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Table 1 Demographics of all patients (given in percentages) in the sample, derivation subgroup and validation subgroup

Variables	Overall (n = 21,445)	Derivation Subgroup (n = 10,774)	Validation Subgroup (n = 10,671)	*P*
Age (years)	74.8	74.9	74.8	0.423
Female	42.0	42.4	41.6	0.234
Acute myocardial infarction	1.7	1.6	1.8	0.224
Atrial Fibrillation	16.6	16.6	16.5	0.956
Dyslipidemia	22.3	22.5	22.1	0.512
Hypertension	49.1	49.2	49.0	0.722
Peripheral vascular disease	0.5	0.4	0.6	0.076
Chronic pulmonary disease	2.4	2.5	2.2	0.106
Connective tissue disease	0.8	0.8	0.8	0.703
Liver disease	0.3	0.3	0.4	0.554
Renal disease	3.5	3.6	3.4	0.333
Metastatic cancer	0.5	0.5	0.5	0.847
JCS Levels 1 to 3	36.4	36.3	36.4	0.921
JCS Levels 10 to 30	9.2	9.2	9.2	0.962
JCS Levels 100 to 300	4.7	4.8	4.6	0.520
Barthel ADL Index <20	54.2	54.6	53.7	0.179
mRS 0	2.8	2.8	2.9	0.902
mRS 1	11.9	11.7	12.1	0.411
mRS 2	17.3	17.4	17.1	0.588
mRS 3	15.2	15.1	15.4	0.582
mRS 4	28.8	28.9	28.6	0.608
mRS 5	24.0	24.0	24.0	0.898
After Hours	21.2	21.0	21.4	0.547
Weekends/Public Holidays	8.9	9.2	8.5	0.093
7-day Mortality	2.5	2.6	2.4	0.355
30-day Mortality	4.4	4.5	4.4	0.765

In-hospital Mortality	6.3	6.2	6.3	0.779

All values are percentages except for age, which is in years. JCS, Japan Coma Scale; ADL, activities of daily living; mRS, modified Rankin Scale. *P* values are calculated using either a two-sided *t*-test (for age) or a chi-squared test (for all other variables) between the derivation and validation subgroups.

Table 2 Prediction model results for 7-day, 30-day and Overall in-hospital mortality in the derivation subgroup

	Prediction Models for In-Hospital Mortality the Derivation Subgroup								
	7-day			30-day			Overall		
Variables	Adjusted Odds Ratio	95% Confidence Intervals	*P*	Adjusted Odds Ratio	95% Confidence Intervals	*P*	Adjusted Odds Ratio	95% Confidence Intervals	*P*
Age	1.00	(0.98,1.01)	0.662	1.01	(1.00,1.02)	0.013	1.03	(1.02,1.04)	<0.001
Female	1.04	(0.79,1.38)	0.762	0.85	(0.68,1.05)	0.135	0.88	(0.73,1.06)	0.176
Acute myocardial infarction	1.25	(0.51,3.02)	0.625	1.34	(0.66,2.70)	0.414	1.01	(0.52,1.98)	0.977
Atrial Fibrillation	1.60	(1.22,2.10)	0.001	1.55	(1.24,1.93)	<0.001	1.42	(1.17,1.72)	<0.001
Dyslipidemia	0.51	(0.30,0.88)	0.014	0.43	(0.28,0.66)	<0.001	0.44	(0.31,0.62)	<0.001
Hypertension	0.60	(0.45,0.79)	<0.001	0.60	(0.48,0.75)	<0.001	0.62	(0.51,0.74)	<0.001
Peripheral vascular disease	2.66	(0.69,10.25)	0.156	2.89	(0.99,8.41)	0.051	3.97	(1.62,9.73)	0.003
Chronic pulmonary disease	0.82	(0.35,1.96)	0.662	1.28	(0.72,2.30)	0.402	1.09	(0.65,1.84)	0.751
Connective tissue disease	1.38	(0.31,6.24)	0.676	1.18	(0.34,4.07)	0.792	1.00	(0.34,2.92)	0.992
Liver disease	1.72	(0.20,14.68)	0.622	3.10	(0.82,11.71)	0.095	1.86	(0.49,7.06)	0.360
Renal disease	1.69	(0.89,3.19)	0.108	2.20	(1.40,3.47)	0.001	2.27	(1.54,3.35)	<0.001
Metastatic cancer	2.82	(0.89,8.95)	0.079	14.32	(7.12,28.82)	<0.001	13.18	(6.81,25.53)	<0.001
JCS Level 0	1.00	Referent	NA	1.00	Referent	NA	1.00	Referent	NA
JCS Levels 1 to 3	2.03	(1.16,3.55)	0.014	2.29	(1.56,3.35)	<0.001	1.71	(1.29,2.28)	<0.001
JCS Levels 10 to 30	5.59	(3.13,10.01)	<0.001	5.17	(3.42,7.82)	<0.001	3.36	(2.43,4.63)	<0.001
JCS Levels 100 to 300	15.59	(8.72,27.87)	<0.001	15.44	(10.15,23.49)	<0.001	9.91	(7.10,13.83)	<0.001

Barthel ADL Index ≥20	1.00	Referent	NA	1.00	Referent	NA	1.00	Referent	NA
Barthel ADL Index <20	1.71	(1.01,2.87)	0.045	1.72	(1.20,2.47)	0.003	2.11	(1.56,2.86)	<0.001
mRS 0 to 3	1.00	Referent	NA	1.00	Referent	NA	1.00	Referent	NA
mRS 4	1.61	(0.83,0.31)	0.158	1.69	(1.11,2.58)	0.014	1.91	(1.37,2.67)	<0.001
mRS 5	6.41	(3.49,11.77)	<0.001	4.65	(3.12,6.94)	<0.001	4.68	(3.38,6.49)	<0.001
After Hours	1.00	(0.73,1.36)	0.996	0.97	(0.76,1.24)	0.791	0.85	(0.69,1.06)	0.142
Weekends/Public Holidays	1.58	(1.06,2.35)	0.025	1.15	(0.82,1.62)	0.419	0.91	(0.67,1.24)	0.552

JCS, Japan Coma Scale; ADL, activities of daily living; mRS, modified Rankin Scale

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Abstract Title

The Association between Quality of Care and Hospital Spending in Patients with Acute Myocardial Infarction: Evidence from Japan

Abstract [Copy and paste abstract into text box below (up to 500 words)] (424/500)

Background: The association between healthcare spending and quality of care has important implications for policy-makers to improve both the long-term sustainability of healthcare financing and quality of care simultaneously, but the relationship has received little attention at the hospital level.

Objective: To estimate the association between hospital spending and quality of care in acute myocardial infarction (AMI) patients in Japan

Methods: We utilized administrative data from patients admitted to 180 hospitals in Japan for AMI from 2008 to 2011. Multilevel logistic regression models were developed based on patients clustered within hospitals, with independent variables inclusive of patient-level risk factors such as age, gender, co-morbidities and infarct location; hospital characteristics such as teaching status, hospital ownership, hospital bed size, AMI case volume, and the number of physicians as well as nurses. To compare the quality of care among hospitals, hospitals were classified according to mean hospital spending, which was divided into four categories: bottom 10%, 11-50%, 51-89%, and top 10% of hospital spending. ANOVA with Bonferroni correction for multiple comparisons was conducted to test differences in process as well as outcome indicators among the categories of hospital spending. Also, Jonckheere-Terpstra tests were conducted to analyze trends in these indicators across the categories.

Study Outcomes: Quality of care for AMI was assessed using process as well as outcome measures: 30-day in-hospital risk-adjusted mortality rates, all-cause readmission rates; and the percentage of patients prescribed aspirin, ß-blockers, and angiotensin-converting enzyme (ACE) inhibitor during hospitalization.

Results: After adjustment for patient and hospital characteristics, the mortality rate decreased from 7.67% for the hospitals in the bottom 10% to 4.20% for those in the top 10% (P<0.01: test for trend). On the other hand, no statistical significance was found in the readmission rates after adjusting for patient and hospital characteristics across the categories of hospital spending (P=0.161: test for trend). Hospitals with higher spending were more likely to be associated with better quality of care in process indicators, and the trends across the categories of hospital spending were found to be statistically significant: the use of aspirin (60.44% in bottom 10% versus 90.32% in top 10%, P<0.001), β-blockers (22.40% in bottom 10% versus 45.34% in top 10%, P<0.001), and ACE inhibitor (47.08% in bottom 10% versus 75.26% in top 10%, P<0.001). Except for readmission, differences in both the mortality and process measures between hospital in bottom 10% and others were statistically significant (P<0.05 in β-blockers, and P<0.001 in the morality and other process measures).

Conclusion: Higher-spending hospitals were significantly associated with better quality of care among Japanese patients admitted for AMI.

The Association between Quality of Care and Hospital Spending in Acute Myocardial Infarction : Evidence from Japan

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Background

- An increasing trend of acute myocardial infarction (AMI) incidence in the Japanese population[1]
- Health care spending for AMI can be expected to rise in Japan
  - The number of elderly people admitted for AMI treatment is expected to rise as age is a significant risk factor in Japan[2,3]
- Increasing pressure of both hospitals and governments to lower health care spending
- However, reducing health care costs without emphasizing quality of care may result in underused resources and treatment, thus compromising the quality of care among patients.
- Therefore, simply reducing health care utilization may not necessarily be the solution.[4]

[1]Ministry of Health, Labour and Welfare, Japan.
[2]Hayashida, et al. 2007. [3]Turin, et al. 2010. [4]Bodenheimer, et al. 2005.

Background

- Evidence for the relationship between health care spending and quality of care are primarily from US reports

- **Literature Review**

WHAT IS KNOWN

- Mixed results regarding the association between health care spending and quality of care
  - No association, or inconsistent association across specific disease[1-4]
  - Positive association[5-8]

WHAT IS UNKNOWN

- Partial evaluation of quality of care using either mortality, process measures, hospital ranking, or a combination thereof
- The impact of hospital structure on quality of care and health care spending
- The association between hospital spending and quality of care in some countries with insurance or reimbursement systems different from US

[1]Chen, et al. 2010. [2]Yasaitis, et al. 2009. [3]Jha, et al. 2009. [4]Kaestner, et al. 2010. [5]Romley, et al. 2011. [6]Barnato, et al. 2010. [7]Stukel, et al. 2012. [8]Ong, et al. 2009.

Objectives

- **The aim of our study**

Objectives

To assess whether higher health care (hospital) spending is associated with better quality of care for patients admitted for AMI in Japan

WHAT THIS STUDY ADDS

- Process and outcome measures as indicators for overall quality of care for AMI patients
- Hospital characteristics that are associated with quality of care and health care spending
- Investigation of the association between hospital spending and quality of care in Japan with different reimbursement system compared to the United States

Methods: Data & Sample Selection

- **Data Sources**
  - Data from hospitals affiliated with the Quality Indicator/Improvement Project (QIP), Kyoto University
- **Subjects**
  - 26,604 patients admitted with a primary diagnosis of AMI (ICD I21) from 180 hospitals enrolled in QIP during the period of April 2008 to March 2011
- **Exclusion Criteria**
  - Patients who were admitted in hospital for durations longer than 90 days
  - Hospitals having case volume of less than 20 over three years
  - Missing data

Methods: Quality of Care Indicators

Outcome Indicators[1]	Process Indicators[2]
▪ 30-day risk-adjusted in-hospital mortality	▪ Utilization of Aspirin ▪ Utilization of ß-blockers ▪ Utilization of angiotensin-converting enzyme [ACE] inhibitors

[1]Acute myocardial infarction (AMI): hospital 30-day, all cause, risk-standardized mortality rate (RSMR) following AMI hospitalization. Agency for Health care Research and Quality (AHRQ).
[2]Specification Manual for National Hospital Quality Measures. Joint Commission on Accreditation of Healthcare Organizations.

Methods: Covariates

Patient Characteristics

- Age
- Sex
- Major co-morbidity risk factors[1-2]
  - Shock
  - Pneumonia
  - Cancer
  - Chronic renal failure
  - Infarct location
- Minor co-morbidity risk factors
  - Co-morbidity group 1 (Cerebrovascular disease / Diabetes / Liver disease / Pericarditis or endocarditis)
  - Co-morbidity group 2 (Acute renal failure / Cardiac dysrhythmia / Congestive heart failure / Pulmonary edema

Hospital Characteristics

- Teaching status
- Hospital ownership
- Hospital AMI case volume over the 3-year study period
- Physician-to-bed ratio
- Nurse-to-bed-ratio
- Hospital size (bed numbers)

[1]Hayashida, et al. 2007. [2]Tu, et al. 2001.

Methods: Hospital Spending

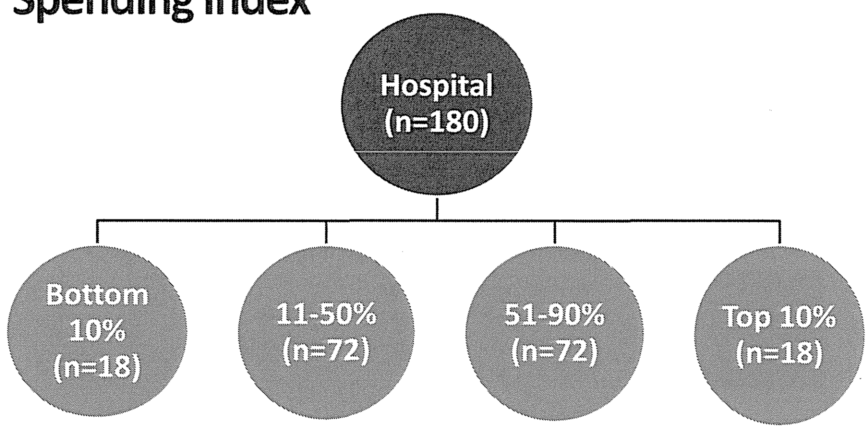
- **Health care Spending during hospitalization**
  - Sum of all fees for hospitalization (e.g., basic and special inpatient care, including initial examination, imaging, pharmacy, injections, treatment, invasive procedure, guidance, and home care)
- **Calculation of Relative hospital spending index**[1,2]

$$\frac{\text{observed mean hospital spending of care per case for patients}}{\text{its expected value of care per case for the same categories of patients}}$$

  - The predicted hospital spending of care per case was calculated by regression analysis on the patients' demographic characteristics such as age, sex, co-morbidities and infarction location

[1]Chen, et al. 2010. [2]Jha, et al. 2009.

Methods: Hospital Categorization into Quartiles based on Relative Hospital Spending Index



Methods: Statistical Analysis

- Test for a relationship between patient and hospital characteristics
  - **Chis-square test** for categorical variables
  - **Analysis of variance** for continuous variables

1. **Multilevel regression model for hospital spending**
   - Adjusting for patient-level factors (age, sex, co-morbidities, and infarction location)

2. **Multilevel logistic regression model for mortality**
   - Adjusting for patient and hospital characteristics (major teaching status, hospital ownership, hospital bed size numbers, AMI case volume, and physician-to-bed ratio, and nurse-to-bed ratio)

Methods: Statistical Analysis

3. **Multilevel logistic regression analysis for mortality**
   - To investigate the impact of type of invasive procedure on mortality rates within the various hospital spending categories
   - Independent Variables

Independent Variables
- The variables from the previous logistic regression model
- Additional variables to indicate the type of AMI invasive procedure performed on each patient

   - AMI treatment procedures were classified into four categories

Invasive Procedures
- No invasive procedures
- Coronary artery bypass graft (CABG)
- Percutaneous coronary intervention (PCI)
- Both PCI and CABG

   - **Patients in the 11-50%** spending group who did not receive an invasive procedure alternatively were used as the **referent category**

Methods: Statistical Analysis

- **Jonckheere-Terpstra test**
  - To analyze trends in process and outcome indicators across hospital spending categories [3]
- **Analysis of variance for multiple comparison**
  - To test differences in process and outcome indicators among hospital spending categories
- *P*-values
  - less than 0.05 were considered statistically significant
- Statistical package
  - Stata 11.2 (Stata Corp., College Station, TX)
  - IBM SPSS 19.0 (SPSS Inc., Chicago, IL).

[1]Hayashida, et al, 2007. [2]Silber, et al. 2010. [3]Bewick, et al. 2004.

Results: Patient Characteristics According to Hospital Spending

	Hospital spending category				
Variable	Bottom 10 %	11-50%	51-90%	Top 10%	Test for Trend
Number of patients (n)	817	9,380	13,173	3,234	
Age (years)	72.79	69.89	69.68	68.97	<0.001
Women (%)	32.58	27.97	27.85	27.03	0.003
Co-morbidities (%)					
Shock	5.39	7.71	8.09	12.69	0.096
Pneumonia	2.88	1.75	2.06	1.71	<0.001
Cancer	3.01	2.33	2.05	1.84	0.181
Chronic renal failure	4.89	3.66	4.21	3.24	0.042
Co-morbidity group 1‡	15.79	11.65	13.34	13.91	0.007
Co-morbidity group 2§	38.47	32.91	38.17	37.79	<0.001
Infarct Location					<0.001
Anterior	30.45	33.13	35.73	34.39	
Inferior	29.95	26.72	28.75	29.28	
Subendocardial	1.75	1.25	0.50	1.03	
Other/unspecified	37.84	38.89	35.02	35.30	

Results: Hospital Characteristics According to Hospital Spending

	Hospital spending category				
Variable	Bottom 10 %	11-50%	51-90%	Top 10%	Test for Trend
Number of hospitals (n)	18	72	72	18	
Observed 30-day in-hospital mortality (%)	27.96	10.76	8.10	6.51	<0.001
Length of stay (mean)	14.52	14.74	17.32	18.24	<0.001
Hospitals with ICU/CCU (%)	22.22	31.94	45.83	72.22	0.012
Number of beds (n)	267.67	386.76	419.82	448.50	0.008
Major teaching facility (%)	66.11	80.56	91.67	83.33	0.037
Hospital ownership (%)					0.089
Municipal	7.52	23.28	28.20	31.34	
Public	39.47	25.87	31.99	53.45	
Private	53.01	50.84	39.82	15.22	
AMI case volume (mean)	44.33	132.96	180.93	178.17	<0.001
Physician-to-bed ratio (mean)	0.14	0.19	0.20	0.22	<0.001
Nurse-to-bed ratio (mean)	0.69	0.82	0.80	0.83	0.075