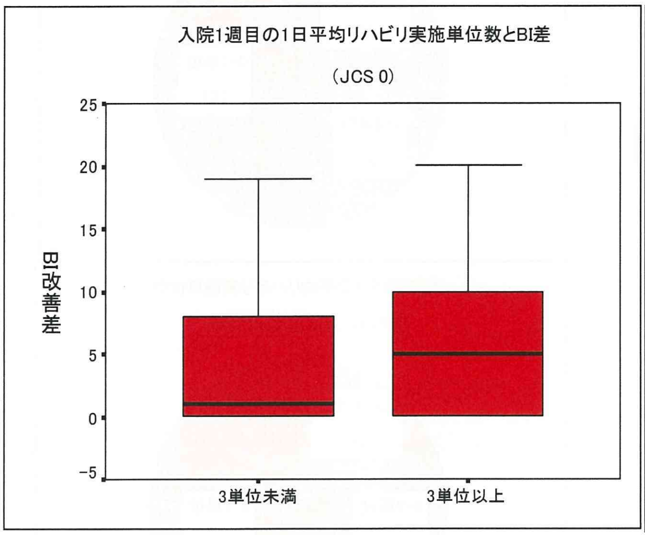
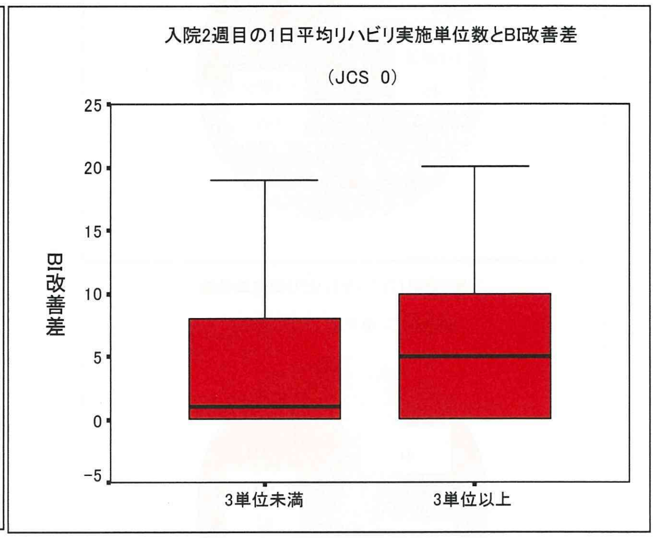
## 入院1週目、2週目に、1日平均1時間以上のリハビリを実施した場合、1時間以下に比べ、ADLの改善差が1.5～1.6点高い

### JCS 0の患者




| | 度数 | BI差 | 標準偏差 | P値 |
|---|---|---|---|---|
| 3単位未満 | 6258 | 4.3 | 5.5 | <0.001 |
| 3単位以上 | 755 | 5.9 | 5.6 | |

| | 度数 | BI差 | 標準偏差 | P値 |
|---|---|---|---|---|
| 3単位未満 | 5887 | 4.2 | 5.5 | <0.001 |
| 3単位以上 | 1126 | 5.7 | 5.5 | |

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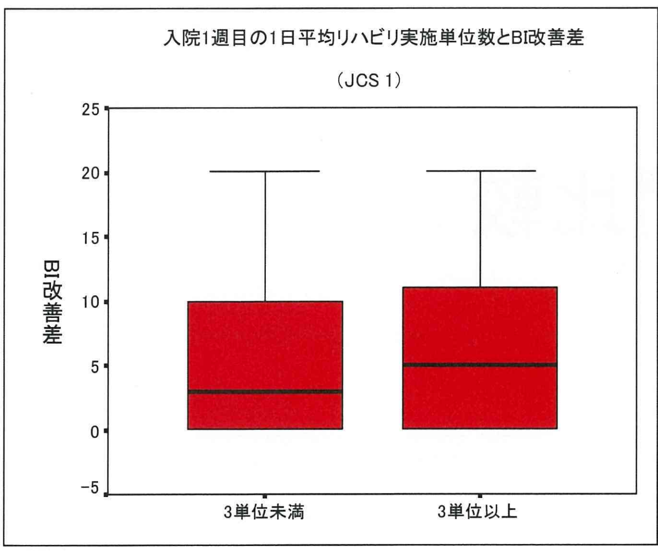
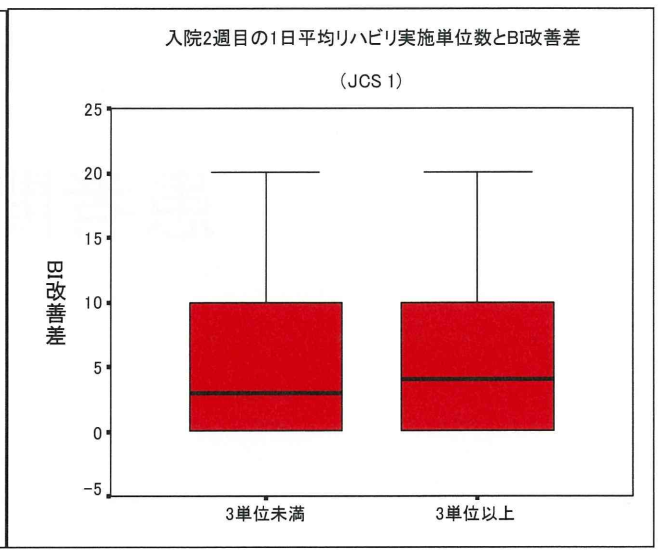
## 入院1週目、2週目に、1日平均1時間以上のリハビリを実施した場合、1時間以下に比べ、ADLの改善差が0.9～1.1点高い

### JCS 1桁の患者




| | 度数 | BI差 | 標準偏差 | P値 |
|---|---|---|---|---|
| 3単位未満 | 3267 | 5.4 | 6.3 | 0.003 |
| 3単位以上 | 320 | 6.5 | 6.2 | |

| | 度数 | BI差 | 標準偏差 | P値 |
|---|---|---|---|---|
| 3単位未満 | 2992 | 5.3 | 6.2 | 0.001 |
| 3単位以上 | 595 | 6.2 | 6.3 | |

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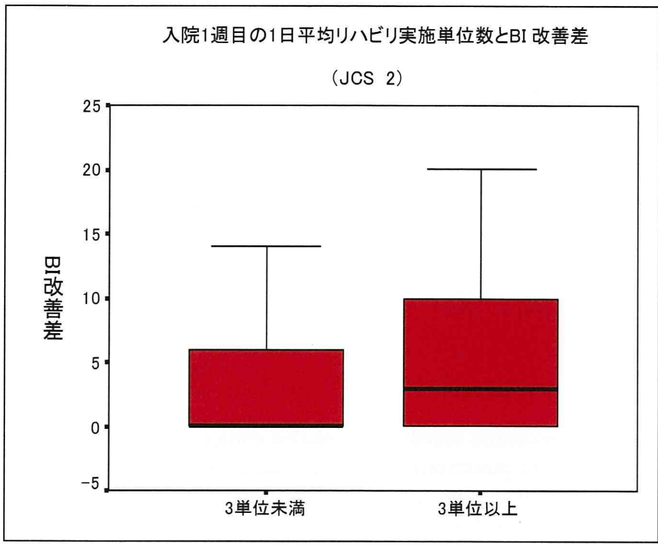
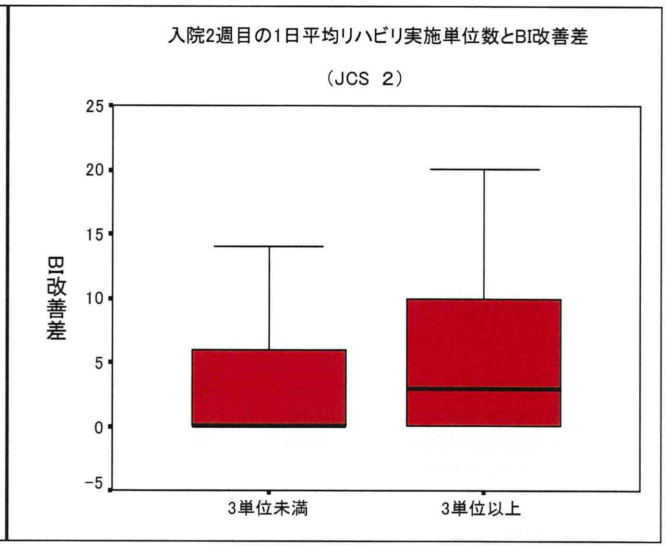
## 入院1週目、2週目に、1日平均1時間以上のリハビリを実施した場合、1時間以下に比べ、ADLの改善差が2.2〜2.4点高い。

### JCS 2桁の患者




| | 度数 | BI差 | 標準偏差 | P値 |
|---|---|---|---|---|
| 3単位未満 | 790 | 3.8 | 6.0 | 0.002 |
| 3単位以上 | 74 | 6.2 | 7.0 | |

| | 度数 | BI差 | 標準偏差 | P値 |
|---|---|---|---|---|
| 3単位未満 | 736 | 3.7 | 5.9 | <0.001 |
| 3単位以上 | 128 | 5.9 | 6.8 | |

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# Physician adherence to asthma treatment guidelines in Japan: focus on inhaled corticosteroids

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**Keywords**
administrative data, asthma management, compliance, database research, insurance claim review, quality measurement

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## Abstract

**Objectives** Asthma treatment guidelines recommend inhaled corticosteroids (ICS) as the first-line therapy. However, ICS are prescribed to lower percentages of asthmatic patients in Japan than in other developed countries. The aim of this study was to reveal factors affecting the prescription of ICS for asthmatic adults.
**Methods** Using insurance claims data in Kyoto Prefecture, Japan, we performed a cross-sectional study. We assessed whether outpatients aged 15 years or older who were diagnosed with asthma had received ICS or not, and conducted logistic regression analyses to identify patients' and facilities' factors associated with ICS use.
**Results** We analysed 13 428 asthmatic adults, of which 51% were prescribed ICS. Patients receiving asthma care at facilities with respiratory or allergy specialists were more likely to receive ICS than facilities without specialists (adjusted odds ratio 2.70; 95% confidence interval 2.46–2.97). Those aged 75 years or older were less likely to receive ICS than those aged 15 to 64 (adjusted odds ratio 0.71; 95% confidence interval 0.64–0.78). An examination of the interaction between the presence or absence of specialists and facility training status suggested that whether asthmatic adults received ICS depended on the former factor rather than the latter.
**Conclusion** The presence of specialists in facilities and the age of patients were strong factors affecting ICS prescription. Increases in ICS therapy for the elderly and ICS prescription by non-specialists would lead to an overall increase in patients receiving ICS and consequently achieving the goal of asthma control.

## Introduction

Clinical practice guidelines are defined as 'systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances' [1]. Adherence to guidelines has been shown to improve the quality of health care by promoting standardized processes of diagnosis and treatment [2]. Asthma is recognized as a global public health problem, afflicting an estimated 300 million patients worldwide [3]. In Japan, asthma prevalence for adults has been reliably estimated to be 4.2% [4], and guidelines have been established for its treatment [5].

Adherence to asthma guidelines contributes to better control of asthma and decreases in asthma-related hospitalizations and fatal cases [6,7]. National guidelines in Japan are based on international guidelines as provided by the Global Initiative for Asthma [3], and modified to take into account local cultural and health care system requirements. Table 1 shows the treatment steps of long-term asthma management as recommended in the Asthma Prevention and Management Guidelines 2009 [5], the current version of the Japanese guidelines. Both international and national guidelines have recommended the use of inhaled corticosteroids (ICS) as the first-line treatment of asthma irrespective of asthma severity. ICS are typically administered via a metered-dose inhaler or a dry powder inhaler.

Asthma Insights and Reality in Japan in 2000 reported that 12% of adults with asthma had been prescribed ICS [8], whereas Asthma Insights and Reality in Europe in 1999 showed this proportion to be 22% [9]. As a consequence of poor adherence to asthma guidelines in Japan, there is a general failure to achieve well-controlled asthma [8].

Previous studies conducted outside Japan have reported physician prescription behaviours in samples of asthmatic patients within specific age ranges [10,11]. Little is known, however, about the risk of non-use of ICS for the elderly with asthma compared to younger adults in multicentre surveys. Insurance claims data in

**Table 1** Long-term asthma management as recommended in the Asthma Prevention and Management Guidelines 2009, Japan*

| Step 1[†] | Step 2[†] | Step 3[†] | Step 4[†‡] |
|---|---|---|---|
| Low-dose ICS | Low- or medium-dose ICS | Medium- or high-dose ICS | High-dose ICS |
| Or any one of the following alone if ICS cannot be used: | And any one of the following if needed: | And any one or a combination of the following: | And a combination of the following: |
| Leukotriene modifier | Long-acting beta2-agonist | Long-acting beta2-agonist | Long-acting beta2-agonist |
| Sustained release theophylline | Leukotriene modifier | Leukotriene modifier | Leukotriene modifier |
| | Sustained release theophylline | Sustained release theophylline | Sustained release theophylline |

*If asthma is not controlled, treatment should be stepped up. If control is maintained for 3 to 6 months, treatment can be stepped down.
†If needed, anti-allergic drugs other than leukotriene modifier can be added in each step. Anti-allergic drugs indicate chemical mediator release inhibitor, H1-antihistamine, thromboxane A2 inhibitor and Th2 cytokine inhibitor.
‡If asthma is not well controlled by the above therapy, addition of anti-IgE treatment and/or oral corticosteroids can be considered.
ICS, inhaled corticosteroids.

Japan include detailed prescription data, which allows for the evaluation of physicians' adherence to asthma treatment guidelines in multiple health care facilities. The aim of our study was to conduct an analysis of claims data in order to reveal the factors affecting ICS prescription in asthmatic adults of all ages in Japan.

## Methods

We utilized a cross-sectional analysis of insurance claims data. The data source was comprised of claims information that had been electronically submitted to National Health Insurance and Long Life Medical Care System from February 2009 to November 2009 by health care facilities in Kyoto Prefecture, located in western Japan. National Health Insurance covers the unemployed population (e.g. farmers, the self-employed, the retired, part-time workers, and their families), while the Long Life Medical Care System covers participants aged 75 or older, as well as those aged between 65 and 74 with disabilities. The number of total participants from Kyoto Prefecture in both systems was 953 000 people. Our database did not include patients' personal information, and patients could not be identified from the data that we utilized. This study was approved by the Ethics Committee of Kyoto University Graduate School of Medicine (E1023).

### Study population

We retrospectively identified all outpatients aged 15 years or older who were diagnosed with asthma. Asthma was identified according to International Classification of Diseases, 10th Revision (ICD-10) codes (see Appendix S1). To ensure a conclusive diagnosis of asthma, patients were required to have had at least two insurance claims for treatment of asthma at one health care facility. Patients were excluded: if they were given a diagnosis of chronic obstructive pulmonary disease (COPD) (ICD-10 codes shown in Appendix S1) in order to avoid confusion with asthma in diagnostic and therapeutic procedures; if they were diagnosed as having rheumatic disease (ICD-10 codes shown in Appendix S1) [12], with which patients are more likely to receive systemic corticosteroids; or if they had not received any anti-asthmatic medication.

We identified allergic rhinitis [13] and gastro-oesophageal reflux disease [14] as co-morbid conditions frequently occurring in combination with asthma (ICD-10 codes shown in Appendix S1). We also determined the presence of the following co-morbidities cited from Charlson co-morbidity index [15] to adjust for pre-existing conditions among patients: myocardial infarction, congestive heart failure, peripheral vascular disease, cerebral vascular disease, dementia, chronic pulmonary disease (excluding asthma and COPD), peptic ulcer, mild to severe liver disease, diabetes without chronic complication, diabetes with chronic complication, hemiplegia or paraplegia, renal disease, malignancy (including lymphoma and leukaemia, and excluding malignant neoplasm of skin) and metastatic solid tumour. These were identified according to ICD-10 coding algorithms for Charlson co-morbidities (see Appendix S1) [12].

Facility characteristics were derived from the prefectural health care facilities information system. Facility type was classified into the following four categories according to facility size and training status: physician's office, non-training hospital, cooperative type of clinical resident training hospital, and management type of clinical resident training hospital. Cooperative type of training hospitals conduct training for a portion of courses for medical residents belonging to management type of hospitals, while management type of training hospitals, including university hospitals, provide all or a large part of medical training courses for clinical residents. The distinction between these two types of hospitals is designated by the Ministry of Health, Labour and Welfare. Specialists were identified as board certified members of Japanese Respiratory Society and Japanese Society of Allergology. Whether facilities are located in the prefectural capital city or not was employed as facility location status.

### Variables for analysis

We created dependent and independent valuables to perform bivariable analysis and multiple logistic regression analysis. The dependent variable used in the analysis was the utilization of ICS in each patient, and categorized as follows: 0 (ICS not utilized) and 1 (ICS utilized).

The independent variables were patient- and facility-level characteristics available in the database. Patients' sex was scored 0 (men) or 1 (women). Patients' age was collapsed into three categories (15 to 64 years, 65 to 74 years, and 75 years or older) because of the quadratic relationship with the dependent variable in the models tested. Patients who were 15 to 64 years old served as the reference group. Variables related to co-morbidity were dichotomized as 0 (no co-morbid condition) or 1 (co-morbid condition) for each co-morbidity. The variables for the characteristics of the facility were as follows: presence (scored 1) versus absence (scored 0) of respiratory or allergy specialists; facility type which was collapsed into the aforementioned four categories; and facility location which was dichotomized as 0 (within the prefectural capital city) or 1 (outside of the prefectural capital city).

### Development of the statistical model

Initially, we performed bivariable analyses using chi-squared testing to determine the relationship between each independent variable and dependent variable. We then constructed multivariable logistic regression models to assess the effect of presence or absence of specialists, facility type and patients' age on the decisions of physicians with regard to prescription of ICS. We also controlled for other variables that could be potential confounding factors (i.e. sex, co-morbidity and facility location). We hypothesized an interaction between the presence or absence of specialists and the facility type. Other statistical methods were considered (e.g. fitting a multivariable model including all possible interactions between specialists, facility type, age and each co-morbidity), but consequently ruled out because of the difficulties in interpreting such complex logistic regression models [16].

In the first model, we utilized all the independent variables as described above. The second model was similar to the first, but with an inclusion of the interaction between the presence or absence of specialists and each of the facility types. The second model enabled us to assess facility characteristics with eight categories, which represented all possible combinations of specialists (presence vs. absence) and facility type (physician's office, non-training hospital, cooperative type of training hospital, and management type of training hospital).

Both models were adjusted for sex, age, each co-morbidity, presence or absence of specialists, facility type and facility location. We calculated adjusted odds ratios (ORs) with 95% confidence intervals (CIs). $P < 0.05$ was considered statistically significant. All *P*-values were two-tailed. Statistical analyses were performed using SPSS software, version 18.0.0 (SPSS Inc., Chicago, IL, USA).

## Results

### Patient description and bivariable analysis

We identified 43 724 adult patients with asthma; of these patients, 30 105 had at least two insurance claims for asthma treatment submitted by one health care facility in the study period, and 21 524 were not diagnosed with COPD or rheumatic disease. Within this sample, 8096 were treated without anti-asthmatic medication. This left a study population of 13 428 patients enrolled from 588 facilities.

Approximately half of the population ($n = 6876$, 51%) received ICS for asthma care. Table 2 provides patient- and facility-level characteristics of patients who did or did not receive ICS. There were more women than men (61% vs. 39%), and patients aged 15 to 64 years, 65 to 74 years, and 75 years or older accounted for about one-third of the study population, respectively. More than half of the patients aged 15 to 64 years and 65 to 74 years received ICS, whereas less than half of those aged 75 years or older did not ($P < 0.001$). The most common co-morbidity was allergic rhinitis ($n = 5031$, 38%).

In facility-level characteristics, facilities with respiratory or allergy specialists provided asthma care for 5155 patients (38% of the study population). Two-thirds of these patients ($n = 3432$) received ICS. In contrast, 42% of patients ($n = 3444$) who were treated at facilities without specialists received ICS ($P < 0.001$). Forty-five per cent of the study population ($n = 5974$) were treated at physicians' offices, with the remaining treated at hospitals. The proportion of ICS use in each facility type ran from 45% (non-training hospital) through 63% (management type of training hospital) ($P < 0.001$). Sixty-one per cent of the patients ($n = 8196$) received regular outpatient treatment at facilities located in the prefectural capital city. We found significant association between facility location and ICS use in the bivariable analysis ($P < 0.001$).

In the results of the bivariable analyses, as shown in Table 2, sex and chronic pulmonary disease (excluding asthma and COPD) were not significantly associated with ICS use.

### Multivariable analysis

Table 3 shows the results of the first model, without taking into account the interaction between the presence or absence of specialists and the facility training status. After adjustment for all the variables listed in Table 2, one of the factors associated with a high possibility of ICS use was presence of specialists (adjusted OR 2.70; 95% CI 2.46–2.97) when compared with their absence. The odds of prescribing ICS were greater when the facility type was physician's office (adjusted OR 1.19; 95% CI 1.07–1.33), cooperative type of training hospital (adjusted OR 1.22; 95% CI 1.06–1.41) or management type of training hospital (adjusted OR 1.44; 95% CI 1.28–1.62), when compared with non-training hospital.

Patients aged 75 years or older had significantly decreased odds of receiving ICS (adjusted OR 0.71; 95% CI 0.64–0.78) compared with a reference group aged 15 to 64 years. In contrast, the odds of receiving ICS for patients aged 65 to 74 years did not differ from those aged 15 to 64 years. We found significant inverse associations between the following co-morbidities and ICS use: allergic rhinitis, congestive heart failure, peripheral vascular disease, cerebral vascular disease, dementia, peptic ulcer, mild to severe liver disease, diabetes without chronic complication, malignancy (including lymphoma and leukaemia, and excluding malignant neoplasm of skin) and metastatic solid tumour. We found that sex, co-morbidities other than those mentioned above, and facility location were not significantly associated with ICS use after adjustment for the effects of the other variables.

Table 4 shows the results of the second model. We examined the interaction between the presence or absence of specialists and the facility training status. After adjustment for sex, age, each co-morbidity and facility location, the 'absence of specialists + physician's office' category was the only category that was significantly less likely to prescribe ICS (adjusted OR 0.79; 95% CI 0.69–0.90) than the 'absence of specialists + non-training hospital' category, which served as the reference group. Facilities with specialists had significantly increased odds of ICS prescription regardless of facility type than the 'absence of specialists + non-training hospital' category. For example, the

**Table 2** Characteristics of study population

| | All patients ($n$ = 13 428) | No ICS therapy ($n$ = 6552) | ICS therapy ($n$ = 6876) | *P*-value* |
|---|---|---|---|---|
| Patient-level characteristics | | | | |
| Sex | | | | |
| Men | 5278 (39.3) | 2561 (39.1) | 2717 (39.5) | 0.61 |
| Women | 8150 (60.7) | 3991 (60.9) | 4159 (60.5) | |
| Age (years) | | | | |
| 15–64 | 4812 (35.8) | 2032 (31.0) | 2780 (40.4) | |
| 65–74 | 3989 (29.7) | 1814 (27.7) | 2175 (31.6) | <0.001 |
| ≥75 | 4627 (34.5) | 2706 (41.3) | 1921 (27.9) | |
| Co-morbidity† | | | | |
| Allergic rhinitis | 5031 (37.5) | 2510 (38.3) | 2521 (36.7) | 0.049 |
| Gastro-oesophageal reflux disease | 2999 (22.3) | 1612 (24.6) | 1387 (20.2) | <0.001 |
| Myocardial infarction | 295 (2.2) | 175 (2.7) | 120 (1.7) | <0.001 |
| Congestive heart failure | 2118 (15.8) | 1290 (19.7) | 828 (12.0) | <0.001 |
| Peripheral vascular disease | 1338 (10.0) | 789 (12.0) | 549 (8.0) | <0.001 |
| Cerebral vascular disease | 2113 (15.7) | 1277 (19.5) | 836 (12.2) | <0.001 |
| Dementia | 346 (2.6) | 247 (3.8) | 99 (1.4) | <0.001 |
| Chronic pulmonary disease‡ | 171 (1.3) | 88 (1.3) | 83 (1.2) | 0.48 |
| Peptic ulcer | 3727 (27.8) | 2026 (30.9) | 1701 (24.7) | <0.001 |
| Mild to severe liver disease | 2095 (15.6) | 1180 (18.0) | 915 (13.3) | <0.001 |
| Diabetes without chronic complication | 2903 (21.6) | 1648 (25.2) | 1255 (18.3) | <0.001 |
| Diabetes with chronic complication | 619 (4.6) | 341 (5.2) | 278 (4.0) | 0.001 |
| Hemiplegia or paraplegia | 82 (0.6) | 51 (0.8) | 31 (0.5) | 0.02 |
| Renal disease | 367 (2.7) | 217 (3.3) | 150 (2.2) | <0.001 |
| Malignancy§ | 1227 (9.1) | 693 (10.6) | 534 (7.8) | <0.001 |
| Metastatic solid tumour | 162 (1.2) | 107 (1.6) | 55 (0.8) | <0.001 |
| Facility-level characteristics | | | | |
| Presence or absence of specialists¶ | | | | |
| Absence | 8273 (61.6) | 4829 (73.7) | 3444 (50.1) | <0.001 |
| Presence | 5155 (38.4) | 1723 (26.3) | 3432 (49.9) | |
| Facility type | | | | |
| Physician's office | 5974 (44.5) | 3228 (49.3) | 2746 (39.9) | |
| Non-training hospital | 2228 (16.6) | 1215 (18.5) | 1013 (14.7) | <0.001 |
| Cooperative type of clinical resident training hospital | 1392 (10.4) | 688 (10.5) | 704 (10.2) | |
| Management type of clinical resident training hospital | 3834 (28.6) | 1421 (21.7) | 2413 (35.1) | |
| Location | | | | |
| Within the prefectural capital city | 8196 (61.0) | 3787 (57.8) | 4409 (64.1) | <0.001 |
| Outside of the prefectural capital city | 5232 (39.0) | 2765 (42.2) | 2467 (35.9) | |

Data are given as number (column percentage) of patients.
*Data are given for the comparison between no ICS therapy and ICS therapy groups.
†Not mutually exclusive.
‡Asthma and chronic obstructive pulmonary disease are excluded.
§Lymphoma and leukaemia are included. Malignant neoplasm of skin is excluded.
¶Specialists indicate respiratory or allergy specialists.
ICS, inhaled corticosteroids.

odds of ICS use were increased in the 'presence of specialists + physician's office' category (adjusted OR 6.89; 95% CI 5.39–8.81). We did not find a significant difference among training status of hospitals without specialists. For example, the odds of prescribing ICS in the 'absence of specialists + management type of training hospital' category did not differ from those in the 'absence of specialists + non-training hospital' category in the second model. Each of the other independent variables (i.e. sex, age, each co-morbidity and facility location) yielded ORs similar to those in the first model that did not include the interaction between the presence or absence of specialists and the facility training status (data not shown).

## Discussion

We identified patients' and facilities' factors affecting ICS prescription for 13 428 patients with asthma from 588 health care facilities in Japan. Our findings are based on an analysis of a patient sample covering a wide age range.

**Table 3** ORs for ICS prescription in the model without taking into account any interaction

| | OR (95% CI) | *P*-value |
|---|---|---|
| Patient-level variable | | |
| Sex | | |
| Men | Reference | |
| Women | 1.00 (0.92–1.07) | 0.92 |
| Age (years) | | |
| 15–64 | Reference | |
| 65–74 | 1.02 (0.93–1.12) | 0.68 |
| ≥75 | 0.71 (0.64–0.78) | <0.001 |
| Co-morbidity* | | |
| Allergic rhinitis | 0.88 (0.81–0.94) | 0.001 |
| Gastro-oesophageal reflux disease | 0.96 (0.88–1.06) | 0.44 |
| Myocardial infarction | 0.91 (0.70–1.18) | 0.47 |
| Congestive heart failure | 0.75 (0.67–0.84) | <0.001 |
| Peripheral vascular disease | 0.81 (0.71–0.92) | 0.001 |
| Cerebral vascular disease | 0.79 (0.71–0.88) | <0.001 |
| Dementia | 0.59 (0.46–0.76) | <0.001 |
| Chronic pulmonary disease† | 0.85 (0.61–1.17) | 0.32 |
| Peptic ulcer | 0.86 (0.79–0.94) | 0.001 |
| Mild to severe liver disease | 0.85 (0.77–0.94) | 0.002 |
| Diabetes without chronic complication | 0.80 (0.73–0.89) | <0.001 |
| Diabetes with chronic complication | 1.01 (0.83–1.22) | 0.93 |
| Hemiplegia or paraplegia | 0.77 (0.47–1.24) | 0.28 |
| Renal disease | 0.91 (0.72–1.15) | 0.44 |
| Malignancy‡ | 0.77 (0.67–0.88) | <0.001 |
| Metastatic solid tumour | 0.51 (0.36–0.73) | <0.001 |
| Facility-level variable | | |
| Specialists§ | | |
| Absence | Reference | |
| Presence | 2.70 (2.46–2.97) | <0.001 |
| Facility type | | |
| Physician's office | 1.19 (1.07–1.33) | 0.002 |
| Non-training hospital | Reference | |
| Cooperative type of clinical resident training hospital | 1.22 (1.06–1.41) | 0.005 |
| Management type of clinical resident training hospital | 1.44 (1.28–1.62) | <0.001 |
| Location | | |
| Within the prefectural capital city | Reference | |
| Outside of the prefectural capital city | 0.96 (0.89–1.04) | 0.33 |

Data are provided as adjusted ORs (95% CI) for all the patient- and facility-level variables.

*Data are provided as ORs when compared with absence of each co-morbidity.

†Asthma and chronic obstructive pulmonary disease are excluded.

‡Lymphoma and leukaemia are included. Malignant neoplasm of skin is excluded.

§Specialists indicate respiratory or allergy specialists.

ICS, inhaled corticosteroids; OR, odds ratio; CI, confidence interval.

The presence of respiratory or allergy specialists in health care facilities was a strong factor affecting the likelihood of ICS use. This finding is consistent with that of a previous study [10]. In facilities without specialists, there may be several potential factors that contribute to suboptimal ICS use, including lack of guideline understanding [17] and underestimation of asthma severity [18]. There are many systematic approach methods to enhance guideline compliances: for instance, an instructive process has been shown to improve general practitioners' prescription behaviour for asthmatic patients in Japan [19]. However, further efforts are required to disseminate guidelines to non-specialists, because 62% of asthmatic adults are treated at health care facilities without specialists.

We also found that patients aged 75 or older were less likely to receive ICS than those aged 15 to 64. In Japan, age-adjusted asthma mortality rates have decreased in recent years [20]. This trend is considered to be associated with increasing ICS use [21]. However, two-thirds of all fatal asthma cases in Japan involved patients that were 75 years or older [22]. Thus, one of the causes of the observed high asthma mortality among the elderly might be the low prescription rate of ICS among patients aged 75 or older. Sin *et al.* [23] have demonstrated that ICS therapy reduces mortality and hospitalization among asthmatic elderly patients. Increasing ICS prescription for the elderly may therefore result in the reduction in asthma mortality in Japan.

## Strengths and limitations

Our study possesses several advantages when compared to those in the existing literature. Because of the comprehensiveness of our data source, we were able to include study patients of all adult ages, rather than be limited to patients of a certain age range. As stated in the introduction, previous studies have focused on physician behaviour prescribing for asthmatic patients within specific age ranges [10,11]. To the best of our knowledge, the present study is the first claims data research that has revealed the increased risk of not prescribing ICS for the elderly when compared to younger adults.

Furthermore, in this study we have examined facility training statuses and their interactions with the presence or absence of specialists on ICS prescription. The training status was shown to affect the prescription or non-prescription of ICS in the model that did not include these interactions as independent variables. The model that included these interactions, however, suggested that whether asthmatic patients received ICS or not depended on the presence or absence of specialists rather than the training statuses of hospitals.

Our study has several limitations. First, health insurance claims are essentially financial documents and not medical records. Information about individual patient details such as asthma severity, control status, smoking habits and patient adherence is scant. ICS should in theory be prescribed for all asthmatic patients because its use is recommended in the guidelines irrespective of these patients' factors. Moreover, the diagnostic accuracy in claims data may be questioned. Previous studies, however, have validated the accuracy of asthma diagnosis in claims data [24]. In fact, there have been numerous influential asthma studies using claims data [25]. As such, we believe our findings to be based on reliable information about diagnosis and prescription.

Second, the database includes prescription information on a facility basis rather than a physician basis. In Japan, some asthmatic patients are treated by non-specialists in hospitals despite the presence of specialists. Also, patients treated at physicians'

 

**Table 4** ORs for ICS prescription in the model examining interaction*

| | OR (95% CI) | *P*-value | OR (95% CI) | *P*-value |
|---|---|---|---|---|
| | Absence of specialists† | | Presence of specialists† | |
| Physician's office | 0.79 (0.69–0.90) | <0.001 | 6.89 (5.39–8.81) | <0.001 |
| Non-training hospital | Reference | | 1.33 (1.12–1.58) | 0.001 |
| Cooperative type of clinical resident training hospital | 0.93 (0.78–1.12) | 0.47 | 2.28 (1.85–2.81) | <0.001 |
| Management type of clinical resident training hospital | 1.20 (1.00–1.44) | 0.051 | 2.72 (2.36–3.13) | <0.001 |

Data are provided as adjusted ORs (95% CI) for all the patient-level variables and facility location.
*Interaction between the presence or absence of specialists and the facility type.
†Specialists indicate respiratory or allergy specialists.
ICS, inhaled corticosteroids; OR, odds ratio; CI, confidence interval.

offices with specialists are more likely to receive specialist care than those treated at hospitals with specialists, because most offices are managed by solo-practitioners. Access to physician-level prescription data may allow us to observe a stronger association between specialists and ICS use.

### Conclusions

We have revealed several factors that influence ICS prescription in various health care facilities. We found that increases in ICS therapy for the elderly and ICS prescription by non-specialists would lead to an overall increase in patients receiving ICS. Consequently, this could contribute to a decrease in asthma mortality rates among the elderly and an increase in the number of patients achieving the goal of asthma control.

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## Supporting information

Additional Supporting Information may be found in the online version of this article:

**Appendix S1** ICD-10 codes for the diseases analysed in our study.

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# Effects of the per diem prospective payment system with DRG-like grouping system (DPC/PDPS) on resource usage and healthcare quality in Japan

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ABSTRACT

*Objectives:* In 2003, Japan introduced the prospective payment system (PPS) with diagnosis-related groups (DRG) rearranged grouping system called the diagnostic procedure combination/per-diem payment system (DPC/PDPS). Even after eight years, little is known about the effects of DPC/PDPS. The purpose of this study was to examine the effects of DPC/PDPS on resource usage and healthcare quality.
*Methods:* Using 2001–2009 (fiscal year) administrative data of acute myocardial infarction patients, four indices, including inpatient total accumulated medical charges, length of stay (LOS), mortality rate, and readmission rate, were compared between patients reimbursed by DPC/PDPS or by fee-for-service.
*Results:* DPC/PDPS significantly reduced total accumulated medical charges by $1061 (95% confidence interval [CI], −2007, −116) and LOS by 2.29 days (95% CI, −3.71, −0.88) after risk adjustment. However, mortality rate (Odds ratio [OR], 0.94; 95% CI, 0.73, 1.21) was unchanged. Furthermore, DPC/PDPS increased the readmission rate (OR, 1.37; 95% CI, 1.03, 1.82).
*Conclusions:* This study showed that DPC/PDPS was associated with reduced resource usage, but not improved healthcare quality, as with DRG/PPSs in other countries. To achieve successful healthcare reform, further discussion on additional motives will be required.



## 1. Introduction

Health expenditure has been steadily increasing throughout the world [1]. The control of health expenditure has become a priority for every government. Sufficient evidence indicates that the performance of healthcare providers is affected by payment methods [2,3]. For instance, Wennberg et al. pointed out that losses in hospital revenues resulting from diagnosis-related groups (DRG) could be offset if physicians modify their admission policies to produce more profit, thereby leading to hospital cost inflation. Based on this, they concluded that cost-containment systems based on fixed, per-admission hospital prices would be needed to control hospitalization rates [2]. Moreover, Ellis and McGuire proposed that a supply-side cost-sharing system, such as a prospective payment system (PPS), would provide strong incentives to providers to contain medical expenses, but that this

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occurs only in the unlikely case that the physician is a perfect agent, i.e., without conflicts of interest. However, physicians obviously cannot function as perfect agents, given that under PPS, they face the conflicting interests of patients and providers. To address this issue, Ellis and McGuire proposed a mixed reimbursement system, which is part prospective and part cost-based [3]. These studies underscore the notion that reimbursement system reform is the key to controlling health expenditure and improving efficiency.

In 1983, the United States Government introduced a prospective payment system (PPS) with diagnosis-related groups (DRG) for Medicare patients nationwide to control costs. To date, many studies have examined the effects of DRG/PPS [4–8]. For instance, Davis and Rhodes compared Medicare patients before and after the implementation of DRG/PPS, and reported that DRG/PPS reduced hospitalization and length of stay (LOS), although mortality and readmission rate did not increase [4]. In another study, Cutler et al. examined mortality and readmission rate of Medicare patients, and found that while 1-year mortality rate remained unchanged, readmission rate increased. This appeared to reflect accounting changes in hospitals, rather than true changes in morbidity [5]. Kahn et al. also documented that LOS decreased by 24%, although 180-day adjusted mortality and readmission rate remained unchanged [6]. These findings demonstrate that DRG/PPS reduces cost and average LOS without affecting healthcare quality.

The success of DRG/PPS encouraged other governments to adopt DRG/PPS-like systems. Over the past 20 years, many countries have introduced DRGs or similar grouping systems as instruments for hospital reimbursement. These reimbursement systems have reduced cost and average LOS, as in the United States [9–17].

Japan has experienced approximately a 3-fold increase in health expenditure over the past 20 years under the fee-for-service (FFS) reimbursement system. This has raised the imminent issue of controlling health expenditure. A pilot program to test the validity of a DRG/PPS-like system was implemented in 1998. In 2003, PPS with a DRG rearranged grouping system called the diagnostic procedure combination/per-diem payment system (DPC/PDPS) was formally introduced [18,19]. At first, only 82 hospitals (less than 1% of all hospitals in Japan) were enrolled. Since then, each acute care hospital has voluntarily chosen whether and when to apply DPC/PDPS, and it has expanded rapidly to other hospitals. In 2009, the enrollment included more than 1200 hospitals, which cover about half of the acute care beds.

DPC/PDPS is similar to DRG/PPS in that reimbursements are pre-determined according to the classification of each inpatient activity. However, it differs in two important aspects. First, DPC/PDPS classifies inpatient activities first by diagnoses and then by procedures, whereas the DRG/PPS classification is a procedure dominant system. For instance, an acute myocardial infarction (AMI) patient who underwent percutaneous coronary intervention (PCI) is first classified as DPC code "050030" based on the disease, and then coded as DPC code "050030xx03" for PCI. Moreover, given the 14-character DPC code, the patient is further classified if additional procedures are carried out, such as intra-aortic balloon pumping (IABP), or by severity or comorbidities. Second, inclusive payments are not "per episode," but rather "per diem." Medical charges under DPC/PDPS consist of inclusive and FFS components. Similar to DRG/PPS, the FFS component reimburses charges for expensive procedures (e.g., surgeries and hemodialysis). In contrast, the inclusive component covers charges for hospitalization, examinations, and medication, and has a flat-rate per diem fee based on diagnostic categories.

The goals of DPC/PDPS are to deliver quality healthcare efficiently and to construct a clinical database. The per diem reimbursement system is assumed to have weaker incentives to reduce resource usage [8]. However, despite being implemented eight years ago, only a few studies have examined whether DPC/PDPS contributes to reduced resource usage, as does DRG/PPS, or its effects on healthcare quality. Accordingly, the aim of this study was to elucidate the effects of DPC/PDPS on resource usage and healthcare quality in Japan.

## 2. Materials and methods

### 2.1. Database and data collection

The Quality Improvement/Indicator Project (QIP) was designed to improve clinical performance and healthcare quality through data analysis, and has been in existence since 1995. Patient-based administrative data (DPC data) for inpatient activity, including clinical information and claims, are routinely collected from voluntarily participating hospitals, which are located nationwide and provide acute care [20,21]. The project was initiated in 1995 with 10 participating hospitals; the current number is approximately 300. Data from this database were used for this study.

We extracted data on all patients who had a principal diagnosis of AMI and were admitted between April 1, 2001 and September 30, 2009 in the QIP database. AMI was defined according to the International Classification of Diseases (ICD) version 10 codes (I21.x, I22.x). AMI was selected for analysis because it is associated with a high mortality rate, a clear definition of the disease exists, and it is associated with the largest number of cases and highest medical expenses in the DPC database, thus representing acute illnesses. Only data from hospitals that submitted data both before and after DPC/PDPS implementation were included, given that the purpose of this study was to compare resource usage and healthcare quality across the period of implementing DPC/PDPS. Hospitals with less than 20 AMI patients were excluded to minimize unstable estimates of the outcome. Patients were excluded if they were younger than 20 years of age at admission, and/or if data were missing or inadequate. A few patients who were admitted to DPC/PDPS implementing hospitals were reimbursed by FFS when classified as severely ill or underwent very rare surgeries, or if their LOS was overly long. For instance, AMI patients who underwent ventricular aneurysm resection were reimbursed by FFS. Practice patterns for these patients probably do not reflect the behavioral changes due to the implementation of DPC/PDPS. Thus, these patients

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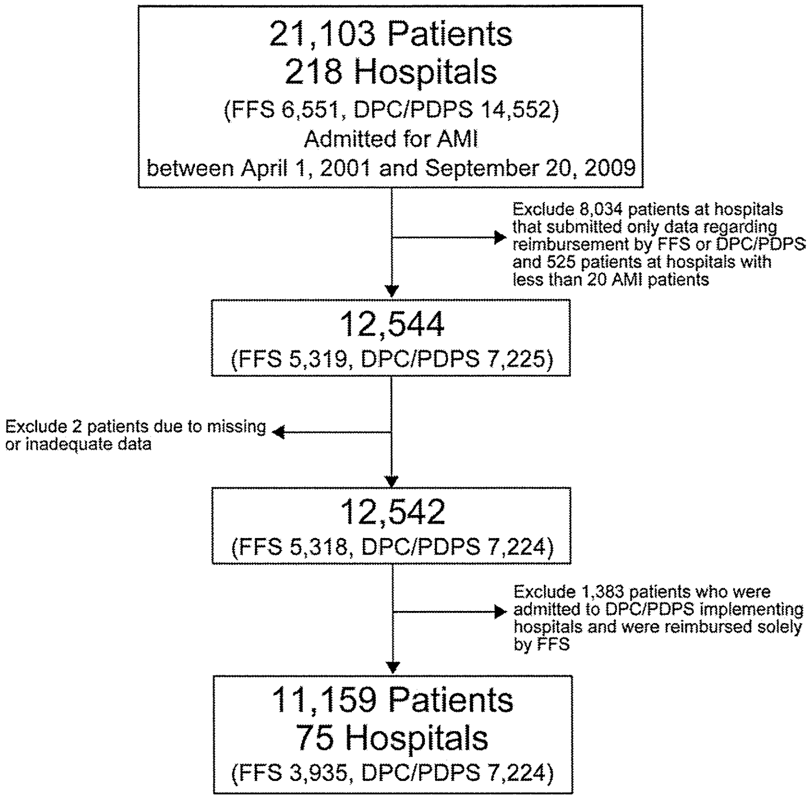


**Fig. 1.** Inclusion and exclusion criteria applied to identify the study population. This figure displays how inclusion and exclusion criteria were applied to identify the study population. From the initial population of AMI patients admitted between April 1, 2001 and Septemper 30, 2009, exclusion criteria were applied sequentially. FFS: fee-for-service, DPC/PDPS: diagnostic procedure combination/per-diem payment system.

were excluded from our analysis. Fig. 1 summarizes how exclusion and inclusion criteria were applied to obtain the final study population.

To assess the influence of DPC/PDPS on resource usage and healthcare quality, we examined total medical charges, LOS, mortality rate, and rate of readmission within 30 days [4–9,11–16]. To assess the difference between FFS and PPS reimbursement systems, medical charge calculations were based on total accumulated charges for hospitalization according to the FFS schedule. Furthermore, the breakdown of charges for procedures (surgeries), examinations (e.g., blood tests, diagnostic imaging, ultrasonography), and medications were calculated to determine changes in resource usage following the introduction of DPC/PDPS. Medical charges were based on official prices in Japanese yen (JPY) and converted to US dollars (USD). One USD corresponds to 110.22 JPY based on purchasing power parities (PPPs) from the International Comparison Program (ICP) of the World Bank [22]. No discounts were performed.

To evaluate the effects of DPC/PDPS on healthcare quality, the survival/death of each patient and their readmission within 30 days after discharge were examined. These were measured as binary variables. Confounding factors included sex, age at admission, comorbidity status (Charlson index [23]), and whether each patient underwent percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG). Age at admission was divided into three groups (i.e., <65, 65–74, and ≥75 years) and dummied.

This study included AMI cases in our database between 2001 and 2009. It is likely that this research period of nine years is long enough to influence resource usage and healthcare quality. The research period affected both DPC/PDPS and control (FFS) groups. Therefore, we adopted a difference in differences (DID) technique to incorporate this effect. DID is a type of quasi-experiment with a before and after design, and includes an untreated comparison group [24]. The advantage of DID is that it uses the control group to subtract out changes other than that of DPC/PDPS over the research period. With this technique, variables that represent the time of admission of each patient were added to the model.

*2.2. Statistical analysis*

To compare variables across DPC/PDPS application, one-way analysis of variance, chi-square test, and the Mann–Whitney test were performed for continuous variables, categorical and binary variables, and ordinal variables, respectively. Multivariate analysis was performed to estimate the effect of DPC/PDPS after adjusting for confounders. Patients in a hospital are more alike than randomly chosen patients, due to similarities in sociodemographic status, and each hospital has its own style of examining and treating patients. Traditional multivariate

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regression and logistic models ignore this correlation within clusters (hospitals) and tend to overestimate the significance of null hypothesis tests [25]. To incorporate this cluster-related correlation, we adopted a multilevel (mixed-effect) regression model for continuous variables (e.g., medical charges and LOS) and a multilevel (mixed-effect) logistic regression model for binary variables (e.g., mortality and readmission). The multilevel regression model includes two levels: the individual patient level and the hospital level.Level 1 (Individual patient level)

$$y_{ij} = \beta_{0j} + \sum_p \beta_p x_{pij} + \varepsilon_{ij}$$

Level 2 (Hospital level)

$$\beta_{0j} = \gamma_{00} + u_{0j},\ u_{0j} \sim N(0, \sigma^2)$$

where $i$ denotes the patient, $j$ denotes the hospital, $\beta_p$ is the fixed-effect coefficient, $\varepsilon_{ij}$ is the random error at the patient level, and $\beta_{0j}$ is the random intercept, which includes $u_{0j}$ (i.e., random error at the hospital level).

The multilevel (mixed-effect) logistic regression model also consists of two levels.Level 1 (Individual patient level)

$$\text{logit}(P_{ij}(Y = 1)) = \beta_{0j} + \sum_p \beta_p x_{pij} + \varepsilon_{ij}$$

Level 2 (Hospital level)

$$\beta_{0j} = \gamma_{00} + u_{0j},\ u_{0j} \sim N(0, \sigma^2)$$

Intra-class correlations (ICCs) were calculated to examine the cluster effect in multilevel regression models. However, given the difficulty of interpreting the effect of clusters using ICC in multilevel logistic models, the median odds ratio (MOR) was calculated as described by Larsen and Merlo [26].

IBM SPSS Ver.18 (SPSS Japan Inc., an IBM company, Tokyo, Japan) was used to extract and transform the administrative date, and Stata/IC Version 11 (StataCorp LP, College Station, Texas) was used to build the multilevel regression models. In the multilevel models, ICC and MOR were calculated using the xtmrho module [27]. $p < 0.05$ was considered significant.

### 2.3. Ethical considerations

This study was approved and registered by the Kyoto University Graduate School and Faculty of Medicine, Ethics Committee.

## 3. Results

A total of 21,103 AMI cases were found in our database. Of these, 8559 were excluded because they were admitted to hospitals that submitted only data regarding reimbursements by FFS or PDPS (8034), or were admitted to hospitals with less than 20 AMI patients (525). Two patients were excluded due to missing or inadequate data. Moreover, 1383 patients were excluded because they were admitted to DPC/PDPS implementing hospitals and were reimbursed solely by FFS. Thus, data were available for a total of 11,159 cases from 75 hospitals. The DPC/PDPS group and the non-DPC/PDPS (FFS) group included 7224 and 3935 cases, respectively. Table 1 shows that the two groups were not significantly different with respect to age, sex, and proportion of those who underwent PCI and CABG; however, the comorbidity status (Charlson index) was more severe (1.76 vs. 1.43; $p < 0.001$) in the DPC/PDPS group than in the FFS group. Patients in the DPC/PDPS group were admitted later than those in the FFS group. This reflects the transition of the Japanese reimbursement system from FFS to DPC/PDPS.

Univariate analysis (see Table 2) revealed that total accumulated medical charges were significantly lower in the DPC/PDPS group ($18,218 vs. $20,686; $p < 0.001$). Charges for examinations and medications were lower by as much as 35% in the DPC/PDPS group (−38% and −36%, respectively). LOS was also shorter in the DPC/PDPS group (17.1 vs. 20.2 days; $p < 0.001$). With respect to healthcare quality, mortality rate (10.1% vs. 9.5%) and readmission rate (6.5% vs. 6.3%) were similar in both groups.

The results of multilevel regression and logistic models are presented in Table 3. Resource usage significantly increased and healthcare quality was aggravated when patients were older or had more severe comorbidity status. Both PCI and CABG significantly improved mortality rate, while they increased resource usage. DPC/PDPS significantly reduced total accumulated medical charges (−$1061; 95% Confidence Interval [CI], −2007, −116), and also shortened LOS (−2.29 days; 95% CI, −3.71, −0.88). With respect to the effect on healthcare quality, DPC/PDPS significantly increased rate of readmission within 30 days (Odds Ratio [OR], 1.37; 95% CI, 1.03, 1.82), although mortality rate was unchanged. Table 4 shows the adjusted effects on the breakdown of medical charges in multilevel regression models. When compared with FFS group averages, DPC/PDPS reduced charges for examinations and medications by more than 15%. However, the reduction in charges for procedures was modest at only 3%.

Trends had a marked influence on resource usage and healthcare quality as seen in the multivariate analysis. Compared to 2001, the 2009 cases had much lower total accumulated medical charges (−$4725; 95% CI, −6530, −2919), much shorter LOS (−7.45 days; 95% CI, −10.15, −4.74), and much lower readmission rate (OR, 0.44; 95% CI, 0.25, 0.77). The effect of time trend on mortality rate was inconsistent. Furthermore, the variance between hospitals had considerable effects on mortality and readmission rate (MOR, 1.46 and 1.57, respectively).

## 4. Discussion

In this study, we examined the effects of DPC/PDPS in acute myocardial infarction (AMI) patients. Since DPC/PDPS is mainly tailored to reimbursements in acute care hospitals, we selected AMI as a representative acute illness.

With respect to effects on resource usage, DPC/PDPS reduced total accumulated medical charges by approximately 5%. Among various medical charges, reductions in examination and medication charges amounted to as much as 15% after adjustment. These reductions may reflect three factors. First, some examinations and medications which had been traditionally used were considered

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**Table 1**
Characteristics of patients.

| | FFS | DPC/PDPS | |
|---|---|---|---|
| No. of patients | 3935 | 7224 | |
| Sex | | | |
| Male | 2785 | 5097 | $p = 0.81$† |
| Female | 1150 | 2127 | |
| Age | | | |
| <65 | 1408 | 2556 | $p = 0.07$† |
| 65–74 | 1142 | 1980 | |
| ≥75 | 1385 | 2688 | |
| Comorbidity (Charlson's index) | 1.43 | 1.76 | $p < 0.001$¶ |
| Time of admission (No. of hospitals) | | | |
| 2001 | 900 (8) | 0 (0) | $p < 0.001$‡ |
| 2002 | 797 (8) | 0 (0) | |
| 2003 | 302 (6) | 0 (0) | |
| 2004 | 75 (4) | 374 (8) | |
| 2005 | 193 (10) | 469 (9) | |
| 2006 | 255 (15) | 1179 (20) | |
| 2007 | 1059 (39) | 1333 (30) | |
| 2008 | 354 (12) | 2717 (60) | |
| 2009 | 0 (0) | 1152 (58) | |
| Rate of procedures | | | |
| PCI | 77.8% | 79.0% | $p = 0.15$† |
| CABG | 2.8% | 3.0% | $p = 0.74$† |

FFS: fee-for-service, DPC/PDPS: diagnostic procedure combination/per-diem payment system.
† Chi-square test.
‡ Chi-square test for number of patients.
¶ Mann–Whitney test.

excessive and unnecessary, and hence withdrawn. For instance, broad-spectrum antibiotics, such as 3rd generation cephalosporin, were administered as prophylaxis for several days after surgery in Japan [28]. These prophylactic usages were replaced by a single administration of narrow spectrum antibiotics based on guidelines [29]. A second factor is the shift to the outpatient department. Since outpatient department reimbursements were paid by FFS as before, some preoperative checkups and medications for comorbidities, such as hypertension and diabetes, were shifted to the outpatient department. Finally, the introduction of generic drugs played a role in reducing medication charges. However, we did not examine the extent to which generic drugs were prescribed in this study due to the lack of detailed prescription data for some patients. In contrast, the reduction in procedure (surgeries) charges was much smaller than that of examination and medication charges. This was because expensive procedures, such as surgeries and hemodialysis, are not included in the prospective payment and are reimbursed by FFS in DPC/PDPS, and these procedures are essential for treatment and cannot be omitted or shifted to the outpatient department.

The per diem reimbursement system is viewed as providing weaker incentives to shorten LOS than per case reimbursement systems, such as DRG/PPS, and its effect on LOS depends on pre-determined hospital rates [8]. In this study, we found that DPC/PDPS significantly shortened LOS. This likely reflects gradual decreases in per diem payment as hospitalization lengthens under the DPC/PDPS system, which serves as an incentive to shorten LOS. These findings on the effects of resource usage are consistent with other reports.

We examined two indices for healthcare quality. Mortality rate was unchanged after DPC/PDPS implementation. However, the readmission rate due to premature discharge increased, which is inconsistent with previous observations made by studies that examined the effects of PPS. The increase in the number of patients who are discharged

**Table 2**
Univariate analysis of the effects of DPC/PDPS on resource usage and healthcare quality.

| | FFS $n = 3935$ | DPC/PDPS $n = 7224$ | |
|---|---|---|---|
| Resource usage | | | |
| Total medical charge (US$) | $20,686 | $18,218 | $p < 0.001$‡ |
| Procedures (surgeries) | $12,637 | $11,458 | $p < 0.001$‡ |
| Examinations | $1781 | $1098 | $p < 0.001$‡ |
| Medications | $1347 | $865 | $p < 0.001$‡ |
| Length of stay (day) | 20.2 | 17.1 | $p < 0.001$‡ |
| Heathcare quality | | | |
| Mortality rate | 9.5% | 10.1% | $p = 0.31$† |
| Readmission rate within 30 days | 6.3% | 6.5% | $p = 0.54$† |

FFS: fee-for-service, DPC/PDPS: diagnostic procedure combination/per-diem payment system.
† Chi-square test.
‡ One-way ANOVA.

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**Table 3**
Effects of DPC/PDPS on resource usage and healthcare quality.

| | Resource usage | | | | Healthcare quality | | | |
|---|---|---|---|---|---|---|---|---|
| | Total medical charges (US$) | | Length of stay (day) | | Mortality rate | | Readmission rate | |
| | Coefficient (95% CI) | *p*-Value | Coefficient (95% CI) | *p*-Value | Odds ratio (95% CI) | *p*-Value | Odds ratio (95% CI) | *p*-Value |
| Fixed effect | | | | | | | | |
| Sex | | | | | | | | |
| Male | Reference | | Reference | | Reference | | Reference | |
| Female | 182 (−345, 707) | 0.50 | 0.95 (0.15, 1.74) | 0.02 | 1.44 (1.25, 1.66) | <0.001 | 0.93 (0.78, 1.11) | 0.39 |
| Age | | | | | | | | |
| <65 | Reference | | Reference | | Reference | | Reference | |
| 65–74 | 1024 (449, 1600) | <0.001 | 1.47 (0.60, 2.34) | 0.001 | 2.06 (1.64, 2.59) | <0.001 | 1.43 (1.18, 1.74) | <0.001 |
| ≥75 | 1586 (1014, 2158) | <0.001 | 4.34 (3.47, 5.20) | <0.001 | 4.37 (3.56, 5.37) | <0.001 | 1.43 (1.17, 1.74) | <0.001 |
| Comorbidity (Charlson's index) | 1436 (1173, 1699) | <0.001 | 2.66 (2.26, 3.06) | <0.001 | 1.09 (1.01, 1.17) | 0.03 | 1.22 (1.12, 1.33) | <0.001 |
| Procedure | | | | | | | | |
| No procedures | Reference | | Reference | | Reference | | Reference | |
| Percutaneous coronary intervention (PCI) | 11,387 (10,799, 11,976) | <0.001 | 3.45 (2.56, 4.34) | <0.001 | 0.18 (0.15, 0.20) | <0.001 | 0.85 (0.69, 1.04) | 0.09 |
| Coronary artery bypass graft (CABG) | 41,682 (40,387, 42,977) | <0.001 | 26.46 (24.5, 28.41) | <0.001 | 0.57 (0.40, 0.82) | 0.002 | 1.47 (1.02, 2.13) | 0.04 |
| Time of admission (fiscal year) | | | | | | | | |
| 2001 | Reference | | Reference | | Reference | | Reference | |
| 2002 | −2027 (−3183, −872) | 0.001 | −2.84 (−4.58, −1.09) | 0.001 | 0.77 (0.54, 1.08) | 0.12 | 0.95 (0.64, 1.40) | 0.77 |
| 2003 | −4263 (−5864, −2661) | <0.001 | −4.86 (−7.28, −2.44) | <0.001 | 0.51 (0.30, 0.86) | 0.01 | 0.80 (0.46, 1.39) | 0.42 |
| 2004 | −4059 (−5685, −2433) | <0.001 | −3.12 (−5.57, −0.67) | 0.01 | 0.41 (0.24, 0.70) | 0.001 | 0.67 (0.40, 1.13) | 0.13 |
| 2005 | −4842 (−6298, −3386) | <0.001 | −4.04 (−6.24, −1.85) | <0.001 | 0.29 (0.18, 0.48) | <0.001 | 0.47 (0.29, 0.76) | 0.002 |
| 2006 | −3546 (−4958, −2135) | <0.001 | −3.21 (−5.33, −1.09) | 0.003 | 0.89 (0.61, 1.31) | 0.54 | 0.49 (0.31, 0.78) | 0.003 |
| 2007 | −3433 (−4776, −2091) | <0.001 | −3.26 (−5.27, −1.24) | 0.002 | 0.67 (0.47, 0.96) | 0.03 | 0.54 (0.36, 0.83) | 0.005 |
| 2008 | −3863 (−5434, −2292) | <0.001 | −4.75 (−7.10, −2.40) | <0.001 | 0.93 (0.62, 1.40) | 0.70 | 0.55 (0.34, 0.90) | 0.02 |
| 2009 | −4725 (−6530, −2919) | <0.001 | −7.45 (−10.15, −4.74) | <0.001 | 1.09 (0.68, 1.74) | 0.73 | 0.44 (0.25, 0.77) | 0.004 |
| Application of DPC/PDPS | −1061 (−2007, −116) | 0.028 | −2.29 (−3.71, −0.88) | 0.002 | 0.94 (0.73, 1.21) | 0.60 | 1.37 (1.03, 1.82) | 0.04 |
| Cluster effects | | | | | | | | |
| Intraclass correlation (ICC) | 0.063 | | 0.055 | | 0.046 | | 0.064 | |
| Median odds ratio (MOR) | – | | – | | 1.46 | | 1.57 | |

CI: confidence interval, DPC/PDPS: diagnostic procedure combination/per-diem payment system.

**Table 4**
Adjusted effects of DPC/PDPS on the breakdown of medical charges.

| Breakdown of medical charges | Adjusted effect[a] (95% CI) | *p*-Value | Proportion of reduction[b] |
|---|---|---|---|
| Total medical charge | −1061 (−2006, −115) | 0.03 | 5.1% |
| Procedures (surgeries) | −387 (−1021, 248) | 0.23 | 3.1% |
| Examinations | −323 (−413, −233) | <0.001 | 18.1% |
| Medications | −220 (−387, −52) | 0.01 | 16.3% |

CI: confidence interval.
[a] Adjusted by sex, age, comorbidity status, procedures, and time trend in the multilevel regression models.
[b] Calculated compared with FFS group averages.

to facilities other than home and stay longer in nursing homes contributes to the unchanged readmission rate in the United States, despite premature discharge [6,7]. Japan has more beds in acute care hospitals and fewer care facilities, such as nursing homes, than countries like the United States. These circumstances, which facilitate access to inpatient care even when nursing home care would suffice, may increase readmission rates in Japan.

We used a DID technique to incorporate the effect of trends. As a consequence, trends had considerable effects on both total medical charges and LOS. The official prices, which form the basis for reimbursement payments and had been reduced by the government every other year, contributed to reduced medical charges. However, the official price-induced reduction constituted only a small percentage of the total reduction. The remainder of the reduction can be attributed to improvements in efficiency, which must be further examined in future studies. Trends also remarkably shortened the LOS. This effect may also be due to improvements in efficiency. However, the mean LOS in Japan has been much longer than in other countries. The Organization for Economic Co-operation and Development (OECD) Health Data indicate that the mean LOS in Japan was 24.8 days in 2000 and 18.8 days in 2008 compared to 7.4 days and 6.5 days, respectively, for all the other OECD countries [1]. Thus, the major reason for reduced LOS may be that the LOS amended itself, irrespective of healthcare system reform. In addition to their effects on resource usage, trends also improved healthcare quality. While DID conferred some benefits, it also has some limitations. First, DID hypothesizes *a priori* that trends may affect both treatment and control groups. This hypothesis is difficult to verify. However, care fees are fixed by the government, and citizens are all insured and have universal access to healthcare in Japan. This universality of the Japanese healthcare system justifies the DID hypothesis. Another limitation is the possibility of an interaction between the implementation of DPC/PDPS and the time period [24]. Additional models used to examine the interaction between these two variables showed that the interaction had no significant effects on any of the four main outcomes. Finally, behavioral changes may occur just prior to treatment. To address this possibility, we tested models that included a dummy variable for one year before DPC/PDPS implementation and found no significant effects on any of the main outcomes.

In Japan, healthcare practice varies from hospital to hospital. Therefore, we adopted multilevel models to assess hospital-related variation and examine the effect of this variation on outcomes. These models revealed that the variance in hospitals accounted for only a few percent of the total variance in resource usage. Interestingly, these models determined that among all dependent variables, variation in hospitals was the most influential factor for healthcare quality. One of the goals of DPS/PDPS is to promote standardization of care. Further research will be needed to determine whether variations among hospitals influence standardization of care. Our results underscore the importance of other motives, such as public reporting for performance and pay for reporting, to improve healthcare quality. As with DID, multilevel models have some methodological challenges [30]. The main concern is model complexity. While a more complicated model likely reflects reality more accurately, such models require larger data sets and sample size calculations are complex. However, the dataset in this study was large enough to overcome this concern. The other issue is that group-level attributes cannot affect individuals independent of all individual-level attributes. This suggests an interaction between group-level and individual-level variables or between group-level variables and unaccounted individual-level attributes. In this study, we allowed only a random intercept for hospitals and did not include hospital-level variables. Hence, further studies are needed to examine the interaction between hospital-level and individual-level variables.

This study has some limitations. First, our study relied on inpatient claim data. This means that detailed clinical data are limited and, therefore, risk adjustment by severity of disease may be insufficient. Unavailable outpatient data made it impossible to examine the extent of the shift in activity from the inpatient to the outpatient department and to compare overall medical charges, including inpatient and outpatient activities, before and after DPC/PDPS implementation. On the other hand, the advantages of using administrative data are the large sample size and fast and inexpensive data collection [31]. These strengths overcame the shortcomings, particularly when considering that the purpose of the study was to examine the nationwide effect of healthcare system reform. The second limitation of this study is generalizability. We examined the effects of DPC/PDPS using AMI patients from our database. Hospitals were included in our database on a voluntary basis, which could have resulted in selection bias. However, characteristics of the participant hospitals were not so different compared to all hospitals which have implemented DPC/PDPS in Japan with respect to bed numbers, staffing, founders, teaching status, and geographical location. It would be interesting to determine how the results generalize to other diseases or other databases. The third limitation is that we assumed that the effect of DPC/PDPS was constant, irrespective of hospitals or the time period.

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But there is possibility that this effect was heterogeneous. However, the Japanese healthcare system is generally universal with respect to cost and access, and the interaction between the implementation of DPC/PDPS and the time period did not have significant effects on outcomes, which support our assumption about the constancy of the effect. Finally, DID and multilevel models have some methodological limitations, which have been discussed above.

## 5. Conclusions

Our results show that DPC/PDPS significantly reduced both inpatient total accumulated medical charges and LOS, and that these decreased over time. With respect to healthcare quality, mortality rate was unchanged, and the readmission rate was compromised. These results indicate that DPC/PDPS was associated with reduced resource usage, but not improved healthcare quality, as with DRG/PPSs in other countries. To achieve successful healthcare reform, further discussion on additional motives will be required.

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## Conflicts of interest

None of the authors have any conflicts of interest associated with this study.

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The Association between Healthcare Spending and Quality: An Analysis of Regional Variations in Stroke Patients

**Objective:** To elucidate the extent of variations and associations between health care spending and the quality of care in ischemic stroke patients in Kyoto prefecture, Japan.

**Methods:** Hospital claims data from all hospitals and clinics in Kyoto prefecture from 2009 onwards were provided by the Kyoto National Health Insurance Organizations, in a project conducted by the Kyoto Prefectural Government. The study sample included admissions for ischemic stroke to hospitals in Kyoto prefecture between February 2009 and March 2010. Patients were excluded from analysis if they had been hospitalized for a previous cerebral infarction within 30 days before the index admission, or if the length of hospital stay duration was longer than 90 days. After exclusions, the final sample size was 3,958 admissions.

Age-sex adjusted health care spending per patient for ischemic stroke was calculated for the 37 municipalities (including the 11 wards of Kyoto city). These were then categorized into quartiles based on the age-sex adjusted spending. Process indicators used in this study included (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 following two indicators were used as outcome indicators: (1) In-hospital mortality and (2) 30-day mortality.

In order to analyze the association between spending for ischemic stroke care and the quality of care, logistic regression models were developed for each of the quality indicators. The binary result of each indicator was used as the dependent variable for each regression model, and the independent variables included patient characteristics and hospital characteristics. Using Quartile 4 (comprising 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 municipalities with lower spending had poorer performance in the various quality indicators than higher spending municipalities.

**Results:** Mean health care spending per patient at the municipality level ranged to a large extent, with a difference of almost 50% between the highest and lowest municipalities. Patients from municipalities in the lowest spending quartile were significantly associated with poorer performance in all process indicators except for CT and MRI scans. In particular, dysphagia rehabilitation and warfarin in AF patients showed poorer performance in all three lower quartiles when compared to Quartile 4. However, the results showed that mortality rates were not significantly different between the lower spending and higher spending municipalities.

**Conclusions:** This paper offers a first glimpse of regional variations in health care spending in Japan. Regional variations in health care spending and quality were observed despite universal insurance and hospital reimbursement systems. Spending was found to be unevenly associated with the quality of care provided, and may indicate an insufficient provision of resources and specialist expertise in the lower spending municipalities. Although the two mortality indicators did not show significant association with spending, the overall low mortality rate in these patients may have influenced the results. Further efforts must be made to improve the quality of care in lower spending regions in Japan, but care must also be taken when policy-makers implement cost-reducing measures in order to ensure that the quality of care provided is not detrimentally affected.

# ESTIMATION OF THE COST OF HOSPITAL-ACQUIRED INFECTIONS IN GASTRECTOMY PATIENTS: AN EXPLORATION OF METHODOLOGY

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1

## INTRODUCTION

- Hospital-Acquired Infections (HAIs) result in higher morbidity and mortality in patients, as well as a greater economic burden to patients, providers and payers (1~3). Problems associated with these infections are further complicated with the rise of multidrug-resistant pathogens in hospitals.

- The recognition of the severity of the problem and the fact that these infections are, to a large degree, preventable, was reflected in 2008 when the Centers for Medicare & Medicaid Services adopted a "no pay for errors" policy, in which such events in hospitals would no longer warrant reimbursements (4). While various interventions have been shown to be effective in reducing infections, limitations in available resources mean that the cost-effectiveness of these interventions must be ensured.

2