

# Investigation of the economic impact of surgical site infection development in cardiovascular surgeries on the prospective payment system in Japan

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## Abstract

The purpose of this study was to evaluate the economic burden of surgical site infections (SSIs) that are included in the category of clean operations in the field of cardiovascular surgery.

In total, 2,583 patients who underwent cardiac surgeries at Juntendo University Hospital in Japan between April 2008 and March 2018 were investigated. Among them, nine SSI cases were individually matched to non-SSI cases based on a combination of age group (in 5-year increments), gender, timing of hospitalization (in 2-year intervals), National Healthcare Safety Network (NHSN) risk index, main disease category, and length of stay (LOS) prior to surgery (with the difference of  $\leq 2$  days). SSI and non-SSI cases were compared in terms of median LOS and piecework reference cost (PRC).

The median LOS was 30 days for SSI cases and 19 days for non-SSI cases ( $p < 0.05$ ). The median PRC was 1,257,630 Japanese yen [JPY] (10,308 Euro [EUR]) for SSI cases and 884,720 JPY (7,251 EUR) for non-SSI cases ( $p < 0.05$ ).

This study demonstrated that the development of SSIs significantly extended LOS and increased excess treatment costs. However, since the current Japanese prospective payment system, the Diagnosis Procedure Combination (DPC)-based payment system is calculated on a daily basis, it was suggested that in some cases it may be more beneficial to keep a certain LOS than to inhibit SSI episodes with an aim to shorten LOS. It was also found that in hospitals with relatively shorter LOS, deemed benefit may be reduced in certain diagnosis-related groups. This may lead to discouraging the prevention of SSIs. The current reimbursement system in some cardiovascular surgeries may need to be revised so that hospitals that have shortened LOS by inhibiting SSI are rewarded.

**Keywords:** surgical site infection, healthcare costs, cardiac surgery, remuneration, Japan

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## Introduction

We previously reported on the economic burden of surgical site infections (SSI) in the colorectal surgery department of a Japanese university hospital,<sup>1</sup> and demonstrated that the development of SSI led to extended length of stay (LOS) and increased excess treatment costs. It was also found that when opportunity costs were taken into account, SSI cases were less profitable than non-SSI cases, indicating that it is desirable from the viewpoint of health economics to inhibit SSIs.

Unlike colorectal surgeries, since cardiac surgeries, in the category of clean surgery, have lower incidences of SSIs, it is difficult to enroll a sufficient number of eligible patients in this kind of study. Therefore, the studies regarding economic burden of SSIs in the cardiovascular field have been very limited so far.<sup>2,3</sup>

In Japan, a Diagnosis Procedure Combination / Per-Diem Payment System (DPC/PDPS) was introduced in 2003. Admission charges have been divided into a DPC component and a fee-for-service (FFS) component, and hospitalized patients have been divided into several thousand groups on the basis of primary diagnoses and the types of operations they underwent. The piecemeal reference cost (PRC) component consists of fees that are related to facility use in nature, such as fees for drug administration, examinations, and nursing services. The FFS component consists of technical fees for medical doctors, such as fees for surgery and treatment. In addition, for the PRC component, a monetary amount per day is set for each DPC group; however, the flat-sum reimbursement revenue ( $F_I - F_{III}$ ) varies depending on the length of stay, and decreases in a three-step manner according to the predetermined length of stay (I - III) (Fig. 1).<sup>1</sup> The predetermined length of stay and the set monetary amount are both revised once every two years on the basis of the actual data obtained from DPC hospitals throughout Japan. This database has been utilized by various research studies to evaluate the quality of healthcare and to facilitate efficient management of hospitals.<sup>4-7</sup>

In the present study, the authors evaluated the economic burden of SSI development in the field of cardiac surgery, using a 'reference cost' instead of

actual medical expenditure, and a relatively longer research period than in our previous study was set to register a sufficient number of patients into this study.

## Materials and methods

### Settings and study population

Juntendo University Hospital is one of the largest Japanese teaching hospitals, with 1,020 acute beds. Among 2,583 patients who underwent cardiac surgeries categorized as CARD in the Department of Cardiovascular Surgery between April 2008 and March 2018, 1,733 patients for whom DPC data were traceable and who underwent a single surgery during a given hospitalization period were enrolled in the study. The operative procedure code used in this study was the International Classification of Diseases 9th Revision Clinical Modification (ICD-9-CM) Coding System.<sup>8</sup>

Among the enrolled patients, 15 developed SSIs, and the incidence (0.87%) was lower than the average provided by the Japan Nosocomial Infections Surveillance (JANIS).<sup>9</sup> For each of the 15 patients with SSI episodes, non-SSI cases were matched for all six eligibility criteria, i.e., age group (in 5-year increments), gender, timing of hospitalization (in 2-year intervals), National Healthcare Safety Network (NHSN) risk index, main disease (expressed as the first six digits of the DPC code), and length of stay prior to surgery (with a difference of  $\leq 2$  days). If more than one candidate for a pair was available, the oldest patient among the candidates was chosen. The reason the timing of hospitalization was included in the eligibility criteria was to have matched pairs who used the same medical fee points: the medical fee points used for calculation of medical fees under the national healthcare insurance system are revised every two years in Japan. Finally, nine matched pairs were used in this study.

### Definitions of income and cost

Figure 2 shows the components of reimbursement revenue under the Japanese DPC-based payment system. Actual income of the hospital consists of the FFS component, which includes fees for surgery and expensive treatments, and the DPC component, including fees for nursing services, drug administration, injections, less expensive treatments, laboratory

examinations, and radiological examinations. The FFS component and the PRC component represent accumulated sums of official prices determined for individual healthcare services provided to patients. The officially determined prices reflect actual costs for services, e.g., labour costs and material costs. Therefore, these accumulated sums of official prices were used as reference costs in this study, and defined the difference between the reference cost and the actual income as a deemed profit.

### Statistical analysis

The SSI group of nine patients was compared with the non-SSI group of nine patients in terms of median values for length of stay and PRC. For statistical analysis, the Wilcoxon signed-rank test was used and the difference was considered statistically significant for  $p < 0.05$ .

## Results

### Attribute distribution

Table I shows the distribution of attributes for the nine matched pairs, comprising three male and six female pairs. The number of pairs in the 65-69, 70-74, 80-84, and 85-89 year groups were six, one, one, and one, respectively. As for timing of hospitalization, two pairs were hospitalized in the period between April 2012 and March 2014, four pairs between April 2014 and March 2016, and three pairs between April 2016 and March 2018. The NHSN Risk Index was 0 for three pairs, 1 for five pairs, and 2 for one pair. The main disease was angina pectoris (O50050) for one pair and valvular disease (O50080) for eight pairs.

### Length of stay and piecework reference cost

Median values for LOS, PRC, total PRC, total income, and total deemed profit are shown in Table II. The median LOS was 30 days for the SSI group and 19 days for the non-SSI group (Interquartile Range [IQR]: 27-35, 17-20), providing a  $p$ -value of 0.004. The median PRC was 1,257,630 Japanese Yen [JPY] (10,308 Euro [EUR]) for the SSI group and 884,720 JPY (7,251 EUR) for the non-SSI group (IQR: 1,221,810 JPY - 1,633,430 JPY, 793,680 JPY - 986,550 JPY) (IQR: 10,014 EUR - 13,388 EUR, 6,505 EUR - 8,086 EUR), giving a  $p$ -value of 0.039. Total deemed profit was -514,180 JPY (-4,214 EUR) for the SSI group and -776,630 JPY (-6,365 EUR) for the non-SSI group.

Because the DPC-based payment system is on daily basis, the income of non-SSI patients with short LOS will be less than those of SSI patients with longer LOS. Therefore, it can happen that the deemed profit for non-SSI is lower than that for SSI.

### Details of piecework reference cost attributed to SSI

PRC consisted of six categories: medicines, injections, treatments, laboratory examinations, radiological examinations, and nursing services. Among these, large differences between the SSI and non-SSI groups were observed in nursing services, injections, and radiological examinations. For injections, data compilation using the first four digits of the therapeutic category code revealed that fractionated plasma products, cephem antibiotics, and other agents affecting the central nervous system ranked high. For radiological examinations, CT and MRI were primary causes for the large differences (Table III).

## Discussion

The reasons for higher PRC in SSI cases were as follows: the higher fees for nursing services might have been caused by the extended length of stay due to SSI development. The higher cost for injections might have occurred because antimicrobial agents and human immunoglobulin were used for treatment of SSI episodes. The frequency of radiological examinations might have been higher in the SSI cases as they were used for the purpose of observing infected lesions.

There were some limitations in this study. First, the FFS component was included in the reference cost, and therefore the deemed profit for the FFS component was calculated to be zero, since the actual income had the same value as the cost (i.e., the reference cost) for surgery and expensive treatments. There is a possibility that this way of analysis may lead to underestimation of the profit per admission. Second, the small number of enrolled patients may result in greater interference by the time dependent bias. However, this bias can be negligible, as the result of post-discharge surveillance was taken into account.

In our previous study evaluating the economic burden of SSIs in the Department of Coloproctological Surgery,<sup>1</sup> we demonstrated that the economic profit for SSI cases was smaller than that for non-SSI cases when opportunity costs were taken into account. It

was suggested that the current DPC-based payment system may positively affect an economic incentive to inhibit SSI episodes in coloproctological surgery. However, the present study demonstrated higher profitability for SSI cases than for non-SSI cases (although those profits were still presented as negative balance in both groups). Hence, the profit for non-SSI cases was lower than SSI cases, even though opportunity costs were taken into account. This might have been related to the fact that our hospital has not been sufficiently reimbursed under the current DPC-based payment system, because the LOS for patients without SSI episodes at our hospital is shorter than the national average LOS, leading to a possibility that in some of the diagnosis-related groups under the current DPC-based payment system, the system may not offer the above-mentioned economic incentive to inhibit SSI episodes.

#### Conflict of interest

All authors report no conflict of interest relevant to this article.

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This study was reviewed and approved by the Ethics Committee of Juntendo University Hospital.

The arbitrated exchange rate in Aug 2019 is 122 JPY/EUR.

**Table I. Distribution of attributes for matched pairs**

	Number of Pairs
<b>Gender</b>	
Male	3
Female	6
<b>Age band (years)</b>	
65-69	6
70-74	1
75-79	0
80-84	1
85-89	1
<b>Timing of hospitalization</b>	
2008.4-2010.3	0
2010.4-2012.3	0
2012.4-2014.3	2
2014.4-2016.3	4
2016.4-2018.3	3
<b>NHNS<sup>a</sup> Risk Index</b>	
0	3
1	5
2	1
3	0
<b>Main Disease</b>	
Angina pectoris	1
Valvular disease	8

<sup>a</sup>NHNS: National Healthcare Network System

**Table II. Median of length of stay (LOS) and piecework reference cost (PRC) between surgical site infection (SSI) episodes and non-SSI episodes**

	SSI episodes	Non-SSI episodes	Significance (p-value)
Number of episodes	9	9	
Median LOS (days)	30	19	p=0.004
Median PRC - Japanese yen: JPY <sup>a</sup>	1,257,630	884,720	p=0.039
Euro: EUR	10,308	7,251	
Total PRC - JPY <sup>a</sup>	12,435,960	7,905,590	
EUR	101,934	64,799	
Total income (DPC component) - JPY <sup>b</sup>	12,950,140	8,682,220	
EUR	106,148	71,165	
Total deemed profit - JPY <sup>c</sup>	-514,180	-776,630	
EUR	-4,214	-6,365	

<sup>a</sup> "Piecework reference cost component" shown in Figure 2.

<sup>b</sup> "DPC component" shown in Figure 2.

<sup>c</sup> "Deemed profit" shown in Figure 2.

**Table III. Major difference in total piecework reference cost (PRC) between surgical site infection (SSI) and non-SSI episodes**

Category	Injections	
	PRC	
	SSI (JPY/EUR)	Non-SSI (JPY/EUR)
Fractionated plasma products	611,370/5,011	179,560/1,471
Cephem antibiotics	296,460/2,430	3,780/30
Other agents affecting the central nervous system	184,880/1,515	0/0
Vancomycin preparations	167,530/1,373	0/0
Glucose	330,030/2,705	181,710/1,489
Category	Radiological examinations	
	PRC	
	SSI (JPY/EUR)	Non-SSI (JPY/EUR)
CT examination	461,500/3,782	283,500/2,323
MRI examination	127,800/1,047	74,600/611

CT: computed tomography, MRI: magnetic resonance imaging, JPY: Japanese yen, EUR: Euro

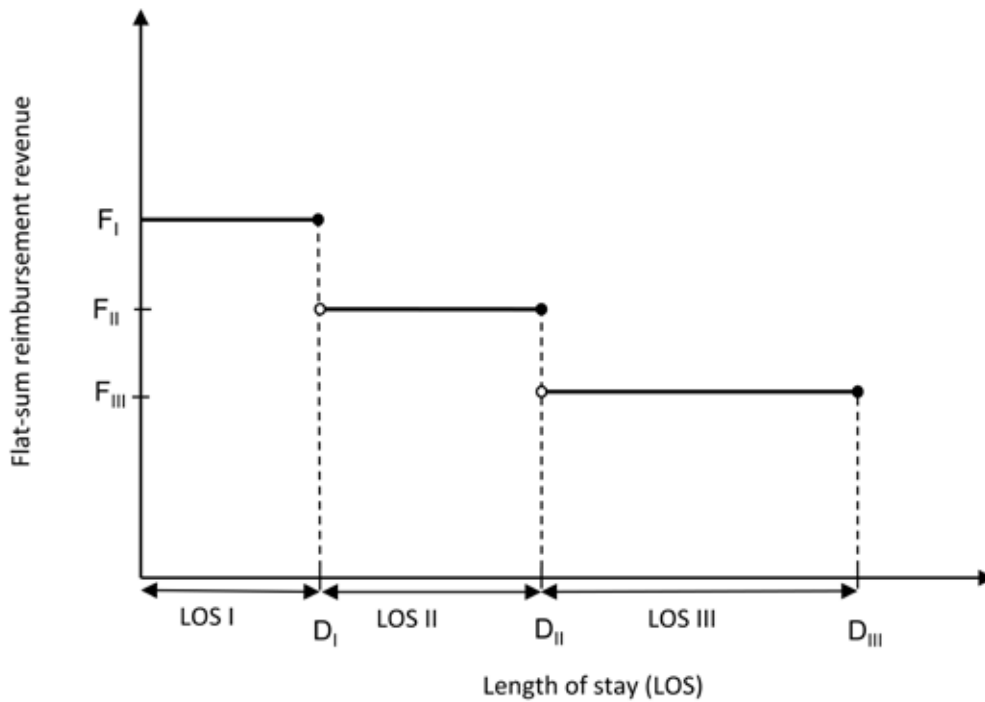


Figure 1. Relationship between length of stay (LOS) and decrease in flat-sum reimbursement revenue under the DPC-based payment system

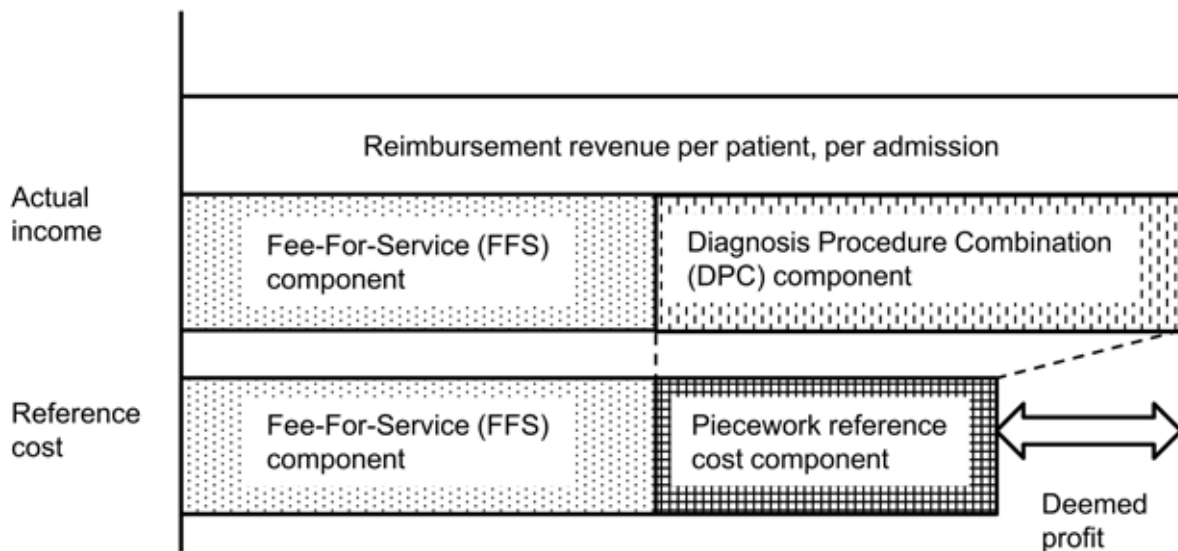


Figure 2. Composition of reimbursement revenue in Diagnosis Procedure Combination (DPC) Payment System

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