Dependent Variable	Warfarin Administration in AF Patients			
Independent Variables	B	S.E.	Exp(B)	P-value
Sex	-0.016	0.183	0.984	0.930
Age upon admission	-0.039	0.012	0.962	0.001
Surgery performed (excluding blood transfusions)	-0.323	0.281	0.724	0.251
Acute myocardial infarction	-0.348	0.479	0.706	0.467
Congestive heart failure	0.156	0.201	1.169	0.437
Peripheral vascular disease	-0.497	1.514	0.608	0.743
Dementia	-0.229	0.526	0.795	0.663
Chronic pulmonary disease	>10.000	>10.000	>10.000	1.000
Connective tissue disease	-1.873	0.763	0.154	0.014
Ulcer	-0.075	0.218	0.928	0.732
Liver disease	-0.233	0.225	0.792	0.300
Diabetes with chronic complications	0.417	0.650	1.517	0.521
Hemiplegia or paraplegia	0.152	0.359	1.164	0.672
Malignancy (excluding skin cancers)	0.068	0.438	1.071	0.876
Metastatic solid tumor	<-10.000	>10.000	0.000	0.999
DPC status	0.444	0.238	1.558	0.062
Teaching status	0.048	0.174	1.049	0.782
Private ownership	0.258	0.094	1.294	0.006
>300 beds	0.257	0.243	1.294	0.289
Quartile 1	-0.743	0.300	0.475	0.013
Quartile 2	-0.544	0.252	0.580	0.031
Quartile 3	-0.543	0.232	0.581	0.019
Constant	3.170	1.221	23.811	0.009
Hosmer Lemeshow P-value	0.330			
AUROC	0.701			

Dependent Variable	In-Hospital Mortality			
Independent Variables	B	S.E.	Exp(B)	P-value
Sex	-0.168	0.150	0.846	0.264
Age upon admission	0.080	0.009	1.083	<0.001
Surgery performed (excluding blood transfusions)	0.461	0.225	1.586	0.041
Acute myocardial infarction	0.213	0.370	1.237	0.565
Congestive heart failure	0.476	0.174	1.610	0.006
Peripheral vascular disease	0.667	0.499	1.948	0.181
Dementia	-0.384	0.424	0.681	0.365
Chronic pulmonary disease	1.833	0.956	6.255	0.055
Connective tissue disease	0.764	0.476	2.146	0.109
Ulcer	-0.291	0.186	0.748	0.118
Liver disease	0.112	0.184	1.119	0.542
Diabetes with chronic complications	-0.345	0.471	0.708	0.464
Hemiplegia or paraplegia	-0.619	0.367	0.538	0.092
Malignancy (excluding skin cancers)	0.320	0.286	1.377	0.263
Metastatic solid tumor	2.031	0.516	7.623	<0.001
DPC status	-0.134	0.197	0.875	0.497
Teaching status	0.022	0.139	1.022	0.877
Private ownership	0.000	0.075	1.000	0.998
>300 beds	-0.224	0.200	0.799	0.263
Quartile 1	-0.131	0.234	0.877	0.575
Quartile 2	-0.108	0.204	0.897	0.596
Quartile 3	-0.001	0.185	0.999	0.997
Constant	-7.172	0.926	0.001	<0.001
Hosmer Lemeshow P-value	0.118			
AUROC	0.739			

Dependent Variable	30-day Mortality			
Independent Variables	B	S.E.	Exp(B)	P-value
Sex	-0.073	0.178	0.930	0.682
Age upon admission	0.077	0.011	1.080	<0.001
Surgery performed (excluding blood transfusions)	-0.085	0.313	0.918	0.785
Acute myocardial infarction	1.043	0.350	2.837	0.003
Congestive heart failure	0.720	0.202	2.054	<0.001
Peripheral vascular disease	0.059	0.748	1.061	0.937
Dementia	-1.069	0.726	0.343	0.141
Chronic pulmonary disease	<-10.000	>10.000	0.000	0.999
Connective tissue disease	0.827	0.549	2.286	0.132
Ulcer	-0.340	0.233	0.711	0.144
Liver disease	0.021	0.228	1.021	0.928
Diabetes with chronic complications	0.486	0.411	1.626	0.237
Hemiplegia or paraplegia	-0.069	0.397	0.933	0.861
Malignancy (excluding skin cancers)	0.401	0.345	1.493	0.245
Metastatic solid tumor	-0.141	1.081	0.868	0.896
DPC status	0.083	0.242	1.087	0.731
Teaching status	0.342	0.180	1.407	0.058
Private ownership	0.023	0.083	1.024	0.780
>300 beds	-0.293	0.237	0.746	0.217
Quartile 1	-0.142	0.279	0.868	0.612
Quartile 2	-0.138	0.242	0.871	0.567
Quartile 3	-0.017	0.216	0.984	0.939
Constant	<-10.000	>10.000	0.000	0.997
Hosmer Lemeshow P-value	0.847			
AUROC	0.726			

Technical Appendix: Logistic regression models for each of the quality indicators. Spending quartiles 1, 2 and 3 were included as dummy variables in addition to the patient and hospital characteristics used as independent variables. Quartile 4 was used as the reference category. The number of observations for all models was 3,958, except for the model for warfarin administered to AF patients, which was 667. Early rehabilitation refers to rehabilitation provided within 30 days of admission. B: Coefficient; S.E.: Standard Error; AUROC: Area under Receiver Operating Characteristic Curve; DPC: Diagnosis Procedure Combination payment system; CT: Computer Tomography; MRI: Magnetic Resonance Imaging; t-PA: Tissue plasminogen activator; AF: Atrial Fibrillation

Quality and Costs of Health Care for Acute Stroke in Japan

Jason LEE, Tetsuya OTSUBO and Yuichi IMANAKA

Department of Healthcare Economics and Quality Management

Kyoto University, Japan

Introduction and Objective

The strain of an aging population have contributed to rising health care costs in Japan. Although the government (at national and local levels) are exploring cost-cutting measures, efforts must also be made to ensure that the quality of care is not reduced.

Regional variations in health care spending and quality have been extensively conducted in other countries [1-3]. Studies in the US have indicated that regional variations in health care spending in the US are not explained by patient case mix, and that the variations are likely due to provider-side factors [1-2], or "supply-sensitive care", which may have led to the overutilization of health care [4].

However, the relationship between regional variations in health care spending and quality of care has yet to be addressed in Japan. Japan has had a universal insurance system 1961, as well as a nationally-uniform reimbursement system for acute care hospitals known as the Diagnosis-Procedure Combination (DPC) prospective payment system implemented from 2003 onwards. These systems may reduce variations in hospital spending. Furthermore, as the DPC system precludes price competition to a large degree, hospitals have to compete in other factors such as quality, which should also reduce wide variations in quality. However, variations can still arise due to an uneven distribution of resources, such as the differential diffusion of technologies and an insufficient supply of physicians to rural regions.[5,6]

Stroke and other cardiovascular diseases remain a major cause of death and disability in Japan [7]. The burdens—both social and economic—of stroke are substantial, and quality of care may be influenced by the availability of resources such as specialist staff and stroke care units.

The objective of this study was to investigate the association between health care costs and quality of care in ischemic stroke patients in Kyoto prefecture, Japan.

Methods

Data

Hospital claims data from all hospitals and clinics in Kyoto prefecture were provided by the Kyoto National Health Insurance Organizations in a project conducted by the Kyoto Prefectural Government. These data included information on patient demographics, comorbidities upon admission, diagnostic and therapeutic procedures, administered medications, hospital ownership, size, teaching status, and DPC system status. This study was approved by the Kyoto University Graduate School and Faculty of Medicine, Ethics Committee (Registration Number E-1023).

Ischemic stroke patients were identified using International Classification of Diseases, 10th Revision (ICD-10) codes that signified admission due to a cerebral infarction (I63x). The study sample included admissions to hospitals in Kyoto prefecture between February 2009 and March 2010. The original sample size was 4,731 admissions.

Patients were excluded from analysis if they had been hospitalized for a previous cerebral infarction within 30 days before the index admission or if they were hospitalized for longer than 90 days. Municipalities with fewer than 10 cases during the study period were excluded from analysis. After exclusions, the final sample size was 3,958 admissions, 667 of which were admissions that presented with atrial fibrillation (AF).

Spending Categories

Age-sex adjusted health care spending per patient for ischemic stroke was calculated for the 37 municipalities (which include the 11 wards of Kyoto city). The municipalities were then categorized into quartiles based on the age-sex adjusted spending: The first quartile (Quartile 1) comprised of municipalities with the lowest spending, and Quartile 4 had the highest spending (Figure 1).

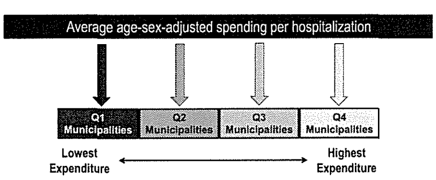

Figure 1. Categorization of municipalities in Kyoto prefecture, Japan by hospital spending

Quality of Care Indicators

Quality of care was assessed using the following stroke process indicators: (1) Computed Tomography (CT) scans or Magnetic Resonance Imaging (MRI) scans conducted during hospitalization; (2) Tissue plasminogen activator (t-PA) administration during hospitalization; (3) Antithrombotics administered during hospitalization; (4) In-hospital rehabilitation services; (5) Early rehabilitation (within 30 days of admission); (6) Rehabilitation for dysphagia; and (7) Warfarin-administered to patients with Atrial Fibrillation (AF). The performance in each quality indicator was calculated for each spending quartile categories.

Statistical Analyses

Logistic regression models were developed for each of the quality indicators to analyze their association with spending. The independent variables used in the models included the following patient characteristics: sex, age upon admission, any surgery performed (excluding blood transfusions), myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, mild liver disease, diabetes with chronic complications, hemiplegia or paraplegia, renal disease, any malignancy excluding skin cancers, and metastatic solid tumour. Also included in each regression model were the following hospital characteristics: DPC status, teaching status, hospital ownership and hospital size (>300 beds). Finally, using Quartile 4 (municipalities with the highest spending) as the reference category, the lower three quartiles were included in the regression models as dummy variables in order to analyze if the municipalities with lower spending had differential performance in the various quality indicators when compared to the high spending municipalities. All statistical analyses were conducted using SPSS, version 19. Statistical significance was set at P-value < 0.05 (two-tailed).

Results

	Health Care Spending Quartiles				
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	
Spending (Mean, USD)	10,657	11,623	12,440	13,407	
Municipalities	8	9	8	8	
Admissions (N)	629	952	1291	1086	
Patient Characteristics					P
Age (Mean, Years)	78.4	78.1	76.8	77.5	0.001
Female (%)	46.1	47.6	44.9	46.1	0.669
Length of Stay (Mean, Days)	25.8	27	25.9	25.7	0.471
Hospital Characteristics					
DPC system hospital (%)	54.5	46.4	58.9	75.8	<0.001
Teaching hospital (%)	65.3	72	61	64.8	<0.001
Private ownership (%)	38.6	56	56.2	57	<0.001
>300 beds (%)	34.3	67.2	60.6	64.8	<0.001

Table 1. Patient and hospital characteristics of the sample in each of the health care spending quartile categories. DPC: Diagnosis Procedure Combination payment system. P-values were calculated using ANOVA between spending categories.

Table 1 shows the patient and hospital characteristics in each of the health care spending quartiles.
The highest spending quartile had mean spending per patient that was 1.26 times that of Quartile 1. No significant variations were observed in sex or mean length of stay (LOS). However, patients in the lower quartiles were slightly older, and hospitals in higher quartiles had more DPC hospitals, private ownership and larger hospitals. Figure 2 shows the unadjusted performances of the various quality indicators through the spending quartiles. All indicators showed increasing use in the higher spending quartiles, although the rise in CT or MRI scans was observed to be very gradual.

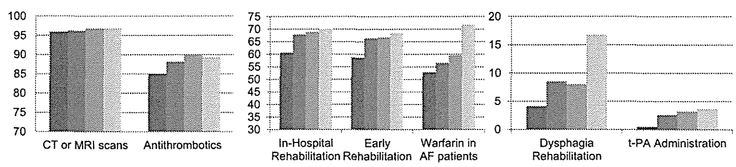

Figure 2. Unadjusted performance of the various quality indicators (given in percentages) through the spending quartiles.
Note: different scales on the Y-axes are used to clearly show the differences in performance among the spending quartiles.

Table 2 shows the results of logistic regression analyses of the various indicators and spending quartile, after correcting for various patient and hospital factors.

The results show that patients admitted to hospitals in municipalities within Quartile 1 were significantly less likely to be provided with the recommended services of t-PA and antithrombotics administration, in-*hospital rehabilitation*, early rehabilitation and dysphagia rehabilitation. Patients in Quartile 1 presenting with AF were also less likely to be administered warfarin during admission. In Quartile 2, patients were significantly less likely to be provided with dysphagia rehabilitation and warfarin administration in AF patients when compared to patients in Quartile 4. Patients from Quartile 3 were significantly less likely to be provided with dysphagia rehabilitation and warfarin when presenting with AF. In all quartiles, CT or MRI scans showed no significant associations with different levels of spending.

	Quartile 1		Quartile 2		Quartile	
Indicators	Odds Ratio	P	Odds Ratio	P	Odds Ratio	P
CT or MRI scans	0.81	0.463	0.83	0.464	1.06	0.822
t-PA Administration	0.15	0.003	0.75	0.291	0.98	0.946
Antithrombotics	0.66	0.012	0.86	0.325	1.05	0.729
In-Hospital Rehabilitation	0.68	0.001	0.89	0.235	0.94	0.525
Early Rehabilitation	0.71	0.003	0.92	0.394	0.94	0.525
Dysphagia Rehabilitation	0.24	<0.001	0.37	<0.001	0.42	<0.001
Warfarin in AF patients	0.48	0.013	0.58	0.031	0.58	0.019

Table 2. Results of regression analyses showing the relationship between the lower quartiles of spending and quality indicators (Quartile 4 was used as the referent category). Early rehabilitation refers to rehabilitation provided within 30 days of admission. CT: Computer Tomography; MRI: Magnetic Resonance Imaging; t-PA: Tissue plasminogen activator; AF: Atrial Fibrillation.

Discussion

In this study, we have analyzed the magnitude of regional variations in expenditure for hospitalization in ischemic stroke patients in Kyoto prefecture, Japan, and investigated the association between spending and quality of care.

Regions with the lowest health care costs were significantly associated with poorer performance in all but one of the process indicators, even after adjusting for variations in patient and hospital characteristics. This may indicate the existence of *resource-dependent* variations in care, where an uneven distribution of resources has led to an inadequate provision of specialist expertise and rehabilitation services in the lower spending regions. The results of the CT and MRI diagnostic tests may reinforce this concept, as the abundance of CT and MRI scanners in Japan may account for the similar performance for this indicator in all spending quartiles.

Care must be taken during the implementation of cost-reducing measures in order to ensure that the quality of care provided is not detrimentally affected, and further efforts must be made to improve the quality of care in regions with lower health care costs in Japan. This study helps us understand the relationship between spending and quality of health care in Japan.

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Quality and Costs of Health Care for Acute Stroke in Japan

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Abstract

Objectives: To investigate the association between health care costs and quality of care in ischemic stroke patients in Kyoto prefecture, Japan.

Methods: We analyzed patients who were admitted to acute care hospitals in Kyoto prefecture due to ischemic stroke between February 2009 and March 2010 using hospital claims data provided by the Kyoto National Health Insurance Organizations, in a project conducted by the Kyoto Prefectural Government. The municipalities in Kyoto prefecture were categorized into quartiles according to age-sex adjusted health care costs (from a third-party payer's perspective) for ischemic stroke admissions, with municipalities with the lowest costs in Quartile 1 and municipalities with the highest costs in Quartile 4. Logistic regression models were used to analyze the association between costs and the quality of care. Quality of care was assessed using stroke process indicators including (1) Computed Tomography (CT) scans or Magnetic Resonance Imaging (MRI) scans conducted during hospitalization; (2) Tissue plasminogen activator (t-PA) administration during hospitalization; (3) Antithrombotics administered during hospitalization; (4) In-hospital rehabilitation services; (5) Early rehabilitation (within 30 days of admission); (6) Rehabilitation for dysphagia; and (7) Warfarin-administered to patients with Atrial Fibrillation (AF). Regression models were developed for each of the quality indicators, and the independent variables in these models included patient age upon admission, sex, comorbidities, as well as hospital characteristics such as teaching status and hospital size. Using Quartile 4 (municipalities with the highest costs) as the reference category, the lower three quartiles were included in the regression models as dummy variables in order to analyze if patients from municipalities with lower cost had poorer performance in the various quality indicators.

Results: Mean health care costs per patient ranged from US$9,749 to US$14,303 from the lowest to highest municipalities, indicating a difference of 47%. Municipalities in Quartile 1 were significantly associated with poorer performance in all of the process indicators except for CT or MRI scans. Patients in Quartile 1 presenting with AF were also less likely to be administered warfarin during admission. In Quartile 2, patients were significantly less likely to be provided with dysphagia rehabilitation and warfarin administration in AF patients when compared to patients in Quartile 4. Patients from Quartile 3 were significantly less likely to be provided with dysphagia rehabilitation and warfarin when presenting with AF.

Conclusions: Regions with the lowest health care costs were significantly associated with poorer performance in all but one of the process indicators, even after adjusting for variations in patient and hospital characteristics. This may indicate an insufficient provision of resources and specialist expertise in the lower cost municipalities, leading to poorer performance in the quality indicators. Care must be taken during the implementation of cost-reducing measures in order to ensure that the quality of care provided is not detrimentally affected, and further efforts must be made to improve the quality of care in regions with lower health care costs in Japan

Introduction and Objective

The strain of an aging population has contributed to rising health care costs in Japan. Although the government (at national and local levels) is exploring cost-cutting measures, efforts must also be made to ensure that the quality of care is not reduced.

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Age-sex adjusted health care spending per patient for ischemic stroke was calculated for the 37 municipalities (which include the 11 wards of Kyoto city). The municipalities were then categorized into quartiles based on the age-sex adjusted spending: The first quartile (Quartile 1) comprised of municipalities with the lowest spending, and Quartile 4 had the highest spending (Figure 1).

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Quality of care was assessed using the following stroke process indicators: (1) Computed Tomography (CT) scans or Magnetic Resonance Imaging (MRI) scans conducted during hospitalization; (2) Tissue plasminogen activator (t-PA) administration during hospitalization; (3) Antithrombotics administered during hospitalization; (4) In-hospital rehabilitation services; (5) Early rehabilitation (within 30 days of admission); (6) Rehabilitation for dysphagia; and (7) Warfarin-administered to patients with Atrial Fibrillation (AF). The performance in each quality indicator was calculated for each spending quartile categories.

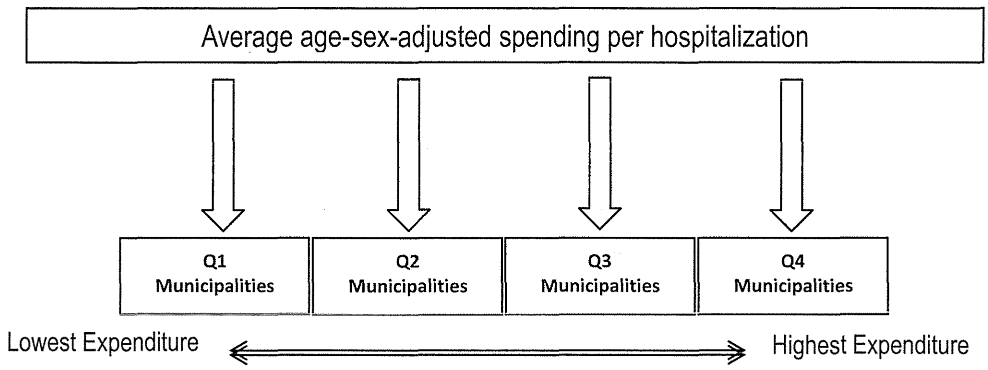

Figure 1. Categorization of municipalities in Kyoto prefecture, Japan by hospital spending

Statistical Analyses

Logistic regression models were developed for each of the quality indicators to analyze their association with spending. The independent variables used in the models included the following patient characteristics: sex, age upon admission, any surgery performed (excluding blood transfusions), myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, mild liver disease, diabetes with chronic complications, hemiplegia or paraplegia, renal disease, any malignancy excluding skin cancers, and metastatic solid tumour. Also included in each regression model were the following hospital characteristics: DPC status, teaching status, hospital ownership and hospital size (>300 beds). Finally, using Quartile 4 (municipalities with the highest spending) as the reference category, the lower three quartiles were included in the regression models as dummy variables in order to analyze if the municipalities with lower spending had differential performance in the various quality indicators when compared to the high spending municipalities. All statistical analyses were conducted using SPSS, version 19. Statistical significance was set at P-value < 0.05 (two-tailed).

Results

Table 1 shows the patient and hospital characteristics in each of the health care spending quartiles.

The highest spending quartile had mean spending per patient that was 1.26 times that of Quartile 1. No significant variations were observed in sex or mean length of stay (LOS). However, patients in the lower quartiles were slightly older, and hospitals in higher quartiles had more DPC hospitals, private ownership and larger hospitals. Figure 2 shows the unadjusted performances of the various quality indicators through the spending quartiles. All indicators showed increasing use in the higher spending quartiles, although the rise in CT or MRI scans was observed to be very gradual.

	Health Care Spending Categories				
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	
Spending (Mean, USD)*	10,657	11,623	12,440	13,407	
Municipalities	8	9	8	8	
Admissions (N)	629	952	1291	1086	
Patient Characteristics					*P*
Age (Mean, Years)	78.4	78.1	76.8	77.5	0.001
Female (%)	46.1	47.6	44.9	46.1	0.669
Length of Stay (Mean, Days)	25.8	27	25.9	25.7	0.471
Hospital Characteristics					
DPC system hospital (%)	54.5	46.4	58.9	75.8	<0.001
Teaching hospital (%)	65.3	72	61	64.8	<0.001
Private ownership (%)	38.6	56	56.2	57	<0.001
>300 beds (%)	34.3	67.2	60.6	64.8	<0.001

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Indicators	Quartile 1		Quartile 2		Quartile	
	Odds Ratio	*P*	Odds Ratio	*P*	Odds Ratio	*P*
CT or MRI scans	0.81	0.463	0.83	0.464	1.06	0.822
t-PA Administration	0.15	0.003	0.75	0.291	0.98	0.946
Antithrombotics	0.66	0.012	0.86	0.325	1.05	0.729
In-Hospital Rehabilitation	0.68	0.001	0.89	0.235	0.94	0.525
Early Rehabilitation	0.71	0.003	0.92	0.394	0.94	0.525
Dysphagia Rehabilitation	0.24	<0.001	0.37	<0.001	0.42	<0.001
Warfarin in AF patients	0.48	0.013	0.58	0.031	0.58	0.019

Table 2. Results of regression analyses showing the relationship between the lower quartiles of spending and quality indicators (Quartile 4 was used as the referent category). Early rehabilitation refers to rehabilitation provided within 30 days of admission. CT: Computer Tomography; MRI: Magnetic Resonance Imaging; t-PA: Tissue plasminogen activator; AF: Atrial Fibrillation.

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Discussion

In this study, we have analyzed the magnitude of regional variations in expenditure for hospitalization in ischemic stroke patients in Kyoto prefecture, Japan, and investigated the association between spending and quality of care.

Regions with the lowest health care costs were significantly associated with poorer performance in all but one of the process indicators, even after adjusting for variations in patient and hospital characteristics. This may indicate the existence of *resource-dependent* variations in care, where an uneven distribution of resources has led to an inadequate provision of specialist expertise and rehabilitation services in the lower spending regions. The results of the CT and MRI diagnostic tests may reinforce this concept, as the abundance of CT and MRI scanners in Japan may account for the similar performance for this indicator in all spending quartiles.

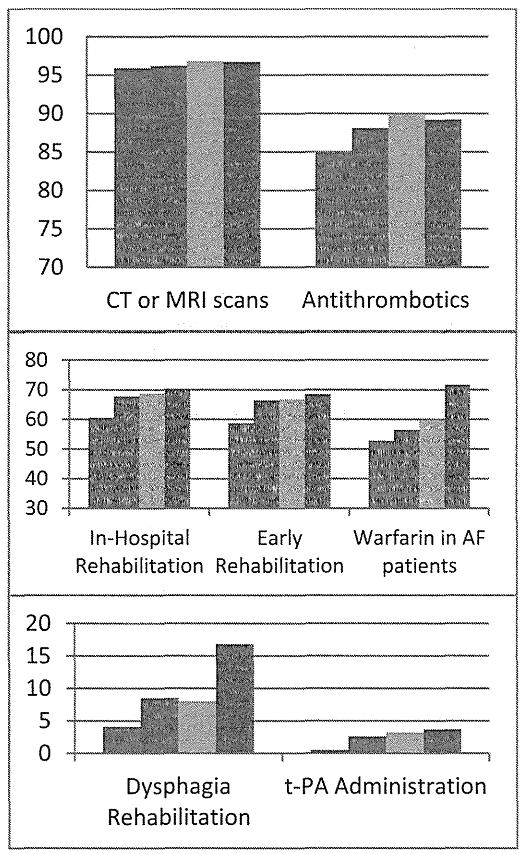

Figure 2. Unadjusted performance of the various quality indicators (given in percentages) through the spending quartiles. Note: different scales on the Y-axes are used to clearly show the differences in performance among the spending quartiles.

Care must be taken during the implementation of cost-reducing measures in order to ensure that the quality of care provided is not detrimentally affected, and further efforts must be made to improve the quality of care in regions with lower health care costs in Japan. This study helps us understand the relationship between spending and quality of health care in Japan.

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Title: Derivation and Validation of In-Hospital Mortality Prediction Models in Ischaemic Stroke Patients Using Administrative Data

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Keywords: acute ischemic stroke, risk factor, stroke, outcome predictive factors, Japan, mortality, administrative data

Word count: 3004 words

Abstract

Background: Stroke and other cerebrovascular diseases are a major cause of death and disability. Predicting in-hospital mortality in ischaemic stroke patients can help to identify high-risk patients and guide treatment approaches. Chart reviews provide important clinical information for mortality prediction, but are laborious and limiting in sample sizes. Administrative data allow for large-scale multi-institutional analyses but lack the necessary clinical information for outcomes research. However, administrative claims data in Japan has seen the recent inclusion of patient consciousness and disability information, which may allow more accurate mortality prediction using administrative data alone. The aim of this study was to derive and validate models to predict in-hospital mortality in patients admitted for ischaemic stroke using administrative data.

Methods: The sample consisted of 21 445 patients from 176 Japanese hospitals, who were randomly divided into derivation and validation subgroups. Multivariable logistic regression models were developed using 7-day, 30-day and overall in-hospital mortality as dependent variables. Independent variables included patient age, sex, comorbidities upon admission, Japan Coma Scale score, Barthel index score, modified Rankin Scale score, and admissions after hours and weekend/public holidays. Models were developed in the derivation subgroup, and coefficients from these models were applied to the validation subgroup. Predictive ability was analysed using C-statistics; calibration was evaluated with Hosmer-Lemeshow chi-squared tests.

Results: All three models showed predictive abilities similar or surpassing that of chart review-based models. The C-statistics were highest in the 7-day in-hospital mortality prediction model, at 0.906 and 0.901 in the derivation and validation subgroups, respectively. For the 30-day in-hospital mortality prediction models, the C-statistics for the derivation and validation subgroups were 0.893 and 0.872, respectively; in overall in-hospital mortality prediction, these values were 0.883 and 0.876.

Conclusions: In this study, we have derived and validated in-hospital mortality prediction models for three different time spans using a large population of ischaemic stroke patients in a multi-institutional analysis. The recent inclusion of Japan Coma Scale, Barthel index, modified Rankin Scale scores in Japanese administrative data has allowed the prediction of in-hospital mortality with accuracy comparable to that of chart review analyses. The models developed using administrative data had consistently high predictive abilities for all models in both the derivation and validation subgroups. These results have implications in the role of administrative data in future mortality prediction analyses.

INTRODUCTION

Stroke and other cerebrovascular diseases are a major cause of death and disability [1,2], and represent the third leading cause of death in Japan [3]. Despite a decrease in stroke incidence in the past few decades, factors such as the ageing population of Japan and the saturation of antihypertensive therapy may have contributed to the disease burden of stroke [4].

Within a backdrop of rising health care costs, hospitals are under pressure by governments and third-party payers to provide high standards of care with limited resources. These standards are frequently evaluated with quality indicators, which can be categorized according to the Donabedian structure, process and outcome facets of health care [5]. In addition to determining quality of care, these evaluations provide benchmarking opportunities that can be used in incentive systems or payment system reform [6].

A common outcome measure in hospital evaluations is in-hospital mortality; although not all deaths can be prevented, appropriate process of care should reduce unnecessary and preventable deaths, particularly in the early stages of admission [7]. Various timespans of in-hospital mortality are used as indicators, ranging from the short-term to the entire admission period [8–12]. But mortality rates are not easily interpretable, as failure to properly account for variations in case mix and patient severity would bias evaluations against hospitals that treat a more severe class of patients.

Predicting in-hospital mortality upon admission may help to provide accurate prognoses to patients and relatives, guide therapeutic goals, and identify high-risk patients [13–15]. Mortality prediction models that use data from chart reviews tend to be more accurate than those using administrative data, as chart reviews provide critical predictors of mortality such as patient level of consciousness and disability levels [16-20]. On the other hand, hospital performance evaluations become more meaningful when interpreted in the context of multi-institutional data, and analysing regional variations can also contribute to understanding the mortality rates of a single hospital. Large-scale data from numerous hospitals are required for such studies, but the laborious nature of chart review analyses can limit sample sizes. Also, the importance of standardized data for proper data collection and determining predictive factors had been shown in previous stroke registries [21,22].

The advent of computerized hospital claims data has brought about more opportunities for researchers and policymakers to analyse health care quality, trends, and outcomes on a scale larger than previously possible. Administrative data has become extensively used in health services research, particularly in process measures of care [23–25]. However, these data generally lack clinical information reflecting patient severity upon admission and are therefore limited in their practical applications for predicting mortality. Previous mortality prediction models that have used administrative data alone have done so with a level of discrimination lower than that of clinical data [26,27].

Recent additions to Japanese administrative claims data include information on patient consciousness and disability levels, which may improve the predictive ability of mortality prediction models based on these data. Additionally, information on the date of stroke occurrence has also become available. This allows researchers to distinguish acute stroke from chronic or subacute stroke, previously a major limitation of administrative data-based stroke analyses.

Aims

The main aim of this study was to utilize the recent additions of patient consciousness and disability levels to administrative claims data in order to derive and validate models to predict 7-day, 30-day and overall in-hospital mortality in patients admitted for acute ischaemic stroke.

METHODS

Data Source and Subjects

Administrative claims data were obtained from hospitals voluntarily enrolled in the Quality Indicator/Improvement Project (QIP), which utilizes large-scale data analysis and feedback for the monitoring, evaluation, and improvement of health care quality. Hospitals in the QIP provide data in a standardized format under the Diagnosis Procedure Combination (DPC) case-mix payment system. These hospitals represent a variety of hospital ownership, teaching statuses, size and patient casemix.

We identified the discharge records of patients who had been admitted into the sample hospitals with acute ischaemic stroke occurring on the date of admission as the main diagnosis or the condition for which the most resources had been used in that admission. We selected only patients who had stroke onset on the day of admission because patients with stroke occurring one or more days earlier would introduce an added layer of uncertainty in the factors affecting mortality, and patients with stroke occurring after admission would imply admission for other reasons. Patients admitted between July 1st, 2010 and June 30th, 2011 were included in analysis. Ischaemic stroke was identified using the International Classification of Diseases, 10th Revision (ICD-10) code for cerebral infarction (I63x). Patients were excluded from analysis if they were below 18 years of age upon admission. Furthermore, patients with extremely short length of stay durations (transferred or discharged alive within 2 days of admission) presented difficulties in post-analysis interpretation of the results. Similarly, patients with extremely long length of stay durations may not reflect mortality in acute ischaemic stroke. As such, both these groups of patients were also excluded from analysis. Finally, patients who had been admitted to hospitals with fewer than 20 cases per year were also excluded.

Mortality Prediction

Study outcomes were defined as in-hospital death for the patients within 7 days from admission, 30 days from admission, and any time within the entire hospitalization period. In this study, the terms "7-day mortality" and "30-day mortality" are used to refer to in-hospital mortality that occurs within the stated timespans, and "in-hospital mortality" is used to refer to mortality that occurs at any point during the entire admission period. Multivariable logistic regression analyses were conducted using the various outcome measures as dependent variables. Independent variables included patient age (as a continuous variable), sex, comorbidities upon admission, patient consciousness and disability levels, and arrival period. Comorbidities included acute myocardial infarction, atrial fibrillation, dyslipidemia, hypertension, peripheral vascular disease, chronic pulmonary disease, connective tissue disease, liver disease, renal disease, and cancer. These comorbidities were identified according to the criteria as stipulated in the Dartmouth-Manitoba version of Charlson comorbidity index [28]. Other comorbidities such as diabetes and paraplegia were also considered, but ultimately excluded from the final model due to low incidence. This may be related to a possible undercoding issue that limits the number of simultaneous diagnoses in the restrictive formats of administrative data.

Patient consciousness and disability/dependence levels included Japan Coma Scale