

# Association Between Hospital Participation in a Medicare Bundled Payment Initiative and Payments and Quality Outcomes for Lower Extremity Joint Replacement Episodes

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**IMPORTANCE** Bundled Payments for Care Improvement (BPCI) is a voluntary initiative of the Centers for Medicare & Medicaid Services to test the effect of holding an entity accountable for all services provided during an episode of care on episode payments and quality of care.

**OBJECTIVE** To evaluate whether BPCI was associated with a greater reduction in Medicare payments without loss of quality of care for lower extremity joint (primarily hip and knee) replacement episodes initiated in BPCI-participating hospitals that are accountable for total episode payments (for the hospitalization and Medicare-covered services during the 90 days after discharge).

**DESIGN, SETTING, AND PARTICIPANTS** A difference-in-differences approach estimated the differential change in outcomes for Medicare fee-for-service beneficiaries who had a lower extremity joint replacement at a BPCI-participating hospital between the baseline (October 2011 through September 2012) and intervention (October 2013 through June 2015) periods and beneficiaries with the same surgical procedure at matched comparison hospitals.

**EXPOSURE** Lower extremity joint replacement at a BPCI-participating hospital.

**MAIN OUTCOMES AND MEASURES** Standardized Medicare-allowed payments (Medicare payments), utilization, and quality (unplanned readmissions, emergency department visits, and mortality) during hospitalization and the 90-day postdischarge period.

**RESULTS** There were 29 441 lower extremity joint replacement episodes in the baseline period and 31 700 in the intervention period (mean [SD] age, 74.1 [8.89] years; 65.2% women) at 176 BPCI-participating hospitals, compared with 29 440 episodes in the baseline period (768 hospitals) and 31 696 episodes in the intervention period (841 hospitals) (mean [SD] age, 74.1 [8.92] years; 64.9% women) at matched comparison hospitals. The BPCI mean Medicare episode payments were \$30 551 (95% CI, \$30 201 to \$30 901) in the baseline period and declined by \$3286 to \$27 265 (95% CI, \$26 838 to \$27 692) in the intervention period. The comparison mean Medicare episode payments were \$30 057 (95% CI, \$29 765 to \$30 350) in the baseline period and declined by \$2119 to \$27 938 (95% CI, \$27 639 to \$28 237). The mean Medicare episode payments declined by an estimated \$1166 more (95% CI, -\$1634 to -\$699;  $P < .001$ ) for BPCI episodes than for comparison episodes, primarily due to reduced use of institutional postacute care. There were no statistical differences in the claims-based quality measures, which included 30-day unplanned readmissions (-0.1%; 95% CI, -0.6% to 0.4%), 90-day unplanned readmissions (-0.4%; 95% CI, -1.1% to 0.3%), 30-day emergency department visits (-0.1%; 95% CI, -0.7% to 0.5%), 90-day emergency department visits (0.2%; 95% CI, -0.6% to 1.0%), 30-day postdischarge mortality (-0.1%; 95% CI, -0.3% to 0.2%), and 90-day postdischarge mortality (-0.0%; 95% CI, -0.3% to 0.3%).

**CONCLUSIONS AND RELEVANCE** In the first 21 months of the BPCI initiative, Medicare payments declined more for lower extremity joint replacement episodes provided in BPCI-participating hospitals than for those provided in comparison hospitals, without a significant change in quality outcomes. Further studies are needed to assess longer-term follow-up as well as patterns for other types of clinical care.

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The Centers for Medicare & Medicaid Services (CMS) launched the Bundled Payments for Care Improvement (BPCI) initiative in 2013 under the authority of the CMS Innovation Center to test whether linking payments for services provided during an episode of care can reduce Medicare payments, while maintaining or improving quality.<sup>1</sup> Hospitals, physician group practices, postacute care (PAC) providers such as skilled nursing facilities (SNFs) and home health agencies, and other entities were invited to participate in BPCI, which holds them accountable for Medicare payments for services provided during an episode of care triggered by a hospitalization. As with other alternative payment models, BPCI is designed to reward clinicians and facilities that deliver care more efficiently and effectively.<sup>2</sup>

Participants were offered multiple structural options in the BPCI initiative, including 4 payment models and 48 clinical episodes. All clinicians and facilities continued to receive Medicare fee-for-service payments, but total episode payments were reconciled against a target price based on discounted, historical payments. When episode payments were below the target, participants were eligible for additional amounts; when payments were above the target, participants may have had to repay CMS.<sup>3</sup>

## Methods

Federal common rule<sup>4</sup> provides an exemption from the institutional review board requirements when the purpose of the research is to study, evaluate, or otherwise examine a public benefit or service program. Contractors signed a data use agreement stating that all data were securely and solely used to study the BPCI initiative. Survey data collection was approved by the Abt Associates Institutional Review Board, which waived informed consent for respondents.

This study includes only hospital participants in the payment model that encompassed all services during an index hospitalization and a 90-day postdischarge period for lower extremity joint replacement episodes initiated from October 1, 2013, to June 30, 2015. The payment model may provide the most extensive insights into the behavioral changes in response to bundled payments because it encompasses the acute care and PAC period. The combination of participant type, payment model, and clinical episode chosen for this study was the most prevalent combination during the study period. Lower extremity joint (primarily hip and knee) replacements are the most common Medicare inpatient surgical procedures, with more than 450 000 procedures costing more than \$6 billion in acute hospitalizations in 2014.<sup>5</sup>

### Data Sources

Medicare Part A and Part B enrollment and claims data from March 1, 2011, to December 31, 2015, contained demographic and enrollment characteristics, diagnoses, and service use. These data were linked to create longitudinal beneficiary histories from 6 months before the hospitalization for the lower extremity joint replacement to 6 months after hospital discharge.

### Key Points

**Question** Is there an association between the Bundled Payments for Care Improvement (BPCI) initiative and Medicare payments and quality of care for lower extremity joint replacement episodes?

**Findings** This study used data from 2011 to 2015 to compare 31 700 lower extremity joint replacement episodes initiated at 176 BPCI-participating hospitals during the first 7 quarters of the initiative with matched episodes initiated at comparison hospitals. The BPCI initiative was associated with a significantly greater reduction in Medicare per-episode payments, with no decline in quality of care.

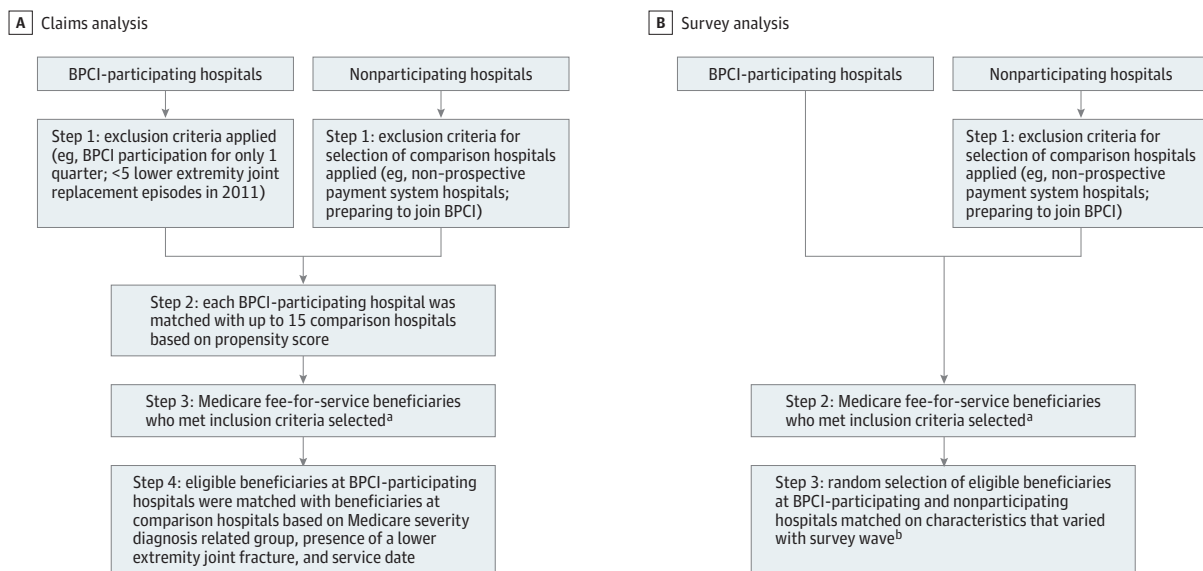
**Meaning** Although more research is needed, bundled payments for lower extremity joint replacement episodes may have the potential to decrease Medicare per-episode payments, while maintaining quality of care.

A mail survey was administered in 3 waves to 1500 beneficiaries hospitalized for a lower extremity joint replacement at a BPCI-participating hospital and 1500 beneficiaries with the same surgical procedure at a comparison hospital. The survey was mailed within 90 days after hospital discharge, with telephone follow-up. It collected satisfaction and self-reported change in functional outcomes. Most survey questions were from validated instruments (eg, the Continuity Assessment Record and Evaluation Item Set, National Health Interview Survey, and 36-Item Short Form Health Survey). New questions underwent cognitive testing with a small convenience sample of Medicare beneficiaries with recent hospital and PAC experience (eFigure 1 in the Supplement). Although the survey instrument consisted of questions that were adapted from validated surveys, the entire instrument was not tested for validity and reliability. Survey participants were asked to estimate their preoperative status at the same time as their postoperative status. Therefore, this part of the analysis should be viewed as exploratory.

### BPCI Population

The BPCI population included Medicare fee-for-service beneficiaries with a qualifying surgical procedure, identified by Medicare severity diagnosis related group (MS-DRG) 469 or MS-DRG 470 at a BPCI-participating hospital from October 1, 2013, to June 30, 2015. Beneficiaries were included if they were continuously enrolled in Medicare Parts A and B, their Medicare eligibility was not owing to a diagnosis of end-stage renal disease, Medicare was not their secondary payer, and they were discharged alive from the hospital. For risk-adjustment purposes, beneficiaries with less than 6 months of Medicare enrollment prior to the hospitalization were excluded from this analysis. All episodes were included regardless of the episode duration chosen by the hospital. During the 21-month study period, hospitals were subject to the intervention for approximately 10 months, on average, because hospitals joined the initiative from October 1, 2013, to April 1, 2015. Hospitals participating in BPCI were excluded if they participated in BPCI for only 1 quarter because of their short exposure to BPCI or if they had fewer than 5 episodes in

Figure. Selection Process of Bundled Payment for Care Improvement (BPCI) and Comparison Group Episodes for Claims Analysis and Survey Analysis



Selection process of BPCI and comparison groups for claims analysis (A) and survey analysis (B).

<sup>a</sup> Beneficiaries were included if they were continuously enrolled in Medicare Parts A and B, their Medicare eligibility was not owing to a diagnosis of end-stage renal disease, Medicare was not their secondary payer, and they were discharged alive from the hospital. For risk-adjustment purposes, beneficiaries with less than 6 months of Medicare enrollment prior to hospitalization were excluded from this analysis.

<sup>b</sup> A sample of BPCI and comparison beneficiaries were selected for the survey. For comparison hospitals, a sample of beneficiaries was randomly drawn from Medicare beneficiaries with a lower extremity joint replacement. The October 2014 and February 2015 survey wave comparison group samples were matched to the sample of BPCI beneficiaries on age and the size and teaching status of the hospital. The May 2015 survey wave sample was matched on Medicare severity diagnosis related group, age, and hospital size.

2011 because they had insufficient volume in the baseline period to generate outcomes for matching.

The survey sample was drawn from beneficiaries who met the same eligibility criteria and were discharged from the hospital in October 2014, February 2015, or May 2015.

### Comparison Population

The comparison population for the claims analysis was selected in 4 steps (Figure). First, nonparticipating hospitals were excluded if they were owned by a BPCI-participating organization, preparing to join BPCI, or not paid under Medicare's inpatient prospective payment system. Hospitals were also excluded if they were located in a market in which more than half of BPCI-eligible discharges were from a BPCI-participating hospital, to minimize downward bias due to potential spillover effects of the initiative. Second, using propensity scores,<sup>6</sup> each BPCI-participating hospital was matched with up to 15 comparison hospitals with a log odds propensity score absolute difference below a caliper of 0.515. The propensity score was based on market and hospital characteristics and baseline outcomes (Table 1). Only BPCI-participating and comparison hospitals with propensity score values in both populations, the region of common support, were included. Third, beneficiaries who met the inclusion criteria were identified from the matched comparison hospitals. Fourth, a sample was drawn from among beneficiaries identified in the previous step to match the BPCI population

in terms of distribution of MS-DRGs, presence of a lower joint fracture, and service dates.

The survey comparison sample selection began with the hospitals identified in the first step. The hospital matching approach was abbreviated for the survey because of the need to send the survey quickly to minimize respondent recall bias. A sample of beneficiaries was randomly drawn from Medicare beneficiaries with a lower extremity joint replacement in comparison hospitals. The October 2014 and February 2015 samples were matched to BPCI beneficiaries on age and the size and teaching status of the hospital. The May 2015 sample was matched on MS-DRG, age, and hospital size.

### Claims-Based Outcomes

Medicare-allowed payments, which include beneficiary cost sharing, and utilization were calculated for all services provided during the hospitalization and the 90-day postdischarge period. Medicare-allowed payments were also calculated for services provided during the 30 days before and 90 days after the episode to assess whether services were shifted outside the episode. Allowed payments were standardized to remove the effects of Medicare's geographic wage, teaching, and other payment adjustments and updated by an inflation factor to represent 2015 amounts (hereafter referred to as payments). Each hospital's lower extremity joint replacement admissions, 30- and 90-day unplanned readmissions, 30- and 90-day postdischarge

**Table 1. Characteristics of Hospitals Participating in the BPCI Initiative for Lower Extremity Joint Replacement Episodes, Nonparticipating Hospitals, and Comparison Hospitals, 2011<sup>a</sup>**

Characteristic	All BPCI-Participating Hospitals (n = 184)	Nonparticipating Hospitals Paid Under Medicare Prospective Payment System (n = 3064)	Standardized Difference	Matched BPCI-Participating Hospitals (n = 176) <sup>b</sup>	Comparison Hospitals (n = 915)	Standardized Difference
<b>Hospital Characteristics</b>						
Ownership, No. (%)						
Nonprofit	137 (74.46)	1810 (59.07) <sup>c</sup>	0.33	130 (73.86)	692 (75.63)	-0.04
Government	6 (3.26)	576 (18.80) <sup>c</sup>	-0.51	6 (3.41)	37 (4.05)	-0.03
For profit	41 (22.28)	678 (22.13)	0.00	40 (22.73)	186 (20.31)	0.06
Location, No. (%)						
Urban	176 (95.65)	2161 (70.53) <sup>c</sup>	0.71	168 (95.45)	870 (95.04)	0.02
Rural	8 (4.35)	903 (29.47) <sup>c</sup>	-0.71	8 (4.55)	45 (4.96)	-0.02
Member of a system, No. (%)	77 (41.85)	1621 (52.90) <sup>c</sup>	-0.22	74 (42.05)	389 (42.52)	-0.01
Teaching hospital, No. (%)	90 (48.91)	940 (30.68) <sup>c</sup>	0.38	85 (48.30)	459 (50.15)	-0.04
Intern and resident to bed ratio <sup>d</sup>						
Mean (SD)	0.13 (0.21)	0.06 (0.15) <sup>c</sup>	0.40	0.13 (0.21)	0.13 (0.22)	0.00
Median (IQR)	0.01 (0.00-0.21)	0.00 (0.00-0.02)		0.01 (0.00-0.21)	0.00 (0.00-0.176)	
Disproportionate share %, mean (SD) <sup>e</sup>	27.51 (14.79)	28.41 (17.21)	-0.06	27.59 (14.83)	27.79 (17.85)	-0.01
Medicare days as % of total patient days, mean (SD)	39.35 (11.15)	41.22 (14.35)	-0.15	39.38 (11.30)	39.53 (11.61)	-0.01
Beds, mean (SD), No.	297 (210)	186 (182) <sup>c</sup>	0.57	299 (213)	314 (267)	-0.06
<b>Hospital Market Characteristics<sup>f</sup></b>						
Population, No.						
Mean (SD)	4 427 732 (5 432 512)	2 488 698 (4 290 621) <sup>c</sup>	0.40	4 429 761 (5 406 293)	4 338 215 (5 103 659)	0.02
Median (IQR)	2 068 283 (693 204-5 992 414)	515 807 (81 449-2 824 724)		2 068 283 (693 204-5 992 414)	2 194 927 (545 394-5 992 414)	
Median household income, mean (SD), \$	53 934 (8873)	48 784 (10 633) <sup>c</sup>	0.53	54 007 (8912)	53 964 (9601)	0.00
Medicare Advantage penetration, mean (SD), % <sup>g</sup>	25.11 (10.56)	23.43 (13.42)	0.14	25.18 (10.69)	25.17 (12.95)	0.00
Skilled nursing facility beds per 10 000 patients, mean (SD), No.	54.54 (20.59)	61.31 (33.83) <sup>c</sup>	-0.24	54.81 (20.69)	55.10 (20.65)	-0.01
Inpatient rehabilitation facility in market, No. (%)	99 (53.80)	922 (30.09) <sup>c</sup>	0.49	95 (53.98)	502 (54.86)	-0.02
Hospital market share, % <sup>h</sup>						
Mean (SD)	16.21 (24.84)	26.75 (35.6) <sup>c</sup>	-0.34	15.82 (24.67)	16.07 (24.20)	-0.01
Median (IQR)	5.55 (1.97-16.28)	6.49 (1.67-41.54)		5.49 (2.00-15.79)	4.39 (1.57-22.44)	
Herfindahl-Hirschman index <sup>i</sup>						
Mean (SD)	0.18 (0.23)	0.34 (0.34) <sup>c</sup>	-0.55	0.18 (0.24)	0.18 (0.23)	-0.01
Median (IQR)	0.08 (0.03-0.23)	0.22 (0.06-0.51)		0.07 (0.03-0.22)	0.06 (0.03-0.25)	
<b>Hospital Patient Characteristics</b>						
Hospital discharges related to BPCI clinical episodes, mean (SD), % <sup>j</sup>	69.64 (5.24)	72.01 (10.53) <sup>c</sup>	-0.28	69.46 (4.97)	69.11 (9.01)	0.05
Lower extremity joint replacement discharges, No.						
Mean (SD)	198 (256)	113 (140) <sup>c</sup>	0.41	186 (164)	204 (220)	-0.10
Median (IQR)	133 (73-245)	66 (18-156)		133 (77-245)	126 (54-269)	

(continued)

**Table 1. Characteristics of Hospitals Participating in the BPCI Initiative for Lower Extremity Joint Replacement Episodes, Nonparticipating Hospitals, and Comparison Hospitals, 2011<sup>a</sup> (continued)**

Characteristic	All BPCI-Participating Hospitals (n = 184)	Nonparticipating Hospitals Paid Under Medicare Prospective Payment System (n = 3064)	Standardized Difference	Matched BPCI-Participating Hospitals (n = 176) <sup>b</sup>	Comparison Hospitals (n = 915)	Standardized Difference
Lower extremity joint replacement admissions discharged to home or facility, %						
Home						
Mean (SD)	9.36 (13.35)	14.35 (17.97) <sup>c</sup>	-0.32	8.91 (12.86)	9.04 (12.88)	-0.01
Median (IQR)	3.74 (1.65-9.95)	5.95 (2.02-20.59)		3.68 (1.64-9.53)	3.48 (1.37-11.43)	
Skilled nursing facility, mean (SD)	47.95 (23.42)	45.31 (23.97)	0.11	48.04 (23.00)	47.91 (23.92)	0.01
Home health agency, mean (SD)	27.12 (17.48)	27.80 (20.07)	-0.04	27.40 (17.58)	27.81 (18.68)	-0.02
Inpatient rehabilitation facility						
Mean (SD)	15.36 (17.60)	12.24 (17.40) <sup>c</sup>	0.18	15.43 (17.75)	15.03 (18.60)	0.02
Median (IQR)	9.24 (2.36-21.95)	4.60 (0.00-17.50)		9.27 (2.37-21.43)	7.80 (1.58-20.83)	
Long-term care hospital						
Mean (SD)	0.22 (0.77)	0.30 (2.06)	-0.05	0.21 (0.76)	0.22 (0.97)	-0.01
Median (IQR)	0.00 (0.00-0.00)	0.00 (0.00-0.00)		0.00 (0.00-0.00)	0.00 (0.00-0.00)	
Range	0.00-0.07	0.00-0.50		0.00-0.07	0.00-0.17	
30-d readmissions of lower extremity joint replacement discharges, mean (SD), %	9.20 (8.05)	7.83 (6.36) <sup>c</sup>	0.19	8.76 (4.41)	8.77 (5.65)	0.00
Medicare Part A standardized allowed payments for hospitalization and 90-d postdischarge period of lower extremity joint replacement discharges, mean (SD), \$	25 713 (4644)	25 098 (6280)	0.11	25 727 (4582)	25 573 (5158)	0.03

Abbreviations: BPCI, Bundled Payment for Care Improvement; IQR, interquartile range.

<sup>a</sup> Unadjusted proportions and means are shown. Characteristics were based on 2011 data, prior to announcement of the BPCI initiative. Each BPCI-participating hospital was matched with up to 15 comparison hospitals with a log odds propensity score absolute difference below a caliper of 0.515 using nearest-neighbor propensity score matching. Comparison hospitals are counted more than once if they are among the 15 nearest neighbors for more than 1 BPCI-participating hospital. For each variable, the standardized difference is the difference in means between the BPCI and comparison populations divided by the standard deviation of the pooled sample.

<sup>b</sup> Matched comparison hospitals were identified for 176 of the 184 BPCI-participating hospitals. Hospitals participating in BPCI were excluded if they participated in BPCI for only 1 quarter (n = 5) because of their short exposure to BPCI or if they had fewer than 5 episodes in 2011 (n = 2) because they had insufficient volume in the baseline period to generate outcomes for matching. One BPCI-participating hospital was excluded from the sample because it was not in the common support region of the propensity score.

<sup>c</sup> Difference in means between BPCI-participating hospitals and

nonparticipating but eligible hospitals is different from 0 at the 5% significance level.

<sup>d</sup> The intern and resident to bed ratio is a measure of the size of the teaching program used in Medicare's teaching adjustment.

<sup>e</sup> Disproportionate share percentage measures the proportion of inpatient days for low-income patients receiving Medicaid and Medicare.

<sup>f</sup> The market is defined as the core-based statistical area of the hospital.

<sup>g</sup> Medicare Advantage penetration is the percentage of Medicare beneficiaries enrolled in a Medicare Advantage plan in the market.

<sup>h</sup> Hospital market share is the number of BPCI-eligible episodes admitted to a hospital, divided by the total number of the same type of episodes admitted to all other hospitals in the given core-based statistical area.

<sup>i</sup> The Herfindahl-Hirschman index values can range from 0 to 1. Values closer to 0 signify a higher degree of competition among hospitals and values closer to 1 signify less competition (ie, 1 or a few hospitals dominate the market).

<sup>j</sup> The BPCI initiative includes 48 different clinical episodes with multiple Medicare severity diagnosis related groups.

mortality, and 30- and 90-day emergency department use were calculated.<sup>7-11</sup> Indicators of clinical complexity were calculated for the BPCI and comparison populations during the baseline and intervention periods to assess changes in patient mix.

### Survey Outcomes

Survey respondents were asked to recall their ability to function in routine tasks before their surgery and on the day of

the survey, and to report their satisfaction with treatment and recovery. Responses were used to create binary indicators of improvement or deterioration. Improvement was defined as having the highest recalled functional status prior to surgery and maintaining that status or as moving from a lower to higher functional status. Deterioration was defined as having the lowest recalled functional status before surgery and not improving or as moving from a higher to lower functional status. Binary indicators were also created for satisfac-



tion with care and recovery. Respondents were asked to report race and ethnicity based on fixed categories to compare the BPCI and comparison populations and evaluate factors that may affect outcomes.

### Statistical Analysis

#### Claims Analysis

The claims analysis relied on a difference-in-differences approach that quantified the associations with BPCI by comparing changes in outcomes between the baseline and intervention periods for the BPCI population with changes for the comparison population. This approach is used with the goal of minimizing biases from time-invariant differences between the BPCI and comparison populations and attempts to control for secular trends.<sup>12</sup> October 1, 2011, to September 30, 2012, was chosen as the baseline period because it is the year before BPCI participants indicated their interest in joining the initiative. The intervention period was from October 1, 2013, to June 30, 2015.

Multivariable regression models were estimated for each outcome. Covariates included risk factors observed before the hospitalization (age, sex, Medicaid eligibility, disability status, hierarchical condition category indicators<sup>13</sup>), prior health care use, MS-DRG, and hospital characteristics (eTable 1 in the [Supplement](#)). Models included BPCI population and intervention period indicators and an interaction term. Coefficients from multivariable regression models were used to construct model-predicted outcomes under 2 scenarios (baseline and intervention) for both the BPCI and comparison populations. Standard errors were calculated using the delta method.<sup>14</sup> Statistical significance was assessed at the 5% level. Analyses were performed using Stata statistical software version 14.1 (StataCorp LP).

Sensitivity analyses were conducted for payment and re-admission outcomes using 5 sets of randomly drawn beneficiary samples from the comparison hospitals to ensure that results were not due to the random selection of episodes. The baseline period was extended to 2 years to test the sensitivity of the estimates to duration of the baseline period. To assess the robustness of the risk-adjustment models, multiple specifications were run varying the aggregation of clinical indicators (eTable 1 in the [Supplement](#)).

#### Survey Analysis

The associations of the intervention with change in functional status were estimated as the difference in the percentage change between the BPCI and comparison survey respondents. The associations of the intervention with satisfaction with care and recovery were estimated as the percentage difference between the BPCI and comparison respondents. Outcomes were risk adjusted using a regression model that accounted for age, sex, Medicaid eligibility, hierarchical condition category index, prior health care use, MS-DRG, presence of a lower joint fracture, the respondent's recalled functional status prior to lower extremity joint replacement surgery, and month of surgery. Survey results were weighted to adjust for sampling and nonresponse. Statistical significance was assessed at the 2-sided 5% level.

## Results

The majority of BPCI-participating hospitals (158 of 184) chose episodes that extended for 90 days after discharge, which accounted for 84.3% of lower extremity joint replacement episodes; 1 hospital with 0.8% of the episodes chose 60-day episodes; and 25 hospitals with 15.0% of the episodes chose 30-day episodes.

Hospitals that participated in BPCI differed from those that did not (Table 1). Compared with all eligible but nonparticipating hospitals prior to the start of the initiative, BPCI-participating hospitals (n = 184) were more likely to be non-profit, urban, part of a system, a teaching hospital, and larger. The BPCI-participating hospitals were located in markets that had larger populations, higher median incomes, and fewer SNF beds; were more likely to have an inpatient rehabilitation facility (IRF); and were more competitive, defined by a lower Herfindahl-Hirschman index. The BPCI-participating hospitals were less dependent on Medicare admissions that could be subject to bundled payments, as measured by the share of hospital admissions in the 48 BPCI clinical episodes. In BPCI-participating hospitals, patients undergoing lower extremity joint replacement prior to the initiative were less likely to be discharged directly home, more likely to be discharged to an IRF, and more likely to be readmitted to a hospital within 30 days of discharge than patients in nonparticipating hospitals. Medicare Part A payments for the hospitalization and the 90-day postdischarge period were not statistically different at baseline between BPCI-participating and nonparticipating hospitals.

Matched comparison hospitals were identified for 176 of the 184 BPCI-participating hospitals. The BPCI-participating hospitals were excluded if they participated in BPCI for only 1 quarter (n = 5) or if they had fewer than 5 episodes in 2011 (n = 2). One BPCI-participating hospital was excluded from the sample because it was not in the common support region of the propensity score (eFigure 2 in the [Supplement](#)). The matched comparison hospitals were not statistically different from the BPCI-participating hospitals with respect to hospital and market characteristics (Table 1). Lower extremity joint replacement patients in matched BPCI-participating and comparison hospitals prior to the initiative were not statistically different in postdischarge site of service or in the level or trends in 30-day readmissions and Medicare payments for the hospitalization and 90-day postdischarge period (eTable 2 in the [Supplement](#)).

The BPCI-participating hospitals in the study sample (n = 176) had 29 441 lower extremity joint replacement episodes during the baseline year and 31 700 during the 21-month intervention period (mean [SD] age, 74.1 [8.89] years; 65.2% women), compared with 29 440 episodes in the baseline period (768 hospitals) and 31 696 episodes in the intervention period (841 hospitals) (mean [SD] age, 74.1 [8.92] years; 64.9% women) at matched comparison hospitals (Table 2). The mean lower extremity joint replacement discharges per quarter for BPCI-participating hospitals increased from 61.5 in the period from April 1, 2012, to June 30, 2012, to

**Table 2. Medicare Payments, Utilization, and Quality Measures for Lower Extremity Joint Replacement Episodes Among Matched BPCI-Participating and Comparison Hospitals in the Baseline and Intervention Periods<sup>a</sup>**

Measure	Risk-Adjusted Mean (95% CI)				Difference-in-Differences Estimate (95% CI)	P Value
	Matched BPCI-Participating Hospitals		Comparison Hospitals			
	Baseline	Intervention	Baseline	Intervention		
Hospitals, No.	176	176	768	841		
Lower extremity joint replacement episodes, No.	29 441	31 700	29 440	31 696		
Total Medicare payments during index hospitalization and 90-d postdischarge period, \$	30 551 (30 201 to 30 901)	27 265 (26 838 to 27 692)	30 057 (29 765 to 30 350)	27 938 (27 639 to 28 237)	-1166 (-1634 to -699) <sup>b</sup>	<.001
Total Medicare Part A payments, \$						
Index hospitalization	13 071 (13 026 to 13 117)	12 509 (12 439 to 12 579)	13 038 (13 010 to 13 065)	12 532 (12 496 to 12 568)	-57 (-136 to 23)	.16
Inpatient readmissions, 90-d postdischarge period	1379 (1320 to 1437)	1251 (1186 to 1317)	1337 (1278 to 1395)	1233 (1174 to 1293)	-24 (-135 to 87)	.67
Total Medicare payments, 90-d postdischarge period, \$						
SNF	6037 (5729 to 6346)	4953 (4664 to 5243)	5778 (5557 to 5998)	5239 (5009 to 5470)	-546 (-892 to -199) <sup>b</sup>	.002
IRF	2058 (1767 to 2350)	1273 (1025 to 1522)	1949 (1699 to 2199)	1609 (1397 to 1821)	-445 (-811 to -79) <sup>b</sup>	.02
Home health agency	2384 (2280 to 2488)	2187 (2028 to 2345)	2415 (2343 to 2487)	2200 (2112 to 2288)	18 (-127 to 163)	.81
Total Medicare Part B payments, 30-d preindex hospitalization, \$	970 (945 to 996)	899 (876 to 922)	963 (942 to 983)	910 (886 to 934)	-19 (-53 to 16)	.28
Total Medicare Part A and Part B payments, 90-d postepisode period, \$	4739 (4425 to 5053)	4415 (4186 to 4644)	4613 (4418 to 4807)	4369 (4196 to 4541)	-80 (-376 to 216)	.60
Patients discharged to institutional PAC (SNF, IRF, LTCH) among patients discharged to any PAC, %	63.7 (61.4 to 65.9)	53.2 (49.9 to 56.5)	61.2 (59.2 to 63.1)	56.4 (54.3 to 58.5)	-5.7 (-9.2 to -2.2) <sup>b</sup>	.001
Total inpatient LOS during index hospitalization, d	4.4 (4.4 to 4.4)	3.9 (3.8 to 4.0)	4.4 (4.4 to 4.5)	4.1 (4.0 to 4.1)	-0.1 (-0.2 to -0.0) <sup>b</sup>	.01
Total institutional PAC days in 90-d postdischarge period among patients with ≥1 institutional PAC day, d	22.2 (21.7 to 22.7)	21.6 (21.0 to 22.1)	22.1 (21.7 to 22.5)	21.9 (21.4 to 22.3)	-0.4 (-1.1 to 0.3)	.29
Unplanned readmission rate by postdischarge period, %						
30 d	6.3 (5.9 to 6.6)	5.8 (5.5 to 6.2)	6.3 (6.0 to 6.6)	6.0 (5.7 to 6.3)	-0.1 (-0.6 to 0.4)	.69
90 d	10.3 (10.0 to 10.7)	9.6 (9.2 to 10.1)	10.1 (9.8 to 10.5)	9.8 (9.4 to 10.2)	-0.4 (-1.1 to 0.3)	.30
Emergency department visit without hospitalization by postdischarge period, %						
30 d	7.5 (7.1 to 7.8)	7.6 (7.2 to 8.0)	7.5 (7.2 to 7.9)	7.8 (7.4 to 8.1)	-0.1 (-0.7 to 0.5)	.81
90 d	13.6 (13.2 to 14.0)	14.1 (13.6 to 14.6)	13.8 (13.4 to 14.3)	14.1 (13.6 to 14.6)	0.2 (-0.6 to 1.0)	.62
Mortality rate by postdischarge period, %						
30 d	0.9 (0.8 to 1.0)	0.9 (0.8 to 1.0)	0.9 (0.8 to 1.0)	0.9 (0.8 to 1.0)	-0.1 (-0.3 to 0.2)	.62
90 d	1.9 (1.8 to 2.1)	1.9 (1.7 to 2.1)	1.9 (1.8 to 2.0)	1.9 (1.7 to 2.1)	-0.0 (-0.3 to 0.3)	.85

Abbreviations: BPCI, Bundled Payment for Care Improvement; IRF, inpatient rehabilitation facility; LOS, length of stay; LTCH, long-term care hospital; PAC, postacute care; SNF, skilled nursing facility.

<sup>a</sup> All results were adjusted for demographic and clinical risk factors observed before the hospitalization (age, sex, Medicaid eligibility, disability status,

and hierarchical condition category indicators), prior health care use, and hospital characteristics. The baseline period was from October 1, 2011, to September 30, 2012; the intervention period was from October 1, 2013, to June 30, 2015, and varied by hospital based on when it was participating.

<sup>b</sup> Statistically significant difference at the 5% significance level.

64.6 in the period from April 1, 2015, to June 30, 2015, compared with a decline for comparison hospitals from 59.6 to

59.2 during the same periods. The difference between the BPCI-participating and comparison hospitals in change in

discharges per quarter was not statistically significant (difference-in-differences estimate, 3.38; 95% CI, -2.4 to 9.2) (eTable 3 in the Supplement).

For BPCI episodes, the mean Medicare payments for the hospitalization and 90-day postdischarge period were \$30 551 (95% CI, \$30 201 to \$30 901) in the baseline period and declined by \$3286 to \$27 265 (95% CI, \$26 838 to \$27 692) in the intervention period. For comparison episodes, the mean Medicare payments were \$30 057 (95% CI, \$29 765 to \$30 350) in the baseline period and declined by \$2119 to \$27 938 (95% CI, \$27 639 to \$28 237) in the intervention period. Payments declined by an estimated \$1166 more (95% CI, -\$1634 to -\$699;  $P < .001$ ) for the BPCI population than for the comparison population between the baseline and intervention periods. The larger payment reduction for the BPCI population was primarily due to reduced payments for institutional PAC. The SNF payments declined \$546 more (95% CI, -\$892 to -\$199;  $P = .002$ ) for the BPCI population than for the comparison population, and the IRF payments declined \$445 more (95% CI, -\$811 to -\$79;  $P = .02$ ) for the BPCI population.

Differential changes in utilization were consistent with the reductions in Medicare payments. During the baseline, 63.7% (95% CI, 61.4% to 65.9%) of BPCI episodes that included any PAC received institutional PAC (SNF, IRF, or long-term care hospital), compared with 53.2% (95% CI, 49.9% to 56.5%) during the intervention period (Table 2). The decline in institutional PAC use for the BPCI population that used any PAC was 5.7% greater (95% CI, -9.2% to -2.2%;  $P = .001$ ) than the decline for the comparison population (baseline: 61.2%; 95% CI, 59.2% to 63.1%; intervention: 56.4%; 95% CI, 54.3% to 58.5%). The index hospital length of stay declined 0.1 day more (95% CI, -0.2 to -0.0;  $P = .01$ ) for the BPCI population than the comparison population.

There was no change in Medicare payments during the 30 days before or the 90 days after the episode for the BPCI population relative to the comparison population. Several indicators of patient severity were examined (Table 3). There was no difference in the change from baseline to the intervention period in the mean number of hierarchical condition category indicators for the BPCI population relative to the comparison population, based on information from the 6 months prior to hospitalization. The proportion of the BPCI population that had a hospitalization, had an SNF stay, or used home health care during the 6 months prior to surgery declined more from the baseline to the intervention period than for the comparison group (hospitalization: -0.8%; 95% CI, -1.6% to -0.1%;  $P = .03$ ; SNF stay: -0.5%; 95% CI, -1.0% to -0.0%;  $P = .04$ ; and home health care: -1.3%; 95% CI, -2.0% to -0.6%;  $P < .001$ ).

Claims-based measures did not indicate differences in quality of care between the BPCI and comparison populations. From baseline to the intervention period, there were no statistically significant differences between the BPCI and comparison populations in the change in 30-day unplanned readmissions (-0.1%; 95% CI, -0.6% to 0.4%), 90-day unplanned readmissions (-0.4%; 95% CI, -1.1% to 0.3%), 30-day emergency department visits (-0.1%; 95% CI, -0.7% to 0.5%), 90-day emergency department visits (0.2%; 95% CI, -0.6% to 1.0%), 30-day postdischarge mortality (-0.1%; 95% CI, -0.3%

to 0.2%), and 90-day postdischarge mortality (-0.0%; 95% CI, -0.3% to 0.3%).

The results did not vary across sensitivity analyses. Reductions in Medicare payments remained significant across alternative comparison samples, duration of baseline periods, and risk adjustment specifications. Confidence intervals overlapped across specifications (eFigure 3 in the Supplement).

A total of 2193 surveys were completed by beneficiaries (1098 for the BPCI population, 1095 for the comparison population) who had a lower extremity joint replacement at a BPCI-participating or comparison hospital, resulting in a 73% response rate (eTable 4 in the Supplement). The characteristics of the BPCI and comparison survey respondents were not significantly different, except that a higher proportion of BPCI respondents had obtained a college degree or greater (34.9% vs 29.9%;  $P = .02$ ) and a lower proportion of BPCI respondents had a lower joint fracture (6.9% vs 10.3%;  $P = .01$ ).

Although exploratory, survey results indicate that BPCI respondents reported greater improvements in mobility, physical and emotional problems, and pain and did not differ from the comparison group with respect to changes in other functional measures or satisfaction (Table 4). Among BPCI respondents, 65.1% reported improved ability to walk without resting from before their surgery to when they completed the survey, compared with 60.0% of the comparison respondents, for a difference of 5.1% (95% CI, 1.2% to 9.0%;  $P = .01$ ). Similarly, 64.8% of BPCI respondents reported improved ability to walk up and down 12 stairs, compared with 58.3% of the comparison respondents, for a 6.6% difference (95% CI, 2.6% to 10.5%;  $P = .01$ ). The BPCI respondents were more likely than the comparison respondents to report improvement in physical and emotional problems that limited social activities (75.8% vs 71.6%, respectively; difference, 4.2%; 95% CI, 0.5% to 7.9%;  $P = .03$ ) and in pain that limited normal activities (80.3% vs 76.0%, respectively; difference, 4.3%; 95% CI, 0.9% to 7.7%;  $P = .01$ ). Consistent with their better improvement in pain, fewer BPCI respondents than comparison respondents reported deterioration of pain limiting normal activities (7.5% vs 11.1%, respectively; difference, -3.6%; 95% CI, -6.2% to -1.0%;  $P = .01$ ). There was no statistically significant difference between the 2 groups in reported improvement or deterioration in other physical or cognitive function measures or in satisfaction with treatment and recovery.

## Discussion

Mean Medicare payments for a lower extremity joint replacement hospitalization and the 90-day postdischarge period declined \$1166 more for Medicare beneficiaries with episodes initiated in a BPCI-participating hospital than for beneficiaries in a comparison hospital. The lower Medicare payments were primarily due to reduced use of institutional PAC. There was no evidence that the greater reduction in payments was due to shifting service use outside the episode period. Claims-based quality measures, including unplanned readmissions, emergency department visits, and mortality, were not statistically different between the BPCI and comparison populations.



**Table 3. Patient, Hospital, and Location Characteristics Among the BPCI and Comparison Populations in the Baseline and Intervention Periods<sup>a</sup>**

Characteristic	BPCI Population		Comparison Population		Difference-in-Differences Estimate (95% CI)	P Value
	Baseline	Intervention	Baseline	Intervention		
<b>Patient Characteristics</b>						
Patients, No.	29 441	31 700	29 440	31 696		
Age, No. (%), y						
65-79	18 195 (61.8)	20 835 (65.7)	18 220 (61.9)	20 846 (65.8)	0.0 (-1.0 to 1.1)	.94
≥80	8702 (29.6)	8297 (26.2)	8786 (29.8)	8200 (25.9)	0.6 (-0.4 to 1.6)	.25
Female, No. (%)	19 764 (67.1)	20 668 (65.2)	19 466 (66.1)	20 566 (64.9)	-0.7 (-1.8 to 0.4)	.20
Medicaid eligibility, No. (%)	3744 (12.7)	3342 (10.5)	3733 (12.7)	3636 (11.5)	-1.0 (-1.7 to -0.2) <sup>b</sup>	.01
Disabled, with no end-stage renal disease, No. (%)	3086 (10.5)	2988 (9.4)	2990 (10.2)	3080 (9.7)	-0.6 (-1.3 to 0.1)	.07
Major joint replacement or reattachment of lower extremity without MCC, MS-DRG 470, No. (%)	27 827 (94.5)	30 193 (95.2)	27 826 (94.5)	30 187 (95.2)	0.0 (-0.5 to 0.5)	.98
<b>Hierarchical condition categories, No.<sup>c</sup></b>						
Mean (SD)	1.2 (1.4)	1.1 (1.4)	1.2 (1.4)	1.1 (1.4)	-0.0 (-0.0 to 0.0)	.72
Median (IQR)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)		
<b>Any utilization 6 mo prior to index hospitalization, No. (%)</b>						
Inpatient acute care hospital	3950 (13.4)	3939 (12.4)	3754 (12.8)	3986 (12.6)	-0.8 (-1.6 to -0.1) <sup>b</sup>	.03
Emergency department admission	4849 (6.5)	5136 (16.2)	4867 (16.5)	5221 (16.5)	-0.2 (-1.0 to 0.6)	.62
Home health care	3353 (11.4)	3067 (9.7)	3402 (11.6)	3523 (11.1)	-1.3 (-2.0 to -0.6) <sup>b</sup>	<.001
Inpatient rehabilitation facility	386 (1.3)	344 (1.1)	343 (1.2)	285 (0.9)	0.0 (-0.2 to 0.3)	.74
Skilled nursing facility	1531 (5.2)	1368 (4.3)	1449 (4.9)	1440 (4.5)	-0.5 (-1.0 to -0.0) <sup>b</sup>	.04
Psychiatric hospital	132 (0.4)	106 (0.3)	130 (0.4)	98 (0.3)	0.0 (-0.1 to 0.2)	.79
Long-term care hospital	23 (0.1)	27 (0.1)	30 (0.1)	32 (0.1)	0.0 (-0.1 to 0.1)	.82
No institutional care	25 116 (85.3)	27 439 (86.6)	25 338 (86.1)	27 417 (86.5)	0.8 (0.0 to 1.6) <sup>b</sup>	.04
No postacute care	20 741 (70.4)	22 918 (72.3)	20 814 (70.7)	22 671 (71.5)	1.0 (0.0 to 2.0) <sup>b</sup>	.05
Institutional nursing facility	1832 (6.2)	1663 (5.2)	1724 (5.9)	1694 (5.3)	-0.5 (-1.0 to 0.1)	.08
<b>Hospital Characteristics</b>						
<b>Ownership, No. (%)</b>						
Nonprofit	24 107 (81.9)	26 633 (84.0)	24 678 (83.8)	26 506 (83.6)	2.3 (1.5 to 3.2)	<.001
Government	607 (2.1)	427 (1.3)	1189 (4.0)	1162 (3.7)	-0.3 (-0.7 to 0.0)	.07
For profit	4727 (16.1)	4640 (14.6)	3573 (12.1)	4028 (12.7)	-2.0 (-2.8 to -1.2) <sup>b</sup>	<.001
<b>No. of beds, No. (%)</b>						
<100	750 (2.5)	619 (2.0)	3622 (12.3)	4532 (14.3)	-2.6 (-3.2 to -2.0) <sup>b</sup>	<.001
100-249	8799 (29.9)	7197 (22.7)	7041 (23.9)	6917 (21.8)	-5.1 (-6.1 to -4.1) <sup>b</sup>	<.001
≥250	19 892 (67.6)	23 884 (75.3)	18 777 (63.8)	20 247 (63.9)	7.7 (6.6 to 8.7) <sup>b</sup>	<.001
<b>Region, No. (%)</b>						
Midwest	6763 (23.0)	5509 (17.4)	7731 (26.3)	8067 (25.5)	-4.8 (-5.7 to -3.8) <sup>b</sup>	<.001
Northeast	9644 (32.8)	12 497 (39.4)	8038 (27.3)	8965 (28.3)	5.7 (4.6 to 6.7) <sup>b</sup>	<.001
South	9584 (32.6)	9979 (31.5)	9729 (33.0)	11 048 (34.9)	-2.9 (-3.9 to -1.8) <sup>b</sup>	<.001
West	3450 (11.7)	3715 (11.7)	3942 (13.4)	3616 (11.4)	2.0(1.3 to 2.7) <sup>b</sup>	<.001

Abbreviations: BPCI, Bundled Payment for Care Improvement; IQR, interquartile range; MCC, major complications or comorbidities; MS-DRG, Medicare severity diagnosis related group.

<sup>a</sup> Analysis of Medicare enrollment and claims data for unadjusted proportions and means across beneficiaries in the BPCI and comparison populations for the baseline period (October 1, 2011, to September 30, 2012) and the intervention period (October 1, 2013, to June 30, 2015). The intervention period varied by hospital based on when it was participating. This table includes the most aggregated forms of risk-adjustment variables. Alternative risk adjusters of different aggregation levels for prior care use, hierarchical

condition categories, and state dummies are provided in eTable 5 in the Supplement.

<sup>b</sup> Statistically significant difference at the 5% significance level.

<sup>c</sup> The hierarchical condition category model is a prospective risk-adjustment model used by the Centers for Medicare & Medicaid Services to adjust Medicare Part C capitation payments for beneficiary health spending risk. The model adjusts for demographic and clinical characteristics. The clinical component of the model uses diagnoses from qualifying services grouped into 70 hierarchical condition category indicators.

**Table 4. Improvement and Deterioration in Function and Overall Satisfaction With Care Among BPCI and Comparison Survey Respondents With Lower Extremity Joint Replacement Episodes<sup>a</sup>**

Measures	BPCI Population		Comparison Population		Difference in Rate (95% CI)	P Value
	Survey Respondents, %	Total No. of Respondents <sup>b</sup>	Survey Respondents, %	Total No. of Respondents <sup>b</sup>		
<b>Improvement</b>						
Bathing, dressing, using the toilet, or eating	84.7	1066	84.6	1065	0.1 (-2.8 to 3.0)	.94
Walking	65.1	1066	60.0	1069	5.1 (1.2 to 9.0) <sup>c</sup>	.01
Use of mobility device, ie, less frequent	62.3	1071	62.7	1070	-0.4 (-4.3 to 3.6)	.86
Walking up and down 12 stairs	64.8	1065	58.3	1049	6.6 (2.6 to 10.5) <sup>c</sup>	.01
Planning regular tasks	76.6	1076	76.7	1077	-0.1 (-3.5 to 3.3)	.95
Physical and emotional problems limiting social activities, ie, less frequent	75.8	1068	71.6	1068	4.2 (0.5 to 7.9) <sup>c</sup>	.03
Pain limiting regular activities, ie, less frequent	80.3	1080	76.0	1078	4.3 (0.9 to 7.7) <sup>c</sup>	.01
<b>Deterioration</b>						
Bathing, dressing, using the toilet, or eating	7.9	1066	8.6	1065	-0.7 (-3.0 to 1.7)	.58
Walking	16.1	1066	17.0	1069	-0.9 (-4.0 to 2.1)	.56
Use of mobility device, ie, more frequent	25.4	1071	25.9	1070	-0.5 (-4.1 to 3.0)	.77
Walking up and down 12 stairs	15.2	1065	17.2	1049	-2.0 (-4.9 to 1.0)	.19
Planning regular tasks	11.7	1076	11.0	1077	0.7 (-1.9 to 3.3)	.60
Physical and emotional problems limiting social activities, ie, more frequent	11.8	1068	13.5	1068	-1.7 (-4.6 to 1.2)	.26
Pain limiting regular activities, ie, more frequent	7.5	1080	11.1	1078	-3.6 (-6.2 to -1.0) <sup>c</sup>	.01
<b>Beneficiary Experience Measure</b>						
Respondents who were extremely or quite a bit satisfied with overall recovery since leaving the hospital	81.6	1019	80.8	1024	0.8 (-2.8 to 4.3)	.67

Abbreviation: BPCI, Bundled Payment for Care Improvement.

<sup>a</sup> Analysis of survey data for beneficiaries with a lower extremity joint replacement in BPCI-participating and comparison hospitals. Differences in rates are between BPCI and comparison samples. Percentages reported in this table were risk adjusted. Outcomes were risk adjusted through a regression-based approach that accounted for age, sex, Medicaid eligibility, hierarchical condition category index, prior health care use, Medicare severity diagnosis related group, whether the respondent had a lower joint fracture, the respondent's recalled functional status prior to the hospitalization, and month in which the episode occurred. Characteristics of the survey respondents are reported in eTable 4 in the Supplement. Survey results

were weighted to adjust for sampling and nonresponse. Improvement in function was defined as having the highest recalled functional status prior to the surgery and maintaining that status or moving from a lower to higher functional status. Deterioration in function was defined as having the lowest recalled functional status prior to the surgery and maintaining that status or moving from a higher to lower functional status. Reference responses for beneficiary experience measures were not at all, slightly, and moderately satisfied.

<sup>b</sup> Number of nonmissing responses for each measure.

<sup>c</sup> Statistically significant difference at the 5% significance level.

These findings are consistent with other research indicating that bundled payments can reduce payments for an episode of care. More limited experiments with bundled payments for lower extremity joint replacement have reduced average payments per case through shorter hospital stays and less PAC.<sup>15,16</sup> Achieving lower payments by reducing institutional PAC is consistent with other research that suggests PAC use can be reduced or changed without adverse effects on recovery, there is little consensus on the appropriate setting for PAC, and current variation in PAC use may be due to factors other than differences in clinical needs.<sup>17-19</sup> Other research has also indicated that patients undergoing lower extremity joint replacement recover mobility better when discharged directly home, and institutional PAC is not associated with better functional recovery.<sup>20</sup>

One concern about bundled payment approaches is that they may provide incentives to increase the number of epi-

sodes, particularly with less intensive patients, because of the opportunity for greater financial rewards.<sup>21,22</sup> If more beneficiaries undergo a procedure, then total payments may increase even if per-episode payments decrease. Additional information about the volume of episodes in a market would be needed to determine whether the relative increase in episodes for BPCI-participating hospitals is indicative of generating additional episodes. Another concern about bundled payment approaches is that participants may select patients who would be less costly to treat. Although several indicators of patient complexity, such as mean number of hierarchical condition category indicators, did not differ between the BPCI and comparison populations, hospitalizations, SNF stays, and home health care use prior to the episode decreased for the BPCI population relative to the change for the comparison population. This could indicate that BPCI participants treated or sought a less costly mix of patients

under the initiative. This warrants additional scrutiny to ensure that patients for whom care is more costly continue to have adequate access to care under a bundled payment approach.

This analysis of lower extremity joint replacement episodes, which account for more than 450 000 Medicare hospitalizations per year,<sup>5</sup> significantly extends the evidence on the use of payment incentives to reduce spending for episodes of care, while maintaining or improving quality. The Centers for Medicare & Medicaid Services has successfully bundled payments for services delivered by a single facility (eg, acute care hospitals, home health agencies) through prospective payment systems and has tested linking the payments of hospitals and physicians for a few conditions.<sup>23,24</sup> Other payers have also implemented limited bundled payment approaches.<sup>25,26</sup> The BPCI initiative is more extensive than prior efforts because it tests bundling services across multiple types of facilities and clinicians over longer episode periods. The ongoing evaluation of BPCI will include more participants with more time under the initiative, as well as other clinical episodes, payment models, and types of participants, to increase understanding of the effects of alternative payment models that reward quality and value.<sup>27</sup>

This observational study has limitations. The BPCI initiative is voluntary and the hospitals that chose to participate differ from other hospitals, precluding causal inferences and generalization of results. In April 2016, CMS began testing a mandatory model of bundled payments for lower extremity joint replacement episodes through the Comprehensive Care for Joint Replacement model, which will provide additional information about responses to bundled payment incentives from a more representative sample of hospitals.<sup>28</sup> Further, the study reflects the experience of only hospital participants and

1 clinical episode that is typically a scheduled procedure.<sup>29</sup> More information is needed before generalizing these results to other health care organizations or clinical episodes. The comparison population, used to infer counterfactual outcomes for the BPCI population, was selected based on hospital, Medicare enrollment, and claims data, which may not adequately account for all relevant patient or hospital differences. Performing statistical tests on multiple outcome measures increases the likelihood of falsely rejecting 1 null hypothesis (type I error) among the multiple measures. The standard errors were not adjusted to account for multiple comparisons. Because survey data were not collected before the BPCI initiative began, change in functional status relied on respondents' recalled functional status, although there was no reason to believe that recall bias differed between the BPCI and comparison populations. Individual survey items were adapted from previously validated sources, but the final survey instrument was not tested for validity and reliability. This study focused on changes in per-episode payments relative to a comparison group and did not account for the reconciliation amounts, so total savings to the Medicare program associated with bundled payments for lower extremity joint replacement episodes cannot be inferred from these results.

## Conclusions

In the first 21 months of the BPCI initiative, Medicare payments declined more for lower extremity joint replacement episodes provided in BPCI-participating hospitals than in comparison hospitals, without a significant change in quality outcomes. Further studies are needed to assess longer-term follow-up as well as patterns for other types of clinical care.

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