developed in 2003 in Japan[1-5], and to estimate regional needs for health care services according to disease structure and the stages of diseases.

❖ Methods

Using 9.4 million micro data records from patient surveys obtained from the Ministry of Health, Labor and Welfare, we have constructed a data warehouse with dimensions including year, regions, disease classification, and age for multidimensional OLAP analysis. Included in the survey data were facility information on all hospitals, outpatient data, and discharge data extracted so that the data represent each of 47 prefectures for outpatient data and 360 secondary medical service areas for inpatient data. Each patient record was assigned to one of 1132 primary case mix classifications of the DPC, as determined from the ICD10 code and operation information.

Regional needs for health care services by DPC groups and stages of diseases were estimated from the regional disease structure and the average quantity of health services provided by acute care hospitals obtained from DPC claim data. The needs for acute care beds were estimated from the number of patients and the average hospital stay in acute care hospitals where the DPC system is applied. The needs for ICU beds were estimated from the average use of ICU beds obtained from DPC claim data. Similarly, needs for expensive radiographic equipment were estimated from the quantity of the corresponding radiography services estimated from DPC claim data. Regional health costs for acute care services were estimated from the regional disease structure, expected hospital stays for specific diseases, and the relative weights for DPC groups.

❖ Results

Regional differences in disease structure were elucidated by multidimensional cross tabulation for dimensions including DPC groups, length of stay and types of operations. As shown in Figures 1 and 2, operation-related short stays are dominant in the metropolitan area whereas long stays related to vascular diseases and cancer are dominant in the rural area.

From the patient database based on the DPC case mix classification, the length of stay, procedures performed, and actual needs for acute care hospital beds were estimated and revealed a large excess of acute care beds in most regions of Japan (Figure 3). Using similar methodology, actual regional needs for emergency rooms, intensive care units (ICU), expensive imaging equipment such as MRI and PET, and long-term care hospitals were estimated and simulative model plans for regional health care covering the spectrum from preventive and primary care to long-term and terminal care were designed. In addition, regional medical expenses for acute care were estimated from standardized relative weights for DPC

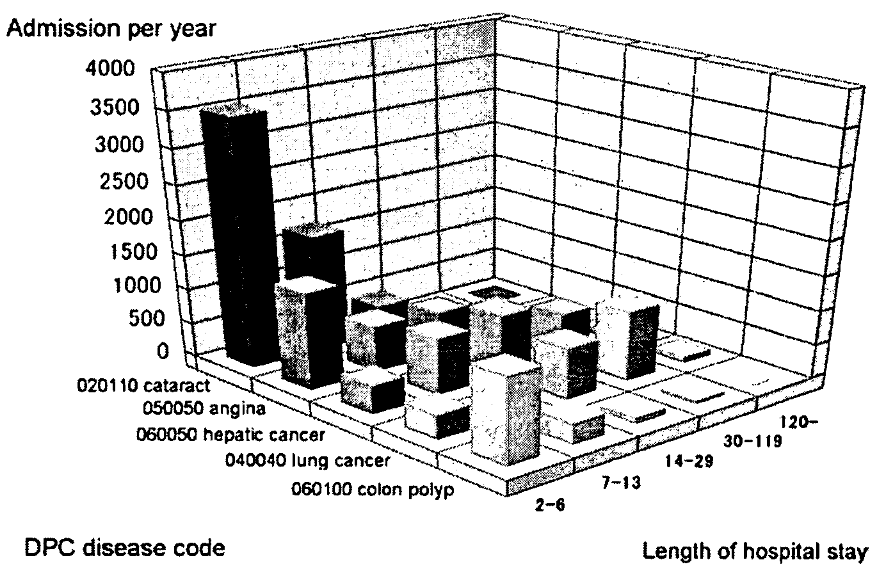

Figure 1. Profile of elderly patients in Tokyo metropolitan area

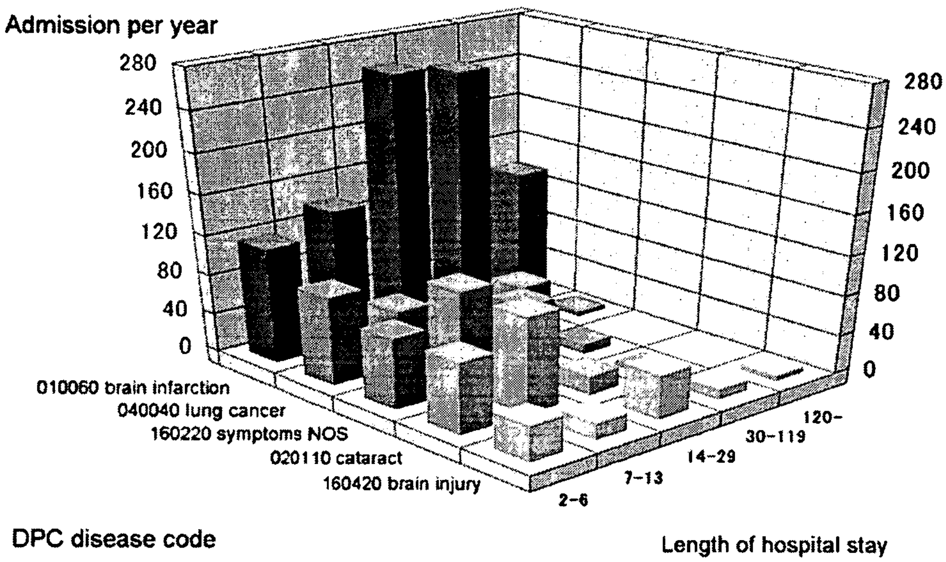

Figure 2. Profile of elderly patients in a rural area near Tokyo

groups, number of patients and length of hospital stay.

Local governments are required to establish medical service areas (MSAs) and to plan regional health care delivery. Secondary MSAs are established to assure that most medical services can be provided to residents within the designated areas, whereas primary MSAs are for primary care and tertiary MSAs for advanced care. We identified considerable gaps between actual medical service areas and the secondary MSAs established by health departments of local governments for several diseases including breast cancer and ischemic heart diseases. In Figure 4, the residential areas for patients are shown on the left and MSAs for admitting hospitals are indicated by the color bars for cardiac surgeries. It is conceivable that four functional MSAs could be formed rather than the

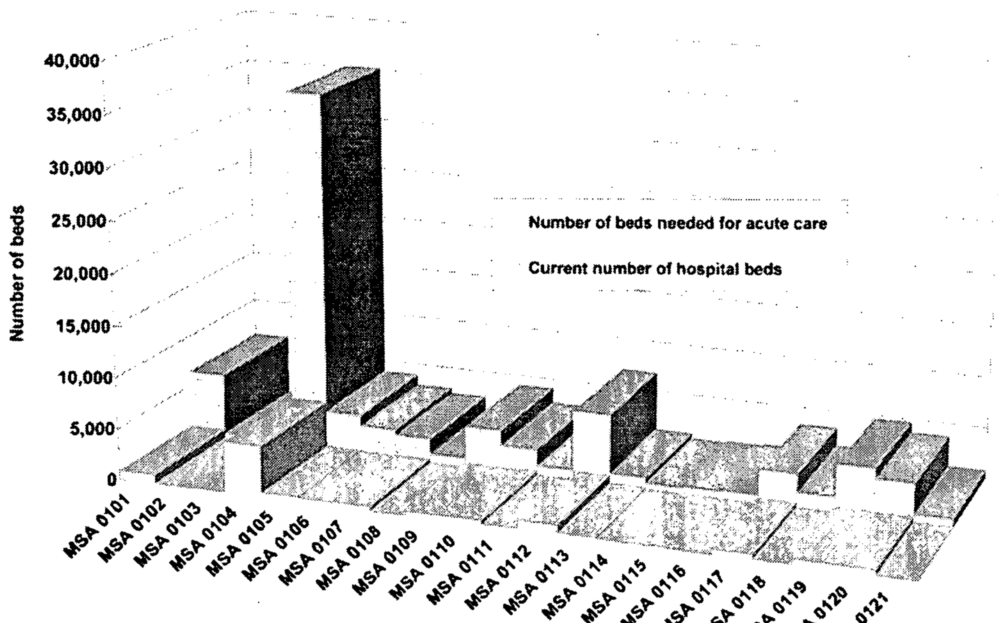

Figure 3. Estimation of number of beds needed for acute care

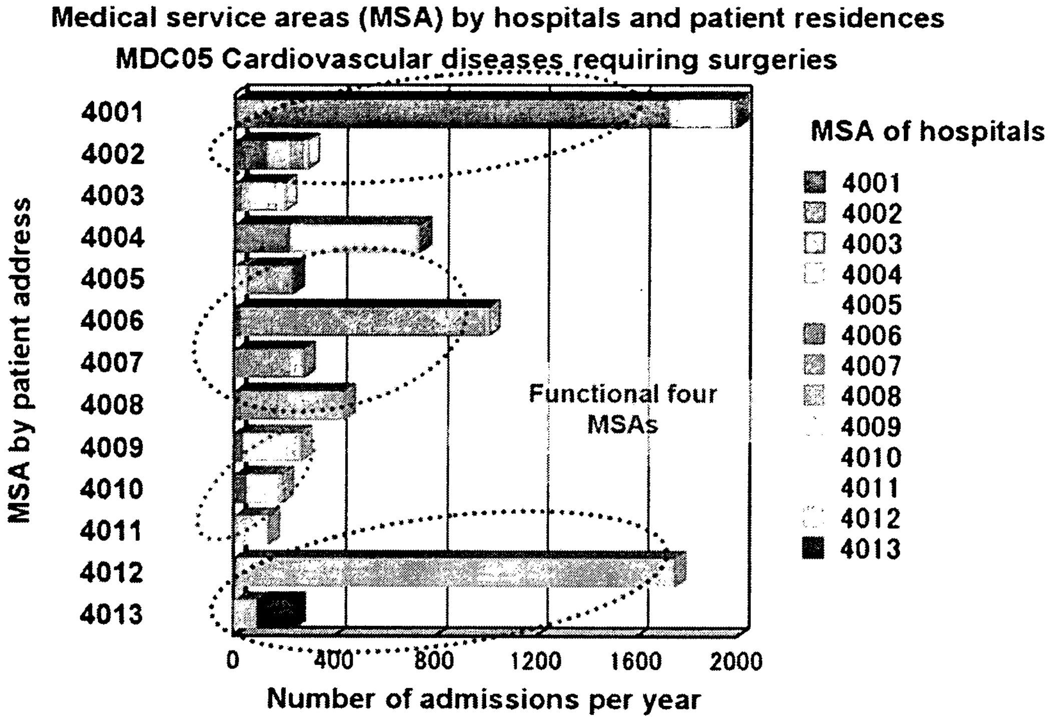

Figure 4. Functional and actual medical service areas different from administrative areas

designated 13 MSAs. We have found functional reconstruction of MSAs to be more frequently observed for elective and relatively high-tech surgeries such as cardiac intervention and surgeries for malignant diseases, indicating patients' preferences and traveling to hospitals with a high volume of surgeries and interventions even when they are available in other MSAs.

❖ Discussion

We have shown the feasibility of arranging regional health care delivery plans using the DPC case mix system and national patient database. Required health care resources in the districts were easily estimated from the DPC-based disease structure and the average use of health services predicted for the relevant DPC groups.

DPC-based estimation of disease structure has the following advantages: First, the recognition and improvement of transparency for professional medical information are anticipated to be simplified. Local governments are required to assess the efficiency and the quality of health services, to plan the delivery of health services, and to provide related information to residents in the designated areas. However, the majorities of officers in charge of local governments are not specialists in medicine and are not familiar with disease names and medical professional terms. By using the DPC system, they can share professional information with medical specialists. This advantage is the same for insurers and patients. These groups can easily share medical professional information with doctors and other health care providers.

Second, reference data can easily be obtained for the assessment of differences in the efficiency and quality of health care in one district as compared to those in other districts. It is well known that there are large geographical variations in the efficiency of care provision, including the average length of hospital stay and cost per admission in Japan. It is expected that these variations can easily be assessed by using the DPC system, since increasing quantities of hospital performance data are being published for acute care hospitals where the DPC payment system is applied.

Finally, the DPC system can be used for health care resource allocation in the region. From the disease structure in the district and standardized resource utility per DPC group, health resources including acute care beds, medical staff, and medical equipment can be appropriately allocated. The strategic resolution of the nursing staff shortage, which has recently been reported in rural areas of Japan, by DPC-based resource allocation for hospital beds and the work force can hopefully be achieved. In addition, the notorious excesses in radiographic scanning machines in Japan, which potentially diminish the efficiency of health care resource utilization, can be accurately assessed by DPC-based resource allocation and over-investment in these types of equipment by hospitals can potentially be restrained.

❖ Acknowledgement

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REGULAR ARTICLE

The association of the number of comorbidities and complications with length of stay, hospital mortality and LOS high outlier, based on administrative data

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Abstract
Objectives With greater concern for efficient resource allocation and profiling of medical care, a case-mix classification was applied for the per-diem payment system in Japan. Many questions remain, one of which is the role of comorbidity and complication (CC) in grouping logic. We examined the association of the number of CC with the length of hospital stay (LOS) and hospital mortality as well as the proportion of LOS high outliers in 19 major diagnostic categories (MDCs).

Methods This study was a secondary data analysis embedded in a government research project, including anonymous claims and clinical data during a 4-month period from July 2002. Every 19 MDC, LOS, hospital mortality or proportion of LOS high outliers was compared by the number of CC and presence of any procedures.
Results From 82 special function hospitals, 241,268 patients were enrolled in this study. Among all patients, 50.5% were identified without any CCs, 32.4% with one or two, 13.4% with three or four, and 3.7% with over five CCs. The overall mean LOS was 22.15 days and hospital mortality 26.05 cases per 1,000 admissions. In any MDC, LOS and the proportion of outliers increased as the number of CC rose. The mortality rate increased prominently in the respiratory system and the hematology system.
Conclusions This study demonstrated that the occurrence of more CC caused longer LOS and higher mortality in some major disease categories. Further study will clarify the association of the weighted CC with resource use through controlling procedures specific for MDC.

Keywords Comorbidity · Complication · Resource use · Mortality · Case mix

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Introduction

The role of comorbidities and complications (CC) in inpatient medicine has been an intense area of investigation, due to their impact on resource use, mortality, functional status, quality of life, and delivery of health care in Western societies [1–6]. Research on the impact of CC on healthcare utilization and quality of medical care is needed, as this is important to hospital payment systems and medical outcome studies [7, 8]. Many health-related problems increase with age, especially with respect to the number of chronic conditions [1]. As the proportion of chronic conditions increases across populations, practice behaviors will change that will impact hospital costs. Meanwhile, innovative procedures have been advocated for the elderly [9, 10]. Under these circumstances, the impact of CC or age on hospital resource utilization has been examined for diseases such as diabetes mellitus or for hospitalizations of trauma patients [11, 12].

In response to increasing costs associated with the rapid evolution of healthcare technology, cost containment policies and case-mix classification systems have advanced worldwide over the past 20 years [7, 8]. However, problems have emerged in situations where some patients are under-reimbursed if they have more CCs and have consumed more hospital resources than those with fewer CCs. Munoz et al. [13] reported major inequities in Diagnosis-Related Group (DRG) prospective payment systems for pediatric patients. Jencks et al. [14] showed that the number of recorded diagnoses was no higher for patients who died than for those who survived. These studies focused on selected conditions, such as pediatric illnesses, cardiovascular disease, and pneumonia.

In this study, our goal was to demonstrate the association of CCs with resource use and outcome by major diagnostic category (MDC) and treatment group (medical or surgical) using a large administrative database developed for the Japanese case-mix classification system (Diagnosis Procedure Combination; DPC). This type of systematic research has never been performed on this scale, and the results may have some important policy implications, in which MDC CCs may be considered in prior risk adjustment for payment or outcomes, such as resource use or mortality. The aims of this study were to generate descriptive statistics of CCs and to profile the association of length of stay (LOS) and hospital mortality with the number of CCs through the stratification of MDCs and treatments. Furthermore, we identified the relationship between the proportion of LOS high outliers and the number of CCs for each MDC.

Materials and methods

We conducted a secondary data analysis of a government research project on DPC development. Anonymous claims information and clinical data were provided by the Ministry of Health, Labor and Welfare (MHLW) through a research contract. Clinical data and claims information, merged into a standardized electronic format, were gathered by the MHLW for 266,677 patients who were discharged from 82 academic hospitals (80 university hospitals, National Cancer Center, and National Cardiovascular Center) between 1 July 2002 and 31 October 2002. The Japanese MHLW permits up to seven CCs (four comorbidities and three complications) to be listed in the DPC dataset. From this original dataset, we selected cases with a LOS of up to 365 days and excluded patients who died within 24 h of admission. A total of 241,268 patients were enrolled in the study. We categorized patients into three groups according to the number of CCs documented (absent, 1 or 2, 3 or 4, and 5 or more), based on a study by Munoz et al. [15].

The DPC system is made up of 16 MDCs. However, the 16th MDC consists of four different clinical entities: injury, poisoning, burns and the toxic effect of drugs; mental diseases and disorders; diseases and disorders of systemic infection; and miscellaneous. We therefore divided the 16th MDC into these four groups and analyzed a total of 19 MDCs (Table 1). The DPC database also allows a maximum of five operative procedures to be listed, for which the definition and pricing are determined from a nationally uniform fee table under the standardized fee-for-service payment system. Patients undergoing at least one surgical procedure, as defined by the Japanese fee table, comprised the "surgical group," while patients not undergoing any surgical procedure comprised the "medical group." We then divided patients into these two treatment groups for all 19 MDCs.

Statistical analysis

Patient characteristics were analyzed in terms of gender, age (under 15, 15–64, and 65 years or older), and number of procedures. The association between CC category and each of these patient characteristics was assessed using Fisher's exact test. The association between these patient characteristics and MDC was also assessed.

The mean age, LOS, and mortality rate per 1,000 admissions were calculated for each CC category and compared using analysis of variance (ANOVA). The mean LOS (days) and mortality rate (per 1,000 cases) were illustrated using spider-radar charts, stratified by treatment group (surgical or medical) and MDC. ANOVA was used to compare the mean LOS and mortality rate by treatment group for each MDC.

To define the proportion of high LOS outliers, we identified the 95th percentile of LOS for each MDC and categorized patients beyond that LOS into eight groups (e.g., four CC groups by two treatment groups). We then calculated the proportion of high LOS outliers (the numerator is the number of LOS outliers and the denominator is the number of all patients in the eight

Table 1 The proportion of comorbidity and complication category by presence of procedure and MDC (%)

Major diagnostic category			Absent	One or two	Three or four	Over five	*N*
Overall		Medical	47.8	33.8	14.9	3.5	123,895
		Surgical	53.4	30.9	11.8	3.9	117,373
MDC1	Nervous system	Medical	46.2	35.1	15.3	3.4	12,292
		Surgical	44.7	32.2	16.0	7.1	3,810
MDC2	Eye system	Medical	65.9	25.3	7.7	1.1	1,854
		Surgical	54.5	32.9	9.9	2.7	17,974
MDC3	Ear, nose, mouth, and throat system	Medical	62.4	26.8	8.5	2.3	5,881
		Surgical	65.0	26.5	6.4	2.1	8,374
MDC4	Respiratory system	Medical	44.2	36.8	15.4	3.6	14,666
		Surgical	47.0	33.5	13.3	6.2	3,609
MDC5	Cardiovascular system	Medical	32.0	40.2	24.4	3.4	12,264
		Surgical	31.5	37.3	23.7	7.5	10,768
MDC6	Digestive tract, hepatobiliary and pancreas system	Medical	49.3	35.3	12.7	2.6	20,697
		Surgical	48.2	34.2	13.4	4.2	24,383
MDC7	Muscuoskeletal and connective tissue system	Medical	51.1	31.2	13.9	3.8	7,671
		Surgical	63.5	24.9	8.8	2.8	11,018
MDC8	Skin and subcutaneous tissue system	Medical	50.3	35.1	11.9	2.7	3,500
		Surgical	69.6	22.8	5.2	2.4	671
MDC9	Breast system	Medical	60.0	27.3	9.9	2.9	1,144
		Surgical	69.7	23.4	5.8	1.1	2,532
MDC10	Endocrine, nutrition and metabolic system	Medical	36.0	36.1	23.7	4.2	8,156
		Surgical	44.0	35.1	15.7	5.2	2,784
MDC11	Kidney, urinary tract and male reproductive system	Medical	51.0	30.7	14.5	3.8	10,031
		Surgical	54.2	29.2	12.3	4.3	7,359
MDC12	Pregnancy, childbirth, puerperium and female reproductive system	Medical	61.1	28.7	7.7	2.5	6,195
		Surgical	59.5	29.6	8.4	2.4	10,951
MDC13	Hematology system	Medical	46.6	29.7	15.7	8.1	4,967
		Surgical	37.5	32.8	17.0	12.7	613
MDC14	Neonate system	Medical	49.6	32.0	12.9	5.5	4,386
		Surgical	66.0	24.0	7.3	2.8	4,202
MDC15	Pediatric system	Medical	64.0	28.8	6.4	0.8	1,916
		Surgical	70.0	20.0	5.0	5.0	20
MDC16	Injury, burns, poisonings and toxic effect of drugs	Medical	53.9	34.1	10.4	1.6	3,580
		Surgical	62.1	26.1	9.0	2.9	6,083
MDC17	Mental health system	Medical	47.1	31.4	16.7	4.8	1,256
		Surgical	0.0	0.0	0.0	0.0	0
MDC18	Systemic infection	Medical	41.9	34.1	16.4	7.6	962
		Surgical	29.2	30.3	17.8	22.7	185
MDC19	Miscellaneous	Medical	46.2	32.9	15.7	5.2	2,477
		Surgical	54.9	29.7	11.3	4.1	2,037

MDC major diagnostic category

groups) and demonstrated it with a broken line for each MDC. Statistical analyses were performed using SPSS version 14. All reported *P* values were two-tailed, and the level of significance was accepted as less than 0.05.

Results

The most frequently documented MDC was the digestive track, hepatobiliary, and pancreatic diseases (45,080 cases, 18.7% of all study cases) and the least frequently documented MDC was systemic infections (1,147 cases, 0.5%). Eye diseases were more common in the surgical group (17,974 cases, 80.7% of all eye diseases), while patients with mental disorders received no surgical treatment. When stratified by CC category, pediatric diseases had the highest proportion of no CCs (64% in the medical group and 70% in the surgical group) and cardiovascular diseases (32% in the medical group and 31.5% in the surgical group) had the lowest proportion of no CCs. On the other hand, hematological diseases (8.1% of medical patients and 12.7% of surgical patients) and systemic infections (7.6 and 22.7%, respectively) had the highest proportion of patients with five or more CCs (Table 1).

Among the 241,268 patients in the study population, 50.5% (47.8% of the medical group and 53.4% of the surgical group) had no CCs; 32.4% (33.8 and 30.9, respectively) had one or two CCs; 13.4% (14.9 and 11.8%, respectively) had three or four CCs; and 3.7% (3.5 and 3.9%, respectively) had five or more CCs. The proportion with no CCs ranged from 41.2% (38.6% of medical group and 43.8% of surgical group) in patients 65 years and older to 65.5% (60.4 and 72.8%, respectively) in patients less than 15 years. The proportion of patients with one or two CCs ranged from 25.9% for those less than 15 years to 35.4% for those 65 years or older; the proportion with three or four CCs ranged from 6.5 to 18.2%; the proportion with five or more CCs ranged from 2.1 to 5.2%. There was no gender difference in the proportion of the four CC categories. In both the medical and surgical groups, the proportion of patients with no CCs and with five or more CCs was statistically different by age and gender. There was a significant difference in the number of procedures for the four CC categories (Table 2).

Overall, the mean age was 51.23 years and the mean LOS was 22.15 days. For patients with no CCs, one or two CCs, three or four CCs, and five or more CCs, the mean ages were 47.09, 53.83, 59.05, and 59.26 years, respectively, and the mean LOS were 17.38, 23.44, 30.60, and 45.47 days, respectively. The overall mortality rate per 1,000 admissions was 26.05 cases (13.51, 26.94, 46.94, and 104.09, respectively). There were significant differences in age, LOS, and hospital mortality rate among the four CC groups (Table 3). As the number of CCs increased, the mean age, mean LOS, and mortality rate also increased.

Table 2 The proportion of comorbidity and complication category by age, gender, and presence of surgical procedure (%)

Category		Absent (%)	One or two (%)	Three or four (%)	Five or more (%)	*N*
Overall*		50.5	32.4	13.4	3.7	241,268
	Medical	47.8	33.8	14.9	3.5	123,895
	Surgical	53.4	30.9	11.8	3.9	117,373
Age*						
Under 15 years		65.5	25.9	6.5	2.1	25,969
	Medical	60.4	29.0	8.2	2.4	15,282
	Surgical	72.8	21.5	4.1	1.6	10,687
15-64 years		53.9	31.6	11.5	3.0	126,982
	Medical	51.1	33.2	12.8	2.9	64,097
	Surgical	56.8	30.0	10.1	3.0	62,885
65 years or more		41.2	35.4	18.2	5.2	88,317
	Medical	38.6	36.4	20.2	4.8	44,516
	Surgical	43.8	34.5	16.1	5.7	43,801
Gender*						
Female		52.3	31.9	12.4	3.4	112,243
	Medical	48.5	33.9	14.2	3.4	56,229
	Surgical	56.1	29.9	10.6	3.4	56,014
Male		48.9	32.8	14.3	4.0	129,025
	Medical	47.1	33.8	15.5	3.6	67,666
	Surgical	51.0	31.8	12.9	4.3	61,359
Number of procedures*						
	1	59.3	27.9	10.0	2.8	78,456
	2	46.1	35.1	13.7	5.1	25,108
	3	31.1	44.0	17.7	7.2	7,354
	4	41.7	34.3	17.2	6.7	4,698
	5	19.9	39.8	25.4	14.9	1,757

* Statistically significance at $P < 0.001$

Table 3 Descriptive characteristics of study variables by comorbidity or complication category and proportion of comorbidity and complication category by mean age, LOS, and mortality, stratified by treatment group

		Overall	Comorbidity and complication category			
			Absent	One or two	Three or four	Five or more
Mean age* (SD)		51.23 (23.39)	47.09 (24.15)	53.83 (22.34)	59.05 (20.02)	59.26 (20.72)
	Medical	50.51 (0.07)	46.15 (0.10)	52.56 (0.11)	58.19 (0.16)	57.53 (0.34)
	Surgical	52.18 (0.07)	47.98 (0.09)	55.29 (0.11)	60.20 (0.16)	60.91 (0.28)
Mean LOS* (SE)		22.15 (0.051)	17.38 (0.06)	23.44 (0.09)	30.60 (0.16)	45.47 (0.40)
	Medical	20.39 (0.07)	16.02 (0.09)	21.12 (0.12)	27.50 (0.20)	42.52 (0.56)
	Surgical	24.02 (0.07)	18.67 (0.08)	26.12 (0.14)	34.74 (0.27)	48.30 (0.56)
Mean mortality per 1,000 cases* (SE)		26.05 (0.32)	13.51 (0.33)	26.94 (0.58)	49.69 (1.21)	104.09 (3.24)
	Medical	36.92 (0.54)	21.90 (0.60)	37.22 (0.92)	62.29 (1.78)	130.63 (5.11)
	Surgical	14.58 (0.35)	5.58 (0.30)	15.06 (0.64)	32.91 (1.52)	78.76 (3.99)

SD standard deviation, *SE* standard error

* Statistically significance at $P < 0.001$

The mean age and LOS were higher in the surgical group than in the medical group, although mortality was higher in the medical group.

The LOS for all MDCs, except for pediatric diseases, increased as the number of CCs increased. In particular, the mean LOS across the four CC categories was longer for hematological diseases, whereas for eye diseases, it was shortest and increased relatively slowly across the CC categories. There was a significant difference in mean LOS among the four CC categories within every MDC, except for the pediatric surgical group ($P = 0.084$) (Fig. 1).

Across the four CC categories, the mortality rate was higher for respiratory disease, digestive tract, hepatobiliary and pancreatic diseases, and hematological diseases than in other MDCs. The mortality rate was approximately zero for eye diseases, skin and soft tissue diseases, mental disorders, and in the pediatric surgical group. Apart from these MDCs, the surgical group had a lower mortality rate than the medical group for respiratory diseases, as well as for digestive tract, hepatobiliary and pancreatic diseases. There were significant differences in hospital mortality among the CC categories within every MDC, except for eye diseases (medical: $P = 0.793$, surgical $P = 0.928$), skin and soft tissue diseases ($P = 0.171$), endocrine, nutritional, and metabolic diseases (medical: $P = 0.920$, surgical $P = 0.416$), and mental disorders ($P = 0.223$) (Fig. 2).

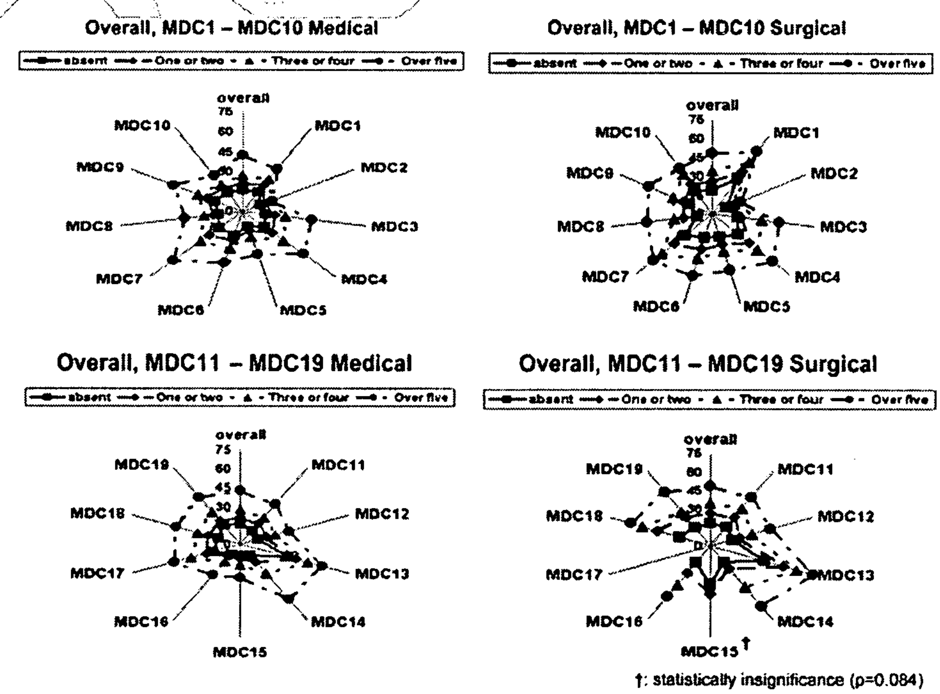

Fig. 1 LOS (days) and number of comorbidities and complications stratified by treatment group (medical or surgical) and major diagnostic category

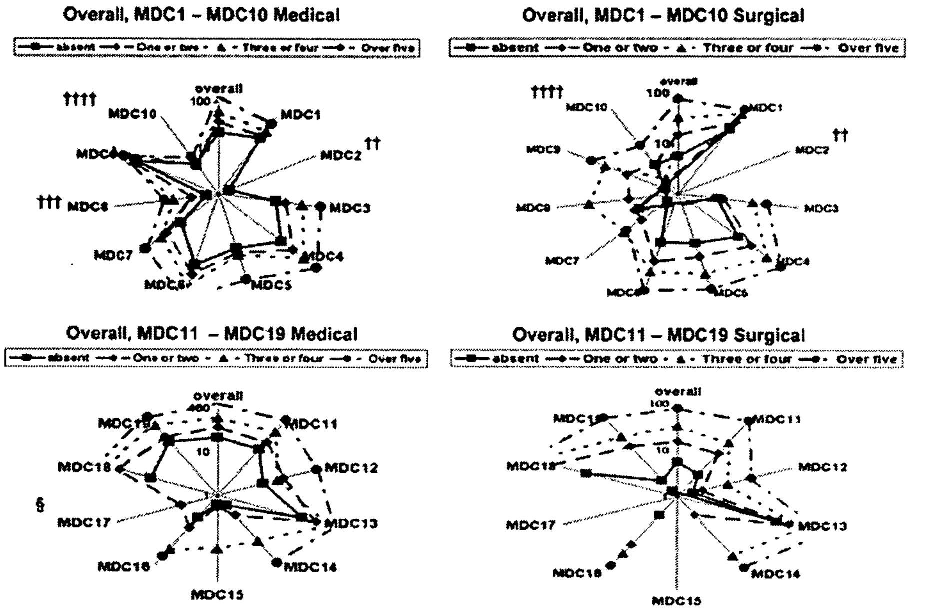

Fig. 2 Hospital mortality (per 1,000 cases) and number of comorbidities and complications, stratified by treatment group (medical or surgery) and major diagnostic category

††: statistically insignificance (medical: p=0.793, surgical: p=0.928). †††: statistically insignificance (medical: p=0.171), ††††: statistically insignificance (medical: p=0.920, surgical: p=0.416). §: statistically insignificance (medical: p=0.223)

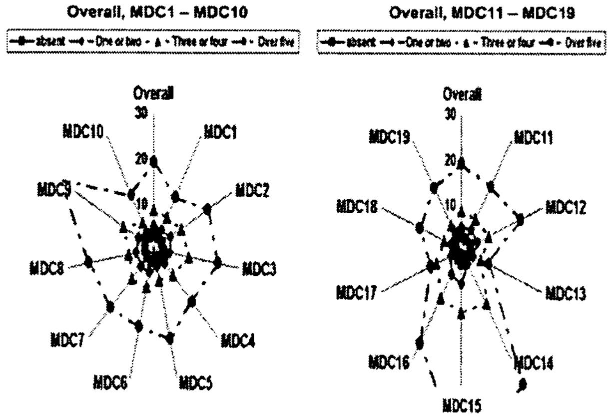

Fig. 3 Proportion (%) of high LOS outliers by comorbidity and complication category stratified by major diagnostic category

The percentage of LOS high outliers increased as the number of CCs increased for all MDCs. The percentage of patients with five or more CCs was identified as 40–50% in MDC14 and 15 (Fig. 3).

Discussion

This study describes the characteristics of patients with CC and the association of LOS and mortality rate with the number of CCs by analyzing a large administrative dataset from Japan. To our knowledge, this is the first study to provide a profile of LOS, hospital mortality, and proportion of LOS high outliers across several diseases from a large database. In all MDCs, both the LOS and the proportion of outliers increased as the number of CCs increased, and the increase was particularly prominent for neonatal and pediatric diseases. Mortality was particularly high among the higher CC categories for respiratory diseases, digestive tract, hepatobiliary and pancreatic diseases, and hematological diseases. Therefore, the number of CCs should be taken into consideration in risk adjustment for mortality. However, the mortality rate did not increase with higher CC categories for eye diseases, skin and soft tissue diseases, mental disorders, or in the pediatric surgical group.

There were several limitations to this study. First, we gathered information from patients who were discharged during only a 4-month period in 2002. Claims data, including some clinical variables, are now being collected throughout the year, so that it will soon be possible to produce this type of study with a larger database. Second, coding accuracy and quality were not taken into consideration. At the start of this study, comorbidity was defined by the MHLW as an associated disease or disorder at admission, regardless of whether that condition was acute or chronic and stable; complication was defined as events occurring unexpectedly or owing to a planned procedure after admission. Both of these were listed separately in the dataset. Although there may be no case-mix classification system in the world where the quality of coding can be assured without chart review, coding guidelines and coder training have been promoted by the Japanese Society of Medical Record Administration. The peer review organization system for coding behavior and DPC creep will be in demand, just like in other countries that are already utilizing those kinds of case-mix classification systems [16–19]. Third, there was a limitation of coding slots in the DPC dataset, whereby only seven secondary diagnoses (four comorbidities and three complications) could be listed. However, the dates and the amount of life-support care or pharmaceutical agents, which may serve as proxy data for some comorbidities or complications, were electronically collected in this DPC database [20]. A more detailed and promising analysis of this data is expected in the near future.

Given the paucity of this kind of analysis in the literature, it is useful to document the mean LOS, mortality rates, and proportions of LOS high outliers by MDC and treatment. In general, economic incentives may induce problems like creeping or changing of coding response, whereby institutions may list more CCs or truncate chronic diagnoses unrelated to resource use, outcome, or payment [21]. As a result, the number of recorded diagnoses on the medical chart may not be significantly higher for patients who die than for those who survive, and the number of CCs would not be a reliable index for predicting complications or hospital mortality. Therefore, setting aside the problem of coding accuracy, this study provides basic but instructive suggestions, as the results were free of reporting bias, due to the lack of opportunities for the up-coding of CCs before the start of the DPC-based payment system.

Overall, the mean LOS in Japan may be longer than that in Western countries. Japanese hospitals accommodate patients with both acute and sub-acute or chronic illnesses, functions that are typically performed by different facilities in Western countries [22]. Table 3 shows that the overall mean LOS was 22.15 days (20.39–42.52 days in medical DPC and 24.02–48.30 in surgical DPC), which is two to six times longer than any other country in the OECD Health Data [23]. These hospitals may not be representative of Japanese acute care hospitals, but these results may more accurately reflect mortality and resource consumption, which would not be captured in Western data that do not include data from external care facilities and other auxiliary health facilities. It might be the strength of this study.

In our study, as the number of CCs increased, resource use indices tended to increase for all MDCs, which corresponded to the results of Munoz et al. [15]. They reported that hospital cost, LOS, percentage of LOS outliers, and mortality increased as the number of CCs per patient increased, even for patients categorized into medical non-complications and comorbidity-stratified DRG groups, resulting in financial risk for hospitals without any DRG adjustments based upon CCs. In another study by Munoz et al. [13], major inequities in the DRG prospective hospital payment system were confirmed for pediatric patients, generating a financial burden for hospital management. For example, if hospital cost correlates positively with LOS, hematological diseases or systemic infections may cause more financial loss, while eye diseases may not. Such comparisons have policy implications, and further studies are needed to examine the presence of cost-profit differences in Japan's DPC system.

The number of CCs may also be selected as a risk factor for LOS or hospital mortality for respiratory diseases, as well as for digestive track, hepatobiliary, and pancreatic diseases. The number of procedures specific for these diseases, clinical severity, or difficulty of executing a procedure in terms of experience or time consumed may affect LOS, mortality, or LOS outlier among the MDCs. Further evaluation will be needed to describe the association of these clinical variables with the number of CCs or some targeted CCs specific for every MDC.

The first key of DPC classification is principal diagnosis and types of procedures or CCs determined by the DPC group [24]. All of these determinant elements are listed in the DPC definition table where many kinds of CCs are also contained, ranging from chronic stable illnesses, such as diabetes mellitus without organ damage, to acute or critical conditions, such as cardiogenic shock [14, 15]. Each MDC includes several CCs determined by the opinion of experts from the relevant specialties. Our research team was requested to identify the CCs responsible for more resource use or higher mortality, while controlling for variables affecting those indices, such as demographics and treatment. According to the report of resource use variation in cardiovascular diseases and malignant respiratory or intestinal neoplasms, CCs had less incremental effect on the proportion of variance in LOS or total charge than other variables, such as treatment type and intensive or neoadjuvant therapy [25]. Among these diseases, CCs of gastric or colonic neoplasms explained more variation than those of any others. Some CCs are strongly associated with other CCs, such as hypertension with atherosclerosis. Therefore, further analyses of this kind will be needed to identify CCs that consume more resources, particularly for musculoskeletal diseases and neonatal disease. Through this type of systematic investigation, we can readily answer questions such as "Is the number of CCs correlated with resource use or outcome?" or "Which factors have the greatest impact on LOS or per diem payment: the number of CCs, a specific CC, or certain treatments?" In making decisions about payments, answering these types of questions will facilitate and improve financial allocation. In addition, health policy makers could examine the extent to which the number of CCs can explain variations in resource use or outcomes, enabling a systematic comparison of healthcare performance across MDCs.

In conclusion, we assessed the association of the number of CCs with LOS, hospital mortality, and the proportion of LOS high outliers. In all MDCs, LOS and the proportion of outliers increased as the number of CCs increased. This study demonstrated that the number of CCs should be taken into consideration in risk adjustment for mortality, especially for respiratory diseases, digestive tract, hepatobiliary and pancreatic diseases, and hematological diseases. Mortality rates were not associated with CCs for eye diseases, skin and soft tissue diseases, mental disorders, and in the pediatric surgical group. Further studies are needed to investigate the type of CCs that impact outcomes and resource use, as well as to assess the impact of CCs on treatment selection. Calculating resource use or mortality with weighted CCs, comparative profiling of CCs, and determining associations of CCs with financial burden across MDCs may all play important roles in policy making for an equitable payment system.

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