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Physician-Induced Demand for Treatments for Heart Attack Patients in Japan:

Evidence from the Tokai Acute Myocardial Study (TAMIS)

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Abstract

Percutaneous Transluminal Coronary Angioplasty, henceforth (PTCA) for patients with acute myocardial infarction (AMI)—a high-tech treatment—is more frequently used in Japan than in other developed countries. This paper adopts the two-phase model to examine whether the high PTCA use is driven by the self-interest of physicians, or by behavioral character. After controlling for a patient's detailed characteristics, we found that increases in the relative numbers of hospitals and physicians are significantly related to physician-initiated expenditures and the effect is higher for high-tech treatments. The results based on municipal-level aggregated data also support this conclusion.

JEL classification: I11

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

1. Introduction

Heart disease is one of the most common causes of death in Japan, and consumes 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 (2.3 percent) to 746 (3.2 percent) billion yen during the same period¹. Among heart diseases, heart attacks are responsible for most of these deaths; more than one third of patients with heart diseases died of acute myocardial infarctions (AMI) in the 1990s.

We observe that the rapid cost expansion in heart diseases during the two decades is mainly attributed to higher per-patient costs, rather than the increasing number of incidences². Naturally, one reason for the higher costs is the technological progress in the AMI treatments that accompanies substantial outlays. According to the two-part of typology (McClellan and Noguchi (1998)), the AMI treatments are classified into high-tech and low-tech procedures. An important set of intensive high-tech treatments for heart attack care begins with cardiac catheterization (CATH) to visualize 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, two types of a "revascularization" procedure are often intended to improve blood flow to the heart. One is the angioplasty (Percutaneous Transluminal Coronary Angioplasty, henceforth, PTCA), which involves the use of a balloon (a stent, lately) 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. Those treatments require very high-skilled labor inputs, including

specialized cardiologists, cardiac surgeons, cardiac nurses, and procedure technicians. In addition, those medical procedures also need carefully controlled and dedicated settings. As a result, it is costly to maintain the capacity to provide those procedures, and those treatments are available in a limited number of hospitals. On the other hand, low-tech treatments require relatively cheaper costs, and in principle are provided by all medical facilities. Those treatments include the utilization of acute drug treatments including aspirin, thrombolytic drugs, beta blockers, calcium channel blockers, and angiotensin-converting-enzyme inhibitors.

Along with the technical advances in the AMI treatment, however, we suspect the possibility that the larger amount of AMI costs is caused by physician-induced demand. Especially, the growth rate of the number of PTCA treatment is much higher in Japan than in the United States, and 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)). Those studies also found that the ratio of PTCA to CABG is very high in Japan, almost five to one. Some cardiovascular surgeons pointed out the possibility that internal cardiologists perform unnecessary, inappropriate PTCA treatments (Sasakuri et al. (1997), Nishida et al. (1997))³.

Physicians are motivated to increase the number of high-tech treatments to cover the initial investment costs and to raise profits, since a high-tech treatment rewards medical doctors a higher amount of payment. Under the Japanese universal health insurance system, all physicians are reimbursed on a fee-for-service basis. Prices are regulated for all medical procedures and a predetermined number of fixed “points” (1 point is equivalent to 10 yen) is assigned to each process, including the dispense of medications, according to the fee schedule.

The fee schedule is determined by the government uniformly, and is applicable for all physicians in Japan.

Table 1 illustrates that the reimbursement rates for PTCA increased between 1993 and 1996 while the CABG reimbursement rates didn't change. During the same period, we observe that availability of those procedures substantially increased. Of more than 8,000 general hospitals in Japan in 1996, 609 and 453 were able to perform PTCA and CABG, respectively⁴. Whereas the total number of hospitals decreased between 1993 and 1996, the number of hospitals capable for high-tech treatments has increased by 228 (60 percent) for PTCA and 56 (14 percent) for CABG. During the same time period, the number of PTCA performed per month increased dramatically by 60 percent, while the number of CABG slightly increased by 4 percent. The increases in the numbers of PTCA hospitals and treatments, associated with the higher reimbursement rate, are, in turn, alleged to stimulate demand for high-tech treatments and contribute to the expansion of expenditures on the AMI treatments. Physicians take advantage of the information asymmetry between supply and demand to stimulate demand for their products. In most cases, patients are not able to not reject any medical care services proposed by physicians, who have high-skilled knowledge. Beginning with the classical studies in the 1970s, this type of moral hazard has been discussed as physician-induced demand (henceforth, PID), and has remained one of the most debated and unsolved issues in the health economics literature.

This study utilizes an original and rich micro-level dataset from the Tokai Acute Myocardial Infarction Study (called TAMIS) to examine whether PID is observed in the AMI treatment in Japan and, if so, how it contributed to the increase in costs. Despite the large volume of literature on PID, to our best knowledge there has been little research on PID

focusing on the comparison between high-tech and low-tech treatments in a specific disease, even in the United States. We explore PID in a specific disease with an emphasize on the difference in technology in the treatment on PID because high-tech treatments are alleged to invite the moral hazard of physicians to stimulate unnecessary expensive treatments so that they cover the investment costs and make profits. Moreover, most previous studies in Japan utilized prefecture-level data and faced difficulties with identification. The unique micro-level survey used in this study enables us to identify PID in the AMI treatment, empowered by the “two-phase model” to discriminate patient-induced demand and PID in the different technology level of the AMI treatments.

The reminder of this paper is organized as follows. The next section reviews related previous studies on PID. Section 3 describes the data. Section 4 justifies an empirical specification we use in this study, and section 5 adopts the two-phase model to investigate the existence and size of PID in the AMI treatments. The final section concludes, and discusses some policy implications of our findings.

2. Previous Studies on PID

Plenty of theoretical and empirical studies have analyzed PID in the economics of health care⁵. The discussion was first motivated by Feldstein (1970), which found an observed positive correlation of physician incomes with physician-population ratios. Some followers succeeded in modeling PID in the 1970s (Fuchs (1974), Evans (1974), and Reinhardt (1978)). A representative model assumes a competitive market for medical services with an upward supply curve and a downward demand curve. A

greater number of suppliers make the supply curve shift out and lower the equilibrium price and a supplier's revenue when price elasticity of demand is less than one. To avoid profit losses, physicians take advantage of the information asymmetry between physicians and patients to shift the demand curve out. Another approach is modeled by the principal-agent relationship to insist that an improper incentive mechanism invites agents (suppliers) to utilize information asymmetry to induce patient demand (McGuire (2001)).

Researchers have reached a consensus on the definition of PID over the past two decades; Physician-induced demand exists when the physician influences a patient's demand for care against the physician's interpretation of the best interest of the patient (McGuire (2001)). Although a number of studies support the existence of PID, most of them stumbled with the identification problem between supply and demand factors. A greater number of suppliers implies the possibility of PID and also affects patient preferences through lower access costs (McGuire (2001)). A famous counterintuitive example is proposed by Dranove and Wehner (1994) which found a positive relationship between the number of physicians and childbirth.

One effective way to discriminate between supply-side and demand-side factors is the "two-phase model" (Escarce (1992), Rossiter and Wilensky (1984)). Instead of examining the factors for total costs, this model divides medical costs into the probability of going to hospitals or clinics and medical costs per patient. Escarce (1992) found that the intensity of physicians affects the share of patients who go to receive medical services, but this is not the case for medical expenditure per patient. Examining the PID hypothesis with regard to different types of medical care has

significant policy implications. Schroeder (1992) reports that a great number of surgical specialists are associated with relatively high utilization of surgical procedures in the United States, and calls for reductions in specialty surgical residency programs. In addition, Crane (1992), Hillman et al. (1992), and Mitchell and Scott (1992) show that physicians who own diagnostic imaging equipment are more likely to order tests than are physicians who do not own equipment. As a result, many states have restricted self-referrals by physicians who own imaging equipment.

This study contributes to the previous studies on PID in the following two sides. First, despite the numerous studies on PID, as far as we know there has been little research focusing on the comparison between high-tech and low-tech treatments in a specific disease. We emphasize the effect of the difference in technology in the treatment on PID because most developed countries have suffered enormous medical costs, and technological advances in treatment account for the increase in per-patient medical expenditures. As discussed above, high-tech treatments are alleged to invite the moral hazard of physicians to cover their investment costs and to generate profits. Second, most previous studies in Japan utilized prefecture-level data, and faced difficulties in identification (Nishimura (1987)). After the 1990s, many studies on PID adopted the two-phase model to region-level data. While Yamada (2002) is supportive of the PID, Suzuki (1998), Kishida (2001) and Yuda (2004) find little effect of PID. To our best knowledge, this is the first research to use chart-based data to examine the existence and magnitude of PID in Japan.

3. Data

We use a unique micro-level dataset based on the Tokai Acute Myocardial Infarction Study (TAMIS)⁶. The main objective of TAMIS is to create a comparable database to the Cooperative Cardiovascular Project (CCP)⁷. The CCP is a major policy initiative to improve the quality of care for Medicare beneficiaries with AMI, undertaken by the Health Care Financing Administration (HCFA, currently called Center for Medicare and Medicaid Services: CMS). TAMIS aims to investigate variation in the quality of health care with respect to treatments and outcomes between the United States and Japan, controlling for chart-based detail clinical information on AMI patients.

The TAMIS charts have been abstracted for 2,020 heart attack patients admitted to 14 high-tech and high-volume medical facilities located in the Tokai area of Japan. All samples were those hospitalized between January 1995 and December 1997, a different period of the sampling for the CCP (between April 1994 and July 1995) in the United States. Since a major technological change in the aggressive use of stents for PTCA was observed in 1996-1997 in both countries, the difference in the sampling timing between both studies might not affect our results. During the survey period of TAMIS, there was no a change of reimbursement rates for treatments related with AMI.

In the process of the data collection, charts were carefully reviewed by research nurses and physicians. We followed the standardized abstractions of the medical records as the HCFA/CMS conducted for 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 influence the appropriateness of major AMI treatment decisions and health outcomes. Of the 2,020 patients, we used 1,047 patients living in 116 municipal areas of Aichi, Mie, Gifu, Shizuoka, and Nagano prefectures. Data for the 973 patients were removed, since the information on the municipal areas they lived were missing. In addition, to construct the physician density variable at municipal-level area ($Dens_{k,i,s}$) during the survey period of TAMIS, we also utilized the information provided by WAMNET (the website of *the Fukushi Iryo Kiko*, provided to a number of suppliers), the National Survey on Medical Facilities, and the Vital Statistics conducted by the MHLW.

Table 2 provides a description of the main variables. First, we observe that 845 (81 percent) and 668 (63 percent) patients underwent CATH and PTCA, respectively and 202 (20 percent) received acute drug treatments. Second, the density variables measurement at the municipal level reports that the number of high-tech hospitals is larger for high-tech than for low-tech patients while the remaining intensity variables are larger for low-tech patients than for high-tech patients. Third, total hospital expenditure for patients who underwent high-tech treatments totaled more than three million yen, much larger than that for low-tech patients (1.8 million yen). The average length of stay from the first hospital admission for high-tech patients (about 30 days) is also longer than that for low-tech patients (24 days) by about 5 or 6 days. Fourth, as regards patient characteristics, high-tech patients were more likely to be male (77 percent versus 66 percent), to be younger (63 versus 71 years old), and to live with a spouse (80 percent versus 64 percent) than low-tech patients. Further, high-tech patients are more likely to enroll into employees' health insurance (43 percent versus 30 percent), but less

likely to enroll into national health insurance (44 percent versus 51 percent) or health insurance for the elderly (31 percent versus 58 percent) than for low-tech patients.

The remainder of Table 2 reports the rates of detailed chart-based comorbid diseases and severity measures. High-tech and low-tech patients differ substantially in almost all of these measures. Overall, patients who underwent high-tech procedures are generally in better health. High-tech patients are much more likely to be in good functional status, e.g., 97 percent versus 87 percent measured in the independent mobility rates. In addition, those patients are less likely to have serious comorbid diseases like angina, prior cardiac heart failure, renal failure, cerebral infarction, and terminal illness. Moreover, patients undergoing high-tech procedure were much more likely to be alert and oriented on initial admission, to have no signs of serious heart failure (e.g., high heart rate), and to have good kidney function shown by unelevated blood nitrogen levels.

It is difficult to interpret the cumulative consequences of the differences for outcomes with a hundred variables that describe patient characteristics. For this reason, we constructed a summary indicator of the disease comorbidity and severity. The Killip class is based on 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 the short-term AMI mortality. The Killip classes 1 and 2 indicate relatively mild heart failure, and Killip classes 3 and 4 refer to moderate and severe heart failure, which are severer than Killip classes 1 and 2. As Table 2 reports, high-tech patients are much more likely to be in lower Killip class 1 or 2.

The basic statistics in Table 2 provide clear evidence that patient characteristics are very heterogeneous, and a simple comparison in the sample statistics is not useful for direct comparisons between high-tech and low-tech treatments. Therefore, we must control for these

detailed patient characteristics carefully to evaluate the presence and magnitude of PID.

4. Empirical Specification and Measurements

In this section, we explain our empirical specification briefly. We aim to use the two-phase model to examine the existence and size of PID for high-tech and low-tech treatments of AMI patients, separately. We define CATH and PTCA performed within the first hospitalization after AMI occurs as a measure of high-tech procedure, and acute drug treatments as low-tech treatments⁸.

First, we will examine “physician initiated demand” using each patient’s medical expenditure of the first hospitalization as a dependent variable. The following regression formula is set up:

$$y_{i,s} = \alpha_0 + \sum_k \alpha_{1k} Dens_{k,i,s} + \sum_l \alpha_{2l} x_{l,i,s} + \varepsilon_{i,s} \quad (1)$$

where $y_{i,s} = \begin{cases} y_{i,s} & \text{if } y_{i,s}^* > 0 \\ 0 & \text{otherwise} \end{cases}$

The dependent variable, $y_{i,s}$, shows a logarithmic value of i th patient’s expenditure for s th treatment, CATH, PTCA, or low-tech acute drug treatments. If a patient did not undergo a treatment of interest, we do not observe $y_{i,s}$ for i th patient’s expenditure, which makes us employ the Tobit estimation. $Dens_{k,i,s}$, the main interest variable, includes six types of density variables at municipal-level area specific characteristics; number of hospital beds per 100,000 population (BEDS); number of high-tech hospitals⁹ (capable of performing PTCA) per 100,000 population (HIGHTECH);

number of low-tech hospitals (incapable of performing PTCA) per 100,000 population (LOWTECH); number of high volume hospitals with more than 100 beds per 100,000 population¹⁰ (HIGHVOL); number of physicians per 100,000 population (MD); and population density per squared kilometer (POPDENS). If the coefficient on those density variables is positive, it implies that physicians are motivated to increase the number of treatments to make profits under Japan's fixed fee-for-service scheme.

$x_{l,i,s}$ presents i th patient's outcome, demographic characteristics, economic status, comorbid, and severity indicators. We include total hospital days (HOSPDAYS) as a patient outcome as an explanatory variable. Demographic characteristics include a patient's age, sex, number of family members living with a patient, and presence of spouse. Since the data on a patient's income is not available, we use three types of health insurance enrollment dummies (employee's health insurance; national health insurance, and health insurance for the elderly) as his economic status. The type of health insurance enrollment is also considered the most appropriate measure of out-of-pocket expenses because of difference in copayments for the services in the survey period (20 percent for employees' health insurance; 10 percent for national health insurance; no copayments for health insurance for the elderly)¹¹. Comorbid and severity indicators are comprised of detailed chart-based information, including continence and mobility status, hypertension, diabetes, cardiac heart failure (CHF), MAP, BMI, highest creatinine, white blood cells, platelets, and EKG records. Finally, $\varepsilon_{i,s}$ is an error term.

Second, to distinguish "patient initiated demand" and "physician initiated demand," we use probability to choose each patient's treatment as a dependent variable. The

specification is as follows:

$$T_{i,s} = \beta_0 + \sum_k \beta_{1k} \text{Dens}_{k,i,s} + \sum_l \beta_{2l} x_{l,i,s} + \omega_{i,s} \quad (2)$$

where $T_{i,s} = \begin{cases} 1 & \text{if } T_{i,s}^* > 0 \\ 0 & \text{otherwise} \end{cases}$

The dependent variable, $T_{i,s}$, shows the tendency for each patient to choose an AMI treatment.

Since we do not observe the probability to select a treatment, we instead use a dummy variable of i th patient's actual choice of s th treatment, CATH, PTCA, or low-tech acute drug treatment. Therefore, we estimate (2) by the probit procedure. The definitions of each explanatory variable are the same as (1), and $\omega_{i,s}$ is an error term. If the coefficient on the density variables is positive and significant, the result indicates a patient's referral demand, which suggests that the higher intensity of physicians could reduce the access costs to physicians. In addition, a higher intensive supply of medical care could lead to higher quality of service due to the increased competition and stimulate demand for those treatments.

Finally, to confirm our micro-based results, we sum up our data at the municipal-level and the following regression corresponding to (1) and (2), since most previous studies on PID utilized aggregated local area-level data.

$$y_{m,s} = \alpha_{0m} + \sum_k \alpha_{2km} \text{Dens}_{k,m,s} + \sum_l \alpha_{3lm} x_{l,m,s} + \varepsilon_{m,s} \quad (3)$$

$$T_{m,s} = \beta_{0m} + \sum_k \beta_{2km} \text{Dens}_{k,m,s} + \sum_l \beta_{3lm} x_{l,m,s} + \omega_{m,s} \quad (4)$$

Equations (3) and (4) examine PID and patient initiated demand, respectively. The dependent variables, $y_{m,s}$ and $T_{m,s}$, stand for a logarithmic value of m th area's average medical expenditure and probability to receive an AMI treatment in the m th area for s th treatment. In those regressions, the high-tech treatments are solely defined as PTCA for the aggregated data. The definitions of $Dens_{k,m,s}$ are the same as above. We also take an average for patient characteristics as well as the mean taxable income in an area instead of health insurance status for an economic status. Since the number of observations for municipal-level data is 116 and extensive comorbid and severity indicators are not appropriate, we use the Killip class rates to represent patient severity.

5. Empirical Results

Table 3 reports the empirical results based on Equations (1) and (2) for PTCA and CABG. Table 4 shows those results for low-tech treatments. Overall, those tables support the presence of either PID or patient initiated induced demand for high-tech and low-tech treatments. The key variables of our interest are $Dens_{k,i,s}$.

The first and second columns of Table 3 report the results based on Equation (1). The coefficients on the numbers of high-tech hospitals (HIGHTECH) and physicians (MD) per 100,000 population are positive and significant. The marginal effect of HIGHTECH indicates that an increase by one in the number of high-tech hospitals per 100,000 raises medical expenses for CATH and PTCA by 1.3 percent and 1.1 percent. On the other hand, an increase in the number of low-tech hospitals (LOWTECH) per 100,000 decreases expenditure on those high-tech treatments. Our results are consistent with Schroeder (1992), Crane (1992), Hillman

et al. (1992), and Mitchell and Scott (1992) in that a great number of high-tech medical facilities attribute to relatively high utilization of the procedures. The marginal effect of an increase by one in the number of physicians per 100,000 raises expenditure by 0.03 percent and 0.05 percent for CATH and PTCA, which are much smaller than HIGHTECH. Not surprisingly, the number of high volume hospitals (HIGHVOL) is also positively correlated with medical expenditure per patient, but not statistically significant.

The remaining columns of Table 3 report the results based on Equation (2). The variables include HIGHTECH, HIGHVOL, and MD are positively correlated with the probability to undergo high-tech treatments. The marginal effects of HIGHTECH indicate that an increase by one in the number of high-tech hospitals per 100,000 raises the probabilities of a patient to choose CATH and PTCA by 8 and 7 percentage points, while an increase in LOWTECH decreases the likelihood to choose high-tech treatments. Further, an increase by one in the number of HIGHVOL raises the probabilities of patient referral choice for CATH and PTCA by 6 and 8 percentage points. The marginal effect of MD on a patient's high-tech choice is also statistically significant, but the size is negligible.

As regards patient characteristics, for PTCA we find positive correlation of a dummy variable of health insurance for the elderly in both (1) and (2), though they are not significant. Patients enrolled into health insurance for the elderly have per patient medical expenses for PTCA that are about 2 percent higher, and they are more likely to choose PTCA at a rate of about 12 percent greater than those with other insurance schemes. In the survey period, the elderly enrolled into this insurance scheme do not have to copay their medical fees, and thus the moral hazard might have been larger.

On the other hand, Table 4 reports the results on Equations (1) and (2) for low-tech

treatments where we observe positive and significant coefficients on the density variables. The first column of Table 4 shows that the number of beds per 100,000 (BEDS) and LOWTECH is positively correlated with medical expenditure per patient, though the marginal effect of BEDS is very small. The marginal effect of LOWTECH indicates that an increase by one in the number of low-tech hospitals per 100,000 raises medical expenses per patient for acute drug treatment by 0.1 percent. In contrast to the results on the high-tech treatments, an increase in HIGHTECH, HIGHVOL, and MD decreases medical expenditure by 0.5 percent, 0.4 percent, and 0.01 percent, respectively.

The second column of Table 4 reports the results based on Equation (2). We observe similar correlations between the density variables and probability to choose low-tech treatments. The marginal effects of BEDS and LOWTECH indicate that an increase by one in the number of beds and low-tech hospitals per 100,000 raises patient initiated demand for acute drug treatment by 0.01 percent and 1.4 percent, respectively while an increase in HIGHTECH, HIGHVOL, and MD decreases patient initiated demand for low-tech treatments by 8 percent, 6 percent, and 0.2 percent, respectively.

Finally, to confirm our micro-level results as above, Table 5 reports municipal-level regression results based on Equations (3) and (4). For high-tech treatments, the coefficients on HIGHTECH are positive and significant for both specifications. An increase by one in HIGHTECH raises expenditure per person by 0.1 percent, and the probability to choose the treatment by 3.0 percent. The effects of LOWTECH and MD are also statistically significant in Equation (3), but the sizes are small. For low-tech treatments, the coefficients on HIGHTECH are negative but insignificant in both (3) and (4). Those results are consistent with our findings based on micro-level data.

6. Conclusions

This paper explores whether either the physician's or patient's initiation of high-tech and low-tech medical services primarily reflects their own self-interest or behavior, using the two-phase model. We use a unique micro-level survey, TAMIS, which provides data on high-tech and low-tech medical care use by detailed patient chart-based characteristics. Furthermore, we merged TAMIS with municipal-level data on the intensity of medical care. After controlling for a patient's detailed characteristics, we found that increases in the relative numbers of hospitals and physicians are significantly related to physician-initiated expenditures and the effect is higher for high-tech treatments. The results based on municipal-level aggregated data also support this conclusion. Positive correlation between the intensity of medical services with medical expenditure indicate that physicians respond to more competition by generating greater demand for their services by increasing outputs, under Japan's fixed reimbursement system. As some cardiovascular surgeons have pointed out, we cannot completely reject the possibility of unnecessary and inappropriate PTCA performed by internal cardiologists.

Although the number of patients who died of AMI in Japan remains smaller than that in the United States, medical costs for the AMI patients are expected to expand due to the increasing number of incidences as well as to the higher cost per patient. The rapid speed of aging in Japan will accelerate the expenditure on AMI in future. Our empirical findings suggest that any policy to prevent moral hazard behavior is indispensable for high-tech

treatments, which cause an enormous increase in medical expenses.

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Notes

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¹ Ministry of Health Labour and Welfare, Kokumin Iryohi (National Medical Care Expenditure).

² 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. The number of patients who died by

AMI per 0.1 million people slightly increased to 40 for males and 20 for females in 1995, partly because of the change in Japan's death certificate and the switch from the ICD9 to the ICD 10 in 1995.

³ The unbalanced treatment pattern between PTCA and CABG may be caused by the three factors: (1) the reimbursement rates for PTCA over CABG, relative to the costs for those procedures, (2) the historically high mortality rate from CABG, and (3) institutional features of the Japanese health care, i.e. the PTCA procedure is, in general, in the domain of internal medicine cardiologists, whereas CABG is in the domain of cardiovascular surgeons. These two specialists, internal medicine and surgery, are almost completely separated in Japan in terms of both education and career path. Many concerns have been expressed over serious lack of communication and coordination between the two parties. Contrary to cardiovascular surgeons' remarks on the PTCA, internal medicine specialists condemn the high mortality rate for CABG, though many cardiovascular surgeons insist that the CABG performance has improved to the level of Western countries.

⁴ The data are available on the Survey on National Medical Facilities (Iryo Shisetsu Chosa). This survey is compiled by the Ministry of Health, Labour and Welfare and provides comprehensive data on medical facilities in Japan.

⁵ McGuire (2001) provides a comprehensive survey on PID.

⁶ 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 really appreciate all the medical facilities that collaborated with us on this project.

⁷ 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) provides 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.

⁸ CABG is also defined as high-tech treatment. Yet, the number of patients who underwent CABG in TAMIS is too few (3.8 percent) to perform regression analysis.

⁹ In 1998, the MHLW defines a medical facility capable of performing 200 or more PTCA treatments and 30 or more CABG treatments per year as a high-tech hospital. WAMNET provides the 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 capable of providing PTCA as a high-tech hospital.

¹⁰ For hospitals in the Tokai area, the median number of beds is 100. Therefore, we define a medical facility with more than 100 beds as a high-volume hospital.

¹¹ The omitted category is patients with other health insurance such as Public Livelihood Assistance, Seamens' Health Insurance, and Mutual Aid Health Insurance.

Table 1: Fee schedule for reimbursement rates, number of high-tech hospitals and treatments performed in September of 1993 and 1996

	1993	1996
<u>PTCA</u>		
Fee schedule for reimbursement	13,800	15,500
Number of PTCA hospitals	381	609
Number of PTCA performed	3,648	5,818
<u>CABG</u>		
Fee schedule for reimbursement		
1	37,100	37,100
2 or more	60,500	60,500
Number of CABG hospitals	397	453
Number of CABG performed	2,699	2,814

Source: Ministry of Health, Labour and Welfare, *Shinryo Hoshu Tensu Hayamihyo* (Quick reference table of fee schedules) and *Iryo-shisetsu chosa* (National Survey on Medical Facilities).

Notes: Reimbursement rates for procedures are measured in points (1point=10yen). The numbers of general hospitals in Japan are 8,752, and 8,421, in 1993 and 1996, respectively.

Table 2: Basic statistics for estimating two-phase model for physician and patient induced demand

Mean (Std. Dev)	Total (N=1,047)	High-tech treatments		Low-tech treatments
		CATH (N=845)	PTCA (N=668)	(N=202)
<u>1. Density at municipal level</u>				
Number of hospital beds per 100,000 population	818.663 (466.628)	806.546 (467.585)	792.384 (439.235)	869.350 (460.295)
Number of high-tech hospitals (PTCA available) per 100,000 population	1.174 (0.603)	1.177 (0.622)	1.189 (0.620)	1.162 (0.521)
Number of low-tech hospitals (no PTCA available) per 100,000 population	3.752 (1.891)	3.660 (1.890)	3.571 (1.892)	4.129 (1.854)
Number of high volume hospitals with more than 100 beds per 100,000 population	2.592 (1.604)	2.573 (1.625)	2.566 (1.574)	2.672 (1.513)
Number of physicians per 100,000 population	157.860 (53.616)	156.189 (52.536)	156.129 (51.422)	164.850 (57.529)
Population density (per squared kilometer)	3,246 (2,724)	3,129 (2,612)	3,100 (2,552)	3,739 (3,109)
Mean taxable income (yen)	3,728,775 (265,179)	3,719,125 (260,001)	3,701,869 (244,194)	3,769,141 (282,946)
<u>2. Patient outcomes</u>				
1st hospitalization-total hospital expenditure (y)	2,870,756 (6,492,285)	3,127,469 (7,035,974)	3,331,333 (7,791,951)	1,796,879 (3,168,448)
1st hospitalization-total hospital days	28.408 (25.256)	29.576 (25.716)	28.647 (25.641)	23.520 (22.645)
<u>3. Patient characteristics</u>				
Sex (Female=1)	0.258 (0.438)	0.238 (0.426)	0.225 (0.418)	0.342 (0.475)
Age	64.634 (11.749)	63.059 (11.268)	62.820 (11.371)	71.213 (11.458)
Number of family members living with a patient	2.272 (1.513)	2.322 (1.502)	2.346 (1.499)	2.064 (1.542)
Presence of spouse (=1 if any)	0.758 (0.428)	0.787 (0.410)	0.807 (0.395)	0.639 (0.482)
Employees' health insurance (enrollment=1)	0.404 (0.491)	0.428 (0.495)	0.428 (0.495)	0.302 (0.460)
National health insurance (enrollment=1)	0.458 (0.499)	0.447 (0.498)	0.442 (0.497)	0.505 (0.501)
Health insurance for the elderly (enrollment=1)	0.360 (0.480)	0.308 (0.462)	0.305 (0.461)	0.579 (0.495)
<u>4. Cormorbidity variables</u>				
Continence: totally continent	0.944 (0.231)	0.961 (0.194)	0.952 (0.214)	0.871 (0.336)
Continence: occasionally incontinent	0.004 (0.062)	0.001 (0.034)	0.001 (0.039)	0.015 (0.121)
Continence: no urine output	0.003 (0.053)	0.001 (0.034)	0.001 (0.039)	0.010 (0.099)
Continence: Unknown Urinary Continence	0.050 (0.217)	0.037 (0.188)	0.045 (0.207)	0.104 (0.306)
Mobility: Walks Independently	0.950 (0.217)	0.970 (0.170)	0.969 (0.175)	0.866 (0.341)
Mobility: Walks with assistance	0.011 (0.106)	0.009 (0.097)	0.010 (0.102)	0.020 (0.140)
Mobility: Unable to walk	0.011 (0.102)	0.004 (0.060)	0.003 (0.055)	0.040 (0.196)
Mobility: Unknown Mobility	0.028 (0.164)	0.017 (0.128)	0.018 (0.133)	0.074 (0.263)
Hypertension	0.374	0.370	0.371	0.391

	(0.484)	(0.483)	(0.484)	(0.489)
Hyperlipemia	0.129	0.135	0.133	0.104
	(0.335)	(0.342)	(0.340)	(0.306)
Diabetes (any type)	0.252	0.246	0.241	0.277
	(0.434)	(0.431)	(0.428)	(0.449)
Diabetes treated by insulin	0.049	0.052	0.048	0.035
	(0.215)	(0.222)	(0.214)	(0.183)
Angina	0.159	0.147	0.150	0.208
	(0.365)	(0.354)	(0.357)	(0.407)
Cardiac heart failure or pulmonary edema	0.064	0.040	0.033	0.163
	(0.245)	(0.197)	(0.179)	(0.371)
Old myocardial infarction	0.098	0.097	0.097	0.104
	(0.298)	(0.296)	(0.297)	(0.306)
Current cigarette smoker	0.521	0.557	0.567	0.366
	(0.500)	(0.497)	(0.496)	(0.483)
Arrhythmia	0.126	0.120	0.102	0.153
	(0.332)	(0.325)	(0.303)	(0.361)
Family medical history of ischemic heart disease	0.158	0.159	0.154	0.153
	(0.365)	(0.366)	(0.361)	(0.361)
Renal failure	0.025	0.019	0.016	0.050
	(0.156)	(0.136)	(0.127)	(0.217)
Cirrhosis	0.005	0.005	0.006	0.005
	(0.069)	(0.069)	(0.077)	(0.070)
Cerebrovascular accident: Cerebral infarction	0.085	0.078	0.073	0.114
	(0.279)	(0.268)	(0.261)	(0.318)
Cerebrovascular accident: Brain hemorrhage	0.010	0.011	0.010	0.005
	(0.097)	(0.103)	(0.102)	(0.070)
Cerebrovascular accident: Subarachnoid hemorrhage	0.004	0.004	0.004	0.005
	(0.062)	(0.060)	(0.067)	(0.070)
COPD	0.011	0.012	0.013	0.010
	(0.106)	(0.108)	(0.115)	(0.099)
Aneurysm of aorta	0.011	0.012	0.009	0.005
	(0.102)	(0.108)	(0.094)	(0.070)
Ulcer pepticum	0.089	0.096	0.090	0.059
	(0.285)	(0.295)	(0.286)	(0.237)
Cancer	0.043	0.040	0.042	0.054
	(0.203)	(0.197)	(0.201)	(0.227)
Autoimmune disease	0.011	0.005	0.004	0.035
	(0.102)	(0.069)	(0.067)	(0.183)
Drug allergy/med reaction	0.055	0.058	0.055	0.045
	(0.229)	(0.234)	(0.229)	(0.207)
Dementia/alzheimer's disease	0.014	0.014	0.013	0.015
	(0.119)	(0.118)	(0.115)	(0.121)
Terminal illness	0.003	0.001	0.001	0.010
	(0.053)	(0.034)	(0.039)	(0.099)
CAG history	0.092	0.088	0.088	0.109
	(0.289)	(0.283)	(0.284)	(0.312)
PTCA history	0.046	0.047	0.049	0.040
	(0.209)	(0.212)	(0.217)	(0.196)
CABG history	0.004	0.005	0.004	0.000
	(0.062)	(0.069)	(0.067)	(0.000)

5. Severity variables on admission

Heart rate	81.010 (20.300)	79.524 (19.020)	79.449 (18.964)	87.433 (24.117)
Temperature	36.211 (0.737)	36.195 (0.731)	36.149 (0.755)	36.286 (0.766)
Systolic blood pressure	129.951 (27.787)	131.668 (27.492)	132.484 (28.103)	122.379 (27.891)
Diastolic blood pressure	73.263 (17.378)	74.102 (17.105)	74.224 (17.535)	69.475 (18.130)
MAP (excluding <0 and >300)	92.432 (19.080)	93.527 (18.776)	93.825 (19.360)	87.483 (19.699)
Height	160.130 (10.192)	160.385 (10.421)	160.610 (10.645)	158.707 (8.711)
Weight	59.552 (11.875)	59.984 (11.835)	60.226 (11.913)	57.117 (11.846)
BMI: (Weight (kg))/(Height (m))^2	18.988 (9.394)	20.115 (8.540)	20.100 (8.524)	14.275 (11.197)
Glucose	179.822 (88.014)	175.612 (80.235)	172.142 (73.440)	197.576 (113.750)
Albumin	3.835 (0.613)	3.859 (0.608)	3.852 (0.619)	3.714 (0.626)
Highest creatinine	1.403 (1.502)	1.393 (1.601)	1.381 (1.577)	1.444 (0.970)
Hematocrit	44.573 (16.870)	45.499 (17.262)	46.431 (18.234)	40.568 (14.428)
White blood cells (unit:000)	10.434 (3.704)	10.442 (3.636)	10.453 (3.657)	10.398 (3.992)
Platelets (unit:0000)	21.945 (7.398)	22.038 (7.112)	21.848 (6.915)	21.539 (8.536)
Blood urea nitrogen (BUN/SUN)	18.323 (9.284)	17.507 (8.682)	17.199 (7.641)	21.867 (10.876)
EKG trace: MI/injury	0.816 (0.388)	0.819 (0.385)	0.837 (0.370)	0.802 (0.399)
EKG trace: transmural (new qwave) MI	0.104 (0.306)	0.105 (0.307)	0.121 (0.327)	0.099 (0.299)
EKG trace: old/remote MI	0.104 (0.306)	0.097 (0.296)	0.094 (0.292)	0.134 (0.341)
EKG trace: ventricular tachycardia/flutter	0.141 (0.349)	0.131 (0.338)	0.141 (0.348)	0.183 (0.388)
EKG trace: atrial fibrillation/flutter	0.094 (0.291)	0.088 (0.283)	0.076 (0.266)	0.119 (0.324)
EKG trace: LBBB	0.020 (0.140)	0.015 (0.123)	0.016 (0.127)	0.040 (0.196)
EKG trace: RBBB	0.074 (0.263)	0.073 (0.261)	0.073 (0.261)	0.079 (0.271)
EKG trace: left fascicular blocks	0.004 (0.062)	0.005 (0.069)	0.006 (0.077)	0.000 (0.000)
EKG trace: heart block, 2nd/3rd degree	0.062 (0.241)	0.063 (0.243)	0.066 (0.248)	0.059 (0.237)
CHF (congestive heart failure) /pulmonary edema on chest X rays	0.292 (0.455)	0.271 (0.445)	0.268 (0.443)	0.381 (0.487)
Stress test suggests ischemia	0.030 (0.170)	0.032 (0.176)	0.027 (0.162)	0.020 (0.140)
Killip1 or Killip2	0.585 (0.493)	0.624 (0.485)	0.623 (0.485)	0.421 (0.495)
Killip class 3	0.189 (0.392)	0.172 (0.377)	0.168 (0.374)	0.262 (0.441)
Killip class 4	0.226 (0.419)	0.205 (0.404)	0.210 (0.407)	0.317 (0.466)

Table 3: Estimates of two-phase model: Tobit estimates of physician-initiated expenditures and Probit estimates of patient-initiated choice for high-tech treatments on first admission

Explanatory variables	Equation (1) Physician-initiated expenditures for high-tech treatments (Tobit)					Equation (2) Patient-initiated choice for high-tech treatments (Probit)						
	CATH		PTCA			CATH		PTCA				
	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect		
	(Std err.)		(Std err.)		(Std err.)		(Std err.)		(Std err.)			
1. Density at municipal level												
Number of hospital beds per 100,000 population	-0.002 (0.001)	-0.002	c	-0.004 (0.002)	-0.003	c	-0.001 (0.0005)	-0.0001	b	-0.001 (0.0004)	-0.0002	b
Number of high-tech hospitals (PTCA available) per 100,000 population	1.286 (0.379)	1.256	a	1.420 (0.651)	1.089	a	0.462 (0.135)	0.081	a	0.194 (0.099)	0.072	a
Number of low-tech hospitals (no PTCA available) per 100,000 population	-0.204 (0.072)	-0.199	a	-0.207 (0.124)	-0.159	b	-0.077 (0.026)	-0.014	a	-0.027 (0.019)	-0.010	c
Number of high volume hospitals with more than 100 beds per 100,000 population	0.734 (0.462)	0.716	c	1.127 (0.783)	0.864	c	0.314 (0.172)	0.055	b	0.221 (0.124)	0.082	b
Number of physicians per 100,000 population	0.026 (0.010)	0.026	a	0.051 (0.016)	0.039	a	0.012 (0.005)	0.002	a	0.010 (0.003)	0.004	a
Population density (per squared kilometer)	-0.001 (0.0002)	-0.001	a	-0.001 (0.0004)	-0.0004	c	-0.0003 (0.0001)	-0.00005	a	-0.0001 (0.0001)	-0.00004	b
2. Patient outcomes												
1st hospitalization-total hospital days	-6.273 (8.798)	0.035		0.018 (0.015)	0.014		0.014 (0.005)	0.002	a	0.001 (0.002)	0.0003	
3. Patient characteristics												
Female	0.411 (0.204)	-5.949	a	-9.813 (14.778)	-6.594		-5.828 (4.515)	-0.996		-7.596 (3.769)	-0.989	a
Age	-0.005 (0.002)	0.402	a	0.484 (0.347)	0.371		0.034 (0.075)	0.006		0.044 (0.053)	0.016	
Age_squared	0.216 (0.278)	-0.004		-0.006 (0.003)	-0.005	a	-0.001 (0.001)	-0.0001		-0.001 (0.000)	-0.0002	c
Female*Age	-0.002 (0.002)	0.210		0.186 (0.468)	0.142		0.175 (0.137)	0.031		0.215 (0.115)	0.080	b
Female*Age_squared	-0.008 (0.154)	-0.002		0.000 (0.004)	0.000		-0.001 (0.001)	-0.0002		-0.001 (0.001)	-0.001	b
Number of family members living with a patient	0.732 (0.585)	-0.008		-0.035 (0.262)	-0.026		-0.003 (0.050)	-0.001		-0.001 (0.039)	-0.0005	
Presence of spouse	-0.684 (0.808)	0.713		2.591 (1.002)	1.927	a	0.225 (0.188)	0.042		0.350 (0.147)	0.133	a
Employees' health insurance	-1.029 (0.773)	-0.668		-1.990 (1.355)	-1.515	c	-0.239 (0.280)	-0.043		-0.313 (0.209)	-0.116	c
National health insurance	0.379 (0.856)	-1.004		-1.937 (1.297)	-1.481	c	-0.366 (0.262)	-0.065		-0.283 (0.199)	-0.105	
Health insurance for the elderly	0.308 (0.462)	0.370		2.295 (1.451)	1.784	c	0.110 (0.272)	0.019		0.339 (0.216)	0.122	c
4. Comorbidity variables												
Continence: occasionally incontinent	-37.041	-11.114		-53.097	-7.872		-	-		-	-	
Continence: no urine output	-3.946 (4.346)	-3.729		0.373 (7.250)	0.288		-0.882 (0.952)	-0.243		-0.060 (0.948)	-0.022	
Continence: Unknown Urinary Continence	2.642 (1.533)	2.604	b	6.952 (2.600)	5.936	a	0.721 (0.491)	0.081	c	0.916 (0.422)	0.260	a
Mobility: Walks Independently	-2.250 (2.176)	-2.165		-3.207 (3.788)	-2.276		-1.116 (0.615)	-0.330	b	-0.425 (0.606)	-0.165	
Mobility: Walks with assistance	-8.610 (3.805)	-7.454	a	-11.711 (6.396)	-6.228	b	-1.083 (1.008)	-0.319		-1.377 (0.887)	-0.491	c
Mobility: Unable to walk	-0.361 (1.886)	-0.352		-4.218 (3.255)	-2.919		0.055 (0.593)	0.009		-0.563 (0.510)	-0.220	
Hypertension	-0.108 (0.453)	-0.105		0.024 (0.766)	0.019		0.047 (0.150)	0.008		0.033 (0.116)	0.012	
Hyperlipemia	-0.334 (0.611)	-0.325		0.218 (1.036)	0.168		-0.123 (0.212)	-0.023		0.108 (0.157)	0.039	
Diabetes (any type)	-1.054 (0.541)	-1.027	b	-0.853 (0.913)	-0.648		-0.354 (0.177)	-0.069	b	-0.145 (0.138)	-0.054	
Diabetes treated by insulin	2.194 (1.090)	2.160	a	0.858 (1.851)	0.669		0.804 (0.405)	0.086	b	0.077 (0.283)	0.028	
Angina	-1.389 (0.651)	-1.349	a	-0.143 (1.096)	-0.109		-0.321 (0.221)	-0.064	c	-0.045 (0.165)	-0.017	
Cardiac heart failure or pulmonary edema	-3.727 (0.986)	-3.549	a	-3.324 (1.749)	-2.377	b	-0.855 (0.282)	-0.223	a	-0.401 (0.244)	-0.155	c
Old myocardial infarction	0.647 (0.850)	0.633		0.180 (1.435)	0.138		0.152 (0.282)	0.024		0.000 (0.214)	0.000	
Current cigarette smoker	0.888 (0.496)	0.867	b	1.700 (0.838)	1.302	a	0.254 (0.165)	0.045	c	0.275 (0.127)	0.102	a
Arrhythmia	0.700 (0.717)	0.685		-2.072 (1.243)	-1.533	b	0.268 (0.237)	0.041		-0.305 (0.175)	-0.116	b
Family medical history of ischemic heart disease	-0.177	-0.173		-0.750	-0.569		-0.036	-0.006		-0.070	-0.026	

	(0.594)		(1.010)		(0.198)		(0.153)		
Renal failure	-2.425 (1.753)	-2.331	-2.051 (3.045)	-1.502	-0.726 (0.572)	-0.186	-0.218 (0.467)	-0.083	
Cirrhosis	0.506 (3.539)	0.496	4.971 (5.822)	4.172	-0.279 (0.921)	-0.058	0.452 (0.825)	0.148	
Cerebrovascular accident: Cerebral infarctio	0.383 (0.865)	0.374	-1.609 (1.471)	-1.196	0.320 (0.298)	0.047	-0.238 (0.220)	-0.091	
Cerebrovascular accident: Brain hemorrhage	4.109 (2.401)	4.065	b 5.033 (4.004)	4.225	-	-	0.844 (0.739)	0.240	
Cerebrovascular accident: Subarachnoid hemorrhage	-2.918 (3.581)	-2.790	1.197 (5.922)	0.942	-1.363 (0.988)	-0.430	0.244 (0.941)	0.085	
COPD	2.514 (1.841)	2.478	4.870 (3.048)	4.074	c 1.256 (0.762)	0.097	b 0.625 (0.485)	0.194	
Aneurysm of aorta	1.039 (2.010)	1.019	-2.183 (3.527)	-1.591	0.575 (1.041)	0.069	-0.263 (0.525)	-0.101	
Ulcus pepticum	1.467 (0.776)	1.440	b 0.086 (1.321)	0.066	0.772 (0.335)	0.089	a -0.029 (0.195)	-0.011	
Cancer	0.811 (1.167)	0.794	2.110 (1.957)	1.685	0.517 (0.442)	0.065	0.289 (0.296)	0.100	
Autoimmune disease	-10.003 (2.366)	-8.345	a -3.820 (3.952)	-2.665	-1.516 (0.557)	-0.488	a -0.211 (0.518)	-0.081	
Drug allergy/med reaction	-0.737 (0.912)	-0.717	-1.955 (1.566)	-1.439	-0.317 (0.280)	-0.066	-0.267 (0.226)	-0.102	
Dementia/alzheimer's disease	0.397 (1.829)	0.389	0.613 (3.114)	0.476	0.334 (0.612)	0.047	0.251 (0.504)	0.087	
Terminal illness	-27.113	-11.052	-38.641	-7.804	-	-	-	-	
CAG history	0.101 (1.136)	0.099	-0.581 (1.955)	-0.441	0.327 (0.365)	0.048	-0.115 (0.278)	-0.043	
PTCA history	0.580 (1.466)	0.568	1.797 (2.475)	1.427	0.067 (0.541)	0.011	0.291 (0.367)	0.101	
CABG history	4.956 (3.034)	4.909	c 5.846 (5.073)	4.965	-	-	0.726 (0.778)	0.216	
5. Severity variables on admission									
Heart rate	-1.271 (0.510)	-1.241	a -2.216 (0.859)	-1.700	a -0.471 (0.229)	-0.082	a -0.274 (0.138)	-0.101	a
Temperature	1.041 (0.341)	1.016	a 1.430 (0.599)	1.097	a 0.282 (0.107)	0.049	a 0.177 (0.086)	0.065	a
MAP (excluding <0 and >300)	1.036 (0.317)	1.011	a 1.541 (0.552)	1.182	a 0.232 (0.101)	0.041	a 0.220 (0.086)	0.081	a
Height	3.215 (4.181)	3.139	1.344 (7.067)	1.031	-0.308 (1.372)	-0.054	-0.194 (1.097)	-0.071	
BMI: (Weight (kg))/(Height (m))^2	0.325 (0.328)	0.317	-0.273 (0.578)	-0.209	0.213 (0.136)	-0.082	c -0.019 (0.085)	-0.007	
Glucose	-0.053 (0.164)	-0.052	0.086 (0.276)	0.066	-0.041 (0.061)	-0.054	0.017 (0.042)	0.006	
Creatinine	-	-	-	-	-	-	-	-	
Albumin	0.433 (0.368)	0.422	1.709 (0.622)	1.311	a 0.170 (0.129)	0.030	0.291 (0.096)	0.107	a
Highest creatinine	1.768 (0.746)	1.726	a 2.624 (1.260)	2.013	a 0.459 (0.272)	0.080	b 0.340 (0.198)	0.125	b
Hematocrit	0.562 (0.640)	0.549	1.300 (1.078)	0.997	0.079 (0.201)	0.014	0.153 (0.158)	0.056	
White blood cells (unit:000)	0.127 (0.759)	0.124	0.491 (1.287)	0.377	-0.013 (0.251)	-0.002	-0.020 (0.192)	-0.007	
Platelets (unit:0000)	1.386 (0.757)	1.354	b -1.095 (1.293)	-0.840	0.362 (0.241)	0.063	c -0.119 (0.191)	-0.044	
Blood urea nitrogen (BUN/SUN)	7.686 (4.830)	7.505	c 23.386 (8.695)	17.940	a 2.653 (1.507)	0.463	b 2.866 (1.311)	1.058	a
EKG trace: MI/injury	-0.959 (0.628)	-0.939	c -0.361 (1.067)	-0.279	-0.339 (0.212)	-0.051	c -0.061 (0.157)	-0.022	
EKG trace: transmural (new qwave) MI	-0.928 (0.836)	-0.903	-0.343 (1.396)	-0.261	-0.259 (0.290)	-0.051	-0.031 (0.227)	-0.011	
EKG trace: old/remote MI	-0.686 (0.800)	-0.668	-0.818 (1.356)	-0.618	-0.248 (0.253)	-0.049	-0.074 (0.202)	-0.027	
EKG trace: ventricular tachycardia/flutter	0.482 (0.678)	0.472	0.980 (1.146)	0.763	0.150 (0.238)	0.024	0.129 (0.177)	0.047	
EKG trace: atrial fibrillation/flutter	1.590 (0.777)	1.561	a -0.561 (1.348)	-0.426	0.502 (0.275)	0.067	b -0.166 (0.198)	-0.063	
EKG trace: LBBB	-2.663 (1.536)	-2.554	b -3.379 (2.666)	-2.390	-0.664 (0.438)	-0.166	c -0.494 (0.393)	-0.193	
EKG trace: RBBB	1.734 (0.825)	1.704	a 2.134 (1.393)	1.698	c 0.552 (0.298)	0.070	b 0.197 (0.212)	0.070	
EKG trace: left fascicular blocks	1.463 (3.414)	1.437	5.392 (5.578)	4.552	-	-	-	-	
EKG trace: heart block, 2nd/3rd degree	1.899 (0.899)	1.868	a 3.779 (1.514)	3.089	a 0.344 (0.314)	0.049	0.594 (0.243)	0.190	a

CHF (congestive heart failure) /pulmonary edema on chest X rays	-0.634 (0.514)	-0.619	-0.648 (0.869)	-0.494		-0.123 (0.169)	-0.022	-0.104 (0.130)	-0.039	
Stress test suggests ischemia	0.799 (1.378)	0.783	-1.539 (2.383)	-1.141		0.245 (0.472)	0.037	-0.241 (0.331)	-0.092	
Constant	-144.209 (106.945)	-140.818	283.085 (181.417)	217.157	c	-53.417 (36.700)		c 37.322 (27.314)	217.157	c
Log-likelihood		-2113.286		-2007.306				-225.601		-389.733

Note: a, b, and c indicate significance at the 5%-, 10%-, and 15%-significance level, respectively.

Table 4: Estimates of two-phase model: Tobit estimates of physician-initiated expenditures and Probit estimates of patient-initiated choice for low-tech treatments on first admission

Explanatory variables	<u>Equation (1)</u>			<u>Equation (2)</u>		
	Physician-initiated expenditures for low-tech treatments			Patient-initiated choice for low-tech treatments (Probit)		
	Coefficient (Std. err.)	Marginal effect		Coefficient (Std. err.)	Marginal effect	
1. Density at municipal level						
Number of hospital beds per 100,000 population	0.010 (0.005)	0.001	b	0.001 (0.0005)	0.0001	b
Number of high-tech hospitals (PTCA available) per 100,000 population	-5.198 (1.599)	-0.505	a	-0.462 (0.135)	-0.081	a
Number of low-tech hospitals (no PTCA available) per 100,000 population	0.904 (0.305)	0.088	a	0.077 (0.026)	0.014	a
Number of high volume hospitals with more than 100 beds per 100,000 population	-3.929 (1.998)	-0.381	b	-0.314 (0.172)	-0.055	b
Number of physicians per 100,000 population	-0.130 (0.055)	-0.013	a	-0.012 (0.005)	-0.002	a
Population density (per squared kilometer)	0.003 (0.0011)	0.0003	a	0.0003 (0.0001)	0.00005	a
2. Patient outcome						
1st hospitalization-total hospital days	-0.123 (0.048)	-0.012	a	-0.014 (0.005)	-0.002	a
3. Patient characteristics						
Female	42.454 (50.062)	14.628		5.828 (4.515)	0.996	
Age	-0.137 (0.855)	-0.013		-0.034 (0.075)	-0.006	
Age_squared	0.006 (0.007)	0.001		0.001 (0.001)	0.0001	
Female*Age	-1.171 (1.497)	-0.114		-0.175 (0.137)	-0.031	
Female*Age_squared	0.007 (0.011)	0.001		0.001 (0.001)	0.0002	
Number of family members living with a patient	-0.054 (0.578)	-0.005		0.003 (0.050)	0.001	
Presence of spouse	-2.766 (2.134)	-0.294		-0.225 (0.188)	-0.042	
Employees' health insurance	1.910 (3.194)	0.189		0.239 (0.280)	0.043	
National health insurance	3.786 (2.993)	0.377		0.366 (0.262)	0.065	
Health insurance for the elderly	-0.078 (3.087)	-0.008		-0.110 (0.272)	-0.019	
4. Comorbidity variables						
Continence: occasionally incontinent	10.551 (12.230)	1.957		-	-	
Continence: no urine output	11.539 (11.834)	2.262		0.882 (0.952)	0.243	
Continence: Unknown Urinary Continence	-8.314 (5.678)	-0.505	c	-0.721 (0.491)	-0.081	c
Mobility: Walks Independently	14.755 (7.075)	3.382	a	1.116 (0.615)	0.330	b
Mobility: Walks with assistance	10.411 (8.295)	1.908		1.083 (1.008)	0.319	
Mobility: Unable to walk	-0.203 (6.743)	-0.019		-0.055 (0.593)	-0.009	
Hypertension	-0.784 (1.734)	-0.075		-0.047 (0.150)	-0.008	
Hyperlipemia	1.476 (2.523)	0.153		0.123 (0.212)	0.023	
Diabetes (any type)	4.428 (2.065)	0.494	a	0.354 (0.177)	0.069	b
Diabetes treated by insulin	-8.934 (4.817)	-0.528	b	-0.804 (0.405)	-0.086	b
Angina	1.836	0.193		0.321	0.064	c

	(2.490)			(0.221)		
Cardiac heart failure or pulmonary edema	9.420	1.525	a	0.855	0.223	a
	(3.080)			(0.282)		
Old myocardial infarction	-2.408	-0.207		-0.152	-0.024	
	(3.226)			(0.282)		
Current cigarette smoker	-3.148	-0.310	c	-0.254	-0.045	c
	(1.954)			(0.165)		
Arrhythmia	-2.866	-0.243		-0.268	-0.041	
	(2.666)			(0.237)		
Family medical history of schemic heart dise	0.583	0.058		0.036	0.006	
	(2.325)			(0.198)		
Renal failure	4.192	0.525		0.726	0.186	
	(5.919)			(0.572)		
Cirrhosis	5.183	0.698		0.279	0.058	
	(11.106)			(0.921)		
Cerebrovascular accident: Cerebral infarctio	-4.936	-0.368	c	-0.320	-0.047	
	(3.246)			(0.298)		
Cerebrovascular accident: Brain hemorrhage	-91.383	-0.700		-		
	.			-		
Cerebrovascular accident: Subarachnoid hemorrhage	16.236	4.065		1.363	0.430	
	(11.988)			(0.988)		
COPD	-16.224	-0.620	b	-1.256	-0.097	b
	(8.527)			(0.762)		
Aneurysm of aorta	-8.928	-0.502		-0.575	-0.069	
	(11.481)			(1.041)		
Ulcus pepticum	-9.694	-0.580	a	-0.772	-0.089	a
	(3.868)			(0.335)		
Cancer	-6.040	-0.411		-0.517	-0.065	
	(4.845)			(0.442)		
Autoimmune disease	16.767	4.260	a	1.516	0.488	a
	(5.466)			(0.557)		
Drug allergy/med reaction	4.368	0.544		0.317	0.066	
	(3.409)			(0.280)		
Dementia/alzheimer's disease	-2.046	-0.175		-0.334	-0.047	
	(7.482)			(0.612)		
Terminal illness	-14.259	-0.585		-		
	(15.575)			-		
CAG history	-2.252	-0.194		-0.327	-0.048	
	(4.243)			(0.365)		
PTCA history	-0.285	-0.027		-0.067	-0.011	
	(6.134)			(0.541)		
CABG history	-90.100	-0.675		-		
	.			-		
<u>5. Severity variables on admission</u>						
Heart rate	5.202	0.505	a	0.471	0.082	a
	(2.385)			(0.229)		
Temperature	-2.545	-0.247	a	-0.282	-0.049	a
	(1.116)			(0.107)		
MAP (excluding <0 and >300)	-2.066	-0.201	a	-0.232	-0.041	a
	(1.029)			(0.101)		
Height	8.899	0.864		0.308	0.054	
	(16.087)			(1.372)		
BMI: (Weight (kg)/(Height (m))^2)	-2.831	-0.275	b	-0.213	0.082	c
	(1.577)			(0.136)		
Glucose	0.448	0.043		0.041	0.054	
	(0.687)			(0.061)		
Albumin	-2.019	-0.196		-0.170	-0.030	
	(1.506)			(0.129)		
Highest creatinine	-4.185	-0.406		-0.459	-0.080	b
	(3.112)			(0.272)		
Hematocrit	-1.477	-0.143		-0.079	-0.014	
	(2.284)			(0.201)		
White blood cells (unit:000)	0.805	0.078		0.013	0.002	
	(2.884)			(0.251)		
Platelets (unit:0000)	-4.353	-0.423	c	-0.362	-0.063	c
	(2.703)			(0.241)		
Blood urea nitrogen (BUN/SUN)	-34.769	-3.376	a	-2.653	-0.463	b
	(17.663)			(1.507)		

EKG trace: MI/injury	3.711 (2.499)	0.308	c	0.339 (0.212)	0.051	c
EKG trace: transmural (new qwave) MI	3.319 (3.321)	0.382		0.259 (0.290)	0.051	
EKG trace: old/remote MI	3.153 (2.887)	0.361		0.248 (0.253)	0.049	
EKG trace: ventricular tachycardia/flutter	-2.807 (2.693)	-0.240		-0.150 (0.238)	-0.024	
EKG trace: atrial fibrillation/flutter	-5.726 (3.057)	-0.416	b	-0.502 (0.275)	-0.067	b
EKG trace: LBBB	8.579 (4.775)	1.394	b	0.664 (0.438)	0.166	c
EKG trace: RBBB	-6.651 (3.440)	-0.455	b	-0.552 (0.298)	-0.070	b
EKG trace: left fascicular blocks	-80.999	-0.659		-		
EKG trace: heart block, 2nd/3rd degree	-3.785 (3.682)	-0.298		-0.344 (0.314)	-0.049	
CHF (congestive heart failure) /pulmonary edema on chest X rays	1.267 (1.949)	0.127		0.123 (0.169)	0.022	
Stress test suggests ischemia	-2.385 (5.509)	-0.200		-0.245 (0.472)	-0.037	
Constant	704.445 (427.351)		c	-53.417 (36.700)		c
Log-likelihood	-754.166			-225.601		

Note: a, b, and c indicate significance at the 5%-, 10%-, and 15%-significance level, respectively.

Table 5: Municipal-level estimates of two-phase model for high-tech treatments

Explanatory variables	Equation (3)		Equation (4)		Equation (3)		Equation (4)	
	High-tech treatments				Low-tech treatments			
	Physician-initiated expenditures		Patient-initiated choice		Physician-initiated expenditures		Patient-initiated choice	
	Coefficient	(Std err.)	Coefficient	(Std err.)	Coefficient	(Std err.)	Coefficient	(Std err.)
1. Density at municipal level								
Number of hospital beds per 100,000 population	-0.0002	(0.0002)	-0.0001	(0.0001)	0.0005	(0.0008)	0.0001	(0.0001)
Number of high-tech hospitals (PTCA available) per 100,000 population	0.106	(0.044)	a	0.030	(0.015)	b	-0.276	(0.168)
							c	-0.030
								(0.015)
Number of low-tech hospitals (no PTCA available) per 100,000 population	-0.021	(0.009)	a	-0.004	(0.003)		0.037	(0.033)
Number of high volume hospitals with more than 100 beds per 100,000 popu	0.006	(0.054)		0.005	(0.019)		0.056	(0.259)
								(0.019)
Number of physicians per 100,000 population	0.002	(0.001)	c	-0.00004	(0.001)		0.009	(0.005)
							b	0.00004
								(0.001)
Population density (per squared kilometer)	-0.00002	(0.00003)		0.00001	(0.00001)		-0.0002	(0.0001)
							c	-0.00001
								(0.00001)
2. Patient outcomes								
1st hospitalization-total hospital days	0.013	(0.005)	a	0.006	(0.002)	a	0.006	(0.018)
								-0.006
								(0.002)
3. Patient characteristics								
Female	-0.381	(0.323)		-1.023	(0.619)	c	-7.931	(6.308)
								1.023
								(0.619)
Age	0.008	(0.013)		-0.007	(0.003)	a	-0.029	(0.040)
								0.007
								(0.003)
Number of family members living with a patient	0.093	(0.082)		0.099	(0.025)	a	-0.704	(0.278)
							a	-0.099
								(0.025)
Presence of spouse	-0.259	(0.331)		-0.039	(0.102)		-0.524	(1.037)
								0.039
								(0.102)
Taxable income	1.325	(0.999)		0.103	(0.343)		0.599	(3.940)
								-0.103
								(0.343)
Killip3	0.143	(0.320)		-0.038	(0.108)		0.334	(1.090)
								0.038
								(0.108)
Killip4	-0.069	(0.275)		-0.059	(0.080)		0.183	(1.031)
								0.059
								(0.080)
Constant	-6.357	(15.187)		-0.610	(5.204)	c	6.199	(60.983)
								0.610
								(5.204)
R-squared	0.210			0.622			0.597	
								0.622

Note: a, b, and c indicate significance at the 5%-, 10%-, and 15%-significance level, respectively.