Introduction

Healthcare-associated infections (HAIs) have previously been identified as having a significant impact in the worsening of ischemic stroke patients[1-4]. In addition to increased morbidity and mortality, the resulting extension in hospital stay results in increased costs to patients and 3rd party payers, as well as a reduction in potential bed-space for healthcare providers.

HAIs have been estimated to develop in over one-third of patients with acute stroke, with the most common infections being lung infections and urinary tract infections[1-2]. Studies have reported HAI incidences of 41.5%[5], stroke-associated pneumonia incidences ranging from 10% to 30.9%[3-4,6-8], and even incidences of significant bacteriuria alone reaching 39.1% [9]. Reported extensions in length of hospital stay ranged from 6 days[6] to 23 days[7]. Risk factors found to be associated with HAIs in stroke patients have include mechanical ventilation, dysphagia, age, parenteral nutrition, post-stroke disability, and urinary catheterization[6, 10-11]. In addition, the Barthel Index has been shown to be significantly associated with infections in acute ischemic stroke patients[12-13] .

Quantifying the increases in hospital charges and length of stay (LOS) associated with HAIs would be useful for healthcare providers and 3rd party payers when considering the cost-effectiveness of interventions aimed at reducing HAIs. While some studies have attempted to quantify the outcomes associated with HAIs in stroke patients at the hospital level[6-7], a multi-institutional analysis that takes into account patient and hospital-related variations would allow for a more meaningful interpretation of each hospital's results.

There are currently no studies to our knowledge that have analyzed HAI incidence in stroke patients in Japanese hospitals, and no studies that have attempted to quantify the economic impact and mortality associated with HAIs at a multi-institutional level.

Aims

The objective of this study was to utilize an administrative database from multiple Japanese hospitals in order to identify HAI incidence in patients admitted for acute ischemic stroke, and to quantify risk-adjusted economic and clinical outcomes associated with HAIs.

Methods

Hospital and Patient Selection

The original sample population consisted of 16,886 ischemic stroke patients admitted during the period of April 1998 to April 2008 into 40 general hospitals *(designated H1 to H40)* enrolled in the Quality Indicator/Improvement Project (QIP), a database of Japanese hospitals that consists of clinical and claims data. Hospitals in the QIP voluntarily join the project and provide claims and administrative data in standardized formats for analysis with the objective of improving the quality and efficiency of healthcare provision. The hospitals included in this study were drawn from this database and represent a variety of public and private, teaching and non-teaching hospitals with different casemixes and specialties.

Clinical diagnoses were identified using ICD10 codes. Pre-existing comorbidity conditions were analyzed using the Charlson comorbidity index (Dartmouth-Manitoba version) [14-15].

Patients who had infections occurring within 48 hours were identified as having community-acquired infections and thus excluded from this study. Other exclusion criteria included minors (below 20 years), and cases with missing data in charge information, age and Japan Coma Scale (JCS)[16] score. For the linear regression models used for hospital charges and LOS, and the logistic regression model used for mortality, cases with standardized residuals greater than 3 standard deviations from the mean were considered outliers and excluded from analysis. In the regression models for hospital charges and LOS, patients who died during the hospitalization period were also excluded.

The JCS is the most widely used clinical tool for evaluating consciousness level in Japanese emergency care, and consists of a scale categorized into four levels: (i) alert; (ii) JCS levels 1~3 (disoriented: awake without stimulation); (iii) JCS levels 10~30 (somnolent: arousable only in the presence of stimulation); and (iv) JCS levels 100~300 (comatose: unarousable despite stimulation).[17]

Healthcare-Associated Infection Identification

HAIs were first identified using hospital-reported ICD10 codes adapted from the Pennsylvania Health Care Cost Containment Council (PHC4)[18]. However, previous studies have shown that the use of ICD codes alone is insufficient for HAI identification[18-19]. Therefore, HAIs were also identified through the use of antibiotic utilization patterns obtained from daily drug claims data, based on a technique adapted from our previous study[20].

Infections were identified where antibiotic utilization did not conform to surgical prophylaxis patterns in patients who had surgeries performed. Patients were identified as having HAIs if, in addition to reported ICD codes, they fell into any of the following categories: (1) Antibiotic utilization episodes with durations of 4 or more days that did not overlap a day in which surgery requiring prophylaxis was performed (2) Three or more antibiotic types used within a single episode of antibiotic utilization (3) Antibiotic types changed or a 2nd antibiotic type added midway during an antibiotic utilization episode (4) Prophylactic antibiotic utilization episodes of 5 or more days in which the start of the episode corresponds to a day where surgery was performed.

Clinical and Economic Outcome Indicators

Total hospital charges (Japanese Yen) and LOS (days) were used as indicators for economic outcome, while mortality was used as the clinical outcome measure.

Statistical Analysis:

Analyses were performed using Dr. SPSS VER. II 11.0.1J. Significance for *P*-values was set at $P < 0.05$(two-tailed).

Risk-Adjustment

Total hospital charges and LOS were natural logarithmically transformed before used as dependent variables in multiple linear regression analysis (Stepwise). Two models were developed for each dependent variable; one in which hospital stratification was included in the independent variables, and another in which hospital stratification was excluded. The former was used to calculate overall risk-adjusted hospital charges and LOS after taking hospital variations into account. The latter model was used in the calculation of hospital-level risk-adjusted hospital charges and LOS, which enabled inter-hospital comparisons.

The models for hospital charges included the following independent variables: age, sex, Barthel index, atherothrombotic stroke, cardioembolic stroke; Charlson score, LOS, surgeries performed, central venous catheter (CVC) use, mechanical ventilation, dysphagia, ICU stay, and JCS score upon admission. The models for LOS included the following independent variables: age, sex, Barthel index, atherothrombotic stroke, cardioembolic stroke; Charlson score, surgeries performed, central venous catheter (CVC) use, mechanical ventilation, dysphagia, ICU stay, and JCS score upon admission. The first model for each dependent variable also included hospital stratification while the second model did not. Apart from atherothrombotic and cardioembolic strokes, patients with other types of stroke were used as a reference for the regression models. The Barthel index used by the hospitals in this sample was the 20-point Collin scoring version[21].

Exponentials of the predicted values from the regression models were calculated in order to obtain expected values in units of Japanese Yen and days, and Duan's smearing coefficient[22-23] was applied to correct for retransformation bias. Risk adjustment was then conducted by dividing each hospital's mean observed value by the mean expected value, and the result was multiplied by the mean value of the entire dataset. Final estimates of hospital charges were adjusted for inflation using the Japanese consumer price index (adjusting all values to the 2008 yen value) and then converted to US dollars using Purchasing Power Parities (JPN 100 Yen = US$0.80[21]).

Mortality was used as the dependent variable in the logistic regression model, and adjusted with the following independent variables: HAI status, age, sex, Barthel index, atherothrombotic stroke, cardioembolic stroke; Charlson score, surgeries performed, CVC use, mechanical ventilation, dysphagia, ICU stay, LOS, JCS score upon admission, and hospital stratification. Calibration was evaluated with a Hosmer-Lemeshow statistical analysis[25], while discrimination was evaluated with a Receiver Operating Characteristic (ROC) curve.

Results

Patient and Hospital Characteristics

After excluding cases that fulfilled the aforementioned exclusion criteria, our final sample for analysis consisted of 8,861 patients from 36 hospitals, with four hospitals exclude due to a lack of patients.

General characteristics of the patients in our sample are shown in Table 1. Elderly patients were heavily represented in the study population, with almost half of the patients older than 75 years of age. There were more men than women at 58.3% versus 41.7%. Of the patients in our sample, 68% were originally admitted to either neurosurgery or neurology departments, 17.3% were admitted to internal medicine departments and the remainder in various other departments. The Barthel Index showed that upon admission, 20.1% of the patients had no form of disabilities, while 43.3% had relatively severe disabilities. Over 21% of the patients were classified as having an atherothrombotic stroke, 10.3% of the patients had a cardioembolic stroke, and 68.5% had strokes which did not fall into either of the above 2 categories. Almost 70% of the patients were completely lucid upon admission according to the JCS, and more than half were admitted without existing comorbidities. Unadjusted mean hospital charges were \$6,471, with a mean LOS of 21.97 days.

The hospitals in our sample consisted of general hospitals providing a range of services not limited to stroke care. Of the 36 hospitals, 27 were private-owned and 9 were publicly-owned. Twenty-nine of the hospitals were teaching hospitals, while 7 of the hospitals were not. The hospitals had a mean of 435 beds, with an inter-hospital range of 98 to 1,125 beds. More than half of the hospitals had ICUs, but only 2 of the hospitals had dedicated stroke care units. There was a mean of 98 doctors (range: 9~392) and 337 nurses (range: 45~1,138) in each hospital. Fourteen of the 36 hospitals in our sample had both neurosurgery and neurology departments, 15 hospitals had only one of the two departments, and 7 hospitals had neither (in which case stroke patients were warded in internal medicine or other departments).

Healthcare-Associated Infection Incidence

The overall HAI incidence in our sample was 16.4%. As seen in Figure 1, there was a large variation of HAI incidence at the hospital level, with a range from 4.7% to 28.3%. Seventeen of the 36 hospitals had HAI incidence proportions lower than the overall mean.

Risk-adjusted Hospital Charges and Length of Stay

The results of the linear regression analyses are shown in Table 2. The first model for both hospital charges and LOS (as dependent variables) included hospital stratification, while the second model excluded hospitals as independent variables. Tests for multicollinearity were performed and all variance inflation factors (VIF) values were found to be below 2.1 (data not shown).

With regard to hospital charges, the first model had an R^2 value of 0.764 ($P < 0.001$). Independent variables which showed significant association with hospital charges included age, sex, Barthel index, both types of stroke, Charlson score, LOS, surgery, CVC use, mechanical ventilation, dysphagia, ICU stay, all JCS levels, and 25 hospitals. LOS showed the strongest association with increased hospital charges ($\beta = 0.781$; $P < 0.001$). All independent variables in the second model ($R^2 = 0.711$; $P < 0.001$) except for CVC use and JCS levels 100~300 showed significant associations with hospital charges.

The first model for LOS ($R^2 = 0.308$; $P < 0.001$) showed that sex, Barthel index, both types of stroke, Charlson score, surgery, mechanical ventilation, dysphagia, ICU stay, all JCS levels, and 24 hospitals had significant associations with increased LOS. Mechanical ventilation, CVC use and JCS levels 100~300 had the highest standardized coefficients amongst the independent variables. In the second model, ($R^2 = 0.222$; $P < 0.001$), sex, atherothrombotic stroke, CVC use and mechanical ventilation showed no significant association with increased LOS.

After conducting risk-adjustment based on data from the first model, the overall mean hospital charges were $6,009 for uninfected patients and $9,076 for infected patients, resulting in an additional $3,067 associated with HAIs. LOS after risk-adjustment was 19.0 days in uninfected patients and 35.3 days in infected patients, with an additional 16.3 day-increase associated with HAIs. Mean hospital charges per day for uninfected and infected patients were thus $317 and $257, respectively.

Using data from the second model for both hospital charges and LOS, risk-adjustment was calculated at the hospital level. Figure 2 shows box-plot graphs of the risk-adjusted hospital charges and LOS for uninfected patients and infected patients by hospital.

After risk-adjustment, there was a hospital-level range of $3,824 (Hospital H6) to $7,710 (Hospital H28) for hospital charges in uninfected patients. For infected patients this range was $5,438 (Hospital H6) and $14,505 (Hospital H24). Therefore, additional charges associated with HAIs ranged from $434 to as high as $7,151 at the hospital level. The 25th, 50th and 75th percentile hospital charges for the uninfected patients were \$5,305, \$5,764 and \$6,232, respectively. The 25th, 50th and 75th percentile hospital charges for infected patients were \$6,379, \$7,983 and \$9,865, respectively. Hospitals H6 and H28 were identified as outliers with inordinately low and high hospital charges, respectively, for uninfected patients.

At the hospital level, the minimum risk-adjusted LOS for uninfected patients was 12.3 days (Hospital H34) and the maximum LOS was 27.2 days (Hospital H1). The 25th, 50th and 75th percentiles for the uninfected patients were 15.9 days, 19.0 days and 21.4 days, respectively. For patients who had an HAI, the risk-adjusted LOS ranged from 21.8 days (Hospital H34) to 47.9 days (Hospital H8). The 25th, 50th and 75th percentiles for infected patients were 32.6 days, 34.2 days and 41.7 days, respectively. Additional LOS associated with HAIs ranged from 5.1 days (Hospital H4) to 25.1 days (Hospital H8). Hospitals H34 was identified as an outlier with exceptionally low LOS in infected patients.

Risk-Adjusted Mortality

After adjusting for patient and hospital variations, the adjusted odds ratio for the association of HAIs and mortality was 23.2 ($P<0.001$; 95% Confidence Interval: 12.5 – 43.2). The area under the ROC was calculated to be 0.995, while the Hosmer-Lemeshow statistic had a chi square value of 5.6 ($P=0.69$). HAI infection status, age, Charlson score, LOS, surgery, CVC use, mechanical ventilation, ICU stay, JCS levels 1~3 and JCS levels 10~30 were all positively associated with increased mortality.

Discussion

In this study, we identified HAI incidence in ischemic stroke patients from 36 Japanese hospitals, and conducted a multi-institutional analysis of the risk-adjusted economic and clinical outcomes associated with HAIs. Our data showed that 68% of the patients were alert upon admission, which was slightly less than the 74.8% reported in 2004 by Kimura *et al*[26].

The HAI incidence observed in our study (16.4%; range: 4.7-28.3%) was fairly similar to infection rates reported in other studies [3-9]. We also found significant increases in both overall hospital charges and LOS associated with HAIs. In order to verify the accuracy of our HAI identification method[20], we conducted a validation study using gastrectomy patients. HAIs identified by our method were compared with those identified by chart review. At the current sample size (n= 425), there is an 89% level of agreement of between the two methods, and Cohen's Kappa coefficient is 0.73, which is generally considered as having a "substantial agreement"[27]. Sensitivity and specificity are 0.86 and 0.91 respectively, showing a high level of accuracy in identification (unpublished data).

At the hospital level, we observed wide variation between healthcare institutions in both hospital charges and LOS. Hospitals such as H4 maintained a relatively low HAI incidence (8.3%), and also managed to control mean hospital charges for both uninfected and infected patients ($5,304 and $6,250, respectively). Hospital H4 also showed the lowest increase in LOS associated with HAIs at 5.1 days.

Hospital H32, on the other hand, had a low HAI incidence at 6.7%. Furthermore, HAIs were associated with an increase of only 13.6 days in LOS in this hospital. Despite this, mean hospital charges, while relatively low for uninfected patients ($4,922), was one of the most expensive for infected patients at $11,908. In comparison, Hospital H6 had a lengthy 21.2 days increase in LOS associated with HAI, but had the lowest hospital charges for both uninfected and infected patients ($3,824 and $5,438, respectively). Therefore, while the regression models show that LOS had the largest association with hospital charges, it is evident that other factors are also important.

Furthermore, in addition to having a high odds ratio associated with increased mortality, Hospital H28 was one of the most expensive hotels for both infected and uninfected patients, at $7,710 and $12,387 respectively. The mean age of the infected patients was 77 years in this hospital, while that of the uninfected was 70 years, and in general it was the older patients (aged greater than 85 years) that resulted in the longer LOS. This high representation of the elderly may explain the high values observed.

The mean hospital charges per day were found to be slightly higher in uninfected patients ($317 vs. $217). This could represent a possible loss of income to hospitals, as infected patients occupy bed-space that could potentially be offered to new patients. With an already lengthy LOS in Japanese acute care hospitals[24], the reduction of unnecessarily protracted LOS would be beneficial to an already strained healthcare system.

LOS has been an issue with Japanese acute care hospitals, and Japan has the longest mean LOS amongst the OECD countries[28]. However, this may be due in part to acute care hospitals in Japan frequently including rehabilitation and palliative care among the provided services. This mixture of acute, subacute and chronic healthcare provision may also explain the wide variations that we observed between hospitals in hospital charges, LOS and mortality

Dedicated stroke units are a rarity in Japan, despite strong recommendations for the use of such units in the treatment of acute stroke patients published in guidelines in 2004[29]. Most hospitals in Japan manage acute stroke patients in general medical wards, and when intensive care was required, these patients were treated in standard ICUs. Since the patients who have had a stint in the ICU would represent more severe cases who required ICU treatment in addition to baseline stroke treatment, it would therefore be unsurprising for ICU stay to have significant and strong associations with hospital charges, LOS and mortality, as shown in our regression models.

HAIs have previously been shown to have positive associations with mortality[30]. Our data corroborates these findings, although we observed a stronger association between HAI s and increased mortality. While the clinical complications associated with stroke have been previously looked at[2, 6], most of these studies focused on single-institution databases. The use of a multi-institutional database in this study helps to increase the generalizability of our results, as well as allow for the interpretation of the results from each individual hospital within the context of other hospitals. Downstream studies could include qualitative studies in which particular characteristics in hospitals with low HAI incidences are identified, as well as elucidating problem areas in hospitals with higher HAI incidences. In this way, the quality of HAI control measures may be increased. Furthermore, the approximate cost-effectiveness of subsequent interventions to reduce infections may benefit from the estimations provided in this study.

The limitations of this study are that the identification method used is unable to specify the types of infections that occurred; therefore the infections identified in this study would potentially include cases of severe pneumonia together with relatively milder infections. As there were no standard stroke severity scales like the Japan Stroke Scale or the NIH Stroke Scale, we were unable to adjust for severity directly, but instead had to use the Barthel index and JCS as approximate proxies. Also, our database did not include the duration after onset at the time of admission, which may have an effect on the results. A multicenter study in Japan conducted by Kimura *et al* has shown that almost 37% of patients were admitted within 3 hours of onset, and 73% within 24 hours[26]. However, due to database limitations, we were unable to include this variable in our analysis. Finally, the hospitals used in this study are voluntarily part of a program known as the Quality Indicator/Improvement Project, in which participating hospitals voluntarily provide data for analysis for the purpose of improving healthcare outcomes. As such, there may be some selection bias involved and the hospitals used in this study may not be indicative of all hospitals in Japan.

Summary

In this study, the use of risk adjustment allows for a more meaningful interpretation of the economic and clinical outcomes from a multi-center database. Quantification of the increases in resource utilization associated with HAIs allows for more precise policy making and planning for interventions.

Due to the use of hospital charges, the economic outcomes here may be interpreted as cost estimation from a 3rd party payer perspective, which in an insurance-centric healthcare payment system such as the one existing in Japan, may be highly useful.

With a rapidly aging population in Japan, diseases such as ischemic stroke that are usually associated with the aged will become more prominent. This study analyzes the incidence and impact of HAIs in stroke patients, and highlights the salient need for interventions for their reduction in Japanese hospitals. Possible interventions could include further hand hygiene practice, dedicated infection control staff, high-risk patient identification and promoting antimicrobial stewardship protocols.

References

1. Walker A, Robins M, Weinfeld F. Clinical findings: the National Survey of Stroke. Stroke 1981;12 (suppl 1):13-37

2. Silver F, Norris J, Lewis A, Hachinski V. Early mortality following stroke: a prospective review. Stroke 1984;15:492-496

3. Chevret S, Hemmer M, Carlet J, Langer M. Incidence and risk factors of pneumonia acquired in intensive care units: results from a multicenter prospective study on 996 patients: European Cooperative Group on Nosocomial Pneumonia. Intensive Care Med 1993; 19:256-264

4. Barsic B, Beus I, Marton E, Himbele J, Klinar I. Nosocomial infections in critically ill infectious disease patients: results of a 7-year focal surveillance. Infection 1999; 27:16-22

5. Yilmaz G, Cevik M, Erdinc FS, Ucler S, Tulek N. The risk factors for infections acquired by cerebral hemorrhage and cerebral infarct patients in a neurology intensive care unit in Turkey. Jpn J Inf Dis 2007; 60(23):87-91

6. Hilker R, Poetter C Findeisen N, et al. Nosocomial pneumonia after acute stroke – implications for neurological intensive care medicine. Stroke 2003;34:975-981

7. Upadya A, Thorevska N, Sena K, Manthous C, Amoateng-Adjepong Y Predictors and Consequences of pneumonia in critically ill patients with stroke. J Crit Care 2004;19(1):16-22

8. Hassan A, Khealani B, Shafqat S, et al. Stroke-associated pneumonia: microbiological data and outcome. Singapore Med J 2006;47(3):204-207

9. Ersoz M, Ulusoy H, Oktar M, Akyuz M. Urinary tract infection and bacteriurua in stroke patients: frequencies, pathogen, microorganisms, and risk factors. Am J Phys Med Rehabil 2007;86:734-41

10. Teramoto S, Ishii T, Yamamoto H, Yamaguchi Y and Ouchi Y. Nasogastric tube feeding is a cause of aspiration pneumonia in ventilated patients. Eur Respir J 2006;27:436-437.

11. Stott D, Falconer A, Miller H, Tilston J, Langhorne P. Urinary tract infection after stroke. QJM 2009;102(4):243-249

12. Hamidon B, Raymond A, Norlinah M, and Jefferelli S. The predictors of early infection after an acute ischaemic stroke. Singapore Med J 2003;44(7):344-346

13. Aslanyan S, Weir C, Diener H, Kaste M, and Lees K, GAIN International Steering Committee and Investigators. Pneumonia and urinary tract infection after acute ischaemic stroke: a tertiary analysis of the GAIN international trial. Eur J Neurol 2004;11(1):49-53

14. Charlson M, Pompei P, Ales K, MacKenzie C. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chron Dis 1987;40:373-383

15. Romano P, Roos L, Jollis J. Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: Differing perspectives. J Clin Epidemiol 1993;46:1075-1079

16. Ohta T, Waga S, Handa W, Saito I, Takeuchi K. New grading of level of disordered consciousness. No Shinkei Geka 1974;2(9):623-627

17. Ohta T, Kikuchi H, Hashi K, Kudo Y. Nizofenone administration in the acute stage following subarachnoid hemorrhage: Results of a multi-center controlled double-blind clinical study. Neurosurgery 1986: 64: 420-26

18. Stevenson KB, Khan Y, Dickman J, et al. Administrative coding data, compared with CDC/NHSN criteria, are poor indicators of health care-associated infections. Am J Infect Control 2008;36:155-64.

19. Sherman E, Heydon K, St John K, et al. Administrative data fail to accurately identify cases of healthcare-associated infection. Infect Control Hosp Epidemiol 2006;27:332-7

20. Lee J, Imanaka Y, Sekimoto M, et al. Risk-adjusted increases in medical resource utilization associated with healthcare-association infections in gastrectomy patients J Eval Clin Prac 2009 (in press)

21. Collin C, Wade D, Davies S and Horne V. The Barthel ADL Index: A reliability study. Intl Disab Studies 1988;10(2):61-63

22. Duan N. Smearing estimate: A nonparametric retransformation method. J Am Stat Assoc 1983;78:605-610

23. Evans E, Imanaka Y, Sekimoto M, et al. Risk adjusted resource utilization for AMI patients treated in Japanese hospitals. Health Econ 2007;16:347-59.

24. Organization of Economic Cooperation-Development (OECD). Main Economic Indicators: OECD; 2008

25. Hosmer D, Lemeshow S. A goodness-of-fit test for the multiple logistic regression model. Comm in Stats 1980; A10:1043-1069

26. Kimura K, Kazui S, Minematsu K, Yamaguchi T. Analysis of 16,922 patients with acute ischemic stroke and transient ischemic attack in Japan. Cerebrovasc Dis 2003; 18:47-56

27. Landis J, Koch. The measurement of observer agreement for categorical data. Biometrics 1977; 33: 378-82

28. Organization of Economic Cooperation-Development (OECD).Health data. Paris: OECD; 2003

29. Hasegawa Y, Yasui N, Hata T et al. Current status and problems of stroke unit care in Japan: A nation-wide survey. Japan Journal of Stroke 2006; 28(4): 545-49 (*in Japanese*)

30. Daud-Gallotti R, Novaes H, Lorenzi M, Eluf-Neto J, Okamura M, Velasco I. Adverse events and death in stroke patients admitted to the emergency department of a tertiary university hospital. Eur Jour Emer Med 2005;12(2):63-71

Table Legends

Table 1: Patient characteristics and pre-risk-adjusted total hospital charges and length of stay

Table 2: Results of multiple linear regression models with hospital charges and length of stay as dependent variables, and a logistic regression model using mortality as the dependent variable. Two multiple linear regression models for each dependent variable are shown, in which the first model included hospital stratification and the second model did not.

Figure Legends

Figure 1: Healthcare-associated infection incidence at hospital level and in total.

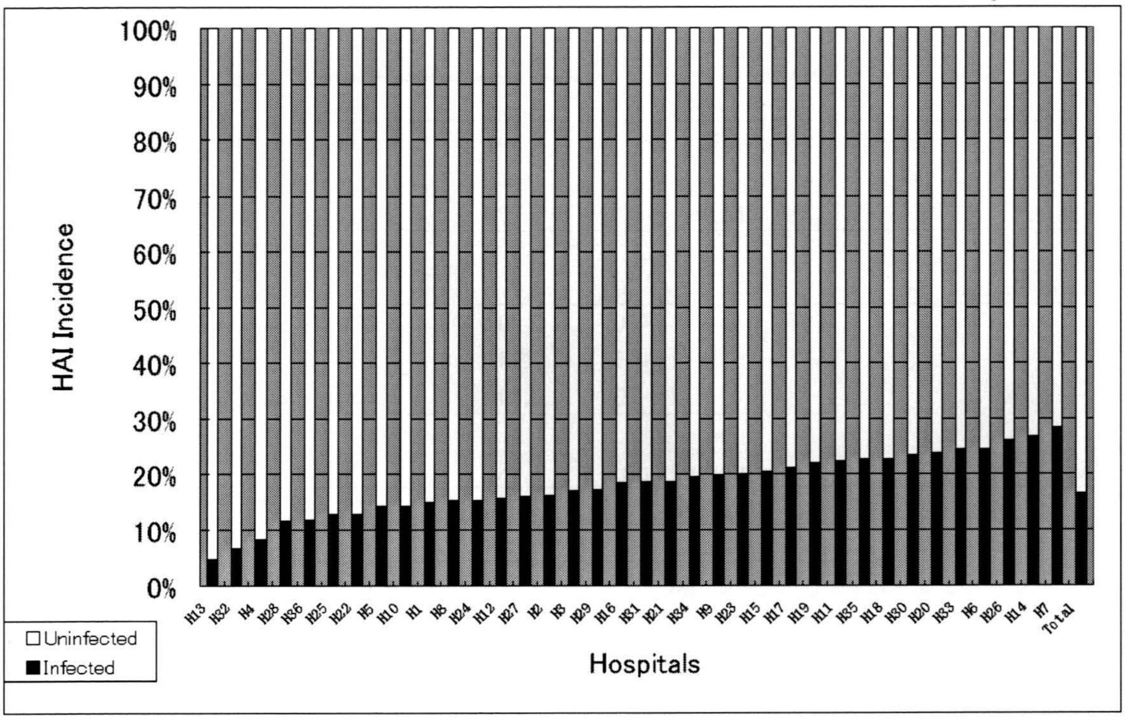
Figure 2: Box-plot graphs of risk-adjusted hospital charges per admission (in US$) and length of stay (in days) for infected and uninfected patients at the hospital level.

Acknowledgements & Funding Page

The authors are grateful to the staff at the hospitals that participated in the Quality Indicator/Improvement Project, and their generosity in allowing the use of their data.

This study was supported in part by a Health Sciences Research Grant from the Ministry of Health, Labour and Welfare of Japan, and a Grant-in-aid for Scientific Research from the Japan Society for the Promotion of Science.

Conflicts of Interest: None


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
HAI Incidence
H13 H32 H4 H28 H36 H25 H22 H5 H10 H1 H8 H24 H12 H27 H2 H3 H29 H16 H31 H21 H34 H9 H23 H15 H17 H19 H11 H35 H18 H30 H20 H33 H6 H26 H14 H7 Total
Hospitals
□Uninfected
■Infected

1

Patient Characteristics	N=8,861		
		N	%
Age	75 years and below	4,470	50.4
	Above 75 years	4,391	49.6
Gender	Male	5,170	58.3
Barthel Index	0	1,778	20.1
	1~10	2,002	22.6
	11~15	1,241	14.0
	16~20	3,840	43.3
Type of Stroke	Atherothrombotic	1,881	21.2
	Embolic	916	10.3
	Others	6,064	68.5
Japan Coma Scale	0	6,022	68.0
	1~3	2,102	23.7
	10~30	520	5.9
	100~300	217	2.4
Charlson Score	0	4,711	53.2
	>=1	4,150	46.8
Surgery Performed		270	3.0
CVC Utilization		189	2.1
Mechanical Ventilation		105	1.2
Dysphagia		555	6.3
ICU Stay		244	2.8
Total Hospital Charges (mean)			US$6,471
Length of Stay (mean)			21.97 days
Mortality		257	2.9

	Dependent Variable: Ln (Hospital Charges)			Dependent Variable: Ln (Hospital Charges)		
	R^2	0.764	***	R^2	0.711	***
Independent Variables	β	SE		β	SE	
Constant		0.018	***		0.015	***
Age > 75 years	-0.049	0.007	***	-0.050	0.007	***
Sex	-0.023	0.006	***	-0.019	0.007	**
Barthel Index	-0.070	0.001	***	-0.111	0.001	***
Atherothrombotic Stroke	0.049	0.009	***	0.028	0.008	***
Cardioembolic stroke	0.063	0.011	***	0.070	0.011	***
Charlson score	0.058	0.003	***	0.088	0.003	***
Length of Stay	0.781	0.000	***	0.748	0.000	***
Surgery	0.030	0.019	***	0.026	0.021	***
CVC use	0.021	0.029	**	0.006	0.032	
Mechanical Ventilation	0.035	0.029	***	0.033	0.032	***
Dysphagia	0.035	0.014	***	0.053	0.014	***
ICU stay	0.076	0.020	***	0.066	0.020	***
JCS Level 1-3 (Grade I)	0.033	0.009	***	0.048	0.010	***
JCS Level 10-30 (Grade II)	0.017	0.011	*	0.028	0.011	***
JCS Level 100-300 (Grade III)	-0.013	0.021	*	-0.011	0.023	
H1	-0.024	0.019	***			
H2	-0.016	0.024	**			
H3	0.005	0.028				
H4	-0.042	0.021	***			
H5	-0.083	0.021	***			
H6	0.011	0.049	*			
H7	-0.040	0.023	***			
H8	-0.023	0.031	***			
H9	-0.007	0.025				
H10	-0.002	0.037				
H11	-0.016	0.044	**			
H12	-0.012	0.026	*			
H13	-0.041	0.045	***			
H14	-0.003	0.019				
H15	-0.021	0.041	***			
H16	-0.008	0.069				
H17	-0.003	0.042				
H18	0.010	0.045				
H19	0.022	0.017	**			
H20	-0.079	0.019	***			
H21	0.018	0.024	**			
H22	0.004	0.019				
H23	-0.027	0.025	***			
H24	-0.006	0.024				
H25	-0.020	0.024	**			
H26	-0.025	0.024	***			
H27	0.010	0.027				
H28	0.044	0.016	***			
H29	0.130	0.014	***			
H30	-0.021	0.017	**			
H31	0.059	0.017	***			
H32	0.014	0.024	*			
H33	0.060	0.024	***			
H34	-0.065	0.019	***			
H35	-0.021	0.027	***			

	Dependent Variable: Ln (Length of Stay)			Dependent Variable: Ln (Length of Stay)		
	R^2	0.308	***	R^2	0.222	***
Independent Variables	β	SE		β	SE	
Constant		0.031	***		0.025	***
Age > 75 years	0.015	0.012		0.037	0.013	**
Sex	0.020	0.012	*	0.014	0.012	
Barthel Index	-0.291	0.001	***	-0.252	0.001	***
Atherothrombotic Stroke	0.039	0.017	**	-0.003	0.015	
Cardioembolic stroke	0.060	0.020	***	0.020	0.020	*
Charlson score	0.100	0.006	***	0.094	0.006	***
Surgery	0.096	0.034	***	0.099	0.035	***
CVC use	0.011	0.054		0.026	0.057	
Mechanical Ventilation	-0.022	0.055	*	-0.012	0.058	
Dysphagia	0.106	0.025	***	0.079	0.025	***
ICU stay	0.086	0.036	***	0.051	0.036	***
JCS Level 1-3 (Grade I)	0.111	0.017	***	0.104	0.017	***
JCS Level 10-30 (Grade II)	0.129	0.020	***	0.137	0.020	***
JCS Level 100-300 (Grade III)	0.046	0.041	***	0.050	0.043	***
H1	0.121	0.035	***			
H2	0.072	0.045	***			
H3	0.062	0.050	***			
H4	0.038	0.041	***			
H5	0.074	0.039	***			
H6	0.017	0.087				
H7	0.013	0.041				
H8	0.034	0.059	**			
H9	0.030	0.045	**			
H10	0.025	0.076	**			
H11	0.013	0.081				
H12	0.056	0.048	***			
H13	0.010	0.083				
H14	0.030	0.035	**			
H15	0.013	0.075				
H16	-0.006	0.126				
H17	0.009	0.082				
H18	-0.038	0.081	***			
H19	0.058	0.032	***			
H20	-0.059	0.034	***			
H21	0.018	0.044				
H22	-0.063	0.035	***			
H23	-0.020	0.046	*			
H24	0.043	0.045	***			
H25	0.023	0.043	*			
H26	0.043	0.044	***			
H27	-0.005	0.047				
H28	-0.096	0.029	***			
H29	-0.110	0.025	***			
H30	-0.061	0.030	***			
H31	0.004	0.032				
H32	-0.026	0.043	**			
H33	0.005	0.045				
H34	-0.084	0.034	***			
H35	0.023	0.052	*			

* Significance at $p < 0.05$; *** Significance at $p < 0.001$

AUROC: Area Under Receiver Operating Characteristic curve