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Diabetes Affects Length of Stay and Hospital Costs for Elderly Patients with Pneumonia: An Analysis of a Hospital Administrative Database

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Objective: The present study investigated the association of having diabetes with length of stay and hospital costs for elderly patients with pneumonia who were admitted to an acute-care hospital in Japan.
Methods: Based on the inpatient administrative claims database of an acute-care hospital in central Tokyo between 2010 and 2013, 753 patients aged ≥ 65 years who were admitted to the hospital presenting with pneumonia and discharged alive were analyzed. The association was analyzed using a negative binomial model, having adjusted for age, sex, body mass index, dyspnea grade, functional evaluation of feeding, use of mechanical ventilation, and use of renal replacement therapy. A log-linear regression model adjusted for the same variables was used in the analysis of hospital costs.
Results: Of the 753 patients (mean age, 82.5 years; men, 58.2%), 225 patients had diabetes. The negative binomial regression revealed that those with diabetes had a 1.19 times longer length of stay (95% CI = 1.06–1.33) compared to those without. The log-linear regression revealed that hospital costs were 1.14 times higher (95% CI = 1.04–1.25) in patients with diabetes.
Conclusion: The presence of diabetes significantly correlated with longer length of stay and higher hospital costs for elderly patients with pneumonia.

Key words: diabetes, pneumonia, length of stay

INTRODUCTION

Pneumonia is a major threat to the elderly people in economically developed countries [1, 2], which could pose substantial burdens to their healthcare systems. In Japan, which is a rapidly aging society, pneumonia was the third leading cause of death in people aged ≥ 65 years in 2012 [3], which was estimated to be 391 deaths per 100,000 people. It was also reported that extensive hospitalizations and mortality in patients with pneumonia arise mainly from elderly people [4]. Therefore, once an elderly patient is admitted to a hospital with pneumonia, rational management of the disease along with an appropriate plan for early discharge is required for preventing exacerbations of the disease and complications related to the patient's conditions; this type of planning could eventually reduce length of stay (LOS) and hospital costs.

Meanwhile, as the population ages, diabetes has become a common comorbid condition for elderly patients. According to the Patient Survey 2008 [5], the prevalence of diabetes among in-hospital patients aged ≥ 70 years in Japan was 18.1%. Hyperglycemia is related to in-hospital adverse events and may lead to longer LOS, unless properly managed [6, 7]. In addition, elderly patients appear to require more time for diabetes management during hospital stay, including assessment of the patient's daily-life patterns, education, and introduction of diabetes treatment (insulin self-administration and glucose monitoring) because of their impaired cognitive and physical abilities. Such situations may also be the case for elderly patients with pneumonia.

In Japan, the Diagnostic Procedure Combination/Per-Diem Payment System (DPC/PDPS) for reimbursements has been implemented in acute-care hospitals since 2003 [8, 9]. DPC/PDPS is a prospective payment system to reduce patient admissions and LOS without compromising quality of care [8, 10]. In this system, the presence of diabetes has not yet been taken into consideration as a subject of increased reimbursements although diabetes may be associated with an increase in the amount of required care. To make the current system reflect the actual medical expenses of pneumonia treatment more accurately, it may be important to estimate the effect of diabetes on LOS and hospital costs for pneumonia patients. There have only been a few reports about the association between diabetes and health economic outcomes in patients with pneumonia [11, 12], and the results were inconclusive. Particularly in elderly patients, the association has seldom been investigated. Because of such limited information, the present study focused on elderly patients, who may be more vulnerable to their diabetes conditions. The

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associations of diabetes with LOS and hospital costs were investigated in elderly patients with pneumonia admitted to an acute-care hospital.

MATERIALS AND METHODS

Study population

This was a retrospective observational study. The Diagnosis Procedure Combination (DPC) database in Saiseikai Central Hospital, which is an acute-care hospital in central Tokyo, was used for the present study. Data used for analyses was from 2010 to 2013. The details of the DPC database were reported elsewhere [13]. Briefly, the DPC database is an inpatient administrative claims database in Japanese hospitals providing acute treatments, which is linked to a prospective payment system. The administrative database includes information on dates of admission and discharge, types of admission (scheduled or emergency), the main diagnosis, comorbidities present at admission, complications occurring during hospitalization, and discharge status. The diagnoses were coded with International Classification of Disease and Related Health Problems 10th Revision (ICD-10). Patient characteristics, including age, sex, height, weight, severity of dyspnea based on the Hugh-Jones Dyspnea Grade at admission, and functional evaluation of feeding at admission, were also recorded. In addition to these data, cost and detailed procedure data were available in the database, which included information on use of mechanical ventilation and use of renal replacement therapy during the admission.

In the present study, the admissions meeting the following criteria were identified: a) patient age ≥ 65 years at the time of admission; b) admission to the department of internal medicine; and c) primary diagnosis of pneumonia caused by microbes (ICD-10 codes: J10–J18) or aspiration pneumonia (J690) at the time of admission. A total of 1,144 admitted cases met the criteria. For patients who were repeatedly admitted to the hospital with the diagnosis of pneumonia, we only used data from the earliest admission to avoid including the same patient multiple times. Eight-hundred twenty eight admissions were included in the analysis.

Definition of diabetes

Patients with diabetes (ICD-10 codes, E10–14) were identified using the DPC database on comorbidities present at the time of admission. However, in the current DPC database in Japan, the number of recorded comorbidities was limited to only four diseases for each admission. The presence of diabetes might not be recorded if a patient has multiple comorbidities. To avoid underreporting diabetes, medical records of each patient was also reviewed. Then, if diabetes was registered as comorbidity in the medical record, a patient was also defined as having diabetes.

Outcome variables

The outcome variables in the present study were LOS and hospital costs in patients with pneumonia during the hospital stay. Hospital costs were calculated by adding all fees for the required services during the hospital stay. It was expressed using Japanese yen. One hundred Japanese yen is approximately equivalent to 0.98 US dollar.

Ethics statement

The study conforms with the principles outlined in the Declaration of Helsinki and was performed in line with the Ethical Guidelines for Epidemiological Research by the Japanese government. The study was approved by the ethics committee of Saiseikai Central Hospital (approval number 381). According to the guidelines, the study satisfied the conditions to waive the requirement for informed consent to individual participants. Therefore, informed consent was waived and the ethics committee approved the waiving.

Statistical analysis

Since in-hospital death could affect LOS, the analyses were performed separately in those who died in the hospital and those who were discharged alive from the hospital. Characteristics of the patients were compared between patients with diabetes and those without. Unpaired t-tests were used for comparing continuous variables. As for length of stay and hospital costs, Mann-Whitney U tests were used because of their skewed distributions. Chi-squared tests or fisher's exact tests were used as appropriate for comparisons between categorical variables. Regarding patients discharged alive, multivariable analyses were performed to estimate the differences in LOS and hospital costs between those with diabetes and those without. On the other hand, multivariable analyses were not performed in patients who died in the hospital because the number of in-hospital deaths was too small to perform such analyses appropriately.

Length of stay

Since the LOS can have only non-negative integer values, count data models are more appropriate than ordinary least-squares regression models [14]. Although Poisson regression is generally used for count data models, a negative binomial regression is preferred when the distribution of the variable is over-dispersed [15–17], namely, when the variance exceeds the mean. Since the LOS was over-dispersed, we employed a negative binomial model. In addition to diabetes status, the multivariable model (Model A) included age (categorical), sex, body mass index, dyspnea grade, functional evaluation of feeding, use of mechanical ventilation, and use of renal replacement therapy as explanatory variables. Then, the ratio of LOS in patients with diabetes compared to those without was calculated as the exponent of the coefficient. In order to confirm the robustness of the results, we further perform analyses. In Model B, the estimate was calculated with the use of age as a continuous variable. In Model C, the estimate was calculated after excluding BMI and dyspnea grade from the Model A, in which a certain proportion of the participants had unspecified data.

Hospital costs

Since the distribution of hospital costs was right skewed without zero outcomes, a log-linear model was constructed. First, logarithmic transformation of hospital costs was performed to mitigate the skewness (Fig. 1). Next, linear regression analysis was performed to compare the log-transformed hospital costs by diabetes status. As in the analysis for LOS, the multivariable

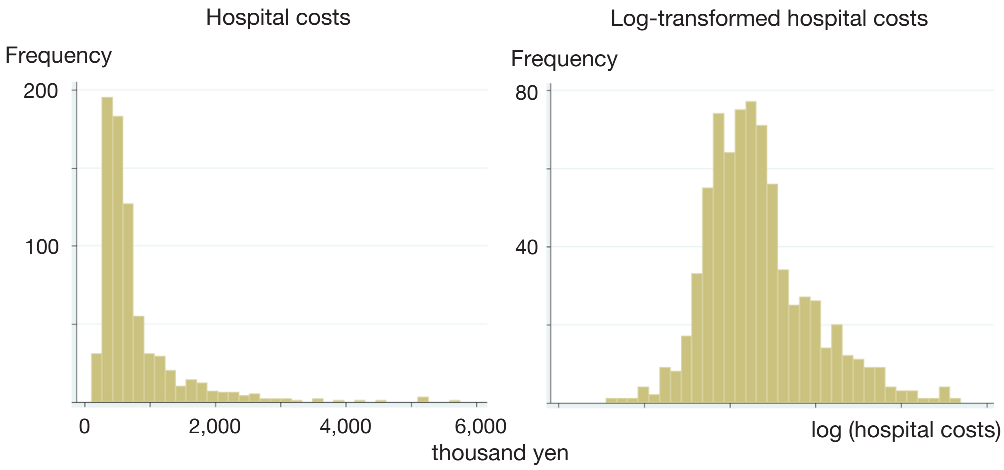

Fig. 1 Distributions of hospital costs and log-transformed hospital costs in patients who were discharged alive from the hospital.

Table 1 In-hospital mortality of study participants by diabetes

	Total	Diabetes		P for difference*
		No	Yes	
Number of patients	828	578	250	
Number of in-hospital deaths	75	50	25	
In-hospital mortality (%)	9.1	8.7	10.0	0.535

* A p-value is calculated using chi-square tests.

models were constructed, which included the same explanatory variables in Model A, B and C. The ratio of the hospital costs in patients with diabetes in relation to those without diabetes was calculated as the exponent of the coefficient.

All analyses were performed using Stata version 11 for Windows (Stata Corp., Texas, USA). All statistical tests were two-sided, and the threshold for statistical significance was $P < 0.05$.

RESULTS

In-hospital mortality

Of the 828 patients, 75 (9.1%) died during the hospital stay. Table 1 shows in-hospital mortality by diabetes. The in-hospital mortality in patients without diabetes was 8.7% whereas that in those with diabetes was 10.0%. The difference in the mortality was not significant between those with diabetes and those without (P = 0.535).

Analysis of patients who were discharged alive from the hospital

Table 2 shows background characteristics of patients who were discharged alive from the hospital. Of the 753 patients, 225 had diabetes (30%). The mean age was 82.5 ± 8.0 years, and 438 patients (58%) were men. When the characteristics were compared between patients with and without diabetes, age composition, sex ratio, body mass index, use of mechanical ventilation, use of renal replacement therapy, and functional evaluation of feeding at the time of admission were found to significantly differ between the two groups. On the other hand, no difference was observed in terms of dyspnea grade. The distributions of length of stay in patients with diabetes and those without are shown in Fig. 2. The median LOS in patients with diabetes and those without diabetes were both 13.0 days (Table 3). The negative binomial regression analysis revealed that patients with diabetes had 1.19 times longer LOS [95% confidence interval (CI) = 1.06–1.33] in relation to those without diabetes after adjustment for age, sex, body mass index, dyspnea grade, functional evaluation of feeding, use of mechanical ventilation, and use of renal replacement therapy (Model A). The estimates did not change largely in Model B or C. Regarding hospital costs, the distributions are shown in Fig. 3. The median hospital costs were 582,000 yen per admission in patients with diabetes, while 546,000 yen in those without diabetes (Table 3). In the multivariable analysis (Model A), the costs were 1.14 times higher (95% CI = 1.04–1.25) in patients with diabetes when compared to that in those without diabetes. The estimates were similar in Model B and C.

Analysis of patients who died in the hospital

In the analysis of the 75 patients who died in the hospital, age composition, sex ratio, body mass index, and functional evaluation of feeding at the time of admission were found to significantly differ between patients with and without diabetes. The median LOS in patients with diabetes and those without diabetes were both 14.0 days. The median hospital costs were 1,150,000 yen per admission in patients with diabetes, while 1,003,000 yen in those without diabetes. No significant differences were observed in terms of LOS and hospital costs (Table 4).

Table 2 Background characteristics of patients who were discharged alive from the hospital

	Total (n = 753)		Diabetes No (n = 528)		Diabetes Yes (n = 225)		P for difference*
Age (continuous), years	82.5	(8.0)	83.4	(8.1)	80.5	(7.5)	< 0.001
Age (categorical), years							
65-69	55	(7.3)	33	(6.3)	22	(9.8)	< 0.001
70-79	232	(30.8)	143	(27.1)	89	(39.6)	
80-89	323	(42.9)	229	(43.4)	94	(41.8)	
90-	143	(19.0)	123	(23.3)	20	(8.9)	
Men	438	(58.2)	277	(52.5)	161	(71.6)	< 0.001
Body mass index, kg/m^2							
-18.4	126	(16.7)	104	(19.7)	22	(9.8)	< 0.001
18.5-22.9	192	(25.5)	125	(23.7)	67	(29.8)	
23.0-	112	(14.9)	55	(10.4)	57	(25.3)	
Unspecified	323	(42.9)	244	(46.2)	79	(35.1)	
Dyspnea grade based on the Hugh-Jones grade							
1	108	(14.3)	68	(12.9)	40	(17.8)	0.231
2	91	(12.1)	58	(11.0)	33	(14.7)	
3	65	(8.6)	44	(8.3)	21	(9.3)	
4	117	(15.5)	86	(16.3)	31	(13.8)	
5	105	(13.9)	76	(14.4)	29	(12.8)	
Unspecified	267	(35.5)	196	(37.1)	71	(31.6)	
Use of mechanical ventilation	20	(2.7)	10	(1.9)	10	(4.4)	0.046
Use of renal replacement therapy	10	(1.3)	3	(0.6)	7	(3.1)	0.005
Functional evaluation of feeding							
Independent	270	(35.9)	207	(39.2)	63	(28.0)	0.007
Partial assistance	182	(24.2)	129	(24.4)	53	(23.6)	
Total assistance	255	(33.9)	160	(30.3)	95	(42.2)	
Unspecified	46	(6.1)	32	(6.1)	14	(6.2)	

Values are presented as count (%) or the mean (standard deviation).

* P-values are calculated using unpaired t-tests for continuous variables, and chi-square tests or fisher's exact tests as appropriate for categorical variables.

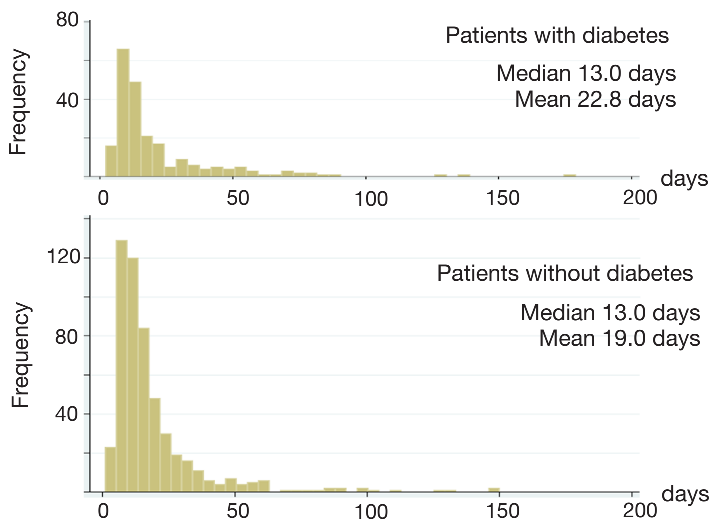

Fig. 2 Distributions of length of stay in patients with diabetes and those without diabetes.

Table 3 Associations of having diabetes with length of stay and hospital costs in patients discharged alive from the hospital

Length of stay

	Number of patients	Length of stay, days		Base model§		Model A¶		Model B#		Model C**	
		Median*	Mean†	Ratio‡	(95% CI)	Ratio‡	(95% CI)	Ratio‡	(95% CI)	Ratio‡	(95% CI)
Total	753	13 (9–21)	20.1 (21.8)								
Non-diabetes	528	13 (9–20.5)	19.0 (18.9)	1.00	reference	1.00	reference	1.00	reference	1.00	reference
Diabetes	225	13 (9–24)	22.8 (27.4)	1.17	(1.03–1.33)	1.19	(1.06–1.33)	1.20	(1.06–1.34)	1.17	(1.04–1.31)

Hospital costs

	Number of patients	Hospital costs, thousand yen		Base model§		Model A¶		Model B#		Model C**	
		Median*	Mean†	Ratio‡	(95% CI)	Ratio‡	(95% CI)	Ratio‡	(95% CI)	Ratio‡	(95% CI)
Total	753	558 (403–829)	781 (749)								
Non-diabetes	528	546 (402–784)	728 (624)	1.00	reference	1.00	reference	1.00	reference	1.00	reference
Diabetes	225	582 (409–989)	904 (971)	1.13	(1.03–1.25)	1.14	(1.04–1.25)	1.14	(1.04–1.25)	1.12	(1.03–1.24)

* Values are presented as the median (interquartile range).
† Values are presented as the mean (standard deviation).
‡ Ratios are calculated as an exponent of the coefficient.
§ The base model includes age (categorical) and sex.
¶ Model A includes age (categorical), sex, body mass index, dyspnea grade, use of mechanical ventilation, use of renal replacement therapy, and functional evaluation of feeding.
# Model B includes age (continuous), sex, body mass index, dyspnea grade, use of mechanical ventilation, use of renal replacement therapy, and functional evaluation of feeding.
** Model C includes age (categorical), sex, use of mechanical ventilation, use of renal replacement therapy, and functional evaluation of feeding.
CI: confidence interval

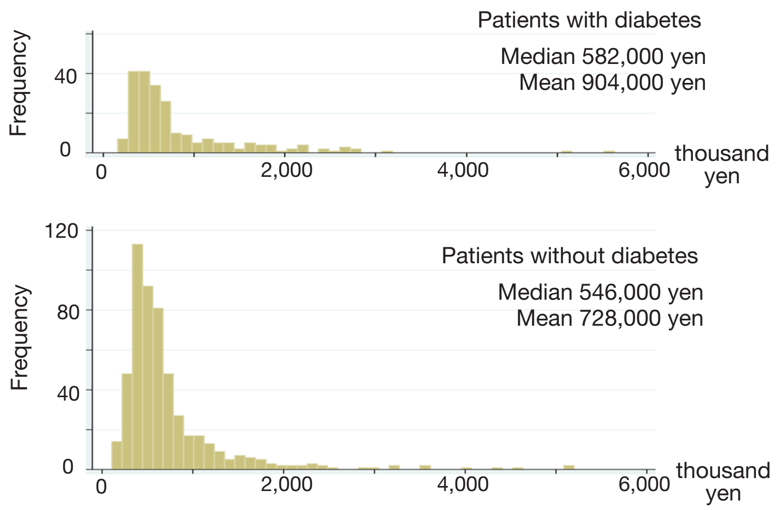

Fig. 3 Distributions of hospital costs in patients with diabetes and those without diabetes.

DISCUSSION

This observational study using the DPC database in an acute-care hospital in Japan investigated the association of having diabetes with LOS and hospital costs in elderly patients with pneumonia. In-hospital mortality appeared moderately higher in patients with diabetes than in those without diabetes although statistical significance was not observed. In the multivariable analysis of patients discharged alive, having diabetes was significantly associated with longer LOS and higher hospital costs. When reviewing LOS among patients with pneumonia, the observed LOS in the present study appeared longer than that reported in a nationwide study [9]. The mean LOS in the present study was 20.1 days while the mean LOS among patients with pneumonia in 248 acute-care hospitals (mean age 73 years, men 58%) in Japan was 14.1 days [9]. The long LOS in the present study could partially reflect older ages (mean age, 83 years) and the high prevalence of diabetes (30%). In terms of the effects of having diabetes, we observed a 19% increase in LOS and a 14% increase in hospital costs in patients with diabetes. Although it may be difficult to compare the findings with those from other countries because of differences in healthcare systems, one study in

Table 4 Background characteristics, length of stay, and hospital costs in patients who died in the hospital

	Total (n = 75)		Diabetes No (n = 50)		Diabetes Yes (n = 25)		P for difference*
Age (continuous), years	84.8	(8.2)	87.1	(7.5)	80.0	(7.7)	< 0.001
Age (categorical), years							
65-69	6	(8.0)	2	(4.0)	4	(16.0)	0.002
70-79	14	(18.7)	5	(10.0)	9	(36.0)	
80-89	35	(46.7)	25	(50.0)	10	(40.0)	
90-	20	(26.7)	18	(36.0)	2	(8.0)	
Men	48	(64.0)	27	(54.0)	21	(84.0)	0.012
Body mass index, kg/m^2							
-18.4	12	(16.0)	9	(18.0)	3	(12.0)	0.003
18.5-22.9	12	(16.0)	8	(16.0)	4	(16.0)	
23.0-	11	(14.7)	2	(4.0)	9	(36.0)	
Unspecified	40	(53.3)	31	(62.0)	9	(36.0)	
Dyspnea grade based on the Hugh-Jones grade							
1	0	(0.0)	0	(0.0)	0	(0.0)	0.928
2	1	(1.3)	1	(2.0)	0	(0.0)	
3	1	(1.3)	1	(2.0)	0	(0.0)	
4	4	(5.3)	3	(6.0)	1	(4.0)	
5	20	(26.7)	12	(24.0)	8	(32.0)	
Unspecified	49	(65.3)	33	(66.0)	16	(64.0)	
Use of mechanical ventilation	15	(20.0)	8	(16)	7	(28.0)	0.221
Use of renal replacement therapy	2	(2.7)	0	(0.0)	2	(8.0)	0.108
Functional evaluation of feeding							
Independent	44	(58.7)	31	(62.0)	13	(52.0)	0.007
Partial assistance	11	(14.7)	8	(16.0)	3	(12.0)	
Total assistance	9	(12.0)	5	(10.0)	4	(16.0)	
Unspecified	11	(14.7)	6	(12.0)	5	(20.0)	
Length of stay, days							0.982
Median	14	(7-36)	14	(7-36)	14	(7-35)	
Mean	25.1	(28.0)	25.9	(30.8)	23.5	(21.6)	
Hospital costs per admission, thousand yen							0.393
Median	762	(351-1468)	748	(334-1453)	945	(503-1540)	
Mean	1052	(850)	1003	(845)	1150	(870)	

Values are presented as count (%), the mean (standard deviation) or the median (interquartile range).
* P-values are calculated using unpaired t-tests age (continuous), Mann-Whitney U tests for length of stay and hospital costs, and chi-square tests or fisher's exact tests as appropriate for categorical variables.

Switzerland [11] examined 875 patients with pneumonia (median age 72 years, men 58%) and reported that diabetes was significantly associated with longer LOS in patients with pneumonia. On the other hand, another study in the United States [12], which included 857 patients (mean age 64 years, men 49%), demonstrated that glucose levels on admission were not associated with LOS or 30-day readmission. As for more elderly patients, there have been few reports on the effect of diabetes on LOS and hospital costs in patients with pneumonia. Now, in Japan, the Ministry of Health, Labour and Welfare is in the process of introducing a "Comorbidity Complication Procedure" matrix into the current DPC/PDPS [9], which takes differences in the severity and comorbidities of a patient into account and reflects the differences in reimbursements. Under such situations, the findings of the present study may provide useful information for estimating the additional healthcare burdens incurred in the hospital stay of elderly diabetes patients with pneumonia.

Several reasons were considered for the association of having diabetes with longer LOS and higher hospital costs in patients presenting with pneumonia and discharged alive. First, the presence of diabetes could be associated with increased severity of pneumonia. Hyperglycemia is associated with decreased immunity and impaired lung function [18], which could complicate the course of a hospital stay. Second, patients with diabetes were more likely to have comorbidities, such as chronic kidney disease, stroke, and cardiovascular diseases, than those without diabetes, which could also affect the clinical course of pneumonia. Third, diabetes management in elderly patients could incur additional costs and require more time. As is often the case with elderly patients, deteriorations in cognitive and physical functions occur frequently during a hospital stay. In such patients, re-evaluation of diabetes management is required, which could result in prolongation of LOS and increases in hospital costs. Particularly in those requiring insulin therapy, implementing or resuming self-management of insulin therapy may be an obstacle to early discharge.

Regarding the analysis of patients who died in the hospital, patients with diabetes appeared to have shorter LOS and higher hospital costs, suggesting patients with diabetes might have had severe conditions and been more likely to die in the early stage of the admission. However, it was difficult to conclude as such in the present study since the differences in LOS and hospital costs were not adjusted for patients' characteristics due to the small number of in-hospital deaths.

Several limitations in the present study should be noted. First, this study was conducted in a single institute, which could limit the generalizability of the findings. Further research on this topic should be performed involving multiple medical institutes. Second, this study was based on hospital administrative data. Therefore, several important clinical characteristics such as HbA1c levels on admission, which could be useful for considering the underlying mechanisms of the association, were not available. However, the methodology of the analysis using the DPC database could be applicable since the data were recorded in a nationally standardized manner. Despite these limitations, the present study, which was based on data of medical practice of an acute-care hospital in Japan, provided useful information on the effect size of the presence of diabetes on LOS and hospital costs in elderly patients with pneumonia.

In conclusion, the present study found that the presence of diabetes was significantly associated with longer LOS and higher hospital costs in elderly patients presenting with pneumonia and discharged alive from the hospital. In patients who died in the hospital, LOS appeared shorter and hospital costs higher if patients had diabetes, although the results were not confirmative. It is indisputable that careful management is required for each patient with pneumonia. Especially for patients with diabetes, additional care should be provided and diabetes management be reviewed as early as possible. These efforts could eventually lead to a reduction in LOS and hospital costs.

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REFERENCES

1) Mizgerd JP. Lung infection--a public health priority. PLoS Med. 2006; 3: 2: e76.
2) Lepper PM, Ott S, Nuesch E, von Eynatten M, Schumann C, Pletz MW, *et al.* Serum glucose levels for predicting death in patients admitted to hospital for community acquired pneumonia: prospective cohort study. BMJ. 2012; 344: e3397.
3) The Cabinet office, Government of Japan. Annual Report on the Aging Society: 2014. Tokyo [cited 2015 30th July]; Available from: http://www8.cao.go.jp/kourei/english/annualreport/2014/pdf/c1-2-2.pdf.
4) Loeb M. Pneumonia in older persons. Clin Infect Dis. 2003; 37: 10: 1335-9.
5) The Ministry of Health, Labour and Welfare. The Patient Survey 2008. [cited 2015 30th July]; Available from: http://www.mhlw.go.jp/english/database/db-hss/dl/sps_2008_06.pdf.
6) Kansagara D, Fu R, Freeman M, Wolf F, Helfand M. Intensive insulin therapy in hospitalized patients: a systematic review. Ann Intern Med. 2011; 154: 4: 268-82.
7) Murad MH, Coburn JA, Coto-Yglesias F, Dzyubak S, Hazem A, Lane MA, *et al.* Glycemic control in non-critically ill hospitalized patients: a systematic review and meta-analysis. J Clin Endocrinol Metab. 2012; 97: 1: 49-58.
8) Hamada H, Sekimoto M, Imanaka Y. Effects of the per diem prospective payment system with DRG-like grouping system (DPC/PDPS) on resource usage and healthcare quality in Japan. Health Policy. 2012; 107: 2-3: 194-201.
9) Uematsu H, Kunisawa S, Yamashita K, Imanaka Y. The Impact of Patient Profiles and Procedures on Hospitalization Costs through Length of Stay in Community-Acquired Pneumonia Patients Based on a Japanese Administrative Database. PLoS One. 2015; 10: 4: e0125284.
10) Davis C, Rhodes DJ. The impact of DRGs on the cost and quality of health care in the United States. Health Policy. 1988; 9: 2: 117-31.
11) Suter-Widmer I, Christ-Crain M, Zimmerli W, Albrich W, Mueller B, Schuetz P. Predictors for length of hospital stay in patients with community-acquired pneumonia: results from a Swiss multicenter study. BMC Pulm Med. 2012; 12: 21.
12) Bhattacharya RK, Mahnken JD, Rigler SK. Impact of admission blood glucose level on outcomes in community-acquired pneumonia in older adults. Int J Gen Med. 2013; 6: 341-4.
13) Shoda N, Yasunaga H, Horiguchi H, Matsuda S, Ohe K, Kadono Y, *et al.* Risk factors affecting inhospital mortality after hip fracture: retrospective analysis using the Japanese Diagnosis Procedure Combination Database. BMJ Open. 2012; 2: 3: e000416. doi: 10.1136/bmjopen-2011.
14) Greene WH. Econometric Analysis. 5th edition ed. Upper Saddle River, New Jersey: Prentice Hall; 2003.
15) Singh CH, Ladusingh L. Inpatient length of stay: a finite mixture modeling analysis. Eur J Health Econ. 2010; 11: 2: 119-26.
16) Soyiri IN, Reidpath DD, Sarran C. Asthma length of stay in hospitals in London 2001-2006: demographic, diagnostic and temporal factors. PLoS One. 2011; 6: 11: e27184.
17) Suh HS, Kang HY, Kim J, Shin E. Effect of health insurance type on health care utilization in patients with hypertension: a national health insurance database study in Korea. BMC Health Serv Res. 2014; 14: 570.
18) Kabeya Y, Kato K, Tomita M, Katsuki T, Oikawa Y, Shimada A. Association of glycemic status with impaired lung function among recipients of a health screening program: a cross-sectional study in Japanese adults. J Epidemiol. 2014; 24: 5: 410-6.