Long-Term Effect of Fee-For-Service–Based Reimbursement Cuts on Processes and Outcomes of Care for Stroke

Interrupted Time-Series Study From Taiwan

Yu-Chi Tung, PhD; Guann-Ming Chang, MD, MS; Shou-Hsia Cheng, PhD

Background—As healthcare spending continues to increase, reimbursement cuts have become 1 type of healthcare reform to contain costs. Little is known about the long-term impact of cuts in reimbursement, especially under a global budget cap with fee-for-service (FFS) reimbursement, on processes and outcomes of care. The FFS-based reimbursement cuts have been implemented since July 2002 in Taiwan. We examined the long-term association of FFS-based reimbursement cuts with trends in processes and outcomes of care for stroke.

Methods and Results—We analyzed all 41 148 patients with stroke admitted to general acute care hospitals in Taiwan during the period 1997 to 2010 through Taiwan’s National Health Insurance Research Database. We used a quasi-experimental design with quarterly measures of healthcare utilization and outcomes and used segmented autoregressive integrated moving average models for the analysis. After accounting for secular trends and other confounders, the implementation of the FFS-based reimbursement cuts was associated with trend changes in computed tomography/magnetic resonance imaging scanning (0.31% per quarter; \(P=0.013\)), antiplatelet/anticoagulant use (−0.20% per quarter; \(P<0.001\)), statin use (0.18% per quarter; \(P=0.027\)), physiotherapy/occupational therapy assessment (0.25% per quarter; \(P<0.001\)), and 30-day mortality (0.06% per quarter; \(P<0.001\)).

Conclusions—There are improvement trends in processes and outcomes of care over time. However, the reimbursement cuts from the FFS-based global budget cap are associated with trend changes in processes and outcomes of care for stroke. The FFS-based reimbursement cuts may have long-term positive and negative associations with stroke care. (Circ Cardiovasc Qual Outcomes. 2015;8:30-37. DOI: 10.1161/CIRCOUTCOMES.114.001086.)

Key Words: health policy ■ insurance, health, reimbursement ■ outcome and process assessment (health care) ■ stroke

As healthcare spending continues to increase, reimbursement cuts have become 1 type of healthcare reform to contain costs such as the Balanced Budget Act (BBA) in the United States and global budgeting in Organization for Economic Cooperation and Development countries.1,2 To the best of our knowledge, previous studies have found that reimbursement cuts from the BBA or global budgeting were associated with mortality for postoperative complications, stroke, acute myocardial infarction, pneumonia, and congestive heart failure.1,3 However, there have been few studies using nationwide longitudinal population-based data to examine the long-term association of fee-for-service (FFS)–based reimbursement cuts with processes and outcomes of care.

As reimbursement cuts lead to reductions in hospital revenues, hospitals may decrease operating expenses, reduce unprofitable care, and increase profitable care to preserve profit.1,3,7 Strategies to reduce operating expenses and unprofitable care may include decreased quantity and quality of nursing staff or levels of care. These strategies in response to lower reimbursements may lead to deficiencies in care, possibly causing poor patient outcomes.1,3,6,7 However, hospitals are more likely to provide more profitable services to preserve profit or to perform more examinations to defray part of the large, fixed capital costs of medical equipment.8

Stroke is one of the leading causes of death worldwide.9 Previous studies have found an association between cuts in reimbursement and mortality for stroke, inferring that reductions in unprofitable care or operating expenses as a result of reimbursement cuts may be associated with higher stroke mortality.2,4 One study found that every 1% reduction in reimbursement was associated with 1.2% higher odds of 30-day mortality in Taiwan.2 Another found that hospitals in the large-cut category relative to the small-cut hospitals experienced smaller decline in 1-year mortality in the post-BBA period compared with their pre-BBA trends by 0.82% points.4 However, it remains unknown whether the processes of care associated with stroke mortality may be affected by reimbursement cuts. Previous studies have found that care in relation to stroke outcomes included the use of computed tomography (CT)/magnetic resonance imaging...
WHAT IS KNOWN

• As healthcare spending continues to increase, reimbursement cuts have become 1 type of healthcare reform to contain costs such as the Balanced Budget Act in the United States and global budgeting in Organization for Economic Cooperation and Development countries.
• Reimbursement cuts from the Balanced Budget Act or global budgeting are associated with mortality for stroke.
• Few studies using nationwide longitudinal population-based data have examined the long-term association of fee-for-service–based reimbursement cuts with processes and outcomes of care for stroke.

WHAT THE STUDY ADDS

• In this study from Taiwan, there were improvement trends in processes and outcomes of care for stroke over time, and reimbursement cuts from the fee-for-service-based global budget cap were associated with trend changes in them.
• The reimbursement cuts were associated with the increasing trends in computed tomography/magnetic resonance imaging use and physiotherapy/occupational therapy assessment to patients with stroke, and with the rapidly increasing use of statin therapy; however, they were also associated with the slowly increasing use of antiplatelet/anticoagulant therapy and the slowly decreasing trend in the 30-day mortality rate after stroke.
• Reimbursement cuts may ensure the provision of services that provide a profit to hospitals while creating pressure to reduce less profitable or resource-intensive services, which in turn may influence mortality.

(MRI) antiplatelet/anticoagulant, statin, and physiotherapy/occupational therapy assessment. To our knowledge, however, there has been no empirical research examining the effect of reimbursement cuts on processes of stroke care. Moreover, there have been no studies on the effect on processes and outcomes of care over the longer term. Long-term data are particularly important because it could take years for providers to reconfigure their approaches to care and changes in health service provisions because of reimbursement cuts may therefore become evident after years of work.

To control escalating health expenditures, Taiwan’s National Health Insurance Administration (previously the Bureau of National Health Insurance) implemented global budgeting for various sectors of healthcare services such as dental care, traditional Chinese medicine, and community clinics. Hospital global budgeting (a global budget cap for the hospital sector) has been implemented since July 2002, accompanied by the original FFS reimbursement plan. After hospital global budgeting, healthcare service claims have been reimbursed with discounted FFS payments to the hospitals. Physicians are used by hospitals in Taiwan.

The goal of this study was to use nationwide population-based data from Taiwan between 1997 and 2010 with interrupted time-series designs to examine whether the long-term implementation of FFS-based reimbursement cuts from the global budget cap had an association with the trends in processes and outcomes of stroke care.

Methods

Database

This study used the National Health Insurance Research Database, which was provided by the National Health Insurance Administration and managed by the National Health Research Institutes in Taiwan. The National Health Insurance Research Database, which is a de-identified secondary national database, consists of the following individual files: inpatient medical claims, inpatient orders, outpatient medical claims, and outpatient orders. This study was approved by the Institutional Review Board of the National Taiwan University Hospital.

Study Population

This study included all patients aged ≥18 years who were admitted to general acute care hospitals between 1997 and 2010 with ischemic stroke as the primary diagnosis for admission. Ischemic stroke was identified through the primary diagnosis of the patients recorded using the International Classification of Diseases, Ninth Revision, Clinical Modification, codes 433 and 434. When a patient had >1 ischemic stroke admission during the study period, only the first admission was included in this analysis. The initial data set contained 411,674 patients. Patients with incomplete data were excluded. The final data set had 411,487 patients.

Measures of Variables

Reimbursement Cuts

The intervention of FFS-based reimbursement cuts was measured as whether the hospital global budgeting was implemented. Reimbursement to hospitals is based on a FFS schedule, which lists the number of points for each service item. The monetary value of each point was fixed as NT $1 (US $0.03) before hospital global budgeting, but after that, it fluctuates and is less than NT $1. Because the global budget cap for the hospital sector for a given year has been determined via negotiation between providers and consumers at the end of the previous year, the quarterly monetary value of each point has been retrospectively calculated as the predetermined fixed budget divided by the total number of points that all hospitals claimed. As such, the FFS-based reimbursement cuts indicate retrospectively discounted FFS payments, which are different from fixed FFS payments before hospital global budgeting.

Reimbursement to hospitals is the sum of the number of claim points multiplied by the monetary value of each point, which is hospital revenue. Therefore, because of the intervention of global budgeting, a decrease in monetary value leads to cuts in reimbursement (reductions in hospital revenues). Hospitals may provide more profitable services or less unprofitable services, or reduce operating expenses to preserve profit after reimbursement cuts compared with before reimbursement cuts. For example, hospitals may hire more casual/temporary nurses, have lower nurse staffing levels, and use higher levels of variable pay for physicians than before.

Outcome Measures

Based on process measures for stroke care used by the Centers for Medicare and Medicaid Services, we used available process indicators in our analysis: examination with CT/MRI scan, antiplatelet/anticoagulant use, statin use, and physiotherapy/occupational therapy assessment. Thrombolytic therapy was not used because Taiwan’s National Health Insurance Administration has covered recombinant tissue-type plasminogen activator use for ischemic stroke since 2004, which followed the implementation of global budgeting. Deep venous
thrombosis prophylaxis was not used because deep venous thrombosis is less common in Asians than in the white population. The rate of receiving CT/MRI scans was measured as the number of patients who received CT or MRI during hospital stays and emergency/outpatient visits on the day of admission divided by the number of patients during the study period. The rate of receiving physiotherapy/occupational therapy assessment was measured as the number of patients who received the assessment during hospital stays divided by the number of patients during the study period.

The outcome measure was all-cause 30-day mortality from the day of admission, which is a frequently used measure in stroke outcome studies. The 30-day mortality rate was calculated as the total number of deaths divided by the number of patients during the study period. The advantage of using 30-day mortality is that the variation in length of stay does not have an undue effect on mortality rates. Without a standardized period, hospitals would have an incentive to adopt strategies that would shift deaths out of the hospital without improving quality of care. Hospital quality would be expected to influence patient outcomes in this time frame. Thirty-day mortality was measured from the date of admission by linking inpatient admission records with the records of withdrawal from National Health Insurance enrollment. The only reason for being withdrawn from National Health Insurance coverage within 30 days of hospital admission would be death. The withdrawal dates are the same as the dates of death, according to the death certificate records.

Other Covariates

The covariates in the analysis included patient characteristics, season of admission, and time trends. According to patient-level studies, patient age, sex, comorbid conditions, intensive care unit (ICU) use, and administration of surgical operation were associated with stroke outcomes. To control for changes in trends in patient characteristics that might influence trends in processes and outcomes of care for stroke, the proportion of male patients, average age, average index of comorbid conditions, rate of using ICU, and rate of surgery were included. The Charlson–Deyo index was used to quantify the comorbidities of patients with stroke. This index is the sum of weighted scores based on the presence or absence of 17 different medical conditions. Cerebrovascular disease and hemiplegia were excluded, however, because they are reflected in the condition we were evaluating. The higher the scores, the greater the comorbidity burden. The season of admission was regarded as 1 covariate because previous studies indicated significant seasonal variation in stroke mortality. The linear time trend was also included to capture all omitted trending variables such as advances in medicine and medical technology and to separate these variables from the impact of FFS-based reimbursement cuts.

Statistical Analysis

We used an interrupted time-series analysis with a longitudinal quasi-experimental design to evaluate the impact of FFS-based reimbursement cuts on processes and outcomes of care for stroke. Using segmented autoregressive integrated moving average (ARIMA) models, we examined the changes in the rates of receiving CT/MRI, antiplatelet/anticoagulant, statin, physiotherapy/occupational therapy assessment, and 30-day mortality in each quarter. After controlling for baseline levels, trends, and other covariates, we used the models to estimate the changes in the levels and trends of the rates after the implementation of FFS-based reimbursement cuts. The unit of analysis was time in quarters. The data were aggregated across the whole country at the population level. Therefore, there were 56 lines of data. Our data consisted of continuous measurements of variables at the population level, summarized at regular, evenly spaced time intervals, making them suitable for an interrupted time-series analysis. We used aggregated time-series data at the population level and thus our analyses were not affected by clustering bias. To estimate changes in the rates of health service provisions and stroke mortality after the intervention, we used segmented ARIMA models controlling for level and trend before the implementation of FFS-based reimbursement cuts, proportion of male patients, average age, average comorbidity index, rates of ICU use and surgery, seasonal effects, 3 autoregressive terms, and 1 moving average term, which are described in detail in the Data Supplement. A segmented ARIMA analysis can examine the changes in levels and trends that follow an intervention. A change in level, for example, a jump or drop in the outcome after the intervention, constitutes an abrupt intervention effect. A change in trend is defined by an increase or decrease in the slope of the segment after the intervention compared with the segment preceding the intervention.

SAS (version 9.2) and SPSS (version 20) statistical software were used for the analysis. The final model was evaluated based on the mean absolute percentage error or the mean absolute error. A lower mean absolute percentage error/mean absolute error value indicates a better fit of the data. The mean absolute percentage error is defined as the average absolute difference between the actual value and the forecast value divided by the actual value. The mean absolute error is defined as the average absolute difference between the actual value and the forecast value. The Ljung-Box Q statistic was also used to evaluate the null hypothesis that the residuals are white noise, that is, that the model is well fit to the data. In an adequately fitted model, the null hypothesis is not rejected.

Whether the effect of FFS-based reimbursement cuts on stroke outcomes might be explained by certain processes of care was judged based on mediational analysis. A process-of-care variable functions as a mediator between the independent variable (FFS-based reimbursement cuts) and the dependent variable (30-day mortality) when it meets the following conditions: (1) the independent variable significantly affects the dependent variable, (2) the mediator significantly affects the dependent variable, (3) the independent variable significantly affects the dependent variable before controlling for the mediator, and (4) when the mediator is controlled, the magnitude of the relationship between the independent variable and the dependent variable becomes weaker. A variable that is part of the causal chain leading from the independent variable to the dependent variable is a mediator rather than a confounder. The mediator should not be adjusted for in the analysis of the independent-dependent association because controlling for the mediator would lead to an underestimate of the independent-dependent association.

Finally, because we selected the first admission for patients with multiple ischemic stroke admissions based on prior related research, we conducted a sensitivity analysis with all those patients with multiple stroke admissions included to see whether the analysis results differ from the primary results. A 2-tailed significance level of 0.05 was used to determine statistical significance.

Results

Descriptive Trends

Table 1 presents patient characteristics during the study period, 1997 to 2010 (N=411,487). The percentage of male patients increased slightly from 57.8% in 1997 to 59.5% in 2010. The mean age of patients also increased slightly from 67.9 to 69.1 years. The mean Charlson–Deyo index increased from 0.52 in 1997 to 0.68 in 2004 and thereafter leveled off. The percentage of patients who had ≥1 ICU stay increased steadily from 9.9% to 17.3%.

Figures 1 and 2 show processes and outcomes of care for patients with stroke from 1997 to 2010. Before global budgeting, there were stable trends in the rates of CT/MRI scans and physiotherapy/occupational therapy assessment; after global budgeting, the rates increased over time. The rates of antiplatelet/anticoagulant therapy and statin use showed increasing trends before global budgeting, after which the increasing trends slowed down and sped up, respectively. The percentage
of patients receiving CT or MRI scans was stable from 75.3% in 1997 to 75.6% in 2002 and then increased to 80.0% in 2010. The percentage of patients receiving antiplatelet/anticoagulant therapy increased from 80.5% in 1997 to 89.0% in 2002 and then increased slightly to 92.8% in 2010. The percentage of patients receiving statin therapy increased from 3.1% in 1997 to 12.0% in 2002 and then increased rapidly to 30.0% in 2010. The percentage of patients receiving physiotherapy/occupational therapy assessment increased slightly from 39.0% in 1997 to 41.1% in 2002 and then increased rapidly to 51.8% in 2010. The 30-day mortality rate showed a decreasing trend before global budgeting, after which the trend became less negative. The 30-day mortality rate decreased significantly from 5.7% in 1997 to 4.6% in 2002 and then decreased slightly to 4.2% in 2010.

Segmented ARIMA Analysis
Tables 2 and 3 present the results of the segmented ARIMA analyses examining the long-term association of FFS-based reimbursement cuts from global budgeting with processes and outcomes of stroke care. ARIMA(3,0,1) models (third-order autoregressive combined with first-order moving average with no differencing) were used. Before global budgeting, there was no significant quarter-to-quarter change in the rate of receiving CT/MRI (P value for baseline trend=0.483). Right after global budgeting, the rate of receiving CT/MRI jumped abruptly by 4.21% per quarter (P=0.026). The increasing rate of receiving CT/MRI after global budgeting was 0.31% per quarter more than before (P=0.013). The increasing rate of antiplatelet/anticoagulant therapy before global budgeting was 0.29% per quarter (P<0.001). The decreasing rate of antiplatelet/anticoagulant therapy after global budgeting was 0.20% per quarter compared with the quarterly trend before global budgeting (P<0.001), so the increasing rate became slow (0.09% per quarter). The rate of statin use showed an increasing trend before global budgeting at a rate of 0.27% per quarter (P=0.006); after global budgeting, the rate increased more rapidly (trend change, 0.18%; P=0.027). The rate of physiotherapy/occupational therapy assessment showed an increasing trend after global budgeting at a rate of 0.25% per quarter (P<0.001).

Before global budgeting, the 30-day mortality showed a decreasing trend at a rate of −0.11% per quarter (P<0.001);
however, the rate slowed down (−0.05% per quarter) after global budgeting (trend change, 0.06%; \(P<0.001\)). According to mediational analysis, the rate of antiplatelet/anticoagulant therapy was added into model 2. The rate of antiplatelet/anticoagulant therapy was not a mediator. Because the trend in the rate of antiplatelet/anticoagulant therapy was not associated with the trend in 30-day mortality (\(P=0.127\)), the rate of antiplatelet/anticoagulant therapy could not account for the association between global budgeting and 30-day mortality. Finally, the results from the sensitivity analysis with all those patients with multiple stroke admissions included were similar to the primary results. Only primary results, not the sensitivity analysis, are presented here.

**Discussion**

This study used nationwide longitudinal population-based data and quasi-experimental study designs to evaluate the long-term association of FFS-based reimbursement cuts from global budgeting with processes and outcomes of stroke care for 14 years. A simple before and after analysis would have produced spurious effects of FFS-based reimbursement cuts because of the lack of control for secular trends and other covariates. Our study, using a time-series analysis, showed that the implementation of the FFS-based reimbursement cuts had independent (trend changes) effects on processes and outcomes of stroke care. After the implementation of FFS-based reimbursement cuts, there were increasing trends in CT/MRI use and physiotherapy/occupational therapy assessment. The increasing trends in statin therapy sped up, however, the increasing trend in antiplatelet/anticoagulant use and the decreasing trend in 30-day mortality slowed down.

The finding of the increasing trend in the rate of patients with stroke receiving CT/MRI after FFS-based reimbursement cuts is similar to that of Jacobs et al.\(^4\) One possible reason for the increase in imaging use in patients with stroke is that CT/MRI scanning has been gradually regarded as an important examination for

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**Table 2.** Segmented Autoregressive Integrated Moving Average Analysis of Processes of Stroke Care

<table>
<thead>
<tr>
<th></th>
<th>CT/MRI Use Rate, %</th>
<th>Antiplatelet/Anticoagulant Use Rate, %</th>
<th>Statin Use Rate, %</th>
<th>Physiotherapy/Occupational Therapy Assessment Use Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline trend</strong></td>
<td>(\beta)</td>
<td>(SE)</td>
<td>(P) Value</td>
<td>(\beta)</td>
</tr>
<tr>
<td>Level change after global budgeting</td>
<td>4.21</td>
<td>1.83</td>
<td>0.026</td>
<td>1.09</td>
</tr>
<tr>
<td>Trend change after global budgeting</td>
<td>0.31</td>
<td>0.12</td>
<td>0.013</td>
<td>−0.20</td>
</tr>
<tr>
<td>Percentage of male patients, %</td>
<td>−0.14</td>
<td>0.29</td>
<td>0.642</td>
<td>0.00</td>
</tr>
<tr>
<td>Mean patient age</td>
<td>−1.60</td>
<td>1.36</td>
<td>0.246</td>
<td>0.25</td>
</tr>
<tr>
<td>Mean Charlson score</td>
<td>22.13</td>
<td>14.75</td>
<td>0.141</td>
<td>11.27</td>
</tr>
<tr>
<td>ICU use rate, %</td>
<td>−0.59</td>
<td>0.35</td>
<td>0.097</td>
<td>0.02</td>
</tr>
<tr>
<td>Surgery use rate, %</td>
<td>−1.42</td>
<td>1.22</td>
<td>0.254</td>
<td>−0.45</td>
</tr>
<tr>
<td>First quarter</td>
<td>0.00</td>
<td>0.64</td>
<td>0.999</td>
<td>−0.19</td>
</tr>
<tr>
<td>Second quarter</td>
<td>−0.82</td>
<td>0.69</td>
<td>0.242</td>
<td>0.59</td>
</tr>
<tr>
<td>Third quarter</td>
<td>−1.71</td>
<td>0.66</td>
<td>0.013</td>
<td>0.36</td>
</tr>
<tr>
<td>AR1</td>
<td>1.76</td>
<td>0.30</td>
<td>&lt;0.001</td>
<td>1.33</td>
</tr>
<tr>
<td>AR2</td>
<td>−1.10</td>
<td>0.39</td>
<td>0.007</td>
<td>−0.36</td>
</tr>
<tr>
<td>AR3</td>
<td>0.27</td>
<td>0.23</td>
<td>0.251</td>
<td>−0.23</td>
</tr>
<tr>
<td>MA1</td>
<td>1.00</td>
<td>9.72</td>
<td>0.919</td>
<td>0.99</td>
</tr>
<tr>
<td>Intercept</td>
<td>189.56</td>
<td>99.80</td>
<td>0.065</td>
<td>58.16</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.877</td>
<td>...</td>
<td>...</td>
<td>0.961</td>
</tr>
<tr>
<td>MAPE</td>
<td>1.390</td>
<td>...</td>
<td>...</td>
<td>0.623</td>
</tr>
<tr>
<td>MAE</td>
<td>1.069</td>
<td>...</td>
<td>...</td>
<td>0.538</td>
</tr>
<tr>
<td>Ljung-Box Q (18)</td>
<td>9.670</td>
<td>...</td>
<td>...</td>
<td>17.076</td>
</tr>
<tr>
<td>(df)</td>
<td>14</td>
<td>...</td>
<td>...</td>
<td>14</td>
</tr>
<tr>
<td>(P) value</td>
<td>0.786</td>
<td>...</td>
<td>...</td>
<td>0.252</td>
</tr>
</tbody>
</table>

\(AR\) indicates autoregressive; \(CT\), computed tomography; \(ICU\), intensive care unit; \(MAE\), mean absolute error; \(MA\), moving average; \(MAPE\), mean absolute percentage error; \(MRI\), magnetic resonance imaging.
Therefore, following the quality indicators suggested by clinical experts, doctors in Taiwan tend to prescribe more CT/MRI scans for patients with stroke, which seems reasonable. The other reasons may include high profit margins associated with imaging and payment incentives for imaging. Hospitals have a stronger incentive to provide more imaging services to preserve overall profit, probably because the margin for radiology is more favorable. In addition, because of FFS-based reimbursement cuts, a decrease in payment per CT/MRI scan leads to a lower positive unit contribution margin. Hospitals may perform more CT/MRI scans to cover the large capital investment.

The finding of an increasing trend in the rate of physiotherapy/occupational therapy assessment after reimbursement cuts is consistent with the findings of Latham et al45 on physiotherapy/occupational therapy. Latham et al 45 found an increase in the percentage of Medicare beneficiaries with 5 common conditions including acute stroke receiving physiotherapy/occupational therapy after the BBA. The contribution margins of physiotherapy and occupation therapy services are still positive. Moreover, rehabilitation services for stroke are often clinically indicated10,11; therefore, there is an increasing trend in the delivery of physiotherapy and occupation therapy assessment services after reimbursement cuts. About medication use, there were increasing trends in antiplatelet/anticoagulant use and statin use, which have been gradually regarded as important treatments for stroke. After reimbursement cuts, the increasing trend in antiplatelet/anticoagulant use slowed down, but the increasing trend in statin use sped up. Hospitals could provide more statins to make up for reimbursement cuts. This is probably because the margin for statin is more favorable.

The decreasing trend in 30-day mortality after stroke slowed down after reimbursement cuts from global budgeting. This finding is similar to the results of previous studies. Moreover, we found that the trend in antiplatelet/anticoagulant use was not associated with the trend in stroke outcomes. The reason why the decreasing trend in mortality rate slowed down was that hospitals might have adopted strategies to cope with reimbursement cuts, such as reducing services that were not related to the National Health Insurance claims or reducing personnel staffing, which accounts for a major proportion of a hospital’s operating cost. Previous studies showed that decreased nurse staffing, lower nurse education levels, and higher proportions of casual or temporary nurses were associated with higher mortality rates.46–50

Finally, we found that the time trend and the trend in ICU use were associated with the trend in mortality, but the trend in the Charlson–Deyo score was not. The Charlson–Deyo score and ICU use were used for adjustment of stroke complexity based on previous patient-level studies. The increasing trend in comorbidity burden is consistent with that of Tu and Gong. The trend in the Charlson–Deyo score was not associated with the trend in mortality but the time trend was associated with a decline in mortality, which implies advances in

### Table 3. Segmented Autoregressive Integrated Moving Average Analysis of 30-Day Mortality

<table>
<thead>
<tr>
<th>30-Day Mortality, %</th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>SE</td>
<td>P Value</td>
<td>β</td>
</tr>
<tr>
<td>Baseline trend</td>
<td>−0.11</td>
<td>0.01</td>
<td>&lt;0.001</td>
<td>−0.10</td>
</tr>
<tr>
<td>Level change after global budgeting</td>
<td>0.07</td>
<td>0.15</td>
<td>0.617</td>
<td>0.14</td>
</tr>
<tr>
<td>Trend change after global budgeting</td>
<td>0.06</td>
<td>0.01</td>
<td>&lt;0.001</td>
<td>0.05</td>
</tr>
<tr>
<td>Antiplatelet/anticoagulant use rate, %</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>−0.05</td>
</tr>
<tr>
<td>Percentage of male patients, %</td>
<td>−0.07</td>
<td>0.07</td>
<td>0.348</td>
<td>−0.09</td>
</tr>
<tr>
<td>Mean patient age</td>
<td>0.45</td>
<td>0.30</td>
<td>0.146</td>
<td>0.47</td>
</tr>
<tr>
<td>Mean Charlson score</td>
<td>−0.23</td>
<td>2.50</td>
<td>0.927</td>
<td>−0.52</td>
</tr>
<tr>
<td>ICU use rate, %</td>
<td>0.24</td>
<td>0.07</td>
<td>&lt;0.001</td>
<td>0.27</td>
</tr>
<tr>
<td>Surgery use rate, %</td>
<td>−0.01</td>
<td>0.21</td>
<td>0.973</td>
<td>−0.13</td>
</tr>
<tr>
<td>First quarter</td>
<td>0.54</td>
<td>0.17</td>
<td>0.002</td>
<td>0.51</td>
</tr>
<tr>
<td>Second quarter</td>
<td>−0.10</td>
<td>0.19</td>
<td>0.592</td>
<td>−0.05</td>
</tr>
<tr>
<td>Third quarter</td>
<td>−0.20</td>
<td>0.17</td>
<td>0.253</td>
<td>−0.16</td>
</tr>
<tr>
<td>AR1</td>
<td>0.50</td>
<td>0.21</td>
<td>0.020</td>
<td>0.56</td>
</tr>
<tr>
<td>AR2</td>
<td>−0.24</td>
<td>0.18</td>
<td>0.177</td>
<td>−0.31</td>
</tr>
<tr>
<td>AR3</td>
<td>0.06</td>
<td>0.20</td>
<td>0.768</td>
<td>0.08</td>
</tr>
<tr>
<td>MA1</td>
<td>1.00</td>
<td>3.99</td>
<td>0.804</td>
<td>1.00</td>
</tr>
<tr>
<td>Intercept</td>
<td>−22.62</td>
<td>20.27</td>
<td>0.271</td>
<td>−18.96</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.928</td>
<td>...</td>
<td>...</td>
<td>0.931</td>
</tr>
<tr>
<td>MAPE</td>
<td>3.899</td>
<td>...</td>
<td>...</td>
<td>3.778</td>
</tr>
<tr>
<td>MAE</td>
<td>0.184</td>
<td>...</td>
<td>...</td>
<td>0.180</td>
</tr>
<tr>
<td>Ljung-Box Q (18)</td>
<td>15.249</td>
<td>...</td>
<td>...</td>
<td>12.259</td>
</tr>
<tr>
<td>$d_f$</td>
<td>14</td>
<td>...</td>
<td>...</td>
<td>14</td>
</tr>
<tr>
<td>$P$ value</td>
<td>0.361</td>
<td>...</td>
<td>...</td>
<td>0.585</td>
</tr>
</tbody>
</table>

ICU indicates intensive care unit; MAE, mean absolute error; MAPE, mean absolute percentage error; and MRI, magnetic resonance imaging.
medicine and medical technology improve stroke outcomes. Our population-level model also confirms the individual-level finding that ICU use is associated with higher mortality.\textsuperscript{2,1,21,22} The use of ICU is regarded as a surrogate for severe stroke.\textsuperscript{21–23} Our study has limitations. First, in common with previous studies using large administrative databases, we did not have information on clinical details for risk adjustment. Nevertheless, we controlled for patient sex, age, comorbid conditions, ICU use, and surgical operation, which are also important for the adjustment of stroke complexity.\textsuperscript{2,1,8,22–25} Second, we lack data on the timing of use of processes of care such as antiplatelet use at discharge,\textsuperscript{11} so we could not assess the association of FFS-based global budgeting with these process measures. Third, we lack data on screening for dysphagia and stroke education used by the Centers for Medicare and Medicaid Services\textsuperscript{11,13} or blood pressure and cholesterol management because the processes of care are not reimbursed individually by Taiwan’s National Health Insurance Administration. This result was from Taiwan and there may be particular aspects of the Taiwan’s healthcare system that cannot be extrapolated to other healthcare systems.

There were improvement trends in processes and outcomes of care for stroke over time, and reimbursement cuts from the FFS-based global budget cap were associated with trend changes in them. The reimbursement cuts were associated with the increasing trends in CT/MRI use and physiotherapy/occupational therapy assessment to patients with stroke, and with the rapidly increasing use of statin therapy; however, they were also associated with the slowly increasing use of antiplatelet/anticoagulant therapy and the slowly decreasing trend in the 30-day mortality rate after stroke. In other words, the FFS-based reimbursement cuts may ensure the provision of profitable services to patients, but the reimbursement cuts may place pressure on hospitals to reduce unprofitable services or levels of nurse staffing, which are in turn associated with mortality. It is imperative that we reduce costs and improve value, but at the same time we need to pay more attention to identifying unexpected effects that are associated with slow improvements in outcomes of stroke care.

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Disclosures

None.

References


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