Regional Variations in Medical Expenditure and Hospitalization Days for Heart Attack Patients in Japan:
Evidence from the Tokai Acute Myocardial Study (TAMIS)

by

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Abstract

The use of percutaneous transluminal coronary angioplasty (PTCA), a costly high-tech treatment for patients with acute myocardial infarction (AMI), is much more frequent in Japan than in other developed countries, resulting in large medical expenditure. Using chart-based data from the Tokai Acute Myocardial Infarction Study (TAMIS) and exploiting regional variations, we explore what factors explain the intensive use of PTCA in Japan, employing propensity score matching to estimate the average treatment effects on hospital expenditure and hospital days. We find that the probability of receiving high-tech treatment is affected by a patient's characteristics as well as the density of medical resources in a region. Moreover, once heterogeneity between treated and non-treated patients is adjusted for, medical expenditure is higher for treated patients while there are no significant differences in hospitalization days. Our findings imply that the higher medical costs resulting from high-tech treatments are not associated with better outcomes and that the frequent use of high-tech treatments is economically motivated.

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Key words: health care in Japan; physician-induced demand; two-part model; acute myocardial infarction (AMI); Tokai Acute Myocardial Infarction Study (TAMIS)

Abstract (104 words)

In Japan, the use of percutaneous transluminal coronary angioplasty (PTCA) for the treatment of acute myocardial infarction (AMI) is extraordinarily frequent, resulting in large medical expenditure. Using chart-based data and exploiting regional variations, we explore what factors explain the frequent use of PTCA, employing propensity score matching to estimate the average treatment effects on hospital expenditure and hospital days. We find that the probability of receiving PTCA is affected by the density of medical resources in a region. Moreover, expenditure is higher for treated patients while there are no significant differences in hospitalization days, implying that the frequent use of PTCA is economically motivated.

1. Introduction

Heart disease is one of the most common causes of death in Japan and accounts for one of the highest shares of total medical expenditure. While Japan's total expenditure on medical care doubled from 11 to 22 trillion yen between 1980 and 1998, the amount of expenditure for patients with ischemic heart diseases increased three-fold, from 246 to 746 billion yen during the same period.[1] Among heart diseases, one of the most serious and widespread is heart attack, with acute myocardial infarctions (AMI) accounting for more than one-third of heart disease-related deaths.[2]

The rapid expansion in health care expenditure associated with heart diseases during the past two decades can mainly be attributed to higher per-patient costs rather than an increase in the incidence of heart diseases.[3] One possibility to account for the higher costs per patient is the increasing use of high-tech AMI treatments. In fact, the level of use of high-tech treatments in Japan is quite extraordinary even among developed economies and raises the question whether the rise in expenditure on AMI treatments is caused by the economic incentives physicians face rather than technical advances alone. This is the question we set out to examine in this paper.

AMI treatments can be classified into two types: high-tech and low-tech procedures (McClellan and Noguchi (1998)). One important element in intensive high-tech treatment for heart attacks is cardiac catheterization to visualize the blood flow to the heart muscle through continuous radiologic pictures of the flow of dye injected into the coronary arteries. If substantial blockages are detected, there are two possible types of "revascularization" procedure to improve blood flow to the heart.

One is angioplasty (percutaneous transluminal coronary angioplasty; henceforth, PTCA), which involves the use of a balloon (or, recently, a stent) at the end of a catheter to eliminate blockages. The other is bypass surgery (coronary-artery bypass graft surgery; henceforth, CABG), a major open-heart surgical procedure to bypass the area of blockage. These treatments require high-skilled labor input, including specialized cardiologists, cardiac surgeons, cardiac nurses and procedure technicians. In addition, these medical procedures also need a carefully controlled and dedicated setting. It is costly to maintain the capacity to provide these procedures and, as a result, such treatments are available only in a limited number of hospitals.

In contrast, low-tech treatments involve relatively lower costs and are provided by all medical facilities. They include the utilization of acute drug treatments using aspirin, thrombolytic drugs, beta blockers, calcium channel blockers, and angiotensin-converting-enzyme inhibitors.

Among the high-tech treatments, the growth rate of the number of PTCA treatments has been much higher in Japan than in the United States and, as a result, PTCA is much more frequently used in Japan than in other developed countries (Endo and Koyanagi (1994), Nippon Shinkekkan Intervention Gakkai Gakujitsu Iinkai (1993), Yoshikawa et al. (2002)). These studies also found that the ratio of the number of PTCA treatments to that of CABG treatments is very high in Japan, almost five to one. The extremely high ratio of PTCA use has often been explained by the alarmingly high rate of mortality following CABG in the early stage of diffusion of bypass surgery in Japan (Sezai et al. (1970); Hayashi (1970); Asada et al. (1970)), an experience that still shapes attitudes today. However, some cardiovascular surgeons have pointed out the possibility that cardiologists perform unnecessary and inappropriate PTCA treatments as a result of the economic incentives provided by Japan's health care system (Sasakuri et al. (1997), Endo et al. (1997)).[4]

This study explores the possibility that the high number of PTCA treatments can be largely explained by the economic motives pursued by hospitals. In order to address this issue, we examine variations in the number of high-tech treatments and hospitalization days across hospitals in central Japan. As will be described in greater detail in Section 2, Japan's universal health insurance system guarantees patients "free access" to any type of physician and hospital, including high-tech and high-volume hospitals, without being referred by a primary-care gatekeeper. A patient is entitled to use medical services at a fixed rate of co-payment and patients' financial burden is limited. A heart-attacked patient is typically directly taken by ambulance to the nearest high-volume hospital with a cardiac department and/or emergency room. Once a heart-attacked patient is hospitalized, a surgeon and his or her colleagues decide which treatment should be administered. Since the decision requires expertise, there is no room for a patient or his/her family members to choose a treatment, which allows us to ignore patients' preferences toward a hospital or treatment. In Japan, all treatments are reimbursed on a per case, fee-for-service basis, regardless of at which hospital or clinic the treatment is performed, and the fee schedule is determined centrally by the government. This system may lead surgeons that want to raise their income to perform high-tech treatments that are not strictly necessary on medical grounds.

Our data set is uniquely suitable for examining the possibility that the increase in PTCA treatments is the result of economic incentives, since it was compiled between 1995 and 1997, thus including the year 1996, when the reimbursement rates for PTCA increased, while the CABG reimbursement rates remained unchanged.[5] We find that, between 1993 and 1996, the availability of both procedures increased substantially. According to the *Survey on National Medical Facilities* (*Iryo Shisetsu Chosa*), the number of hospitals capable of providing high-tech treatments in that period increased by 228 (60 percent) for PTCA and by 56 (14 percent) for CABG. As a result, of more than 8,000 general hospitals in Japan in 1996, 609 were able to perform PTCA and 453 were able to perform CABG. Moreover, between 1993 and 1996, the number of PTCA performed per month also increased dramatically, by 60 percent, while that of CABG increased only slightly.

It is important to note, however, that not all hospitals able to perform PTCA saw a large increase in such treatments and there were substantial regional variations. We exploit these regional variations, which are caused by the presence of large hospitals in a particular region, to explore what factors are associated with the intensive use of PTCA treatment, employing a unique micro-level dataset that contains detailed information on patients' and hospitals' characteristics. Since the allocation of patients to hospitals may not be random (i.e., a patient with a severe heart attack is more likely to be hospitalized in a well-equipped hospital with skilled staff), we employ propensity score matching to correct for patient heterogeneity and estimate the average treatment effects of high-tech procedures on hospital expenditure and hospital days.

We find that the probability of undergoing high-tech treatment is affected by a patient's characteristics as well as the intensity of medical resources in a region. Moreover, once heterogeneity between patients that received high-tech treatment ("treated patients") and those that did not ("non-treated patients") is adjusted for, medical expenditure is higher for treated patients while hospitalization days are similar. Our findings imply that the higher medical costs caused by high-tech treatments are not associated with better outcomes and are driven by economic incentives.

The remainder of this paper is organized as follows. Sections 2 and 3 review the Japanese health care system and the related literature, respectively. Section 4 describes the data, while Section 5 explains our empirical strategy. Section 6 then investigates the relationship between treatment choices and variations in health care intensity across difference spheres, and estimates the average treatment effects of high-tech procedures on hospital expenditure and hospital days. Section 7 concludes.

2. The Japanese health care system

This section provides a brief overview of the Japanese health care system, focusing on those elements which provide physicians with an incentive to prescribe high-cost high-tech treatments. In the United States, physicians, including cardiologists, perform medical procedures as self-employed professional entrepreneurs with hospital privileges. In contrast, in Japan, there are two types of physicians. Some are self-employed and have their own hospital with cardiac care facilities. In most cases, such hospitals are relatively low-volume hospitals or clinics with less than twenty hospital beds. The other type of physicians are either full-time or part-time salaried employees hired by high-tech and high-volume hospitals. Note that, with only a very few exceptions, all hospitals and clinics in Japan are non-profit institutions.

Under the Japanese universal health insurance system, all treatments are reimbursed on a per case, fee-for-service basis, regardless of the hospital or clinic where a treatment is performed. The fee schedule, determined by the government and applicable uniformly across Japan, assigns a predetermined number of fixed "points" (1 point is equivalent to 10 yen) to each, including the dispensing of medications. Therefore, the first, hospital-owning type of physicians benefit directly from increasing the number of high-tech treatments they perform, and there is indeed evidence that, in the case of such physicians, the high ratio of PTCA treatments is a response to the economic incentives, that is, the larger reimbursement for angioplasty than clinically risky bypass surgery (Yoshikawa et. al (2002)).

The second type of physicians, that is, those employed by a hospital and paid a given salary that is independent of the number of procedures they perform, may nevertheless indirectly be affected by economic considerations, even though all hospitals are not-for-profit. This is because although physicians employed by hospitals are not directly rewarded for each case, they know that a higher volume of high-tech procedures increases total reimbursements to the hospital and will ultimately affect their salary. If such considerations play a role, physicians are more likely to implement high-tech treatments.[6]

Other factors further contribute to a system that provides incentives for high-tech treatments. Central among these is the "free access" guarantee. In Japan, several neighboring municipalities are legally integrated as a "sphere" to serve the medical needs of the entire population in the region (called *iryo-ken*), which is geographically larger than a municipality and smaller than a prefecture, and the "free access" guarantees patients or their family access to their preferred hospital within their sphere (although this may still be relatively far from where they live).[7] In the case of AMI, where time is of the essence, the "free access" guarantee means that patients are likely to be hospitalized in the medical institution nearest to the place where the heart attack occurred, regardless of the patient's place of residence or "sphere." In other words, the "free access" guarantee means that patients are not denied hospitalization in a particular facility, or are denied a particular treatment. In this sense, "free access" and the low financial burden on patients mean that costs do not play an immediate role in the decision to perform a treatment, thus potentially providing an incentive for unnecessary and/or inappropriate PTCA treatments.

3. Previous studies

A large number of studies have examined the economic implications of variations in physicians' treatment choices, medical expenditure, accessibility and quality of care across regions. Broadly speaking, these studies can be classified into two types. The first type examines the association between physicians' economic incentives and the number of treatments performed, while the other type of studies deals with the effect of physician density on health outcomes.

It appears that with regard to the relationship between physicians' economic incentives and the volume of treatments, studies to date have not reached a consensus. Several studies suggest that there is a positive association. Schroeder (1992), for instance, looking at the situation in the United States, showed that a greater number of surgical specialists was associated with a relatively high utilization of surgical procedures. Moreover, Crane (1992), Hillman et al. (1992), and Mitchell and Scott (1992) showed that physicians who own diagnostic imaging equipment were more likely to order tests than were physicians who did not own such equipment. In fact, many U.S. states have restricted self-referrals by physicians who own imaging equipment. Finally, Delattre and Dormont (2003), using panel data on French physicians, demonstrated that the fee-for-service scheme leads providers to stimulate unnecessary elderly care use if there is large potential demand.

Studies along these lines are closely associated with the large body of literature on physician-induced demand (henceforth, PID) pioneered by Feldstein (1970), Evans (1974), Fuchs (1978), and Reinhardt (1978).[8] One of the challenges in examining PID is to discriminate between demand- and supply-side factors. In order to address this issue, Rossiter and Wilensky (1983, 1984) used a “two part model” to separate initial physician visits mainly initiated by patients and the follow-up visits influenced by physicians. Similarly, Escarce (1992) distinguished between demand-side and supply-side factors in the case of surgery by defining the former in terms of patients’ initial contact with a doctor and the latter in terms of physician density and found that physician density affects the share of patients who receive medical services but not medical expenditure and concluded that utilization was driven by patients.[9] Overall, it seems fair to say that, despite the tremendous number of studies on the subject, there is no clear evidence for the existence of PID.

In contrast, the second type of studies seems to have reached the consensus that physician density has little effect on outcomes. Two recent studies are representative. Fisher et al. (2003), for instance, found that regional differences in Medicare spending are largely explained by physicians’ treatment patterns and regions in which Medicare expenditure is higher do not enjoy better quality of care. And Sirovich et al. (2006), examining the dramatic differences in health care utilization and spending across U.S. regions with similar levels of patient illness, found that physicians in regions of high health care intensity do not provide higher quality of care.

To our best knowledge, this is the first study to use micro-level chart-based data to examine treatment patterns and outcomes for AMI patients admitted to hospitals in Japan. We would like to emphasize that one of the merits of focusing on AMI patients is that they have no choice over which hospital they are taken to, which eliminates patients' preferences toward particular hospitals or treatments as a potential factor. An initial major heart attack can occur unexpectedly anytime and anywhere. The guidelines for treating AMI patients in Japan (Uematsuse et al. (2001)) clearly state that physicians should diagnose patients within ten minutes, explain the risks and benefits of the treatments they will perform and start treating patients within thirty minutes after hospitalization. Because time is crucial in saving heart attack patients' lives, physicians must take the initiative in all treatments. As a result, there are no patient selection processes that we need to take into account and we can focus on examining physicians' behavior.

4. Data

We use a unique micro-level dataset based on the Tokai Acute Myocardial Infarction Study (TAMIS).[10] The main objective of the TAMIS is to create a database comparable to the Cooperative Cardiovascular Project (CCP).[11] The CCP is a major policy initiative in the United States to improve the quality of care for Medicare beneficiaries with AMI, undertaken by the Health Care Financing Administration (HCFA, now the Center for Medicare and Medicaid Services, CMS). The TAMIS aims to investigate variations in the quality of health care with respect to treatments and outcomes between Japan and the United States, controlling for chart-based detailed clinical information on AMI patients.

The TAMIS has abstracted charts for 2,020 heart attack patients living in 116 municipal areas of the Tokai region (Aichi, Mie, Gifu, Shizuoka, and Nagano prefectures), who were admitted to thirteen high-tech and high-volume hospitals. All observations are for patients hospitalized for the first time for AMI treatment between

January 1995 and December 1997, a different observation period from that for the CCP (April 1994 to July 1995) in the United States.

In the data collection process, charts were carefully reviewed by research nurses and physicians. We followed the standardized abstractions of medical records used by the HCFA/CMS in the CCP. The record abstracts contain more than 100 comorbid diseases and severity measures that collectively summarize all of the major associated diseases and functional status impairments. Moreover, the abstracts include the AMI severity measures following the CCP's expert advisory panel, which are correlated with the appropriateness of AMI treatment decisions and health outcomes.

Of the observations for 2,020 patients, observations for 1,263 patients unfortunately had to be removed, since information on patient characteristics necessary for this study was missing. Therefore, we have observations on 757 patients admitted into 11 hospitals in 8 different spheres. In addition, to construct the physician density variable at the municipal level during the TAMIS survey period, we utilized data obtained from WAMNET (the website of the *Fukushi Iryo Kiko*), the *National Survey on Medical Facilities*, and the *Vital Statistics* published by the Ministry of Health, Labour and Welfare (MHLW).

Table 1 provides a description of the main variables. The first column shows the definitions of variables and the remaining columns show the means and standard deviations of each variable for three groups: those who underwent catheterization (CATH; we call this the "CATH group"), those who underwent both CATH and PTCA (the "PTCA group"), and those who received low-tech treatments (the "low-tech group"). First, we observe that 608 patients (80 percent) underwent CATH and 480 patients (63 percent) underwent CATH and also received PTCA, while 149 patients (20 percent) received acute drug treatments. Note that all patients who received PTCA also underwent CATH since CATH is the starting procedure for high-tech treatments. Of total expenditures for the first hospitalization, medical costs accounted for around 2.5 million yen for patients in the CATH and PTCA groups and 1.4 million yen for patients in the low-tech group. Moreover, the average length of stay from the first hospital admission is about 4 days longer for patients in the CATH and PTCA groups than for those in the low-tech group. These mean values are similar to those in previous studies for Japan (Yamane et al. (2000); Yoshida et al. (1997); Suzuki (2000)).

Second, the statistics for the density of medical facilities at the sphere level show that the numbers of high-tech and high-volume hospitals per 100,000 persons were larger in the case of patients that received high-tech treatment than for patients that received low-tech treatment. In contrast, the remaining density variables, such as the number of low-tech hospitals (no PTCA available), physicians and hospital beds per 100,000 persons, were larger for patients in the low-tech treatment group than for those in the two high-tech groups. Third, as regards patient characteristics, the CATH and PTCA groups had a lower share of females. In addition, patients' average age was lower in the CATH and PTCA groups and the share of those enrolled in the health insurance for the elderly was also smaller. Moreover, patients in these two groups were more likely to live with a spouse which may be a reflection of the fact that, on average, they are younger.

The remaining rows of Table 1 report the rates of detailed chart-based comorbid diseases and severity measures. We observe a substantial difference between the high-tech and low-tech groups in almost all of these measures. Overall, patients who underwent high-tech procedures were in better health conditions.

Patients in the high-tech groups were much more likely to enjoy a good functional status as measured by independent-mobility indicators. In addition, such patients were less likely to have serious comorbid diseases such as angina, prior cardiac heart failure, renal failure, cerebral infarction, or a terminal illness. Furthermore, the health condition of patients undergoing high-tech treatment was less severe on initial admission. On average, such patients had a lower heart rate and better kidney function, as shown by their lower blood nitrogen levels.

In addition, we constructed a summary indicator of disease comorbidity and severity, the Killip class. Reported in the last three rows, this is constructed using a number of clinical characteristics related to the extent of heart failure in an AMI patient and has been shown to provide a reliable predictor of short-term AMI mortality. Killip classes 1 and 2 indicate relatively mild heart failure and Killip classes 3 and 4 refer to moderate and severe heart failure. We observe that patients in the high-tech groups are much more likely to be in the lower Killip classes 1 or 2.

Finally, the last column in Table 1 shows whether the differences in the means across hospitals in our data set are statistically significant, based on F-statistics. We see a substantial variation in treatments undergone, patients' expenditure and hospitalization days, which are significantly different across facilities. Since the hospitals we examine are large and account for a major share of treatments in each sphere, the variation across regions that we see reflects variations across hospitals. As regards demographic characteristics, sex, age, and enrollment into the health insurance for the elderly, these are balanced across hospitals. The significant difference in the number of family members and the presence of a spouse may reflect the role of hospitals' location. For comorbid diseases, more than half of the key indicators (e.g., hypertension, old myocardial infarction, renal failure, cerebral infarction, and terminal illness) are balanced across hospitals. In contrast, the severity measures in the Killip classes vary significantly across hospitals, and in rural areas, patients with relatively mild heart failures were more likely to be admitted to hospitals.

In sum, we see a large variation in the number of different treatments, per patient expenditure and hospitalization days across facilities. Patients' demographic characteristics and comorbid diseases, factors already present before the AMI, were relatively homogenous, but post-AMI, the severity measures in the Killip classes were not balanced across hospitals. This implies that the variations in treatment, per patient expenditure and hospitalization days across hospitals were caused by the non-random allocation of patients and we have to carefully control for selection bias when evaluating the effect of high-tech treatment on medical expenditure and hospitalization days.

5. Empirical Strategy and Measurements

In this section, we describe the propensity score model that we use to estimate the average treatment effects on hospital expenditure and hospital days. Expenditure and hospitalization days can differ across hospitals in such a way that a specific type of patients is more likely to be undergo high-tech treatment. Propensity score matching enables us to adjust for patient heterogeneity between treated and nontreated patients to obtain the treatment effects. We define treated patients as those who underwent CATH or PTCA during the first hospitalization for the heart attack.[1 2] The propensity score is defined by Rosenbaum and Rubin (1983) as the conditional probability of receiving a treatment given pre-treatment characteristics.

First, we examine the determinants of the probability that a particular treatment is chosen for a particular patient using the following probit estimation:

$$p(Intens_i, x_i) = \Pr\{T_i = 1 \mid Intens_i, x_i\} = \Phi(\tau(Intens_i, x_i)) \qquad (1)$$

where T_i ={0,1} takes 1 when a patient underwent high-tech treatment.[13] As regards the covariates, $Intens_i$, the main variables of interest, four measures of medical intensity at the sphere level are chosen: (1) the number of high-tech hospitals (capable of performing PTCA) per 100,000 population;[14] (2) the number of low-tech hospitals (not capable of performing PTCA) per 100,000 population; (3) the number of high volume hospitals with more than 100 beds per 100,000 population;[15] and (4) the number of physicians per 100,000 population. We also include the number of hospital beds per 100,000 population, the population density per square kilometer, and the logarithm value of mean taxable income as explanatory variables. x_i presents the i th patient's demographic characteristics, comorbid diseases, and severity indicators. Demographic characteristics include a patient's age, sex, number of family members, the presence of spouse, and enrollment into the health insurance for the elderly. Comorbid diseases and severity indicators are comprised of detailed chart-based information, including information on the continence and mobility status, hypertension, diabetes, cardiac heart failure (CHF), the mean arterial pressure (MAP), the body mass index (BMI), the highest creatinine level, white blood cell and platelet levels, and EKG records. Finally, $\Phi(\bullet)$ denotes the normal cumulative density function and $\tau(Intens_i, x_i)$ is a function of covariates with linear and higher order terms.

If the coefficients on the medical resource density variables are significantly positive, this suggests that a greater density of medical resources is associated with a greater use of high-tech treatments. A positive coefficient could be interpreted as reflecting the fact that a greater density of medical resources reduces patients' access costs, but such an interpretation does not apply here, since, as mentioned, in the case of AMI, patients are taken to the nearest medical facility and patient choice therefore plays no role.

Given the first probit estimates of (1), the average treatment effect on the treated population (ATT) can be estimated as follows:

$$
\begin{aligned}
ATT &\equiv E\{y_{1i} - y_{0i} \mid T_i = 1\} \\
&= E\{E\{y_{1i} - y_{0i} \mid T_i = 1, p(Intens_i, x_i)\}\} \\
&= E\{E\{y_{1i} \mid T_i = 1, p(Intens_{i,} x_i)\} - E\{y_{01} \mid T_i = 0, p(Intens_i, x_i)\} \mid T_i = 1\} \qquad (2)
\end{aligned}
$$

where y_{1i} and y_{0i} indicate the expected outcomes of being treated and non-treated, respectively, and the outer estimation is over the distribution of $(p(Intens_i, x_i) \mid T_i = 1)$. Propensity-score methods use a categorical function to classify observations into g equally spaced groups of the propensity score that are as "balanced" as possible in terms of observable characteristics influencing treatment (Rosenbaum and Rubin (1984)). In this case, the subgroups within which treated and non-treated patients are compared are a categorical function $p(Intens_i, x_i)$ that seeks to balance the many observed covariates. The propensity score reduces the dimensionality problem of matching treated and control units based on the multidimensional vector x_i (Becker and Ichino (2002) and Deheijia and Wahba (2002)).

In order to estimate ATT, we use the kernel matching method because the number of observations in our data is very limited and therefore the size of the neighborhood is small. The procedure of the kernel matching model is described in detail by: [16]

$$ATT^{Kernel} = \frac{1}{N^T}\sum_{i\in T}\left\{ y_i^T - \frac{\sum_{j\in C} y_i^C K\left(\frac{p(Instens_j, x_j) - p(Intens_i, x_i)}{\tau(Intens_n, x_n)}\right)}{\sum_{l\in C} K\left(\frac{p(Instens_l, x_l) - p(Intens_i, x_i)}{\tau(Intens_n, x_n)}\right)} \right\} \quad (3)$$

where the subscripts, T and C, denote the treated and non-treated population and y_i^T and y_j^C are the observed outcomes of being treated and non-treated, respectively. N_T shows the number of treated patients. $K(\bullet)$ is a Gaussian kernel function and $\tau(Intens_n, x_n)$ is a bandwidth parameter. Obviously, the latter term, $\sum_{j\in C} y_i^C K(p_j - p_i/\tau_n) / \sum_{l\in C} K(p_l - p_i/\tau_n)$ indicates y_{0i} which is the expected consistent outcome of being non-treated. We will obtain standard errors by using bootstrap replication.

6. Empirical Results

Table 2 reports the results for the probit estimation described in (1). We present only the key estimates of interest, $Intens_i$, for the two high-tech treatments. Note that the estimates are controlled for patients' characteristics, including demographic characteristics, comorbid diseases and severity measures, which are reported in Table 1. For the estimation for PTCA, we exclude 49 patients with CATH who did not undergo PTCA, in order to more clearly compare the treatment effects of

PTCA and drug use only.

We find that the probability of undergoing high-tech treatment is affected by a patient's characteristics as well as the density of medical resources in a region. The coefficients on the numbers of high-tech hospitals and physicians per 100,000 persons are significantly positive in the case of both CATH and PTCA use. The marginal effects indicate that an increase by one in the number of high-tech hospitals per 100,000 persons raises the probabilities of CATH and PTCA use by 10 and 12 percentage points, respectively. We obtain similar results for the number of physicians per 100,000 persons, but the sizes of the effects are much smaller. An increase by one in the number of physicians per 100,000 persons will raise the probabilities of CATH and PTCA by 0.2 and 0.3 percentage points, respectively. The number of high-volume hospitals has no effect on CATH, but does have an effect on PTCA use, with one additional high-volume hospital raising the probability of PTCA use by 12 percentage points. On the other hand, both CATH and PTCA are negatively correlated with the number of low-tech hospitals per 100,000 population, and an increase by one in the number of such hospital is associated with a 2 percentage point decrease in the probability of CATH and PTCA use. Finally, the number of hospital beds and population density have a negative effect on the probability of both CATH and PTCA use but the size of these effects is negligible.

Based on the probit estimates, we perform the kernel matching to estimate the average treatment effect, ATT^{Kernel}, for CATH versus no CATH (implying high-tech versus low-tech) and PTCA versus drug use only on per patient medical expenditure and hospitalization days. Table 3 reports the results. Patients' characteristics are also controlled for, as in the estimates for Table 2. The upper and lower panels report the results for the differences in medical expenditure and hospital days between the treated and non-treated group, respectively. In addition to the kernel matching method, we also perform a simple least-squares regression (LS) to examine the gap between before and after adjusting for selection bias. In the LS regression, the average treatment effect is represented by the coefficient on the dummy variable for those who underwent high-tech treatment.

Regarding the effects of high-tech treatment on hospital expenditure, the LS estimates show that the differences in patients' medical expenditure between treated and non-treated patients are approximately 1,183 thousand yen for CATH versus low-tech and 1,279 thousand yen for PTCA versus low-tech. Next, the estimated sizes of ATT^{Kernel} are 843 thousand for CATH and 912 thousand yen for PTCA. Although the effects are smaller in the kernel matching model, all of these estimates are statistically significant. These results show that the variations in per patient expenditure across hospitals can be explained by differences in the use of high-tech treatments. The difference between the LS estimates and the Kernel matching implies that in the LS estimates, selection bias was not adjusted for and the average treatment effect was therefore overestimated.

Next, we look at the difference in hospital days. In the LS model, the difference between the treated and the non-treated is about 3 days. However, once heterogeneity is adjusted for using the kernel matching method, unlike per patient expenditure, the sizes of the ATT^{Kernel} estimates increase slightly to 5 days, which is larger than in the LS estimates, but the difference is not statistically significant.

Our findings can be summarized as follows. We observe a substantial regional variation in the number of high-tech treatments, resultant per patient medical expenditure and hospitalization days. As stated above, we find that the probability of receiving high-tech treatment is affected by a patient's characteristics as well as the density of medical resources in a region. That the differences in high-tech treatment use across hospitals appear to be significantly influenced by the regional variations in the density of medical resources is consistent with previous studies which found that a greater number of high-tech hospitals within a regional area will contribute to a relatively high utilization of high-tech procedures. Moreover, once heterogeneity between treated and non-treated patients is adjusted for, medical expenditure is higher for treated patients. Obviously, the inclination toward the use of high-tech procedures leads to a higher hospital expenditures. However, we do not see a significant difference in hospitalization days. Our findings imply that higher medical costs as a result of the greater use of high-tech treatments is not associated with better outcomes, indicating that such treatments are used inefficiently. We suspect that the high volume of high-tech treatments is driven by economic motives, especially in crowded regions where hospitals compete with each other.

7. Conclusion

The use of PTCA treatments in Japan is extraordinarily high, resulting in large medical expenditures. Using a unique chart-based data set, TAMIS, which provides data on high-tech and low-tech medical care use and detailed patient characteristics, the purpose of this study was to examine what factors account for the high use of PTCA. To this end, we employed propensity score matching to estimate the average treatment effects of high-tech procedures on hospital expenditure and hospital days.

We found that the probability of receiving high-tech treatment was affected by a patient's characteristics as well as the density of medical resources in a region. Moreover, once heterogeneity between treated and non-treated patients is adjusted for, medical expenditure was higher for treated patients, although we found no significant differences in hospitalization days. Our findings imply that the higher medical costs resulting from high-tech treatments are not associated with better outcomes and the use of high-tech treatments is driven by economic motives. In other words, against the background of the fee-for-service scheme, hospitals administer high-tech services in response to competition in their sphere. Our empirical findings suggest that it is indispensable to formulate an effective policy to remove economic incentives which encourage the inefficient use of resources and to eliminate unnecessary and inappropriate use of high-tech treatments so as to restrain the enormous increase in medical expenses.

NOTES

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[1] Ministry of Health, Labour and Welfare, "Kokumin Iryohi" (National Medical Care Expenditure), various years.

[2] According to Japanese data for the 1990s.

[3] According to the vital statistics compiled by the Ministry of Health, Labour and Welfare, the age-adjusted mortality ratio was on a decreasing trend until the 1990s. Although there was a slight increase in the number of deaths per 100,000 population due to AMI to 40 for males and 20 for females (1995), this was partly the result of changes in Japan's death certificate system and the switch from ICD-9 to ICD-10 in 1995.

[4] The unbalanced pattern in terms of PTCA and CABG treatments may also reflect institutional features of the Japanese health care system. In general, the PTCA procedure is in the domain of internal medicine cardiologists, whereas CABG is in the domain of cardiovascular surgeons. These two types of specialization, internal medicine and surgery, are almost completely separated in Japan in terms of both education and career path.

[5] For details, see Appendix Table 1. Reimbursement rates are revised every three years by the government. The *Survey on National Medical Facilities* is compiled by the Ministry of Health, Labour and Welfare and provides comprehensive data on medical facilities in Japan.

[6] This tendency may be reinforced by the "non-distributional constraint," i.e., the fact that non-profit institutions are prohibited from distributing net earnings outside of the organization. Hansmann (1980) pointed out this feature of non-profit organizations and suggested that this may lead to a non-profit wage premium. Noguchi and Shimizutani (2007) empirically confirmed that such a premium exists in Japan's at-home care market. In this study, we focus on the behavior of nonprofit high-tech and high-volume hospitals rather than individual physicians' behavior, because our data do not allow us to match each patient to an individual physician.

[7] Since patients' hospital visits have not been well-managed in Japan due to the "free access" principle, patients often have to wait for many hours in a hospital lounge for medical examinations taking only a few minutes. This is particularly the case in high-volume and high-tech hospitals like university hospitals. In order improve the situation, the Ministry of Health, Labour and Welfare reformed the fee-schedule as of April of 2006, introducing reimbursements for the referral of patients by primary-care offices to other medical facilities. Primary-care offices thus have a financial incentive to refer patients to other hospitals, although the reform will reduce patients'

access to high-volume hospitals because patients now have to pay 10% to 30% of the referral fee out of pocket (with the rate depending on the type of insurance a patient is enrolled in).

[8] See McGuire (2000) for a comprehensive survey of the literature.

[9] There are also several Japanese studies that have tried to examine physician induced demand using prefecture-level data. Since the 1990s, many studies on PID adopted the two-phase model to region-level data. Whereas Yamada (2002) finds evidence of PID, Suzuki (1998), Kishida (2001) and Yuda (2004) do not.

[10] TAMIS is funded by the Pfizer Health Research Foundation, the Japan Foundation Center for Global Partnership, and the Economic and Social Research Institute, Government of Japan. We are very grateful to all the medical facilities that collaborated with us on this project.

[11] During the “national” phase of the project, HCFA conducted standardized abstractions of the medical records of all Medicare beneficiaries hospitalized with AMI over an eight-month period at essentially all hospitals in the United States that had not participated in a four-state “pilot” phase. The eight-month sampling frame was continuous at each hospital, and all sampling occurred between April 1994 and July 1995. Marciniak et al. (1998) provide more details on the CCP goals, sampling and data collection strategy, and methods to assure standardization and completeness of the medical record reviews. Charts were abstracted for approximately 180,000 AMI patients. These data were linked to Medicare administrative records (enrollment and hospitalization files), which have been used in previous observational studies of AMI practices and outcomes, but do not include the clinical details present in the medical record abstracts. The enrollment files include comprehensive all-cause mortality information from Social Security records.

[12] We also define CABG as a high-tech treatment, but the number of patients who underwent CABG in the TAMIS is too small (3.8 percent of the total) to perform regression analyses.

[13] We do not show the results for low-tech treatment effect. Since all patients who are not treated by CATH are categorized into the low-tech treatment group, the results are exactly the inverse of the CATH results.

[14] In 1998, the MHLW defined medical facilities capable of performing 200 or more PTCA

treatments and 30 or more CABG treatments per year as high-tech hospitals. WAMNET provides data on which procedures are available in a hospital, but the number of procedures performed is not available. In this study, we define a medical facility as a high-tech hospital if it is capable of providing PTCA.

[15] For hospitals in the Tokai area, the median number of beds is 100. Therefore, we define high-volume hospitals as medical facilities with more than 100 beds.

[16] See Becker and Ichino (2002).

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