Stroke Quality Metrics
Systematic Reviews of the Relationships to Patient-Centered Outcomes
and Impact of Public Reporting

Carol Parker, MPH; Lee H. Schwamm, MD; Gregg C. Fonarow, MD; Eric E. Smith, MD, MPH; Mathew J. Reeves, PhD

Background and Purpose—Stroke quality metrics play an increasingly important role in quality improvement and policies related to provider reimbursement, accreditation, and public reporting. We conducted 2 systematic reviews examining the relationships between compliance with stroke quality metrics and patient-centered outcomes, and public reporting of stroke metrics and quality improvement, quality of care, or outcomes.

Methods—MEDLINE and EMBASE databases were searched to identify studies that evaluated the relationship between stroke quality metric compliance and patient-centered outcomes in acute hospital settings and public reporting of stroke quality metrics and quality improvement activities, quality of care, or patient outcomes. We specifically excluded studies that evaluated the effect of stroke units or hospital certification.

Results—Fourteen studies met eligibility criteria for the review of stroke quality metric compliance and patient-centered outcomes; 9 found mostly positive associations, whereas 5 found no or very limited associations. Only 2 eligible studies were found that directly addressed the public reporting of stroke quality metrics.

Conclusions—Some studies have found positive associations between stroke metric compliance and improved patient-centered outcomes. However, high-quality studies are lacking and several methodological difficulties make the interpretation of the reported associations challenging. Information on the impact of public reporting of stroke quality metric data is extremely limited. Legitimate questions remain as to whether public reporting of stroke metrics is accurate, effective, or has the potential for unintended consequences. The generation of high-quality data examining quality metrics and stroke outcomes as well as the impact of public reporting should be given priority. (Stroke. 2012;43:00-00.)

Key Words: acute stroke outcomes public reporting quality metrics
patient-centered outcomes remains to be proven for stroke. Second, although public reporting of performance data from health care providers resonates with many, several concerns remain, including the validity of the measures reported, whether public reporting directly improves quality of care,8 or whether it leads to inaccurate characterizations of hospitals and providers.9,10

The objectives of this article are to conduct systematic reviews of observational studies examining the relationship between stroke quality metrics and patient-centered outcomes and public reporting of stroke quality metrics and QI activity, quality of care, or patient-centered outcomes.

Materials and Methods

Studies included in the systematic review of stroke quality metrics and patient outcomes were limited to observational studies that evaluated the relationship between compliance with ≥2 quality metrics and patient-centered outcomes in a broad population of acute stroke admissions. Additional criteria excluded studies that were conducted in a single hospital setting or that were limited to specific subpopulations of age, race, sex, or stroke subtype. Eligible quality metrics were not limited to those advocated by any specific accrediting body, government institution, or nonprofit corporation. Patient-centered outcomes included measures of mortality, disability, physical function, complications, quality of life, and patient satisfaction.11 The literature search was conducted using MEDLINE and EMBASE and included studies published before December 31, 2010. We conducted several searches by first combining the term “stroke” with the following key words or phrases: “quality of care,” “performance measure,” “quality improvement,” “quality metric,” “quality measure,” and “process of care.” These searches were then combined with the following outcomes-related terms: “outcome,” “complications,” “mortality,” and “patient satisfaction.” We supplemented the search by screening the bibliographies of the articles that underwent full review. The search was limited to articles with an English language abstract.

For the relevancy screen, 2 authors (CP, MR) independently reviewed each title and abstract. Articles identified as potentially relevant by either reviewer underwent a full independent review to determine if the article met inclusion criteria. Final determination of study eligibility was performed by consensus. We excluded studies that evaluated the efficacy of stroke units because an extensive evidence base including meta-analyses of randomized and nonrandomized studies already exists.12,13 Similarly, we excluded studies that examined the impact of stroke center certification14 if they did not directly evaluate individual stroke metrics. Because of heterogeneity of the studies, we were unable to assess study quality.

A similar approach was used to identify studies that addressed the public reporting of stroke quality metrics and the relationship to QI activity, quality of care, or patient-centered outcomes. Adapting terms used in a previous systematic review,15 we conducted several searches by combining the term “stroke” with the following key words or phrases: “public report,” “public reporting,” “provider profile,” “report card,” “public information,” “consumer information,” “patient information,” “consumer report,” “public performance report,” and “public performance.” We also supplemented the search by screening the bibliographies of the articles that underwent full review.

Results

Systematic Review of Relationship Between Stroke Quality Metric Compliance and Patient-Centered Outcomes

Figure 1 displays the results of the literature search that identified 352 unique articles. After reviewing titles and abstracts for relevancy, 27 studies underwent full review and 14 were deemed eligible. The 14 studies’ characteristics and major conclusions are summarized in the Table. Eligible studies incorporated a wide variety of study populations, quality metrics, and patient-centered outcomes. Of the 14 studies, 6 were undertaken in the United States,16–21 2 were performed in Denmark,22,23 and 1 each was performed in England,24 Holland,25 New Zealand,26 Italy,27 Scotland,28 and Taiwan.29 Of the 6 U.S. studies, 4 utilized the Veteran’s Health Administration system,16,18–20 1 used national Medicare data,21 and the other used academic medical centers.17 Whereas the majority involved relatively small patient populations selected from a limited number of acute care hospitals, 5 studies (2 from the United States,17,21 2 from Denmark,22–23 and 1 from Taiwan29) involved >10 000 patients each.

Although all studies included process measures, measures varied in number and substance. Six of the 14 studies examined ≥12 measures,16–17,22–24,29 with the remaining studies using between 17 and almost 100 measures.18–21,25–28 Only 3 studies included structural measures.17,19–20 Most of the studies selected measures based on published guidelines, accreditation needs, or other QI efforts, including the Royal College of Physicians Stroke Audit Package,26,28 Agency for Health Care Policy and Research Clinical Guidelines,18–19

Figure 1. Summary of search results for systematic review of studies examining the relationship between stroke quality metrics and patient-centered outcomes.
### Table. Characteristics of Observational Studies That Have Examined Associations Between Stroke Quality Metrics (Structure/Process Measures) and Stroke Outcome Measures

<table>
<thead>
<tr>
<th>Author (Y)</th>
<th>Location</th>
<th>Study Population</th>
<th>N</th>
<th>Structure/Process Measures</th>
<th>Outcome Measures</th>
<th>Conclusions</th>
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<td>Mostly positive relationships</td>
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<tr>
<td>Ingeman (2011)22</td>
<td>Denmark</td>
<td>Stroke unit admissions from 10 hospitals in 2 counties (Danish National Indicator Project 2003–2008)</td>
<td>11 757</td>
<td>9 processes of acute stroke care</td>
<td>7 medical complications</td>
<td>After risk adjustment, study found a significant inverse dose–response relationship between the number of processes of care received and the risk of 5 medical complications; 6 of the 9 processes were associated with a lower risk for &gt;1 complication (OR range, 0.43–0.97), although not all were statistically significant.</td>
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<tr>
<td>Hsieh (2010)29</td>
<td>Taiwan</td>
<td>Patients in 39 academic and community hospitals across Taiwan</td>
<td>30 599</td>
<td>5 Get With The Guidelines-Stroke performance measures and 1 safety indicator</td>
<td>mRS and risk of cardiovascular events/death at 1, 3, and 6 mo after stroke</td>
<td>After risk adjustment, mRS scores at 1, 3, and 6 mo were better for those who received IV tPA (adjusted OR range, 0.47–0.52; P&lt;0.0012); risk of cardiovascular events/death at 1, 3, and 6 mo was lower for antithrombotics at discharge (adjusted OR=0.19, 0.33, and 0.41, respectively; P&lt;0.0001), and anticoagulation at discharge (OR=0.28, 0.51, and 0.59, respectively; P=0.0005), but not statins at discharge (P&gt;0.20).</td>
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<tr>
<td>Bravata (2010)16</td>
<td>United States</td>
<td>Patients in 3 U.S. Department of VA Hospitals and 2 non-VA Hospitals</td>
<td>1487</td>
<td>7 process measures of acute stroke care identified by a national expert stroke panel</td>
<td>Combination of in-hospital mortality, discharge to hospice, discharge to a SNF</td>
<td>After risk adjustment, the study found swallowing evaluation (OR, 0.64; 95% CI, 0.43–0.94), DVT prophylaxis (OR, 0.60; 95% CI, 0.37–0.98), and treatment of hypoxia (OR, 0.26; 95% CI, 0.09–0.73) were independently associated with improvements in the combined outcome measure.</td>
</tr>
<tr>
<td>Ingeman (2008)22</td>
<td>Denmark</td>
<td>Nationwide sample of admissions from 40 hospitals (Danish National Indicator Project 2003–2005)</td>
<td>29 573</td>
<td>7 process measures of acute stroke care identified by a national expert panel</td>
<td>30-d and 90-d mortality</td>
<td>After adjustment, 6 of 7 measures were associated with significantly lower 30-d and 90-d mortality; strong dose–response relationship between the number of care processes received and lower mortality was identified.</td>
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<tr>
<td>Micieli (2002)27</td>
<td>Italy</td>
<td>4 acute care hospitals</td>
<td>386</td>
<td>47 process measures derived from AHA clinical guidelines for acute stroke care</td>
<td>Mortality, stroke recurrence, and BI at D/C, 3-mo and 6-mo</td>
<td>Greater noncompliance with processes of care was associated with higher mortality (RR, 3.0; 95% CI, 1.75–5.23; for subjects with ≥5 missed guideline recommendations compared to &lt;5 missed recommendations); higher noncompliance was also associated with less improvement in disability (BI discharge (P=0.04), but had no relationship at 3 or 6 mo.</td>
</tr>
<tr>
<td>Kahn (1990)21</td>
<td>United States</td>
<td>National sample of Medicare patients (297 hospitals)</td>
<td>14 012</td>
<td>90 process measures based on expert opinion of stroke care</td>
<td>30-d mortality</td>
<td>After adjustment for sickness at admission, better care was associated with lower 30-d mortality; RR of mortality was 1.36 (P&lt;0.01) for stroke patients in lowest quartile of care vs highest quartile; significant relationships between poorer care and higher mortality seen in 3 of 4 process subscales.</td>
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<tr>
<td>Mostly limited or no relationships</td>
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<tr>
<td>Lingsma (2008)23</td>
<td>Holland</td>
<td>Patients in 10 centers in the Netherlands</td>
<td>579</td>
<td>17 process measures that cover acute stroke care and prevention measures</td>
<td>Death or disability (score ≥3 mRS at 1 y)</td>
<td>After adjustment, the majority of variation in outcome measure was explained by patient characteristics at admission; only a small proportion was attributed to differences in quality of care.</td>
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<tr>
<td>Douglas (2005)17</td>
<td>United States</td>
<td>Patients in 34 academic medical centers</td>
<td>16 853</td>
<td>11 structural measures used to designate primary stroke centers</td>
<td>In-hospital mortality, discharge home</td>
<td>After adjustment, none of the 11 structural measures was associated with decreased in-hospital mortality or increased discharge home.</td>
</tr>
<tr>
<td>Mohammed (2005)24</td>
<td>England</td>
<td>Patients in 8 acute care hospitals selected with either high or low 30-d mortality</td>
<td>702</td>
<td>12 process measures selected from Intercollegiate Stroke Audit Package (ISAP)</td>
<td>30-d mortality</td>
<td>After removing 1 outlier hospital, there was no association between mortality and quality of care; the only significant difference in care between hospitals with low vs high mortality was screening for dysphagia (58% of patients in low-mortality hospitals vs 41% in high-mortality hospitals; P=0.0057); case-mix adjustment could not be performed because of missing data.</td>
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(Continued)
American Hospital Association clinical guidelines, the Intercollegiate Stroke Audit Package, and Brain Attack Coalition’s organized stroke care guidelines.

All but 4 of the studies included mortality as an outcome measure, although the time frame varied from in-hospital mortality to 1, 3, 6, or 12 months postdischarge. Six studies included ≥1 measures of functional capacity, including Functional Independence Measure, Short Form-36, modified Rankin Scale, Instrumental Activities of Daily Living, Stroke Impact Scale, and Barthel Index. Other outcome measures included medical complications, stroke recurrence, and patient satisfaction.

Given the variation in study characteristics, quality measures, and outcomes used, it was not possible to generate summary estimates describing the relationship between quality metric compliance and patient-centered outcomes. Six studies found mostly positive relationships between increased compliance with stroke care quality metrics and improved patient-centered outcomes. However, 5 studies reported mostly limited or no significant relationships between quality metrics and outcomes.

Table. Continued

<table>
<thead>
<tr>
<th>Author (Y) Location Study Population N</th>
<th>Structure/Process Measures</th>
<th>Outcome Measures</th>
<th>Conclusions</th>
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<tbody>
<tr>
<td>McNaughton (2003) New Zealand 3 acute care hospitals 181</td>
<td>60 process measures from RCPSAP plus 4 additional measures</td>
<td>FIM, mRS, SF-36 and mortality at discharge, and 1-y mortality</td>
<td>After case-mix adjustment, there were only weak relationships between RCPSAP process measures and discharge outcomes and no significant relationships by 12 mo</td>
</tr>
<tr>
<td>Weir (2001) Scotland 5 acute care hospitals 2724</td>
<td>60 process measures from RCPSAP, plus 5 measures of organized stroke care</td>
<td>6-mo mortality</td>
<td>After adjustment for case-mix, variation in hospital mortality was reduced, although an outlier hospital was still identifiable; moderate differences in process measures among the remaining 4 hospitals were not related to differences in adjusted mortality</td>
</tr>
<tr>
<td>Duncan (2002) United States 11 U.S. Department of VA hospitals 286</td>
<td>19 AHCPR process measures assessing acute (n=8) and postacute (n=11) rehabilitation care</td>
<td>6-mo FIM, SF-36 PFM, IADL, SIS</td>
<td>After adjustment, postacute care measures but not acute measures were associated with improved FIM, IADL, and SIS outcomes at 6 mo</td>
</tr>
<tr>
<td>Hoenig (2002) United States 11 U.S. Department of VA hospitals 128</td>
<td>10 structural measures organized into 3 domains and 11 AHCPR postacute rehabilitation process measures</td>
<td>6-mo FIM</td>
<td>After adjustment, the structural measures were significantly and positively associated with process measures (P&lt;0.01), but not 6-mo FIM; after adjustment, process of care measures were significantly and positively associated with improved 6-mo FIM (P&lt;0.05)</td>
</tr>
<tr>
<td>Reker (2002) United States 11 U.S. Department of VA hospitals 286</td>
<td>3 structural measures and 20 acute (n=9) and postacute (n=11) AHRQ guideline dimensions</td>
<td>Patient satisfaction score at 6-mo</td>
<td>After adjustment, postacute care measures but not acute measures were associated with improved patient satisfaction at 6 mo</td>
</tr>
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</table>

AHA indicates American Heart Association; AHCPR, Agency for Health Care Policy and Research; BI, Barthel Index; CI, confidence interval; D/C, discharge; DVT, deep venous thrombosis; FIM, functional independence measure; IADL, instrumental activities of daily living; ISAP, Intercollegiate Stroke Audit Package; IV, intravenous; mRS, Modified Rankin Scale; OR, odds ratio; RCPSAP, Royal College of Physicians Stroke Audit Package; RR, relative risk; SF-36 PFM, Medical Outcomes Study Short Form (SF-36) physical function module; SIS, stroke impact scale; SNF, skilled nursing facility; tPA, tissue plasminogen activator; VA, Veterans Affairs.

Systematic Review of Relationship Between Public Reporting of Stroke Metrics and QI Activity, Quality of Care, and Patient-Centered Outcomes

Results of the literature search identified 70 unique articles, 4 of which passed the relevancy screen and underwent full review, and 2 were ultimately deemed eligible (Figure 2). In the first study, Kelly et al compared rankings of 157 New York state hospitals generated by 2 different organizations. Using risk-adjusted models, the 2 organizations classified hospitals as below average, average, or above average with.
respects to in-hospital stroke mortality. However, only 61% (n=96) of hospitals were classified as having the same level of in-hospital mortality by the 2 organizations. The authors concluded that these data illustrate the difficulties associated with the reliability of publically reported data on quality of stroke care, and suggested that a national standard for public reporting be developed that included explicit rules to reduce bias and ensure minimum standards.30

In the second study, Hollenbeak et al31 conducted an analysis of Pennsylvania hospitals to examine the impact of variations in the intensity of public reporting in the state on in-hospital mortality for 6 acute conditions, including hemorrhagic and ischemic stroke. Using propensity score methods, they found that stroke patients treated at Pennsylvania hospitals during a period of intensive public reporting (from 2000–2003) had a significantly lower mortality (odds ratio, 0.57 for hemorrhagic stroke; odds ratio, 0.77 for ischemic stroke) than patients treated at non-Pennsylvania hospitals with limited or no public reporting requirements during the same time period. A caveat, however, was that all 200 Pennsylvania hospitals were required to submit data, whereas the reporting for non-Pennsylvania hospitals was voluntary and based on only 34 centers.

Discussion

Our systematic review confirmed that most stroke quality metrics primarily document process-centered aspects of acute hospital-based stroke care, and that most were founded on evidence-based guidelines or accreditation needs. However, we found that there is a limited evidence base addressing the relationships between quality metric compliance and stroke-related outcomes. Of the 14 studies included in this review, 9 reported mostly positive associations between stroke quality metric compliance and stroke outcomes. Although we found only a relatively modest evidence base supporting the relationship between stroke quality metric compliance and improved patient outcomes, it could be argued that this evidence base is stronger than that present in the literature for other cardiovascular diseases (ie, acute myocardial infarction and heart failure), in which the number of significant associations indicating a positive relationship between higher quality of care and better patient outcomes is surprisingly limited.32–35

In addition to the limited number of studies identified, the authors of these studies have cautioned against over-interpreting their results because of the fundamental methodological challenges associated with determining causal relationships between stroke metrics and patient outcomes.36 There are at least 5 distinct methodological challenges associated with determining these causal associations. First, statistical risk adjustment methods for stroke outcomes are not sufficiently developed to satisfactorily account for differences in patient populations (eg, age, stroke severity, comorbidities) across health care providers and settings.28,37,38 Unfortunately, there is wide variability in the number and scope of patient-level variables included in risk adjustment models and the statistical methods used to develop and validate them. In addition, many organizations generating data for public reporting use proprietary and undisclosed methods, highlighting the need for greater oversight and transparency.39 Second, analyses of facility-level data are often hampered by small sample sizes, both in the number of subjects who are eligible for a given metric, as well as the number of subjects experiencing a given outcome, eg, mortality or complications. The resulting imprecision translates to findings that vary substantially across sites or over time because of random error alone.

Third, confounding by indication, which describes the phenomenon whereby medical treatment is directly influenced by the patient’s prognosis,40 is a fundamental limitation of observational studies examining the association between quality metrics and patient outcomes. Confounding by indication can result in paradoxical associations between quality of care and outcomes. For example, patients with severe stroke have inherently poor prognosis but may be treated more aggressively and therefore may receive higher-quality care. Similarly, better care may be delivered to patients who have a higher burden of risk factors or comorbidities,41 whereas, conversely, patients with mild disease or few comorbidities are not treated as aggressively. The net impact of these different confounding mechanisms may be impossible to discern.

A fourth challenge is determining the relevant time window for measuring outcomes relative to when care was provided. Outcomes measured soon after the provision of care (ie, ambulatory status at discharge) are unlikely to accurately reflect the quality or effectiveness of the care provided. Equally, outcomes measured many months after care was provided are unlikely to be a valid reflection of the care provided. The American Hospital Association/American College of Cardiology task force on perfor-
mance measures has recommended that stroke outcomes be measured 1 month after hospital discharge. Finally, although in-hospital mortality is readily measured, it is not a good reflection of the quality of care provided. In-hospital mortality varies according to length of stay, is impacted by hospital policies related to hospice use, and may be influenced by patient/family preferences. Patients with care directives that limit the aggressiveness of medical care after a disabling stroke who receive compassion- ate or hospice care resulting in death are treated in many mortality models as having experienced a poor or adverse outcome rather than high-quality care. Given these limitations, there is a critical need to expand stroke mortality measures to include longer time periods (ie, 30 days, 90 days, and 1 year) and to incorporate other patient-centered outcomes, such as care preferences, functional outcomes, and quality of life.

We found only 2 studies that directly addressed the relationship between public reporting of stroke quality metrics and either QI activity, quality of care, or patient-oriented stroke outcomes. Several other reports have been motivated by the concerns raised about public reporting of stroke metrics, but these did not meet our inclusion criteria for the review. Public reporting of performance data has been a primary objective of many consumer advocates, insurance industry, and government agencies, including the Centers for Medicare and Medicaid Services. The central premise is that public reporting will lead to higher quality of care because providers will undertake efforts to improve care and consumers will choose plans or hospitals that provide better care. Solid evidence is still lacking.

Outside of stroke research, results of studies examining the effects of public reporting on quality or patient outcomes have been quite variable. There have been at least 2 systematic reviews; in 2000, Marshall et al conducted a review of the impact of public disclosure of performance data but could only find 7 United States-based peer-reviewed studies. They concluded that hospitals were most responsive to the publication of performance data, but found limited evidence that this was associated with improved health outcomes. In 2008, a systematic review of 11 studies also found that public reporting stimulated QI activity in hospitals but did not affect hospital selection by patients. The authors found mixed evidence for an association between public reporting and better patient outcomes, but commented that the included studies were mostly descriptive in nature and had limited strength of evidence. In more recent studies, a follow-up analysis of the Hospital Compare program, a public reporting initiative by the Centers for Medicare and Medicaid Services, found that public reporting was associated with increased performance, especially in hospitals that were low performers at baseline. This increased performance was shown to positively affect by reducing mortality, length of stay, and readmission rates for acute myocardial infarction patients. A recent randomized study of 86 Ontario hospitals evaluated the effect of public reporting on quality of care provided to acute myocardial infarction and heart failure patients. Public report cards documenting baseline care performance were either released early for 44 randomly selected hospitals or delayed (by 18 months) for 42 remaining hospitals. Hospitals randomized to early data release were significantly more likely to start QI initiatives compared to hospitals receiving delayed feedback (73.2% versus 46.7% and \( P=0.003 \) for acute myocardial infarction care; 61.0% versus 50.0% and \( P=0.04 \) for heart failure care); however, they did not show any significant improvements in composite process-of-care measures.

Whether mandatory public reporting of stroke quality metric data at the hospital or physician level will induce greater or more widespread quality gains compared to what has already been achieved through the current voluntary, confidential reporting approach remains to be determined. It is noteworthy that, as evidenced by the widespread participation in national-level stroke QI registries, there is currently widespread tacit support for using quality metrics for QI purposes that does not rely on public reporting.

Our report has several potential limitations. First, because we excluded research specific to evaluation of stroke units or hospital stroke center certification, our conclusions do not generalize to these 2 areas. Second, it is likely that our search strategies missed relevant articles, and that our exclusion criteria may have prevented consideration of all pertinent reports. Third, the limited number of peer-reviewed reports on public reporting of stroke metrics likely reflects the impact of publication bias in that relevant research conducted on this topic has, for whatever reason, failed to become peer-reviewed literature. Fourth, heterogeneity of study designs precluded any formal quality scoring assessment efforts or the generation of quantitative summary estimates of effect. Finally, we note that some articles included in our review were based on the same underlying data source (ie, the Veteran’s Health Administration and the Danish Indicator Project). Although some of these data may represent duplicate cases, each study met our inclusion criteria because it reported on different outcome measures.

In summary, although much work has been performed regarding validating individual stroke quality metrics and increasing data reliability, there remain challenging methodological difficulties—including inadequate risk adjustment, small sample sizes, confounding by indication, appropriate time window, and use of in-hospital mortality—to proving a causal relationship between quality metrics and stroke outcomes. Because of the fundamental problems in measuring and interpreting outcome-based measures from observational studies, several authors have cautioned against using outcome measures to gauge quality of care, advocating instead that process measures should remain the primary method of comparing quality across hospitals and providers. The challenges identified in this review should be addressed before quality metrics are incorporated widely into programmatic and regulatory policies, particularly those associated with provider reimbursement and institutional accreditation. There is great need for the generation of valid evidence demonstrating the relationship between stroke quality metric compliance and patient-centered outcomes, as well as the public reporting of these metrics, so that the current consid-
Disclosures

L.H.S. serves as chair of the American Heart Association (AHA) Get With The Guidelines (GWTG) Steering Committee, is a consultant to the Massachusetts Department of Public Health, and provided expert medical opinions in malpractice lawsuits regarding stroke treatment and prevention. G.C.F. is a member of the AHA GWTG Steering Committee, is a consultant to Novartis, and receives research support from the National Institutes of Health and the Agency of Healthcare Research and Quality. E.E.S. serves as chair of the AHA GWTG-Stroke Science Subcommittee and reports research funding from the National Institutes of Health, Canadian Institutes for Health Research, Canadian Stroke Network, and Heart and Stroke Foundation of Canada. M.J.R. serves as a member of the AHA GWTG Quality Improvement and Stroke Science Subcommittees and receives salary support from the Michigan Paul Coverdell Stroke Registry.

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