本研究では、初回化療に選択されるレジメンは患者年齢との関連性を認めず、高齢者群でも若年者群と同等の割合でプラチナ・タキサンの薬剤が選択されていた。しかし、高齢者群に分割投与が多いという特徴が明らかになった。これは、これまでの報告同様に日本でも、高齢者に対し標準治療に従った化学療法を施行した時の有害事象の発生を医師が懸念したためであると考えられる。

本研究は化学療法の薬剤選択と投与法に施設間の大きなばらつきが存在することを示した。調査対象期間中、一貫して比較的高い割合でプラチナ・タキサン療法が施行されていたが、日本の卵巣癌ガイドライン策定後の症例で標準レジメンを使用する割合の増加は認められず、薬剤選択を始めとした治療パターンへのガイドラインの明らかなインパクトは認識できない。ガイドラインの広範囲な遵守はまだ達成できておらず、ガイドラインの認知と普及の促進へまだ余地が存在する。

手術の入院中に初回化療をせずに退院させる施設では、手術から初回化療までの期間が長くなる傾向であった。術後化学療法の遅延は予後の不良と関連することが知られているが、手術から化療までの適正な期間はまだ明らかでない。そのため、卵巣癌のガイドラインでは特別な期間の推奨はなく、手術から化療までの期間のばらつきは、ある意味自然な結果であるかも知れない。ガイドラインに十分な記載がある推奨度の高い事項でさえ本研究ではばらつきが明らかであり、記載されていない事項では適切な治療手順を確立するためのさらなる研究が必要である。

本研究の対象者の39%（73/209例）に入院中の化学療法の記録がなかった。この73例は、手術のみで治療が完結する症例であったり、術後の化学療法が外来で施行された症例であったり、何らかの理由で必要な化学療法が施行されなかった症例であったと考えられる。術後化学療法が省略できる卵巣癌症例は全体の約13%程度であり、患者の拒否や全身状態の悪化のため化学療法が行われない症例はおそらく少数であろうことから、73例の大部分は何らかの外来化学療法が行われていると考える。この外来化学療法のレジメン選択の結果は、本研究の結果に大きな影響を与えることが予想される。一般的にプラチナ・タキサン療法は数時間の点滴で終了し、大量の輸液を必要とするような治療レジメンに比べ、外来で管理しやすいレジメンである。外来化学療法を施行できる施設において、卵巣癌の治療レジメンがプラチナ・タキサン療法である可能性は高いと考えられ、そうであれば、全体の標準化学療法の施行割合は我々の研究結果より高くなる可能性がある。しかし、がん専門病院ではない施設が対象であることを考慮すると、標準レジメンではなく、単剤の抗がん剤による治療であったり、化療が行われなかったりする可能性も十分にありえ、その場合は、我々は標準化学療法の施行割合を高く見積もっている可能性もある。どちらの状況であるかを明確にすることは困難であり、本研究の限界である。また、解析によっては対象者がかなり減少し、結果をゆがめている可能性がある。また、利用したadministrative dataは癌の組織型の情報は含まず、患者の病期、併存症、入院後の合併症などの情報が完全には入力されていない場合もある。これらの情報は、標準化療以外のレジメンの使用に関連する可能性があるため、正確な結果を導くためにはデータベースの質を高める必要がある。またデータの提出が通年分でない施設も存在し情報バイアスが存在する可能性があるが、初回化学療法は手術から短期間で施行されることが多いため、その影響は比較的小さいと考える。

以上をまとめると、日本で治療された卵巣癌の初回化学療法のパターンにおいて、標準化学療法の施行割合は、全体では欧州の報告とほぼ同様であったが施設間で大きくばらついた。年齢に

よって薬剤の選択に差は認めなかったが、高齢者は分割投与法で治療されており、また分割投与は患者数の少ない施設で多く認められた。ガイドラインの発刊は化療選択のパターンに大きな影響を与えていないように思われ、卵巣癌の化学療法にはまだ標準化の余地があると考えられる。

Table 1. Patient characteristics by hospital

Hospital	A	B	C	D	E	F	G	All	p-value
No. of patients	25	13	8	35	28	42	58	209	
Age (yr), mean(SD)	58.0(12.6)	68.0(14.6)	63.4(14.4)	59.2(11.2)	58.2(11.8)	53.9(17.1)	57.5(16.5)	58.1(14.8)	0.10
Charlson score, mean(SD)	0.7(1.2)	2.2(2.7)	0.5(1.1)	1.3(1.6)	0.2(0.7)	0.3(0.8)	0.7(1.4)	0.8(1.4)	**<0.001**
In-patient chemotherapy	19(76%)	9(69%)	4(50%)	18(51%)	18(64%)	28(67%)	40(69%)	136(65%)	0.48
Regimen									
Platinum-taxane	19(100%)	7(78%)	4(100%)	17(94%)	10(56%)	9(32%)	35(87%)	101(74%)	**<0.001**
Platinum without taxane	0(0%)	1(11%)	0(0%)	1(6%)	6(33%)	15(54%)	2(5%)	25(19%)	
Non platinum	0(0%)	1(11%)	0(0%)	0(0%)	2(11%)	4(14%)	3(8%)	10(7%)	
Cases with TC therapy	14(74%)	7(78%)	3(75%)	17(94%)	6(33%)	9(32%)	35(88%)	91(67%)	**<0.001**
Initial chemotherapy in the same hospitalization with surgery (%)	9(64%)	0(0%)	3(100%)	13(76%)	4(67%)	7(78%)	30(86%)	66(73%)	**<0.001**
Dose									
Full(monthly TC*)	13(93%)	1(14%)	1(33%)	17(100%)	1(17%)	0(%)	26(74%)	59(65%)	**<0.001**
Divided(weekly TC*)	1(7%)	6(86%)	2(67%)	0(0%)	5(83%)	9(100%)	9(26%)	32(35%)	
Interval between surgery and chemotherapy in days, mean(SD)	22.5(14.0)	31.9(12.3)	14.0(1.0)	16.5(8.2)	17.0(5.4)	17.6(6.7)	17.9(7.9)	19.2(9.8)	**0.008**

*TC = Paclitaxel with carboplatin chemotherapy

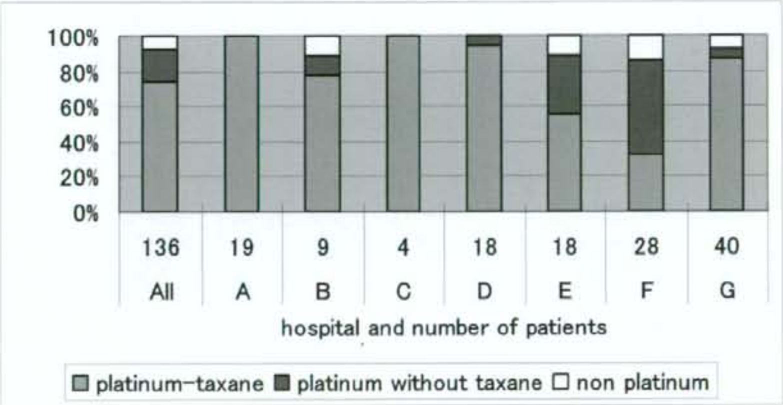
Table 2. Comparison of chemotherapy practice patterns by age group

Age group	<65 yrs	≥65 yrs	p-value
No. of patients	141	68	
Charlson score, mean(SD)	0.6(1.2)	1.1(1.7)	**0.019**
% receiving inpatient chemotherapy	65% (92/141)	65% (44/68)	0.939
Regimen			
Platinum-taxane	75% (69/92)	73% (32/44)	0.906
Platinum without taxane	17% (16/92)	20% (9/44)	
Non platinum	8% (7/92)	7% (3/44)	
Dosing schedule			
% receiving full-dose regimens (monthly)	68% (63/92)	43% (19/44)	**0.005**
% receiving divided regimens (weekly)	32% (29/92)	57% (25/44)	
Interval between surgery and chemotherapy in days, mean(SD)	16.8(9.2)	19.4(13.3)	0.198

Table 3. Impact of treatment guideline publication on chemotherapy practice patterns

Admission-year	< 2005	≥ 2005	p-value
No. of patients	56	153	
Age in years, mean(SD)	55.7(14.9)	59.0(14.7)	0.164
Charlson score, mean(SD)	0.5(1.1)	0.9(1.5)	0.092
% receiving inpatient chemotherapy	66% (37/56)	65% (99/153)	0.854
Regimen			
Platinum-taxane	70% (26/37)	76% (75/99)	0.510
Platinum without taxane	24% (9/37)	16% (16/99)	
Non platinum	6% (2/37)	8% (8/99)	
Dosing schedule			
% receiving full-dose regimens (monthly)	59% (22/37)	61% (60/99)	0.903
% receiving divided regimens (weekly)	41% (15/37)	39% (39/99)	
Interval between surgery and chemotherapy in days, mean(SD) chemotherapy in days, mean(SD)	15.5(9.0)	18.5(11.2)	0.159

Figure 1. Selection of chemotherapy regimens by hospital



B．　胃切除術における
病院感染による
患者リスク調整コスト増加分の検討

Risk-adjusted increases in medical resource utilization associated with healthcare-acquired infections in gastrectomy patients

Summary

Rationale, aims and objectives: Quantifying the impact of healthcare-acquired infections (HAIs) on medical resource utilization is necessary for payers and providers to appropriately allocate limited resources for interventions. However, previous studies tend to involve single institutions and do not take into account patient and practice variations between several hospitals. The objective of this study was to conduct a multi-institutional risk-adjusted comparison of HAI-associated impact on medical resources in gastrectomy patients in Japan.

Methods: HAIs were identified using a combination of ICD10 codes and antibiotic utilization patterns in 1,058 gastrectomy patients from 10 Japanese hospitals. Multiple linear regression models and risk-adjustment were used to analyze the impact of HAIs on 1) total hospital costs, 2) antibiotic costs, and 3) post-surgical length of stay (LOS).

Results: Overall HAI incidence for the database was 20.3%, with a range of 8.8% to 29.6% amongst the 10 hospitals. Regression models showed that HAIs were significantly associated with increases in all 3 indicators. Risk-adjusted comparisons revealed that HAIs were associated with an increase of US$2,767 (Range: US$1,035-US$6,513) in overall hospital cost, US$202 (US$98.8-US$764.6) antibiotic costs and 10.6 (4.7-24 days) post-surgical LOS days.

Conclusions: Even after adjusting for patient characteristics and other variables, there was still a high degree of variation observed in the impact of HAIs on total hospital costs and antibiotic costs from a 3rd party payer's perspective and post-surgical LOS amongst the 10 hospitals. This information can increase the efficiency of allocation of resources for interventions to reduce HAIs.

Introduction

The control of healthcare-acquired infections (HAIs) is a particularly important yet elusive goal for increasing the quality of healthcare. In addition to decreased quality of life[1, 2] and increased morbidity and mortality[3], HAIs represent potentially preventable increases in medical resource utilization[4-7]. These increases in resource utilization must first be quantified in order for providers and payers to decide how to appropriately allocate limited resources for preventive measures.

While studies that estimate the impact of HAIs on resource utilization generally involve data from one or two hospitals[8-12], a multi-institutional comparison would provide a wider contextual backdrop in which to interpret the results of each hospital. However, risk-adjustments must first be conducted in order to account for practice variations and patient characteristics before meaningful comparisons can be made. To the best of our knowledge, there is no current risk-adjusted multi-institutional comparison of the impact of HAIs on medical resource utilization in a Japanese setting.

The aforementioned studies generally involved chart reviews[8, 9] or prospective studies[10-12]. However, these methods are extremely labor-intensive and tend to be self-limiting in terms of population sample size and study period duration. An alternative approach is the use of reimbursement data or administrative data, which provides a standardized and detailed database that can be used for multi-institution comparative studies. The hospital payment system in Japan uses an identical reimbursement schedule for all acute-care hospitals, and it is required for hospitals to produce data in similar formats. Therefore, this data is easily obtained, analyzed and used to compare multiple institutions in a Japanese setting.

Infection identification using administrative data can be conducted by the use of International Classification of Diseases (ICD) codes. However, the use of these codes alone to identify HAIs has been found to have poor identification capability[13, 14]. In order to improve identification capability, we chose to complement ICD code-based identification with the use of antibiotic utilization patterns as a clinically relevant indicator of infection incidence.

The objective of this study was to quantify increases in medical resource utilization associated with infections in gastrectomy patients from several Japanese hospitals, and conduct a risk-adjusted comparison of performance between the hospitals.

Methods

1. Patient Selection:

Patient information was obtained from hospitals enrolled in the Quality Indicator/Improvement Project (QIP), a database of 16 Japanese hospitals (at the time of study) that consists of clinical and claims data on discharged patients. We selected patients with gastric cancer who were hospitalized for the purpose of gastrectomy as our target population as gastric cancer occurs with very high incidence in Japan[15]. By focusing on patients who had only undergone gastrectomies, we reduced the intrinsic variation associated with procedural differences.

Data was obtained on patients who were admitted from April 2004 to January 2007. Total and subtotal gastrectomies for gastric cancer performed were identified using the Diagnostic Procedure Combination (DPC) coding system for reimbursement, a national fee schedule introduced into Japan in 2003. The sampled hospitals had a bed size ranging from 280 to 1106 beds, with a mean of 561 beds. Patients were excluded if they fulfilled any of the following criteria: (1) Patients who had died during admission; (2) Patients who were given antibiotics prior to the day that gastrectomy was performed; (3) Patients who had other surgeries prior to gastrectomy; (4) Patients admitted directly from the emergency ward; (5) Patients with missing data with regards to antibiotic payments and anesthesia time. Finally, hospitals with fewer than 30 cases were excluded from analysis.

Clinical diagnoses were conducted using ICD10 (10th revision of ICD codes). Pre-existing comorbidity conditions were analyzed using the Charlson comorbidity index (Dartmouth-Manitoba version)[16,17].

2. Identification of post-surgical HAI

Antibiotic utilization patterns were discerned using daily drug claims data, which allowed us to identify antibiotic administration, type of antibiotic, and dosage on a day-to-day basis. We used antibiotic utilization patterns that would not occur in the simple pre-surgical prophylaxis observed in uninfected patients. Patients were deemed to have HAIs if they fell into any of the following categories: (1) Post-admission complications with ICD10 codes indicating HAI, adapted from the Pennsylvania Health

Care Cost Containment Council (PHC4)[18]; (2) The use of 3 or more different types of antibiotics during their hospital stay; (3) The use of 2 types of antibiotics in which a 2nd antibiotic type was added or changed midway through the course; (4) >1 day of antibiotics given in a separate time-frame in which no surgery was conducted; (5) The use of > 3 days of antibiotics starting from the day of surgery. The final sample size (N) used for analysis was 1,058 patients from 10 hospitals.

3. Resource Utilization Indicators:

Total hospital costs and antibiotic costs from a 3rd party payer's perspective, as well as post-surgical length of stay (LOS) were used as indicators of medical resource utilization.

4. Statistical Analysis:

Analyses were performed using Dr. SPSS VER. II 11.0.1J; *P*-values reported were two-tailed and the level of significance was set at $P < 0.05$. Multiple linear regression models were developed to estimate the impact of HAIs on medical resource utilization. Total hospital costs, antibiotic costs and post-surgical LOS were natural logarithm transformed before being used as dependent variables in the regression models. The independent variables used were age (equal to and above 70 yrs), gender, post-surgical infection, comorbidities, pre-surgical LOS, type of gastrectomy (total or partial), number of surgeries, surgery duration, and hospital stratification. Seventy years of age was selected as preliminary analysis showed that that the proportions of patients above and below this age were approximately equal, and univariate analysis showed highly significant association with HAI presence/absence (data not shown). Anesthesia time (minutes) was used as a proxy indicator for surgery duration.

Hierarchal regression models were developed, with covariates grouped into patient characteristics, comorbidities and surgery-associated factors. The first model for each dependent variable excluded the use of hospitals as dummy variables, while the second model included hospital stratification. Risk-adjusted values were obtained using the first regression models as described above, but with hospital stratification and post-surgical infection status excluded as variables. These regression models were then used to produce predicted values for each of the 3 medical resource utilization indicators. As the dependent variables were logarithmic transformed before analysis, the exponentials of the predicted values were calculated in order to obtain expected values with units of Japanese Yen and days. Duan's smearing coefficient[19, 20] was applied to correct for retransformation bias. Risk adjustment was conducted by dividing each hospital's mean observed value (O) by the mean expected value (E), and multiplying the result by the mean value of the entire dataset. Final estimates were adjusted for inflation using the Japanese consumer price index (to adjust all values to the 2007 yen value) and then converted to US dollars using Purchasing Power Parities (JPN 100 Yen = US$0.85; April 2007)[21].

Results

The distribution of patient characteristics and gastrectomy type are presented in Table 1. The population was skewed towards an older patient population, with 47.9% of the subjects equal or over 70 years of age. 9.7% of the study population suffered from diabetes, and 9.5% exhibited metastatic cancer. There were more patients (64.2%) who underwent subtotal gastrectomies than those who underwent total gastrectomies.

Figure 1 shows HAI incidence in total and at the hospital level. In general, there was an infection incidence of 20.3% (215 cases) in our sample population, and a range from 8.8% (Hospital A) to 29.6% (Hospital E). A breakdown of infection cases by identification method shows that the use of ICD10 codes resulted in 85 cases (8.03%) identified. 72 of these cases were also identified by antibiotic utilization. Of the cases identified by ICD codes, 70% were "unspecified infections following a procedure", 20% were specified as "surgical site infections" (SSI), and the remaining 10% consisted of unspecified pneumonia, septicemia n¥and urinary tract infections (UTI). There were an additional 130 patients identified by antibiotic utilization alone. Furthermore, while "the use of > 3 days of antibiotics starting from the day of surgery" was included as a criterion for infection identification, all of the cases that were identified as infected patients by this particular criterion were also identified by at least one of the other 4 criteria.

The regression models used are shown in Table 2. Cases with post-surgical HAIs showed highly significant association in all 3 indicators of increased medical resource utilization ($P < 0.001$) in all of the 6 models constructed.

The first regression model constructed was able to account for 60.7% of variation observed in total hospital costs. With hospital stratification, the model accounted for 64.3% of variation. Age and all surgery-associated factors were significantly associated with total hospital costs, while gender was not. Congestive heart failure was the only comorbid condition that was consistently significant in both models for total hospital costs, and diabetes showed significance when hospital stratification was included in analysis.

In the case of antibiotic costs, the regression model was able to account for 34.9% of variation observed, and 66.3% with hospital stratification included. Age and gender were not significant with antibiotic costs in both models. When hospitals were not included in analysis, pre-surgical LOS and gastrectomy type were significantly associated with antibiotic costs. When hospitals were included, only gastrectomy type remained significant, and surgery duration gained significance.

The regression models developed were able to account for 28.2% of variations in post-surgical LOS, and 32.2% after taking into account hospital stratification. Age showed significant association in both models, while gender showed association only when hospitals were not included in analysis. The only comorbid condition significantly associated with post-surgical LOS was diabetes with complications in the first model. Furthermore, pre-surgical LOS, gastrectomy type, and number of surgeries were significant factors associated with post-surgical LOS.

The risk-adjusted differences for all 3 medical resource utilization indicators between infected and uninfected patients at hospital level were shown in Table 3. Risk adjustment resulted in reducing the variation between infected and uninfected patients. Infected patients showed a risk-adjusted increase in US$2,767, or approximately 24% for total hospital costs (and a pre-adjusted increase of US$4,423.4). At the hospital level, there was a range of adjusted infection-based increases in total hospital costs from US$1,035 (Hospital C) to US$6,513 (Hospital A). In general, infections were associated with an increase in US$202.4 in mean antibiotic costs. Prior to adjustment, the difference in antibiotic costs between infected and uninfected patients was US$235. Hospital E showed the least amount of increase at a risk-adjusted mean of US$98.8. The highest increase in antibiotic costs as a result of infections was seen in Hospital A, at US$764.6. In addition, hospitals B, E and F presented very low antibiotic costs for their respective uninfected populations, at less than US$15.

Hospital stay was extended by an adjusted average of 10.6 days post-surgery, as a result of infection. While most hospitals managed to control the extended LOS to approximately 10 days or less, Hospitals A and G large increases of 24 days and 20.7 days, respectively. Hospital B showed the lowest increase in mean post-surgical LOS in infected patients at only 4.7 days.

Discussion

In this study, we used a combination of ICD codes and antibiotic utilization patterns in order to identify HAIs in gastrectomy surgery patients admitted into 10 hospitals in Japan. Regression analysis was conducted to estimate the impact of medical resource utilization increases involved with infections, with resource utilization measured in 3 indicators – total hospital costs, antibiotic costs and post-surgical LOS. Finally, we conducted risk-adjusted performance comparisons within the 10 hospitals.

Previous studies have shown that the use of ICD codes to identify HAIs has poor sensitivity and positive predictive value[13, 14]. Furthermore, using claims data alone to derive secondary diagnoses has been found to lack distinguishing ability between pre-existing conditions and conditions that occur post-admission[22]. In response to these issues, we complemented ICD code identification with antibiotic utilization data and adjusted selection criteria to reduce misidentification of pre-existing conditions. The use of ICD codes alone would have resulted in an infection incidence of approximately 8%. ICD codes alone may have been limited to the more serious infections, while antibiotic utilization allowed us to include less severe infections in our calculations that were not reflected in ICD codes..

Evidence-based medicine supports that even with gastrectomy surgeries, a single dose of cefazolin before surgery is sufficient prophylaxis[23, 24]. However, the Japanese Society for Chemotherapy produced guidelines that recommended 3-4 days of prophylaxis for clean-contaminated surgeries such as gastrectomy. Furthermore, a previous study[25] showed that the mean prophylaxis given to gastrectomy patients was approximately 3-4 days. Taking this into account, we adjusted for this over-utilization of antibiotics by allowing for a 3-day prophylactic period post-surgery, and identifying cases with 4 or more days of antibiotic utilization as infections. The failure to do so may have resulted in mistakenly identifying antibiotic over-utilization as infections. However, there would be an uncertainty as to the validity of cases identified as infected by this criterion alone, as cases with 4 or more days of antibiotic utilization may simply represent antibiotic administration practice variation. Despite this, all cases that were identified by this criterion were further confirmed by at least one other identification criteria. A previous study of a single hospital in Japan showed a 13.8% incidence of SSIs associated with gastrectomy[26], while the sample population here presented a 20.3% incidence proportion of infections that included other infections in addition to SSIs, such as bloodstream infections and pneumonia.

In all six regression models that we used, post-surgical HAIs were significantly associated with increases in total hospital costs, antibiotic costs and post-surgical LOS. Amongst the independent variables, comparisons of standardized coefficients (Table 2) showed that HAIs had the third highest magnitude of impact on total hospital costs (after type of gastrectomy and pre-surgical LOS), and the highest magnitude of impact on antibiotic costs and post-surgical LOS. Total hospital costs and post-surgical LOS were sensitive to all surgery-associated factors, but antibiotic costs were unsurprisingly less sensitive to this group of variables. Post-surgical LOS showed significant associations with both age and gender, with elderly ($\geq$ 70 years) male patients associated with longer hospital stays. This was consistent with previous studies that showed longer LOS periods associated with elderly[27] and male patients[28]. The problems of increases in post-surgical LOS associated with HAIs are further exacerbated by the already-lengthy hospital stay durations in Japan[29].

Pre-existing comorbid conditions did not seem to show consistent or strong influences on increases in medical resource utilization based on our models, which may be due to the low volume of cases with comorbidity scores. The 2 most common comorbidities (that occurred in approximately 10% of the dataset population) were diabetes and metastatic cancer, which showed significant association with total hospital costs and antibiotic costs, respectively.

Even after risk-adjustment, we observed large degrees of variation in HAI-associated increases in all 3 indicators. The difference between mean total hospital costs uninfected and infected patients ranged as much as from US$1,035 in Hospital C to US$6,513 in Hospital A. Hospital A had approximately 2.4 times the overall mean of increased total hospital costs associated with HAI, and had the largest observed difference between infected and uninfected patients with regards to post-surgical LOS. A more detailed inspection of the cases in hospital A revealed that 2 of the 5 had MRSA infections, which may have accounted for the increased medical resource utilization reflected. The overall risk-adjusted mean of increased antibiotic costs associated with HAIs was US$202. Table 2 showed that the R^2 value for the regression model using antibiotic costs as the dependent variable that had included hospital stratification was much higher than that of the model that did not. Furthermore, when hospital stratification was included in analysis, most of the hospitals showed significant association, implying high variation in antibiotic use at the hospital level. Hospital B showed the lowest adjusted antibiotic costs for uninfected patients at US$8.9, while hospitals E and F also had very low values in this category. An analysis of the cases in these hospitals revealed that all uninfected cases were given the appropriate 1-day only prophylaxis method as prescribed by evidence-based medicine. In addition to these laudable achievements, Hospitals B and E managed to control the increase in antibiotic costs in infected patients to US$99 and US$105, respectively. Increases in antibiotic costs in Hospital F were closer to the overall average at US$198. This could imply that there may be stringent antibiotic utilization guidelines in place at Hospitals B and E, and that they are strictly adhered to even in infected cases. The other 7 hospitals had higher adjusted antibiotic costs in their uninfected cases, and an analysis of these hospitals showed that the majority of cases were given approximately 2-3 days of prophylaxis. This unfavorable utilization rates for uninfected cases reflected the results reported previously[25], and resulted in unnecessary cost as well as increase the risk of developing resistant bacteria.

With regards to limitations of this study, the sampled hospitals were part of a database known as the Quality Indicator/Improvement Project. These hospitals had voluntarily entered this project in order to improve healthcare quality and management, and as such, may not represent the general situation of hospitals in Japan. Therefore, there may be a degree of selection bias and resulting generalizability issues.

We believe the method presented here can be similarly applied to analyzing patients with other diseases and procedures. We have used this technique to quantify the increases in medical resource utilization associated with post-surgical HAIs, and also shown that even after adjusting for variations in patient characteristics and other variables, a large degree of variation still exists between hospitals in terms of resource utilization. In this study we observed both good performers in terms of controlling infection incidence and the resulting resource utilization, as well as hospitals that did not perform as well. The results of this study were reported back to the participating hospitals in order to commend and encourage further good practice in good performers, as well as to bring attention to problem areas in the other hospitals. This information is highly useful for the hospitals involved as they represent not only information about their own hospitals, but provide a context of other hospitals in which to compare their own performance.

Acknowledgements

This study was supported in part by the Grant-in-aid for Scientific Research from the Ministry of Education, Culture, Sports, Science and Technology of Japan, and the Health Sciences Research Grants for the Research on Policy Planning and Evaluation from the Ministry of Health, Labor and Welfare of Japan. The authors are grateful to the staff at the sixteen hospitals that participated in the Quality Indicator/Improvement Project: Aizawa Hospital, Iizuka Hospital, Kameda Medical Center, Kawakita General Hospital, Keijinkai Hospital, Keiju Medical Center, Kurashiki Central Hospital, Nakagami Hospital, Nakano General Hospital, Nikko Memorial Hospital, Omura Municipal Hospital, Saitama Cooperative Hospital, Seirei Hamamatsu General Hospital, Takeda General Hospital, Teishinkai Hospital, and Urasoe Sogo Hospital.

References

1. Whitehouse JD, Friedman ND, Kirkland KB, Richardson WJ, Sexton DJ. (2002) The impact of surgical-site infections following orthopedic surgery at a community hospital and a university hospital: adverse quality of life, excess length of stay, and extra cost. *Infection Control and Hospital Epidemiology*. 23:183-9.

2. Davey P, Hernanz C, Lynch W, Malek M, Byrne D. (1991) Human and non-financial costs of hospital-acquired infection. *Journal of Hospital Infection*.18 Suppl A: 79-84.

3. Klevens RM, Edwards JR, Richards CL Jr, Horan TC, Gaynes RP, Pollock DA, et al. (2007) Estimating health care-associated infections and deaths in U.S. hospitals, 2002. *Public Health Reports*. 122:160-6.

4. Mahieu LM, Buitenweg N, Beutels P, De Dooy JJ. (2001) Additional hospital stay and charges due to hospital-acquired infections in a neonatal intensive care unit. *Journal of Hospital Infection*. 47:223-9.

5. Song X, Srinivasan A, Plaut D, Perl TM. (2003) Effect of nosocomial vancomycin-resistant enterococcal bacteremia on mortality, length of stay, and costs. *Infection Control and Hospital Epidemiology*. 24:251-6.

6. Thompson DA, Makary MA, Dorman T, Pronovost PJ. (2006) Clinical and economic outcomes of hospital acquired pneumonia in intra-abdominal surgery patients. *Annals of Surgery*. 243:547-52.

7. Shorr AF, Tabak YP, Killian AD, Gupta V, Liu LZ, Kollef MH. (2006) Healthcare-associated bloodstream infection: A distinct entity? Insights from a large U.S. database. *Critical Care Medicine*. 34:2588-95.

8. Halasa NB, Williams JV, Wilson GJ, Walsh WF, Schaffner W, Wright PF. (2005) Medical and

economic impact of a respiratory syncytial virus outbreak in a neonatal intensive care unit. *The Pediatric Infectious Disease Journal* 24:1040-4.

9. Yamashita S, Yamaguchi H, Sakaguchi M, Satsumae T, Yamamoto S, Shinya F. (2000) Longer-term diabetic patients have a more frequent incidence of nosocomial infections after elective gastrectomy. *Anesthesia & Analgesia*. 91:1176-81.

10. Herwaldt LA, Cullen JJ, Scholz D, French P, Zimmerman MB, Pfaller MA et al. (2006) A prospective study of outcomes, healthcare resource utilization, and costs associated with postoperative nosocomial infections. *Infection Control and Hospital Epidemiology* .27:1291-8.

11. Dominguez TE, Chalom R, Costarino AT Jr. (2001) The impact of adverse patient occurrences on hospital costs in the pediatric intensive care unit. *Critical Care Medicine*. 2001;29:169-74.

12. Coskun D, Aytac J, Aydinli A, Bayer A. (2005) Mortality rate, length of stay and extra cost of sternal surgical site infections following coronary artery bypass grafting in a private medical centre in Turkey. *Journal of Hospital Infection*. 60:176-9.

13. Stevenson KB, Khan Y, Dickman J, Gillenwater T, Kulich P, Myers C et al. (2008) Administrative coding data, compared with CDC/NHSN criteria, are poor indicators of health care-associated infections. *American Journal of Infection Control*. 36:155-64.

14. Sherman ER, Heydon KH, St John KH, Teszner E, Rettig SL, Alexander SK et al. (2006) Administrative data fail to accurately identify cases of healthcare-associated infection. *Infection Control and Hospital Epidemiology* 27:332-7

15. Center for Cancer Control and Information Services, National Cancer Center, Japan. Cancer Statistics in Japan '07. http://ganjoho.ncc.go.jp/public/statistics/backnumber/odjrh3000000o8is-att/FIG04.PDF Accessed: 2 April 2008.

16. Sundararajan V, Henderson T, Perry C, Muggivan A, Quan H, Ghali WA. (2004) New ICD-10 version of the Charlson comorbidity index predicted in-hospital mortality. *Journal of Clinical Epidemiology*. 57:1288-94.

17. Luthi JC, Troillet N, Eisenring MC, Sax H, Burnand B, Quan H et al. (2007) Administrative data outperformed single-day chart review for comorbidity measure. *International Journal of Quality in Health Care*. 19:225-31.

18. Pennsylvania Health Care Costs Containment Council. (PHC4) Available at http://www.phc4.org/ Accessed February 10, 2008.

19. Duan N. (1983) Smearing estimate: A nonparametric retransformation method. *Journal of the American Statistical Association* 78:605-610

20. Evans E, Imanaka Y, Sekimoto M, Ishizaki T, Hayashida K, Fukuda H et al. (2007) Risk adjusted resource utilization for AMI patients treated in Japanese hospitals. *Health Economics*.16:347-59.

21. OECD statistics on Purchasing Power Parities (PPP): comparative price levels. http://www.oecd/org/dataoecd/48/18/18598721.pdf Accessed: 7 March 2008.

22. Naessens JM, Campbell CR, Berg B, Williams AR, Culbertson R. (2007) Impact of diagnosis-timing indicators on measures of safety, comorbidity and case mix groupings from administrative data sources. *Medical Care*. 2007;45:781-8

23. Page CP, Bohnen JM, Fletcher JR, McManus AT, Solomkin JS, Wittmann DH. (1993) Antimicrobial prophylaxis for surgical wounds. Guidelines for clinical care. *Archives of Surgery*

128:79-88

24. The Medical Letter Consultants. (1992) Antimicrobial prophylaxis in surgery. *The Medical Letter on Drugs and Therapeutics*. 34:5-8

25. Sekimoto M, Imanaka Y, Evans E, Ishizaki T, Hirose M, Hayashida K et al. (2004) Practice variation in perioperative antibiotic use in Japan. *International Journal for Quality in Health Care*. 16:367-73

26. Imai E, Ueda M, Kanao K, Miyaki K, Kubota T, Kitajima M. (2005) Surgical site infection surveillance after open gastrectomy and risk factors for surgical site infection. *Journal of Infection and Chemotherapy* 11:141-5

27. Takahashi R, Okugawa S, Matsushita S. Long-term hospitalization of elderly patients in a regional hospital. (1993) *Nippon Ronen Igakkai Zasshi* 30:301-7 In Japanese

28. Yang X, Imai H. (2003) Transition of the average length of stay in a university hospital – II. Comparison between the genders and age groups. *Hospital Administration* Vol 40 (4) 345-55

29. Ministry of Health, Labor and Welfare. (2002) Medical Institution Survey. Japan *In Japanese*

Table 1: Distribution of patients, patient characteristics and type of gastrectomy by hospital and in total

Hospital	A	B	C	D	E	F	G	H	I	J	Total	%
N	57	31	85	222	81	37	93	220	159	73	1058	100
Patient Characteristics												
Female	16	8	30	61	28	12	31	74	59	24	343	32.4
Age ≥ 70 yrs	24	16	52	102	41	15	30	102	92	33	507	47.9
Acute Myocardial Infarction	2	0	1	0	4	0	1	2	5	0	15	1.4
Congestive Heart Failure	0	1	0	0	1	1	0	0	4	0	7	0.7
Peripheral Vascular Disease	1	0	0	1	0	0	0	1	0	1	4	0.4
Cerebral Vascular Disease	3	1	3	7	7	0	3	3	6	2	35	3.3
Pulmonary Disease	2	1	4	13	3	1	1	6	8	1	40	3.8
Peptic Ulcer	3	2	8	7	2	1	0	9	13	9	54	5.1
Liver Disease	0	0	0	3	1	0	0	1	1	0	6	0.6
Diabetes	10	4	10	30	3	2	4	16	21	3	103	9.7
Diabetes w/ Complications	0	1	0	1	7	0	0	1	2	0	12	1.1
Renal Disease	2	0	0	2	1	0	2	1	7	1	16	1.5
Metastatic Cancer	8	3	5	15	1	13	1	38	12	4	100	9.5
Gastrectomy Type												
Subtotal	37	19	42	153	54	23	69	148	99	35	679	64.2

Table 2: Regression models showing association between Patient Characteristics, Comorbid Conditions, Surgery Associated Factors and Hospital Stratification on Total Hospital Costs, Antibiotic Costs, and Post-surgical Length of Stay. Beta refers to standardized coefficients and B refers to unstandardized coefficients.

Models	Total Hospital Costs 1			Total Hospital Costs 2			Antibiotic Costs 1			Antibiotic Costs 2			Post-surgical length of stay 1			Post-surgical length of stay 2		
R^2	0.607			0.643			0.349			0.661			0.282			0.322		
	Beta	B	*P*-value	Beta	B	*P*-value	Beta	B	*P*-value	Beta	B	*P*-value	Beta	B	P-value	Beta	B	P-value
Patient Characteristics																		
Age (≥70 years)	0.061	0.032	0.002	0.064	0.034	0.001	0.009	0.023	0.713	0.008	0.020	0.662	0.083	0.078	0.002	0.072	0.068	0.007
Gender	0.006	0.003	0.779	-0.002	-0.001	0.929	-0.015	-0.039	0.546	-0.004	-0.010	0.835	0.053	0.053	0.049	0.045	0.046	0.084
Post-surgical infection	0.325	0.216	>0.001	0.315	0.209	>0.001	0.580	1.716	>0.001	0.593	1.755	>0.001	0.404	0.473	>0.001	0.401	0.469	>0.001
Comorbid Conditions																		
Acute myocardial infarction	0.022	0.050	0.252	0.010	0.022	0.597	-0.050	-0.502	0.047	-0.023	-0.232	0.208	0.025	0.099	0.343	0.013	0.051	0.619
Congestive heart failure	0.057	0.189	0.004	0.055	0.182	0.004	-0.027	-0.397	0.286	0.021	0.311	0.253	0.047	0.276	0.075	0.043	0.247	0.103
Peripheral vascular disease	-0.008	-0.035	0.679	-0.007	-0.029	0.720	0.013	0.256	0.596	0.014	0.280	0.425	0.009	0.072	0.719	0.013	0.099	0.614
Cerebral vascular accident	0.014	0.022	0.462	0.008	0.011	0.682	0.000	0.003	0.984	0.016	0.105	0.389	-0.004	-0.010	0.882	-0.009	-0.025	0.716
Pulmonary disease	-0.023	-0.032	0.246	-0.014	-0.020	0.447	0.013	0.081	0.606	0.000	-0.002	0.986	0.005	0.013	0.842	0.009	0.022	0.724
Peptic ulcer	-0.002	-0.003	0.905	0.000	0.000	0.988	-0.034	-0.181	0.184	-0.024	-0.127	0.202	-0.004	-0.009	0.881	-0.006	-0.014	0.808
Liver disease	0.016	0.056	0.420	0.021	0.075	0.254	0.002	0.033	0.933	-0.002	-0.024	0.933	0.021	0.132	0.423	0.023	0.141	0.378
Diabetes	0.024	0.021	0.228	0.037	0.034	0.046	0.020	0.079	0.436	0.000	-0.001	0.989	0.026	0.042	0.318	0.034	0.054	0.187
Diabetes w/complications	0.035	0.089	0.073	0.024	0.061	0.206	-0.021	-0.234	0.410	0.034	0.387	0.064	0.060	0.265	0.024	0.038	0.168	0.151
Renal disease	0.032	0.071	0.097	0.025	0.054	0.191	-0.046	-0.453	0.065	-0.043	-0.418	0.019	0.012	0.045	0.658	0.007	0.025	0.799
Metastatic cancer	0.007	0.006	0.723	0.036	0.033	0.064	0.036	0.145	0.164	0.051	0.209	0.007	0.010	0.016	0.718	0.031	0.050	0.243
Surgery Associated Factors																		
Pre-surgical LOS	0.333	0.019	>0.001	0.325	0.019	>0.001	0.069	0.018	0.006	-0.026	-0.007	0.175	0.090	0.009	0.001	0.065	0.006	0.018
Gastrectomy Type	0.359	0.200	>0.001	0.352	0.196	>0.001	0.061	0.152	0.020	0.058	0.145	0.003	0.144	0.142	>0.001	0.132	0.129	>0.001
No. of Surgeries	0.194	0.071	>0.001	0.221	0.081	>0.001	-0.039	-0.064	0.144	0.031	0.051	0.154	0.070	0.046	0.012	0.121	0.079	>0.001
Surgery duration	0.148	0.000	>0.001	0.136	0.000	>0.001	0.010	0.000	0.707	0.043	0.001	0.040	0.091	0.000	0.001	0.070	0.000	0.018
Hospitals																		
B				0.023	0.036	0.316				-0.255	-1.801	>0.001				0.118	0.329	>0.001
C				0.030	0.029	0.309				0.218	0.954	>0.001				0.058	0.100	0.153
D				-0.075	-0.049	0.043				0.256	0.749	>0.001				-0.016	-0.018	0.758
E				0.067	0.067	0.019				-0.161	-0.719	>0.001				0.119	0.211	0.002
F				-0.068	-0.099	0.006				-0.212	-1.372	>0.001				-0.103	-0.265	0.003
G				0.137	0.129	>0.001				0.126	0.529	>0.001				0.069	0.115	0.082
H				-0.014	-0.009	0.700				0.238	0.698	>0.001				0.096	0.111	0.057
I				0.050	0.038	0.139				0.065	0.215	0.051				0.123	0.162	0.009
J				0.036	0.038	0.195				-0.105	-0.493	>0.001				0.030	0.055	0.434