Original Article

An Analysis of Thai Diagnosis Related Group (TDRG) Reimbursement for Primary Total Knee Arthroplasty

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Background: Thai Diagnosis Related Group [TDRG] version 5 has been widely used in Thailand as a coding and information system for managing hospital reimbursement.

Objective: The present study aimed to examine how well TDRG reflects actual inpatient costs of primary total knee arthroplasty [TKA] at Naresuan University Hospital.

Materials and Methods: Records of patients admitted from October 2014 through September 2015 were obtained from the hospital's financial department. A total of 394 TKA patients were identified, including 224 patients covered under the Civil Servant Medical Benefit Scheme [CSMBS] and 170 covered under the Universal Health Coverage Scheme [UHC].

Results: (1) The adjusted relative weights [AdjRWs] of UHC and CSMBS beneficiaries were not statistically significantly different, although CSMBS patients had a longer average length of hospital stay [LOS]. (2) Despite the fact that bilateral TKAs doubled the health care cost compared to unilateral TKA, the AdjRW was approximately double that for unilateral TKA, reflecting a fair and reasonable hospital reimbursement. (3) Although the difference was not statistically significant, we found that the variation in the cost of care for primary TKA depended on the severity of the patient's co-morbidity, *e.g.*, greater need for treatment, higher AdjRW, and longer LOS. Hospital reimbursement for patients with comorbidities was higher than hospital care costs for patients none regardless of the severity level of the comorbidity. (4) The vendor managed inventory [VMI] system for knee prostheses did not affect the AdjRW and did not make a statistically significant difference in hospital profit or loss. (5) The AdjRW, LOS, and hospital net profits varied with the surgeon who performed the TKA.

Conclusion: TDRG version 5 is a reasonable system for reimbursement of patient' cost for primary TKA, and it seems to reimburse appropriately for comorbid TKA patients as well. Cost containment strategies that focus on shortening LOS and cost-saving related to treatment plans managed by individual surgeons could potentially enhance the hospital's net profit.

Keywords: Thai Diagnosis Related Group [TDRG], Reimbursement, Vendor Managed Inventory (VMI), Total knee arthroplasty

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Total knee arthroplasty [TKA] has become one of the most common orthopedic procedures in recent years[(1)]. This surgical procedure is performed to replace parts of the knee joint with prostheses. It is usually indicated for patients who have end-stage of various diseases of the knee including primary and secondary osteoarthritis, inflammatory arthritis, and osteonecrosis, conditions that are common in elderly patients. In the US, over 600,000 TKAs are being performed annually among older patients; that number is expected to increase by 673% by 2030[(2)], and the hospital costs for geriatric patients with comorbidities undergoing the TKA will increase immensely as well[(3)]. Thailand is one of the countries with concerns over the high healthcare costs related to TKA, as it will become an aging society in a decade. However, reports involving the incidence of TKA among the Thai population and the concomitant health expenditures are limited. Studies to determine the variables associated with the cost of care in Thai population should be conducted to help identify potential means of

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controlling and reducing expenses related to TKA procedures.

Thailand has adopted three health insurance programs: (1) the Civil Servant Medical Benefit Scheme [CSMBS], (2) the Social Security Scheme (SSS), and (3) the Universal Health Coverage Scheme [UHC][4]. The CSMBS and SSS are health insurance programs for people in the formal employment sector, while the UHC is for those in the informal employment sector including children and the elderly. UHC is managed by the National Health Security Office [NHSO]. Payments to hospitals from the three public health insurance schemes also depend on the Thai Diagnosis Related Group [TDRG] version 5, a system for classifying inpatient cases and for measuring hospital output with a principle of iso-resource group and for subsequent reimbursement[5,6]. The classification system is based on diagnosis, procedures, comorbidities, and discharge status as well as demographic data. Each hospital providing care for health insurance program enrollees is paid based on the specific level of services using the adjusted relative weight [AdjRW]. Higher AdjRW results in increased reimbursement for the hospitals[7].

There are differences in the cost of care among patients with the same TDRG code depending on many factors. A study by Lavernia et al demonstrated that patients with a higher severity of illness and a risk of mortality had a significantly longer length of stay [LOS] and higher hospital costs[8]. Effenberger et al found that geographic location also had an influence on the cost of care after TKA. Their post hoc analysis revealed that the cost variation depended on the patient's demographic data, medications used, implant materials, and level of nursing care provided[9]. According to Courtney et al, patients with a low socioeconomic status utilized more resources during postoperative periods[10]. The system used for hospital reimbursement, however, should reflect fair inpatient care expenses regardless of the patient's socioeconomic status. This study aimed to scrutinize how well TDRG reflects inpatient costs and reimbursements for patients undergoing primary TKA with variations in the severity of comorbidities and complications, whether unilateral or bilateral procedure, the individual surgeon performing an index procedure, and the implant management system (the vendor-managed inventory of prosthesis by the NHSO vs. the non-VMI system for the UHC).

Materials and Methods

Data on UHC and CSMBS beneficiaries who underwent primary TKA during October 2014 through September 2015 were retrieved from the Naresuan University Hospital's financial department. All patients had International Classification of Diseases 10th Revision [ICD-10] code M17 (Osteoarthritis) with an International Classification of Diseases 9th Revision, Clinical Modification [ICD-9-CM] of 81.54 (Primary TKA). Information obtained included demographic data, the surgeon performing the operation, TDRG codes, comorbidities and complications (CC) reflecting clinical complexity, LOS, AdjRW, system of implant management, reimbursement, and hospital net profit. All cases had the same first four digits of TDRG (or Disease Cluster) of 0803, with the fifth digit 0, 1, 3, or 4 indicating the level of CC. The TDRG 08030 represents patients with the least severity, whereas TDRG 08034 is for the most complicated cases. The study hospital had seven orthopaedic surgeons performing TKA procedures. Four different commercial companies supplied cemented posterior-stabilized knee prostheses used in the surgeries. The cost of the prosthesis per case was not allowed to exceed a ceiling of 50,000 baht. Naresuan University Hospital had adopted two systems of implant management for UHC beneficiaries: the vendor managed inventory [VMI] of the National Health Security Office [NHSO] and the non-VMI system. CSMBS beneficiaries are under a different system which was not included in the sub-analysis in this study. Hospital net profit was calculated by subtracting cumulative reimbursements and hospital charges for care which were assumed as proxies for hospital resource use and hospital costs from reimbursements received. Any number less than zero reflects hospital operating expenses that exceeded reimbursements. The present study was approved by the Institutional Ethics Committee of Naresuan University.

The demographic data were analyzed using descriptive statistics. Our preliminary analysis of cost and hospital net profit data demonstrated the non-normal distribution of the data. Non-parametric statistics were used to test the differences and relationships among study factors. A Z-test was used to compare differences in demographic data, LOS, and AdjRW between UHC and CSMBS groups. Independent Student's t-test, Pearson's Chi-square and Fisher's exact test were used for bivariate analysis of the relationships. For multivariate analysis, Analysis of Variance [ANOVA] and the Kruskal-Wallis test were used to identify significant relationships between independent factors (of normal and non-normal distributions, respectively). Statistical analyses were

carried out using SPSS software (Statistical Package for Social Sciences, Version 17.0; SPSS Inc, Chicago, IL, USA). Statistical significance was defined as a *p*-value <0.05.

Results

A total of 394 patient records were analyzed. Of these, 63 (16%) were males, and 331 (84%) were females. The CSMBS beneficiaries accounted for 56.9%, and 43.1% were UHC. The majority of patients underwent unilateral TKA (89.1%). Although the LOS for the CSMBS group were significantly higher than for the UHC group (*p*-value = 0.02), there was no statistically signficant difference in AdjRW between these two groups (Table 1). When stratified by the type of TKA, patients who underwent bilateral TKA did not have a significantly longer LOS compared to individuals with unilateral TKA (*p*-value = 0.10). However, the bilateral TKA group had a higher AdjRW (*p*-value <0.01) (Table 2).

The authors conducted a sub-analysis of the clinical complexity according to CC level of disease cluster 0803 unilateral TKA (a total of 316 cases; the 35 cases done by other surgeons who had performed fewer than 20 TKAs were dropped). We found that increasing severity of comorbidities was associated with incremental increases in LOS (*p*-value <0.01), AdjRW (*p*-value <0.01), and hospital net profits (*p*-value = 0.01) (Table 3).

Four surgeons performing unilateral TKA showed significant differences in LOS (*p*-value = 0.000), AdjRW (*p*-value <0.01), hospital net profit (*p*-value <0.01), and the level of CC (*p*-value <0.01) (Table 4).

The majority of UHC beneficiaries used the VMI system (70%). We also found that LOS and AdjRW for VMI and non-VMI users were not statistically signficantly different, suggesting that the implant management systems were not associated with hospital net profit (Table 5).

Discussion

TKA is an expensive procedure, and the frequency of performing this treatment is expected to increase substantially in the next decade. Many studies have demonstrated that current hospital reimbursements may not accurately reflect the actual cost of caring for patients undergoing TKA, leading to a decline in hospital net profit[8-10]. In this present study, the authors aimed to examine how well TDRG version 5 reflects inpatient costs for TKA patients at Naresuan University Hospital. We found that implementing TDRG as the system for hospital reimbursement reasonably reflected health care expenses in spite of cost variations among patients. The study also identified factors related to

Table 1. Patient characteristics

Variable	No. (%) of patients (n = 394)		*p*-value
	UHC	CSMBS	
Number of patients (%)	170 (43.1%)	224 (56.9%)	
Unilateral total knee arthroplasty	148 (87.1%)	203 (90.6%)	0.88
Bilateral total knee arthroplasty	22 (12.9%)	21 (9.4%)	
LOS (days) (mean ± SD)	6.75±1.21	7.18±2.01	0.02 *
AdjRW (mean ± SD)	3.73±0.45	3.72±0.34	0.92

* Statistically significant

Table 2. Length of stay and adjusted relative weight by unilateral and bilateral total knee arthroplasty

Variable	Unilateral TKA	Bilateral TKA	*p*-value
Number of patients (%)	351 (89.0%)	43 (11%)	
LOS (days) (mean ± SD)	6.99±1.77	7.53±2.03	0.10
AdjRW (mean ± SD)	3.73±0.41	6.73±1.06	<0.01*

* Statistically significant

Table 3. Length of stay, adjusted relative weight, and hospital net profit by clinical complexity of unilateral total knee arthroplasty

Variable	TDRG 08030	TDRG 08031	TDRG 08033	TDRG 08034	*p*-value
Number of patients (%)	149 (47.2%)	128 (40.5%)	36 (12.3%)	3 (9%)	
LOS (days) (mean ± SD)	6.56±1.03	7.27±1.68	7.22±1.89	14.33±6.65	<0.01*
AdjRW ± SD	3.5015±0.00	3.7548±0.00	4.2813±0.00	6.8585±0.00	<0.01*
Hospital net profit ± SD (baht)	9,683.62± 11,065.07	9,818.85± 12,366.41	16,316.60± 12,672.73	20,076.58± 12,048.10	0.01*#

* Statistically significant, # Kruskal-Wallis test

Table 4. Length of stay, adjusted relative weight, and hospital net profit by surgeon performing unilateral total knee arthroplasty

Variable	Surgeon 1	Surgeon 2	Surgeon 3	Surgeon 4	*p*-value
Number of patients (%)	113 (35.8%)	54 (17.1%)	96 (30.4%)	53 (16.8%)	
LOS (day) (mean ± SD)	7.06±2.23	7.74±1.23	6.80±1.33	6.45±1.25	<0.01*
AdjRW ± SD	3.81±0.47	3.83±0.48	3.64±0.24	3.60±0.22	<0.01*
Hospital net profit ± SD (baht)	10,115.69± 12,182.62	13,831.16± 11,640.25	8,587.67± 11,790.50	11,942.05± 12,120.82	<0.01*#
No co-morbidity	31 (27.4%)	13 (24.1%)	64 (66.7%)	41 (77.4%)	<0.01*
Mild co-morbidity	66 (58.4%)	32 (59.3%)	22 (22.9%)	8 (15.1%)	
Moderate to severe co-morbidity	14 (12.4%)	8 (14.8%)	10 (10.4%)	4 (7.5%)	
Catastrophic co-morbidity	2 (1.8%)	1 (1.9%)	0 (0%)	0 (0%)	

* Statistically significant, # Kruskal-Wallis test

Table 5. Length of stay and adjusted relative weight by implant management system

Variable	VMI	Non-VMI	*p*-value
Number of patients (%)	119 (70%)	51 (30%)	
LOS (day) (mean ± SD)	6.98±1.37	6.75±2.16	0.39
AdjRW (mean ± SD)	3.99±0.99	4.40±1.40	0.06

hospital net profit including type of health insurance program, type of TKA, patient comorbidities and complications, as well as AdjRW. Our study found that the CSMBS group has a longer LOS compared to the UHC group, although their AdjRWs were not statistically different (Table 1). As the mean LOS for both groups were less than the average LOS for the general TKA population, the average number of the LOS was used to calculate the national standard AdjRW for the Thai population[6]. The LOS in our findings was not associated with changes in AdjRW.

Although a previous study suggested that performing bilateral TKA was negatively correlated with hospital reimbursement[11], our findings were discordant for hospital net profit. Bilateral TKA might involve increased blood loss, difficulty in rehabilitation, and a higher incidence of complications such as deep vein thrombosis and cardiovascular events. However, performing bilateral TKA may have some advantages over two unilateral TKA operations on the same patient including single anesthesia, shorter total recovery time to work, and econimic benefits for the hospital. Our study showed that the mean LOS for patients undergoing bilateral and unilateral TKA were not statistically signficantly different; however, the AdjRW for the bilateral group was approximately two times higher than the unilateral group (Table 2). That higher AdjRW reflects the higher reimbursement to the hospital. Despite a higher cost for implant materials as well as pre- and postoperative care, the total expenses

in the bilateral TKA group did not exceed the hospital compensation.

It should be noted that 62% of the patients in this study had at least a mild comorbidity, and that increasing severity of comorbidities was associated with incremental increases in LOS, AdjRW, and hospital net profits (Table 4). Prior studies from Padegimas et al and Pugely et al reached the same conclusion[12,13]. Their study demonstrated that patients with multiple comorbidities were associated with increased resource use and LOS[13]. Moreover, the greater reimbursement was associated with a higher cost of care[12]. In our study, since the severity of CC increased proportionately to AdjRW, the reimbursement also increased, resulting in a positive net profit. These findings demonstrate that TDRG codes for CC represent a fair system for calculating hospital reimbursement. It is interesting that Pine et al[14] found that 96% of excess hospital costs resulted from ineffective management of patients without comorbidities. In our study, patients coded no CC resulted in the least net profit. To produce sizable cost savings without compromising the quality of care, an intervention system to identify cases with low risk of prolonged LOS should be developed, and a routine care model for patients in this group should be designed.

Our sub-analyses show different surgeons had variations in LOS, AdjRW, and hospital net income. One reason for this could be that each surgeon had preferred treatment plan choices. For example, one surgeon might choose more expensive medication for analgesic drugs, antibiotics, or nonsteroidal anti-inflammatory drugs [NSAIDs]. We also found that some surgeons (surgeons 1 and 2) treated patients with more severe CC, while the others (surgeons 3 and 4) treated healthier patients (Table 5). These factors are possibly related to LOS, AdjRW, and hospital net income. Further, Pongpirul et al found that hospital coding structure and process in Thailand varied among hospitals[15]. Individiual hospital staff and surgeons might have different understandings of the coding process. Those differences could result in incomplete or miscoded data. Research investigating these variables should be conducted.

The study hospital had adoped the VMI system for implant management in some UHC patients. This system is believed to be more cost effective and to reduce invoice processing and payment time. Although our findings demonstrate that the majority of UHC beneficiaries used the VMI system (70%); the LOS and AdjRW for VMI and non-VMI users were not statistically different, suggesting that the implant management systems were not associated with hospital net profit (Table 6). There was no reason to conclude that the VMI system is superior to the non-VMI since there is only a limited selection of implant models provided by suppliers. Some models may not be compatible for use with patients with more complicated osteoarthritis of the knee. A qualitative study should be carried out to clarify this issue.

The present study has some important limitations. First, data collection in the Financial Department database ends with inpatient discharge, so the cost of care during the post-discharge period was not considered in this analysis. Because of that, the true associated cost for treatment may be underestimated. Second, our findings reflect associations rather than demonstrating causations. More severe CC did not necessarily cause higher cost or LOS. Instead, the condition was associated with increased resource use. Additionally, our data were retrieved from a university hospital where patient characteristics may be different from the entire TKA population. Thus, these findings may not truly represent the prevalence of the procedure and its cost. The present study did not include patients of the SSS since hospital reimbursement for that scheme is different from the others. Finally, all patient data were extracted from discharge administrative claims data. It is possible that miscoding of claims data may have resulted in an inaccurate representation of the actual data. Despite these limitations, the authors believe our findings provide valuable information to increase understanding of the drivers of admission costs for patients undergoing primary TKA.

Conclusion

Evaluation of TKA patient records demonstrated that TDRG version 5 is a reasonable system for reimbursing inpatient costs for primary TKA, and it seems to reimburse appropriately for comorbid patients. Cost containment strategies that focus on shortening LOS and cost saving treatment plans managed by individual surgeons may enhance the hospital net profit, whereas the VMI system does not affect hospital net profit. Further investigation of factors that could potentially affect the AdjRW and reimbursement schemes should be conducted.

What is already known on this topic?

The TDRG was developed and is used to determine reimbursement for inpatient costs. However,

there has been discussion about whether this system is appropriate for determining how hospital resources will be used. The current version of TDRG has not been investigated in terms of reimbursement for patients undergoing primary TKA with variations in severity of comorbidities and complications, bilateral procedures, surgeons performing an index procedure, or the implant management system.

What this study adds?

The study demonstrates that TDRG version 5 is a reasonable system for determining reimbursement of inpatient costs for primary TKA, and it seems to reimburse appropriately in cases of comorbid patients as well as bilateral procedures. Cost containment strategies should focus on cost-saving involving treatment plans managed by individual surgeons.

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Potential conflicts of interest

The authors declare no conflicts of interest.

References

1. Haas DA, Kaplan RS. Variation in the cost of care for primary total knee arthroplasties. Arthroplast Today 2017;3:33-7.
2. Cram P, Lu X, Kates SL, Singh JA, Li Y, Wolf BR. Total knee arthroplasty volume, utilization, and outcomes among Medicare beneficiaries, 1991-2010. JAMA 2012;308:1227-36.
3. Kuperman EF, Schweizer M, Joy P, Gu X, Fang MM. The effects of advanced age on primary total knee arthroplasty: a meta-analysis and systematic review. BMC Geriatr 2016;16:41.
4. Paek SC, Meemon N, Wan TT. Thailand's universal coverage scheme and its impact on health-seeking behavior. Springerplus 2016;5:1952.
5. Fetter RB, Thompson JD, Mills RE. A system for cost and reimbursement control in hospitals. Yale J Biol Med 1976;49:123-36.
6. Edwards N, Honemann D, Burley D, Navarro M. Refinement of the Medicare diagnosis-related groups to incorporate a measure of severity. Health Care Financ Rev 1994;16:45-64.
7. Jongudomsuk P, Srithamrongsawa S, Patchara narumol W, Limwattananon S, Pannarunothai S, Vapatanavong P, et al. The Kingdom of Thailand health system review [Internet]. Manila, Philippine: World Health Organization, Regional Office for the Western Pacific; 2015 [cited 2018 May 17]. Available from: http://www.searo.who.int/entity/asia_pacific_observatory/publications/hits/hit_thailand/en/.
8. Lavernia CJ, Laoruengthana A, Contreras JS, Rossi MD. All-patient refined diagnosis-related groups in primary arthroplasty. J Arthroplasty 2009;24:19-23.
9. Effenberger H, Rehart S, Zumstein MD, Schuh A. Financing in knee arthroplasty: a benchmarking analysis. Arch Orthop Trauma Surg 2008;128:1349-56.
10. Courtney PM, Huddleston JI, Iorio R, Markel DC. Socioeconomic risk adjustment models for reimbursement are necessary in primary total joint arthroplasty. J Arthroplasty 2017;32:1-5.
11. Della Valle CJ, Idjadi J, Hiebert RN, Jaffe WL. The impact of medicare reimbursement policies on simultaneous bilateral total hip and knee arthroplasty. J Arthroplasty 2003;18:29-34.
12. Padegimas EM, Verma K, Zmistowski B, Rothman RH, Purtill JJ, Howley M. Medicare reimbursement for total joint arthroplasty: The driving forces. J Bone Joint Surg Am 2016;98:1007-13.
13. Pugely AJ, Martin CT, Gao Y, Belatti DA, Callaghan JJ. Comorbidities in patients undergoing total knee arthroplasty: do they influence hospital costs and length of stay? Clin Orthop Relat Res 2014;472:3943-50.
14. Pine M, Fry DE, Jones BL, Meimban RJ, Pine GJ. Controlling costs without compromising quality: paying hospitals for total knee replacement. Med Care 2010;48:862-8.
15. Pongpirul K, Walker DG, Winch PJ, Robinson C. A qualitative study of DRG coding practice in hospitals under the Thai Universal Coverage scheme. BMC Health Serv Res 2011;11:71.