

Impact of payment system change from per-case to per-diem on high severity patient's length of stay

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Abstract

A new payment system, the diagnosis-related group (DRG) system, and Korean diagnosis procedure combination (KDPC, per-diem) payment system were officially introduced in 2002 and in 2012, respectively. We evaluated the impact of payment system change from per-case to per-diem on high severity patient's length of stay (LOS).

Claim data was used. A total of 36,240 case admissions and 72,480 control admissions were included in the analysis. Segmented regression analysis of interrupted time series between cases and controls was conducted. Hospitals that consistently participated in the DRG payment system and changed to the KDPC payment system were defined as case hospitals. Hospitals that consistently participated in the DRG payment system were defined as control hospitals.

LOS increased by 0.025 days per month ($P=0.0055$) for 3 surgical diagnosis-related admissions due to the bundled payment system change. LOS among emergency admissions also increased and showed an increasing tendency under the KDPC. The LOS increase was observed specifically for complex procedure admissions and high severity cases (CCI 0, 1: 0.022, $P=0.0142$; CCI 2, 3: 0.026, $P=0.0288$; CCI ≥ 4 : 0.055, $P=0.0003$).

Although both payment systems are optimized to decrease LOS, incentives to reduce LOS are stronger under the DRG system than under the KDPC system. It is worth noting that too strong incentive for reducing LOS is suitable to high severity cases.

Abbreviations: AUC = area under the curve, CCI = Charlson comorbidity index, DPC = diagnosis procedure combination, DRG = diagnosis-related group, FFS = fee-for-service, HIRA = Health Insurance Review and Assessment Service, KDPC = Korean diagnosis procedure combination, LOS = length of stay, NHI = National Health Insurance, NHIC = National Health Insurance council, PPS = prospective payment system, SD = standard deviation.

Keywords: bundled payment, diagnosis-related group, DRG, KDPC, Korean diagnosis procedure combination

Editor: Neil Merrett.

Authors' contribution: PCE and LSG contributed to the conception and KTH contributed to the design of the study. NCM and PSH contributed to the analysis and interpretation of data. JSI was responsible for the acquisition of data. All authors have contributed to the revision of the manuscript and approved publication of the final version.

Funding/support: This research has been supported by the research grant of Research Institute for Healthcare Policy, KMA in 2015.

The authors have no conflicts of interest to disclose.

Supplemental Digital Content is available for this article.

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Medicine (2016) 95:37(e4839)

Received: 13 May 2016 / Received in final form: 9 August 2016 / Accepted: 19 August 2016

<http://dx.doi.org/10.1097/MD.0000000000004839>

1. Introduction

It is well known that the system by which purchasers choose to pay providers has a significant impact on the medical decisions and clinical and professional behavior of providers.^[1-4] Due to this impact, insurance payment systems have been used to achieve political objectives, such as cost containment and recruitment to underserved areas.^[5,6] Since the introduction of the National Health Insurance (NHI) in 1977, fee-for-service (FFS) has been the primary payment system for medical services and supplies in Korea.^[7] Although the Korean government has regulated some medical costs, including reimbursements to medical suppliers,^[8] health-related spending has increased consistently and sharply. Both experts and the government have argued that the FFS system, which offers providers autonomy in medical decision-making, is the root of uncontrolled health care costs.^[3,7-9]

The adoption of a diagnosis-related group (DRG)-based payment system, which is a form of a case-based prospective payment system (PPS) under which payment is based on particular diagnosis for hospital inpatient services,^[10] was officially proposed by the task force for health care reform in 1994, partly as a political move. Since the implementation of the Medicare inpatient care payment system in the United States in 1983, DRG-based payment systems have emerged as a popular hospital payment system in many European countries and other countries worldwide.^[11,12] Compared with the FFS-based payment system, the DRG-based payment system is a supply-side cost-sharing payment system that

incentivizes providers to contain medical expenses by introducing economic consequences of health care utilization to the provider.^[13] The Korean government accepted and started a pilot project to implement a DRG-based system as a means to contain health care costs in October 1997.^[17] The DRG-based payment system was officially introduced in 2002 for 7 DRG principal diagnoses, including 3 principal surgical diagnoses (appendicitis, hernia, and hemorrhoid) on a voluntary basis. The DRG-based payment system has been mandatory for 7 principal diagnoses since July 2012, and was expanded to include all medical institutes except long-term care hospitals and public hospitals in July 2013.

Meanwhile, another bundled payment system, the diagnosis procedure combination (DPC), was introduced in 2009. The name of this bundled payment system in Korean means “new DRG.” However, in this study, we have named this bundled payment system the Korean diagnosis procedure combination (KDPC), because this system is very similar to the Japanese DPC. The DPC-based system is a mixed system that includes a flat-rate (i.e., per-case or per-diem) payment and FFS payment, which distinguishes the KDPC from the DRG-based system.^[14] The Health Insurance Review and Assessment Service (HIRA), which is a government agency that reviews claims submitted by providers, assesses the quality of care provided, and makes decisions for reimbursement, introduced the KDPC as a payment system for 550 principal diagnoses admissions at all public hospitals in July 2012.

Therefore, 3 payment systems currently coexist in Korea. The government has set a goal to introduce a bundled payment system as the national basic payment system to contain costs by transitioning risk to the suppliers. This system is also expected to improve administrative conveniences. Suppliers are resistant to a bundled payment system. Furthermore, there is no public consent about the best system. The National Health Insurance council (NHIC), which is the top decision-making body of the NHI contract, suggested a roadmap that would expand a bundled payment system to combine DRG and KDPC. However, although several studies have reported the effect of the payment system change from FFS to DRG^[8,10,15–20] and from FFS to KDPC,^[21,22] no studies have directly compared the DRG-based system with the KDPC-based system. Hence, there exists a need for a more comprehensive comparison and evaluation of these systems to determine which system would be more appropriate in Korea and to inform the overall decision of the NHIC. Although DRG admissions are forced to reduce length of stay (LOS) for financial reason, KDPC admissions with LOS longer than the standard LOS also incur a financial penalty due to the decreasing per-diem fee schedule. We had assumed that there are difference effects between DRG and KDPC on reducing LOS, especially among high severity admission. So the null hypothesis of this study is “there are no difference between the effect of LOS of DRG and KDPC.” Therefore, this study analyzed the impact of change from DRG to KDPC with a focus on the average LOS. A difference observed between DRG and KDPC may provide important evidence for selecting or developing the next-generation payment system in Korea.

2. Methods

2.1. Study design

In this study, hospitals that consistently participated in the DRG payment system from January 2007 to June 2012 and underwent a change in payment system to the KDPC payment system from

July 2012 to June 2014 were defined as case hospitals. All case hospitals are public hospitals because the KDPC has been implemented in public hospitals only. Hospitals that consistently participated in the DRG payment system from January 2007 to June 2014 were defined as control hospitals. All control hospitals are private hospitals because these hospitals were not required to change to the KDPC system. Among the 39 public hospitals that implemented the KDPC payment system, 2 hospitals previously used an FFS payment system and were excluded from this study. Two additional hospitals were excluded from the study due to missing data. Therefore, 35 hospitals were included as case hospitals in our study. Among 1996 medical institutes that were paid more than once by the DRG payment system for principal surgical DRGs, 326 institutes consistently participated in the DRG payment system. Clinics were excluded because no clinics were included as case hospitals. Therefore, 60 hospitals were included as control hospitals in this study. General characteristics of hospitals are presented in Table S4, <http://links.lww.com/MD/B274>, in appendix.

The number of admissions to case hospitals was 39,364 and the number of admissions to control hospitals was 477,668. We conducted 1:2 sampling using the propensity score matching method for age, sex, Charlson comorbidity index (CCI), sub-DRG, and admission date (month). The area under the curve (AUC) value was 0.836. A total of 36,240 case admissions and 72,480 control admissions were included in the final analysis. Figure 1 shows the case and control groups during the study period and the selection of the study population.

The Institutional Review Board of Yonsei University Graduate School of Public Health approved the study (approval no. 2015–406).

2.2. Data and variables

This study used claim data provided by HIRA. Seven principal DRGs are included in the DRG payment system in Korea. Surgical principal DRGs include appendectomy (G08), hernia procedures (G09), and anal procedures (G10). Each principal DRG includes 4 sub-DRGs (supplementary Table 1, <http://links.lww.com/MD/B274>, reports the sub-DRGs by principal DRGs).

The dependent variable in our study is LOS of the admission case. LOS is a representative index that reflects the effectiveness of admission and is commonly used to evaluate the impact of a payment system change. Prior studies that have evaluated payment system change from an FFS-based payment system to a case-based payment system report a decrease in LOS under case-based systems. This result is expected due to the difference in cost-sharing between FFS and bundled payment systems. A case-based payment system, such as the DRG or KDPC, provides incentives to reduce LOS for profit maximization. Therefore, LOS is considered a proper index to estimate differences between DRG and KDPC in this study. Theoretically, KDPC does not provide as much incentive to decrease LOS as DRG. Therefore, a change in LOS due a change from DRG to KDPC may reflect other effects in addition to economic incentives.

Age, sex, region (hospital location), sub-DRG, CCI, season, and year were included as individual-level covariates. Hospital type, ownership, teaching status, region, number of beds, number of doctors, and number of nurses were included as hospital-level covariates. Age, number of beds, number of doctors, and number of nurses were included as continuous variables. Sub-DRG included 12 subgroups (Table S1, <http://links.lww.com/MD/B274>). CCI was calculated yearly based on Quan’s methods^[23];

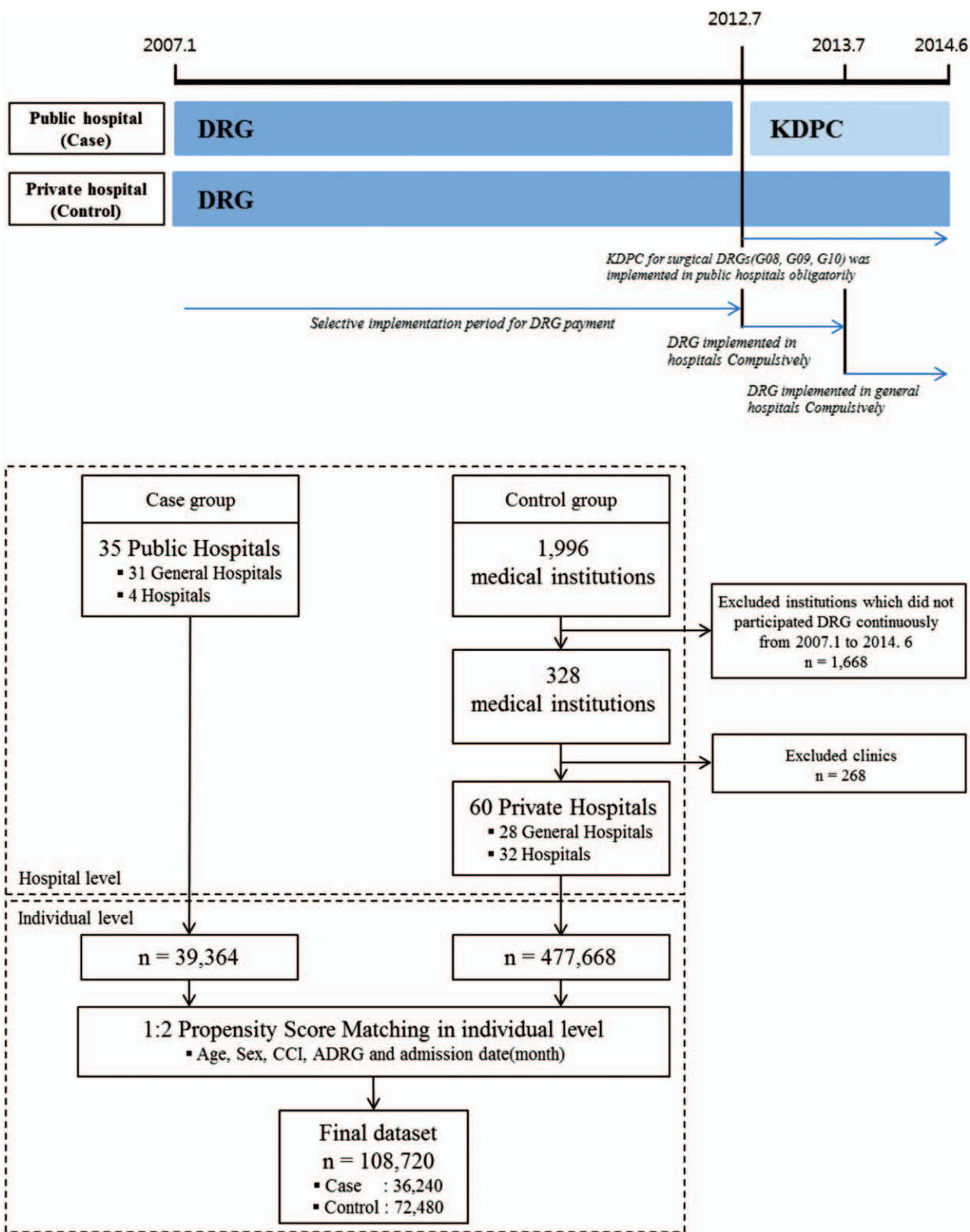


Figure 1. Study design and the population selection flow.

19 diseases were classified into scores of 1, 2, 3, or 6. CCI per subject was calculated from the sum of all scores. In this study, CCI was grouped as scores of 0, 1, 2, 3, and 4 or more. Four seasons were included to adjust for seasonal variations due to known seasonality in temperature and medical service utilization in Korea. The season variable was created as dummy variable.

Hospital type was classified as either general hospital or hospital. The bundled payment fee schedule varies between these 2 hospital types in Korea. Ownership was classified as public, corporate, or private. The KDPC was compulsory only in public hospitals; therefore, there are no private hospitals among the case hospitals and no public hospitals among the control hospitals. So

finally, 31 public hospitals, 4 corporation hospitals, and 0 private hospitals are included in case, and 28 corporation hospitals and 32 private hospitals are included in control (Tables S2 and S4, <http://links.lww.com/MD/B274>). Teaching status (teaching or non-teaching) and region (urban or rural) were included as binary variables.

2.3. Statistical method

Segmented regression analysis of interrupted time series with control was carried out for analysis in this study, using the following equation (Equation 1):

$$Y_t = \beta_0 + \beta_1 \text{time}_t + \beta_2 \text{KDPC implementation}_t + \beta_3 \text{time after KDPC implementation}_t + \beta_4 \text{Case} + \beta_5 \text{time}_t \times \text{Case} + \beta_6 \text{KDPC implementation}_t \times \text{Case} + \beta_7 \text{time after KDPC implementation}_t \times \text{Case} + \beta_8 \text{season}_t + \mu_1 Z_1 + \dots + \mu_p Z_p + e_t \dots (1)$$

Y_t : average length of stay of month t

t : time period (month)

time_t : a continuous variable started in January 2007 by month

Case : a binary variable (0 control hospitals; 1 case hospitals)

$\text{KDPC implementation}_t$: a binary variable (0 before June 2012; 1 after July 2012)

$\text{time after KDPC implementation}_t$: a continuous variable started in July 2012

Season_t : seasonality (1 spring, 2 summer, 3 autumn, 4 winter)

$\mu_p Z_p$: independent variables (1... p)

e_t =random variation in length of stay across time within hospital (within hospital variation).

In Equation 1, β_6 represents the level of change in the difference between case and control LOS at the time of KDPC implementation. β_7 represents the trend in the difference between case and control LOS after KDPC implementation. Equation 1 was implemented in PROC GENMOD (All analyses were conducted using the SAS statistical software package, version 9.4, SAS Institute Inc.) as a generalized estimation equation (GEE) and mixed model with *link identity, distribution normal, and AR(1)*.

3. Results

Before propensity score matching, all variables were significantly different between cases and controls. Table 1 presents the general characteristics of the study population following the application of propensity score matching methods for age, sex, sub-DRG, and CCI. In addition, the time of the outcome was also included as a matching variable in order to implement time-series analysis

Table 1
General characteristics of admissions after propensity score matching (n, %).

Variables	Case (n=36,240)		Control (n=72,480)		P
Length of stay (mean, SD)	5.28	±2.36	4.80	±2.50	<0.001
Age (mean, SD)	40.8	±21.3	40.7	±21.1	0.155
<10	1949	5.4	4259	5.9	<0.001
10–19	5928	16.4	11,613	16.0	
20–29	4504	12.4	8918	12.3	
30–39	5079	14.0	9949	13.7	
40–49	5465	15.1	10,985	15.2	
50–59	5143	14.2	10,577	14.6	
60–67	4268	11.8	8845	12.2	
≥70	3904	10.8	7334	10.1	
Sex					
Male	22,798	62.9	46,758	64.5	<0.001
Female	13,442	37.1	25,722	35.5	
Principal diagnosis					
Appendectomy	44,867	61.9	22,360	61.7	0.744
Hernia procedures	11,856	16.4	5989	16.5	
Hemorrhoid procedures	15,757	21.7	7891	21.8	
Charlson comorbidity index					
0	17,416	48.1	34,693	47.9	0.007
1	5987	16.5	11,994	16.6	
2	5013	13.8	10,384	14.3	
3	4228	11.7	8639	11.9	
≥4	3596	9.9	6670	9.3	
Season					0.184
Spring	9760	26.9	19,853	27.4	
Summer	9617	26.5	18,851	26.0	
Autumn	7707	21.3	15,533	21.4	
Winter	9156	25.3	18,243	25.2	
Period					<0.001
2007.1–2008.6	7435	20.5	15,506	21.4	
2008.7–2009.6	4855	13.4	10,194	14.1	
2009.7–2010.6	5007	13.8	9867	13.6	
2010.7–2011.6	4513	12.5	9330	12.9	
2011.7–2012.6	4935	13.6	9494	13.1	
2012.7–2013.6	4589	12.66	8865	12.23	
2013.7–2014.6	4906	13.54	9224	12.73	
Total	36,240	33.3	72,480	66.7	

Table 2
Length of stay for hospitals by case and control (mean, SD).

Variables	Case (n = 39,364)			P	Control (n = 72,480)			P		
	Before intervention, 2007.1–2012.6	After intervention, 2012.7–2014.6			Before intervention, 2007.1–2012.6	After intervention, 2012.7–2014.6				
Age										
<10	4.71	±2.21	4.41	±2.04	0.013	4.62	±2.58	4.66	±3.23	0.711
10–19	5.21	±1.87	5.12	±1.80	0.117	5.08	±1.96	4.91	±1.91	<0.0001
20–29	5.23	±2.07	5.13	±1.89	0.177	4.79	±2.11	4.41	±2.00	<0.0001
30–39	5.28	±2.21	5.05	±2.03	0.001	4.69	±2.26	4.43	±2.40	<0.0001
40–49	5.41	±2.47	5.09	±2.20	<0.0001	4.75	±2.51	4.54	±2.46	<0.0001
50–59	5.57	±2.75	5.09	±2.38	<0.0001	4.83	±2.62	4.53	±2.60	<0.0001
60–67	5.47	±2.58	5.01	±2.43	<0.0001	4.84	±2.83	4.70	±3.00	0.044
≥70	5.69	±2.98	5.15	±2.80	<0.0001	5.16	±3.02	4.77	±3.13	<0.0001
Sex										
Male	5.23	±2.38	4.90	±2.26	<0.0001	4.67	±2.45	4.41	±2.56	<0.0001
Female	5.55	±2.44	5.35	±2.16	<0.0001	5.18	±2.46	5.02	±2.58	<0.0001
Principal diagnosis										
Appendectomy	5.75	±2.27	5.61	±2.12	<0.0001	5.66	±2.36	5.58	±2.53	0.002
Hernia procedures	4.93	±2.23	4.38	±2.22	<0.0001	3.91	±2.22	3.50	±2.28	<0.0001
Hemorrhoid procedures	4.53	±2.61	4.07	±2.07	<0.0001	3.16	±1.70	3.02	±1.61	<0.0001
Charlson comorbidity index										
0	5.17	±2.07	5.03	±1.93	<0.0001	4.84	±2.18	4.61	±2.26	<0.0001
1	5.40	±2.44	5.06	±2.19	<0.0001	4.74	±2.49	4.49	±2.41	<0.0001
2	5.56	±2.72	5.09	±2.37	<0.0001	4.82	±2.64	4.57	±2.68	<0.0001
3	5.49	±2.57	4.98	±2.37	<0.0001	4.86	±2.80	4.68	±2.96	0.011
≥4	5.74	±3.11	5.23	±2.90	<0.0001	5.22	±3.11	4.83	±3.19	<0.0001
Season										
Spring	5.34	±2.41	5.10	±2.24	<0.0001	4.85	±2.44	4.57	±2.52	<0.0001
Summer	5.35	±2.37	5.01	±2.27	<0.0001	4.90	±2.45	4.68	±2.64	<0.0001
Autumn	5.37	±2.37	5.14	±2.29	<0.0001	4.90	±2.49	4.67	±2.58	<0.0001
Winter	5.35	±2.46	5.02	±2.13	<0.0001	4.77	±2.48	4.57	±2.58	<0.0001
Period										
2007.1–2008.6	5.64	±2.36			<0.0001	5.00	±2.51			<0.0001
2008.7–2009.6	5.45	±2.31				4.88	±2.37			
2009.7–2010.6	5.28	±2.43				4.83	±2.45			
2010.7–2011.6	5.14	±2.43				4.79	±2.51			
2011.7–2012.6	5.09	±2.46				4.68	±2.45			
2012.7–2013.6			4.98	±2.16				4.64	±2.57	
2013.7–2014.6			5.14	±2.30				4.60	±2.59	
Hospital type										
General hospital	5.33	±2.38	5.04	±2.23	<0.0001	5.47	±2.37	5.42	±2.51	0.092
Hospital	5.79	±2.80	5.47	±2.34	0.031	4.26	±2.41	3.87	±2.41	<0.0001
Hospital ownership										
Public	5.40	±2.38	5.12	±2.21	<0.0001	–	–	–	–	
Corporation	5.03	±2.50	4.70	±2.38	<0.0001	5.51	±2.48	5.44	±2.58	0.033
Private	–	–	–	–		4.37	±2.34	3.99	±2.40	<0.0001
Teaching status										
Teaching	5.72	±2.39	5.33	±2.28	<0.0001	5.35	±2.29	5.45	±2.44	0.007
Non-teaching	5.19	±2.39	4.95	±2.20	<0.0001	4.67	±2.50	4.32	±2.56	<0.0001
Region										
Urban	5.48	±2.57	5.03	±2.43	<0.0001	4.61	±2.46	4.37	±2.57	<0.0001
Rural	5.30	±2.33	5.08	±2.14	<0.0001	5.56	±2.35	5.39	±2.47	<0.0001
Number of beds (means)										
<300 beds	5.16	±2.33	4.92	±2.06	<0.0001	4.53	±2.47	4.13	±2.49	<0.0001
300–499 beds	5.61	±2.34	5.76	±2.37	0.022	5.54	±2.00	5.29	±1.86	<0.0001
500–700 beds	5.72	±2.52	5.22	±2.38	<0.0001	5.16	±2.36	5.24	±2.72	0.347
Total	5.35	±2.40	5.06	±2.23	<0.0001	4.85	±2.46	4.62	±2.58	<0.0001

for propensity score matching with 1:2 ratio samples. Tables S2 and S3, <http://links.lww.com/MD/B274>, in the Appendix report general admission characteristics before and after propensity score matching by period.

Average LOS was significantly higher in cases compared with controls. There were no significant differences in average age between cases and controls (40.8 vs 40.7 years, respectively).

Over 60% of patients were male in both groups. Although we performed propensity score matching, the proportion of CCI classes remained significantly different between cases and controls; however, the proportion of each CCI level is more similar between groups than before matching was applied.

Table 2 reports LOS for case and control hospitals stratified by several variables. Before implementation of the KDPC system,

Table 3**Results of the segmented regression analysis with control for length of stay (LOS).**

Parameter		Estimate	SE	95% Confidence limits		P
Intercept β		3.164	0.367	2.445	3.883	<.0001
Baseline trend		-0.002	0.004	-0.010	0.005	0.5827
Level change		-0.012	0.061	-0.132	0.108	0.8450
Trend change		-0.004	0.006	-0.016	0.009	0.5877
Difference between case and control		0.186	0.268	-0.339	0.711	0.4872
Baseline trend of difference between case and control		-0.007	0.003	-0.014	0.000	0.0412
Level change of difference between case and control		-0.117	0.150	-0.412	0.178	0.4366
Trend change of difference between case and control		0.025	0.009	0.008	0.043	0.0055
Age		0.016	0.002	0.013	0.018	<.0001
Sex	Male	-0.099	0.019	-0.136	-0.063	<.0001
	Female	ref.				
Sub-DRG	G081	3.922	0.223	3.485	4.360	<.0001
	G082	1.154	0.144	0.872	1.435	<.0001
	G083	2.896	0.390	2.132	3.661	<.0001
	G084	0.906	0.154	0.604	1.207	<.0001
	G095	-0.463	0.307	-1.064	0.138	0.1308
	G096	-0.077	0.200	-0.469	0.316	0.7028
	G097	-0.606	0.357	-1.304	0.093	0.0895
	G098	0.216	0.331	-0.432	0.865	0.5129
	G102	0.146	0.082	-0.016	0.307	0.0766
	G104	-1.058	0.171	-1.393	-0.722	<.0001
	G105	-0.347	0.240	-0.818	0.123	0.1477
	G106	ref.				
Charlson comorbidity index	0	-0.163	0.095	-0.350	0.023	0.0858
	1	-0.247	0.087	-0.417	-0.076	0.0047
	2	-0.234	0.076	-0.384	-0.085	0.0021
	3	-0.247	0.050	-0.346	-0.148	<.0001
	≥ 4	ref.				
Hospital type	General hospital	0.118	0.291	-0.452	0.688	0.6846
	Hospital	ref.				
Hospital ownership	Public	0.454	0.358	-0.247	1.156	0.2044
	Corporation	0.365	0.277	-0.179	0.909	0.1885
	Private	ref.				
Teaching status	Teaching	0.584	0.190	0.212	0.955	0.0021
	Non-teaching	ref.				
Region	Urban	-0.034	0.224	-0.472	0.405	0.8808
	Rural	ref.				
Season	Spring	-0.049	0.017	-0.083	-0.015	0.0045
	Summer	-0.044	0.021	-0.086	-0.003	0.0378
	Autumn	-0.038	0.025	-0.086	0.011	0.1275
	Winter	ref.				
Year	2007	0.143	0.261	-0.368	0.654	0.5832
	2008	0.118	0.217	-0.307	0.543	0.5849
	2009	0.059	0.194	-0.321	0.438	0.7612
	2010	0.115	0.157	-0.194	0.423	0.4654
	2011	0.059	0.131	-0.197	0.315	0.6509
	2012	-0.020	0.118	-0.252	0.212	0.8634
	2013	0.067	0.064	-0.059	0.193	0.2962
	2014	ref.				
Number of beds		0.003	0.001	0.002	0.004	<.0001
Number of doctors		-0.005	0.001	-0.007	-0.003	<.0001
Number of nurses		-0.005	0.002	-0.009	-0.002	0.0005

DRG=diagnosis-related group, SE=standard error.

average LOS was 5.35 days (SD=2.40) among cases and 4.85 days (SD=2.46) among controls. After implementation of the KDPC system, average LOS was 5.06 days (SD=2.23) among cases and 4.62 days (SD=2.58) among controls. LOS increased with increasing age, and LOS was longer among female patients compared with male patients. Appendectomy had the longest LOS and hernia procedures had the second longest LOS. LOS was longer for higher CCI. Average LOS decreased over time from January 2007 to June 2014 (described in Table S5, <http://links.lww.com/>

MD/B274). LOS was longer at general hospitals compared with hospitals among cases. In contrast, among controls, LOS was longer at hospitals compared with general hospitals. LOS was longer in teaching hospitals compared with non-teaching hospitals. Average LOS was longer at rural hospitals compared with urban hospitals among controls; there was no significant difference in LOS between urban and rural hospitals among cases.

Table 3 reports the results of the segmented regression analysis with control for case and control LOS. The estimate for *baseline*

Table 4**Results of the segmented regression analysis with control for length of stay (LOS) by diagnosis-related group (DRG).**

Parameter	Estimate	SE	95% Confidence limits		P
Appendectomy					
Intercept β	5.551	0.535	4.503	6.598	<.0001
Baseline trend	-0.002	0.005	-0.012	0.008	0.6720
Level change	0.037	0.074	-0.109	0.182	0.6222
Trend change	-0.004	0.009	-0.021	0.013	0.6151
Difference between case and control	0.042	0.235	-0.419	0.502	0.8598
Baseline trend of difference between case and control	-0.005	0.004	-0.012	0.003	0.2680
Level change of difference between case and control	-0.161	0.176	-0.506	0.184	0.3595
Trend change of difference between case and control	0.021	0.011	0.000	0.041	0.0496
Hernia procedures					
Intercept β	0.762	0.743	-0.695	2.219	0.3051
Baseline trend	-0.017	0.008	-0.033	-0.001	0.0376
Level change	-0.129	0.149	-0.421	0.163	0.3862
Trend change	0.012	0.013	-0.013	0.037	0.3480
Difference between case and control	-0.131	0.407	-0.928	0.666	0.7472
Baseline trend of difference between case and control	-0.015	0.005	-0.025	-0.005	0.0033
Level change of difference between case and control	0.091	0.218	-0.337	0.519	0.6772
Trend change of difference between case and control	0.040	0.014	0.011	0.068	0.0058
Hemorrhoid procedures					
Intercept β	2.734	0.596	1.567	3.902	<.0001
Baseline trend	0.006	0.007	-0.007	0.019	0.3373
Level change	-0.011	0.091	-0.190	0.168	0.9071
Trend change	-0.012	0.009	-0.030	0.006	0.1837
Difference between case and control	0.646	0.369	-0.077	1.369	0.0800
Baseline trend of difference between case and control	-0.010	0.006	-0.022	0.002	0.1027
Level change of difference between case and control	-0.196	0.285	-0.755	0.363	0.4914
Trend change of difference between case and control	0.022	0.017	-0.012	0.055	0.2072

Adjusted age, sex, Charlson comorbidity index (CCI), hospital type, hospital ownership, teaching status season, year, number of bed, number of doctor, and number of nurse. SE=standard error.

trend in difference between cases and controls, -0.007 ($P=0.0412$), reflects a trend in the difference in LOS between cases and controls prior to KDPC implementation. The estimate for level change in difference between cases and controls reflects a difference in the change of LOS between cases and controls at the time of KDPC implementation. As reported in Table 3, the difference in LOS between cases and controls was as much as 0.117 days at the time of KDPC implementation, but was not statistically significant ($P=0.4366$). The estimate for trend change in difference between cases and controls reflects the change in trend difference in LOS between cases and controls after implementation. Thus, an estimate of 0.025 indicates that the trend difference in LOS between cases and controls was an increase of 0.025 days ($p=0.0055$) compared with baseline.

Table 4 reports the results of the segmented regression analysis with control for LOS stratified by DRG. The estimate for trend change in difference between cases and controls is 0.021 ($P=0.0496$) for appendectomy and 0.040 ($P=0.0058$) for hernia procedures. In addition, the estimate for baseline trend in difference between cases and controls is 0.015 ($P=0.0033$). No significant estimates were found for hemorrhoid procedures.

The time-series graph in Fig. 2A reports average LOS for total admissions stratified by month. Red dots represent monthly average LOS for cases and blue dots represent average LOS for controls. The red dotted line represents the average standard LOS (4.89 days) for KDPC admissions, and the blue dotted line represents the average standard LOS (5.20 days) for DRG admissions. LOS consistently decreased among controls, whereas LOS decreased among cases and then increased following KDPC implementation.

Time-series graphs for 3 surgical DRGs are shown in Fig. 2B, C, and D. For appendectomy, LOS trend lines overlapped between cases and controls (Fig. 2B). However, after adjusting for confounding variables, an increasing trend in LOS was observed after KDPC implementation among cases. An increasing trend in LOS among cases after KDPC implementation is more obvious for hernia procedures (Fig. 2C). The trend change is relatively small in hemorrhoid procedures compared with other DRGs (Fig. 2D).

We performed subgroup analyses to determine which subgroup was more influenced by KDPC implementation. Subgroup analyses were performed for total, appendectomy, hernia, and hemorrhoid procedures. We used Equation 1 to evaluate statistically significant differences among subgroups. Results of subgroup analyses for CCI and hospital type are reported in Table 5 and Fig. 3.

Table 5 reports the results of the segmented regression analysis with control for LOS stratified by CCI subgroup and hospital type subgroup, respectively. Among total admissions, those with a higher CCI exhibited a higher increasing trend change in LOS (CCI 0, 1: 0.022, $P=0.0142$; CCI 2, 3: 0.026, $P=0.0288$; CCI \geq 4: 0.055, $P=0.0003$). Among appendectomy admissions, only the CCI \geq 4 subgroup exhibited a statistically significant estimate for trend change in difference between cases and controls (0.077, $P=0.0044$). Among hernia procedure admissions, all CCI subgroups exhibited a statistically significant increasing trend change (CCI 0, 1: 0.033, $P=0.0361$; CCI 2, 3: 0.049, $P=0.0045$; CCI \geq 4: 0.043, $P=0.0379$).

Among total admissions, the estimate for trend change in difference between cases and controls was significant for the general hospital subgroup (0.030, $P=0.0048$). Similarly, for

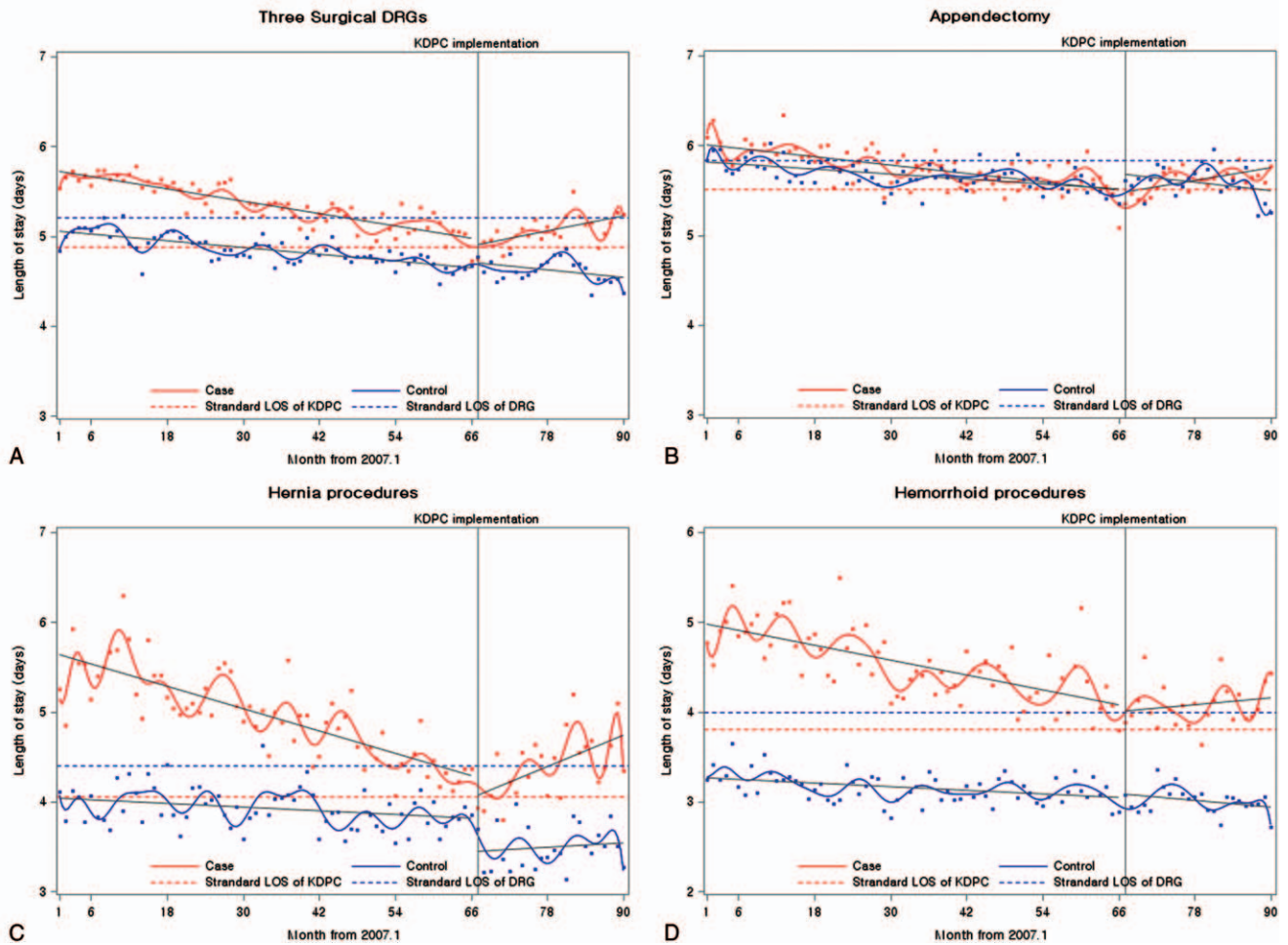


Figure 2. The length of stay (LOS) during 90 months. (A) LOS of 3 surgical diagnosis-related groups (DRGs). (B–D) LOS of appendectomy, hernia procedure, and hemorrhoid procedures, respectively.

Table 5

Results of the segmented regression analysis with control for length of stay (LOS) by CCI subgroup.

			Level change of difference between public and private			Trend change of difference between public and private		
			Estimate	SE	P	Estimate	SE	P
By CCI subgroup	Total	0, 1	-0.163	0.15	0.2794	0.022	0.009	0.0142
		2, 3	-0.148	0.204	0.469	0.026	0.012	0.0288
		≥4	0.161	0.221	0.4664	0.055	0.015	0.0003
	Appendectomy	0, 1	-0.181	0.169	0.2855	0.019	0.01	0.0608
		2, 3	-0.068	0.254	0.7891	0.018	0.016	0.2422
		≥4	-0.27	0.563	0.6308	0.077	0.027	0.0044
	Hernia procedures	0, 1	-0.038	0.263	0.8844	0.033	0.016	0.0361
		2, 3	-0.021	0.312	0.9465	0.049	0.017	0.0045
		≥4	0.243	0.286	0.3965	0.043	0.021	0.0379
Hemorrhoid procedures	0, 1	-0.179	0.282	0.5254	0.021	0.016	0.1927	
	2, 3	-0.329	0.357	0.3556	0.012	0.021	0.5545	
	≥4	-0.289	0.436	0.5072	0.066	0.037	0.0721	
By hospital type subgroup	Total	General hospital	-0.097	0.163	0.5512	0.030	0.011	0.0048
		Hospital	-0.398	0.408	0.3291	0.010	0.023	0.6513
	Appendectomy	General hospital	-0.094	0.183	0.6082	0.024	0.012	0.0447
		Hospital	-0.668	0.488	0.1709	0.024	0.019	0.1982
	Hernia procedures	General hospital	-0.089	0.225	0.6938	0.043	0.017	0.0091
		Hospital	2.589	1.182	0.0285	- 0.125	0.029	<.0001
	Hemorrhoid procedures	General hospital	- 1.086	0.318	0.0006	-0.004	0.024	0.8645
		Hospital	-0.307	0.352	0.383	0.03	0.02	0.1277

CCI=Charlson comorbidity index, SE=standard error.

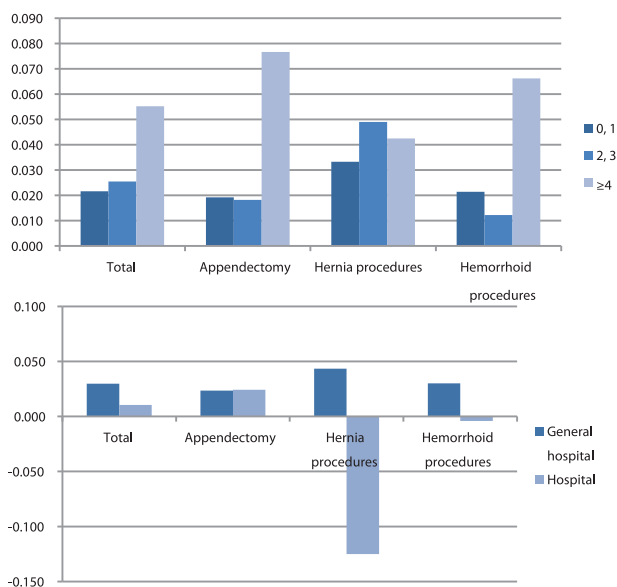


Figure 3. The results of the segmented regression analysis for length of stay (LOS) by Charlson comorbidity index (CCI) and hospital type subgroup.

appendectomy admissions, the estimate for *trend change in difference between cases and controls* was statistically significant for the general hospital subgroup only (0.024, $P=0.0447$). In contrast, for hernia procedures, the trend change estimates for both the general hospital and hospital subgroups were statistically significant (general hospital: 0.043, $P=0.0091$; hospital: -0.125 , $P<0.001$). Significant level changes in difference between cases and controls were also observed for hernia procedures among the hospital subtype (2.589, $P=0.0285$) and for hemorrhoid procedures among the general hospital subtype (-1.086 , $P=0.0006$).

Figure 3 shows the estimate values of level and trend changes in the difference between cases and controls from Table 5 as a bar graph.

4. Discussion

The results of this study suggest that the payment system change from DRG to KDPC increased LOS. However, this effect was not consistent across 3 surgical DRGs and was significant for appendectomy and hernia procedures only. Compared with the other two surgical DRGs, hemorrhoid procedures are relatively noninvasive, LOS is usually short, emergency procedures or complex cases are relatively rare, and the level of surgical difficulty is low (based on the relative value resource-based scale, RVRBS). Although we cannot conclude that these characteristics contributed to the result observed in the current study, we cannot conceive of other reasons for differences. If the difference is associated with DRG invasiveness, then the severity of admission may also have a similar association with the impact.

The results of stratified analysis by severity (i.e., CCI) are consistent with this expectation. The impact of the payment system change on the trend change in LOS is twice as high in the highest severity group (CCI ≥ 4 : 0.055) compared with the lowest severity group (CCI 0, 1: 0.022). This result is observed for each DRG subtype in the stratified analysis by severity degree. This association is also observed for the hospital type subgroup analysis. General hospitals are larger than hospitals. In addition,

more patient cases are generally admitted to general hospitals. Therefore, our hypothesis that the payment system change would have more of an impact on high severity cases (or complex procedures) is appropriate.

It is unclear, however, why LOS among more severe cases is more susceptible to payment system change. The transition from a DRG- to KDPC-based payment system reduces the incentive to decrease LOS. According to Ishii,^[24] the fee schedule structure of DRG provides more incentives for decreasing LOS than the Japanese DPC. Given that the fee schedule structure of KDPC is very similar to the original Japanese DPC, we can infer that incentives to decrease LOS are attenuated in the KDPC-based system.

Despite the attenuated incentives for decreasing LOS in the KDPC compared with the DRG, the structure of the KDPC fee schedule is per diem, with profit maximized for shorter LOS. Therefore, an increase in LOS due to a change in the payment system means that the payment system change also is associated with profit minimization. There exists, therefore, a trade-off between decreasing LOS and profit maximization between the DRG- and KDPC-based payment systems. The impact of this trade-off is the greatest for high severity admission cases. Although it is difficult to define what an appropriate LOS is, the fact that LOS increased only in high severity cases suggests that the DRG system provides excessive incentives to reduce LOS for high severity cases.

This increase in LOS should be interpreted differently than the LOS decrease that was observed following the payment system change from FFS to DRG. Under FFS, long LOS is associated with profit maximization, whereas long LOS is associated with a decrease in average profits under KDPC. Therefore, increasing LOS in the present study suggests that the DRG-based system promotes excessive decreases in LOS in certain situations in Korea.

There are several reasons for the observation of LOS decrease under DRG but not KDPC. First, the financial incentives for LOS decrease are higher for DRG than KDPC. In Fig. 2, the blue dotted line, which represents the standard average LOS for DRG, was located above the blue dot that represents the real average LOS for that month. This finding indicates that money was saved under the DRG-based system, because the DRG fee schedule is designed to compensate costs during standard LOS. Despite these savings, however, average LOS continuously decreases under the DRG-based system. In contrast, the red dotted line, which represents the average standard LOS for three surgical DRGs under the KDPC-based system, is located mainly below the red dots during the KDPC period (2012.7–2014. 6). KDPC admissions with LOS longer than the standard LOS incur a financial penalty due to the decreasing per-diem fee schedule. Despite this penalty, we observed that average LOS increases under the KDPC-based system. If LOS increase is due to financial incentives, then LOS should not increase over the standard LOS. Therefore, differences in financial incentives alone cannot explain the results of our study.

A second possible explanation is the contribution of “checks and balances.” “Checks and balances” refers to the balance between the medical decisions of the physicians and the pressure of the hospital manager. Unlike in the United States, physicians’ fees and hospital fees are not separate in Korea. In addition, the medical fees of the NHI are relatively low compared with the United States. Therefore, the physician’s decision has less of an impact than the manager’s decision. Thus, in contrast to FFS or a per-diem fee schedule, which gives more power to the physician’s

professional decision, checks and balances are more difficult to achieve under a DRG-based system.^[25,26] Checks and balances may be easier to achieve under KDPC due to structural differences in the payment system. However, Kwon insists that a checks and balances structure is meaningless in Korea, because most physicians are employed by the hospital and there are few checks and balances between the hospital and the physician in terms of quality, which is in contrast to the attending system in the United States.^[8] Therefore, to identify the existence and action of checks and balances in Korea, other indexes about health care outcomes or processes, such as spending resources and mortality, should be investigated in future studies.

Although KDPC is a per-diem based payment system, there is also incentive to decrease LOS under KDPC because its fee schedule is designed to provide more incentives during the early admission period. Compared with DRG, the incentive scale of KDPC is relatively small due to the FFS component. Therefore, the incentive for LOS decrease is not as strong for KDPC compared with DRG. However, KDPC may be sufficient for reducing LOS comprehensively in Korea, if LOS reduction is not the sole purpose for a payment system change.

This study has several limitations. First, case hospitals included only public (and quasi-public) hospitals and control hospitals included only private hospitals. To minimize this problem, we used time-series analysis and sampled individuals using propensity score matching.

Second, we did not assess other factors that may be affected by the payment system change, such as costs or supplied services, due to lack of data. KDPC fee schedule includes more expensive services that are not included in the DRG schedule. Therefore, comparing claim costs only between KDPC and DRG is meaningless. However, LOS is an index that reflects medical service supply. Given that the aim of this study was to compare two bundled payment systems to provide evidence for the development of an appropriate reimbursement system, we think that LOS may be an appropriate and sufficient dependent variable for this study.

Finally, we analyzed only 3 surgical DRGs. More DRGs, especially medical DRGs, should be explored in future studies. The results of this study provide important evidence regarding the impact of payment system change on surgical DRGs.

5. Conclusion

Average LOS for surgical DRG admissions increased following payment system change from DRG to KDPC. This LOS increase was observed specifically for complex procedure admissions and high severity cases. Although both payment systems are optimized to decrease LOS, incentives to reduce LOS are stronger under the DRG system than the KDPC system. Therefore, these findings suggest that incentives under the DRG lead to excessive LOS decrease in Korea.

Further increases in medical spending are expected due to the aging population, development of new medical technology, and higher standards of living. A provider-side cost-sharing payment system will be introduced in the future, because payment system changes have been met with low resistance by patients, and have introduced few burdens compared to other policy changes. We have already implemented DRG and KDPC, and the new payment system, which is based on these 2 bundled payment systems, is expected to be the next national payment system in Korea. A change in the national payment system should be undertaken with caution because enrollment of all medical

institutions in the NHI is compulsory. We suggest that policy-makers and stakeholders should focus on the development of an appropriate reimbursement system that focuses on more than cost containment, saving resources, or LOS reduction. More evidence and studies that focus on associations between payment systems and medical outcomes, resource spending, and quality will be needed to achieve this goal.

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