Are Quality Improvements in the Get With The Guidelines-Stroke Program Related to Better Care or Better Data Documentation?

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Background—Increased compliance with performance measures could reflect better care or better data documentation. We examined trends in the documentation of eligibility criteria, treatment contraindications, and missing data in the Get With The Guidelines-Stroke program to quantify their contribution to increased performance measure compliance.

Methods and Results—Data on 569,883 ischemic stroke admissions to 1028 GWTG-Stroke hospitals between April 2003 and September 2009 were obtained. Seven measures were examined: intravenous recombinant tissue plasminogen activator therapy, early antithrombotics, deep vein thrombosis prophylaxis, anticoagulants for atrial fibrillation/flutter, discharge antithrombotics, lipid therapy, and smoking cessation. Within each target population, the proportion of subjects treated, not treated, not treated because of contraindications, or with missing data were generated by calendar year. There were minimal changes in the size of the target populations for 6 of the measures; however, the size of the deep vein thrombosis prophylaxis population was reduced ~5% in 2008 because of a format change to the data collection form. All measures showed significant increases in the proportion of eligible subjects treated across the study period. These increases occurred without major shifts in contraindications or missing data, with the exception of anticoagulation for atrial fibrillation/flutter where the increase occurred in conjunction with a decline in contraindications. Similar findings were seen when the data were examined by the duration of hospital participation in the program.

Conclusions—These findings suggest that the majority of performance improvement in the Get With The Guidelines-Stroke program represent an increase in the number of patients with stroke treated and not changes to the underlying target populations or documentation of contraindications or missing data. (Circ Cardiovasc Qual Outcomes. 2011;4:00-00.)

Key Words: registries ■ quality of health care ■ stroke ■ therapy ■ data quality ■ quality improvement

Prior Get With The Guidelines (GWTG)-Stroke reports have shown large and rapid increases in compliance with stroke performance measures over time.1,2 However, the degree to which these changes reflect actual improvements in patient care has not been determined. Performance measures quantify the quality of medical care by determining the proportion of eligible subjects who receive a specific treatment or care intervention.3,4 An increase in performance measure compliance is assumed to be an indicator of better patient care; however, increased compliance could potentially be a result of changes in data documentation and abstraction. For example, improvements in data collection processes can affect performance measures by reducing the amount of missing data. Changes in data collection also can affect the size and accuracy of the population deemed eligible for a particular intervention through better documentation of eligibility criteria and treatment contraindications. As has been pointed out previously,5 one way of improving performance in a registry is for hospitals to reduce the number of reported eligible subjects (ie, decreasing the size of the measure denominator) rather than to provide more necessary care (ie, increasing the size of the measure numerator). Although the goal of the GWTG-Stroke program is to improve the quality of stroke care (defined as an increase in the appropriate treatment of eligible subjects), participation in the program may directly affect the quality of data collection because the program uses specific data abstraction instructions in conjunction with a structured online database to promote the collection of valid and reliable data.

Given the rapid and substantial increases in the quality of stroke care reported by the GWTG-Stroke program, it is important to determine the relative contribution of better care
versus better data documentation to these trends. The objectives of this study, therefore, were to understand the relative contributions of data documentation trends to performance measure compliance among ischemic stroke cases entered in the GWTG-Stroke program between 2003 and 2009. Specifically, the objectives were to assess the changes in the proportions of ischemic strokes that (1) were deemed eligible for each stroke performance measure, (2) had documented contraindications or other exceptions to treatment for each performance measure, and (3) had missing data necessary to construct each performance measure.

**WHAT IS KNOWN**

- Quality improvement registry programs like GWTG often show increases in performance measure compliance over time, which is assumed to be an indicator of better patient care.
- Increases in compliance could be a result of changes in data documentation, leading to reductions in the amount of missing data and better documentation of eligibility criteria and treatment contraindications.
- Hospitals could improve performance by reducing the number of reported eligible subjects (ie, decreasing the measure denominator) rather than by improving care (ie, increasing the measure numerator).

**WHAT THE STUDY ADDS**

- This analysis found that increases in stroke performance measures in the GWTG-Stroke program were associated with an increase in the proportion of eligible subjects treated (ie, increases in the measure numerator) and not changes in the documentation of missing data or contraindications.
- These findings suggest that the majority of the quality gains in the GWTG-Stroke program reflect an increase in the number of eligible patients with ischemic stroke being treated rather than changes to the underlying target population or in the documentation of contraindications or missing data.

**Methods**

The GWTG-Stroke program is a voluntary national quality improvement program sponsored by the American Heart Association/American Stroke Association that was launched nationally in April 2003. Details of the design and conduct of the GWTG-Stroke program, including case ascertainment methods, have been described previously. The current analysis was limited to 569,883 acute ischemic stroke admissions that were treated at 1028 GWTG-Stroke hospitals between April 2003 and September 2009. Hospitals enrolled in the program throughout the 7-year period, with most (81%) joining before the end of 2006; the peak year of enrollment was 2005, when 255 (25%) hospitals entered the program.

**Training, Chart Abstraction, and Data Entry**

Hospital personnel receive detailed online and telephone-based training on chart abstraction and data entry from Outcome Sciences (Cambridge, MA), which serves as the data collection vendor and coordination center for GWTG. The GWTG-Stroke database includes extensive data definitions and detailed instructions on chart abstraction and data entry. Deidentified patient data are entered into the GWTG-Stroke database using an Internet-based patient management tool (PMT). Data included demographics, medical history, diagnosis and evaluation, initial brain imaging findings, intravenous recombinant tissue plasminogen activator (IV-rtPA) therapy, in-hospital treatments, interventions and complications, contraindications to treatment, discharge treatment and counseling, in-hospital mortality, and discharge destination. The PMT includes range checks and other predefined logic features to alert the user to potentially invalid data. Required fields are structured so that valid data must be entered before the case can be saved as a completed record in the database. All hospital personnel using the PMT receive individual passwords to create an audit trail for data entry and editing. Participating sites also receive individual data quality reports to promote data completeness and accuracy. The Duke Clinical Research Institute serves as the data analysis center and has Institutional Review Board approval to analyze the aggregated deidentified data for research purposes.

**Definition of Target Populations for Performance Measures**

By applying the appropriate inclusion criteria for each measure, we first identified the subgroups of acute ischemic stroke cases that were broadly eligible for each of 7 GWTG-Stroke performance measures of interest. These populations are hereafter referred to as the target populations and represent the broad population eligible for each measure before the application of exclusions because of contraindications or missing values in the treatment variables. Detailed definitions of the target populations for the 7 measures are shown in Table 1 and include (1) IV-rtPA 2 hours (among those who arrived ≤2 hours of symptom onset), (2) early antithrombotics (within 48 hours of admission and not comfort measures only [CMO]), (3) deep vein thrombosis (DVT) prophylaxis (within 48 hours of admission among those who were nonambulatory and not CMO), (4) discharge anticoagulants for atrial fibrillation/flutter (AF) (among those with documented AF with regular hospital discharge and not CMO), (5) discharge antithrombotics (among those with regular hospital discharge and not CMO), (6) discharge lipid therapy (among those with specific indications, regular hospital discharge, and not CMO), and (7) discharge smoking cessation counseling (among current smokers with regular hospital discharge and not CMO).

Patients who were identified as CMO on hospital day 2 were excluded from DVT prophylaxis and early antithrombotics measures, whereas those who were identified as CMO at hospital discharge were excluded from the discharge-related measures (ie, anticoagulants, antithrombotics, lipid therapy, smoking cessation). Measures were also limited to patients who had a regular hospital discharge, meaning that those who died in the hospital, had been discharged to hospice or another short-term general hospital, left against medical advice, or had a missing discharge destination were excluded. Detailed operational definitions for the target populations are available in online-only Data Supplement Table 1.

**Definitions of Treated, Nontreated, Contraindications, and Missing Data Among the Target Populations**

To identify patients who should with certainty receive a particular treatment or intervention, the GWTG-Stroke program excludes from the target populations cases with contraindications to treatment or those with missing information on treatment-related variables. In the PMT, the presence of a contraindication that justified nontreatment was recorded using a checkbox (referred to as NC for none contraindicated). For 4 measures (IV-rtPA, early antithrombotics, discharge anticoagulants, discharge antithrombotics), the specific contraindications that justified nontreatment also were recorded either as a write-in text field or as a checkbox (eg, risk of adverse reaction, allergy, patient/family refusal, terminal illness). Patients with contraindications to DVT prophylaxis, lipid therapy, or smoking cessation also were identified using the NC checkbox, but the specific type of contraindication was not recorded. Patients who had
Table 1. Detailed Definitions of Target Populations, Contraindications, and Treated Patients for the 7 Performance Measures Relevant to Patients With Acute Ischemic Stroke

<table>
<thead>
<tr>
<th>Measure</th>
<th>Target Population*</th>
<th>Contraindications</th>
<th>Treated Patients (Numerator)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV-rtPA 2 h†</td>
<td>Patients with ischemic stroke presenting within 2 h of symptom onset (or last known well time).</td>
<td>Specific contraindications or warnings to rtPA recorded as a reason treatment was not given.</td>
<td>IV-rtPA given within 3 h of symptom onset.</td>
</tr>
<tr>
<td>Early antithrombotics</td>
<td>All patients with ischemic stroke at the end of hospital day 2. Patients who were CMO by the end of hospital day 2 were excluded. Those treated with IV-rtPA also were excluded.</td>
<td>Contraindications to antithrombotics noted as a reason treatment was not given.</td>
<td>Antithrombotic therapy, including antiplatelet or anticoagulant therapy but not DVT prophylactic doses of subcutaneous heparins.</td>
</tr>
<tr>
<td>DVT prophylaxis</td>
<td>All patients with ischemic stroke who were nonambulatory by the end of hospital day 2. Patients who were CMO by end of the hospital day 2 were excluded.</td>
<td>Contraindications to DVT prophylaxis noted as a reason treatment was not given (option added to PMT in 2007).</td>
<td>DVT prophylaxis, including warfarin, heparinoids, other anticoagulants or pneumatic compression devices, provided by the end of hospital day 2.</td>
</tr>
<tr>
<td>Discharge antithrombotics</td>
<td>All patients with ischemic stroke who had a regular hospital discharge.‡ Patients who were CMO at discharge were excluded.</td>
<td>Specific contraindications to antithrombotics recorded as a reason treatment was not given.</td>
<td>Antithrombotic therapy, including antiplatelet or anticoagulant therapy, prescribed at discharge.</td>
</tr>
<tr>
<td>Anticoagulation for AF</td>
<td>All patients with ischemic stroke with a history of AF or AF present during hospitalization who had a regular hospital discharge.‡ Patients who were CMO at discharge were excluded.</td>
<td>Specific contraindications to anticoagulants recorded as a reason treatment was not given.</td>
<td>Anticoagulant therapy, including therapeutic doses of warfarin, heparinoids, or other anticoagulants, prescribed at discharge.</td>
</tr>
<tr>
<td>Discharge on lipid therapy</td>
<td>All patients with ischemic stroke who had an LDL &gt;100 mg/dL, were taking lipid-lowering agents on admission, or had lipid testing not documented and who had a regular hospital discharge.‡ Patients who were CMO at discharge were excluded.</td>
<td>Contraindications to lipid therapy noted as a reason treatment was not given.</td>
<td>Lipid-lowering agents, including statins, fibrates, niacin, or other medications, prescribed at discharge.</td>
</tr>
<tr>
<td>Smoking cessation</td>
<td>Current smoker (cigarette use reported within the past year) who had a regular hospital discharge.‡ Patients who were CMO at discharge were excluded.</td>
<td>No contraindications.</td>
<td>Smoking cessation intervention (appropriate medication, counseling, or both) provided at discharge.</td>
</tr>
</tbody>
</table>

AF indicates atrial fibrillation/flutter; CMO, comfort measures only; DVT, deep vein thrombosis; IV-rtPA, intravenous recombinant tissue plasminogen activator; LDL, low-density lipoprotein; PMT, patient management tool.

*Inclusion criteria applied to define the broad target population for each measure of care before any other exclusion due to contraindications or missing values in the treatment variables.

†Acute rtPA measure also excluded patients with missing or erroneous onset, arrival, or treatment times, who began rtPA at an outside hospital; or who started rtPA after 180 min from onset.

‡Regular discharge excluded patients who died in the hospital, were discharged to hospice or another short-term general hospital, or left against medical advice.

Data missing on the relevant treatment-related variables also were excluded from the measure denominator because it was impossible to determine their treatment status. Table 1 includes a summary of the contraindications for each measure as well as a summary of the interventions that define the numerator of each measure (ie, treatment was received). More detailed descriptions of these definitions are provided in online-only Data Supplement Table 1.

After applying the definitions for contraindications and missing data to the target populations, we were then able to identify the number of eligible subjects who either received or did not receive treatment. Each target population, therefore, was divided into the following 4 mutually exclusive groups: (1) the proportion of eligible subjects who received treatment, (2) the proportion of eligible subjects who did not receive treatment, (3) the proportion of subjects with documented contraindications, and (4) the proportion of subjects with missing data on treatment-related variables.

**Statistical Analyses**

Changes in the relative size (ie, proportion) of the target populations for the 7 performance measures were first examined across all years (2003 to 2009). The statistical significance (P<0.05) of time trends by year were quantified by treating calendar year as an ordinal variable; specifically, for categorical variables, P values were generated by Cochran-Mantel-Haenszel row-mean scores statistics, whereas for continuous data, P values were generated using Cochran-Mantel-Haenszel 1-degree of freedom rank correlation (nonparametric) tests. Changes in the relative proportions of the 4 mutually exclusive groups (ie, treated, not treated, contraindications, missing data) also were examined across all years (2003 to 2009).

Given that the duration of participation in the GWTG-Stroke program varied depending on when hospitals first joined, we repeated these analyses by the number of years of program participation (ie, baseline, 1, 2, 3, 4, or ≥5 years, where baseline refers to data from 30 cases collected just before joining the program). We also examined hospital characteristics (ie, teaching status, number of beds, annual ischemic stroke caseload) by the calendar year that the hospitals joined the program. For those characteristics that changed over time, we examined the influence of these characteristics on differences in treatment patterns. All statistical analyses were performed using SAS version 9.1 (SAS Institute Inc; Cary, NC) software.

**Results**

The median age of the 569 883 patients with acute ischemic stroke was 73 years, 52.4% were women, 26.6% were nonwhite, 29% had a history of coronary heart disease or myocardial infarction, 4.7% had a history of stroke, and 20% were current smokers. Medical history included 79% with hypertension, 39% with dyslipidemia, 32% with diabetes, 19% with AF, and 4.7% with carotid stenosis. Figure 1 illustrates the large and rapid increases in performance measure compliance among patients with acute ischemic stroke entered into the GWTG-Stroke program between 2003...
and 2009. These data represent the proportion of eligible subjects who received treatment, after cases with contraindications or missing data were excluded from the target populations, and are therefore equivalent to the compliance measures widely published in other GWTG reports.

Figure 2 shows the proportion of patients with acute ischemic stroke who met the broad inclusion criteria and were therefore included in the target populations for each of the 7 measures between 2003 and 2009. With the exception of IV-rtPA and smoking cessation, all other measures showed statistically significant (\(P < 0.01\)) differences across time. However, examination of the absolute changes revealed that there were no meaningful shifts in the proportion of ischemic stroke cases that were eligible for each of the measures over time, with the exception of DVT prophylaxis. Between 2007 and 2008, the proportion of patients included in the target population for DVT prophylaxis declined from 52.5% to 46.8% (Figure 2). This decline was associated with a change in the data collection tool, specifically, a format change to the 2008 form that decreased the number of patients who were identified as nonambulatory by day 2, which resulted in a smaller target population.

Data in Table 2 and Figure 3 show the overall proportions of the 4 mutually exclusive groups (ie, treated, not treated, contraindications, missing data) for all 7 measures. Virtually all measures showed statistically significant changes in the relative size of the 4 groups across the study years (\(P < 0.0001\)). We repeated these analyses to examine the trends in the proportion of patients treated, not treated, having contraindications, or having missing data by the duration of hospital participation in the program (ie, baseline, 1, 2, or 3, 4, or \(\geq 5\) years) (online-only Data Supplement Figure 1). Overall, the findings for the 7 performance measures were essentially the same as that seen when calendar year was used, so we focused on presenting the data by calendar year.

For IV-rtPA (Figure 3A) the proportion of eligible patients who received treatment doubled over the 7-year period from 2003 to 2009.
14.2% (2003) to 28.9% (2009), with a concomitant decline in the proportion of eligible patients who were not treated. There was relatively little change in the proportion of patients with documented contraindications or missing data (Table 2). These data patterns are consistent with improved care (ie, more eligible subjects treated). Both DVT prophylaxis and lipid therapy also showed a similar pattern of improved care as defined by an increasing proportion of eligible patients treated with minimal concurrent changes in contraindications or missing data. The data for DVT prophylaxis (Figure 3C) indicate a strong positive trend toward more eligible patients being treated between 2003 (69.4%) and 2009 (91.0%), with a concomitant decline in the proportion of eligible subjects who were not treated (Table 2). For lipid treatment (Figure 3F), the proportion of eligible patients who received treatment doubled from 39.9% in 2003 to 83.7% in 2009 (with a concomitant decline in the proportion of eligible patients not treated).

The 2 antithrombotic measures (early antithrombotics [Figure 3B] and antithrombotic therapy at discharge [Figure 3E]) both showed patterns consistent with the maintenance of high-quality care throughout the study period, with minimal changes in contraindications or missing data (Table 2). Discharge anticoagulants for patients with AF (Figure 3D)
also showed a pattern consistent with better quality of care, although the mechanism was different from that seen with IV-rtPA, DVT prophylaxis, or lipid therapy. In this measure, documentation of contraindications declined substantially over the 7 years from 58.4% in 2003 to 27.1% in 2009, whereas the proportion of eligible patients who were treated increased from 28.0% in 2003 to 69.1% in 2009. The proportion of subjects defined as eligible but not treated remained low across all years (ie, < 4%) (Table 2). To understand these changes further, we examined trends in the documentation of contraindications to the use of anticoagulants in the PMT. For anticoagulants, the PMT included an

Figure 3. Trends in the proportion of patients treated, not treated, with contraindications, or with missing data among the target populations for 7 performance measures by calendar year 2003 to 2009. A, IV-rtPA. B, Early antithrombosis. C, DVT prophylaxis. D, Anticoagulation for AF at discharge. E, Antithrombotic therapy at discharge. F, Lipid therapy at discharge. G, Antismoking treatment at discharge. Abbreviations as in Figure 1.
NC checkbox followed by a series of checkboxes to document the specific contraindication (ie, risk of bleeding, risk of falls, mental status, terminal illness, patient refused, allergy/complication, serious side effect). We found that there was a large decline in the number of patients for whom the NC checkbox was checked but where no specific contraindication was provided; among all patients in the target population, the proportion with an unspecified contraindication declined from 48.1% in 2003 to 4.9% in 2009. During this same period, there was a slight increase in the reporting of 3 specific contraindications: risk of bleeding (7.9% in 2003, 13.7% in 2009), risk of falls (3.2% in 2003, 8.7% in 2009), and patient refused (0.8% in 2003, 2.9% in 2009); however, these accounted for only a small amount of the decline in unspecified contraindications. Finally, for smoking cessation (Figure 3G), the proportion of current smokers who received intervention increased dramatically from 43.0% in 2003 to 94.5% in 2009 (Table 2). There were no contraindications specifically defined for smoking cessation and only minimal changes in missing data during this period.

Overall, participating GWTG-Stroke hospitals tend to be larger, academic centers; the median size was 292 beds (interquartile range, 185 to 426 beds), and 50% of hospitals were classified as academic. The characteristics of the hospitals by the calendar year that they joined the program are shown in Table 3. There was a significant trend toward smaller hospitals joining the program in the later years; for example, the median size was 322 beds in 2003 but declined to 264 beds for hospitals that joined in 2008, whereas the median annual ischemic stroke caseload was 119 for hospitals that joined in 2003 and only 46 for hospitals that joined in 2008. The changes also were reflected in a decline in the proportion of teaching hospitals that joined the program during the course of the program.

Examination of treatment patterns by hospital characteristics (teaching status, number of beds, stroke caseload) found that the proportion of patients who received IV-rtPA treatment was significantly higher in teaching hospitals compared than in nonteaching hospitals (25.8% versus 21.0%), as they were for DVT prophylaxis (89.8% versus 84.6%) and lipid therapy at discharge (74.6% versus 68.7%). These same treatment differences also were observed in larger hospitals and those with larger stroke caseloads. There were no meaningful differences in contraindications recorded or missing data by hospital characteristics.

### Discussion

The most important conclusion from this study is that the improvements in performance measure compliance in the GWTG-Stroke program appear to reflect an increase in the number of eligible patients who received guideline-based care rather than reflecting shifts in the size of the target populations or increased documentation of contraindications. Although the proportion of patients with ischemic stroke who met the broad eligibility criteria defined by the target populations varied widely for each measure (from ≈16% for IV-rtPA and smoking cessation to ≈86% for discharge antithrombotics), these proportions did not change to any important degree over time. Thus, we found little evidence that the performance improvements in the GWTG-Stroke program resulted from individual hospitals reducing the number of patients reported as being eligible for an intervention instead of providing more care to those that needed it, which has been identified as 1 mechanism by which registry hospitals could improve performance. Similarly, we found little evidence that performance improvements resulted from more patients being excluded because of increased documentation of contraindications. All 7 measures examined showed an increase in the proportion of eligible patients who received treatment, including 4 measures (IV-rtPA, anticoagulants at discharge, lipid therapy at discharge, and smoking cessation) where treatment rates more than doubled. For both antithrombotic measures, the data indicated that the high treatment rates observed at baseline in 2003 where maintained and even improved on during the course of the program.

The finding that the predominant mechanism for performance measure improvement appeared to be that more eligible patients were treated rather than excluded because of increased documentation of contraindications is consistent with other cardiovascular quality improvement programs.8 The results of the present study have important implications for other cardiovascular quality improvement programs that measure and track the quality of care through process-based performance measures. Our results strongly suggest that the
GWTG-Stroke quality improvement program increased the number of eligible patients who received guideline-based care during this period, which to the extent that these care processes are clinically effective should result in meaningful improvements in stroke outcomes.

The present findings also have relevance to other programs that have undertaken detailed evaluations of the validity of performance measure documentation, especially in the context of pay-for-performance programs. For example, a recent study of family practices in England examined the use of exception reporting in the context of the potential for “gaming” pay-for-performance programs. Exception reporting refers to the removal of patients from a quality measure who are deemed inappropriate because of contraindications or other reasons, such as patient refusal. This particular study found limited evidence that practices were inappropriately excluding patients through exception reporting. Other studies also have examined the accuracy or appropriateness of documented contraindications and exclusions. After expert review of medical records from a large midwestern internal medicine practice, it was found that the documentation of medical exceptions were mostly accurate and appropriate. In a Scottish study, exception reporting by general practitioners of patients with a history of stroke or transient ischemic attack was found to be mostly accurate and appropriate.

The present study demonstrates how changes in the documentation of contraindications can have a meaningful impact on specific performance measures. Although the size of the target population for the anticoagulation measure remained relatively stable during the study period, within this population of patients with AF, the proportion of those who received treatment increased dramatically because far fewer contraindications were documented (58.4% in 2003, 27.1% in 2009). After further examination of the contraindications documented, we found that the decline in the proportion of patients with a contraindication appeared to be a result of hospital abstractors choosing to not check the unspecified contraindication box on the PMT. Because most of the patients who did not have a contraindication documented received anticoagulation treatment, we hypothesize that this change reflected an increased recognition that the benefits of anticoagulation often outweigh the potential risks in patients with AF hospitalized for acute ischemic stroke. Several previous reports also have observed increasing trends in the use of anticoagulation treatment, including a hospital-based acute stroke study as well as community-based studies.

We also found an example that illustrated how the format and definitions of specific inclusion criteria matter in terms of defining particular target populations. Changes to the format of the 2008 PMT had a noticeable impact on the size of the target population for DVT prophylaxis. Specifically, an automatic form control was added to the 2008 PMT whereby if a checkbox indicating that the patient was ambulatory by the end of hospital day 2 was checked, the DVT prophylaxis field was automatically disabled because the patient was no longer eligible for prophylaxis. By adding the checkbox and automatic skip pattern, the proportion of patients in the target population decreased by 5.7% (from 52.5% in 2007 to 46.8% in 2008); however, the treatment rate among the target population increased only very slightly (from 89.4% in 2007 to 91.0% in 2008). These findings illustrate how the design of electronic data collection tools can directly affect the accuracy of data documentation.

Finally, the rapid reduction in the frequency of missing data in the present study demonstrates that the quality of data documentation improved quickly among participating hospitals. These findings illustrate the value of having a structured data collection tool along with detailed online data element definitions and abstraction instructions. The fact that the amount of missing data declined after the first year of the program also illustrates the impact of the data training and feedback mechanisms given to data collectors by American Heart Association/American Stroke Association staff and Outcome Sciences.

There are some important limitations to consider in this study. First, because the present study did not include a comparison group of hospitals that were not participating in the GWTG-Stroke program, we are unable to quantify the underlying secular trends in treatment improvements that could have occurred outside of the program. Second, a validation audit study of the national GWTG-Stroke program currently is ongoing, so the accuracy of the data recorded in the program during the 2003 to 2007 period is unknown. However, several state-level reliability studies have been undertaken and have shown very encouraging results in terms of the high completeness and reliability of the data items examined. Based on these data, there is no reason to believe that the increasing number of eligible patients who were documented as having received treatment in this study do not represent tangible improvements in care performance. Third, this study did not examine clinical outcomes; it is possible that the improvements to these stroke performance measures—whether real or illusory—may not have translated into improved clinical outcomes for these patients. Fourth, as the GWTG-Stroke program expanded, the hospitals that joined in the later years tended to be smaller and were less likely to be teaching hospitals. However, analyses of these data illustrated the widely reported phenomena that smaller, nonteaching hospitals tend to provide poorer care, so the inclusion of these hospitals would have tended to lower the overall quality of care in later years, which is opposite to the observed trends showing continued quality gains during these later years. Fifth, we did not include data on 3 other stroke performance measures (dysphagia screening, assessed for rehabilitation, and stroke education) because these were only added to the program data in 2008. Finally, participation in the GWTG-Stroke program is voluntary; thus, the findings may not be generalizable to other stroke quality improvement registries.

In summary, the findings provide evidence that the majority of the improvement in performance measure compliance in the GWTG-Stroke program reflect an increase in the number of patients with ischemic stroke treated rather than the changes to the underlying target populations or in the documentation of contraindications or missing data. These data suggest that hospitals participating in the GWTG-Stroke program over this 7-year period substantially improved the quality of care delivered to patients with ischemic stroke by
increasing the delivery of guideline-based care to eligible patients. Further work is required to assess whether these performance improvements result in meaningful changes in outcomes for patients with stroke treated at GWTG-Stroke hospitals.

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SUPPLEMENTAL MATERIAL

Table 1.

Figure 1.
Supplemental Tables.

Table 1: Detailed data definitions for target populations, and 4-level variable (eligible treated, eligible not treated, contraindications, and missing) for 7 performance measures

1. IV rtPA 2 hr

Target Population:
- Ischemic strokes
- IV-rtPA outside hospital = No
- Arrival datetime - lastknownwell datetime <=120 min (if >120 min, then exclude)

Exclusions:
- Arrival datetime - lastknownwell datetime >120 min.
- lastknownwell / arrival datetime missing
- precision datetime not accurate
- arrival datetime>lastknownwell datetime*

4-Level variable (l4ivtPA):
4=Missing:
- iv-rtPA information missing OR
- time for ivtPA administration missing OR
- iv-rtPA datetime precision not accurate OR
- iv-rtPA datetime<lastknownwell datetime

3=Contraindication:
- valid contraindications/warnings for iv-rtPA

2=Eligible not treated:
- IV-rtPA trt=NO or
- IV-rtPA trt=YES and ivtPA datetime – lastknownwell datetime >3hr

1=Eligible treated:
- IV-rTPA trt=YES
- ivtPA datetime – lastknownwell datetime <=3hr

2. Early Antithrombotics

Target Population:
- Ischemic Strokes
- No “comfort measures only” by the end of day 2
- Discharge after hospital day 2 (so discharge datetime-arrival datetime >= 2 days)
- No IV-rtPA initiated
- No ia-catheter-based reperfusion
- Admitted in hospital (not transferred to another acute care facility)

Exclusions /considerations:
  - Discharge datetime missing: DO NOT EXCLUDE
  - Arrival datetime missing: EXCLUDE

4-Level variable (l4rxasa2)
  4=Missing:
    - Antithrombotic medication missing OR
    - Discharge datetime is missing
  3=Contraindications:
    - Documented contraindications for antithrombotic therapy
  2=Eligible not treated:
    - Antithrombotic medication=NO/ND
  1=Eligible treated:
    - Antithrombotic medication=YES

3. DVT Prophylaxis

Target Population:
- Ischemic Strokes
- No “comfort measures only” by the end of day 2
- Discharge after the end of hospital stay 2 (so discharge datetime-arrival datetime >= 2 days)
- Admitted to hospital (not transferred to another acute care facility)
- Patient ambulating at the end of hospital day 2

Exclusions:
  - Discharge datetime missing: DO NOT EXCLUDE
  - Arrival datetime missing: EXCLUDE

4-Level variable (l4dvtrisk)
  4=Missing
    - DVT prophylaxis by 2nd day missing OR
- Discharge datetime missing
  3=Contraindications
  - Documented contraindications for DVT OR
  2=Eligible not treated:
  - DVT prophylaxis=NO/ND
  1=Eligible not treated:
  - DVT prophylaxis=YES

4. **Antithrombotics at discharge**

**Target Population:**
- Ischemic Strokes
- No “comfort measures only” at discharge
- Admitted to hospital (not transferred to another acute care facility)
- Regular hospital discharge i.e., patients not in any of these categories:
  - Discharged/transferred to another short term general hospital (3)
  - Left AMA (8)
  - Expired (10-11)
  - Discharged to hospice (12-13)
  - Discharged/transferred to a CAH/ psychiatric unit/ federal health care facility/ other type of institution (20, 18, 19, 6)
  - Discharge destination unknown (missing)

**4-Level variable (l4dcathrmb)**

4=Missing :
- Antithrombotics at discharge missing
  3=Contraindications:
  - Documented contraindications for antithrombotics
  2=Eligible not treated:
  - Antithrombotics at discharge=NO/ND
  1=Eligible treated:
  - Antithrombotics at discharge=YES
5. **Anticoagulants for atrial fibrillation/flutter at discharge (WARAFRXDC).**

**Target Population:**
- Ischemic Strokes
- History/diagnosis of atrial fibrillation/flutter
- No “comfort measures only” at discharge
- Regular hospital discharge, patients not in any of these categories:
  - Discharged/transferred to another short term general hospital (3)
  - Left AMA (8)
  - Expired (10-11)
  - Discharged to hospice (12-13)
  - Discharged/transferred to a CAH/ psychiatric unit/ federal health care facility/ other type of institution (20, 18, 19, 6)
  - Discharge destination unknown (missing)
- Admitted to hospital (not transferred to another acute care facility)

4-Level variable (l4dcafrix)

4=Missing:
- Anticoagulation therapy missing for patients with atrial fibrillation/flutter

3=Contraindications (from Total Population):
- Documented contraindications for anticoagulation

2=Eligible not treated:
- Anticoagulation therapy =NO/ND

1=Eligible treated:
- Anticoagulation therapy =YES

6. **LDL 100 or ND**

**Target Population:**
- Ischemic Strokes
- LDL not documented or LDL>=100 or history of cholesterol-reducing therapy prior admission
- No “comfort measures only” at discharge
- Regular hospital discharge, patients not in any of these categories:
  - Discharged/transferred to another short term general hospital (3)
  - Left AMA (8)
- Expired (10-11)
- Discharged to hospice (12-13)
- Discharged/transferred to a CAH/psychiatric unit/federal health care facility/other type of institution (20, 18, 19, 6)
- Discharge destination unknown (missing)

- Admitted in hospital (no transferred to another acute care facility)

4-Level variable (l4ldl)

4=Missing:
- Cholesterol reducing therapies all missing
3=Contraindication:
- Documented contraindication for cholesterol-reducing therapies
2=Eligible not treated:
- Cholesterol-reducing therapy = NONE/ND
1=Eligible treated:
- Cholesterol-reducing therapy prescribed at discharge (statin, fibrate, other med, niacin, absorption inhibitor)

7. **Smoking cessation counseling**

**Target Population:**

- Ischemic Strokes
- Current Smokers
- No “comfort measures only” at discharge
- Admitted to hospital (not transferred to another acute care facility)
- Regular hospital discharge i.e., patients not in any of these categories:
  - Discharged/transferred to another short term general hospital (3)
  - Left AMA (8)
  - Expired (10-11)
  - Discharged to hospice (12-13)
  - Discharged/transferred to a CAH/psychiatric unit/federal health care facility/other type of institution (20, 18, 19, 6)
  - Discharge destination unknown (missing)
4-Level variable (l4dsmk)

4=Missing:
- Antismoking trt at discharge missing

3=Contraindications:
- There are no contraindications for anti-smoking so this category will be omitted.

2=Eligible not treated:
- Antismoking at discharge=NO/ND/NC

1=Eligible treated:
- Antismoking =YES
Supplemental Figures

Figure 1: Trends in the proportion of subjects treated, not treated, contraindications, or missing data among the target populations for 7 performance measures by duration of program participation (baseline through 5+ years).

Panel A – IV-rtPA

Panel B – Early anti-thrombotics
Panel C – DVT prophylaxis

DVT Prophylaxis

<table>
<thead>
<tr>
<th>Years in Program</th>
<th>% Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>75.7</td>
</tr>
<tr>
<td>1 year</td>
<td>83.1</td>
</tr>
<tr>
<td>2 years</td>
<td>87.6</td>
</tr>
<tr>
<td>3 years</td>
<td>89.8</td>
</tr>
<tr>
<td>4 years</td>
<td>91.0</td>
</tr>
<tr>
<td>5+ years</td>
<td>92.1</td>
</tr>
</tbody>
</table>

- Missing: 21.2%
- Contraindications: 14.6%
- No Treatment: 11.4%
- Treatment: 5.9%

Panel D – Anticoagulation for AF at discharge

Anticoagulation for atrial fibrillation

<table>
<thead>
<tr>
<th>Years in Program</th>
<th>% Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>36.8</td>
</tr>
<tr>
<td>1 year</td>
<td>37.1</td>
</tr>
<tr>
<td>2 years</td>
<td>33.8</td>
</tr>
<tr>
<td>3 years</td>
<td>30.4</td>
</tr>
<tr>
<td>4 years</td>
<td>28.5</td>
</tr>
<tr>
<td>5+ years</td>
<td>27.1</td>
</tr>
</tbody>
</table>

- Missing: 4.9%
- Contraindications: 3.5%
- Eligible NO TRT: 4.4%
- Eligible TRT: 2.1%

% Subjects
Panel E – Anti-thrombotic therapy at discharge

Antithrombotics at discharge

Panel F – Lipid therapy at discharge

LDL >100 or ND
Panel G – Anti-smoking treatment at discharge

Anti-Smoking Treatment at Discharge

<table>
<thead>
<tr>
<th>Years in Program</th>
<th>Missing</th>
<th>No Treatment</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>33.0</td>
<td>66.0</td>
<td>100%</td>
</tr>
<tr>
<td>1 year</td>
<td>24.3</td>
<td>75.1</td>
<td>100%</td>
</tr>
<tr>
<td>2 years</td>
<td>15.4</td>
<td>84.3</td>
<td>100%</td>
</tr>
<tr>
<td>3 years</td>
<td>10.5</td>
<td>89.4</td>
<td>100%</td>
</tr>
<tr>
<td>4 years</td>
<td>8.0</td>
<td>91.9</td>
<td>100%</td>
</tr>
<tr>
<td>5+ years</td>
<td>6.4</td>
<td>93.4</td>
<td>100%</td>
</tr>
</tbody>
</table>