Episode-of-Care Characteristics and Costs for Hip and Knee Replacement Surgery in Hospitals Belonging to the High Value Healthcare Collaborative Compared With Similar Hospitals in the Same Health Care Markets

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Background: To inform consumers and restrain health care cost growth, efforts to promote transparency and to reimburse for care episodes are accelerating in the United States.

Objective: To compare characteristics and costs of 30-day episode of care for hip and knee replacement occurring in High Value Healthcare Collaborative (HVHC)-member hospitals to those occurring in like non-HVHC-member hospitals in the same 15 health care markets before interventions by HVHC members to improve health care value for those interventions.

Research Design: This is a retrospective analysis of fee-for-service Medicare data from 2012 and 2013.

Subjects: For hip arthroplasty, 4030 HVHC-member and 7572 non-HVHC-member, and for knee arthroplasty, 6542 HVHC-member and 13,900 non-HVHC-member fee-for-service Medicare patients aged 65 and older.

Measures: Volumes, patient demographics, hospital stay characteristics, and acute and postacute care standardized costs for a 30-day episode of care.

Results: HVHC-member hospitals differed from similar non-HVHC-member hospitals in the same health care markets when considering volumes of surgeries, patient demographics, Charlson scores, and patient distance to care during the index admission. There was little variation in acute care costs of hip or knee replacement surgery across health care markets; however, there was substantial variation in postacute care costs across those same markets. We saw less variation in postacute care costs within markets than across markets. Regression analyses showed that HVHC-member status was not associated with shorter lengths of stay, different complication rates, or lower total or postacute care costs for hip or knee replacement.

Conclusions: Health care regions appear to be a more important predictor of episode costs of care than HVHC status.

Key Words: total joint arthroplasty, care costs, geographic variation, episode of care, Medicare

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The Centers for Medicare & Medicaid Services (CMS) is expanding and accelerating use of alternative payment models¹ including “bundling” payments for an episode of care. Bundled payments are anticipated to reduce costs of care^{2,3} and encourage providers to engage patients⁴ and transparently demonstrate value.^{5–7} As part of this effort, in April, 2016, CMS implemented its comprehensive care for joint replacement model in 67 metropolitan statistical areas, impacting ~800 hospitals.⁸

The High Value Healthcare Collaborative (HVHC) is a consortium of health care delivery systems formed to improve care quality while reducing cost.⁹ In 2012, HVHC received an Innovation Challenge Award from the Center for Medicare and Medicaid Innovation (CMMI) to test the impact of patient engagement interventions—including implementation of decision aids and use of educational materials to inform preoperative patients on their anticipated treatment course—on, among other measures, outcomes, and costs for hip and knee replacements. Within the HVHC

membership, a retrospective, cross-sectional analysis of 30-day episode of care for hip and knee arthroplasty in 2012 or 2013 (which we considered to be baseline data because of the length of time it took to roll out interventions across HVHC members) showed that adjusted per-capita utilization rates varied across HVHC systems, postacute care reimbursements varied >3-fold for both types of arthroplasty, and total episode and postacute care reimbursements significantly differed across HVHC members after considering patient demographic differences.¹⁰

To extend that work, HVHC members sought to understand the performance of HVHC hospitals relative to hospitals where patients might have alternatively sought care. In particular, we were interested in whether some differences within HVHC members might be attributable to differences in care processes across geographic settings; we thought such differences might be captured by comparing episode-of-care results of HVHC-member hospitals to like hospitals providing care in the same markets. Therefore, this paper compares patient demographics, lengths of stay, complication rates, and standardized Medicare reimbursements for 30-day episode of care for uncomplicated hip replacement and knee replacement surgeries in HVHC hospitals and non-HVHC hospitals that had similar characteristics and provided those services in the same health care markets at baseline in 2012 and 2013, before efforts designed to improve value for these interventions in HVHC hospitals were firmly enacted.

METHODS

As previously reported,¹⁰ an awardee of a CMMI award, the HVHC obtained 100% of the fee-for-service Medicare data for Dartmouth-Atlas defined hospital referral regions (HRRs) in which participating HVHC members had a market presence for calendar years 2012 and 2013. This evaluation was approved by CMS as well as by the centralized Institutional Review Board at Dartmouth College (CPHS #23820). CMMI personnel were not involved with and did not influence this analysis; however, per the requirements of the award, CMMI personnel reviewed our publication for accuracy, messaging, politically sensitive issues, prohibited statements, and general reasonableness of and support for claims made. Because we followed CMS suppression rules, we do not report information that was derived from <11 patients. Data manipulation and statistical analysis were performed with the SAS 9.4 software Cary, NC.

Procedures Examined

We used methods virtually identical to those reported elsewhere,¹⁰ but to give readers easy access to them, provide details here, using virtually the same wording. We examined cohorts of patients who received 1 of 2 procedures that occurred during an index admission: uncomplicated hip replacement (MSDRG 470, ICD-9-CM procedure code 81.51) and uncomplicated knee replacement (MSDRG 470, ICD-9-CM procedure code 81.54). To ensure that the reasons for the surgeries that we examined were similar and improve that chances that patient populations would be similar, we limited hip and knee replacement analysis to those conducted on

patients who had a primary diagnosis of hip osteoarthritis (ICD-9-CM diagnostic codes 715.09, 715.15, 715.25, 715.35, or 715.95) or knee osteoarthritis (ICD-9-CM diagnostic codes 715.09, 715.16, 715.26, 715.36, or 715.96), respectively.

Comparison Groups

We sought to compare hospitals with similar characteristics. We did so because we reasoned that patients who used not-for-profit academic medical centers (those having residency programs) might be different than those who did not. Therefore, we used the American Hospital Association annual dataset to identify, and limit our analysis to, HVHC and non-HVHC-member hospitals that were not-for-profit, had at least 1 Accreditation Council for Graduate Medical Education (ACGME) accredited residency program, and were accredited by The Joint Commission. This resulted in 26 HVHC hospitals and 92 comparison hospitals, all of which met the inclusion criteria, in 15 HRRs. For each HRR, we present data for HVHC-member and non-HVHC-member hospitals.

Patient Demographics

From Medicare files, we obtained patient age, sex, and race (which we present, in aggregate, as the proportion of patients who were white). We limited our analysis to fee-for-service Medicare patients who were Medicare-eligible by virtue of age. We used ICD-9-CM diagnosis codes to calculate Deyo-modified Charlson scores.^{11,12} From Medicare files, we also determined whether patients were concurrently enrolled in Medicaid (defined as at least 1 month of dual enrollment during the year). Because of concerns that HVHC hospitals could be more likely to be referral centers and therefore draw patients from larger catchment areas, we used patient and hospital ZIP codes to calculate the distance in miles to the hospital that each patient used. Finally, we calculated the length of stay for the index admission. All analyses performed were procedure-level analyses.

Data Elements

The outcomes measures that we measured included length of stay, measures of episode costs, and complication rates. Length of stay was calculated as the number of days between admission and discharge from the index admission claim. Acute care cost was defined as the sum of all Medicare claim costs found within 3 days before admission through discharge for index event. Postacute care cost was defined as the sum of all Medicare claims with service in the 30-day episode, beginning at the date of discharge from the index admission; for institutional claims, when admission occurred during the episode but discharge occurred after the end of the episode, the cost for the institutional claim was prorated using the proportion of days which occur during the episode period. Total episode cost was the sum of acute and postacute care costs.

We obtained definitions of complications for hip or knee replacement surgery from the Agency for Health Research and Quality.¹³ We identified a complication as a binary variable indicating whether there was an associated surgical complication or during the admission or an all-cause

readmission within 30 days of discharge. Specific complications (and their timing to count as 1) included: acute myocardial infarction (during the index admission or within 7 d of admission); pneumonia (during the index admission or within 7 d of admission); sepsis, septicemia, or septic shock (during the index admission or within 7 d of admission); surgical-site bleeding (during the index admission or within 30 d of admission); death (during the index admission or within 30 d of admission); pulmonary embolism (during the index admission or within 30 d of admission); periprosthetic joint infection or wound infection (during the index admission or within the lesser of 90 d postadmission and 30 d postdischarge); and mechanical complications (during the index admission or within the lesser of 90 d postadmission and 30 d postdischarge). Complications that were readmissions were for readmission for any cause, occurring between 2 and 30 days postdischarge.

Calculation of Price-standardized Bundled Episode-of-Care Costs

The HVHC program management office developed a methodology that identified the index admissions for these procedures and calculated Medicare reimbursements for all care from 3 days before admission to 30-day postdischarge. We divided total costs of the episode into 2 periods: the acute care period that consists of the time the patient was admitted during the index admission and the postacute care period that began the day after discharge and ended 30 days after the discharge date. The acute care period included 3 service categories: the index Diagnosis Related Group (DRG) payment; part B professional fees that include consultative expenses during the index admission; and outpatient facility fees, generally associated with care provided in anticipation of admission over the 3 days before admission. The postacute care period included 7 reimbursement service categories: outpatient facility fees, skilled nursing facility care, inpatient rehabilitation care, long-term nursing home care, home health care, part B professional fees, and inpatient acute care reimbursement that included costs associated with readmission. In cases where postacute care extended past the 30-day period, the associated costs were prorated for the relative number of days in that period. Patients who expired during the 30-day period were removed from the analysis.

Because organizations in different geographies experience different Medicare reimbursement rates, we standardized Medicare reimbursement as follows. For each unit of consumption (for instance, index DRG, day of skilled nursing facility or rehabilitation hospital, or part B charge) we applied the Health Partners Total Cost of Care—Total Care Relative Resource Value methodology which were standardized to 2014 costs and calibrated to Medicare allowed amounts, to generate a standardized reimbursement for all service categories.¹⁴

Statistical Analysis

T tests and χ^2 tests were performed to compare descriptive statistics between HVHC and comparator hospitals for means and proportions, respectively.

Generalized linear mixed effects models were estimated to assess whether there were significant differences in the outcome variables between HVHC and comparator hospitals between 2012 and 2013 (HVHC by year interaction term), while controlling for various patient-level covariates. Covariates included in all models were age (grouped as 65–69, 70–74, 75–79, 80–84, 85+), sex, race (white vs. nonwhite), Charlson score (grouped as 0, 1–2, 3–4, 5+), dual-eligibility (yes vs. no), and distance from hospital (grouped as 0–4.4, 4.5–9.8, 9.9–22.8, and >22.9 miles). All covariates were kept in the models regardless of statistical significance, and any statistically significant interactions between the patient-level covariates were also included.

To account for variability between HRRs and hospitals, we allowed for random intercepts at the HRR and hospital within HRR levels and tested whether the random effects were significant using a likelihood ratio test. Random effects were removed from the model if they were not significant or the parameter estimates were negative.

To model complications, we used the logit link and binomial distribution for the error term. Length of stay and total and postacute costs were modeled with a log link and the gamma distribution for the error terms. For the total episode and postacute costs, an additional indicator variable indicating the presence or absence of any utilization in the 3 days before the index admission was added to improve model fit.

Because there were no significant HVHC by year interactions, the models were rerun without the interaction term to determine if there was any significant difference between HVHC and comparator hospitals after controlling for the other variables; therefore, we present only the data for both years combined, without the interaction terms. In supplemental tables, we provide model parameters and their SEs for the nonrandom effects (Supplemental data, Supplemental Digital Content 1, <http://links.lww.com/MLR/B358>). To compare the adjusted means between HVHC and comparators, the model estimated marginal means and 95% confidence intervals were calculated and the inverse-link was applied to back-transform them to their original scale.

RESULTS

Variation in Numbers of Surgeries, Patient Characteristics, and Lengths of Stay Between HVHC and Non-HVHC-member Hospitals in the Same Health Care Markets

We found substantial variation in the volume and length of stay of procedures as well as in patient characteristics across HRRs for hip replacement (Table 1A) and knee replacement (Table 1B) surgeries. Volumes of hip replacement surgery in HVHC-member hospitals over the 2-year period ranged from 28 to 706, whereas those for non-HVHC-member hospitals ranged from 20 to 2499. Volumes of knee replacement surgery in HVHC-member hospitals ranged from 101 to 1131, whereas those for non-HVHC-member hospitals ranged from 41 to 4408. On an average, patients seeking either hip or knee replacement surgery at HVHC-member hospitals were slightly older, more likely to

TABLE 1. Characteristics of Hip and Knee Replacement Surgeries for 26 HVHC-member Hospitals and 92 Similar non-HVHC Member Hospitals Providing Care in the Same 15 Listed Health Care Markets

										Mean Charlson Score		Mean Length of Stay (d)		Mean Distance to Care (miles)	
		No. Surgeries		Mean Age (y)		Male (%)		White (%)							
HRR	HRR Number	HVHC	Non-HVHC	HVHC	Non-HVHC	HVHC	Non-HVHC	HVHC	Non-HVHC	HVHC	Non-HVHC	HVHC	Non-HVHC	HVHC	Non-HVHC
A. Hip replacement surgery															
Boston, MA	227	102	2499	73.6	74.2	35.3	35.4	82.4	94.3	3.07	2.18	3.37	3.21	20.4	29.0
Dallas, TX	391	280	213	74.4	74.3	41.1	41.3	91.1	86.4	2.28	2.21	2.89	2.96	40.1	30.2
East Long Island, NY	301	536	423	75.5	74.8	37.1	35.5	90.9	84.9	2.83	2.80	3.44	3.22	28.2	12.5
Jacksonville, FL	123	255	472	74.5	72.8	43.5	39.8	91.4	86.7	2.14	2.37	3.09	3.08	163.4	23.0
La Crosse, WI	448	66	20	73.5	73.4	40.9	S	98.5	100.0	1.45	2.50	3.30	2.90	22.0	236.3
Los Angeles, CA	56	93	1030	75.2	74.6	38.7	34.4	81.7	76.8	2.12	2.72	3.55	2.93	11.3	35.7
Manhattan, NY	303	289	1916	73.9	74.3	34.9	34.0	85.5	87.4	2.54	2.73	3.34	3.44	51.2	39.6
Minneapolis, MN	251	225	69	75.6	74.9	39.1	50.7	97.8	98.6	1.86	1.61	3.09	3.55	46.7	97.2
Phoenix, AZ	12	260	36	74.9	72.9	43.5	41.7	96.2	94.4	2.01	2.25	2.74	2.92	314.4	78.5
Portland, ME	222	445	57	74.2	74.1	34.2	42.1	98.9	96.5	1.45	2.37	1.69	2.33	134.4	19.6
Portland, OR	344	292	265	73.0	74.4	38.0	36.2	94.5	95.8	1.30	2.03	2.05	3.02	84.7	97.1
Salt Lake City, UT	423	187	64	74.7	73.7	36.9	39.1	96.3	89.1	1.96	1.84	2.56	3.28	47.6	123.2
Seattle, WA	439	706	341	73.9	74.3	39.7	31.7	93.8	95.3	1.62	1.74	2.70	2.79	57.5	52.4
Spokane, WA	440	266	108	73.6	74.6	38.7	35.2	97.0	93.5	1.62	1.81	2.70	2.92	56.6	91.3
Waco, TX	418	28	59	75.0	74.4	42.9	37.3	96.4	91.5	1.93	1.92	3.36	3.24	23.1	23.5
Total/weighted mean		4030	7572	74.4	74.2	38.5	35.4	93.3	89.0	1.99	2.40	2.79	3.18	81.7	37.7
B. Knee replacement surgery															
Boston, MA	227	193	4408	74.0	73.6	26.4	34.7	73.1	90.9	2.87	2.22	3.28	3.25	29.4	27.7
Dallas, TX	391	476	419	74.4	74.1	34.0	29.8	86.6	81.6	2.59	2.54	3.04	3.32	44.4	16.1
East Long Island, NY	301	798	782	74.7	74.3	30.1	28.0	85.7	67.3	2.95	2.88	3.32	3.33	91.5	41.5
Jacksonville, FL	123	520	1559	73.9	72.7	36.5	35.2	91.7	86.3	2.08	2.42	3.15	3.01	96.5	23.8
La Crosse, WI	448	182	41	72.6	74.5	40.1	43.9	98.4	100.0	1.71	2.00	3.22	3.05	21.9	38.5
Los Angeles, CA	56	164	2133	74.0	74.0	28.7	30.3	64.6	63.0	2.59	2.71	3.43	3.16	13.4	23.9
Manhattan, NY	303	387	2796	73.8	74.1	33.3	28.7	76.7	73.9	2.80	2.89	3.50	3.71	46.3	38.7
Minneapolis, MN	251	380	145	74.6	74.9	37.4	45.5	98.7	98.6	1.74	2.32	3.17	3.50	30.9	91.5
Phoenix, AZ	12	423	89	74.0	73.1	42.8	34.8	95.7	38.2	1.78	2.13	2.68	3.67	283.6	43.3
Portland, ME	222	530	106	74.2	75.4	37.7	33.0	96.8	99.1	1.76	2.08	2.90	2.49	72.1	15.9
Portland, OR	344	507	317	73.2	72.4	33.1	36.6	92.3	86.8	1.72	1.86	2.38	2.94	81.1	54.7
Salt Lake City, UT	423	373	146	73.8	72.6	32.2	31.5	95.4	88.4	1.97	1.88	2.78	3.11	65.4	83.8
Seattle, WA	439	1131	655	73.8	73.8	37.0	37.3	88.1	90.7	1.60	1.80	2.85	3.00	51.3	46.3
Spokane, WA	440	378	116	73.7	73.4	45.0	33.6	97.1	95.7	1.63	1.87	2.86	3.04	61.8	19.9
Waco, TX	418	101	188	72.7	72.7	35.6	36.7	90.1	83.0	2.02	1.88	3.19	3.15	20.0	19.2

S means that data are based on <11 data points and therefore are suppressed.

HVHC indicates High Value Healthcare Collaborative; HRR, hospital referral region.

be male, and more likely to be white than those obtaining such care at non-HVHC-member hospitals. Patients obtaining hip or knee replacement surgery at HVHC-member hospitals had lower Charlson scores and shorter lengths of stay than those obtaining such care at non-HVHC-member hospitals. HVHC users tended to live further from care than non-HVHC users, though results varied substantially across HRRs.

Variation in Acute and Postacute Reimbursements in 30-Day Episodes for HVHC Members

Mean acute care costs for hip and knee replacement were relatively consistent across the 15 health care markets. Without adjustment, mean acute care costs were slightly lower for HVHC-member hospitals: \$19,184 for hip replacement vs. \$19,472 (Fig. 1) and \$19,171 for knee replacement vs. \$19,279 (Fig. 2). For both hip and knee replacement surgery, postacute care costs varied dramatically; however, differences across health care markets were much larger than those between HVHC-member and non-HVHC-

member hospitals in the same markets. For instance, for hip replacement surgery, across all health care settings examined postacute care costs varied 4.8-fold from \$3051 to \$14,697 (\$11,646 in absolute terms); for knee replacement surgery, postacute care costs varied 4.3-fold from \$3579 to \$15,378 (\$11,799 in absolute terms). However, differences between HVHC-members and non-HVHC-members within health care markets varied considerably less: \$7394 in absolute terms for hip replacement and \$3965 in absolute terms for knee replacement.

Regression Analysis

For each outcome that we modeled, χ^2 tests of random effects were statistically significant at $P < 0.05$ ($P < 0.001$ for length of stay and all modeled costs in both models; $P = 0.007$ for hip complications and $P = 0.0107$ for knee complications). The results of our regression analysis revealed that, after adjusting for patient age, sex, Medicaid eligibility status, race, distance to care, year of arthroplasty, and Charlson score, HVHC-member status was not associated with shorter lengths of stay, different complication

FIGURE 1. Medicare reimbursements for 30-day episode of care for hip replacement surgery in 26 HVHC-member hospitals and 92 similar non-HVHC-member hospitals in 15 health care markets. Costs of care for inpatient admission is separated from costs of care for the postacute part of the episode of care. DME indicates durable medical equipment; HVHC, High Value Healthcare Collaborative; Rehab, rehabilitation.

FIGURE 2. Medicare reimbursements for 30-day episode of care for knee replacement surgery in 26 HVHC-member hospitals and 92 similar non-HVHC-member hospitals in 15 health care markets. Costs of care for in index admission is separated from costs of care for the postacute part of the episode of care. DME indicates durable medical equipment; HVHC, High Value Healthcare Collaborative; Rehab, rehabilitation; SNF, skilled nursing facility.

rates, or lower total or postacute care costs for hip or knee replacement (Table 2).

CONCLUSIONS

We examined variation in volumes, patient demographics, and episode-of-care costs for total hip replacement

and total knee replacement in 26 HVHC-member hospitals and 92 like non-HVHC-member hospitals in 15 health care markets in which those hospitals compete. We found that HVHC-member hospitals provided care to patients who were slightly older, but more likely to be white, male, and healthier than patients whose care was provided by non-HVHC-member hospitals. HVHC-member hospitals had somewhat shorter

TABLE 2. Results of the Regression Analysis

	HVHC Hospitals		Comparator Hospitals	
	Inverse-link Marginal Mean	95% CI	Inverse-link Marginal Mean	95% CI
Hip replacement				
Length of stay	2.93	2.73–3.14	3.14	2.96–3.33
Complication rate	4.3%	3.6%–5.2%	4.1%	3.6%–4.8%
Total episode cost (\$)	26,944	25,515–28,453	27,192	25,863–28,590
Postacute care cost (\$)	6672	5528–8053	6820	5705–8153
Knee replacement				
Length of stay	3.05	2.91–3.19	3.25	3.14–3.37
Complication rate	3.8%	3.3%–4.4%	4.0%	3.6%–4.5%
Total episode cost (\$)	27,228	25,769–28,769	26,914	25,567–28,332
Postacute care cost (\$)	7373	6135–8861	6803	5724–8086

CI indicates confidence interval; HVHC, High Value Healthcare Collaborative.

unadjusted lengths of stay and slightly lower unadjusted acute- and postacute care costs overall; however, those differences were no longer statistically significant when we controlled patient characteristics in the multivariate analysis. Seemingly, most differences in 30-day episode costs of care were more attributable to the health care market in which a hospital provided care than to HVHC-member status.

Our findings confirmed that much of the variability in total episode costs is attributable to differences in postacute care costs.^{10,15} Although, other factors, such as differences in patient needs,¹⁶ could explain our findings, it is possible that regional differences in practice patterns (found even within health care delivery systems¹⁷) drove cost differentials. As patient expectations about care patterns within an episode of care may help drive utilization, it may be difficult to mitigate regional differences in postacute care costs; however, financial strategies that target high-utilizers or expensive postacute care settings might be used to accelerate the mitigation of such differences.^{18,19}

Our study has several limitations. First, we used an internal method to determine episode costs; had we used different methods, our results might have been different. Second, we examined only older Medicare fee-for-service beneficiaries and did not include an analysis of their out-of-pocket costs; examination of other populations—including those covered by commercial insurance—or inclusion of direct or indirect costs of care might have generated different results. Third, our definition of “like” hospitals was based on 3 criteria and substantially restricted the number of non-HVHC hospitals examined; use of other criteria may generate different results.

Nonetheless, this work demonstrates that there is ample room for reduction of variation in postacute care costs for the procedures we examined. In particular, health care systems with high postacute care costs might consider substituting lower cost settings for higher cost ones, as long as they can maintain high-quality care, as measured by other parameters. As is the case within HVHC members, other health care systems might collaborate to learn more efficient ways to manage care processes from one another.

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