the 1-year period (Figure 1).

Given the varying trends of cumulative resource use across age groups, multiple regression analyses were performed to assess for any significant associations (Table 4). These analyses revealed that among surviving patients, both age and age$^2$ significantly associated with cumulative total charges, diagnostic examination fees, and drug expenses. The standardized coefficient of patient age was positive and that of age$^2$ was negative for total charges and diagnostic examination fees, whereas that of age was negative and that of age$^2$ was positive for drug expenses. Among non-surviving patients, there was no significant association between patient age and resource use. The total length of hospitalization (natural log-transformed) was very significantly associated with resource use among both surviving and non-surviving patients.

To assess the equality of cumulative resource distribution across age groups, the Gini coefficients were calculated, with a higher value indicating more unequal distribution (Table 5). Gini coefficients for total hospitalization charges and diagnostic examination fees among surviving patients were fairly stable across age groups. However, cumulative drug charges demonstrated greater Gini coefficients for surviving patients than non-surviving patients in all age groups. Furthermore, cumulative drug charges showed greater Gini coefficients than the total hospitalization fees or diagnostic examination fees. In addition, Gini coefficients among non-surviving patients 75 years or older were greater than those among non-surviving patients 74 years or younger, in total, diagnostic examinations, as well as drug charges.

## DISCUSSION

We examined the association between patient age and cumulative resource use for 9,695 inpatients at a Japanese teaching hospital during a 1-year period and also investigated the equality of cumulative resource use between age groups. Multiple linear regression analyses revealed a quadratic relationship between patient age, cumulative total charges, diagnostic examination charges, and drug charges among surviving patients. However, patient age was not significantly associated with cumulative resource use among patients who did not survive. Furthermore, the total length of hospitalization (natural log-transformed) was very significantly associated with resource use among both surviving and non-surviving patients. Our study also showed that cumulative resource use for inpatients was substantially unequally distributed and that the inequality of resource use among non-surviving patients differed by age group.

No linear association was found between patient age and resource use among either surviving or non-surviving patients. Both total charges and diagnostic examination charges among surviving patients demonstrated a positive standardized coefficient for age and a negative one for $age^2$. This finding indicates a quadratic relationship between patient age and total cost and diagnostic examinations fees. In other words, cumulative total charge and diagnostic examinations fees increased with age, peaked, and then decreased with age. A quadratic relationship was also demonstrated for cumulative drug charges among surviving patients. Namely, total drug charges decreased, reached a nadir, and then increased with age. These results from the regression models are supported by the descriptive analysis (Table 3). The findings in this study are consistent with two US studies and one German study that also did not identify a linear relationship between patient age and resource use [2, 3, 19], despite the differences in health care system between these countries and Japan. The present study further indicates that the influence of patient age on resource use completely differed between survival outcomes.

This study also found that the number of comorbid conditions significantly associated with total hospitalization charges, diagnostic examination fees, and drug charges among surviving patients, but not among non-surviving patients. Despite the difference in payment systems between Japan and the US, these results are consistent with the finding that US Medicare beneficiaries with chronic conditions had higher expenditures than did those without chronic conditions [20]. Patients with comorbid conditions consume greater health care resources because they are sicker than those without a priori diseases. Given such a relationship, why wasn't the association between comorbid conditions and resource use significant among non-surviving patients? One possible explanation is that resource use for the primary diagnosis may be substantially greater than that for comorbid conditions among non-surviving patients. Therefore, the effect of comorbid conditions on resource use may be too small for a significant association to be detected.

The present study showed that the length of hospitalization was strongly associated with resource use among both surviving and non-surviving patients. Charges during hospitalization are calculated on a fee-for-service basis with governmentally defined universal point-fee tables under Japan's universal health insurance system. Therefore, it is not surprising to find a positive correlation between the number of hospitalization days and resource use. Recently, the Japanese government has attempted to contain the increases in health care expenditures. One strategy is to reduce the length of hospitalization. The average length of a hospital stay in Japan was 37.5 days in 2002 [1], which is much longer than in Western countries. Several possible explanations exist for the extended length of stay. First, because Japanese hospitals provide inpatients with acute and post-acute care during the same hospital care episode, Japanese physicians are likely to let inpatients stay in hospitals until they are able to perform activities of daily living at levels similar to those prior to disease onset. Second, there is no financial risk for Japanese physicians in letting their patients continue to remain hospitalized for an extended period because charges during in-hospital stay are reimbursed in the fee-for-service manner as described above. The strong positive association between the length of hospitalization and resource use in an acute hospital in the present study support the notion that the Japanese government might partially control the increase in health care expenditures by reducing the average length of hospital stay.

The present study revealed that cumulative total charges per deceased patient were greater than those per surviving patient. A previous study has shown that non-surviving patients consume greater resource than surviving patients [3]. Yang *et al.* have examined the relative contributions of both time to death and age to US Medicare expenditures and concluded that death is the major cause of increased in-hospital Medicare expenditures [21]. Other studies also reported that proximity to death drives health care costs [7, 22, 23]. These results are rationalized by dying patients having greater needs for health care resources due to their disease severity [24, 25]. Although non-surviving patients contributed a substantially greater per person total hospitalization cost than surviving patients during a 1-year period, the amount of total charges for all patients who did not survive their final hospitalization accounted for 16% of all expenditures (US$123.8 million). These results are consistent with the findings of previous studies: health care expenditures in the last year of life account for a small fraction of the total expenditures in Japan (12%) [9], and the Netherlands (10% [26] and 11% [27]).

Our study revealed that acute care use for inpatients during the one-year period before the index discharge was substantially unequal, i.e. the Gini coefficients for cumulative total charges, diagnostic examinations fees, and drug charges ranged from 0.47 to 0.68 among surviving patients and from 0.34 to 0.59 among non-surviving patients. These results indicate that the distribution of resource use for patients who needed acute care was substantially skewed to the right. In terms of the inequality of health care utilization, Brockmann has shown that 50% of the total hospital population in two German sickness funds accounted for less than 15% of total annual hospital expenses [19]. The present study showed a similar pattern in that half of inpatients used less than 15% of total cumulative charges regardless of age or discharge status (Lorenz curves not included). To the best of our knowledge, this is the first study to estimate Gini coefficients for cumulative charges for diagnostic examinations and drugs as well as comparing them among age groups.

We found that Gini coefficients for cumulative drug charges among surviving patients were more likely to be greater than among non-surviving patients in all age groups. We assume that this reflects diversity in surviving patients' need for drug therapy in acute disease. It is common for seriously ill patients to require many kinds of expensive drugs, whereas slightly ill patients need only a few inexpensive drugs. On the other hand, among non-surviving patients, substantial differences in Gini coefficients were found for resource use in acute care between age groups. Non-surviving patients 85 years or older had the greatest Gini coefficients for total cumulative charges and cumulative charges for diagnostic examinations, and those 75 to 84 years had the second greatest coefficients. There are at least two possible explanations for the difference in Gini coefficients between patients 75 years or older and those 74 years or younger. First, it is essential to keep in mind the principle of individual variation among older people [28]. Some patients 75 years or older may be too frail to undergo invasive examinations, which would result in inequality of resource use. Second, health care resource use among non-surviving patients varies with the cause of death. Lunney et al. [29] have proposed four theoretical trajectory groups of dying (sudden death, terminal illness, organ failure, and frailty) and identified substantial variations in Medicare expenditures among the four groups due to clinical differences. Although this study examined resource use in only an acute care setting at a single hospital, different trajectories of dying may result in substantial inequality of resource use among elderly patients in this study, as with the findings from the US Medicare beneficiaries.

Several limitations must be considered when interpreting the results of the present study. First, as a general limitation, the identified resource use only encompassed in-hospital care during a 1-year period before the index discharge. We could not include resource use for ambulatory care or long-term nursing care services due to a lack of such information in our database. Second, we collected administrative data from only one private teaching hospital located in northern Japan. Although the results of this study may not be generalized to all hospitals in Japan, they may still provide a good indicator for patients receiving acute medical care in hospitals similar to the one studied. Since all residents of Japan are required to enroll in a public health insurance plan under Japan's universal health insurance system, all insured individuals can receive medical care at any hospital at any time with a relatively low out-of-pocket payment [30, 31]. Therefore, in Japan, there is no difference in patients' access to private hospitals or public hospitals due to their ability to pay. Finally, we used charge data rather than actual cost data in this study. Because only a few Japanese hospitals tentatively estimate actual costs for hospital care, these data are currently not available in our database. However, we believe that for countries that calculate annual health care expenditure based on charge data, it is useful to analyze charge-based data to examine factors associated with resource use.

As stated previously, the Japanese government has submitted several proposals in an effort to contain rising health care expenditures, such as through primary and secondary prevention of metabolic syndrome, reducing the length of hospitalization, promoting home hospice care, and eliminating redundant office visits. These proposals seem to have efficacy for controlling the increase in health care expenditures; however, these proposals are not based on studies that examined factors associated with health care expenditures using a large amount of individual patient data, as has been published in Western countries [4, 5, 7, 19, 22-25]. Although the Japanese government believes that the substantial rise in health care expenditures may be attributed to population aging, this study shows that a quadratic association exists between patient age and cumulative resource use among surviving patients during the 1-year period and that the effect of patient age on resource use differed completely between patients who survived and those who did not. Generating practical policy recommendations for cost containment in Japan will require detailed analyses of factors associated with health care resource use using individual patient data including outpatient care, inpatient care, and long-term nursing care during a longer period. Given the increasing elderly population worldwide, the results from this study may assist in shaping policy in both Japan and other countries by providing important information about health care expenditures in older patients.

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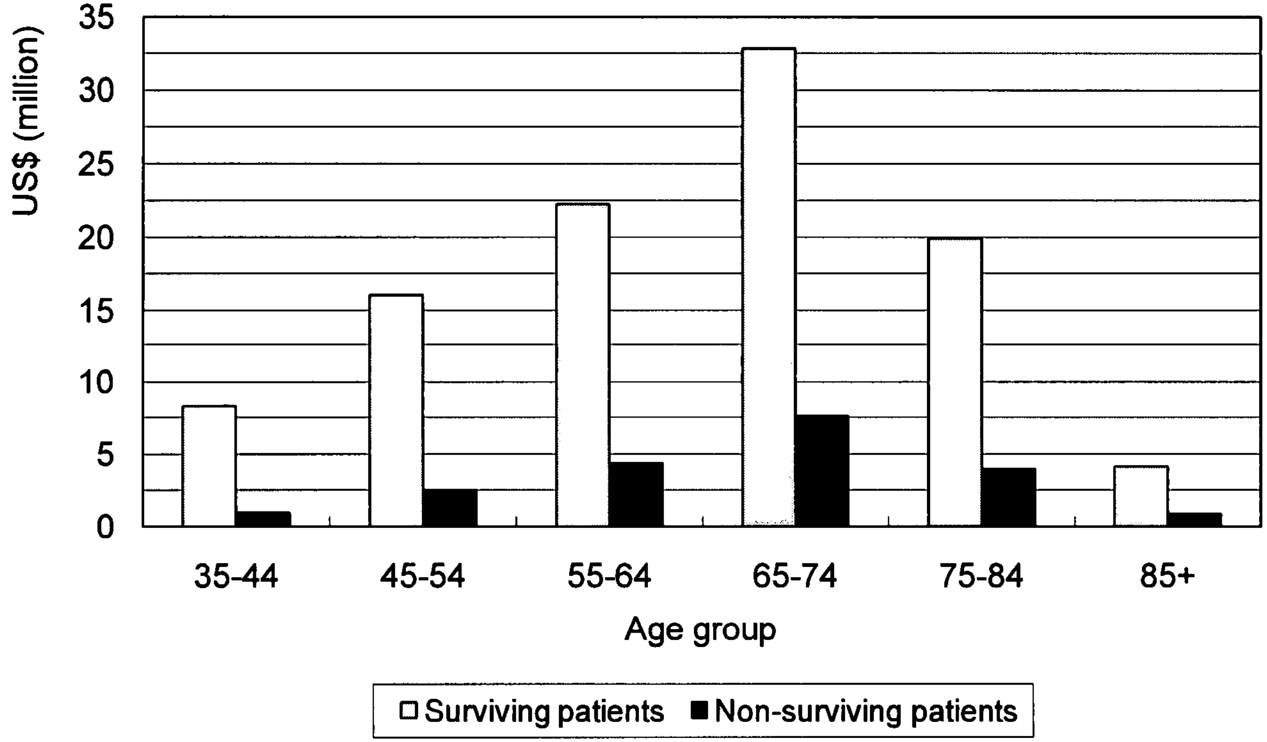


**Figure 1. The total amount of cumulative total charges during the 1-year period before the index discharge among 9,695 patients 35 years or older, stratified by age group and discharge survival status (N = 9,695: surviving patients = 9,145, non-surviving patients = 550).**

**Table 1. Characteristics of patients who were discharged from a teaching hospital in Japan during a 2-year period**

| | | Total (n = 9,695) | Surviving patients (n = 9,145) | Non-surviving patients (n = 550) |
|---|---|---|---|---|
| Sex (%) | Men | 51.5 | 50.7 | 64.9 |
| Age (years) | Mean (standard deviation) | 63.2 (14.1) | 62.8 (14.1) | 69.5 (12.1) |
| Age group (%) | 35-44 | 12.4 | 13.0 | 2.9 |
| | 45-54 | 16.8 | 17.2 | 10.4 |
| | 55-64 | 19.4 | 19.5 | 18.0 |
| | 65-74 | 27.7 | 27.4 | 33.1 |
| | 75-84 | 18.6 | 18.2 | 25.6 |
| | 85+ | 5.0 | 4.7 | 10.0 |
| Primary diagnosis (%) | Neoplasm | 18.0 | 15.7 | 55.8 |
| | Cardiovascular | 17.1 | 17.0 | 19.5 |
| | Eye | 15.2 | 16.1 | 0.4 |
| | Digestive | 12.8 | 13.3 | 5.3 |
| | Urinogenitary | 6.9 | 7.2 | 2.9 |
| | Injuries and exogenous | 6.3 | 6.5 | 3.1 |
| | Respiratory | 6.0 | 5.9 | 6.9 |
| | Endocrine and metabolism | 3.4 | 3.5 | 1.8 |
| | Others | 14.2 | 14.8 | 4.4 |
| Comorbid condition (%) | Any tumor | 14.3 | 11.6 | 59.5 |
| | Diabetes with chronic complications | 11.1 | 11.1 | 11.6 |
| | Metastatic tumor | 5.0 | 3.0 | 37.5 |

| | | | | |
|---|---|---|---|---|
| | Renal diseases | 3.8 | 3.5 | 8.7 |
| | Chronic pulmonary disease | 3.6 | 3.5 | 4.5 |
| | Peripheral vascular diseases | 3.0 | 3.0 | 4.2 |
| | Dementia | 1.5 | 1.3 | 3.5 |
| | Connective tissue diseases | 0.8 | 0.8 | 0.9 |
| | Mild liver disease | 0.4 | 0.3 | 1.3 |
| | Moderate or severe liver disease | 0.3 | 0.3 | 0.7 |
| | Diabetes | 0.2 | 0.2 | 0.4 |
| The number of comorbid conditions (%) | 0 | 67.0 | 69.8 | 20.5 |
| | 1 | 23.3 | 22.8 | 32.0 |
| | 2 | 8.4 | 6.4 | 41.8 |
| | 3 or 4 | 1.3 | 1.0 | 5.7 |
| Total number of hospitalizations (%) | 1 | 82.0 | 83.8 | 53.5 |
| | 2 | 12.6 | 11.9 | 24.4 |
| | 3 | 3.4 | 2.8 | 13.5 |
| | 4+ | 2.0 | 1.5 | 8.6 |
| Total number of surgical procedures (%) | 0 | 31.8 | 30.6 | 50.7 |
| | 1 | 60.1 | 61.4 | 39.5 |
| | 2 | 6.4 | 6.3 | 7.6 |
| | 3+ | 1.7 | 1.7 | 2.2 |

**Table 2. Median length of hospital stay and total charges in the top two principal diagnoses among discharged patients at a Japanese teaching hospital**

| | | | Most prevalent primary diagnosis | | | | Second most prevalent primary diagnosis | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Age group | n | Disease | % | Cumulative length of hospital stay (days) | Cumulative total charges (US$) | Disease | % | Cumulative length of hospital stay (days) | Cumulative total charges (US$) |
| **Surviving patients** | 35-44 | 1,188 | Pregnancy, Delivery | 21.7% | 6 | 1,316 | Digestive | 16.5% | 9 | 4,095 |
| | 45-54 | 1,569 | Neoplasm | 18.5% | 19 | 8,214 | Digestive | 18.5% | 12 | 5,113 |
| | 55-64 | 1,781 | CVD | 20.3% | 16 | 14,391 | Neoplasm | 15.7% | 25 | 10,119 |
| | 65-74 | 2,507 | CVD | 21.2% | 19 | 16,449 | Eye | 21.1% | 8 | 4,972 |
| | 75-84 | 1,666 | Eye | 26.5% | 8 | 4,895 | CVD | 18.8% | 21 | 14,089 |
| | 85+ | 434 | Eye | 24.2% | 8 | 4,924 | CVD | 20.0% | 18 | 7,988 |
| **Non-surviving patients** | 35-44 | 16 | Neoplasm | 68.8% | 106 | 42,082 | --- | --- | --- | --- |
| | 45-54 | 57 | Neoplasm | 70.2% | 94.5 | 37,112 | CVD | 14.0% | 17.5 | 21,770 |
| | 55-64 | 99 | Neoplasm | 74.7% | 97.5 | 36,739 | CVD | 13.1% | 40 | 23,928 |
| | 65-74 | 182 | Neoplasm | 58.8% | 95 | 38,540 | CVD | 18.7% | 18 | 18,205 |
| | 75-84 | 141 | Neoplasm | 44.0% | 53 | 23,581 | CVD | 19.9% | 11.5 | 16,395 |
| | 85+ | 55 | CVD | 41.8% | 10 | 5,512 | Neoplasm | 23.6% | 58 | 23,169 |

CVD: cardiovascular disease

**Table 3. Median length of hospital stay and charges during the 1-year period before the index discharge among discharged patients in a Japanese teaching hospital**

| | | Surviving patients | | | | | Non-surviving patients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | n | cumulative length of hospitalization (days) | cumulative total charges (US$) | cumulative charges for diagnostic examinations (US$) | cumulative charges for drugs (US$) | n | cumulative length of hospitalization (days) | cumulative total charges (US$) | cumulative charges for diagnostic examinations (US$) | cumulative charges for drugs (US$) |
| Total | | 9,145 | 14 | 5,851 | 831 | 353 | 550 | 55 | 25,938 | 3,015 | 7,160 |
| Sex | Men | 4,636 | 15 | 6,479 | 1,048 | 420 | 357 | 61 | 28,648 | 3,282 | 7,860 |
| | Women | 4,509 | 13 | 5,405 | 646 | 317 | 193 | 49 | 23,765 | 2,654 | 5,749 |
| Age group | 35-44 | 1,188 | 10 | 3,858 | 427 | 269 | 16 | 106 | 40,733 | 4,866 | 10,174 |
| | 45-54 | 1,569 | 14 | 6,029 | 834 | 342 | 57 | 82 | 36,774 | 4,118 | 13,692 |
| | 55-64 | 1,781 | 15 | 6,492 | 959 | 379 | 99 | 67 | 28,675 | 3,674 | 8,810 |
| | 65-74 | 2,507 | 16 | 6,568 | 1,022 | 399 | 182 | 75 | 31,586 | 3,828 | 9,059 |
| | 75-84 | 1,666 | 16 | 6,435 | 902 | 403 | 141 | 39 | 21,136 | 2,389 | 5,419 |
| | 85+ | 434 | 14 | 5,379 | 671 | 336 | 55 | 14 | 8,644 | 1,301 | 1,650 |
| Primary diagnosis (top 8) | Neoplasm | 1,435 | 22 | 8,733 | 1,493 | 722 | 307 | 85 | 31,756 | 3,848 | 9,757 |
| | Cardiovascular | 1,554 | 18 | 14,081 | 2,384 | 1,070 | 107 | 16 | 15,788 | 1,866 | 3,061 |
| | Eye | 1,473 | 8 | 5,014 | 218 | 248 | 2 | 35 | 13,300 | 1,565 | 3,464 |
| | Digestive | 1,213 | 13 | 5,131 | 1,008 | 387 | 29 | 33 | 24,671 | 2,963 | 6,890 |
| | Urinogenitary | 656 | 14 | 5,194 | 650 | 336 | 16 | 77 | 42,594 | 5,685 | 7,466 |
| | Injuries and exogenous | 591 | 19 | 6,529 | 545 | 347 | 17 | 15 | 14,298 | 831 | 3,922 |
| | Respiratory | 542 | 11 | 3,561 | 654 | 343 | 38 | 30 | 16,515 | 1,872 | 3,629 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Endocrine and metabolism | 324 | 19 | 6,642 | 1,033 | 278 | 10 | 21 | 9,411 | 1,781 | 2,329 |
| Total number | 1 | 7,653 | 12 | 5,048 | 656 | 294 | 294 | 24 | 17,017 | 1,868 | 4,468 |
| of | 2 | 1,085 | 31 | 14,052 | 1,924 | 973 | 134 | 83 | 28,272 | 3,609 | 7,953 |
| hospitalizations | 3 | 260 | 51 | 24,323 | 3,248 | 1,765 | 74 | 112 | 42,701 | 5,052 | 11,505 |
| | 4+ | 147 | 80 | 36,451 | 5,240 | 3,688 | 48 | 153 | 54,745 | 7,578 | 13,110 |
| Total number | 0 | 2,800 | 12 | 3,858 | 873 | 317 | 279 | 35 | 16,688 | 2,036 | 5,105 |
| of surgical | 1 | 5,613 | 14 | 6,119 | 660 | 323 | 217 | 67 | 33,436 | 4,321 | 9,250 |
| procedures | 2 | 577 | 33 | 17,626 | 2,206 | 967 | 42 | 111 | 42,505 | 5,711 | 10,174 |
| | 3+ | 155 | 55 | 32,022 | 4,473 | 1,742 | 12 | 107 | 51,652 | 7,379 | 9,503 |
| Total number | 0 | 6,386 | 11 | 4,956 | 563 | 283 | 113 | 13 | 11,915 | 1,435 | 2,315 |
| of comorbid | 1 | 2,085 | 23 | 10,683 | 1,675 | 859 | 176 | 46 | 25,239 | 2,788 | 6,771 |
| conditions | 2 | 583 | 37 | 16,087 | 2,437 | 1,754 | 230 | 86 | 34,384 | 4,189 | 9,831 |
| | 3+ | 91 | 46 | 21,215 | 3,036 | 2,466 | 31 | 82 | 33,629 | 3,879 | 9,518 |

**Table 4. Factors associated with cumulative resource use during the 1-year period before the index discharge among discharged patients at a Japanese teaching hospital (multiple regression analyses)**

| | | Cummulative total charges (US$) [natural log-transformed] | | Cummulative charges for diagnostic examinations (US$) [natural log-transformed] | | Cummulative charges for drugs (US$) [natural log-transformed] | |
|---|---|---|---|---|---|---|---|
| **Surviving patients** | | β | *P* value | β | *P* value | β | *P* value |
| Age at final discharge | Age (for 1 year) | 0.233 | < 0.001 | 0.397 | < 0.001 | -0.137 | 0.023 |
| | $Age^2$ (for 1 year) | -0.231 | < 0.001 | -0.355 | < 0.001 | 0.119 | 0.046 |
| Surgical treatment | Present vs. none (ref.) | 0.178 | < 0.001 | -0.077 | < 0.001 | 0.015 | 0.075 |
| Comorbidity | 1 vs. 0 (ref.) | 0.021 | < 0.001 | 0.064 | < 0.001 | 0.022 | 0.007 |
| | 2 vs. 0 (ref.) | 0.018 | < 0.001 | 0.035 | < 0.001 | 0.046 | < 0.001 |
| | 3 or 4 vs. 0 (ref.) | 0.010 | 0.026 | 0.016 | 0.048 | 0.018 | 0.011 |
| Cumulative length of hospitalization (natural log-transformed) | | 0.818 | < 0.001 | 0.455 | < 0.001 | 0.726 | < 0.001 |
| | Adjusted $R^2$ | 0.833 | | 0.444 | | 0.549 | |
| **Non-surviving patients** | | β | *P* value | β | *P* value | β | *P* value |
| Age at final discharge | Age (for 1 year) | 0.039 | 0.842 | 0.229 | 0.260 | 0.103 | 0.667 |
| | $Age^2$ (for 1 year) | -0.094 | 0.631 | -0.262 | 0.202 | -0.176 | 0.462 |
| Surgical treatment | Present vs. none (ref.) | 0.169 | < 0.001 | 0.174 | < 0.001 | 0.037 | 0.188 |
| Comorbidity | 1 vs. none (ref.) | -0.002 | 0.956 | 0.032 | 0.324 | 0.014 | 0.722 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 vs. none (ref.) | -0.064 | 0.080 | 0.000 | 0.997 | -0.024 | 0.591 |
| | 3 or 4 vs. none (ref.) | -0.007 | 0.772 | 0.030 | 0.257 | -0.010 | 0.734 |
| Cumulative length of hospitalization (natural log-transformed) | | 0.914 | < 0.001 | 0.848 | < 0.001 | 0.860 | < 0.001 |
| | Adjusted $R^2$ | 0.766 | | 0.742 | | 0.647 | |

ref. = reference category, β= standardized coefficient

All coefficients were adjusted for sex (men or women), total number of admissions, and primary diagnosis.

**Table 5. Gini coefficients for cumulative resource use during the 1-year period before the index discharge among all discharged patients at a Japanese teaching hospital**

| | Age group | n | Gini coefficient for cummulative total charges | Gini coefficient for cummulative charges for diagnostic examinations | Gini coefficient for cummulative charges for drugs |
|---|---|---|---|---|---|
| **Surviving patients** | 35-44 | 1,188 | 0.52 | 0.58 | 0.68 |
| | 45-54 | 1,569 | 0.50 | 0.51 | 0.66 |
| | 55-64 | 1,781 | 0.52 | 0.51 | 0.67 |
| | 65-74 | 2,507 | 0.51 | 0.53 | 0.66 |
| | 75-84 | 1,666 | 0.48 | 0.53 | 0.66 |
| | 85+ | 434 | 0.47 | 0.51 | 0.68 |
| | Total | 9,145 | 0.51 | 0.54 | 0.67 |
| **Non-surviving patients** | 35-44 | 16 | 0.45 | 0.35 | 0.50 |
| | 45-54 | 57 | 0.34 | 0.38 | 0.45 |
| | 55-64 | 99 | 0.45 | 0.40 | 0.51 |
| | 65-74 | 182 | 0.43 | 0.42 | 0.49 |
| | 75-84 | 141 | 0.46 | 0.43 | 0.53 |
| | 85+ | 55 | 0.51 | 0.52 | 0.59 |
| | Total | 550 | 0.46 | 0.44 | 0.53 |

**Gini coefficients: 0 = completely equal, 1 = completely unequal**

# Ⅵ章

# 医療安全活動、説明と同意、記録・書類作成が医療のコストに及ぼす影響