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AHA/ASA Get With The Guidelines ¡V Stroke Performance Indicators: Surveillance of Stroke Care in the Taiwan Stroke Registry

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Abstract

Background and Purpose: Stroke is a leading cause of death around the world. Improving quality of stroke care is a global priority despite the diverse healthcare economies across nations. The AHA/ASA Get With the Guidelines-Stroke (GWTG-Stroke) has shown significant impact in improving quality of stroke care in 790 US academic and community hospitals with broad implications in the country. The generalizability of GWTG-Stroke across national and economic boundaries remains to be tested. The Taiwan Stroke Registry (TSR) with 30,599 stroke admissions between 2006 and 2008 was used to assess the applicability of GWTG-Stroke in Taiwan.

Methods: TSR, sponsored by Taiwan Department of Health engaging 39 academic and community hospitals, covers broadly the entire country with 4 steps of quality control to ensure reliability of entered data. Five GWTG-Stroke performance measures and 1 safety indicator are applicable to assess TSR quality of stroke care.

Results: Demographic and outcome figures are comparable between GWTG-Stroke and TSR. Two indicators (early and discharge antithrombotics) are close to GWTG-Stroke standards while 3 other (IV tPA, anticoagulation for atrial fibrillation, lipid-lowering medication) and 1 safety indicator fall behind. Preliminary analysis shows compliance with selected GWTG-Stroke guidelines is associated with better outcomes.

Conclusions: Results suggest GWTG-Stroke performance measures, with modification for ethnic factors, can be global standards across national and economic boundaries for assessing and improving quality of stroke care and outcomes. GWTG-Stroke can be incorporated into ongoing stroke registries across nations.

Key Words: stroke registry, stroke care, quality performance

With the efficacy of thrombolytic therapy within a limited time window confirmed in clinical trials[1], initiatives have been actively taken to improve the quality of stroke care in the US. [2, 3] This was followed by the implementation of the American Heart Association/American Stroke Association Get With the Guidelines–Stroke program (GWTG-Stroke).[4] GWTG-Stroke was the first large-scale nation-wide assessment of the quality of stroke care based on a set of predefined performance measures in the US. The 790 participating hospitals showed substantial and sustained improvement in quality of stroke care over time. The significant impact of GWTG-Stroke on a large number of hospitals broadly covering both academic as well as community settings suggests the generalizability of this program across the nation.[4]

Stroke is the second leading cause of death globally[5] with nations of diverse health care systems facing similar medical and economic burdens.[6] Whether the successful GWTG-Stroke is applicable beyond the US remains to be tested. A key determinant that may prevent broad application of GWTG-Stroke around the world is the diverse healthcare economies. □ It could be difficult for nations spending substantially less in healthcare dollars to apply GWTG-Stroke standards. To examine whether GWTG-Stroke is workable across nations with substantial disparity in health expenditure, we applied GWTG-Stroke to assess quality of stroke care in Taiwan. Like the US, stroke is the third leading cause of death in Taiwan. In 2008, the total cost of stroke in the US, with 780,000 new or recurrent stroke cases, was estimated to be $65.5 billion with direct (medical) costs constituting two thirds or 43.6 billion.[5] Taiwan with a population of 23 million, 1/13 of the US size with approximately 80,000 new or recurrent strokes a year, spent a total of US$ 375 million in medical costs for stroke in 2007.[7] The total medical costs per new or recurrent stroke patient were approximately one-tenth of those spent in the US.[5] The Taiwan Stroke Registry

(TSR) is an appropriate program to assess the generalizability of GWTG-Stroke across national as well as economic boundaries. TSR, sponsored by DOH, was launched in 2006. With the exception of anticoagulation for deep vein thrombosis (DVT) and measures for smoking cessation, all the parameters adapted by GWTG-Stroke for assessing quality of stroke care have been included in TSR.

Materials and Methods

TSR design and the criteria for hospital selection

TSR is the first nation-wide effort to establish a reliable national stroke database for assessing the quality of stroke care and for identifying areas that require improvement. TSR was designed and a TSR Operation Manual developed following a series of consensus conferences attended by an expert panel (16 stroke neurologists and 2 epidemiologists). The Operation Manual was revised after a 3-month pilot study to streamline the whole operation. Approval of TSR as a human study protocol and informed consent to be signed by the subjects giving permission for follow-up by TSR were obtained from the Institutional Review Board of each participating hospital. A total of 39 hospitals, caring for approximately 18% of all stroke patients in the nation, which had conformed to the TSR criteria (Online Appendix I) were included. TSR was formally launched on August 1, 2006. Based on National Health Insurance statistics, stroke admissions (ICD430-437, excluding 432 [subdural hemorrhage] and 435 [TIA]) in 2005, 77.41% of stroke admissions were categorized as ischemic and 22.59% hemorrhagic in comparison with the TSR data with 79.72% ischemic and 20.28% hemorrhagic. These findings suggest that TSR is representative of the national stroke figures.

Case ascertainment and case definition

TSR identified acute stroke admissions using a prospective design. All subjects met 1 of the 5 stroke type definitions, namely ischemic stroke, TIA, intracerebral hemorrhage (ICH), subarachnoid hemorrhage (SAH), and cerebral venous thrombosis (Online Appendix II) were entered if the following criteria were fulfilled: (1) presented within 10 days of symptom onset to a TSR hospital and (2) received examination including computed tomography (CT) or/and magnetic resonance

imaging (MRI) for this index event. Ischemic strokes were classified into 5 major subtypes according to the Trial of ORG 10172 in Acute Stroke Treatment (TOAST) criteria[8]: large artery atherosclerosis, small vessel occlusion, cardioembolism, specific etiology, and undetermined etiology.

Data collection

Data were compiled prospectively by TSR-trained neurologists and their study nurses. Investigators responsible for rating National Institutes of Health Stroke Scale (NIHSS) had to be certified by the Taiwan Stroke Society and trained for data entry through a web-based TSR database system. The key items in the TSR form include (1) pre-admission data: demographic profiles, past medical history, pre-admission medications, date and time of stroke onset and arrival at the emergency room (ER), arrival mode, vital signs and coma scale, times of first examination by ER doctors and neurologists respectively, NIHSS at ER, time of IV tPA treatment; (2) inpatient elements: clinical care during hospitalization, NIHSS at admission, evolution of symptoms and signs, in-hospital complications, stroke risk factors (Online Appendix III), electrocardiogram (ECG), CT and MRI findings, medications during admission and (3) discharge information: date, NIHSS, modified Rankin Scale (mRS), Barthel Index and medications and (4) follow-up at 1, 3 and 6 months includes disposition, mRS, Barthel Index and medications. The follow-up data were collected only from patients with written informed consents for follow-up evaluation. For 1-month follow-up, 95.2% of the patients were available; for 3-month, 90.6% and for 6 months, 87.8%. Laboratory results were categorized into two groups with or without fasting respectively (Online Appendix IV).

Assurance of data quality

Four quality assurance processes were used to ensure the quality of TSR. The

first is logic check for consistency. Only data with the key items completed and passed the logic check could be uploaded into the permanent databank. The second is random auditing of 5% of all cases entered into TSR first by web-based examination followed by on-site auditing by a contract research organization (CRO) independent of TSR to ensure the existence of the registered cases and accuracy of the data entered. The third process is matching TSR data with NHI billings for stroke care. Finally, a data quality review meeting has been held quarterly to review all the registry data and hospital enrollment record. Information security measures have also been implemented after DOH certification with periodic follow-up review based on the DOH Information Security Check and Privacy Enforcement Act.

Quality measures for stroke care and prevention

Five GWTG-Stroke performance measures and one safety indicator were used to assess the quality of acute stroke care and prevention[4], in patients with ischemic stroke and TIA. One of the GWTG-Stroke quality indicators on anticoagulant prophylaxis for DVT was not included because symptomatic DVT is very rare in immobilized patients including those with stroke in Asia.[9] There were only 69 DVT cases (0.2%) in TSR during the period of 2006 to 2008. GWTG-Stroke quality indicator on smoking cessation was also not included. Measures for smoking cessation are not paid by NHI and cannot be validated in medical records or based on NHI billings. Administration of tPA for acute ischemic stroke in Taiwan followed a protocol established by the Taiwan Stroke Society.[10] The composite measures, similar to those reported by GWTG-Stroke[4], were also derived based on 5 individual performance indicators.

Statistical analysis

A median with interquartile range was employed for variables including age,

arrival time, length of stay, and NIHSS to avoid the influence of outliers. The logistic regression model with generalized estimating equations (GEE)[11] accounting for within-hospital correlation was used to test the trends of performance and safety measures from 2006 to 2008. The linear regression model with GEE[11] was used to determine the extent of guideline adherence based on the composite measures. In Table 4, the unfavorable stroke functional outcome for the stroke performance indicator of IV tPA for 2hours is defined as mRS≧2 and the favorable functional outcome as mRS<2. For the other stroke performance indicators, risk of cardiovascular events and death were analyzed based on any cardiovascular event including stroke recurrence, ischemic cardiac event, or death from all causes within 1-, 3-, and 6-month post stroke. Multivariate logistic regression models were used to determine the effect of guideline adherence on outcomes based on four performance measures. Only the variables significant in univariate logistic regressions were applied in the multivariate logistic regression models. The variables used in the univariate logistic regressions were age, gender, hypertension, diabetes mellitus, ischemic heart disease, and NIHSS on admission. The statistical significance was set at a two-sided p value less than 0.05. Analyses were performed using the SAS statistical software 9.1 (SAS Institute, Cary, NC).

Results

By the end of September 2009, a total of 46,049 stroke or TIA events were registered. Among these, 30,599 admissions between May 1, 2006 and July 31, 2008 with follow-up data available were presented in this report. A total of 29,195 stroke patients contributed to these events and 20,512 (70.3%) had first-ever strokes. Among the 30,599 stroke events, the majority were ischemic (74.0%). Other stroke types in order of frequency were ICH (16.1%), TIA (6.7%), SAH (2.8%), and cerebral venous thrombosis (0.2%) (Table 1).

Patient characteristics in different stroke types

Patient characteristics including risk factors, and in-hospital mortality and disposition profiles in TSR were comparable with those in GWTG-Stroke[4] with a few exceptions. In TSR, the age was younger and body mass index smaller with fewer patients carrying the diagnosis of TIA (Table 2). There was a reversal of gender dominance: female in GWTG-Stroke vs. male in TSR. TSR hospital characteristics are comparable with the GWTG-Stroke report.[4] In general, the hospital sizes (median: 966 beds) are larger with annual stroke discharges per hospital greater in TSR than GWTG-Stroke. Proportion of hospitals participating in major teaching (43.6%) is comparable between TSR and GWTG-Stroke.

Guideline adherence based on GWTG-Stroke measures

Quality of stroke care and prevention based on GWTG-Stroke measures showed variations between GWTG-Stroke and TSR (Table 3). IV tPA for those ischemic patients admitted within 2 hours was 7.67% with slight improvement to 10.42% in 2 years as compared to an initial rate of 42.09% with improvement to 65.00% in 2 years in GWTG-Stroke.[4] The great majority of patients with ischemic stroke or TIA were prescribed antithrombotic therapy during hospitalization (94.14%) comparable to the

GWTG-Stroke figures. The prescription rate for antithromotics at discharge (85.54%) was lower than the GWTG-stroke figures of greater than 95%. Among patients with atrial fibrillation, 28.28% were prescribed warfarin and another 37.87% aspirin which is also a treatment option for patients with atrial fibrillation. Even with the combination of these 2 regiments, only 61.98% of TSR patients with atrial fibrillation received anticoagulant or aspirin prophylaxis, far below the GWTG-Stroke figures on anticoagulant prophylaxis for atrial fibrillation (95.03% at baseline with improvement to 97.85% in 2 years). Only 38.69% of patients with dyslipidemia were prescribed lipid-lowering drug at discharge in comparison to the corresponding GWTG-Stroke figures of greater than 73%. The composite measures (73.12%) were also lower than corresponding GWTG-Stroke figures (83.52% at baseline and 90.63% 2 years later). The rate of symptomatic ICH among patients receiving IV tPA therapy was 8.21%, which did not change significantly between 2006 and 2008 (range 6.78% to 9.41%, p=0.9078). The corresponding GWTG-Stroke figures are from 4.49% to 5.95%.[4]

Outcomes based on performance indicators

As shown in Table 4, functional outcomes based on mRS at 1- 3- and 6-month post stroke were better in those patients who were admitted within 2 hours of stroke onset and received IV tPA than those who were admitted within 2 hours of stroke onset but did not receive IV tPA after adjustment for variables including age, gender, hypertension, diabetes mellitus, ischemic heart disease, and NIHSS at admission. Reduction in the risk of cardiovascular events and death within 1- 3- and 6-month post stroke is noted in stroke patients who received antithrombotics at discharge as compared to those without. The same favorable outcomes were noted in those patients with atrial fibrillation who received anticoagulation at discharge as compared to those without. However, no apparent impact on outcomes was noted with lipid-lowering

agents.

Discussion

Improving the quality of stroke prevention and care is a global priority. Evidence-based therapeutic and preventive measures are available for ischemic stroke but remain underutilized even in the US. GWTG-Stroke, a landmark AHA/ASA initiative, showed substantial and sustained improvements based on predefined performance measures on quality of stroke care and prevention in 790 US hospitals. Whether GWTG-Stroke is applicable outside the US to benefit nations with different healthcare infrastructures and economies remains to be determined. We used TSR, a national stroke registry with stringent quality control of data entry, to explore the applicability of AHA/ASA GWTG-Stroke in a country which spends substantially less in healthcare dollars under a public health insurance program. Patient characteristics, including stroke types/subtypes, risk factor profile and mortality are largely comparable between TSR and GWTG-Stroke and stroke registries in Japan[12], the US[13], and other countries.[14, 15] TSR contains all performance measures collected for assessing quality of stroke care defined by GWTG-Stroke with the exceptions of anticoagulant prophylaxis for DVT and interventions for smoking cessation. Five performance indicators, the composite measures and a safety factor on the symptomatic ICH rate following IV tPA treatment in GWTG-Stroke could be derived from TSR by combing patients with ischemic stroke and TIA. Among the GWTG-Stroke parameters, early prescription of antithrombotics was followed in a rigorous manner comparable with the GWTG-Stroke figures (94.14% in TSR vs. 97.04 % in GWTG-Stroke). Antithrombotics upon discharge were prescribed at a lower rate (TSR: 85.54%; GWTG-Stroke: 98.88%). This could be attributed partly to

the local practice which does not favor aggressive stroke prevention in patients with poor functional outcomes (mRS < 4: 92.37%; mRS ≥ 4: 77.45%). This gap suggests more efforts are needed to improve quality of stroke prevention in Taiwan including those with poor functional outcomes, especially when more favorable outcomes were noted among those receiving antithrombotics upon discharge than those without. The lower DVT in Taiwan reflects a prevailing notion of relatively lower thrombo-embolic tendency in the Asian population. The other performance measures show substantial disparity between TSR and GWTG-Stroke. The most striking difference was IV tPA for those arriving within 2 hours of stroke onset. It was 8.84% in TSR vs. 72.84% in GWTG-Stroke. TSR data also show that only 1.5% of patients with ischemic stroke received IV tPA treatment, lower than that reported by the Paul Coverdell National Acute Stroke Registry in the United States (3.0%~8.5%)[13] and the German Stroke Registers Study Group (3.0%).[14] IV tPA is an important measure of the quality of stroke care and reflects readiness of a stroke center in treating stroke patients in an emergency setting with adequate facilities, staffing and training. The relatively late arrival of the stroke patients is a likely cause of the low IV tPA rate. Only 26.2% of TSR patients with ischemic stroke arrived within 2 hours of stroke onset to be in time for IV tPA treatment. More public education and more rigorous community outreach programs are needed. Together these findings suggest stroke centers in Taiwan are behind in fulfilling an important therapeutic measure in acute stroke care, especially when better functional outcomes were noted in patients with ischemic stroke who arrived within 2 hours and received tPA than those who also arrived within 2 hours but did not receive tPA. It should be noted that while IV tPA was approved by FDA in the US in 1996, it was not until 2004 when DOH approved NHI reimbursement for IV tPA treatment. A lag of 8 years could be a major reason

that TSR hospitals are not up to the level of GWTG-Stroke hospitals in IV tPA performance. In Germany with IV tPA approved in 2002, the figure (10.4%)[14] was also relatively low and comparable with Taiwan (8.84%). The GWTG-Stroke IV tPA performance indicator can serve as a yardstick for countries outside the US such as Taiwan and Germany to catch up.

Anticoagulant for patients with atrial fibrillation was prescribed at a substantially lower rate in TSR than GWTG-Stroke. Even with anticoagulant and antiplatelet regiments combined, only 61.98% of TSR patients with atrial fibrillation received anticoagulant or aspirin prophylaxis, far below the comparable GWTG-Stroke figures on anticoagulant prophylaxis for atrial fibrillation (97.85%). This finding indicates that an important preventive measure is in great need of improvement in Taiwan, especially when the impact of anticoagulation on outcomes is favorable in TSR. It should be noted that only 30.5% of patients with atrial fibrillation received anticoagulant prophylaxis in a recent Germany study.[16] GWTG-Stroke performance on this stroke prevention measure offers another global standard for countries like Taiwan and Germany to improve.

Only 38.69% of patients with dyslipidemia were on lipid-lowering drug at discharge. The corresponding GWTG-Stroke figures were greater than 73%. According to the NHI guideline in Taiwan, the lipid-lowering medication can be reimbursed only when the LDL level is greater than 130 mg/dl, which is higher than the GWTG-Stroke standard (LDL > 100 mg/dl). Discrepancy between TSR and GWTG-Stroke on this parameter raises the need for NHI in Taiwan to review the lipid-lowering guidelines for changing reimbursement policies. Lack of impact of lipid-lowering medications on outcomes could be related to a relatively short follow-up period (6 months).

The composite measures (73.12%) were also lower than corresponding GWTG-Stroke figures. In contrast to an improvement from 83.52% at baseline to 90.63% in 2 years, corresponding TSR numbers failed to show improvement with time. It should be noted that TSR had started before GWTG-Stroke results were published. Furthermore, DOH did not mandate improvement in quality in TSR over time. However, the impressive advances in the GWTG-Stroke 790 hospitals suggest that implementing GWTG-Stroke in TSR is likely to improve quality of stroke care.

The rate of symptomatic ICH among patients receiving IV tPA therapy was 8.21%, higher than the GWTG-Stroke figures (4.49% to 5.95%) or other US numbers (6.4% in the NINDS tPA trial[1] and 6.0% in the multicenter rt-PA acute stroke survey[17]). This safety indicator is another important objective for TSR hospitals to improve. The IV tPA guidelines established by the Taiwan Stroke Society follow the same tPA dosage used in the US. The tPA dosage received by TSR patients, however, was lower than the recommended dosage of 0.9mg/kg in more than half of the patients. The lower tPA dosage in a subset of TSR hospitals has been reported recently.[18] Lower tPA dosage (0.6 mg/kg) has been shown to achieve comparable safety and efficacy in Japan.[19] Further studies are needed to establish the efficacy of a smaller tPA dosage in Taiwan.

TSR does not contain a performance measure on compliance with anticoagulant prophylaxis for DVT because it is rarely symptomatic among Asians.[9] The low symptomatic rate of DVT in TSR patients (only 0.2%) is consistent with the earlier observation.[9] Thus, this GWTG-Stroke performance measure may not be applicable in Taiwan. However, recent ultrasonographic studies found high incidence (16-45%) of DVT, mostly asymptomatic, among stroke patients in Japan and Singapore.[20, 21] We will explore the merit of adding DVT prophylaxis as a performance indicator by

searching for asymptomatic DVT among TSR patients in the future.

TSR data show that smoking, noted in 39.8% of patients, is also an important risk factor, especially in males (62.1%). Smoking could increase stroke risk by 2- to 4-fold.[22] According to the 2007 annual DOH report in Taiwan[23], smoking rates in males and females over the age of 18 years were 38.9% and 5.1%, respectively. Thus, smoking cessation should be an important initiative for stroke prevention. Because measures for smoking cessation are not payable based on the current NHI reimbursement policies, validation of measures taken for smoking cessation by the participating hospitals was not possible in TSR. However, TSR findings substantiate smoking as a major stroke risk factor. GWTG-Stroke has insightfully made smoking cessation one of the 7 performance measures. Implementation of smoking cessation measures for stroke prevention should be a top priority in future revisions of NHI reimbursement policies in Taiwan.

Schwamm et al. found that differences in quality of care defined by 7 performance measures had no measurable impact on short-term in-hospital outcomes. These GWTG-Stroke leaders suggest that the association between quality of care and outcomes will require analysis of post discharge (eg, day 90 or 1 year) health status, stroke disability, and mortality.[24] Fonarow et al. reported a reduced risk-adjusted in-hospital mortality rate in GWTG-Stroke hospitals. This same group of GWTG-Stroke leaders recommend further study to determine if these improvements in mortality are due to improvement in guideline-adherence.[25] In TSR data, outcomes based on mRS at 1-, 3- and 6-month post stroke or risks of cardiovascular events and death at 1-, 3- and 6-month post stroke are available. Patients receiving IV tPA within 2 hours of stroke onset, patients receiving antithrombotics at discharge or patients with atrial fibrillation receiving anticoagulation at discharge had better outcomes than

the corresponding groups without these therapies based on GWTG-Stroke guidelines. The favorable outcomes associated with adherence to selected GWTG guidelines should be interpreted with caution because of possible inherent biases. However, these preliminary results are encouraging and provide a stronger drive for adherence to GWTG guidelines to overcome the inertia in improving stroke prevention and treatment performance in Taiwan.

Taiwan has an excellent public health insurance program that provides comprehensive medical services to its citizens with little co-payments from the insured. However, data collected in the TSR, while presenting a reliable national stroke profile, reveal that several performance indicators that gauge quality of acute stroke care and prevention in Taiwan need to be improved to reach the GWTG levels. More efforts and more resources from the community, healthcare providers and the governments at different levels have to be devoted to improve the quality of stroke care and prevention in Taiwan. Based on the TSR findings and corresponding numbers noted in other countries (e.g., Germany), GWTG-Stroke performance measures, with some exceptions (e.g., anticoagulant for DVT prophylaxis), are applicable to countries outside the US with different healthcare systems and economies. The GWTG-Stroke figures can serve as important global standards for improving quality of care and prevention around the world. An important feature of GWTG-Stroke is its impact in improving quality of stroke care over time. Applying GWTG-Stroke in TSR and registries in other countries is likely to be an effective mechanism for quality improvement.

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References

1. Tissue plasminogen activator for acute ischemic stroke. The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. *N Engl J Med.* 1995;333(24):1581-1587.

2. Adams R, Acker J, Alberts M, Andrews L, Atkinson R, Fenelon K, Furlan A, Girgus M, Horton K, Hughes R, Koroshetz W, Latchaw R, Magnis E, Mayberg M, Pancioli A, Robertson RM, Shephard T, Smith R, Smith SC, Jr., Smith S, Stranne SK, Kenton EJ, 3rd, Bashe G, Chavez A, Goldstein L, Hodosh R, Keitel C, Kelly-Hayes M, Leonard A, Morgenstern L, Wood JO. Recommendations for improving the quality of care through stroke centers and systems: an examination of stroke center identification options: multidisciplinary consensus recommendations from the Advisory Working Group on Stroke Center Identification Options of the American Stroke Association. *Stroke.* 2002;33(1):e1-7.

3. Schwamm LH, Pancioli A, Acker JE, 3rd, Goldstein LB, Zorowitz RD, Shephard TJ, Moyer P, Gorman M, Johnston SC, Duncan PW, Gorelick P, Frank J, Stranne SK, Smith R, Federspiel W, Horton KB, Magnis E, Adams RJ. Recommendations for the establishment of stroke systems of care: recommendations from the American Stroke Association's Task Force on the

Development of Stroke Systems. *Circulation*. 2005;111(8):1078-1091.

4. Schwamm LH, Fonarow GC, Reeves MJ, Pan W, Frankel MR, Smith EE, Ellrodt G, Cannon CP, Liang L, Peterson E, Labresh KA. Get With the Guidelines-Stroke is associated with sustained improvement in care for patients hospitalized with acute stroke or transient ischemic attack. *Circulation.* 2009;119(1):107-115.

5. Di Carlo A. Human and economic burden of stroke. *Age Ageing*. 2009;38(1):4-5.

6. Johnston SC, Mendis S, Mathers CD. Global variation in stroke burden and mortality: estimates from monitoring, surveillance, and modelling. *Lancet Neurol.* 2009;8(4):345-354.

7. Department of Health, Executive Yuan, Taiwan. Inpatient medical benefit claims of major illness/injury 2007. Available at: http://www.doh.gov.tw/CHT2006/DM/DM2_2.aspx?now_fod_list_no=10902&class_no=440&level_no=2. Accessed December 15, 2009.

8. Adams HP, Jr., Bendixen BH, Kappelle LJ, Biller J, Love BB, Gordon DL, Marsh EE, 3rd. Classification of subtype of acute ischemic stroke. Definitions for use in a multicenter clinical trial. TOAST. Trial of Org 10172 in Acute Stroke Treatment. *Stroke.* 1993;24(1):35-41.

9. Keenan CR, White RH. The effects of race/ethnicity and sex on the risk of venous thromboembolism. *Curr Opin Pulm Med.* 2007;13(5):377-383.

10. The guideline for IV tPA treatment. Taiwan Stroke Society. Available at: http://www.stroke.org.tw/guideline/guideline_3.asp. Accessed December 15, 2009.

11. Zeger SL, Liang KY. Longitudinal data analysis for discrete and continuous outcomes. *Biometrics.* 1986;42(1):121-130.

12. Kobayashi S. International experience in stroke registry: Japanese Stroke Databank. *Am J Prev Med.* 2006;31(6 Suppl 2):S240-242.

13. Reeves MJ, Arora S, Broderick JP, Frankel M, Heinrich JP, Hickenbottom S, Karp H, LaBresh KA, Malarcher A, Mensah G, Moomaw CJ, Schwamm L, Weiss P. Acute stroke care in the US: results from 4 pilot prototypes of the Paul Coverdell National Acute Stroke Registry. *Stroke.* 2005;36(6):1232-1240.

14. Heuschmann PU, Berger K, Misselwitz B, Hermanek P, Leffmann C, Adelmann M, Buecker-Nott HJ, Rother J, Neundoerfer B, Kolominsky-Rabas PL. Frequency of thrombolytic therapy in patients with acute ischemic stroke and the risk of in-hospital mortality: the German Stroke Registers Study Group. *Stroke.* 2003;34(5):1106-1113.

15. Silver FL, Kapral MK, Lindsay MP, Tu JV, Richards JA. International

experience in stroke registries: lessons learned in establishing the Registry of the Canadian Stroke Network. *Am J Prev Med.* 2006;31(6 Suppl 2):S235-237.

16. Weimar C, Benemann J, Katsarava Z, Weber R, Diener HC. Adherence and quality of oral anticoagulation in cerebrovascular disease patients with atrial fibrillation. *Eur Neurol.* 2008;60(3):142-148.

17. Tanne D, Kasner SE, Demchuk AM, Koren-Morag N, Hanson S, Grond M, Levine SR. Markers of increased risk of intracerebral hemorrhage after intravenous recombinant tissue plasminogen activator therapy for acute ischemic stroke in clinical practice: the Multicenter rt-PA Stroke Survey. *Circulation.* 2002;105(14):1679-1685.

18. Chao AC, Hsu HY, Chung CP, Liu CH, Chen CH, Teng MM, Peng GS, Sheng WY, Hu HH. Outcomes of thrombolytic therapy for acute ischemic stroke in Chinese patients: the Taiwan Thrombolytic Therapy for Acute Ischemic Stroke (TTT-AIS) Study. *Stroke.* 2010;41(5):885-890.

19. Yamaguchi T, Mori E, Minematsu K, Nakagawara J, Hashi K, Saito I, Shinohara Y. Alteplase at 0.6 mg/kg for acute ischemic stroke within 3 hours of onset: Japan Alteplase Clinical Trial (J-ACT). *Stroke.* 2006;37(7):1810-1815.

20. De Silva DA, Pey HB, Wong MC, Chang HM, Chen CP. Deep vein

thrombosis following ischemic stroke among Asians. *Cerebrovasc Dis.* 2006;22(4):245-250.

21. Kawase K, Okazaki S, Toyoda K, Toratani N, Yoshimura S, Kawano H, Nagatsuka K, Matsuo H, Naritomi H, Minematsu K. Sex difference in the prevalence of deep-vein thrombosis in Japanese patients with acute intracerebral hemorrhage. *Cerebrovasc Dis.* 2009;27(4):313-319.

22. Shinton R, Beevers G. Meta-analysis of relation between cigarette smoking and stroke. *BMJ.* 1989;298(6676):789-794.

23. Department of Health, Executive Yuan, Taiwan. 2007 Annual Report of the Bureau of Health Promotion. Available at: http://health99.doh.gov.tw/media/public/pdf/21592.pdf. Accessed December 15, 2009.

24. Schwamm LH, Reeves MJ, Pan W, Smith EE, Frankel MR, Olson D, Zhao X, Peterson E, Fonarow GC. Race/ethnicity, quality of care, and outcomes in ischemic stroke. *Circulation.* 2010;121(13):1492-1501.

25. Fonarow GC, Reeves MJ, Smith EE, Saver JL, Zhao X, Olson DW, Hernandez AF, Peterson ED, Schwamm LH. Characteristics, Performance Measures, and In-Hospital Outcomes of the First One Million Stroke and Transient Ischemic Attack Admissions in Get With The Guidelines-Stroke. *Circ Cardiovasc Qual*

Outcomes. 2010 Feb 22. [Epub ahead of print].

Table 1. Distribution of stroke types and subtypes

Type	*n*	%
Ischemic stroke*	22642	74.0
Large artery atherosclerosis	6270	27.7
Small vessel occlusion	8541	37.7
Cardioembolism	2465	10.9
Specific etiology	332	1.5
Undetermined etiology	5034	22.2
TIA	2053	6.7
ICH	4913	16.1
SAH	846	2.8
Cerebral venous thrombosis	46	0.2
Other	99	0.3
Total	30599	100.0

* TOAST criteria[8] were used to classify ischemic stroke subtypes.

TIA, transient ischemic attack; ICH, intracerebral hemorrhage;

SAH, subarachnoid hemorrhage; Other: stroke of more than one type

Table 2. Key variables in different stroke types

Items	Ischemic stroke/TIA n=24695	ICH n=4913	SAH n=846
Age (median, IQR)	69.9(59.6-77.9)	62.2(51.9-73.7)	57.6(47.4-70.4)
Gender			
Male (%)	59.8	65.7	40.7
Body mass index	24.3(22.0-26.8)	23.9(21.5-26.7)	23.5(21.2-26.0)
Arrival time (hour)* (median, IQR)	5.5 (1.8-19.7)	2.1 (0.9-5.2)	2.7 (0.9-7)
Length of stay (day) (median, IQR)	8 (5-15)	13 (7-29)	17 (7-33)
MRI (%)	61.4	10.8	11.0
CT (%)	92.1	98.6	99.3
NIHSS (admission) (median, IQR)	5 (2-9)	10 (4-21)	4 (0-18)
Medical history (%)			
Atrial fibrillation	16.5	6.4	5.4
Previous stroke/TIA	34.1	24.1	8.4
CAD/prior MI	13.6	6.9	4.7
Carotid stenosis	10.6	-	-
Diabetes mellitus	45.4	37.0	37.2
Hypertension	79.2	84.9	65.3
Dyslipidemia	49.4	29.4	20.5
Obesity	23.7	22.7	17.8
Ever smoking	40.4	38.4	31.3
Male	63.4	55.8	61.9
Female	6.3	5.5	10.6

Discharge destination (%)			
Home	88.9	69.6	71.4
Nursing home	5.6	11.4	6.0
Respiratory care ward	0.4	1.9	1.5
Transfer to other hospital	5.2	17.1	21.1
Died	4.0	17.9	29.0
Functional status[†]			
1-month mRS (%)			
0-1	6941(38.8)	577(21.4)	134(35.1)
≧2	10928(61.2)	2126(78.7)	248(64.9)
3-month mRS (%)			
0-1	7549(45.5)	729(29.6)	160(45.3)
≧2	9048(54.5)	1735(70.4)	193(54.7)
6-month mRS (%)			
0-1	7915(50.6)	824(35.8)	184(54.6)
≧2	7734 (49.4)	1481(64.3)	153(45.4)

Data are expressed as % or median (IQR; interquartile range, 25th–75th percentile).

[*] Only subjects with documented time of stroke onset were included.

[†] From patients with written informed consents.

Table 3. Performance measures in acute stroke care and prevention from 2006 to 2008 in the Taiwan Stroke Registry

Performance/safety measures (%)	2006	2007	2008	Total	Trend test β (SE), p value
Performance measures					
IV tPA for 2hr[*]	7.67	8.55	10.42	8.84	0.17 (0.09), 0.0581[#]
Antithrombotics during hospitalization[†]	92.39	94.54	94.76	94.14	0.21 (0.04), <0.001[#]
Antithrombotics at discharge[‡]	85.57	85.09	86.60	85.54	0.04 (0.03), 0.1012[#]
Anticoagulation for atrial fibrillation[§]	32.12	27.71	26.14	28.28	-0.15 (0.05), 0.0060[#]
Lipid-lowering drug at discharge[‖]	37.00	38.97	39.54	38.69	0.05 (0.03), 0.0629[#]
Safety measure					
Symptomatic ICH after IV tPA therapy	6.78	9.41	7.00	8.21	-0.03 (0.27), 0.9078[#]
Composite measure, mean±SD	74.00 ±4.59	74.20 ±5.82	73.19 ±6.32	73.12 ±5.33	0.02 (0.01), 0.0581※

[*]Patients with ischemic stroke presenting within 2 hours of symptom onset who received IV tPA within 3 hours of symptom onset.

[†]Antithrombotics (antiplatelet or anticoagulant) prescription for patients with ischemic stroke or TIA during hospitalization.

[‡]Antithrombotic (antiplatelet or anticoagulant) prescription for patients with ischemic stroke or TIA at discharge.

[§]Wafarin prescription for patients with ischemic stroke or TIA with atrial fibrillation at

discharge.

[‖]Lipid-lowering drug prescription for patients with ischemic stroke or TIA with LDL>100mg/dl or patients taking lipid lowering agents on admission.

[#]Trends of performance/safety measures from 2006 to 2008 were tested by the logistic regression model and ※composite measure by the linear regression model using generalized estimating equations accounting for within-hospital correlation.[11] SE: standard error.

Table 4. Outcomes based on performance indicators

	n	aOR[‡]	95% CI		p value
Functional outcomes (mRS)*: IV tPA for 2hr					
at 1-month post stroke	1240	0.51	0.33	0.77	0.0013
at 3-month post stroke	1043	0.47	0.32	0.70	0.0002
at 6-month post stroke	960	0.52	0.35	0.77	0.0010
Risk of cardiovascular events and death[†]: Antithrombotics at discharge					
within 1-month post stroke	17952	0.19	0.16	0.24	<.0001
within 3-month post stroke	16908	0.33	0.28	0.39	<.0001
within 6-month post stroke	16163	0.41	0.35	0.48	<.0001
Risk of cardiovascular events and death[†]: Anticoagulation for atrial fibrillation at discharge					
within 1-month post stroke	2496	0.28	0.16	0.51	<.0001
within 3-month post stroke	2319	0.51	0.35	0.74	0.0004
within 6-month post stroke	2190	0.59	0.44	0.80	0.0006
Risk of cardiovascular events and death[†]: Lipid-lowering agents at discharge					
within 1-month post stroke	8881	0.81	0.60	1.11	0.1977
within 3-month post stroke	8406	0.92	0.73	1.15	0.4437
within 6-month post stroke	8075	0.94	0.78	1.13	0.5142

[*] Functional outcomes were categorized as unfavorable with mRS≧2 at 1-,3-, and 6-month post stroke.

[†] Risk of cardiovascular events including stroke recurrence, ischemic cardiac event, or death from all causes within 1-, 3-, and 6-month post stroke.

[‡] aOR indicates adjusted odds ratio. Odds ratios (ORs) were adjusted for the variables which was significant in the univariate logistic regression model. The variables used in the univariate logistic regression were age, gender, hypertension, diabetes mellitus,

ischemic heart disease, and NIHSS at admission.