

Topic : Application of DPC data for evidence-based health policy

<Note>

**Estimation of per-case hospitalization charges from  
Diagnosis-Procedure-Combination (DPC) data and an international  
comparison of hospital prices**

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**Abstract**

**Objectives:** OECD launched a project to compare price levels of hospital charges internationally using purchasing-power-parity (PPP). The comparison is made for seven disease categories from internal medicine, 21 surgical procedures and four day-surgeries using per-case charges covering admission to discharge. The results of a pilot study in 16 countries are already published. To obtain Japan's data, the per-case hospital charges of said categories and procedures were estimated and compared with the results of the pilot study.

**Methods:** The per-case hospital charges were estimated from the "survey on the effects of the introduction of DPC (diagnosis-procedure-combination) reimbursement" by applying log-normal distributions to the 25th, 50th, 75th and 90th percentiles of length-of-stay (LOS). Surgical procedures and anesthesia are reimbursed on a fee-for-service basis and surgical charges were added to the estimated hospital charges.

**Results:** Comparison was made in terms of seven disease categories from internal medicine and 17 surgical procedures. Japan was ranked as most expensive for cholelithiasis (top among 15 countries) and least expensive for PTCA (percutaneous transluminal coronary angioplasty) (11<sup>th</sup> among 17 countries). Japan was ranked above the middle in 17 out of 24 categories/procedures.

**Conclusions:** Japan's hospitals were rather expensive among OECD countries due mainly to the excessively long LOS. Japan's LOS was longest in 19 out of 24 categories/procedures. Japan was ranked 4<sup>th</sup> among 11 countries even for its shortest LOS of angina).

**keywords:** hospital charges, diagnosis-procedure-combination (DPC), length-of-stay, log-normal distribution

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**I. Objectives**

OECD is conducting the "Hospital Purchasing-Power-Parity (PPP) survey" to develop the internationally comparable price indices of hospitalization. Hospitalization charges are all-inclusive charges including room and board, medication and laboratory, surgery and anesthesia covering the entire length of stay from hospitalization to discharge. They are difficult to measure particularly in

countries with wide variety of length of stay. Japan's length of stay is the longest among OECD countries and estimation of hospitalization per-case charges is a methodological challenge.

We attempted to estimate the hospitalization charges using Diagnosis-Procedure-Combination (DPC) data by applying a statistical model of log-normal distribution and compared the estimated per-case hospital prices with 12 OECD countries from the pilot study.

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## II. Data and Methods

### 1. OECD hospital survey

OECD launched an international comparative survey on hospital charges in 2008 and the results of the pilot study on 12 participating countries is published [1]. It collects the charges billed for certain “defined” hospitalization (case types). To achieve international comparability, the charges are compared using purchasing power parity or PPP, a common tool for comparing price levels across countries.

Case types include nine medical inpatient services (IM01-09) and 23 surgical inpatient services (IS02-24). Medical services are defined by primary diagnoses and surgical services are defined by surgical procedures.

### 2. Japan's DPC classification

DPC is a Japan's patient classification system for acute care hospitalization consisting of 2658 categories in 2010 fee schedule, of which 1875 DPCs were reimbursed on a per-diem basis (DPC per-diem payment system or DPC-PDPS). DPC-PDPS are selected from categories with sufficient sample size ( $N \geq 20$ ) and patients classified into the rest of DPCs will be reimbursed on a traditional fee-for-service (FFS) basis.

PDPS bundles room and board, medication and injection, clinical procedures priced less than 20000 yen. It does not include surgery and anesthesia, which will be billed separately. PDPS is staged at three levels by the length of stay. There is a maximum on the LOS and prolonged hospitalization beyond the maximum LOS will be reimbursed on a traditional FFS.

There were a total of 7,528 acute somatic hospitals with 899,385 acute care beds as of October 2011 according to the Health Care Facilities Survey, of which 1,634 hospitals with 491,282 beds are assigned as DPC wards. There were a total of 8,777,507 discharges from DPC wards, of which 8,310,372 discharges (94.7%) were reimbursed on PDPS for one year between April 2011 and March 2012.

Data of DPC-PDPS (1825 DPCs,  $N=8,310,372$ ) are available over the Ministry of Health, Labour & Welfare website [2] and includes the following:

- 1) the number of discharges in each DPC broken down by:
  - (1)sex
  - (2)age groups (in eight categories: 0-2, 3-5, 6-15, 16-20, 21-40, 41-60, 61-79 and 80 or over)
  - (3)prognoses at discharge (in eight categories: cured, alleviated, improved, no change, exacerbated, death due to the most resource-intensive diagnosis, death due to other diagnoses, and others)
  - (4)the most resource-intensive diagnosis classified by ICD10

- (5)types of surgery provided if any (in Japan's local surgery code called Kcode)

### 2) distribution of length of stay (LOS)

- (1)minimum, maximum, arithmetic mean, coefficient of variance

- (2)25th, 50th, 75th, 90th percentiles

A simplest way of calculating charges for a hospitalization would be to break the arithmetic mean of LOS into three stages and multiply with per-diem reimbursement prices. For example, a DPC 010010xx010xx (Brain tumor with no surgery) will be reimbursed 2878 points for the first 10 days, 2127 points between 11<sup>th</sup> and 21<sup>st</sup> days and 1808 points for the LOS over 22<sup>nd</sup> day. There was a total of 7469 cases and the arithmetic mean of LOS was 23.58 days. Then, the charge of a hospitalization can be calculated by  $2878 \text{ points} \times 11 \text{ days} + 2127 \text{ points} \times 10 \text{ days} + 1808 \text{ points} \times 2.58 \text{ days} = 57592.64 \text{ points}$ .

Historically, Japan's health insurance system fixed the point charge at 10 yen. However, in DPC, each hospital is assigned different level of point charge ranging from the lowest of 8.922 yen to the highest of 13.556 yen. The eventual price ranges from the lowest of 513,841 yen to the highest of 780,726 yen for exactly the same case.

However, such a simple calculation is likely to overestimate the charges because the LOS is not normally distributed. The distribution of LOS is known to be skewed to right because a small number of patients stay exorbitantly long (The maximum LOS of this DPC was 220 days).

In this study, we applied log-normal distribution to better estimate per-case charges.

## 3. Method

Log-normal distribution functions were estimated for each of DPCs ( $N=1875$ ) using the 25th, 50th, 75th and 90th percentiles LOS ( $X$ ). Log-normal functions are determined by geometric mean (GM, arithmetic mean of  $\text{LN}(X)$ ) and geometric standardized deviation (GSD, standard deviation of  $\text{LN}(X)$ ). GM and GSD were estimated using Excel Solver to minimize the sum of squares of the differences between the observed percentile LOS and estimated percentile LOS.

Let the observed 25th, 50th, 75th and 90th percentiles LOS be expressed as  $\text{LOS}_{0.25}$ ,  $\text{LOS}_{0.5}$ ,  $\text{LOS}_{0.75}$  and  $\text{LOS}_{0.9}$  respectively. Further, the estimated percentile LOS using an Excel function, LOGINV, is expressed as  $\text{LOGINV}(0.25, \text{GM}, \text{GSD})$ ,  $\text{LOGINV}(0.5, \text{GM}, \text{GSD})$ ,  $\text{LOGINV}(0.75, \text{GM}, \text{GSD})$  and  $\text{LOGINV}(0.9, \text{GM}, \text{GSD})$  respectively (LOGINV is an Excel function to give  $X$  value of a log-normal distribution of given GM, GSD and cumulative probability,  $p$  and is expressed as  $X = \text{LOGINV}(p, \text{GM}, \text{GSD})$ ).

GM and GSD were estimated to minimize the following

sum of squares

$$\sum_{i=0.25}^{0.9} (\text{LOS}_i - \text{LOGINV}(i, \text{GM}, \text{GSD}))^2$$

#### i) probability of hospitalization on the $X$ th day

Once GM and GSD were estimated, the probability of a patient being hospitalized for **a length of  $X$  days** is expressed by a probability function of the estimated log-normal distribution and the probability of a patient being hospitalized for **a length of one to  $X$  days** is expressed by a cumulative probability function of log-normal distribution. Then, the probability of a patient hospitalized on the  $X$ th day is expressed as **1-cumulative probability( $X-1$ )** because patients whose LOS is  $X-1$  days or less are discharged before the  $X$ th day. Using an Excel function, it is expressed as:

$$1-\text{LOGNORMDIST}(X-1, \text{GM}, \text{GSD})$$

#### ii) estimation of per-case charges

Let the per-diem price of DPC on the  $X_{th}$  day be  $H_x$ , then the total price of a hospitalization of a given DPC is (max is the maximum LOS of each DPC):

$$\sum_{x=1}^{\max} (H_x * (1 - \text{LOGNORMDIST}(X-1, \text{GM}, \text{GSD})))$$

#### iii) estimation of average point charges

Reimbursement rate of DPC is expressed in points and must be multiplied with point charge to translate it into yen amount. Historically, Japan's health insurance system has fixed a point at 10 yen. However, in DPC system, each hospital is assigned a different point charge. The average point charge was estimated by weighted average of entire hospitals ( $N=1,634$ ) using the number of DPC cases as weight.

#### iv) estimation of surgical charges

DPC does not include surgery and anesthesia and they are reimbursed separately on a fee-for-service basis (point charge is set at 10yen). Surgical fees were estimated separately from DPC database. The DPC database included the number of cases for which surgeries are performed by Japan's local surgical coding (KCODE).

For example, appendectomy is defined by the following ICD-9-CM coding:

- 47.01 Laparoscopic appendectomy
- 47.09 Other appendectomy
- 47.11 Laparoscopic incidental appendectomy
- 47.19 Other incidental appendectomy

The above ICD-9-CM coding is translated into the following Japan's KCODE

- K718-01 Appendectomy without peripheral abscess
- K718-02 Appendectomy with peripheral abscess
- K718-21 Laparoscopic appendectomy without

peripheral abscess

K718-22 Laparoscopic appendectomy with peripheral abscess

The above KCODEs are performed in a total of 48,598 cases spreading over 38 DPCs, of which DPC "060150xx02xx0x" accounts for 38,605 cases (79.4%) followed by "060150xx02xx1x" with 8,440 cases (17.4%). The first six digits denote the most resource-intensive diagnosis: "060150", "appendicitis" and the last but one digit from right: '0' and '1', denotes the absence/presence of secondary diagnoses. The total cases of these two DPCs were 39,211 and 8,790 respectively. Although appendectomy is by far the most common procedures performed on patients with appendicitis, some of them are performed with different surgical procedures such as surgeries for acute pan-peritonitis. Since OECD defines surgical cases based on types of surgical procedures, per-case price as well as average length of stay of 38 DPCs had to be collated using the number of appendectomy as weight (actually the least frequent 13 DPCs had only one appendectomy each).

### III. Results

The average point charge was estimated as 10.96 yen per point. The total charges of DPC-PDPS cases ( $N=8,310,372$ ) was estimated to be 3.756 trillion yen or 451,981 yen per discharge (US\$4520 when \$1 = ¥100).

The results of the number of cases, average length of stay (ALOS) and hospitalization prices converted into US\$ (\$1=¥100) are presented in [Table1], [Table2] and [Table3] respectively incorporating the results from 12 OECD countries to allow international comparison. In [Table2] and [Table3], the ranking of Japan in OECD countries which provided data is also included.

As for ALOS, Japan is known as a country with the longest ALOS. True, Japan ranked as the 1st in 19 of 24 case types. It is noteworthy that Japan's ALOS is shorter than US in inguinal hernia repair. As for prices, Japan ranks in the upper half of OECD countries in most case types. It is noteworthy that Japan's hospital is more expensive than US in three internal medicine case types: cholelithiasis, heart failure and pneumonia. This may be explained by Japan's long ALOS.

### IV. Discussion

Analyzing DPC data, we were able to provide internationally comparable prices of hospitalization of Japan. So far, Japan has not been used to capture the price of an entire hospitalization from admission to discharge.

Our findings revealed that Japan's hospitals occupy higher end of the price lists of OECD countries. Japan's



length of stay is still long and it is considered to be a major reason why Japan's hospitals are more expensive than OECD standards. These results suggest that Japan's hospitals need more efficiency through shortening the length of stay.

There are some limitations to this study. The data year was 2011 while the data of other countries were of 2007. This was inevitable because DPC participating hospitals were not as many as they are today. Also in that year, only six months data were collected. For the first time in FY2011, data covering an entire year were collected from 1,634 DPC participating hospitals. The sheer sample size of 8,310,372 discharges is only second to the US and almost comparable to Germany according to [Table1] making it sufficiently large to enable international comparison.

Another limitation is that prices are converted into US\$ under the current exchange rate (\$1=¥100) and is amenable to the fluctuation of exchange rate. OECD advocates using PPP for international comparison incorporating consumer prices. Unfortunately, we did not attempt to calculate PPP in this study.

And, most importantly, DPC data do not cover the entire Japan's acute admissions. Only acute care hospitals fulfilling certain requirements (such as the number of medical and nursing staff per bed) are permitted to use DPC PDPS. Still, nearly half of acute

care admissions occur in non-DPC hospitals, one cannot generalize the findings from DPC data to the entire country.

Despite the above limitations, our estimates of per-case hospital charges are pioneering in nature and will bring about various implications for not only international comparison but also for domestic health policy development.

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## DPCデータを用いた入院費用の推計と、OECD加盟国との価格比較

### 抄録

**目的：**OECDは病院費用を疾患別に国際比較するプロジェクトを開始した。9内科疾患、23外科手術、4日帰り手術について入院から退院までの総費用を推計し、購買力平価（PPP）で比較するもので、2010年に16か国で実施されたパイロット調査の結果が公表済みであり、2013年より本調査が開始された。DPC調査を用いて、わが国急性期病院の疾患別入院費用を推計し、パイロット調査されたOECD加盟国の価格と比較する。

**方法：**2011年度DPC導入の影響調査結果より在院日数の25, 50, 75, 90%タイル値に対数正規分布を適用し、1875DPC毎の入院から退院までの包括点数の平均を算出した（一点単価は医療機関別係数に病院毎の症例数を加重平均した10.96円）。内科疾患については医療資源投入病名（ICD10）よりOECD指標の対象疾患を抽出しDPC平均点数を症例数で加重平均した。外科系疾患については実施された手術（K）コード数で加重平均し手術と麻酔点数を加えた。得られた疾患別、手術別入院費用を米ドル換算してパイロットスタディ参加国と比較した（パイロットスタディでは物価補正したPPPは算出されず）。

**結果：**7内科疾患と17外科手術を比較できた。わが国順位が最も高かったのは胆石症で15か国中1位、最も低いのはPTCAで17か国中11位であった。24疾患・手術中17でわが国は中位より上であった。

**結論：**公表されている（算術）平均在院日数で算出したらわが国は突出した高額だったため、対数正規分布を適用し幾何平均を用いたが、それでもわが国入院費用はOECD加盟国中高額の部類であった。その最大要因はわが国の在院日数の長さであり、24疾患・手術中19でトップであった（最も短かったのは狭心症で11か国中4位）。

キーワード：病院費用、DPC（診断群分類）、在院日数、対数正規分布

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