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Original research

Is a shortened length of stay and increased rate of discharge to home associated with a low readmission rate and cost-effectiveness after primary total knee arthroplasty?

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ABSTRACT

Background: It is controversial whether shortening the average length of hospital stay and increasing discharge from a rehabilitation facility to home with either health care or outpatient physical therapy is safe and cost-effective.
Methods: We computed the average length of hospital stay; the rate of discharge to a rehabilitation facility, home with health care, or home with outpatient physical therapy; the all-cause readmission rate within 30 days of discharge per year; and cost savings for 2328 consecutive patients treated with a unilateral primary total knee replacement between 2009 and 2014.
Results: The average length of hospital stay per year shortened from 2.0 to 1.3 days ($P < .0001$); the rate of discharge per year to a rehabilitation facility decreased from 41% to 1% and increased from 9% to 53% to home with outpatient physical therapy ($P < .0001$); and the rate of readmission within 30 days per year did not change ($P = .38$). The cost savings averaged $3245 per patient.
Conclusions: A shorter length of hospital stay and an increased rate of discharge to home was not associated with an increased rate of readmission within 30 days and was cost-effective.
Level of Evidence: Level IV, Therapeutic study

Introduction

The aging population wants to maintain an active lifestyle, which is increasing the demand for total knee arthroplasty. Based on 2003 estimates, the demand for total knee arthroplasty will grow 673% by the year 2030, which burdens the cost of health care born by the government and insurers [1]. Coordination between physicians, hospitals, patients, and care providers at home is needed to provide safe, cost-effective, and high-quality transitional care from hospital to home [2,3]. The all-cause rate of readmission within 30 days of discharge per year is one measurement of safety and cost-effectiveness and is the metric the Affordable Care Act intends to use to administer financial incentives and penalties to improve coordination of care from hospital to home [3]. Accordingly, a shortening of the average length of hospital stay per year would be considered safe and cost-effective as long as there is no associated change in the rate of readmission within 30 days of discharge per year [4].

It is controversial whether shortening the average length of hospital stay and increasing discharge from a rehabilitation facility to home with either health care or outpatient physical therapy is safe and cost-effective. Medicare data showed that a 7% reduction in the average length of hospital stay from 4.1 to 3.8 days in 2007 after total knee arthroplasty was not associated with an increase in the rate of readmission within 30 days [5]. Whereas very short lengths of stay were associated with discharge to more costly rehabilitation facilities, which might have been avoided by discharge to home or had the patients remained in the acute care hospital for an additional 1 or 2 days [6]. Another unintended complication from discharging patients to a rehabilitation facility in place of home is a higher risk of unplanned readmissions within 90 days of discharge after adjustment of

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differences in sex, age, and American Society of Anesthesiologists scores between the rehabilitation facility and home groups [7,8].

The present study determined for 2328 patients treated with a unilateral primary total knee replacement from 2009 to 2014 whether (1) the average length of stay per year shortened, the rate of discharge to home per year increased, and the all-cause 30-day readmission rate per year changed; (2) how our hospital's average length of stay, discharge disposition, and 30-day readmission rate per year compares to percentile rankings of comparative hospitals in a national database; and (3) the cost savings per patient achieved by shortening the average length of stay and increasing the rate of discharge to home.

Material and methods

An institutional review board determined that this quality control study required no approval because protective health information was not used. We queried the electronic database of a 162-bed, nonspecialty community hospital (Methodist Hospital, Sacramento, CA) and identified 2328 consecutive patients treated with a primary unilateral total knee arthroplasty from January 1, 2009 to October 1, 2014 by 1 surgeon. During this time interval, all the total knee arthroplasties performed by this surgeon were performed at this facility. Included were all patients with a primary unilateral total knee arthroplasty, with no exclusions for severity of illness, severity of deformity, or type of knee diagnosis. We recorded demographics, the type and number of diagnoses per patient as determined by the International Classification of Diseases, Ninth Edition (ICD-9-CM) Code assigned on discharge. We categorized the number of diagnoses per patient as 0 to 4, 5 to 9, 10 to 14, 15 to 19, 20 to 24, and >24. Software categorized an All-Patient Refined Diagnosis-Related Groups Severity of Illness (APR-DRG SOI) to each patient, which is a weighted index that is intended to reflect a patient's medical health as 1: minor, 2: moderate, 3: major, and 4: severe (DataVision Web Application; Midas+ Solutions, Tucson, AZ; www.midasplus.com).

The following is a brief description of the delivery of the perioperative care and surgical technique. Each patient received an instructional handout and was asked to attend a free, hospital-sponsored, preoperative patient education class. Surgical treatment consisted of a kinematically aligned total knee arthroplasty. Patient-specific guides (OtisKnee; OtisMed, Inc., Hayward, CA) were used on the first 270 knees in 2009, and generic or manual instruments were used on the subsequent 2058 knees [9–11]. In the knees with varus deformities and most valgus deformities, the posterior cruciate, medial collateral, and lateral collateral ligaments were not released. In the knees with severe fixed valgus deformities, pie-crusting technique with use of a spinal needle incrementally lengthened the lateral collateral ligament. A lateral retinacular release was performed in those knees with a chronically dislocated patella and maltracking after implantation of the components. All components were cemented, and surgery was performed under a general anesthetic without regional or peripheral nerve blocks. All patients received an intraoperative injection of 30 cc of 0.5% bupivacaine with epinephrine and 30 mm of ketorolac, which the knee retained because ligaments were infrequently released. Postoperatively, pain was managed with intravenous and oral anticoagulants as tolerated. Each patient not on anticoagulant before admission received prophylaxis against deep vein thrombosis and pulmonary embolism with the use of aspirin 325 mg p.o. bid on the day of surgery and continued for 30 days postoperatively. Those patients that discontinued an anticoagulant before admission were managed with coumadin with a target international normalized ratio of between 1.5 and 2.0 and were converted back to their preferred method of anticoagulation after 21 days. The patients were encouraged to ambulate on the day of surgery and attend a joint replacement education class the following day. The patient determined the day of discharge by ambulating independently with a walker, climbing stairs, and feeling relief of pain with use of oral pain medications and by requesting to go home.

Our main outcomes were the average length of hospital stay per year; rate of discharge to a rehabilitation facility, to home with health care, or to home with outpatient physical therapy per year; and all-cause rate of readmission within 30 days of discharge per year (Table 1). The length of hospital stay was calculated as the difference between the dates of discharge and admission. We compared these outcomes and measures per year to percentile rankings of comparative hospitals in a national database, which included approximately 166,000 total knee arthroplasties and 700 hospitals as of December 2014 (DataVision Web Application; Midas+ Solutions, Tucson, AZ). We computed cost savings per patient achieved by shortening the average length of stay and increasing the rate of discharge to home with health care or to home with outpatient physical therapy per year with use of 2014 costs provided by the hospital (Table 2).

Statistical analyses

We used descriptive statistics (mean, standard deviation, 95% confidence interval [CI] of the mean) and univariate analyses to examine the association between the treatment year (January 1, 2009–October 1, 2014) and patient characteristics, outcomes, and measures of interest. Chi-square tests and Fisher's exact tests (for expected or observed values <5) determined whether the categorical variables of sex, race, severity of illness on discharge (1–4), number of discharge diagnoses (6 groups), discharge disposition (3 groups), and the incidence of readmission within 30 days. A one-factor analysis of variance determined whether the average age and average length of hospital stay per year changed. A post hoc Tukey's test determined the significance of differences between years. Software performed the statistical analyses (JMP version 10.0.2 for the Macintosh; SAS Institute, Inc., Cary, NC; www.jmp.com).

Results

Between January 1, 2009 and October 1, 2014, we noted the yearly change in the characteristics of the study population (Table 3), which showed no change in the average age, or distribution of race or sex; a slight decrease in the severity of illness from a change in the distribution of the category of illness; and a slight increase in the number of diagnosis per patient from a change in the distribution of the category of the number of diagnosis.

We observed a 35% reduction in the average length of hospital stay per year from 2.0 ± 0.7 (95% CI, 1.9–2.1) days in 2009 to 1.3 ± 0.6 (95% CI, 1.2–1.3) days in 2014 ($P < .0001$; Table 1). Our hospital's average length of hospital stay per year was shorter than the top 5th percentile of all comparative hospitals in the national database from 2009 to 2014 (Fig. 1).

Comparing from 2009 to 2014, the rate of discharge to a rehabilitation facility per year decreased from 41% to 1%, the rate of discharge to home with health care per year decreased from 50% to 42%, and the rate of discharge to home with outpatient physical therapy per year increased from 9% to 53% ($P < .0001$; Table 1). Our hospital's rate of discharge to home per year with either health care or outpatient physical therapy was higher than the top 95th percentile of all comparative hospitals in the national database from 2010 to 2014 (Fig. 2).

The rate of readmission within 30 days per year of 1.3% in 2009 and 0.9% 2014 did not change ($P = .38$), and the average rate over these 6 years was 1.1% (range: 0.3%–1.3%). There was a broad range

Table 1
Total patients per year, length of hospital stay, discharge disposition, annual rate of readmission within 30 days, and causes of readmission by treatment year.

Characteristic	2009	2010	2011	2012	2013	2014	*P* value
	Number of patients (%)	Number of patients (%)	Number of patients (%)	Number of patients (%)	Number of patients (%)	Number of patients (%)	
Total	386 (100)	368 (100)	375 (100)	407 (100)	461 (100)	331 (100)	
Length of Stay (d)	2.0 ± 0.7	1.9 ± 0.7	1.8 ± 0.7	1.6 ± 0.7	1.4 ± 0.6	1.3 ± 0.6	<.0001
Discharge disposition							<.0001
Skilled nursing facility	160 (41)	8 (2)	7 (2)	11 (3)	9 (2)	2 (1)	
Home with health care	193 (50)	319 (87)	255 (68)	204 (50)	226 (49)	154 (46)	
Home with outpatient physical therapy	33 (9)	41 (11)	113 (30)	192 (47)	226 (49)	175 (53)	
Readmissions within 30 days	5 (1.3)	4 (1.1)	1 (0.3)	4 (1)	6 (1.3)	3 (0.9)	.38
Altered mental status					1		
Bronchitis	1						
Disruption external wound	1						
Fracture of vertebrae-neoplasm	1						
Infected knee prosthesis	1						
Pneumonia	1						
Gastric ulcer with hemorrhage		1					
Superficial wound infection		1					
Urinary tract infection		1					
Ruled out knee infection		1					
Pulmonary embolism			1		1		
Hypotension/syncope				1	1		
Ruled out deep vein thrombosis and cellulitis				2		1	
Skin infection				1			
Contact dermatitis					1		
Deep vein thrombosis					2		
Dislocated prosthesis						2	

of diagnoses at the cause of the readmission (Table 1). Our hospital's rate of readmission within 30 days of discharge per year was below the 30th percentile of the comparative hospitals in the national database from 2009 to 2014 (Fig. 3).

The savings based on 2014 costs from shortening the average length of hospital stay per year from 2.0 days in 2009 to 1.3 days in 2014 was $851 per patient (Table 2). The savings from discharging a patient to home with health care instead of to a rehabilitation facility was $3698 per patient. The savings from discharging a patient to home with outpatient physical therapy instead of to a rehabilitation facility was $6402 per patient. Therefore, the savings per patient in 2014, which was achieved because of the differences in the average length of hospital stay and the discharge disposition from those in 2009, was $3245. These computations did not include the associated costs for readmission each year.

Discussion

The most important findings from our review of 2328 patients treated with a unilateral primary total knee replacement from January 1, 2009 to October 1, 2014 were that our average length of hospital stay per year shortened from 2.0 to 1.3 days, the rate of discharge to home per year increased from 59% to 99%, and the all-cause 30-day readmission rate per year did not change; (2) the per-year average length of stay, discharge disposition, and rate of readmission after 30 days compared favorably to percentile rankings of comparative hospitals in a national database, and (3) the savings per patient in 2014 was $3245.

Table 2
Average hospital costs per day and discharge costs per disposition in 2014 in US dollars.

Cost item	Average cost 2014 (US dollars)
Hospital costs	
Inpatient hospital cost for TKA stay of 1 day	$10092
Inpatient hospital cost for TKA stay of 2 days	$11,308
Inpatient hospital cost for TKA stay of 3 days	$12,654
Inpatient hospital cost for TKA stay of 4 days	$13,603
Discharge costs	
Rehabilitation facility	$6865
Home with health care	$3167
Home with outpatient physical therapy	$463

TKA, total knee arthroplasty.

Four limitations should be discussed before interpreting the findings of our study. First, the rate of readmission within 30 days if discharge per year in the present study might be higher than that reported by the hospital's database because we were unable to capture readmissions to other hospitals. Second, the present study relied on administrative data, which may result in underestimation or overestimation of the length of hospital stay, discharge disposition, or patient severity of illness if not coded properly. However, we are unaware of any change in reporting or coding over the time frame of the study, and any differences in results over time are internally consistent and therefore likely to reflect real differences in outcomes. Third, this study is a retrospective analysis and we are unable to determine the causes for the shortening of the length of hospital stay, the increased rate of discharge to home, and the low rate of readmission within 30 days of discharge. Finally, we did not include the readmission costs in the computation of the cost savings because the readmission diagnosis and associated costs for readmissions were inconsistent year to year. Therefore, the computation of savings was based solely on the shortening of the average length of hospital stay per year and the change in the discharge disposition per year.

Multiple studies have reported shortening the average length of hospital stay after total knee replacement; however, we are unaware of any study reporting a 35% reduction in the average length of hospital stay per year from 2.0 days in 2009 to 1.3 days in 2014. A study of 4057 Medicare total knee arthroplasty patients showed a 7% reduction from 4.1 days in the period of 2002 to 2004 to 3.8 days in the period of 2005 to 2007 [5]. A review of a multimodal pathway implemented in 211 total knee arthroplasty patients in 2007 showed a 7% reduction from a length of hospital stay of 4.03 to 3.77 days [12]. A review of a multicenter database of 182,146 total knee arthroplasty patients showed an average length of hospital

Table 3
Mean age, age group, race, sex, severity of illness, and number of discharge diagnoses by treatment year.

Characteristic	2009	2010	2011	2012	2013	2014	*P* value
	Number of patients (%)	Number of patients (%)	Number of patients (%)	Number of patients (%)	Number of patients (%)	Number of patients (%)	
Total	386 (100)	368 (100)	375 (100)	407 (100)	461 (100)	331 (100)	
Mean age (y) ± SD	68 ± 10.1	68 ± 9.5	66 ± 9.8	67 ± 9.3	68 ± 9.3	68 ± 9.3	.07
Age group							
<50 y	13 (3)	7 (2)	9 (2)	12 (3)	3 (1)	8 (2)	
50–59 y	66 (17)	62 (17)	92 (25)	73 (18)	84 (18)	57 (17)	
60–69 y	143 (37)	149 (40)	139 (37)	155 (38)	174 (38)	123 (37)	
70–79 y	113 (29)	110 (30)	96 (26)	123 (30)	140 (30)	108 (33)	
>79 y	51 (13)	40 (11)	39 (10)	44 (11)	60 (13)	35 (11)	
Race							.113[a]
White	309 (82)	328 (89)	317 (85)	346 (85)	401 (87)	279 (84)	
Black	32 (8)	8 (2)	13 (3)	17 (4)	8 (2)	14 (4)	
Hispanic	1	1	1	1	1	0	
Asian	14 (4)	11 (3)	16 (4)	23 (6)	16 (3)	13 (4)	
Other/unknown/refusal	30 (6)	20 (6)	28 (8)	20 (5)	35 (8)	25 (8)	
Female	229 (59)	208 (56)	220 (59)	247 (61)	264 (57)	208 (62)	.54
Severity of illness (APR-DRG)							.02[a]
1: Minor	0 (0)	0 (0)	0 (0)	7 (2)	3 (1)	0 (0)	
2: Moderate	212 (55)	216 (59)	202 (54)	201 (49)	279 (61)	208 (63)	
3: Major	161 (42)	143 (39)	163 (43)	178 (44)	173 (38)	118 (36)	
4: Severe	13 (3)	9 (2)	10 (3)	21 (5)	6 (1)	5 (2)	
Number of diagnoses (ICD-9)	8.6 ± 3.3	9.9 ± 3.6	10.3 ± 3.8	10.8 ± 3.9	10.8 ± 3.6	11.0 ± 4.6	<.0001[a]
0–4	35 (9)	14 (4)	12 (3)	8 (2)	13 (3)	17 (5)	
5–9	219 (57)	168 (46)	161 (43)	156 (38)	160 (35)	121 (37)	
10–14	104 (27)	143 (39)	150 (40)	181 (44)	220 (48)	121 (37)	
15–19	28 (7)	38 (10)	46 (12)	47 (12)	59 (13)	56 (17)	
20–24		5 (1)	6 (2)	15 (4)	9 (2)	14 (4)	
>24						2 (1)	

[a] Fisher's exact test compared nominal data between 2009 and 2014; chi-square analysis was not used because expected count was <5 in some cells.

stay of 3.9 days between 2003 and 2005 [13]. Our hospital's short length of hospital stay of 1.3 days cannot be explained by a low severity of illness (ie, APR-DRG). The overall severity of illness of the 2328 patients in the present study (0% minor, 63% moderate, and 36% major, 1% severe) was more severe than the overall severity of illness of the 182,146 patients in the multicenter database (35% minor, 45% moderate, 20% major, 0% severe; P < .0001) [13]. The inconsistency between the APR-DRG, which suggests that the patients were significantly more healthier later in the series (only 123 major or severe in 2014 vs. 175 in 2009), and the number of diagnosis, which suggests that the patients were significantly more sickly later in the series (22% with ≥15 diagnoses in 2014 vs. 7% in

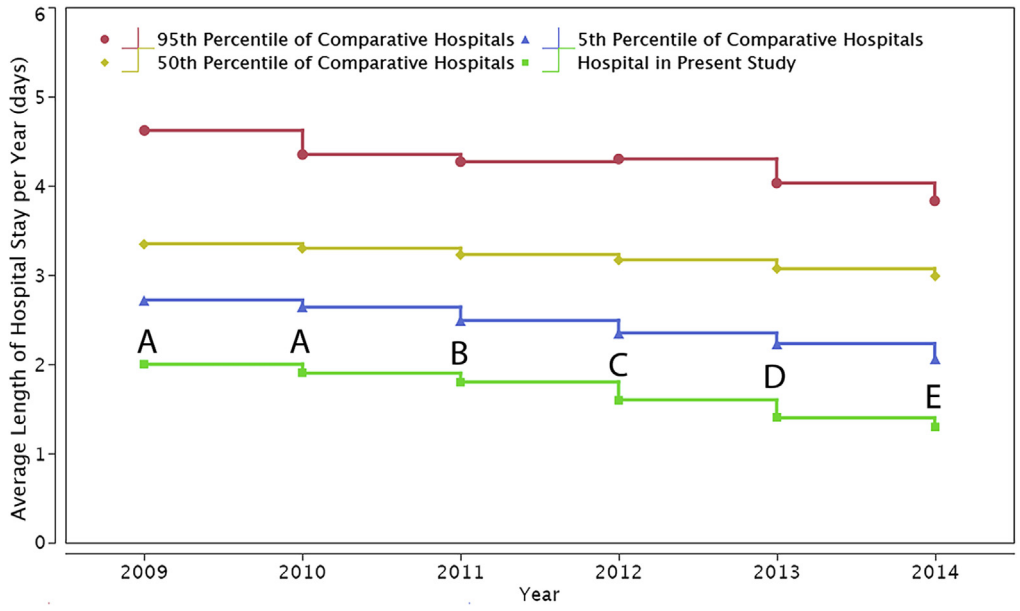

Figure 1. Overlay plot shows the average length of hospital stay per year for the hospital in the present study, which is juxtaposed with the 5th, 50th, and 95th percentiles of the 540 (2009) to 700 (2014) comparative hospitals in the national database. From 2009 to 2014, the average length of hospital stay per year in the present study shortened 37% from 2.0 to 1.3 nights ($P < .0001$) and was shorter than the 5th percentile of the comparative hospitals in the national database. Different letters (A–E) show those years with a change in the average length of hospital stay per year ($P < .05$).

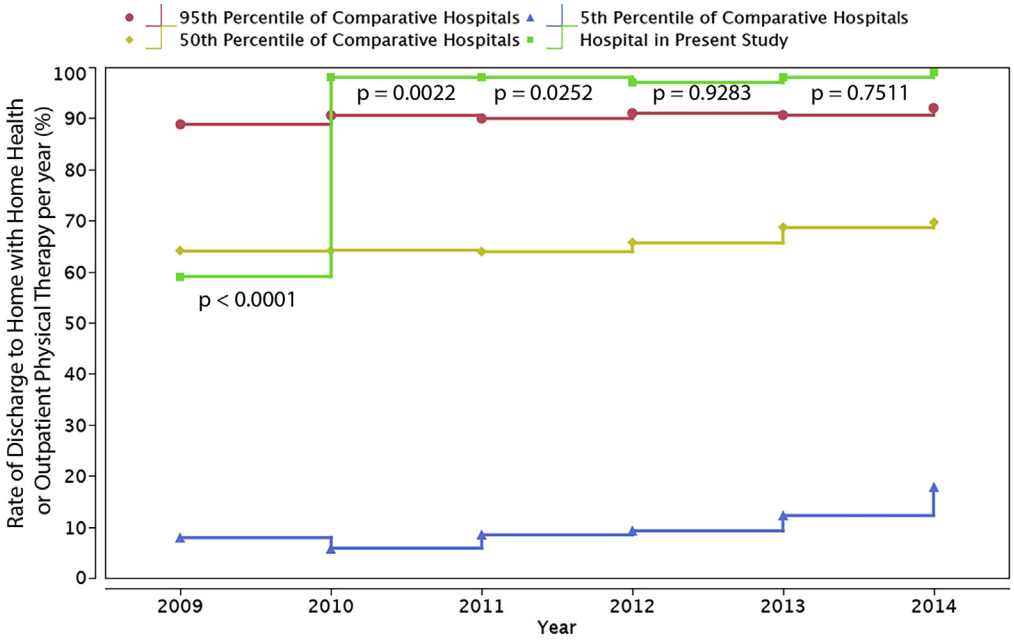

Figure 2. Overlay plot shows the rate of patients discharged home per year with home health or outpatient physical therapy for the hospital in the present study, which is juxtaposed to the 5th, 50th, and 95th percentiles of the comparative hospitals in the national database. The percentage of patients discharged home per year in the present study increased from 59% in 2009 to 99% in 2014 and was higher than the 95th percentile of the comparative hospitals in the national database from 2010 to 2014. For the hospital in the present study, a value of $P < .05$ shows consecutive years in which the distribution of patients discharged to rehabilitation facility, home with health care, and home with outpatient physical therapy changed significantly.

2009), can be explained by the different methods used to compute these two metrics of the health of a population.

There is an interest in discharging the total knee arthroplasty patient to home instead of to a rehabilitation facility to lower the burden of the cost of health care [7,8]. A unique finding of our study was the increase in the rate of discharge to home per year from 59% to 99%, which was associated with a relatively high overall severity of illness between 2010 and 2014, a shortening of the average length of hospital stay, and no increase in the a rate of readmission within 30 days after discharge per year, which is different from the national database (Fig. 2). The dramatic increase in the rate of discharge to home per year between 2009 and 2010 and the reduction in the length of stay from 2009 to 2014 were associated with the use of a preoperative education class that clearly set progress, treatment, and discharge expectations, and the initiation of gait training on the day of surgery by physical therapy.

Several studies have tried to determine whether shortening the average length of the hospital stay per year is associated with a

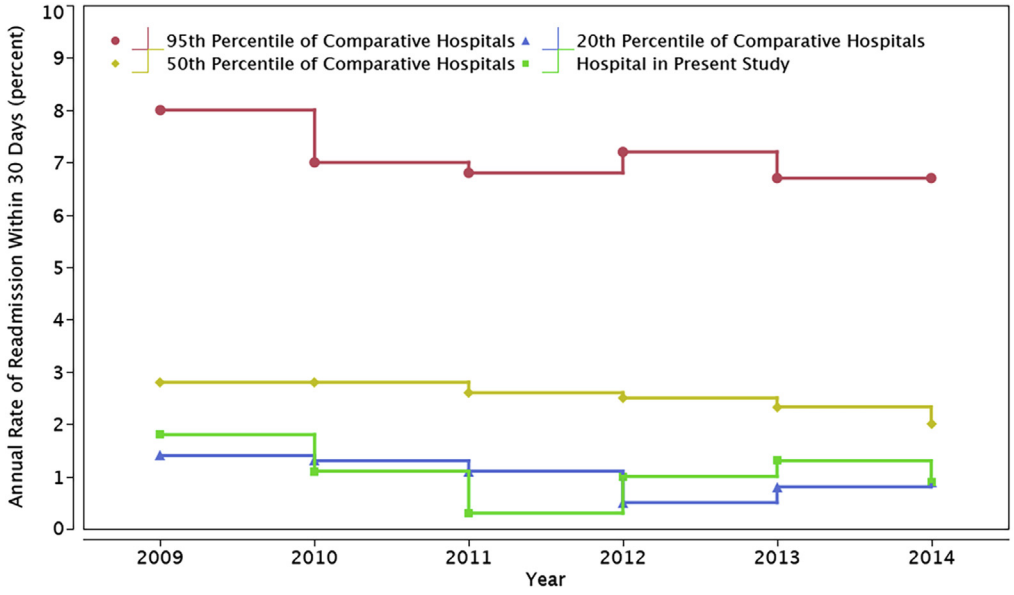

Figure 3. Overlay plot shows the all-cause rate of readmission within 30 days of discharge per year for each year for the hospital in the present study, which is juxtaposed to the 20th, 50th, and 95th percentiles of the comparative hospitals in the national database. The annual rate of readmission within 30 days in the present study of 1.3% in 2009 and 0.9% in 2014 did not change ($P = .38$), and the annual rate of readmission within 30 days was not >10 points above the 20th percentile of the comparative hospitals in the national database.

detrimental increase in the rate of readmission within 30 days after discharge per year. An analysis of 3,271,851 Medicare total knee arthroplasty patients from 1991 to 2010 showed that the all-cause readmission rate within 30 days declined initially but then increased in recent years when the length of hospital stay shortened from 7.9 to 3.5 days [4]. A retrospective review of 4057 Medicare total knee arthroplasty patients reported no difference in the readmission rate within 30 days when the length of hospital stay shortened from 4.1 to 3.8 days between 2002 and 2007 [5]. A multicenter study of retrospective analysis of 23,655 total knee arthroplasty patients showed the risk of readmission within 30 days for patients with a 2-day length of stay was not different from patients with a 3-day length of stay between 2009 and 2011 [14]. Our study supports the safety of shortening the average length of hospital stay per year to 1.3 days because we found no associated change in the rate of readmission within 30 days of discharge and because the average rate of readmission was <30th percentile of the comparative hospitals in the national database (Fig. 3).

Shortening the average length of hospital stay per year, increasing the rate of discharge to home with outpatient physical therapy per year, and lowering the rate of readmission within 30 days per year are three methods that lower costs after total knee arthroplasty. A balance is required between these methods as an excessively short hospital stay might increase the rate of readmission within 30 days after discharge [4,6]. In our hospital, discharging the patient to home with health care instead of to a rehabilitation facility saved $3696, and discharging the patient to home with outpatient physical therapy instead of to home with health care saved $2704, both of which are greater than the savings of $1216 from discharging the patient on day 1 instead of on day 2 (Table 2). Hence, savings are greater when the hospital has a bed that enables the patient an extra day and the stay of an extra day changes the discharge to home instead of to a rehabilitation facility.

Conclusions

In summary, shortening the average length of hospital stay per year to 1.3 days and increasing the rate of discharge per year to home with either home with health care or home with outpatient physical therapy without a change in the rate of readmission within 30 days of discharge per year saved $3245 per patient in 2014 when compared to 2009.

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