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DIFFERENTIAL EFFECTS OF DECLINING RATES IN A PER DIEM PAYMENT SYSTEM

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ABSTRACT

The paper demonstrates differential effects of a prospective payment system with declining per diem rates, dependent on the percentiles of length of stay. The analysis uses dynamic panel data estimates and a recent nationwide administrative database for major diagnostic categories in 1068 Japanese hospitals in 2006–2012 to show that average length of stay significantly increases for hospitals in percentiles 0–25 of the pre-reform length of stay and significantly decreases for hospitals in percentiles 51–100. The decline of the average length of stay is larger for hospitals in higher percentiles of the length of stay. Hospitals in percentiles 51–100 significantly increase their rate of nonemergency/unanticipated readmissions within 42 days after discharge. The decline in the length of total episode of treatment is smaller for hospitals in percentiles 0–25. The findings are robust in terms of the choice of a cohort of hospitals joining the reform. The paper discusses applicability of 'best practice' rate-setting to help improve the performance of hospitals in the lowest quartile of average length of stay. Copyright © 2014 John Wiley & Sons, Ltd.

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KEY WORDS: health care financing; prospective payment system; diagnosis-related groups; length of stay; readmission rate; health care quality

1. INTRODUCTION

The inpatient prospective payment system (PPS), which involves a fixed payment for an episode of medical care provision to a patient within a given diagnosis group, is a significant example of a reimbursement policy aimed at creating adequate incentives for cost containment by providers (Chalkley and Malcomson 2000; Holmstrom and Milgrom, 1994; Shleifer, 1985). PPS shortens length of stay and may increase cost efficiency of hospital operations, as hospitals start to bear the financial burden of excessive medical treatment (Fetter and Freeman, 1986; Thompson *et al.*, 1979). Yet, a system with per diem payments linked to diagnosis groups may be adequate for a number of specialized hospitals, where it is sufficient to regulate daily resource use.[1] Per diem prospective payments may become a part of a mixed system, where hospital facility charges are paid on the per diem basis, whereas expensive procedures (and/or physician services) are reimbursed according to fee-for-service (FFS). Such a mixed system tends to emerge in countries with high variation of treatment patterns, an emphasis on medical procedures, and historical differences in hospital reimbursement (MHLW, 2010a; Busse and Schwartz, 1997). Because per diem payments generally have fewer incentives for cost containment (Busse and Riesberg, 2004;

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[Correction added on 7 July 2015, after first online publication: In the above address for correspondence, the address was wrongly listed and this has now been updated.]

[1] For example, psychiatric hospitals, skilled nursing facilities, and hospices.

Rosko and Broyles, 1987), declining rates of payment might be used as a tool to stimulate shorter hospitalizations. However, the way the rates are diminished is a key issue in avoiding the unwanted effects of a per diem payment system (Drummond *et al*., 1997; Monrad Aas, 1995).

Whereas some studies pay attention to potential adverse effects of the PPS and per diem payment system, focusing on a hospital's length of stay and quality (Grabowski *et al*., 2011; Sood *et al*., 2008; McKnight, 2006; Gold *et al*., 1993; Coulam and Gaumer, 1991; Morrisey *et al*., 1984), only a few papers explore the undesired effects of *declining rates* in a per diem payment system. To the best of our knowledge, Nawata and Kawabuchi (2012) is the only paper to suggest that decrease of mean average length of stay (ALOS) owing to a step-down tariff within a per diem payment system might be separated into increase of ALOS at some hospitals and decrease of ALOS at other hospitals.[2] As regards hospital quality, Kondo and Kawabuchi (2012) assume that patients who require treatment of long duration (e.g., rehabilitation after surgery owing to hip fractures) are vulnerable to premature discharges owing to incentives inherent to the declining rates in a per diem payment system.

The novelty of the present paper is the use of a variety of diagnoses and a large longitudinal sample of 1068 hospitals for empirical estimates of the differential effects of a mixed payment system with declining per diem rates. We focus on the length of stay during each hospitalization, length of the total episode of hospitalization, and the nonemergency/unanticipated readmission rate within 42 days after discharge, as a proxy for hospital quality. The paper uses the nationwide administrative data (2006–2012) for the recent Japanese experience of changing from a FFS remuneration to an inpatient payment system with stepdown rates dependent on length of stay within per diem reimbursement component, related to diagnosis groups. The empirical analysis is conducted for each Major Diagnostic Category (MDC)—aggregate groups of diagnoses constructed in Japan on the basis of the International Classification of Diseases (ICD-10), with minor modifications. The results offer persuasive evidence supporting differential effects of per diem payment system with declining rates. The ALOS significantly increases for hospitals in percentiles 0–25 of the pre-reform nationwide length of stay and significantly decreases for hospitals in percentiles 51–100. The decrease of the ALOS is larger for hospitals in higher percentiles of the pre-reform length of stay. The decline in the length of total episode of treatment is smaller for hospitals in percentiles 0–25. At the same time, readmission rate at hospitals in percentiles 51–100 decreases. The findings are robust in terms of the choice of the cohort of hospitals joining the reform.

The remainder of this paper is structured as follows. Section 2 outlines major features of a mixed inpatient payment system, introduced to replace the FFS reimbursement in Japan. Section 3 offers theoretical methodology and gives specifications for the empirical analysis. Section 4 describes the data, Section 5 summarizes the results of the estimations, and the discussion about declining rates in a per diem payment system is presented in Section 6.

2. PER DIEM PAYMENT SYSTEM IN JAPAN

Cost containment entered the agenda of Japanese health care policy makers in the 1970s, when the rate of health care expenditure growth started to exceed the rate of growth of gross domestic product (Fujii and Reich, 1988). The factors behind soaring health care costs were aging of the population and the spread of new medical technologies in an environment of physician-induced demand with FFS reimbursement.[3] Consequently, the Japanese social health insurance system became highly subsidized.[4] By the early 2000s, the policy of raising coinsurance rates and lowering fees in a unified fee schedule had been exhausted as an effective means of containing health care costs (Ikegami, 2009). So the Ministry of Health, Labor, and Welfare (MHLW) decided to introduce an inpatient PPS for acute-care hospitals to create incentives for cost containment.

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[2] Similarly, Yasunaga *et al.* (2006) argue that decline in ALOS often occurs at large hospitals that deal primarily with surgical patients.

[3] Additionally, the shrinkage of the labor force resulted in a falling share of enrollees in insurance plans for workers and a growing share of enrollees in subsidized health insurance plans.

[4] In 2012, for example, central government financed 25.3% of health care expenditure (MHLW, 2012b), which represented 10.2% of the government budget (Ministry of Finance 2012).

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An inpatient payment system, linked to diagnosis groups, was piloted in Japan in 1990, when inclusive per diem rates (unadjusted for case mix) were employed in 50% of geriatric hospitals that satisfied the required staffing criteria (MHLW, 2012a; Ikegami, 2005; Okamura *et al*., 2005). The per diem PPS led to reduction of excess costs for material and laboratory tests (Ikegami, 2005; Okamura *et al*., 2005). Later, a system with per case payments was introduced at 10 acute-care hospitals in 1998–2004 (Kondo and Kawabuchi, 2012). However, owing to high diversity of medical treatment patterns, the effect of this full PPS was ambiguous, and the system was not expanded nationwide[5] (Kondo and Kawabuchi, 2012; Okamura *et al*., 2005). Instead, a special version of the per diem payment system was introduced in 2003 at 82 special-function hospitals, providing high-technology health care. In 2004–2013, there was a steady increase in the number of hospitals joining this scheme. As of April 2013, 20.0% of acute-care (general) hospitals, accounting for 53.4% of hospital beds in Japan, were financed using the new payment system (MHLW, 2013).[6]

The Japanese per diem payment system is essentially a mixed system. The two-part tariff is the sum of a component related to diagnosis–procedure combinations (DPCs) and a FFS component, with approximate shares of 0.7 and 0.3, respectively (Okamura *et al*., 2005). Each DPC incorporates diagnosis, medical treatment algorithm, procedures, and comorbidity.[7] Diagnoses are coded according to ICD-10, and procedures are classified on the basis of the Japanese Procedure Code, commonly used under FFS reimbursement (Matsuda *et al*., 2008; MHLW, 2004).[8] The DPC component covers the cost of the basic hospital fee, examinations, diagnostic images, pharmaceuticals, injections, and procedures worth less than 10,000 yen.

For each group of DPCs, the amount of the inclusive per diem payment is a step-down function of the patient's length of stay. For a standard DPC (i.e., a DPC without particularly high or particularly low medical cost at the beginning of the treatment), the amount of the daily inclusive payment is flat over each of the three consecutive periods: period I represents the 25-percentile of length of stay calculated for all hospitals submitting data to MHLW[9]; period II contains percentiles 26 to mean ALOS; and period III includes two standard deviations from the mean ALOS (MHLW, 2010a, 2010b). After the end of period III, hospitals are reimbursed according to the FFS system. To create incentives for shorter lengths of stay, per diem payment in period I is 15–50% higher than in period II, and in period II is15% higher than in period III (Figure 1).

The FFS component reimburses medical teaching, surgical procedures, anesthesia, endoscopies, radioactive treatment, pharmaceuticals, and materials used in operating theaters, as well as procedures costing more than 10,000 yen (MHLW, 2012a; Yasunaga *et al*., 2005a).

The two-component system may be justified in part by the practice patterns that have evolved in Japanese hospitals (Hamada *et al*., 2012; Campbell and Ikegami, 1998). Moreover, ICD coding, which is a prerequisite for full PPS, had very low prevalence in Japan; it was employed in only 10% of hospitals (Ikegami and Campbell, 2004). The Japanese two-part tariff may be regarded as analogous to the German PPS in 1996–2003, where the per diem fee was the sum of a department-specific prospective component for medical costs and a hospital-specific retrospective component for nonmedical costs (Busse and Schwartz, 1997).

The introduction of a per diem payment system in Japan led immediately to a decline of the ALOS nationally (MHLW, 2005), as predicted by models on hospital behavior and suggested by empirical evidence in other countries (Suthummanon and Omachonu, 2004; Laffont and Tirole, 1993; Rosko and Broyles, 1988). A number of Japanese

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[5] Arguably, it must have been difficult to calculate a fair diagnosis-related group (prospective payment system) reimbursement for these hospitals.

[6] Small hospitals seem to be more reluctant to change over to a new payment system. Indeed, almost half of hospitals with 300–500 beds and two thirds of hospitals with over 500 beds joined the reform by 2013, yet the corresponding figures for hospitals with 20–99 (100–199) beds are only 5.7% (14.3%).

[7] According to Matsuda *et al.* (2008), DPCs are based on the Dutch Diagnose Behandeling Combinatie, with an influence of the pricing systems in Austria, Belgium, France, and the UK.

[8] The classification of DPCs employed nationwide in 2003 consisted of 2552 expertly determined diagnosis groups. The per diem rates were set on the basis of 1860 homogeneous groups, which covered about 90% of admissions (Ikegami 2005). Subsequently, the numbers of diagnoses were adjusted (with slight increases and decreases), and as of 2012/2013 revision of the unified fee schedule, there are 2927 diagnosis groups and 2241 DPCs.

[9] The initial rates were set according to the claim data on 267,000 patients discharged from 82 targeted hospitals in July–October 2002.

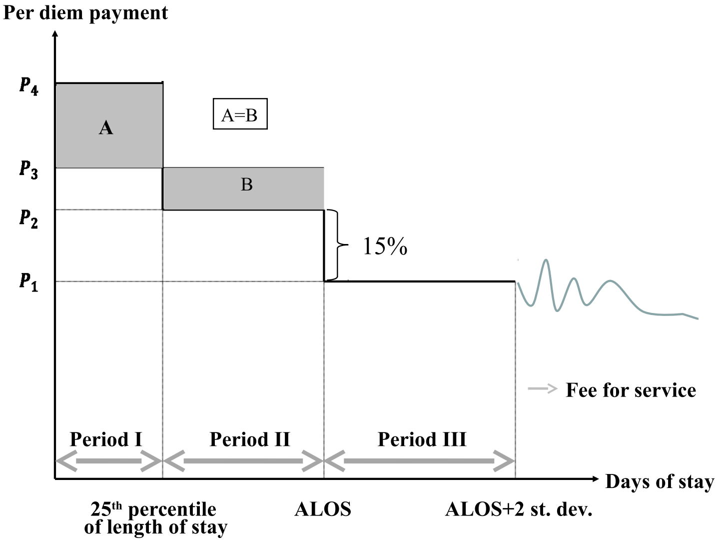

Figure 1. Step-down per diem inclusive rates for a given DPC (source: MHLW (2010a, 2010b)). P_3 is determined as the average amount of per diem payment in hospitals submitting data to MHLW (Originally it was estimated according to the data in the 82 front-runner hospitals in 2002). P_2 and P_4 are set so that area A in period I equaled to area B in period II (P_4 would be 15% higher than P_3 for a standard DPC). P_1 is 15% lower than P_2. According to MHLW (2012a) and daily distribution of material costs in Yasunaga *et al.* (2005a, 2005b), FFS reimbursement after the end of period III is likely to fluctuate around the value of P_1 or be lower than P_1

hospitals use classic measures to shorten ALOS by raising the efficiency of medical treatment (Borghans *et al.*, 2012; Besstremyannaya, 2011; Kuwabara *et al.*, 2011; Suwabe, 2004). However, both technical and cost efficiency of Japanese local public hospitals show only a minor improvement following the reform (Besstremyannaya, 2013), and the impact on hospital costs is ambiguous (Nishioka, 2010; Yasunaga *et al.*, 2006; Yasunaga *et al.*, 2005a). Moreover, the per diem payment system might not have shortened ALOS in a number of cases (Nawata and Kawabuchi, 2012; Yasunaga *et al.*, 2006).

3. METHODOLOGY

3.1. Joining the new system and predictions about differential effects

The behavior of Japanese hospitals under the FFS reimbursement for treating a patient with a given disease can be analyzed with the approach of Grabowski *et al.* (2011),[10] which defines hospital's profit as $\pi = (p(i) - c(i))\cdot LN(B(L,i))$, where per diem payment $p(i)$ depends on intensity i, $c(i)$ is per diem cost, $p(i) - c(i)$ is margin of the service, $L\cdot N(B(L,i))$ is health care volume, L is length of stay, benefit to patient B is a function of L and i ($B_i > 0$), and $N(B)$ is the number of discharges ($N_B > 0$).[11] The first-order conditions derived in Grabowski *et al.* (2011) are as follows:

$$\partial\pi/\partial L = 0 \text{ implies } N + LN_B B_L = 0, \text{ and since } N > 0 \text{ and } N_B > 0, \text{ it must hold that } B_L < 0. \quad (1)$$

$$\partial\pi/\partial i = 0 \text{ leads to} (p_i - c_i)N + (p - c)N_B B_i = 0, \text{ and effect of increasing } i \text{ on } N \text{ is ambiguous.} \quad (2)$$

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[10] The model regards a hospital as a profit-maximizing supplier of health care in a certain volume and to a certain level of quality (He and Mellor 2012; Ma 1998; Ellis and McGuire 1996; Hodgkin and McGuire 1994; Laffont and Tirole 1993; Ellis and McGuire 1986).

[11] Although the model of Grabowski (2011) describes the optimization problem for US long-term care facilities under the per diem PPS, it is also relevant for analyzing the behavior of Japanese hospitals under the FFS reimbursement, as p(i) is a realistic approximation of FFS remuneration related to treatment of a particular disease.

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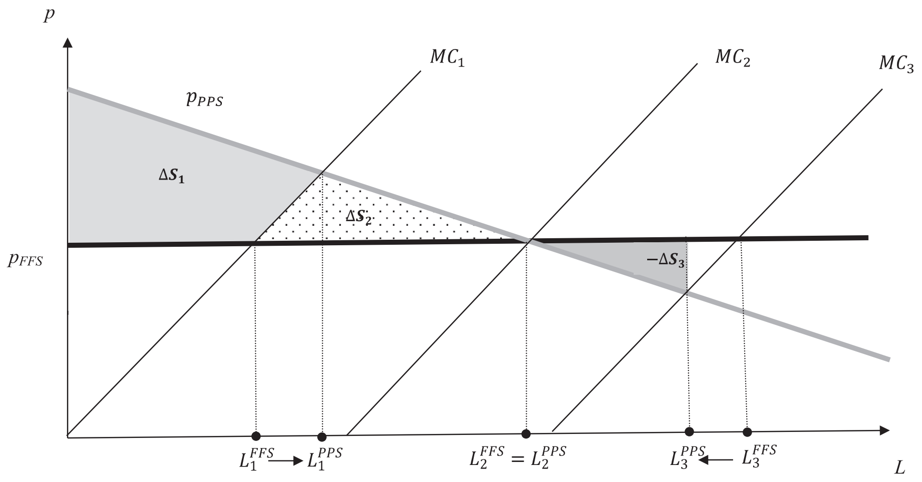

Figure 2. Change in length of stay and producer surplus owing to an introduction of a per diem payment system (PPS)

To model a per diem system with payment, dependent on the length of stay, we modify the approach of Grabowski *et al.* (2011) and regard p as a function of both intensity and length of stay: $p = p(i,L)$. The per diem payment in a new Japanese system decreases with length of stay, so $p_L < 0$. The profit function becomes $\pi = (p(i,L) - c(i)) \cdot LN(B(L,i))$ so 1 changes to the following:

$$\partial\pi/\partial L = 0 \text{ implies } p_L + (p - c)(1/L + N_B B_L/N) = 0 \qquad (1')$$

The fact that $B_L < 0$ may no longer be deduced from $1'$.[12]

In a simplified case with constant treatment intensity i for a given diagnosis group,[13] a hospital's choice between a FFS and a new per diem payment system may be described graphically as follows. Suppose per diem payment is fixed in a FFS system. Define a new per diem schedule as a declining function of L. Consider three price discriminating hospitals ($j = 1,\ldots, 3$) with different marginal cost MC_j,[14] so that at the optimum in the FFS system $L_1 < L_2 < L_3$ and optimal values of L_2 were the same for both systems (Figure 2). Hospital 1 increases its length of stay under the new system and raises its surplus by ΔS_1, hospital 2 does not change its length of stay and acquires an addition ($\Delta S_1 + \Delta S_2$) to its surplus. Hospital 3 decreases its length of stay, and the change in its surplus is $\Delta S_1 + \Delta S_2 - \Delta S_3$. Whereas hospitals 1 and 2 clearly benefit from the new system in terms of producer surplus, the effect for hospital 3 is ambiguous. So some hospitals with longer length of stay may have no incentive to participate, and therefore hospitals submitting data to MHLW are expected to have length of stay shorter than the national average.

3.2. Average length of stay

To the best of our knowledge, Ellis and McGuire (1996) is the only paper to explicitly demonstrate heterogeneous effect of the PPS on changes in length of stay for patients at different percentiles of pre-reform length of stay.[15] The

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[12] The change from a FFS to a new per diem payment system may be also regarded as an increase in payment generosity ($p_i > 0$) for hospitals with short L. Grabowski *et al.* (2011) show that the effects of payment generosity on L and N move in opposite directions, which can be linked to the length of stay and readmittance trade-off for hospitals in the lowest percentiles of ALOS.

[13] It should be noted that an introduction of a prospective payment system does not necessarily lead to decrease in intensity of treatment (Cutler *et al.* 2003).

[14] For simplicity, the marginal cost functions have equal slopes and differ only in the intercept (the minimum length of stay).

[15] Figure 3 on page 275. A few papers use the division into smaller number of groups according to the values of non-ALOS variables (Sood *et al.* 2008; McKnight 2006).

Table I. Average length of stay at acute-care beds at local public hospitals

Group	Statistics	2006	2007	2008	2009	2010	2011
Fee-for-service and did not submit the data to MHLW	Mean	23.18	21.90	23.07	22.43	22.01	21.68
	St Dev	10.91	15.62	13.22	11.08	11.54	11.65
	Obs	604.00	596.00	569.00	550.00	532.00	514.00
Fee-for-service and submitted the data to MHLW	Mean	15.66	17.91	15.72	16.22	15.51	15.15
	St Dev	2.35	19.40	2.41	2.40	2.14	2.26
	Obs	73.00	223.00	173.00	36.00	33.00	33.00
Introduced new payment system in corresponding year	Mean	15.04		14.68	15.02	15.83	14.38
	St Dev	1.76		2.13	2.50	2.47	2.00
	Obs	31.00		72.00	144.00	23.00	9.00

For each fiscal year in 2006–2011, the table shows mean length of stay for all discharged patients at local public hospitals that did not submit the data to MHLW; submitted the data to MHLW but remained in the fee-for-service system, and introduced the new payment system in each corresponding fiscal year.

present paper similarly tests for differential effects of the per diem PPS reform, looking at 25-percentiles of ALOS, which are the units for the length of steps in the declining per diem schedule.

The highest rate in the Japanese per diem system is paid during the period corresponding to the 0–25 percentile of the nationwide ALOS. Therefore, hospitals in percentiles 0–25 might be likely to increase their ALOS up to the nationwide threshold value of the 25th percentile. Indeed, given the capability of sustaining high bed occupancy rate (Abe *et al*., 2005), hospitals in percentiles 0–25 are indifferent between admitting a new patient or treating a patient who is already in hospital for longer. As for percentiles 26–50 of ALOS, a part of hospitals that cannot decrease their ALOS up to the value of the 25th percentile might increase it up to the value of the mean nationwide ALOS. However, a part of hospitals would strive to lower their ALOS to the value of the 25th percentile. Consequently, the overall effect for hospitals in percentiles 26–50 is ambiguous. Finally, hospitals in percentiles 51–100 of ALOS will attempt to decrease their ALOS to the value of the mean nationwide ALOS. Moreover, the closer the hospital's pre-reform ALOS to the mean nationwide ALOS, the smaller will be the reduction of ALOS.

Accordingly, Hypothesis I forecasts that ALOS is likely to *increase* for hospitals in percentiles 0–25 of the empirical nationwide ALOS and is likely to *decrease* for hospitals in percentiles 51–100 of ALOS. Hypothesis II predicts larger decline of ALOS for hospitals in higher percentiles of nationwide ALOS. The hypothesis stems from the findings of Ellis and McGuire (1996) and Nawata and Kawabuchi (2012), who demonstrate larger reduction of ALOS for patients (or at hospitals) with larger pre-reform ALOS. Similarly, the argument about longer length of stay resulting from per diem rates set above marginal costs (Lave, 2003; Frank and Lave, 1989; Frank and Lave, 1986) might offer a theoretical explanation for larger decline of ALOS at hospitals with larger pre-reform ALOS.

Because submission of data was voluntary, there is an inevitable selection bias, and this bias cannot be fully assessed owing to the unavailability of data for hospitals that do not intend to introduce the new payment system. However, using the data on all *local public* hospitals,[16] we can compare hospital-level ALOS at acute-care beds. The mean values of ALOS for FFS local public hospitals that decided to submit MDC-level data in the fiscal years 2006–2011 are approximately two thirds of ALOS at FFS local public hospitals that did not submit the data to MHLW.[17] The new payment system was introduced at local public hospitals where ALOS was on average 10% lower than in all data-submitting local public hospitals (Table I).

It should be noted that hospitals joining the reform are subject to the rates linked to quartiles of ALOS in the sample of data-submitting hospitals. So the effect for hospitals in percentiles 0–25 (if they join the reform) would be opposite to the effect for hospitals in percentiles 50–100, regardless of how the particular group of data-submitting hospitals compares with all national hospitals. But the scale of the effect may depend on the annual subsamples of all

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[16] Constitute about 10% of Japanese hospitals and are run by prefecture, prefectural city, municipality, or a union of municipalities. See Besstremyannaya (2011) for details about Japanese local public hospital database.

[17] Standard deviation at data-submitting local public hospitals is almost 10 times lower than in the FFS hospitals.

data-submitting hospitals. This is why we compare the effects in the cohort of hospitals submitting data since 2007 (697 hospitals) and in the cohort sending data since 2006 (371 hospitals). The hospitals from cohort 1, which introduced the reform in 2009, tend to be distributed in the highest percentiles of the first quartile of ALOS in the first year of submitting the data (2007). On the contrary, hospitals in cohort 2, which joined the reform in 2008, are distributed more uniformly within the first quartile in 2006.[18] This may result in higher prevalence of the effects, forecasted by Hypothesis I in the second cohort.

3.3. Quality

It is commonly noted that the reverse side of the new Japanese payment system is quality deterioration, reflected in the growing prevalence of ‘remission’ reports and decline in the number of ‘healing (cure)’ reports[19] for discharged patients nationally (MHLW, 2009) and for certain diagnoses (Kondo and Kawabuchi, 2012). The MHLW’s data enable the use of the readmission rate within 42 days after discharge (‘early readmission rate’ in Japanese definition) as an indicator of hospital quality (Halfon *et al*., 2006; Lopes *et al*., 2004; Weissman *et al*., 1999; Ashton *et al*., 1997). This paper tests, in particular, whether the declining rates result in differential changes in the nonemergency/unanticipated (i.e., planned) early readmission rate.[20] Indeed, the rise of the early readmission rate owing to the reform (Hamada *et al*., 2012; Yasunaga *et al*., 2005a) might be primarily explained by an increase in the prevalence of nonemergency/unanticipated readmissions (Okamura *et al*., 2005) which, in turn, would be caused by step-down of the per diem PPS tariff (Kondo and Kawabuchi, 2012).

Arguably, hospitals in the upper percentiles of the empirical distribution of ALOS would seek to adhere to the MHLW’s threshold levels (mean ALOS or mean ALOS plus 2 standard deviations) in order to obtain reimbursement according to new payment schedule. However, such hospitals might not be able to change their technology within a short period of time. As a result, these hospitals will have to readmit their patients.[21] To sum up, Hypothesis III predicts that the nonemergency/unanticipated readmission rate within 42 days after discharge is likely to increase for Japanese hospitals in percentiles 51–100 of the empirical distribution of nationwide ALOS.

It should be noted that the substitution between length of stay and readmittance should not necessarily be regarded as adverse effects of the reform, if total length of episode of illness and patient outcomes remain unaffected. We therefore use the existing data to assess changes in the total length of hospitalization in each

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[18] It should be noted that for most MDCs hospitals in cohort 1 belong to percentiles 0–25 or 76–100 of data-submitting hospitals in the pre-reform year more frequently than to middle percentiles. By contrast, hospitals in cohort 2 are equally distributed within quartiles of all data-submitting hospitals in the pre-reform year.

[19] According to MHLW (2009), there are the following patient outcomes: (1) healing (*chiyu*): there is no need for outpatient treatment after discharge; (2) improvement (*keikai*): improvement was achieved in the course of treatment. In principle, there is a need for continuous outpatient care after discharge; (3) remission (*kankai*): radical treatment (e.g., as in the case of circulatory system diseases) was applied during hospital stay, and there was temporary improvement; but there is a chance that the disease will reoccur; (4) no change (*fuhen*): no improvement was achieved in the course of the relevant treatment in hospital; (5) worsening (*dzouaku*): worsening was noticed in the course of the relevant treatment in hospital (Besstremyannaya’s (2010) translation. Kondo and Kawabuchi (2012) use the terms cured, improved, and tentatively improved for outcomes (1), (2), and (3), respectively).

[20] MHLW (2005) groups readmissions into anticipated, emergency (i.e., unplanned), and nonemergency/unanticipated (i.e., planned) as follows. *Anticipated* readmissions: (1) anticipated worsening of medical condition; (2) anticipated worsening of comorbidity; (3) temporary discharge to raise patient’s quality of life; (4) discharge from previous hospital stay at the patient’s request; (5) other reasons. *Emergency* readmissions: (1) unanticipated worsening of medical condition; (2) unanticipated worsening of comorbidity; (3) emergence of other acute medical condition; (4) other reasons. *Nonemergency/unanticipated* (i.e., planned) readmissions: (1) operation after preliminary tests; (2) scheduled operation or procedures; (3) chemotherapy or radiation therapy; (4) scheduled examinations/tests; (5) examination/operation was stopped during the previous treatment, and the patient was discharged; (6) patient was sent home for recuperation before an operation.

[21] It should be noted that owing to the strong personal relationship and high degree of trust, which tend to be established between doctor and patient in Japan, the days of treatment are negotiated, and the patient is likely to seek continuation of his/her care at the same hospital (Muramatsu and Liang 1996). The phenomenon was the reason for MHLW’s prohibition of nonemergency/unanticipated readmissions with the same diagnosis within 3 days after patient’s discharge (Nishioka 2010).

quartile of hospital cohorts.[22] Hospital-level data regarding cost of illness, patient outcomes, and substitution effect between inpatient and outpatient care are unavailable. However, we note the national trend toward growing prevalence of discharge reports indicating incomplete care and increase in the share of discharged patients who are transferred to the outpatient division of the same hospital.

3.4. Dynamic panel data model

Our analysis assumes that a hospital strongly adheres to its practice patterns, which is a reasonable supposition in view of historical links in Japan between hospital departments and certain medical universities, and hierarchical relations within each department (Campbell and Ikegami, 1998). We therefore apply a habit-formation model, where value of the ALOS (or readmission rate) for each group of diagnoses depends on the value of the variable in the previous period. Formally, the analysis for each MDC is based on the autoregressive specification[23]:

$$y_{it} = \beta_0 + \beta_1 y_{i,t-1} + \beta_2 y_{i,t-1}\mathrm{PPS}_{it} + \beta_3 \mathrm{PPS}_{it} + \gamma X_{it} + v_i + \varepsilon_{it} \qquad (3)$$

The dependent variable, y_{it}, is ALOS or readmission rate. PPS_{it} is the reform dummy that equals unity if hospital i introduced PPS in year t, $\mathbf{X}_{it}$ are hospital control variables (without constant term), v_i are hospital fixed effects, ε_{it} are i.i.d. with zero mean, and β_0 is a constant. When included in 3, time dummies proved insignificant for most MDCs;[24] therefore, they are not used in the analysis. The identification condition for the AR(1) process[25] is $0 < \beta_1 < 1$. In case of a stationary AR(1) process, this would also imply an existence of a long-term mean value of y (Hamilton, 1994).[26]

Equation 3 is estimated using Arellano and Bover (1995)/Blundell and Bond (1998) estimator,[27] with robust variance–covariance matrix.[28] As $y_{i,t\text{-}1}$ is a factor of the cross-term $y_{i,t\text{-}1}\mathrm{PPS}_{it}$, the cross-term is treated as a predetermined variable. Owing to the voluntary participation, a hospital is assumed to make a decision about introducing PPS, considering the value of its ALOS in the pre-reform year. Consequently, PPS_{it} must be regarded as a predetermined variable, too. Lagged levels and lagged differences of y_{it}, PPS_{it}, and $y_{i,t\text{-}1}\mathrm{PPS}_{it}$ are used as instruments for the differenced equation. Arellano and Bond (1991) test does not reject the hypothesis about the absence of order two serial correlation in the first differenced errors.[29]

3.5. Hypotheses testing

We use two hospital cohorts with largest panel size and longest available pre-reform and post-reform time-series data:

1) 697 hospitals (July 2007 to March 2012), which started submitting data in 2007 and gradually joined the reform from 2009 onward; and
2) 371 hospitals (July 2006 to March 2012), which sent data since 2006 and gradually introduced the reform from 2008 onward.

Because the rates are set on the basis of the empirical distribution for all hospitals submitting data to MHLW, the attribution to each 25-percentile group uses the data for all 1428 (731) hospitals in the database in the first analyzed year 2007 (2006).

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[22] Average length of stay for the first, second, and third hospitalizations, aggregated at the hospital level for three major reasons of planned readmissions, are also available. However, absence of data on the prevalence of second and third hospitalizations makes it impossible to compute a weighted average, and estimations with an unweighted sum might be misleading.

[23] The length of time-series generally does not enable the use of specifications with higher order lags.

[24] Indeed there were no significant reforms in the MHLW's PPS rate-setting in the analyzed period of time.

[25] In terms of absence of unit root and significance of the positive lagged dependent variable.

[26] If we adopt the approach in Hamilton's (1994) eq.3.4.10 for our model with a cross-term variable and focus exclusively at the reformed hospitals, we can compute the long-term value of y.

[27] More efficient than Arellano and Bond (1991) estimator.

[28] Exploiting one-step Arellano and Bover (1995)/Blundell and Bond (1998) or two-step (Windmeijer 2005) variance–covariance matrix estimator leads to similar results. The results in the paper are presented for the one-step estimator.

[29] Exception is MDC14 in the estimates with ALOS and MDC6 in the estimates with readmission rate.

To test hypotheses I–III, the empirical analysis focuses on the changes in the mean fitted value of the dependent variable (i.e., ALOS or readmission rate) in the s post-reform years and the pre-reform year.[30] More precisely, for each $s = 1,\dots, 3$ let

$$\delta_{y,i,s} = 1/s\sum_{j=1}^{s}\hat{y}_{i,t+j} - \hat{y}_{i,t} \tag{4}$$

where $\hat{y}_{i,t}$ is the fitted value of the corresponding dependent variable estimated in 3, $t = 2008$ for cohort 1, and $t = 2007$ for cohort 2.

For each cohort of hospitals, we compute mean values of $\delta_{y,i,s}$ in each of the 25-percentile groups[31] and compare them with zero using t-test.

3.6. Robustness check

As robustness check, we measure $\delta_{y,i,s}$ by estimating cross-section analogs of Equation 3 for each post-reform year. The cross-section specifications enable taking into account time-invariant hospital characteristics in $\mathbf{X}_{it}$, which are differenced out in the analysis using dynamic panel data.

We also analyze relative changes in the mean fitted value of the dependent variable, defining $\delta_{y,i,s}$ as

$$\delta_{y,i,s} = \left((1/s)\cdot\sum_{j=1}^{s}\hat{y}_{i,t+j} - \hat{y}_{i,t}\right)/\hat{y}_{i,t} \tag{5}$$

4. DATA

The analysis uses an administrative database from Japan's MHLW (August 21, 2012) on annual hospital-MDC level aggregated information for patients who were discharged in July–December 2006–2010 and July 2011 to March 2012.[32] The data are voluntarily sent to MHLW by hospitals that plan to join the PPS reform. Hospitals may join the PPS reform after the trial period (commonly after 2 years), may postpone the decision and keep submitting data to the MHLW, or may choose never to join the reform and discontinue sending their data.

The annual files allow us to retrieve the full 2-year pre-reform information for hospitals that joined the PPS in 2009. Merging the MHLW's annual files by hospital name (checking for any change of name due to restructuring, mergers, and closures), we construct an unbalanced panel of 697 hospitals that have submitted data to MHLW since 2007. The subsample is the largest cohort of hospitals in the database. Of these institutions, 566 employed PPS in 2009, 33 in 2010, and 14 in 2011, whereas the rest remained in the FFS reimbursement system. It should be noted that six FFS hospitals left the database in 2008, seven discontinued submitting the data in 2009, 14 stopped sending the data in 2010, and two in 2011.[33] One hospital that introduced PPS in 2009 does not have any data in subsequent years owing to hospital merger.[34]

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[30] Taking the average value of the two pre-reform years (i.e., fully collapsing the data in the pre-reform and post-reform periods) would be desirable; yet, estimations of dynamic panel involve the first differences and do not enable obtaining the fitted value of the dependent variables in the initial year.

[31] The division into larger numbers of groups would decrease group size and, albeit desirable, is inappropriate with existing hospital data.

[32] In 2002, the MHLW decided that survey data on hospital discharges be collected annually for the period from July to October. The length of period was gradually extended: July to December in each fiscal year in 2006–2009; July 2010 to March 2011 in fiscal year 2010, and full fiscal year 2011 (April 2011 to March 2012). The released data for the latest rounds of MHLW's survey covers the periods of July–December in each year 2006–2010, and July 2011 to March 2012. The data exclusively for July–December 2011 (which would be a better annual subsample for comparison with the previous rounds) are unavailable.

[33] The distributions of ALOS for FFS hospitals that left the database and remained in the database are similar.

[34] In 2010, *Okaya enrei* hospital in Nagano prefecture merged with *Shiritsu Okaya* hospital.

To assess potential selection bias in the values of $\delta_{y,i,s}$, we use the second largest cohort in the database: 371 hospitals that started submitting the data since 2006.[35] Of these hospitals, 358 joined PPS in 2008 and one in 2009. As regards FFS hospitals in the cohort, three left the database in 2009, two in 2010, and three in 2011/2012.

As the MHLW's database does not provide a combination of hospital ALOS and quality by each DPC, we conduct the analysis at the level of MDCs (Hayashida *et al*., 2009; Kuwabara *et al*., 2008). It should be noted that 16 MDCs existed in Japan in the pre-2008 period. In 2008, the 16th MDC, which encompassed unclassified diseases, was subdivided into three categories: 'Trauma, burns, poisoning' (new MDC 16); 'Mental diseases and disorders' (new MDC 17), and 'Miscellaneous' (new MDC 18). Therefore, because our econometric analysis deals with data for 2006–2011/2012, we use only 15 MDCs. Aggregating/disaggregating of certain diagnoses in Japanese MDCs relative to ICD-10 is explained in Table II. Finally, the MDC-level readmission data for 2006 are not presented in detailed format, so our analysis with cohort 2 is only limited by estimations of the ALOS as the fitted value for readmission rate in the pre-reform year could not be estimated.

The dependent variables in the empirical analysis are ALOS and prevalence of nonemergency/unanticipated readmissions within 42 days after discharge. Whereas the values of ALOS are available at the MDC level, the database reports prevalence of nonemergency/unanticipated readmissions only at the hospital level. However, the MDC-level data are released for three major reasons of these readmissions: 'Operation after preliminary tests', 'Scheduled operation or therapy', and 'Chemotherapy and radiation therapy', which account for 72–82% of nonemergency/unanticipated readmissions. The total number of nonemergency/unanticipated readmissions is imputed for each MDC assuming that the share of these three reasons is constant across all MDCs and equals to the hospital-level share.

Hospital characteristics (the number of beds as hospital size and proxy for capital; the number of hospital departments as proxy for diversity; the time-invariant dichotomous variables for rural, emergency, university hospitals, for the presence of MRI or CT scanners) come from the 2011 online version of *The Handbook of Hospitals* ('*Byouin yoran*'). The data from the Japan Council for Quality Health Care (2013) enable construction of a time-varying dichotomous variable that equals unity if the hospital is given accreditation by the beginning of the corresponding financial year.[36] The MHLW (2011a) data are employed to create a time-varying dichotomous variable with unity value for hospitals that received the status of designated local hospital (and hence, subsidy per each admission) by the beginning of the financial year. Because ownership and geographic region are shown to be a significant determinant of length of stay (Kuwabara *et al*., 2011; Kuwabara *et al*., 2006), we construct dichotomous variables for public hospitals[37] and for eight geographic regions in Japan, with Shikoku as the reference category (Table III).

The quality of the available data brings some limitations to our analysis. Firstly, we employ the MDC-level data, implicitly assuming that the composition of DPCs within each MDC is the same in all analyzed hospitals. Secondly, the fact that the Japanese DPC database only contains data for those FFS hospitals that plan to employ PPS in the immediate future introduces a selection bias in the estimations. To correct for the bias in estimating the fitted values of the dependent variable, we employ various types of hospital control variables, which may be regarded as determinants of the length of stay (or readmission rate). However, our analysis with percentiles of ALOS implicitly assumes that the bias is the same in each quartile. As regards the use of particular subsamples of hospitals, we compare the estimates for two hospital cohorts. Finally, the data do not contain variables related to individual patient characteristics.

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[35] Although hospital names for this cohort are anonymous in 2006, we recover the names using the 2007 data on facility-level average length of stay and other hospital variables, reported for both 2006 and 2007.

[36] The third-party accreditation started in Japan in 1997 and is granted to hospitals that fulfill seven standards: (1) mission, policy, organization, and planning; (2) community needs; (3) medical care and medical care support systems; (4) nursing care; (5) patient satisfaction and safety; (6) administration; (7) specific standard for rehabilitation and psychiatric hospitals (Hirose *et al*. 2003).

[37] Public hospitals in this paper are national (*kokuritsu*), prefectural (*kenritsu*, *douritsu*, and *furitsu*), city (*shimin* and *shiritsu*), town (*chouritsu*), village (*sonritsu*), and municipal (*kouritsu*) hospitals, and hospitals in the National Health Insurance system (*kokuho*) and the system for health care of workers (*roudousha kenkou fukushi kikou*).

Table II. Average length of stay, readmission rate, and patient cases for hospitals that submit data since 2007 and introduced PPS in 2009

			Patient cases					Average length of stay					Readmission rate				
MDC	Definition	*N*	2007	2008	2009	2010	2011/2012	2007	2008	2009	2010	2011/2012	2007	2008	2009	2010	2011/2012
1	Nervous system	537	80,554	81,310	83,756	85,523	128,476	2.3	20.7	20.5	21.3	21.5	0.0693	0.0706	0.0733	0.0787	0.0883
2	Eye system	334	47,409	47,820	50,548	52,583	79,791	6.5	6.3	5.6	5.3	5.0	0.1117	0.1117	0.1309	0.0573	0.0345
3	Ear, nose, mouth, and throat system	489	48,159	47,942	44,328	47,044	66,523	8.3	8.2	7.6	7.3	7.4	0.0242	0.0196	0.0164	0.0181	0.0122
4	Respiratory system	539	151,653	152,654	157,150	161,992	257,537	18.3	18.2	17.6	18.1	17.9	0.2047	0.1817	0.1819	0.2153	0.2106
5	Circulatory system	523	116,850	121,448	126,555	128,625	201,674	15.7	15.7	14.8	15.0	15.1	0.1998	0.1917	0.2102	0.2626	0.2639
6	Alimentary, liver, biliary tree, and pancreas	542	284,800	301,237	307,766	311,295	457,503	15.5	15.0	13.8	13.7	13.3	0.7584	0.7796	0.7793	0.8368	0.8298
7	Musculoskeletal and connective tissue system	528	60,668	64,337	65,715	62,099	90,784	21.5	21.0	19.8	20.0	20.0	0.1413	0.1463	0.1429	0.1580	0.1584
8	Skin and subcutaneous tissue	369	13,409	13,714	13,088	18,068	26,553	12.5	12.6	11.9	13.2	14.0	0.0010	0.0029	0.0029	0.0105	0.0059
9	Breast system	292	14,221	14,342	14,468	14,421	20,494	14.3	12.9	11.6	12.0	11.7	0.1105	0.1198	0.1061	0.1140	0.1033
10	Endocrine, nutritional, and metabolic system	525	38,555	38,199	36,919	39,978	56,995	17.7	17.2	16.5	16.1	16.2	0.0145	0.0163	0.0138	0.0113	0.0119
11	Kidney, urinary tract, and male reproductive system	532	92,307	94,762	95,942	99,673	145,604	15.5	15.6	14.7	14.7	14.6	0.1784	0.1687	0.1598	0.1750	0.1604
12	Female reproductive system and puerperal diseases, abnormal pregnancy, and abnormal labor	292	75,637	77,857	76,984	79,182	115,559	12.4	11.5	11.0	11.0	10.8	0.2949	0.2927	0.2541	0.2708	0.2458
13	Blood and blood forming organs and immunological disorders	438	20,935	22,239	25,638	26,814	40,644	24.6	23.7	23.5	23.3	23.2	0.0853	0.0795	0.0945	0.0980	0.0905
14	Newborn and other neonates, congenital anomalies	241	23,835	24,921	24,709	26,107	38,720	11.4	10.6	10.7	10.4	10.2	0.0179	0.0180	0.0195	0.0215	0.0198
15	Pediatric diseases	449	27,675	24,867	18,428	22,927	34,820	7.8	8.1	8.0	7.7	7.7	0.0010	0.0003	0.0007	0.0007	0.0002
16	Trauma, burns, poison	536		87,445	88,390	94,220	145,001		19.3	18.5	18.4	18.9		0.0308	0.0313	0.0386	0.0389
17	Mental diseases and disorders	96		2,298	1,730	1,443	2,341		12.8	12.0	10.8	8.6		0.0004	0.0003	0.0001	0.00002
18	Miscellaneous	447	109,202	18,104	20,332	22,692	34,509	18.9	17.6	22.2	22.2	23.3	0.0664	0.0179	0.0185	0.0146	0.0121

(1) The numbers of Japanese MDCs are given as of 2008. Therefore, MDC18 (‘miscellaneous’) in 2007 is equivalent to the sum of MDC16, MDC17, and MDC18 in 2008–2011/2012. (2) The Japanese MDC6 encompasses MDC6 and MDC7 in ICD-10, MDC11 incorporates MDC11 and MDC12 in ICD-10, MDC12 combines MDC13 and MDC14 in ICD-10, and MDC13 includes MDC16 and MDC17 in ICD-10. At the same time, MDC9 in ICD-10 is disaggregated into the Japanese MDC8 and MDC9. (3) Readmission rate stands for the prevalence of nonemergency/unanticipated readmissions within 42 days after discharge. (4) The data for *Okaya Enrei* hospital are not included. (5) English equivalents of MHLW’s MDCs (2012c) are adopted from Hayashida *et al*. (2009), Kuwabara *et al*. (2008), and Ishikawa *et al*. (2005). (6) 2007–2010 denote the time period July to December in each year; 2011/2012 denotes July 2011 to March 2012. (7) *N* indicates the number of hospitals in 2009. Owing to nonreported data, for some MDCs the number of hospitals in specifications with readmission rate may be 1–3% smaller than in corresponding specifications with ALOS in some years.

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Table III. Descriptive statistics for unbalanced panels of hospital cohorts

Variable	Definition	Cohort 1 (2007–2011/2012)		Cohort 2 (2006–2011/2012)	
		Mean	St Dev	Mean	St Dev
Dependent variable					
ALOS	Average length of stay during one hospitalization, days	14.95	2.47	14.64	2.35
$ALOS\_MDC_{1}$	Average length of stay for patients in MDC1	20.84	5.88	20.40	5.18
$ALOS\_MDC_{2}$	Average length of stay for patients in MDC2	5.58	2.36	5.86	2.48
$ALOS\_MDC_{3}$	Average length of stay for patients in MDC3	7.59	3.58	7.90	3.72
$ALOS\_MDC_{4}$	Average length of stay for patients in MDC4	17.89	5.02	17.27	4.60
$ALOS\_MDC_{5}$	Average length of stay for patients in MDC5	15.13	5.06	14.49	4.80
$ALOS\_MDC_{6}$	Average length of stay for patients in MDC6	13.91	2.95	13.96	2.89
$ALOS\_MDC_{7}$	Average length of stay for patients in MDC7	20.18	5.48	19.78	5.17
$ALOS\_MDC_{8}$	Average length of stay for patients in MDC8	13.04	4.55	12.68	4.02
$ALOS\_MDC_{9}$	Average length of stay for patients in MDC9	12.20	5.15	12.17	4.94
$ALOS\_MDC_{10}$	Average length of stay for patients in MDC10	16.46	4.45	16.30	4.30
$ALOS\_MDC_{11}$	Average length of stay for patients in MDC11	14.80	4.69	14.22	4.03
$ALOS\_MDC_{12}$	Average length of stay for patients in MDC12	11.16	3.81	11.17	2.93
$ALOS\_MDC_{13}$	Average length of stay for patients in MDC13	23.17	8.85	24.31	8.74
$ALOS\_MDC_{14}$	Average length of stay for patients in MDC14	10.47	4.86	11.72	5.60
$ALOS\_MDC_{15}$	Average length of stay for patients in MDC15	7.78	2.46	7.84	2.34
Reform indicator					
PPS	=1 if joined inpatient PPS by corresponding financial year	0.52	0.50	0.58	0.49
Hospital variables					
Beds	Total number of beds	292.80	168.96	353.16	184.71
Departments	Total number of departments	15.31	6.14	17.76	6.37
Urban	=1 if urban hospital	0.89	0.31	0.87	0.33
Public	=1 if public hospital	0.28	0.45	0.23	0.42
Designated	=1 if granted the status of designated local hospital by corresponding financial year	0.08	0.27	0.11	0.31
Accredited	=1 if given independent accreditation by Japan Council for Quality Health Care by corresponding financial year	0.62	0.49	0.46	0.50
Emergency	=1 if emergency hospital	0.84	0.37	0.85	0.35
University	=1 if university hospital	0.02	0.13	0.04	0.18
MRI/CT	=1 if has MRI or CT scanner	0.93	0.25	0.93	0.26

The total number of observations for hospitals in cohort 1 (cohort 2) is 3408 (1850). Number of beds (departments) are available only for 1830 (1840) hospitals of cohort 2, owing to restructuring into clinics, closures, and/or mergers. Prefecture grants the status of designated hospital and financial support of 10,000 yen per each admission to local hospital that satisfies the following requirements: (1) has over 200 beds; (2) the share of patients referred from other facilities is over 60%; (3) shares its beds and expensive equipment (e.g., MRI and CT scanner) with other hospitals; (4) educates local health care officials; and (5) has emergency status.

5. EMPIRICAL ANALYSIS

The results of our estimates reveal that the identification condition for dynamic panel data analysis holds for most specifications of the ALOS and of readmission rate.[38]

Comparison of mean values of $\delta_{\mathrm{ALOS},s}$ ($s = 1, \dots, 3$) in each of the 25-percentile groups in each cohort shows that the reform effect is more noticeable in the first post-reform year than in later years. The significance and sign of mean δ_{ALOS} (or $\delta_{\mathrm{readmission}}$) are similar for estimations with raw changes defined in 4 or relative changes measured according to 5.

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[38] β_1 belongs to the interval (0,1) for 14 MDCs and is statistically significant for 13 (10) MDCs, respectively. For the average of all MDCs and for MDC 4 in specification with ALOS and for MDC 8 in the specification with planned early readmission rate, we fit the model in the first differences since dynamic panels in levels proved to be nonstationary.

Table IV. Relative change in the average length of stay for PPS hospitals in the two cohorts

	Cohort 1				Cohort 2			
	0–25 percentile	26–50 percentile	51–75 percentile	76–100 percentile	0–25 percentile	26–50 percentile	51–75 percentile	76–100 percentile
All MDCs	−0.012*** (0.004)	−0.026*** (0.003)	−0.049*** (0.002)	−0.064*** (0.004)	0.101*** (0.015)	−0.008* (0.005)	−0.054*** (0.004)	−0.103*** (0.007)
MDC1	0.027*** (0.002)	0.0003 (0.002)	−0.010*** (0.003)	−0.041*** (0.002)	0.044*** (0.004)	−0.0001 (0.009)	−0.016 (0.013)	−0.078*** (0.006)
MDC2	−0.024** (0.011)	−0.090*** (0.013)	−0.101*** (0.009)	−0.163*** (0.012)	0.127*** (0.025)	−0.062*** (0.012)	−0.170*** (0.011)	−0.214*** (0.011)
MDC3	0.005 (0.009)	−0.028*** (0.010)	−0.085*** (0.008)	−0.106*** (0.014)	0.025 (0.026)	−0.017 (0.027)	−0.052*** (0.018)	−0.117*** (0.027)
MDC4	0.002 (0.004)	−0.023*** (0.005)	−0.024*** (0.006)	−0.074*** (0.006)	0.093*** (0.009)	0.023*** (0.006)	−0.030*** (0.005)	−0.110*** (0.008)
MDC5	0.001 (0.003)	−0.022*** (0.002)	−0.051*** (0.003)	−0.098*** (0.003)	0.069*** (0.005)	0.007** (0.003)	−0.030*** (0.004)	−0.116*** (0.007)
MDC6	−0.029*** (0.005)	−0.067*** (0.003)	−0.083*** (0.003)	−0.120*** (0.004)	0.070*** (0.021)	−0.055*** (0.008)	−0.097*** (0.008)	−0.146*** (0.008)
MDC7	0.024*** (0.004)	−0.030*** (0.002)	−0.060*** (0.002)	−0.114*** (0.003)	0.029*** (0.006)	−0.033*** (0.004)	−0.073*** (0.002)	−0.128*** (0.006)
MDC8	0.045*** (0.006)	−0.008** (0.004)	−0.062*** (0.005)	−0.145*** (0.008)	0.017** (0.009)	−0.046*** (0.008)	−0.072*** (0.008)	−0.165*** (0.011)
MDC9	0.045*** (0.014)	−0.034*** (0.014)	−0.116*** (0.013)	−0.238*** (0.013)	0.095*** (0.017)	−0.058*** (0.010)	−0.149*** (0.008)	−0.326*** (0.014)
MDC10	0.004* (0.003)	−0.03*** (0.002)	−0.048*** (0.002)	−0.093*** (0.003)	0.030*** (0.007)	−0.032*** (0.003)	−0.079*** (0.004)	−0.161*** (0.004)
MDC11	−0.043*** (0.003)	−0.055*** (0.004)	−0.064*** (0.003)	−0.091*** (0.004)	0.064*** (0.008)	−0.026*** (0.003)	−0.074*** (0.003)	−0.158*** (0.005)
MDC12	−0.002 (0.003)	−0.021*** (0.003)	−0.034*** (0.003)	−0.078*** (0.005)	0.019*** (0.006)	−0.046*** (0.003)	−0.098*** (0.004)	−0.174*** (0.006)
MDC13	0.137*** (0.016)	0.029** (0.014)	−0.046*** (0.010)	−0.124*** (0.009)	0.094*** (0.016)	0.011 (0.016)	−0.079*** (0.012)	−0.180*** (0.007)
MDC14	0.075*** (0.015)	0.009 (0.016)	−0.014 (0.020)	−0.037** (0.017)	0.043** (0.022)	0.006 (0.018)	−0.016 (0.015)	−0.029 (0.028)
MDC15	0.009* (0.006)	0.003 (0.006)	−0.007* (0.005)	−0.013* (0.009)	0.270*** (0.037)	0.091*** (0.025)	0.014 (0.033)	−0.136*** (0.031)

Cohorts 1 (2) are hospitals that submit data since 2007 (2006) and joined the reform in 2009 (2008). Hospitals are sorted according to the value of their average length of stay (for all MDCs or corresponding MDC) in their first year of submitting the data. For each hospital i in each cohort, we compute the relative change in the average fitted value of the dependent variable $\hat{y}_{i,t}$ (average length of hospital stay) in the s post-reform years (here $s = 1$) and the pre-reform year: $\delta_{y,i,s} = (\hat{y}_{i,t+1} - \hat{y}_{i,t})/\hat{y}_{i,t}$. Mean $\delta_{y,s} = (1/N_q) \cdot \sum_{i=1}^{Nq} \delta_{y,i,s}$, where N_q is the number of hospitals from the cohort in the qth quartile of nationwide ALOS (here $q = 1, \ldots, 4$). Robust standard errors (estimated for t-test for comparison of mean $\delta_{y,s}$ with zero) in parentheses. *p-value < 0.1. **p-value < 0.05. ***p-value < 0.01.

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As regards hospital cohort 1, the mean values of δ_{ALOS} are positive in percentiles 0–25 of the nationwide ALOS for 8 to 11 MDCs in 2009–2011/2012 and for the average of all MDCs in 2010–2011/2012. The positively significant values are observed for the average of all MDCs in 2010–2011/2012 and for eight MDCs in 2009–2011/2012. Even when the mean values of δ_{ALOS} are negatively significant in percentiles 0–25, the absolute value of the decrease in ALOS is smaller than in percentiles 26–100.

In percentiles 51–75, negatively significant mean δ_{ALOS} are observed for the average of all MDCs, 14 MDCs in 2009, and 13 MDCs in 2010–2011/2012. As for percentiles 76–100, negatively significant values are found for the average of all MDCs and each MDC in 2009–2011/2012. The mean values of δ_{ALOS} reveal smaller decline of ALOS in higher percentiles of ALOS (Table IV and Appendix Tables SI—SIV).

To test robustness of the estimates, we conducted cross-section calculations and discovered slightly better results: the mean values of δ_{ALOS} are positive in percentiles 0–25 ALOS for 9 to 10 MDCs in 2009–2011/2012.[39] As for percentiles 51–100, δ_{ALOS} are negative for the average of all MDCs and for 14 to 15 MDCs in 2009–2011/2012.

As regards hospital cohort 2, we fit 3 with AR(1) process for the average of all MDCs and 10 MDCs out of 15 and with AR(2) for five MDCs.[40] The results of the estimates demonstrate that the supposition of Hypothesis I concerning percentiles 0–25 is supported for 14 MDCs and the average of all MDCs and is not rejected for the remaining one MDC. The supposition of Hypothesis I concerning percentiles 50–100 and Hypothesis II holds for all MDCs (Table IV and Appendix Tables SV and SVI). Better results for cohort 2 (particularly in case of MDCs 2, 6, and 11) may be explained by more equal distribution of these hospitals in the first quartile of ALOS (Appendix Figure SI).

Overall, the evidence for both cohorts is consistent with Hypothesis I (for most MDCs, hospitals in percentiles 0–25 increase their ALOS and hospitals in percentiles 51–100 decrease it) and Hypothesis II (larger decline of ALOS at hospitals in higher percentiles of ALOS). A failure of Hypothesis I for some MDCs in cohort 1 may be explained by a large prevalence of surgical patients, for whom material costs are well covered within the DPC schedule (Yasunaga *et al.*, 2006). MDC2 ‘Eye system’, where nonsurgical patients constitute only 5% (Hayashida *et al.*, 2009; Kuwabara *et al.*, 2008), may provide an example of such case.

The mean values of $\delta_{\text{readmission}}$ are positive in percentiles 51–75 (76–100) of the average ALOS of all MDCs in 2009–2011/2012, nine (11) MDCs in 2009, and 10 (11) MDCs in 2010–2011/2012. Significantly positive values are found for the average of all MDCs in 2009–2011/2012; for five (nine) MDCs in 2009, nine (nine) MDCs in 2010, and 10 (nine) MDCs in 2011/2012 (Table V and Appendix Tables SI–SIV). This may be interpreted as failure to reject Hypothesis III and as a trade-off between length of stay and readmittance in percentiles 51–100. The results of cross-section estimations similarly indicate that Hypothesis III holds for the average of all MDCs and for most MDCs. As regards percentiles 0–50, the trade-off is less evident: increase (decrease) of ALOS in percentiles 0–25 (26–50) is not necessarily accompanied by a fall (rise) of the planned early readmission rate.

It should be noted that the MDC-level estimations are based on the assumption that the share of the three reasons for nonemergency/unanticipated readmissions is the same for all MDCs. Justified by the desire to achieve a reasonable approximation in the absence of available data, the assumption is likely to be questionable for MDC2 ‘Eye system’, MDC3 ‘Ear, nose, mouth, and throat’, and MDC12 ‘Female reproductive system, abnormal pregnancy’ (which would not have many scheduled readmissions within 42 days after discharge for the following reason: ‘Chemotherapy and radiation therapy’).[41] Overall, because we cannot quantitatively assess the assumption, the MDC-level results for the nonemergency/unanticipated readmission rate can only be treated as tentative.

Finally, we estimate the relative change in the total episode of hospitalization in quartiles of hospitals according to 5. The length of total episode is approximated as ALOS multiplied by the number of

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[39] Negatively significant for three MDCs in 2009, four MDCs in 2010, and five MDCs in 2011/2012.

[40] In case of MDCs 2, 3, 6, 14, and 15, Arellano and Bond (1991) test rejected the hypothesis about the absence of second-order correlation in the first differenced errors. As the rejection rate exceeds the acceptable value of first-order error, we reestimate 3 using second-order lags, increasing length of the panel till 2012/2013 when necessary.

[41] This may explain the fact that Hypothesis III does not hold for these MDCs.

Table V. Relative change in readmission rate for hospitals that submit data since 2007 and joined PPS in 2009

	Cohort 1			
	0–25 percentile	26–50 percentile	51–75 percentile	76–100 percentile
All MDCs	0.163*** (0.031)	0.180*** (0.037)	0.261*** (0.035)	0.244*** (0.030)
MDC1	0.099** (0.057)	0.071 (0.060)	0.085 (0.069)	0.177 (0.130)
MDC2	0.476*** (0.073)	0.462*** (0.067)	0.617*** (0.069)	0.574*** (0.068)
MDC3	0.240*** (0.044)	0.130** (0.062)	−0.028 (0.054)	−0.174*** (0.060)
MDC4	−0.012 (0.012)	0.006 (0.013)	−0.020** (0.012)	−0.034*** (0.012)
MDC5	0.181*** (0.031)	0.127*** (0.026)	0.133*** (0.031)	0.104*** (0.020)
MDC6	0.020** (0.009)	−0.018*** (0.005)	0.013** (0.007)	0.009 (0.007)
MDC7	−0.028** (0.014)	0.026*** (0.010)	0.020** (0.011)	0.049*** (0.008)
MDC8	−0.267*** (0.049)	−0.264*** (0.031)	−0.190*** (0.041)	−0.243 (0.102)
MDC9	0.025 (0.100)	0.024 (0.061)	−0.063 (0.338)	0.265*** (0.104)
MDC10	0.013 (0.058)	0.082** (0.035)	−0.092 (0.096)	0.134*** (0.031)
MDC11	−0.068*** (0.014)	−0.037*** (0.014)	−0.010 (0.012)	0.041*** (0.010)
MDC12	−0.110*** (0.026)	−0.133*** (0.018)	−0.113*** (0.023)	−0.114*** (0.019)
MDC13	0.377*** (0.035)	0.337*** (0.039)	0.310*** (0.034)	0.329*** (0.054)
MDC14	−0.284* (0.199)	−0.129* (0.097)	1.301 (1.142)	−0.078 (0.145)
MDC15	34.707*** (7.345)	24.633*** (8.889)	35.645*** (5.537)	34.434*** (7.672)

Hospitals are sorted according to the value of their average length in each MDC in the 2007. For each hospital i in each cohort, we compute the relative change in the average fitted value of the dependent variable $\hat{y}_{i,t}$ (nonemergency/unanticipated readmission rate within 42 days after discharge) in the s post-reform years (here $s = 1$) and the pre-reform year: $\delta_{y,i,s} = (\hat{y}_{i,t+1} - \hat{y}_{i,t})/\hat{y}_{i,t}$. Mean $\delta_{y,s} = \left(1/N_q\right)\cdot\sum_{i=1}^{Nq}\delta_{y,i,s}$, where N_q is the number of hospitals from the cohort in the qth quartile of nationwide ALOS ($q = 1,\dots, 4$). Robust standard errors (estimated for t-test for comparison of mean $\delta_{y,s}$ with zero) in parentheses. Extremely low prevalence of readmissions and low number of cases for MDC15 (see Table II) may explain sharp relative changes, reported in this table. *p-value < 0.1. **p-value < 0.05. ***p-value < 0.01.

hospitalizations per discharged patient. Given data availability, the variable could only be computed at the hospital level (average for all MDCs). The results (Table VI) indicate that the length of total episode of hospitalization declines after the introduction of a new payment system for hospitals in percentiles 26–100 for both cohorts, does not change in percentiles 0–25 for cohort 1, and declines less than in other quartiles for cohort 2.

6. DISCUSSION

The empirical analysis in this paper confirms the presence of differential effects of a per diem payment system with declining rates on hospitals' ALOS and quality. The hypotheses concerning differential effects are essentially built on the fact that there is a certain length of each period to which the declining rates apply (Monrad Aas, 1995). In particular, the length of period I corresponding to the 25th percentile of the nationwide ALOS may be greater than the ALOS at some most efficient hospitals. Therefore, the new Japanese inpatient payment system makes hospitals raise their ALOS up to the end of the first period. Our finding is similar to the conclusion of Okamura *et al.* (2005) about a disincentive for a sharp decline in ALOS within the Japanese per diem tariff.

As for the nonemergency readmission rate, the economic theory suggests that it increases when a readmitted patient has a higher revenue-to-cost margin compared with a potential patient who might have been admitted to sustain the same bed occupancy rate (Hockenberry *et al.*, 2013; Kondo and Kawabuchi, 2012). The findings in the present paper for percentiles 26–100 may be viewed as an empirical confirmation of this assumption.

Our estimations suggest that the effect of the new per diem payment system in terms of both ALOS and total episode of hospitalization (and potentially, in terms of total cost of an illness episode) is adverse for hospitals in the first quartile of ALOS. In this regard, we suggest applying 'best practice' rate-setting: decreasing the length of period I to ALOS at the best performing hospital, and establishing a flat per diem rate for all other days of treatment. Indeed, according to the model of Grabowski *et al.* (2011), an efficient way of setting per diem rates

Table VI. Relative changes in total episode of hospitalization for PPS hospitals in the two cohorts

	Cohort 1			Cohort 2		
	Mean δ_1	Mean δ_2	Mean δ_3	Mean δ_1	Mean δ_2	Mean δ_3
Percentiles 0–25	−0.003 (0.018)	−0.002 (0.019)	−0.004 (0.018)	−0.044*** (0.017)	−0.034** (0.019)	−0.041** (0.019)
Percentiles 25–50	−0.039*** (0.013)	−0.052*** (0.013)	−0.055*** (0.013)	−0.057*** (0.016)	−0.056*** (0.016)	−0.060*** (0.016)
Percentiles 51–75	−0.036*** (0.015)	−0.049*** (0.013)	−0.059*** (0.013)	−0.059*** (0.013)	−0.044*** (0.013)	−0.048*** (0.012)
Percentiles 76–100	−0.067*** (0.013)	−0.069*** (0.013)	−0.065*** (0.015)	−0.046*** (0.015)	−0.046*** (0.014)	−0.050*** (0.014)

Cohorts 1 (2) are hospitals that submit data since 2007 (2006) and joined the reform in 2009 (2008). Hospitals are sorted according to the value of their average length of stay (for all MDCs) in their first year of submitting the data. Length of total episode of hospitalization for all MDCs (l_{it}) is measured as average length of stay multiplied by average number of hospitalizations per patient. For each hospital i, we compute the relative change in the length of total episode of hospitalization in the s post-reform years ($s = 1,\dots, 3$) and the pre-reform year: $\delta_{l,i,s} = \left((1/s)\cdot\sum_{j=1}^{s} l_{i,t+j} - l_{i,t} \right)/l_{i,t}$. Mean $\delta_s = \left(1/N_q\right)\cdot\sum_{i=1}^{Nq} \delta_{l,i,s}$, where N_q is the number of hospitals from the cohort in the qth quartile of nationwide ALOS ($q = 1,\dots, 4$). Robust standard errors (estimated for t-test for comparison of mean δ_s with zero) in parentheses. *p-value < 0.1. **p-value < 0.05. ***p-value < 0.01.

would require a step function $p(i)$, so that the implication of the first-order condition $p_i - c_i < 0$[42] could be satisfied at a set of points, where $p' = 0$.

After the development of medical standardization, the suggestion might be applicable to Japanese hospitals in order to alleviate the adverse effects of the reform. MHLW's (2012a) decrease of period I to 1 day for 22 DPCs with high medical costs may be regarded as a move toward 'best practice' rate-setting.

It should be noted that despite the limitations of per diem rates, a changeover to full PPS would be a premature measure in Japan. Indeed, the failure of the per case PPS in 10 national hospitals in 1998–2004 was due to underdeveloped standardization, when patients with different conditions were assigned the same diagnosis group (Kondo and Kawabuchi, 2012). Therefore, Japan sustains the per diem character of its new payment system: introduced in 2003 with the name 'inclusive payment system according to diagnosis–procedure combinations', the system was renamed in 2010 as 'diagnosis–procedure combination/per diem payment system'—DPC/PDPS (MHLW, 2011b).

Finally, the fact that data were only available for a self-selected sample of hospitals that started sending data to MHLW meant that only empirical identification of hospitals' objective function re-optimization strategy under a new set of payment constraints was possible. The metrics of MDC-level patient outcomes and total spending need to be taken into account in a more detailed analysis of adverse effects of the payment schedule.

7. CONCLUSION

The paper estimates differential effects of a PPS with declining per diem rates. The analysis using recent data for each major diagnostic category at 1068 hospitals in Japan (July 2006 to March 2012) indicates that the ALOS significantly increases for hospitals in percentiles 0–25 of the pre-reform nationwide length of stay and significantly decreases for hospitals in percentiles 51–100. The decline of ALOS is larger for hospitals in higher percentiles of the pre-reform length of stay. At the same time, the nonemergency/unanticipated readmission rate within 42 days after discharge rises at hospitals in percentiles 51–100 of the nationwide ALOS. Whereas the length of total episode of hospitalization decreases for hospitals in percentiles 26–100, it does not change or it declines to a smaller extent for hospitals in percentiles 0–25. The findings are generally robust in terms of the choice of a cohort of hospitals joining the reform. The adverse effect for the lowest quartile of the length of stay may be explained by the step-down rates in the per diem tariff dependent on length of stay.

The results of our analysis concerning potential adverse effects of declining rates in a per diem payment system may be relevant both at the country level and for generalizations by medical specialty. Indeed, in addition to the experience of Japan and Germany, per diem PPSs are currently employed in the US at Medicaid's and Medicare's psychiatric hospitals and also at Medicare's skilled nursing facilities and hospices.

CONFLICT OF INTEREST

I do not have any conflict of interests.

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[42] Follows from Grabowski *et al.* (2011) (Equation 3 on p. 677), as at the optimum sign $(p_i - c_i) = -\text{sign}(p - c)\, N_B B_i < 0$.

University, 2010) and out of the CEFIR/NES working paper, Besstremyannaya and Shapiro (2012) Heterogeneous effect of prospective payment system on hospital's volume and quality.

[Correction added on 26 July 2016, after first online publication: A statement was added in the Acknowledgement section to reflect the origins of the research.]

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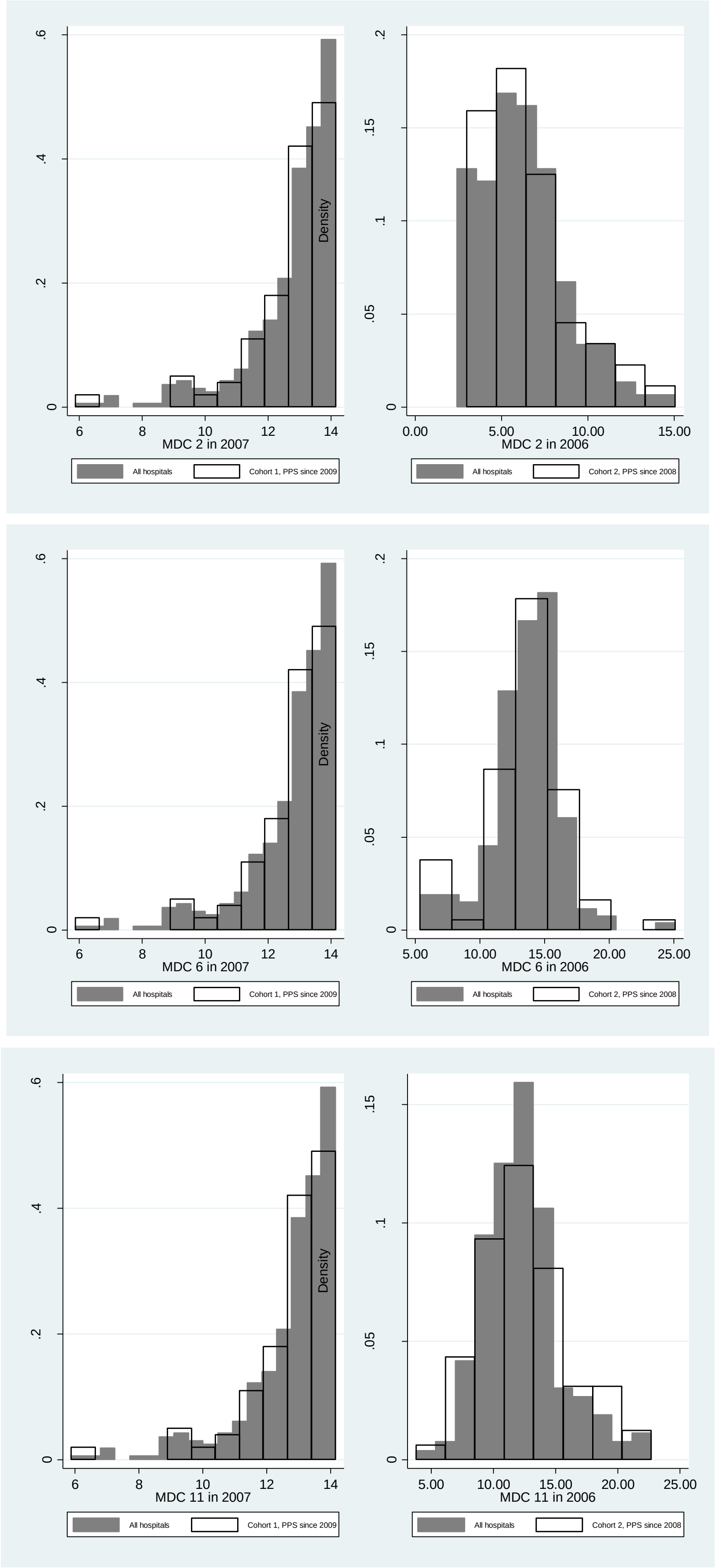

Figure S-I. Initial distribution of average length of stay in the first quartiles of MDCs 2, 6 and 11 for subsamples of hospital cohorts, which introduced the reform

Table S-I. Changes in the average length of stay and readmission rate for hospitals which submitted data since 2007 and joined PPS in 2009 (percentiles 0-25)

	Average length of stay						Readmission rate					
	Mean δ_1		**Mean δ_2**		**Mean δ_3**		**Mean δ_1**		**Mean δ_2**		**Mean δ_3**	
All MDCs	-0.169***	(0.055)	-0.117**	(0.055)	-0.071	(0.059)	0.0021**	(0.0013)	0.0022**	(0.0013)	0.0022**	(0.0014)
MDC1	0.520***	(0.047)	0.890***	(0.048)	1.130***	(0.051)	-0.0031	(0.0042)	0.0032	(0.0037)	0.0059**	(0.0036)
MDC2	-0.103**	(0.051)	-0.051	(0.051)	-0.103**	(0.051)	0.0109*	(0.0072)	-0.0213***	(0.0074)	-0.0402***	(0.0074)
MDC3	0.031	(0.056)	-0.019	(0.052)	-0.057	(0.049)	-0.0028***	(0.0020)	-0.0034**	(0.0019)	-0.0046***	(0.0019)
MDC4	0.021	(0.066)	0.413***	(0.079)	0.579***	(0.085)	-0.0027	(0.0022)	0.0091***	(0.0021)	0.0111***	(0.0022)
MDC5	0.008	(0.050)	0.174***	(0.053)	0.235***	(0.056)	0.0281***	(0.0056)	0.0494***	(0.0051)	0.0603***	(0.0053)
MDC6	-0.400***	(0.060)	-0.481***	(0.057)	-0.571***	(0.059)	0.0095*	(0.0062)	0.0337***	(0.0062)	0.0366***	(0.0064)
MDC7	0.428***	(0.068)	0.429***	(0.070)	0.404***	(0.063)	-0.0084***	(0.0025)	0.0006	(0.0026)	0.004*	(0.0026)
MDC8	0.506***	(0.062)	1.003***	(0.060)	1.502***	(0.062)	0.0018***	(0.0005)	0.0056***	(0.0005)	0.007***	(0.0010)
MDC9	0.506***	(0.145)	0.520***	(0.148)	0.296**	(0.150)	-0.0249**	(0.0115)	-0.0198*	(0.0129)	-0.0211*	(0.0134)
MDC10	0.068*	(0.048)	-0.277***	(0.047)	-0.232***	(0.048)	0.0007	(0.0010)	-0.0028***	(0.0011)	-0.0038***	(0.0011)
MDC11	-0.651***	(0.044)	-0.587***	(0.043)	-0.559***	(0.044)	-0.0155***	(0.0029)	-0.0125***	(0.0029)	-0.0161***	(0.0030)
MDC12	-0.024	(0.034)	0.012	(0.030)	-0.084***	(0.029)	-0.0450***	(0.0081)	-0.0421***	(0.0085)	-0.0452***	(0.0089)
MDC13	2.429***	(0.223)	2.399***	(0.230)	2.299***	(0.237)	0.0185***	(0.0027)	0.0212***	(0.0029)	0.0206***	(0.0028)
MDC14	0.567***	(0.105)	0.443***	(0.118)	0.352***	(0.121)	-0.0033	(0.0037)	-0.0037*	(0.0025)	-0.0054***	(0.0020)
MDC15	0.073*	(0.047)	-0.056*	(0.034)	-0.121***	(0.034)	0.0004***	(0.0001)	0.0005***	(0.0001)	0.0004***	(0.0001)

Note: Hospitals are sorted according to the value of their average length in each MDC in 2007. For each hospital *i* we compute the change in the average fitted value of dependent variable $\hat{y}_{i,t}$ (average length of hospital stay or readmission rate) in the *s* post-reform years (s=1,…,3) and the prereform year: $\delta_{y,i,s} = (1/s)\cdot\sum_{j=1}^{s}\hat{y}_{i,t+j} - \hat{y}_{i,t}$.

Mean $\delta_{y,s} = (1/N_q)\cdot\sum_{i=1}^{Nq}\delta_{y,i,s}$, where N_q is the number of hospitals from the cohort in the q-th quartile of nationwide ALOS (here q=1). Robust standard errors (estimated for t-test for comparison of mean $\delta_{y,s}$ with zero) in parentheses. * p-value <0.1, ** p-value <0.05, *** p-value<0.01

Table S-II. Changes in the average length of stay and readmission rate for hospitals which submitted data since 2007 and joined PPS in 2009 (percentiles 26-50)

	Average length of stay						Readmission rate					
	Mean δ_1		**Mean δ_2**		**Mean δ_3**		**Mean δ_1**		**Mean δ_2**		**Mean δ_3**	
All MDCs	-0.387***	(0.049)	-0.397***	(0.054)	-0.401***	(0.054)	0.0029***	(0.0012)	0.0020**	(0.0012)	0.0017	(0.0013)
MDC1	0.007	(0.049)	0.330***	(0.050)	0.513***	(0.053)	-0.0030	(0.0037)	0.0011	(0.0039)	0.0063*	(0.0040)
MDC2	-0.509***	(0.071)	-0.588***	(0.070)	-0.674***	(0.068)	0.0133**	(0.0066)	-0.0160***	(0.0062)	-0.0379***	(0.0066)
MDC3	-0.220***	(0.078)	-0.404***	(0.058)	-0.453***	(0.052)	-0.0034**	(0.0017)	-0.0033**	(0.0015)	-0.0050***	(0.0015)
MDC4	-0.403***	(0.082)	-0.059	(0.077)	0.009	(0.077)	0.0013	(0.0025)	0.0140***	(0.0026)	0.0184***	(0.0028)
MDC5	-0.336***	(0.032)	-0.186***	(0.040)	-0.115***	(0.047)	0.0177***	(0.0054)	0.0439***	(0.0047)	0.0567***	(0.0051)
MDC6	-0.971***	(0.037)	-1.061***	(0.034)	-1.185***	(0.033)	-0.0168***	(0.0039)	0.0075**	(0.0040)	0.0122***	(0.0042)
MDC7	-0.623***	(0.038)	-0.606***	(0.045)	-0.588***	(0.051)	0.0013	(0.0018)	0.0117***	(0.0018)	0.0146***	(0.0019)
MDC8	-0.107***	(0.044)	0.470***	(0.042)	0.986***	(0.048)	0.0019***	(0.0004)	0.0057***	(0.0004)	0.0065***	(0.0005)
MDC9	-0.472***	(0.154)	-0.433***	(0.137)	-0.612***	(0.139)	-0.0135**	(0.0073)	-0.0055	(0.0078)	-0.0073	(0.0080)
MDC10	-0.512***	(0.039)	-0.821***	(0.035)	-0.761***	(0.035)	0.0016***	(0.0006)	-0.0007	(0.0006)	-0.0015**	(0.0008)
MDC11	-0.861***	(0.059)	-0.842***	(0.059)	-0.811***	(0.061)	-0.0093***	(0.0028)	-0.0061**	(0.0027)	-0.0095***	(0.0027)
MDC12	-0.229***	(0.029)	-0.230***	(0.025)	-0.320***	(0.024)	-0.0501***	(0.0064)	-0.0486**	(0.0065)	-0.0503***	(0.0066)
MDC13	0.487**	(0.253)	0.450**	(0.257)	0.416*	(0.260)	0.0184***	(0.0021)	0.0205***	(0.0021)	0.0202***	(0.0021)
MDC14	0.038	(0.137)	-0.188*	(0.115)	-0.175*	(0.128)	-0.0077***	(0.0013)	-0.0065***	(0.0013)	-0.0063***	(0.0015)
MDC15	0.025	(0.047)	-0.153***	(0.046)	-0.184***	(0.040)	0.0003***	(0.0001)	0.0005***	(0.0001)	0.0002	(0.0002)

Note: Hospitals are sorted according to the value of their average length in each MDC in 2007. For each hospital *i* we compute the change in the average fitted value of dependent variable $\hat{y}_{i,t}$ (average length of hospital stay or readmission rate) in the *s* post-reform years (s=1,…,3) and the prereform year: $\delta_{y,i,s} = (1/s)\cdot\sum_{j=1}^{s}\hat{y}_{i,t+j} - \hat{y}_{i,t}$.

Mean $\delta_{y,s} = (1/N_q)\cdot\sum_{i=1}^{Nq}\delta_{y,i,s}$, where N_q is the number of hospitals from the cohort in the q-th quartile of nationwide ALOS (here q=2). Robust standard errors (estimated for t-test for comparison of mean $\delta_{y,s}$ with zero) in parentheses. * p-value <0.1, ** p-value <0.05, *** p-value<0.01

Table S-III. Changes in the average length of stay and readmission rate for hospitals which submitted data since 2007 and joined PPS in 2009 (percentiles 51-75)

	Average length of stay						Readmission rate					
	Mean δ_1		**Mean δ_2**		**Mean δ_3**		**Mean δ_1**		**Mean δ_2**		**Mean δ_3**	
All MDCs	-0.783***	(0.039)	-0.838***	(0.041)	-0.831***	(0.042)	0.0067***	(0.0009)	0.0060***	(0.0010)	0.0054***	(0.0010)
MDC1	-0.218***	(0.053)	0.061	(0.054)	0.282***	(0.056)	-0.0002***	(0.0036)	0.0013	(0.0032)	0.0060**	(0.0028)
MDC2	-0.708***	(0.063)	-0.869***	(0.073)	-1.017***	(0.072)	0.0229***	(0.0062)	-0.0110*	(0.0067)	-0.0307***	(0.0067)
MDC3	-0.729***	(0.070)	-0.772***	(0.059)	-0.862***	(0.057)	-0.0063***	(0.0018)	-0.0071***	(0.0018)	-0.0087***	(0.0019)
MDC4	-0.454***	(0.111)	-0.377***	(0.101)	-0.403***	(0.100)	-0.0041***	(0.0022)	0.0110***	(0.0022)	0.0143***	(0.0024)
MDC5	-0.791***	(0.051)	-0.650***	(0.055)	-0.598***	(0.061)	0.0156***	(0.0058)	0.0441***	(0.0062)	0.0575***	(0.0061)
MDC6	-1.269***	(0.040)	-1.382***	(0.035)	-1.526***	(0.035)	0.0053	(0.0049)	0.0295***	(0.0051)	0.0333***	(0.0052)
MDC7	-1.290***	(0.048)	-1.300***	(0.049)	-1.318***	(0.052)	0.0006	(0.0018)	0.0106***	(0.0018)	0.0143***	(0.0018)
MDC8	-0.795***	(0.062)	-0.212***	(0.053)	0.277***	(0.053)	0.0016***	(0.0005)	0.0052***	(0.0005)	0.0058***	(0.0008)
MDC9	-1.484***	(0.151)	-1.326***	(0.119)	-1.515***	(0.121)	0.0019	(0.0067)	0.0110*	(0.0068)	0.0094*	(0.0070)
MDC10	-0.834***	(0.037)	-1.125***	(0.035)	-1.062***	(0.034)	-0.0014***	(0.0016)	-0.0029***	(0.0011)	-0.0027***	(0.0009)
MDC11	-1.011***	(0.043)	-0.994***	(0.043)	-0.992***	(0.047)	-0.0042***	(0.0024)	-0.0018	(0.0025)	-0.0047**	(0.0026)
MDC12	-0.395***	(0.039)	-0.420***	(0.033)	-0.525***	(0.034)	-0.0437***	(0.0067)	-0.0380***	(0.0066)	-0.0378***	(0.0067)
MDC13	-1.159***	(0.203)	-1.136***	(0.203)	-1.210***	(0.222)	0.0197***	(0.0025)	0.0227***	(0.0024)	0.0218***	(0.0024)
MDC14	-0.114	(0.231)	-0.195	(0.235)	-0.259	(0.230)	0.0111	(0.0101)	0.0165**	(0.0092)	0.0227**	(0.0107)
MDC15	-0.058*	(0.041)	-0.172***	(0.036)	-0.185***	(0.035)	0.0004***	(0.0001)	0.0004***	(0.0001)	0.0002**	(0.0001)

Note: Hospitals are sorted according to the value of their average length in each MDC in 2007. For each hospital *i* we compute the change in the average fitted value of dependent variable $\hat{y}_{i,t}$ (average length of hospital stay or readmission rate) in the *s* post-reform years (s=1,…3) and the prereform year: $\delta_{y,i,s} = (1/s)\cdot\sum_{j=1}^{s}\hat{y}_{i,t+j} - \hat{y}_{i,t}$.

Mean $\delta_{y,s} = (1/N_q)\cdot\sum_{i=1}^{Nq}\delta_{y,i,s}$, where N_q is the number of hospitals from the cohort in the q-th quartile of nationwide ALOS (here q=3). Robust standard errors (estimated for t-test for comparison of mean $\delta_{y,s}$ with zero) in parentheses. * p-value <0.1, ** p-value <0.05, *** p-value<0.01

Table S-IV. Changes in the average length of stay and readmission rate for hospitals which submitted data since 2007 and joined PPS in 2009 (percentiles 76-100)

	Average length of stay						**Readmission rate**					
	Mean δ_1		**Mean δ_2**		**Mean δ_3**		**Mean δ_1**		**Mean δ_2**		**Mean δ_3**	
All MDCs	-1.123***	(0.068)	-1.213***	(0.069)	-1.223***	(0.073)	0.0052***	(0.0012)	0.0047***	(0.0012)	0.0048***	(0.0012)
MDC1	-0.902***	(0.056)	-0.579***	(0.055)	-0.359***	(0.055)	-0.0022	(0.0033)	-0.0014	(0.0027)	0.0026	(0.0026)
MDC2	-1.430***	(0.107)	-1.744***	(0.117)	-1.897***	(0.118)	0.0286***	(0.0056)	-0.0036	(0.0058)	-0.0233***	(0.0058)
MDC3	-1.184***	(0.152)	-1.318***	(0.161)	-1.384***	(0.165)	-0.0100	(0.0024)	-0.0108***	(0.0021)	-0.0125***	(0.0022)
MDC4	-1.616***	(0.138)	-1.374***	(0.127)	-1.333***	(0.125)	-0.0066	(0.0022)	0.0089***	(0.0023)	0.0117***	(0.0026)
MDC5	-1.689***	(0.063)	-1.556***	(0.065)	-1.493***	(0.067)	0.0106***	(0.0041)	0.0380***	(0.0045)	0.0499***	(0.0050)
MDC6	-2.000***	(0.067)	-2.176***	(0.065)	-2.369***	(0.066)	0.0023	(0.0047)	0.0268***	(0.0050)	0.0306***	(0.0051)
MDC7	-2.627***	(0.078)	-2.611***	(0.080)	-2.618***	(0.082)	0.0050***	(0.0013)	0.0146***	(0.0013)	0.0185***	(0.0013)
MDC8	-2.012***	(0.112)	-1.375***	(0.098)	-0.860***	(0.097)	0.0025***	(0.0010)	0.0058***	(0.0010)	0.0052***	(0.0009)
MDC9	-3.424***	(0.208)	-3.129***	(0.193)	-3.274***	(0.191)	0.0114*	(0.0076)	0.0293***	(0.0059)	0.0277***	(0.0060)
MDC10	-1.682***	(0.049)	-1.939***	(0.050)	-1.844***	(0.050)	0.0025***	(0.0005)	0.0005	(0.0005)	-0.0001	(0.0005)
MDC11	-1.514***	(0.063)	-1.504***	(0.063)	-1.486***	(0.061)	0.0049***	(0.0019)	0.0073***	(0.0018)	0.0052***	(0.0019)
MDC12	-0.987***	(0.075)	-1.025***	(0.071)	-1.138***	(0.071)	-0.0366***	(0.0060)	-0.0308***	(0.0062)	-0.0296***	(0.0060)
MDC13	-3.778***	(0.261)	-4.062***	(0.271)	-4.151***	(0.278)	0.0191***	(0.0031)	0.0224***	(0.0027)	0.0219***	(0.0027)
MDC14	-0.598**	(0.269)	-0.821***	(0.266)	-0.986***	(0.273)	0.0030	(0.0057)	0.0053	(0.0050)	0.0086*	(0.0064)
MDC15	-0.094*	(0.070)	-0.273***	(0.057)	-0.300***	(0.055)	0.0004***	(0.0001)	0.0004**	(0.0002)	0.0002	(0.0002)

Note: Hospitals are sorted according to the value of their average length in each MDC in 2007. For each hospital *i* we compute the change in the average fitted value of dependent variable $\hat{y}_{i,t}$ (average length of hospital stay or readmission rate) in the *s* post-reform years (s=1,…,3) and the prereform year: $\delta_{y,i,s} = (1/s)\cdot\sum_{j=1}^{s}\hat{y}_{i,t+j} - \hat{y}_{i,t}$.

Mean $\delta_{y,s} = (1/N_q)\cdot\sum_{i=1}^{Nq}\delta_{y,i,s}$, where N_q is the number of hospitals from the cohort in the q-th quartile of nationwide ALOS (here q=4). Robust standard errors (estimated for t-test for comparison of mean $\delta_{y,s}$ with zero) in parentheses. * p-value <0.1, ** p-value <0.05, *** p-value<0.01

Table S-V. Changes in the average length of stay for hospitals which submitted data since 2006 and joined PPS in 2008 (percentiles 0-25 and 26-50)

	Percentiles 0-25						Percentiles 26-50					
	Mean δ_1		Mean δ_2		Mean δ_3		Mean δ_1		Mean δ_2		Mean δ_3	
All MDCs	1.014***	(0.135)	0.887***	(0.142)	0.850***	(0.146)	-0.121*	(0.074)	-0.269***	(0.071)	-0.287***	(0.079)
MDC1	0.713***	(0.059)	0.815***	(0.092)	0.892***	(0.117)	-0.046	(0.136)	0.105	(0.170)	0.214	(0.196)
MDC2	0.342***	(0.083)	0.289***	(0.084)	0.269***	(0.089)	-0.460***	(0.081)	-0.565***	(0.083)	-0.668***	(0.089)
MDC3	-0.094	(0.150)	-0.035	(0.148)	-0.052	(0.152)	-0.451**	(0.212)	-0.418**	(0.206)	-0.479**	(0.221)
MDC4	1.322***	(0.113)	1.274***	(0.112)	1.205***	(0.103)	0.374***	(0.101)	0.282***	(0.101)	0.305***	(0.108)
MDC5	0.863***	(0.058)	0.849***	(0.064)	0.855***	(0.070)	0.093**	(0.046)	0.095**	(0.051)	0.091**	(0.055)
MDC6	0.427**	(0.187)	0.348**	(0.186)	0.278*	(0.192)	-0.890***	(0.137)	-1.020***	(0.140)	-1.162***	(0.148)
MDC7	0.472***	(0.090)	0.476***	(0.089)	0.491***	(0.089)	-0.696***	(0.074)	-0.765***	(0.074)	-0.754***	(0.073)
MDC8	0.189**	(0.100)	0.370***	(0.100)	0.463***	(0.103)	-0.595***	(0.100)	-0.383***	(0.098)	-0.257***	(0.107)
MDC9	1.004***	(0.168)	0.928***	(0.161)	0.878***	(0.174)	-0.735***	(0.124)	-0.670***	(0.110)	-0.695***	(0.111)
MDC10	0.426***	(0.100)	0.499***	(0.111)	0.507***	(0.124)	-0.530***	(0.051)	-0.516***	(0.054)	-0.495***	(0.059)
MDC11	0.801***	(0.094)	0.727***	(0.088)	0.668***	(0.074)	-0.369***	(0.042)	-0.398***	(0.040)	-0.423***	(0.039)
MDC12	0.185***	(0.062)	0.134**	(0.062)	0.087*	(0.059)	-0.535***	(0.037)	-0.592***	(0.034)	-0.641***	(0.035)
MDC13	1.883***	(0.268)	1.957***	(0.278)	1.971***	(0.295)	0.146	(0.307)	0.208	(0.328)	0.324	(0.345)
MDC14	0.105	(0.143)	0.045	(0.144)	-0.049	(0.161)	-0.222	(0.176)	-0.328**	(0.138)	-0.433***	(0.166)
MDC15	1.383***	(0.206)	1.373***	(0.211)	1.345***	(0.208)	0.404**	(0.179)	0.456***	(0.184)	0.429**	(0.185)

Notes: Hospitals are sorted according to the value of their average length in each MDC in 2006. For each hospital *i* we compute the change in the average fitted value of dependent variable $\hat{y}_{i,t}$ (average length of hospital stay) in the *s* post-reform years (s=1,…,3) and the prereform year: $\delta_{y,i,s} = (1/s)\cdot\sum_{j=1}^{s}\hat{y}_{i,t+j} - \hat{y}_{i,t}$.

Mean $\delta_{y,s} = (1/N_q)\cdot\sum_{i=1}^{Nq}\delta_{y,i,s}$, where N_q is the number of hospitals from the cohort in the q-th quartile of nationwide ALOS, here q=1(percentiles 0-25) and q=2 (percentiles 26-50). As AR(2) estimation does not allow identifying fitted values of the dependent variable in the prerefom period, actual values of ALOS in 2006 are used for MDCs 2,3,6,14,15. Robust standard errors (estimated for t-test for comparison of mean $\delta_{y,s}$ with zero) in parentheses. * p-value <0.1, ** p-value <0.05, *** p-value<0.01

Table S-VI. Changes in the average length of stay for hospitals which submitted data since 2006 and joined PPS in 2008 (percentiles 51-75 and 76-100)

	Percentiles 51-75						Percentiles 76-100					
	Mean δ_1		**Mean δ_2**		**Mean δ_3**		**Mean δ_1**		**Mean δ_2**		**Mean δ_3**	
All MDCs	-0.863***	(0.061)	-1.094***	(0.060)	-1.164***	(0.066)	-1.975***	(0.153)	-2.321***	(0.162)	-2.426***	(0.163)
MDC1	-0.431**	(0.220)	-0.359*	(0.228)	-0.275	(0.237)	-1.709***	(0.112)	-1.730***	(0.112)	-1.720***	(0.111)
MDC2	-1.442***	(0.111)	-1.712***	(0.123)	-1.858***	(0.134)	-2.250***	(0.151)	-2.652***	(0.169)	-2.954***	(0.186)
MDC3	-0.696***	(0.179)	-0.750***	(0.168)	-0.821***	(0.168)	-2.147***	(0.398)	-2.539***	(0.409)	-2.837***	(0.437)
MDC4	-0.538***	(0.087)	-0.604***	(0.079)	-0.625***	(0.080)	-2.448***	(0.193)	-2.644***	(0.197)	-2.622***	(0.195)
MDC5	-0.463***	(0.063)	-0.491***	(0.063)	-0.513***	(0.063)	-2.055***	(0.147)	-2.144***	(0.144)	-2.182***	(0.145)
MDC6	-1.694***	(0.150)	-1.959***	(0.150)	-2.118***	(0.151)	-2.786***	(0.175)	-3.182***	(0.181)	-3.471***	(0.187)
MDC7	-1.512***	(0.045)	-1.506***	(0.055)	-1.476***	(0.062)	-2.899***	(0.142)	-2.963***	(0.146)	-2.927***	(0.150)
MDC8	-1.011***	(0.108)	-0.897***	(0.110)	-0.827***	(0.119)	-2.285***	(0.157)	-2.070***	(0.142)	-1.943***	(0.133)
MDC9	-1.990***	(0.116)	-1.949***	(0.102)	-1.932***	(0.097)	-5.602***	(0.330)	-5.421***	(0.313)	-5.350***	(0.321)
MDC10	-1.386***	(0.063)	-1.346***	(0.062)	-1.343***	(0.063)	-3.009***	(0.082)	-2.964***	(0.083)	-2.938***	(0.084)
MDC11	-1.146***	(0.054)	-1.212***	(0.058)	-1.256***	(0.058)	-2.803***	(0.104)	-2.911***	(0.105)	-2.933***	(0.105)
MDC12	-1.210***	(0.050)	-1.304***	(0.055)	-1.334***	(0.054)	-2.468***	(0.121)	-2.604***	(0.125)	-2.692***	(0.130)
MDC13	-2.156***	(0.253)	-2.039***	(0.282)	-2.033***	(0.302)	-5.507***	(0.252)	-5.485***	(0.272)	-5.501***	(0.285)
MDC14	-0.425**	(0.196)	-0.776***	(0.169)	-0.996***	(0.185)	-1.282***	(0.344)	-1.522***	(0.272)	-1.674***	(0.286)
MDC15	-0.497*	(0.299)	-0.441*	(0.307)	-0.454*	(0.309)	-1.728***	(0.349)	-1.674***	(0.354)	-1.351***	(0.311)

Notes: Hospitals are sorted according to the value of their average length in each MDC in 2006. For each hospital *i* we compute the change in the average fitted value of dependent variable $\hat{y}_{i,t}$ (average length of hospital stay or readmission rate) in the *s* post-reform years (s=1,…3) and the prereform year: $\delta_{y,i,s} = (1/s)\cdot\sum_{j=1}^{s}\hat{y}_{i,t+j} - \hat{y}_{i,t}$.

Mean $\delta_{y,s} = (1/N_q)\cdot\sum_{i=1}^{Nq}\delta_{y,i,s}$, where N_q is the number of hospitals from the cohort in the q-th quartile of nationwide ALOS, here q=3(percentiles 51-75) and q=4 (percentiles 76-100). As AR(2) estimation does not allow identifying fitted values of the dependent variable in the prerefom period, actual values of ALOS in 2006 are used for MDCs 2,3,6,14,15. Robust standard errors (estimated for t-test for comparison of mean $\delta_{y,s}$ with zero) in parentheses. * p-value <0.1, ** p-value <0.05, *** p-value<0.01