Patient Factors
Sex
Age upon admission
Surgery performed (excluding blood transfusions)
Acute myocardial infarction
Congestive heart failure
Peripheral vascular disease
Dementia
Chronic pulmonary disease
Connective tissue disease
Ulcer
Liver disease
Diabetes with chronic complications
Hemiplegia or paraplegia
Malignancy (excluding skin cancers)
Metastatic solid tumor
Hospital Factors
DPC status
Teaching status
Private ownership
>300 beds

Table 1. Independent variables used in regression analyses.

	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	1 291	1 086	
Patient Characteristics					P-value
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 2. Patient and hospital characteristics of the sample in each of the health care spending quartile categories. Spending refers to age-sex adjusted health care spending per admission for ischemic stroke care. DPC: Diagnosis Procedure Combination payment system. P-values were calculated using ANOVA between spending categories.

	Health Care Spending Categories				
Indicators	Quartile 1	Quartile 2	Quartile 3	Quartile 4	P-value
CT or MRI scans	95.9	96.2	96.8	96.7	0.688
t-PA Administration	0.5	2.6	3.2	3.7	0.001
Antithrombotics	84.9	88.1	89.9	89.2	0.010
In-Hospital Rehabilitation	60.6	67.8	68.8	70.1	<0.001
Early Rehabilitation	58.7	66.4	66.7	68.4	<0.001
Dysphagia Rehabilitation	4.1	8.5	8	16.8	<0.001
Warfarin in AF patients	52.8	56.5	59.6	71.6	<0.001
In-Hospital Mortality	6.2	5.8	5.9	6.1	0.984
30-day Mortality	4.1	3.9	3.8	4.4	0.879

Table 3. Performance (%) of the various quality indicators, by spending quartile. Municipalities in Quartile 1 had the lowest spending, and municipalities in Quartile 4 had the highest spending. 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. P-values were calculated using ANOVA between spending categories.

Indicators	Quartile 1			Quartile 2			Quartile 3		
	Odds Ratio	P-value	95% Confidence Intervals	Odds Ratio	P-value	95% Confidence Intervals	Odds Ratio	P-value	95% Confidence Intervals
CT or MRI scans	0.81	0.463	0.452-1.435	0.83	0.464	0.509-1.360	1.06	0.822	0.659-1.692
t-PA Administration	0.15	0.003	0.045-0.520	0.75	0.291	0.431-1.287	0.98	0.946	0.623-1.556
Antithrombotics	0.66	0.012	0.475-0.913	0.86	0.325	0.643-1.158	1.05	0.729	0.796-1.385
In-Hospital Rehabilitation	0.68	0.001	0.546-0.857	0.89	0.235	0.726-1.082	0.94	0.525	0.787-1.130
Early Rehabilitation	0.71	0.003	0.567-0.886	0.92	0.394	0.754-1.118	0.94	0.525	0.790-1.128
Dysphagia Rehabilitation	0.24	<0.001	0.152-0.378	0.37	<0.001	0.268-0.506	0.42	<0.001	0.320-0.550
Warfarin in AF patients	0.48	0.013	0.264-0.856	0.58	0.031	0.354-0.950	0.58	0.019	(0.369-0.916)
In-Hospital Mortality	0.88	0.575	0.554-1.388	0.90	0.596	0.601-1.340	1.00	0.997	0.696-1.435
30-day Mortality	0.87	0.567	0.502-1.501	0.87	0.939	0.542-1.399	0.98	0.997	0.644-1.502

Table 4. The relationship between the lower quartiles of health care spending and quality of care indicators. Odds ratios, statistical significance and 95% confidence intervals were calculated using logistic regression analyses. Dependent variables in the regression models were the respective quality of care indicators, and independent variables included patient age, sex, comorbidities, surgeries performed, hospital size, teaching status and ownership. Patients in Quartile 4 of hospital spending (highest hospital spending) were used as the reference 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.

Appendix: [Note to production editor: Appendix is web-only]

Dependent Variable	CT or MRI scans			
Independent Variables	B	S.E.	Exp(B)	P-value
Sex	-0.211	0.189	0.809	0.264
Age upon admission	-0.003	0.010	0.997	0.764
Surgery performed (excluding blood transfusions)	-0.090	0.338	0.914	0.791
Acute myocardial infarction	0.216	0.616	1.241	0.726
Congestive heart failure	0.064	0.275	1.066	0.817
Peripheral vascular disease	-1.175	0.555	0.309	0.034
Dementia	0.719	0.727	2.052	0.323
Chronic pulmonary disease	>10.000	>10.000	>10.000	0.999
Connective tissue disease	-0.023	0.736	0.977	0.975
Ulcer	0.332	0.255	1.394	0.192
Liver disease	-0.187	0.224	0.830	0.405
Diabetes with chronic complications	0.463	0.526	1.589	0.379
Hemiplegia or paraplegia	0.405	0.443	1.499	0.361
Malignancy (excluding skin cancers)	0.316	0.487	1.372	0.515
Metastatic solid tumor	-0.067	1.090	0.935	0.951
DPC status	-0.866	0.248	0.420	<0.001
Teaching status	0.656	0.164	1.927	<0.001
Private ownership	0.135	0.101	1.145	0.182
>300 beds	0.019	0.257	1.019	0.942
Quartile 1	-0.216	0.294	0.806	0.463
Quartile 2	-0.183	0.251	0.833	0.464
Quartile 3	0.054	0.241	1.056	0.822
Constant	3.235	1.354	25.409	0.017
Hosmer Lemeshow P-value	0.103			
AUROC	0.666			

Dependent Variable	t-PA administration			
Independent Variables	B	S.E.	Exp(B)	P-value
Sex	-0.478	0.213	0.620	0.025
Age upon admission	-0.001	0.011	0.999	0.957
Surgery performed (excluding blood transfusions)	-0.247	0.382	0.781	0.518
Acute myocardial infarction	-0.261	0.753	0.770	0.729
Congestive heart failure	0.760	0.262	2.137	0.004
Peripheral vascular disease	0.953	0.775	2.593	0.219
Dementia	0.243	0.616	1.275	0.693
Chronic pulmonary disease	1.916	1.328	6.795	0.149
Connective tissue disease	-0.106	1.075	0.899	0.921
Ulcer	-0.235	0.272	0.790	0.388
Liver disease	-0.221	0.283	0.801	0.434
Diabetes with chronic complications	-0.268	0.526	0.765	0.610
Hemiplegia or paraplegia	0.992	0.403	2.695	0.014
Malignancy (excluding skin cancers)	-0.323	0.598	0.724	0.589
Metastatic solid tumor	<-10.000	>10.000	0.000	0.998
DPC status	-0.156	0.305	0.855	0.608
Teaching status	0.759	0.328	2.137	0.020
Private ownership	0.353	0.095	1.423	0.000
>300 beds	0.230	0.399	1.259	0.564
Quartile 1	-1.876	0.623	0.153	0.003
Quartile 2	-0.295	0.279	0.745	0.291
Quartile 3	-0.016	0.234	0.984	0.946
Constant	<-10.000	>10.000	0.000	0.998
Hosmer Lemeshow P-value	0.658			
AUROC	0.751			

Dependent Variable	Antithrombotics administration			
Independent Variables	B	S.E.	Exp(B)	P-value
Sex	0.001	0.110	1.001	0.992
Age upon admission	-0.045	0.006	0.956	<0.001
Surgery performed (excluding blood transfusions)	0.028	0.200	1.029	0.888
Acute myocardial infarction	0.159	0.329	1.172	0.629
Congestive heart failure	0.282	0.158	1.326	0.075
Peripheral vascular disease	-0.666	0.402	0.514	0.097
Dementia	-0.266	0.274	0.767	0.332
Chronic pulmonary disease	>10.000	>10.000	>10.000	0.999
Connective tissue disease	-0.281	0.404	0.755	0.487
Ulcer	0.350	0.143	1.420	0.014
Liver disease	0.095	0.139	1.100	0.494
Diabetes with chronic complications	0.176	0.305	1.192	0.564
Hemiplegia or paraplegia	0.859	0.283	2.361	0.002
Malignancy (excluding skin cancers)	-0.602	0.207	0.548	0.004
Metastatic solid tumor	-0.440	0.504	0.644	0.383
DPC status	-0.430	0.141	0.650	0.002
Teaching status	0.360	0.096	1.434	<0.001
Private ownership	0.281	0.059	1.325	<0.001
>300 beds	0.052	0.143	1.053	0.719
Quartile 1	-0.417	0.167	0.659	0.012
Quartile 2	-0.148	0.150	0.863	0.325
Quartile 3	0.049	0.141	1.050	0.729
Constant	4.754	0.784	116.057	<0.001
Hosmer Lemeshow P-value	0.687			
AUROC	0.698			

Dependent Variable	In-Hospital Rehabilitation			
Independent Variables	B	S.E.	Exp(B)	P-value
Sex	-0.142	0.073	0.868	0.051
Age upon admission	0.014	0.004	1.014	<0.001
Surgery performed (excluding blood transfusions)	0.388	0.140	1.475	0.006
Acute myocardial infarction	-0.238	0.228	0.788	0.297
Congestive heart failure	-0.163	0.104	0.849	0.116
Peripheral vascular disease	0.610	0.389	1.841	0.116
Dementia	0.011	0.217	1.011	0.960
Chronic pulmonary disease	>10.000	>10.000	>10.000	0.999
Connective tissue disease	0.425	0.316	1.529	0.180
Ulcer	-0.002	0.088	0.998	0.982
Liver disease	0.215	0.091	1.240	0.018
Diabetes with chronic complications	0.296	0.182	1.344	0.104
Hemiplegia or paraplegia	1.179	0.185	3.251	<0.001
Malignancy (excluding skin cancers)	-0.072	0.166	0.931	0.666
Metastatic solid tumor	-0.489	0.436	0.613	0.262
DPC status	-0.085	0.096	0.919	0.379
Teaching status	0.377	0.071	1.457	<0.001
Private ownership	-0.073	0.036	0.930	0.043
>300 beds	0.027	0.102	1.028	0.789
Quartile 1	-0.379	0.115	0.684	0.001
Quartile 2	-0.121	0.102	0.886	0.235
Quartile 3	-0.059	0.092	0.943	0.525
Constant	-0.516	0.566	0.597	0.362
Hosmer Lemeshow P-value	0.479			
AUROC	0.615			

Dependent Variable	Early Rehabilitation			
Independent Variables	B	S.E.	Exp(B)	P-value
Sex	-0.131	0.072	0.878	0.070
Age upon admission	0.014	0.004	1.014	<0.001
Surgery performed (excluding blood transfusions)	0.432	0.139	1.540	0.002
Acute myocardial infarction	-0.301	0.224	0.740	0.180
Congestive heart failure	-0.149	0.103	0.862	0.148
Peripheral vascular disease	0.366	0.354	1.442	0.302
Dementia	-0.012	0.213	0.988	0.955
Chronic pulmonary disease	>10.000	>10.000	>10.000	0.999
Connective tissue disease	0.734	0.331	2.083	0.027
Ulcer	0.054	0.087	1.056	0.536
Liver disease	0.143	0.089	1.153	0.110
Diabetes with chronic complications	0.281	0.178	1.324	0.116
Hemiplegia or paraplegia	1.044	0.170	2.840	<0.001
Malignancy (excluding skin cancers)	-0.123	0.164	0.884	0.453
Metastatic solid tumor	-0.493	0.438	0.611	0.260
DPC status	-0.057	0.095	0.944	0.548
Teaching status	0.391	0.070	1.479	<0.001
Private ownership	-0.054	0.036	0.947	0.127
>300 beds	0.130	0.100	1.139	0.194
Quartile 1	-0.344	0.114	0.709	0.003
Quartile 2	-0.086	0.101	0.918	0.394
Quartile 3	-0.058	0.091	0.944	0.525
Constant	-0.357	0.583	0.700	0.541
Hosmer Lemeshow P-value	0.303			
AUROC	0.623			

Dependent Variable	Dysphagia Rehabilitation			
Independent Variables	B	S.E.	Exp(B)	P-value
Sex	0.091	0.117	1.096	0.435
Age upon admission	0.033	0.007	1.034	<0.001
Surgery performed (excluding blood transfusions)	0.916	0.165	2.499	<0.001
Acute myocardial infarction	0.134	0.349	1.143	0.701
Congestive heart failure	-0.013	0.168	0.988	0.941
Peripheral vascular disease	0.075	0.621	1.078	0.904
Dementia	0.561	0.297	1.753	0.059
Chronic pulmonary disease	1.767	0.974	5.854	0.070
Connective tissue disease	-0.140	0.566	0.869	0.804
Ulcer	-0.253	0.153	0.776	0.097
Liver disease	0.037	0.147	1.037	0.803
Diabetes with chronic complications	0.088	0.282	1.092	0.756
Hemiplegia or paraplegia	-0.740	0.345	0.477	0.032
Malignancy (excluding skin cancers)	0.189	0.257	1.209	0.460
Metastatic solid tumor	<-10.000	>10.000	0.000	0.998
DPC status	-0.388	0.159	0.679	0.015
Teaching status	0.222	0.139	1.248	0.111
Private ownership	-0.023	0.051	0.977	0.652
>300 beds	1.163	0.200	3.200	<0.001
Quartile 1	-1.429	0.233	0.239	<0.001
Quartile 2	-0.999	0.162	0.368	<0.001
Quartile 3	-0.869	0.138	0.420	<0.001
Constant	-4.208	0.784	0.015	<0.001
Hosmer Lemeshow P-value	0.232			
AUROC	0.743			

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

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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).

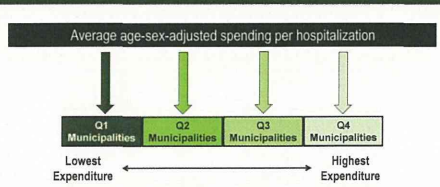

Figure 1. Categorization of municipalities in Kyoto prefecture, Japan by hospital spending

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.

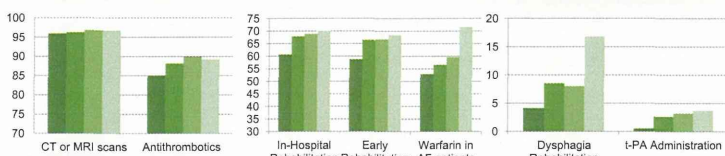

Figure 2. Unadjusted performance of the various quality indicators (given in percentages) through the spending quartiles. Note: different scales on the Y-axes are used to clearly show the differences in performance among the spending quartiles.

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.

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).

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.

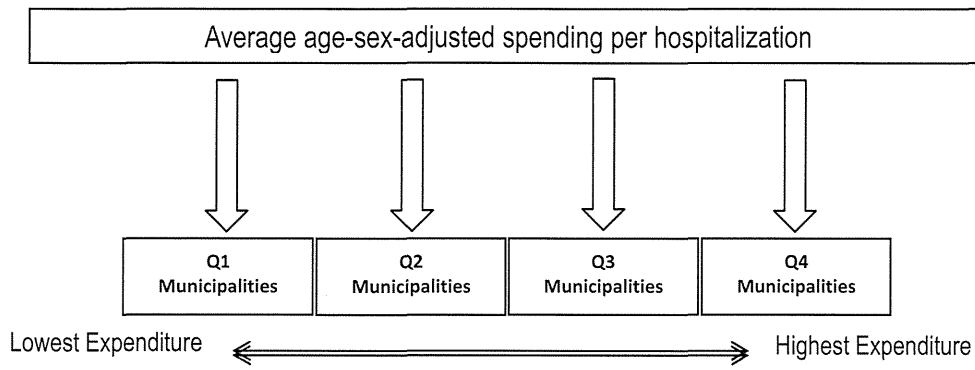

Figure 1. Categorization of municipalities in Kyoto prefecture, Japan by hospital spending

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).

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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.

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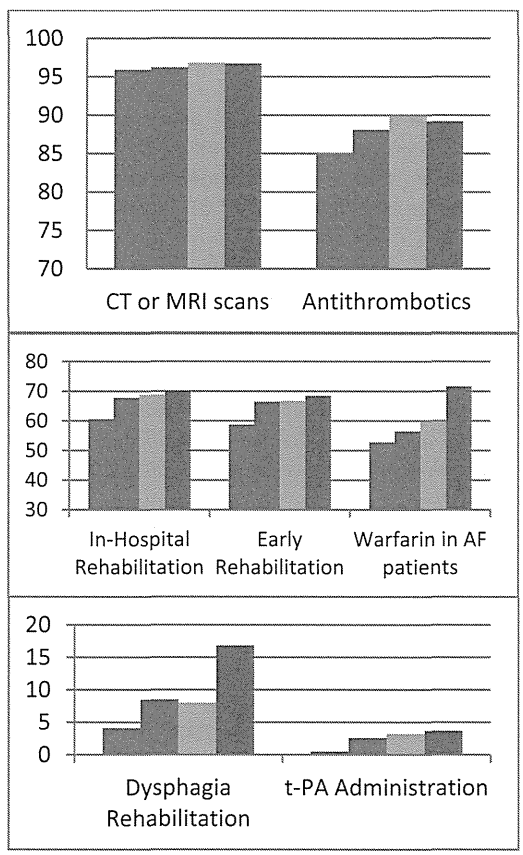

Figure 2. Unadjusted performance of the various quality indicators (given in percentages) through the spending quartiles. Note: different scales on the Y-axes are used to clearly show the differences in performance among the spending quartiles.

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