic stroke. *J Am Heart Assoc* 2012;1:e002345x.
95. Sequeira D, Martin-Gill C, Kesinger MR, *et al.* Characterizing strokes and stroke mimics transported by helicopter emergency medical services. *Prehospital Emergency Care: Official Journal of the National Association of EMS Physicians and the National Association of State EMS Directors* 2016:1–6.
96. Sharma M, Helzner E, Sinert R, *et al.* Patient characteristics affecting stroke identification by emergency medical service providers in Brooklyn, New York. *Intern Emerg Med* 2016;11:229–36.
97. Studnek JR, Asimos A, Dodds J, *et al.* Assessing the validity of the Cincinnati prehospital stroke scale and the medic prehospital assessment for code stroke in an urban emergency medical services agency. *Prehosp Emerg Care* 2013;17:348–53.
98. Menon BK, Saver JL, Goyal M, *et al.* Trends in endovascular therapy and clinical outcomes within the Nationwide get with the Guidelines-Stroke Registry. *Stroke* 2015;46:989–95.
99. Stecker M, Michel K, Antaky K, *et al.* Risk factors for DVT/PE in patients with stroke and intracranial hemorrhage. *Open Neurol J* 2014;8:1–6.
100. Douds GL, Hellkamp AS, Olson DM, *et al.* Venous thromboembolism in the get with the Guidelines-Stroke acute ischemic stroke population: incidence and patterns of prophylaxis. *J Stroke Cerebrovasc Dis* 2014;23:123–9.
101. Masrur S, Smith EE, Saver JL, *et al.* Dysphagia screening and hospital-acquired pneumonia in patients with acute ischemic stroke: findings from get with the guidelines--stroke. *J Stroke Cerebrovasc Dis* 2013;22:e301–e309.
102. Messe SR, Pervez MA, Smith EE, *et al.* Lipid Profile, Lipid-lowering medications, and intracerebral hemorrhage after tPA in get with the Guidelines-Stroke. *Stroke* 2013;44:1354–9.
103. Goldstein JN, Marrero M, Masrur S, *et al.* Management of thrombolysis-associated symptomatic intracerebral hemorrhage. *Arch Neurol* 2010;67:965–9.
104. Lewis WR, Fonarow GC, LaBresh KA, *et al.* Differential use of warfarin for secondary stroke prevention in patients with various types of atrial fibrillation. *Am J Cardiol* 2009;103:227–31.
105. Patel PA, Zhao X, Fonarow GC, *et al.* Novel oral anticoagulant use among patients with Atrial Fibrillation hospitalized with ischemic stroke or transient ischemic attack. *Circ Cardiovasc Qual Outcomes* 2015;8:383–92.
106. Saposnik G, Fonarow GC, Pan W, *et al.* Guideline-directed low-density lipoprotein management in high-risk patients with ischemic stroke: findings from get with the Guidelines-Stroke 2003 to 2012. *Stroke* 2014;45:3343–51.
107. Schwamm LH, Reeves MJ, Pan W, *et al.* Race/ethnicity, quality of care, and outcomes in ischemic stroke. *Circulation* 2010;121:1492–501.
108. Reeves MJ, Fonarow GC, Zhao X, *et al.* Quality of Care in Women with ischemic stroke in the GWTG Program. *Stroke* 2009;40:1127–33.
109. Xian Y, Holloway RG, Smith EE, *et al.* Racial/Ethnic differences in process of Care and Outcomes among Patients hospitalized with intracerebral hemorrhage. *Stroke* 2014;45:3243–50.
110. Fonarow GC, Reeves MJ, Zhao X, *et al.* Age-related differences in characteristics, performance measures, treatment trends, and outcomes in patients with ischemic stroke. *Circulation* 2010;121:879–91.
111. James ML, Cox M, Xian Y, *et al.* Sex and age interactions and differences in outcomes after intracerebral hemorrhage. *J Womens Health* 2017;26:380–8.
112. James ML, Grau-Sepulveda MV, Olson DM, *et al.* Insurance status and outcome after intracerebral hemorrhage: findings from get with the Guidelines-stroke. *J Stroke Cerebrovasc Dis* 2014;23:283–92.
113. Mochari-Greenberger H, Xian Y, Hellkamp AS, *et al.* Racial/Ethnic and sex differences in Emergency Medical Services Transport among Hospitalized US Stroke Patients: analysis of the National get with the Guidelines-Stroke Registry. *J Am Heart Assoc* 2015;4:e002099.
114. Asdaghi N, Romano JG, Wang K, *et al.* Sex disparities in ischemic stroke care: fl-pr CRESO study (Florida-Puerto Rico Collaboration to reduce Stroke disparities). *Stroke* 2016;47:2618–26.
115. Sacco RL, Gardener H, Wang K, *et al.* Racial-ethnic disparities in Acute Stroke Care in the Florida-puerto Rico Collaboration to reduce Stroke Disparities Study. *J Am Heart Assoc* 2017;6:e004073.
116. Medford-Davis LN, Fonarow GC, Bhatt DL, *et al.* Impact of insurance status on outcomes and use of Rehabilitation Services in acute ischemic stroke: findings from get with the guidelines-stroke. *J Am Heart Assoc* 2016;5:e004282.
117. Reeves MJ, Smith E, Fonarow G, *et al.* Off-Hour Admission and In-Hospital Stroke Case Fatality in the get with the Guidelines-Stroke Program. *Stroke* 2009;40:569–76.
118. Smith EE, Liang L, Hernandez A, *et al.* Influence of stroke subtype on quality of care in the get with the Guidelines-Stroke Program. *Neurology* 2009;73:709–16.
119. Fonarow GC, Smith EE, Reeves MJ, *et al.* Hospital-Level variation in mortality and rehospitalization for Medicare beneficiaries with acute ischemic stroke. *Stroke* 2011;42:159–66.
120. Allen NB, Kaltenbach L, Goldstein LB, *et al.* Regional variation in Recommended Treatments for ischemic stroke and TIA: get with the Guidelines-Stroke 2003-2010. *Stroke* 2012;43:1858–64.
121. O'Brien EC, Zhao X, Fonarow GC, *et al.* Quality of Care and ischemic stroke risk after hospitalization for transient ischemic attack: findings from get with the Guidelines-Stroke. *Circ Cardiovasc Qual Outcomes* 2015;8:S117–24.
122. Bangalore S, Schwamm L, Smith EE, *et al.* Secondary prevention after ischemic stroke or transient ischemic attack. *Am J Med* 2014;127:728–38.

123. O'Brien EC, Wu J, Zhao X, *et al.* Healthcare Resource Availability, Quality of Care, and acute ischemic stroke outcomes. *J Am Heart Assoc* 2017;6:e003813.
124. Berthiaume JT, Tyler PA, Ng-Osorio J, *et al.* Aligning financial incentives with "Get With The Guidelines" to improve cardiovascular care. *Am J Manag Care* 2004;10:501-4.
125. Hsieh FI, Lien LM, Chen ST, *et al.* Get with the Guidelines-Stroke performance indicators: surveillance of stroke care in the Taiwan Stroke Registry: get with the Guidelines-Stroke in Taiwan. *Circulation* 2010;122:1116-23.
126. Wang CJ, Wang CX, Zhang L, *et al.* Advances in stroke care and research in 2010. *Clin Exp Pharmacol Physiol* 2011;38:562-9.
127. Li Z, Wang C, Zhao X, *et al.* Substantial Progress yet Significant Opportunity for Improvement in Stroke Care in China. *Stroke* 2016;47:2843-9.
128. Wang Y, Cui L, Ji X, *et al.* The China National Stroke Registry for patients with acute cerebrovascular events: design, rationale, and baseline patient characteristics. *Int J Stroke* 2011;6:355-61.
129. Hao Y, Liu J, Liu J, *et al.* Rationale and design of the improving care for Cardiovascular Disease in China (CCC) project: a national effort to prompt quality enhancement for acute coronary syndrome. *Am Heart J* 2016;179:107-15.
130. Salinas J, Sprinkhuizen SM, Ackerson T, *et al.* An International Standard set of Patient-Centered Outcome measures after Stroke. *Stroke* 2016;47:180-6.