Marked Regional Variation in Acute Stroke Treatment Among Medicare Beneficiaries

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Background and Purpose—Little is known about how regions vary in their use of thrombolysis (intravenous tissue-type plasminogen activator and intra-arterial treatment) for acute stroke. We sought to determine regional variation in thrombolysis treatment and investigate the extent to which regional variation is accounted for by patient demographics, regional factors, and elements of stroke systems of care.

Methods—Retrospective cross-sectional study of all fee-for-service Medicare patients with ischemic stroke admitted via the Emergency Department from 2007 to 2010 who were assigned to 1 of 3436 hospital service areas. Multilevel logistic regression was used to estimate regional thrombolysis rates, determine the variation in thrombolysis treatment attributable to the region and estimate thrombolysis treatment rates and disability prevented under varied improvement scenarios.

Results—There were 844,241 ischemic stroke admissions of which 3.7% received intravenous tissue-type plasminogen activator and 0.5% received intra-arterial stroke treatment without or without intravenous tissue-type plasminogen activator over the 4-year period. The unadjusted proportion of patients with ischemic stroke who received thrombolysis varied from 9.3% in the highest treatment quintile compared with 0% in the lowest treatment quintile. Measured demographic and stroke system factors were weakly associated with treatment rates. Region accounted for 7% to 8% of the variation in receipt of thrombolysis treatment. If all regions performed at the level of 75th percentile region, ≈7000 additional patients with ischemic stroke would be treated with thrombolysis.

Conclusions—There is substantial regional variation in thrombolysis treatment. Future studies to determine features of high-performing thrombolysis treatment regions may identify opportunities to improve thrombolysis rates.

Key Words: health services research ■ stroke ■ therapeutic thrombolysis

Thrombolysis (intravenous tissue-type plasminogen activator [tPA] and acute intra-arterial treatment [IAT]) treatment reduces post stroke disability but is underutilized.1,2 Although it is known that US hospitals vary widely in their use of thrombolysis, the extent to which this reflects differences in eligibility or differences in thrombolytic use among eligible patients is unknown.3 It is probable that hospital thrombolysis rates are, at least in part, dependent on regional factors that influence thrombolysis eligibility.

In this context, we sought to explore regional variation in thrombolysis treatment and determine the extent that patient demographics, regional factors, and elements of stroke systems of care influence treatment rates. Determining thrombolysis rates in high-performing regions and understanding the role of immutable regional factors will establish real world regional benchmarks. Ultimately, a better understanding of regional influences on thrombolysis may inform future interventions to increase thrombolysis treatment rates and inform the magnitude of the opportunity for nationwide improvement in thrombolysis treatment.

Methods
This is a retrospective cross-sectional study of regional differences in thrombolysis rates among Medicare fee-for-service beneficiaries. We used Medicare MedPAR files from 2007 to 2010 to identify all patients with a primary diagnosis of ischemic stroke using International Classification of Diseases Ninth Revision (ICD-9) codes ICD-9 433.x1, 434.x1, 436 admitted from the emergency department. The majority of the hospital care in the United States is provided at the hospital closest to the patient’s home.4 Thus, the primary exposure was the hospital service area (HSA) determined from the home zip code of the patient with ischemic stroke. There are 3436 HSAs in the United States and >60% contain >1 hospital.5 HSAs were chosen as the unit of regional analysis because they represent local markets for healthcare, whereas hospital referral regions represent tertiary referral regions. Given the time constraints in thrombolysis treatment, we hypothesized that regional factors would be better measured at the more granular HSAs level rather than in hospital referral regions.

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Demographics, Vascular Risk Factors, Comorbidities, and Procedures Among Ischemic Stroke Patients by Quintiles of Thrombolysis Treatment

| Table 1 | Regional Variation in Acute Stroke Treatment |

The primary outcome was any thrombolysis which included both intravenous tPA (diagnosis related group [DRG] 559, MS-DRG 61–63, or ICD-9 procedure code 99.1). IAT (CPT codes 37184–6, 37201, 75896) and the combination (intravenous+IAT) identified using DRG and procedure codes from MedPAR and CPT codes from the Medicare Carrier file. Drip and ship cases were identified with ICD-9 procedure code V4588 and counted as intravenous cases if no IAT code was identified or combination therapy if there was also an IAT code. We included IAT as part of our primary outcome for 2 reasons. First, guidelines suggested IAT was an option for major middle cerebral artery stroke under 6 hours and in patients who had contraindications to intravenous tPA. To exclude IAT from the primary outcome would have potentially penalized regions with greater IAT rates.

Regional and Patient Factors
Regional factors included elements of stroke systems of care, such as primary stroke centers (PSCs) and emergency medical service (EMS) bypass systems. The number of PSCs per region was determined by counting the number of PSCs in a given zip code (using the PSC Website), mapping zip codes to HSAs using the Dartmouth atlas and summing the number of PSCs within each HSA. EMS bypass was determined by mapping patient zip codes to a previous systematic review of regions with EMS bypass. Both PSCs and bypass variables reflect the time at which they were established. For example, a region that established bypass in 2008 would have been categorized as without bypass before that time and with bypass subsequent to that time. To explore regional factors that may be associated with prehospital delay and that are intrinsic to the region, US census data were linked to Medicare data using patient zip code to capture regional education, median household income, proportion of population unemployed.

### Regional factors
- **Population density 1000 population/square mile, mean (SD)**
  - Quintiles 1-5: 0.3 (1.4) - 4.5 (4.7)
- **Bachelor’s degree**
  - Quintiles 1-5: 16.8 (8.9) - 26.2 (15.5)
- **Unemployed**
  - Quintiles 1-5: 8.8 (5.0) - 9.2 (4.5)
- **Median income per $10,000, mean (SD)**
  - Quintiles 1-5: 4.2 (1.4) - 5.4 (2.2)

### Stroke systems of care
- **Emergency medical service bypass**
  - Quintiles 1-5: 8670 (34.3%) - 433484 (51.3%)
- **Primary stroke center(s)/region, mean (SD)**
  - Quintiles 1-5: 2.7 (3.8) - 4.5 (4.7)

### Demographics
- **Age mean (SD)**
  - Quintiles 1-5: 77.5 (10.6) - 78.9 (10.3)
- **Women**
  - Quintiles 1-5: 14.358 (56.8%) - 482903 (57.2%)
- **Non-Hispanic White**
  - Quintiles 1-5: 21.278 (84.2%) - 679621 (80.5%)
- **Black**
  - Quintiles 1-5: 2916 (11.5%) - 170305 (18.1%)
- **Hispanic**
  - Quintiles 1-5: 326 (1.3%) - 4493 (5.2%)
- **Unknown/other**
  - Quintiles 1-5: 646 (2.6%) - 17042 (2.0%)

### Comorbidities
- **Hypertension**
  - Quintiles 1-5: 17.656 (69.9%) - 602716 (71.4%)
- **Hyperlipidemia**
  - Quintiles 1-5: 7596 (30.1%) - 291032 (34.5%)
- **Diabetes mellitus**
  - Quintiles 1-5: 7649 (30.3%) - 247159 (29.3%)
- **Atrial fibrillation**
  - Quintiles 1-5: 5964 (23.6%) - 212559 (25.2%)
- **Smoking**
  - Quintiles 1-5: 1689 (6.7%) - 54034 (6.4%)
- **Myocardial infarction**
  - Quintiles 1-5: 1558 (6.2%) - 54219 (6.4%)
- **Peripheral vascular disease**
  - Quintiles 1-5: 1605 (6.4%) - 56808 (6.7%)
- **Congestive heart failure**
  - Quintiles 1-5: 4282 (17%) - 141577 (16.8%)
- **Dementia**
  - Quintiles 1-5: 1418 (5.6%) - 49510 (5.9%)
- **Chronic obstructive pulmonary disease**
  - Quintiles 1-5: 3826 (15.1%) - 123366 (14.6%)

### Vascular Risk Factors
- **Medicare data**
  - Quintiles 1-5: 170305 (18.1%) - 17042 (2.0%)
- **Emergency medical service bypass**
  - Quintiles 1-5: 8670 (34.3%) - 433484 (51.3%)

### Procedures
- **Emergency medical service bypass**
  - Quintiles 1-5: 8670 (34.3%) - 433484 (51.3%)
- **Primary stroke center(s)/region, mean (SD)**
  - Quintiles 1-5: 2.7 (3.8) - 4.5 (4.7)
Statistical Analysis
We first determined the proportion of patients with ischemic stroke who received thrombolysis treatment over the 4-year period. Individual and regional characteristics were then compared using descriptive statistics across quintiles of thrombolysis treatment rates. To estimate the effect of region on the proportion of ischemic stroke patients treated with thrombolysis, multilevel logistic regression was used with and without adjustment for patient, regional, and elements of stroke systems of care with a random regional-level intercept. The proportion of variance at the regional level was estimated using the interclass correlation coefficient. Regional thrombolysis rates were estimated for each region using shrunken means from the empty model and regions were divided into quintiles on the basis of mean treatment rates. The impact of each regional factor was estimated using average marginal effects and compared using Wald tests from the fully adjusted model.

Finally, we developed a simple model to estimate the societal impact of increasing regional thrombolysis rates using 1 or 2 strategies: (1) targeted increases in thrombolysis rates in low-performing regions and (2) nationwide increases in thrombolysis rates. For each model, to represent the entire stroke population as opposed to only the Medicare fee-for-service population, we linearly scaled the number of service beneficiaries of which 3.9% received thrombolysis treatment—3.7% with intravenous tPA only and 0.5% received IAT with or without intravenous tPA; 20.1% of regions did not administer thrombolysis treatment over the 4-year period. Regional variation in the proportion of strokes receiving thrombolysis ranged from 9.3% to 0% in the highest to lowest use quintiles and from 5.9% to 2.2% after accounting for variation in the number of strokes per region. There were no marked differences in demographics or comorbidities across thrombolysis treatment quintiles (Table 1). Regions with higher treatment rates generally had higher population density, more bachelor’s degrees, and EMS bypass.

The proportion of patients with ischemic stroke who received thrombolysis varied from 14% of patients in the

Table 2. The 20 Regions With the Highest Proportion of Ischemic Stroke Patients Treated With Thrombolysis From 2007 to 2010

<table>
<thead>
<tr>
<th>Rank</th>
<th>Annual Mean Treatment Rate, %</th>
<th>Lower CI, %</th>
<th>Upper CI, %</th>
<th>City</th>
<th>State</th>
<th>Total Strokes</th>
<th>Untreated</th>
<th>Intravenous</th>
<th>IAT</th>
<th>Intravenous+IAT</th>
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</thead>
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<tr>
<td>1</td>
<td>14.3</td>
<td>11.0</td>
<td>18.3</td>
<td>Stanford</td>
<td>CA</td>
<td>317</td>
<td>266</td>
<td>43</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>13.8</td>
<td>11.7</td>
<td>16.1</td>
<td>Asheville</td>
<td>NC</td>
<td>910</td>
<td>779</td>
<td>113</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>12.9</td>
<td>9.1</td>
<td>18.1</td>
<td>Waconia</td>
<td>MN</td>
<td>183</td>
<td>154</td>
<td>24</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>11.9</td>
<td>10.0</td>
<td>14.2</td>
<td>Langhorne</td>
<td>PA</td>
<td>862</td>
<td>754</td>
<td>106</td>
<td>1</td>
<td>1</td>
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<tr>
<td>5</td>
<td>11.2</td>
<td>7.2</td>
<td>17.0</td>
<td>Brevard</td>
<td>NC</td>
<td>127</td>
<td>108</td>
<td>17</td>
<td>0</td>
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<tr>
<td>6</td>
<td>11.2</td>
<td>8.6</td>
<td>14.4</td>
<td>Iowa City</td>
<td>IA</td>
<td>422</td>
<td>370</td>
<td>47</td>
<td>4</td>
<td>1</td>
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<tr>
<td>7</td>
<td>11.1</td>
<td>7.0</td>
<td>17.0</td>
<td>Hastings</td>
<td>NE</td>
<td>120</td>
<td>102</td>
<td>18</td>
<td>0</td>
<td>0</td>
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<tr>
<td>8</td>
<td>10.8</td>
<td>8.0</td>
<td>14.5</td>
<td>Wheat Ridge</td>
<td>CO</td>
<td>317</td>
<td>278</td>
<td>37</td>
<td>0</td>
<td>2</td>
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<tr>
<td>9</td>
<td>10.7</td>
<td>7.8</td>
<td>14.7</td>
<td>Provo</td>
<td>UT</td>
<td>274</td>
<td>240</td>
<td>19</td>
<td>3</td>
<td>12</td>
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<tr>
<td>10</td>
<td>10.7</td>
<td>7.5</td>
<td>15.0</td>
<td>Holyoke</td>
<td>MA</td>
<td>228</td>
<td>199</td>
<td>27</td>
<td>1</td>
<td>1</td>
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<tr>
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<td>10.7</td>
<td>6.4</td>
<td>17.4</td>
<td>Hutchinson</td>
<td>MN</td>
<td>88</td>
<td>74</td>
<td>12</td>
<td>1</td>
<td>1</td>
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<tr>
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<td>7.0</td>
<td>16.0</td>
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<td>NC</td>
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<td>1</td>
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<td>13</td>
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<td>8.1</td>
<td>13.7</td>
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<td>380</td>
<td>46</td>
<td>0</td>
<td>4</td>
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<tr>
<td>14</td>
<td>10.5</td>
<td>8.5</td>
<td>12.9</td>
<td>Cedar Rapids</td>
<td>IA</td>
<td>716</td>
<td>636</td>
<td>68</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>15</td>
<td>10.3</td>
<td>7.2</td>
<td>14.6</td>
<td>Encinitas</td>
<td>CA</td>
<td>219</td>
<td>192</td>
<td>23</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>10.3</td>
<td>8.9</td>
<td>11.7</td>
<td>San Francisco</td>
<td>CA</td>
<td>1790</td>
<td>1602</td>
<td>169</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>17</td>
<td>10.1</td>
<td>5.7</td>
<td>17.4</td>
<td>Southbridge</td>
<td>MA</td>
<td>66</td>
<td>55</td>
<td>10</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>10.0</td>
<td>7.0</td>
<td>14.2</td>
<td>Pekin</td>
<td>IL</td>
<td>236</td>
<td>208</td>
<td>25</td>
<td>0</td>
<td>3</td>
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<tr>
<td>19</td>
<td>10.0</td>
<td>8.9</td>
<td>11.3</td>
<td>Denver</td>
<td>CO</td>
<td>2396</td>
<td>2152</td>
<td>222</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>20</td>
<td>9.8</td>
<td>6.3</td>
<td>15.0</td>
<td>American Fork</td>
<td>UT</td>
<td>141</td>
<td>123</td>
<td>10</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; and IAT, intra-arterial treatment.
highest region compared with some regions where thrombolysis treatment was not administered during the study period. The top 10 regions spanned from North Carolina to California, and include large and small stroke volume regions (Table 2). Figure shows the regional variability thrombolysis treatment in the United States.

Region was an important predictor of receipt of thrombolysis, intraclass correlation coefficient in an empty model was 0.075, suggesting that region explains ≈8% of all variance in thrombolysis treatment rates. The interclass correlation coefficient decreased to 0.070 in the fully adjusted model, suggesting that all factors included in our model explained a modest amount of the variance in the empty model, and that most of the regional variance was not explained by factors measured in this study. Older Americans, women, and racial/ethnic minorities were less likely to receive thrombolysis (Table 3). EMS bypass and the number of PSCs in a region were associated with increased thrombolysis. Among regions with the lowest number of PSCs, 4.0% (95% confidence interval [CI], 3.9–4.1%) of patients with stroke received

### Table 3. The Association of Patient Demographics, Regional Factors, and Elements of Stroke Systems of Care With Thrombolysis Treatment*

<table>
<thead>
<tr>
<th>Demographic/Regional Factor</th>
<th>Odds Ratio</th>
<th>P Value</th>
<th>Lower Confidence Interval</th>
<th>Upper Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (continuous)</td>
<td>0.986</td>
<td>&lt;0.001</td>
<td>0.984</td>
<td>0.987</td>
</tr>
<tr>
<td>Women</td>
<td>0.918</td>
<td>&lt;0.001</td>
<td>0.898</td>
<td>0.939</td>
</tr>
<tr>
<td>Race/ethnicity (ref: White)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>0.709</td>
<td>&lt;0.001</td>
<td>0.681</td>
<td>0.738</td>
</tr>
<tr>
<td>Other</td>
<td>0.823</td>
<td>&lt;0.001</td>
<td>0.752</td>
<td>0.900</td>
</tr>
<tr>
<td>Asian</td>
<td>0.779</td>
<td>&lt;0.001</td>
<td>0.703</td>
<td>0.862</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.882</td>
<td>0.006</td>
<td>0.807</td>
<td>0.964</td>
</tr>
<tr>
<td>Native American</td>
<td>0.738</td>
<td>0.005</td>
<td>0.596</td>
<td>0.915</td>
</tr>
<tr>
<td>Population density</td>
<td>1.004</td>
<td>&lt;0.001</td>
<td>1.002</td>
<td>1.007</td>
</tr>
<tr>
<td>Bachelor’s degree or higher</td>
<td>1.006</td>
<td>&lt;0.001</td>
<td>1.005</td>
<td>1.007</td>
</tr>
<tr>
<td>Unemployment (%)</td>
<td>1.001</td>
<td>0.667</td>
<td>0.997</td>
<td>1.005</td>
</tr>
<tr>
<td>Median household income</td>
<td>1.010</td>
<td>0.045</td>
<td>1.000</td>
<td>1.019</td>
</tr>
<tr>
<td>No. of primary stroke</td>
<td>1.011</td>
<td>&lt;0.001</td>
<td>1.005</td>
<td>1.017</td>
</tr>
<tr>
<td>Emergency medical service</td>
<td>1.097</td>
<td>&lt;0.001</td>
<td>1.043</td>
<td>1.152</td>
</tr>
</tbody>
</table>

*Analyses adjusted for all variables listed and Charlson comorbidities and include data from 2007 to 2010.
thrombolysis compared with 4.8% (95% CI, 4.4–5.1%) in regions with the highest number of PSCs (Table 4). In areas without EMS bypass systems 4.0% (95% CI, 3.9–4.1%) of patients with stroke received thrombolysis compared with 4.4% (95% CI, 4.2–4.5%) of patients with stroke in regions with EMS bypass systems. Of regional demographic factors, education was the most important. Regions with the lowest proportion of college graduates had a smaller proportion of patients treated with thrombolysis (3.7%; 95% CI, 3.6–3.9%) compared with regions with the highest proportion of college graduates (5.0%; 95% CI, 4.8–5.2%).

If lower performing regions administered thrombolysis treatment at the rates of higher performing regions, considerable disability could be prevented (Table 5). For example, if the 1670 regions that currently perform below the median were increased to the median rate, we estimate that 2717 additional patients would be treated annually resulting in approximately an additional 236 stroke patients without disability. An optimistic ceiling for acute thrombolysis treatment in the United States can be estimated by increasing all regional treatment rates to that of the highest performing region which would yield an additional 92,847 patients treated with thrombolysis and 8078 stroke patients without disability.

**Discussion**

This study is the first to assess regional variation in thrombolysis treatment in the United States. There are regions that have more double the national thrombolysis treatment average. Conversely, 20% of regions did not treat any patients over the 4-year period. These results suggest considerable opportunity to improve outcomes in patients with acute ischemic stroke—if
all regions performed like those in the top 10%, ≈16,000 additional patients would receive thrombolysis treatment annually. Given the exclusions to thrombolysis treatment, every patient with stroke should not receive thrombolysis treatment. A previous study estimated that ≈6% of patients with stroke in the greater Cincinnati region were eligible for thrombolysis, with the major exclusion being delay in hospital presentation.11 Yet, we found that ≈20% of regions, had actual thrombolysis rates higher than this estimate and that the highest performing regions performed at more than double this rate. This, and other limited data on regional variation in time of stroke onset to hospital presentation,12 suggest that eligibility rates probably vary considerably by region and that improving eligibility, presumably by reducing delays to presentation, could have considerable benefits.

By identifying high-performing regions within the context of the current US healthcare environment, our findings are the first step toward improving US regional thrombolysis treatment rates.13 Immutable regional factors and stroke systems of care accounted for little of the regional variation suggesting further work is needed to understand how high-performing regions achieved their success and whether that success can be replicated in other regions. This work should include determination of the relative importance of hospital and regional factors. Such work is challenging given the inability to differentiate hospital effects from regional effects in the absence of national patient-level data on time to arrival and other important eligibility criteria. For example, regional characteristics such as EMS bypass may increase the proportion of eligible stroke patients at a given hospital which could artificially attribute the effect of a regional intervention (EMS bypass) to the hospital.

Consistent with previous work,14-16 we found that an increased numbers of PSCs and EMS bypass systems were associated with increased thrombolysis rates. Whether PSCs or EMS bypass is the key causal element in increased treatment rates17 and, if so, the specific mechanisms by which they increase thrombolysis rates are unknown. Regional measures of socioeconomic status, including education, median income, and unemployment were modestly associated with thrombolysis. Explanations for the association of increased thrombolysis in higher socioeconomic regions are unknown. We also found that women, older Americans, and racial/ethnic minorities were less likely to receive thrombolysis; a finding that is consistent with other studies.18,19 Although population density was associated with thrombolysis treatment, the association was small. Given the intrinsic differences in rural and urban stroke care, and lack of detailed measures of both urban (eg, hospital prenotification and hospital-based quality initiatives) and rural (eg, telestroke or emergency air evacuation programs) stroke systems, our analysis may underestimate the role of rural/urban differences.

Our study has several limitations. Intravenous tPA treatment was based on ICD-9, and DRG codes which while broader than previous definitions may still underestimate thrombolytic treatment when compared with pharmacy data.20,21 This underestimate is unlikely to explain the measured regional variation for 2 reasons. First, the introduction of DRG 559 in 2005 and MS-DRG 061-063 created a strong incentive for hospitals to improve thrombolysis coding.22 Second, the magnitude of regional variation is considerably greater than the overall amount of miscoding previously documented. Although previous studies of intravenous tPA have included transient ischemic attack and patients with hemorrhagic stroke in estimates

### Table 5. Projected Thrombolysis Treatment Rates and Disability Prevented Under Various Regional and National Improvement Scenarios

<table>
<thead>
<tr>
<th>No. of Regions Changing Rates</th>
<th>National Mean Regional Treatment Rate, %</th>
<th>Increase in No. of Patients Treated</th>
<th>Number Alive, Favorable Outcome (MRS, 0–1) Assuming All Treated Within 3 h</th>
<th>No. of Patients Disability-Free Because of Treatment Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>5.56</td>
<td>41,416</td>
<td>3603</td>
<td></td>
</tr>
<tr>
<td>Increase thrombolysis treatment rates in underperforming regions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase below 10th percentile to 10 percentile (3.1%)</td>
<td>334</td>
<td>5.62</td>
<td>41,388</td>
<td>422</td>
</tr>
<tr>
<td>Increase below 25th percentile to 25th percentile (3.8%)</td>
<td>835</td>
<td>5.72</td>
<td>42,621</td>
<td>1205</td>
</tr>
<tr>
<td>Increase below median quintiles to median (4.4%)</td>
<td>1670</td>
<td>5.92</td>
<td>44,133</td>
<td>2717</td>
</tr>
<tr>
<td>Increase below 75th percentile quintiles to 75 percentile (5.6%)</td>
<td>2505</td>
<td>6.48</td>
<td>48,279</td>
<td>6863</td>
</tr>
<tr>
<td>Increase below 90th percentile quintiles to 90th percentile (7.3%)</td>
<td>3006</td>
<td>7.67</td>
<td>57,139</td>
<td>15,724</td>
</tr>
<tr>
<td>Increase all regions to 99th percentile (11.3%)</td>
<td>3306</td>
<td>11.37</td>
<td>84,729</td>
<td>43,313</td>
</tr>
<tr>
<td>Increase all regions to highest region, Stanford (18.0%)</td>
<td>3340</td>
<td>18.02</td>
<td>134,262</td>
<td>92,847</td>
</tr>
<tr>
<td>Across the board increases in treatment rates in all regions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase all regional rates by 10%</td>
<td>3340</td>
<td>6.12</td>
<td>45,557</td>
<td>4142</td>
</tr>
<tr>
<td>Increase all regional rates by 25%</td>
<td>3340</td>
<td>6.95</td>
<td>51,769</td>
<td>10,354</td>
</tr>
<tr>
<td>Increase all regional rates by 50%</td>
<td>3340</td>
<td>8.34</td>
<td>62,123</td>
<td>20,708</td>
</tr>
<tr>
<td>Increase all regional rates by 100%</td>
<td>3340</td>
<td>11.12</td>
<td>82,831</td>
<td>41,416</td>
</tr>
<tr>
<td>Increase all regional rates by 200%</td>
<td>3340</td>
<td>16.68</td>
<td>124,247</td>
<td>82,831</td>
</tr>
</tbody>
</table>

*Based on 2010 regional thrombolysis rates and rounded to integers.*
of thrombolysis,20,21 these patients were excluded in our study given the concern for miscoding. In addition, as procedure codes have a low sensitivity for identifying IAT,22 we linked hospitalization data, to physician payment data, Medicare Part B files. Similar approaches have been used to identify other procedures that are unreliably recorded in hospital-based claims records.23 Although the sensitivity and specificity of this approach for IAT is uncertain, there is strong financial incentive for institutions and providers to accurately code these claims. The study population was limited to Medicare fee-for-service enrollees and thus our results do not apply to working age stroke patients or Medicare managed care beneficiaries. Although the majority of Americans receive care at their local hospital, there are those who do not which may result in some misclassification.4 Comprehensive stroke center certification was not in existence during the study period and thus was not included in the analysis. Thrombolysis treatment eligibility and stroke severity were not available in our data set. However, as our primary analysis was at the regional level, it is less likely that differences in severity per se, would lead to major differences in regional treatment rates.24

In conclusion, there is substantial regional variation in thrombolysis treatment. Further study of regions with high thrombolysis treatment rates may identify opportunities to increase nationwide thrombolysis treatment.

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Disclosures
None.

References
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