

Appendix for

“Association of hospital participation in a Medicare bundled payment program with volume and case-mix of lower extremity joint replacement episodes”

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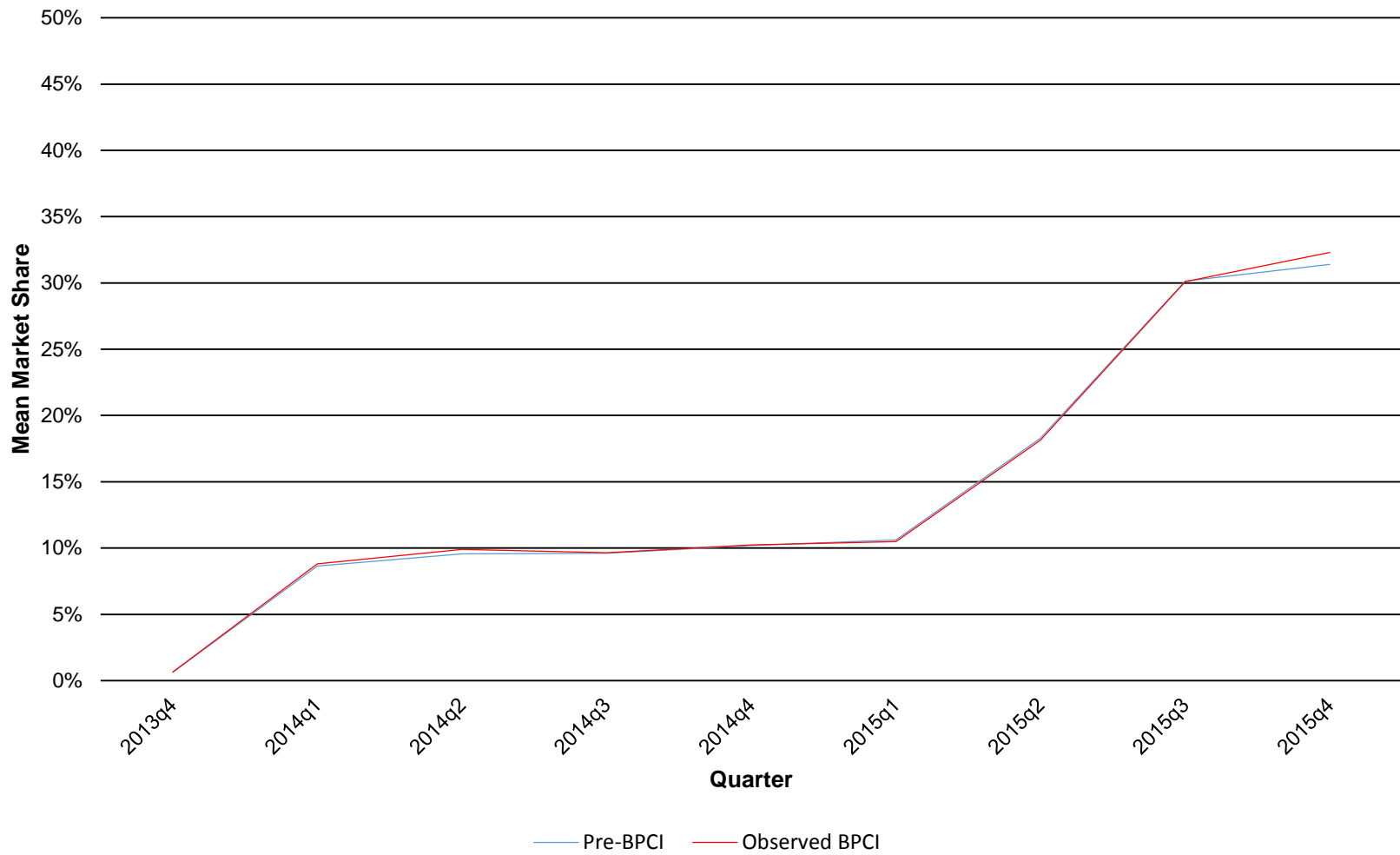
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eFigure 1. Comparison of Mean share of LEJR episodes in BPCI markets performed by BPCI participant hospitals with summed pre-BPCI share (exposure variable) in the BPCI period (2013 Quarter 4 to 2015 Quarter 4)

Abbreviations: BPCI, Bundled Payments for Care Improvement program by Medicare

We used a continuous quarterly measure of the LEJR market share for BPCI markets (n=131). We first measured LEJR market shares at each hospital in the pre-BPCI period (2011 Quarter 1 to 2013 Quarter 3). Market shares were measured in the pre-BPCI period to avoid the circularity that would result from measuring LEJR market volume as both a dependent variable and component of the independent variable. Second, in each post-BPCI quarter, we summed the pre-BPCI LEJR market shares for hospitals that were participating in BPCI in that quarter in that market – and assigned this market-level value as the quarterly exposure to BPCI in BPCI markets (Figure 1). This market-quarter value was updated in each quarter so that as more hospitals joined BPCI within a market, the value of market-level BPCI participation grew. In this figure, we plot the mean of the exposure variable based on pre-BPCI LEJR market share (Pre-BPCI) and the mean of the observed LEJR market share of BPCI participating hospitals at the market level by quarter. This figure demonstrates that the exposure variable, which was used to avoid circularity in the regression (i.e., LEJR market volume on both sides of the regression equation), tracks very closely with the observed LEJR market share of BPCI participating hospitals.

eFigure 1. Comparison of Mean share of LEJR episodes in BPCI markets performed by BPCI participant hospitals with summed pre-BPCI share (exposure variable) in the BPCI period (2013 Quarter 4 to 2015 Quarter 4)



eMethods 1. Evaluating estimated changes in Market Volume

We also estimated changes in *Market Volume*: (1) *LEJR volume in Non-BPCI markets*; (2) *LEJR volume in BPCI markets if BPCI did not exist*, which reflects secular trends in volume plus the impact of BPCI on episode spending but without any potential changes on overall LEJR volume; and (3) *LEJR volume in BPCI markets observed under BPCI*, which reflects observed LEJR volume in BPCI that is composed of secular trends in volume plus the impact of BPCI on procedural volume.

We then used these scenarios to estimate changes in LEJR volume based on actual market share of BPCI participating hospitals and plotted them in Figure 2 (all LEJR volume) and eFigure 3 (uncomplicated LEJR).

At the average market exposure of 14%, BPCI markets would have experienced a differential 0.40% volume increase (i.e., 0.06 additional procedures per BPCI market per quarter) for uncomplicated LEJR in 2014-2015, though for all LEJR (0.32%) and complicated LEJR (-1.2%) the changes in volume were not statistically significant.

eMethods 2. Propensity score matching of BPCI hospitals to non-BPCI hospitals in non-BPCI markets

To decrease differences between BPCI participant hospitals and Non-BPCI hospitals, we used propensity score matching on a variables drawn from Medicare claims and AHA Annual Survey data (see eTable 4 below for all the variables). Our propensity model used logistic regression with a binary dependent variable of participation in BPCI during any quarter in the BPCI period for the LEJR episode and independent variables listed in eTable 4. We further limited Non-BPCI hospitals to those located in markets without any BPCI participation (Non-BPCI markets) because Non-BPCI hospitals in BPCI markets may still be affected by the policy because of shifting of volume and case-mix between Non-BPCI and BPCI hospitals. Using a minimum of a 2 digit propensity score match, we were able to match 265 out of 322 BPCI hospitals with Non-BPCI hospitals in Non-BPCI markets in a 1:1 match. Comparison of hospital characteristics between Non-BPCI and BPCI hospitals before and after matching is presented in eTable 4 below.

eTable 1. Tests of Parallel Trends between BPCI and Non-BPCI Markets for All and Uncomplicated LEJR Market Volume

This table shows the results of generalized linear regression models with log link and negative binomial distribution, dependent variables All LEJR volume or Uncomplicated LEJR volume, and independent variables of a continuous time variable, BPCI market indicator variable, and the interaction. The bolded interaction term coefficients are not statistically significant, indicating no divergent trends in the pre-period for either dependent variable.

All LEJR		
Adjusted Results		
	Difference-in-Differences Estimate	P-Value
Time Effect	1.0006	0.82
BPCI Market	1.04	0.09
BPCI Market x Time Effect	1.0004	0.92
Uncomplicated LEJR		
Adjusted Results		
	Difference-in-Differences Estimate	P-Value
Time Effect	1.001	0.70
BPCI Market	1.043	0.09
BPCI Market x Time Effect	1.0007	0.86

eTable 2. Patient Characteristics by Hospital BPCI participation, 2011-2015

Sample Characteristics										
	Non-BPCI Markets			BPCI Markets						
	Pre-BPCI period			Pre-BPCI period						
Markets, No.	175			131						
Hospitals, No. ^a	1,340			1,955						
Beneficiaries, No.	13,625,041			18,048,915						
Characteristics of Beneficiaries Receiving LEJR										
	Non-BPCI Markets			BPCI Markets						
	Non-BPCI Hospitals (Group A)			Non-BPCI Hospitals			BPCI Hospitals (Group B)			
	Pre-BPCI Period (n=420, 518)	BPCI Period (n=331, 786)	Difference between Periods, %	Pre-BPCI Period (n=376, 753)	BPCI Period (n=298, 286)	Difference between Periods, %	Pre-BPCI Period (n=159, 525)	BPCI Period (n=130, 375)	Difference between Periods, %	Group A vs. Group B Differences P-Value
Age, mean year (SD)	75 (1)	74 (1)	-1	75 (1)	75 (1)	-1	75 (1)	75 (1)	0	<0.001
Age ≥ 85, % (SD)	11 (2)	10 (2)	-1	11 (3)	10 (2)	-0.7	12 (4)	10 (4)	2	<0.001
Race/ethnicity										
Black, % (SD)	4.5 (5.8)	4.4 (5.5)	-0.1	4.6 (5.3)	4.4 (5.0)	-0.2	4.9 (7.0)	4.9 (7.7)	0.0	0.28
Other, % (SD) ^b	95.5 (5.8)	95.6 (5.5)	0.1	95.4 (5.3)	95.6 (5.0)	0.2	95.1 (7.0)	95.1 (7.7)	0.0	
Female, % (SD)	64.4 (3.0)	63.0 (2.8)	-1.4	65.0 (2.7)	63.0 (2.6)	-2.1	65.4 (3.8)	63.6 (3.9)	-1.8	<0.001
Dual-eligible, % (SD)	8.4 (4.8)	7.7 (4.1)	-0.7	9.7 (7.4)	8.5 (6.2)	-1.1	9.3 (7.2)	8.6 (6.5)	-0.7	0.53
Residence in ZIP code										
Low-income, % (SD) ^c	22.9 (18.2)	22.2 (17.8)	-0.7	19.3 (17.5)	18.4 (17.3)	-0.9	17.9 (17.4)	17.2 (17.0)	-0.7	<0.001
Low-education, % (SD) ^d	14.7 (17.3)	14.4 (17.1)	-0.4	14.2 (14.0)	20.5 (14.9)	-0.7	13.5 (14.6)	12.9 (13.9)	-0.6	0.38

	Non-BPCI Markets			BPCI Markets						Group A vs. Group B Difference -in- Differences P-Value
	Non-BPCI Hospitals (Group A)			Non-BPCI Hospitals			BPCI Hospitals (Group B)			
	Pre-BPCI Period (n=420, 518)	BPCI Period (n=331, 786)	Difference between Periods, %	Pre-BPCI Period (n=376, 753)	BPCI Period (n=298, 286)	Difference between Periods, %	Pre-BPCI Period (n=159, 525)	BPCI Period (n=130, 375)	Difference between Periods, %	
Elixhauser score^e										
Elixhauser score for beneficiaries receiving LEJR, mean (SD)	2.0 (0.8)	1.9 (0.8)	-0.1 ^f	1.9 (0.8)	1.9 (0.8)	-0.0 ^f	2.1 (1.2)	1.9 (1.3)	-0.2 ^f	0.75
Elixhauser score for beneficiaries receiving uncomplicated LEJR, mean (SD)	1.6 (0.7)	1.4 (0.8)	-0.2 ^f	1.5 (0.8)	1.4 (0.7)	-0.1 ^f	1.7 (1.1)	1.5 (1.1)	-0.2 ^f	0.13
Elixhauser score for beneficiaries receiving complicated LEJR, mean (SD)	11.0 (2.1)	11.2 (2.2)	0.2 ^f	10.6 (2.2)	11.0 (2.6)	0.4 ^f	10.6 (3.6)	11.5 (3.8)	0.9 ^f	0.53
High complexity, % (SD) ^f	20.4 (4.7)	19.7 (4.5)	-0.7	19.9 (4.8)	19.6 (4.7)	-0.2	20.8 (6.5)	20.1 (6.2)	-0.7	0.30
Comorbidities										
Obesity, % (SD)	15.5 (5.4)	18.3 (6.3)	2.9	14.9 (5.0)	17.4 (5.2)	2.5	16.0 (6.3)	18.7 (7.5)	2.7	<0.001
Diabetes, % (SD)	23.2 (3.5)	22.9 (3.7)	-0.2	22.3 (3.4)	22.0 (3.6)	-0.3	22.2 (4.3)	22.2 (4.5)	0.0	0.002
Complex diabetes, % (SD)	2.2 (0.7)	2.8 (0.9)	0.6	2.2 (0.9)	2.8 (1.1)	0.6	2.3 (1.0)	2.8 (1.2)	0.5	<0.001
Coronary artery disease, % (SD)	20.0 (4.7)	17.5 (4.0)	-2.5	18.4 (3.9)	16.5 (3.9)	-1.9	20.2 (7.2)	17.6 (5.1)	-2.6	<0.001
Congestive heart failure, % (SD)	6.2 (1.8)	6.1 (1.9)	-0.1	5.6 (1.6)	5.7 (1.6)	0.1	6.4 (2.9)	6.2 (2.5)	-0.2	<0.001
Drug use, % (SD)	0.1 (0.1)	0.2 (0.2)	0.1	0.1 (0.2)	0.2 (0.2)	0.1	0.1 (0.2)	0.3 (0.4)	0.2	0.46
Alcohol use, % (SD)	0.4 (0.3)	0.6 (0.4)	0.2	0.4 (0.2)	0.7 (0.5)	0.2	0.5 (0.5)	0.6 (0.5)	0.1	<0.001
Depression, % (SD)	13.2 (3.0)	14.2 (3.1)	1.1	12.5 (2.9)	13.6 (3.5)	1.1	13.1 (4.1)	14.3 (3.9)	1.2	<0.001

	Non-BPCI Markets			BPCI Markets						
	Non-BPCI Hospitals (Group A)			Non-BPCI Hospitals			BPCI Hospitals (Group B)			
	Pre-BPCI Period (n=420, 518)	BPCI Period (n=331, 786)	Difference between Periods, %	Pre-BPCI Period (n=376, 753)	BPCI Period (n=298, 286)	Difference between Periods, %	Pre-BPCI Period (n=159, 525)	BPCI Period (n=130, 375)	Difference between Periods, %	Group A vs. Group B Difference -in- Differences P-Value
Psychoses, % (SD)	2.3 (0.8)	2.4 (0.9)	0.0	2.3 (1.0)	2.4 (1.1)	0.1	2.3 (1.4)	2.5 (1.4)	0.2	<0.001
Frailty, % (SD)	2.4 (1.1)	2.9 (1.2)	0.5	2.9 (1.5)	3.5 (1.9)	0.5	3.2 (1.9)	3.7 (2.0)	0.5	<0.001
Two or more comorbidities, % (SD)	67.5 (6.8)	67.2 (6.8)	-0.3	66.6 (7.3)	66.1 (7.4)	-0.5	68.0 (7.8)	67.5 (8.2)	-0.5	<0.001
Any utilization in 12 months prior to index hospitalization										
Acute care hospital, % (SD)	21.2 (2.2)	20.1 (2.5)	-1.2	21.2 (2.1)	19.9 (2.7)	-1.3	21.9 (3.0)	20.7 (3.4)	-1.2	<0.001
Inpatient rehabilitation facility, % (SD)	1.8 (1.5)	1.6 (1.4)	-0.2	2.0 (1.7)	1.7 (1.5)	-0.3	2.0 (1.8)	1.6 (1.6)	-0.4	0.02
Skilled nursing facility, % (SD)	5.7 (2.0)	5.3 (1.9)	-0.4	6.1 (2.0)	5.6 (2.2)	-0.5	6.9 (2.6)	6.1 (2.6)	-0.8	<0.001
Market Structure Characteristicsⁿ										
	Non-BPCI Markets			BPCI Markets						
	Pre-BPCI Period	BPCI Period	Difference between Periods, % ^b	Pre-BPCI Period	BPCI Period	Difference between Periods, % ^b	Difference -in- Differences Value	Difference -in- Differences P-Value		
Medicare Advantage penetration, % (SD) ⁱ	22.8 (13.5)	26.7 (14.0)	3.9	25.8 (12.7)	29.9 (13.3)	4.1	0.2	0.93		
ACO penetration, % (SD) ^j	4.1 (5.8)	14.5 (12.9)	10.4	5.2 (6.6)	20.3 (15.0)	15.1	4.7	<0.001		
Hospital concentration, HHI (SD) ^k	3,856.1 (2,219.4)	3,889.6 (2,218.0)	0.9	2,628.7 (1,793.8)	2,669.5 (1,794.5)	1.6	0.7	0.98		
Skilled nursing facility concentration, HHI (SD) ^k	1,859.6 (1,321.7)	1,707.9 (1,202.3)	-8.2	1,167.7 (859.5)	1,104.9 (808.9)	-5.4	2.8	0.12		
Markets with physician group practice, % ⁱ	0	41	41	0	51	51	10.0	NA		

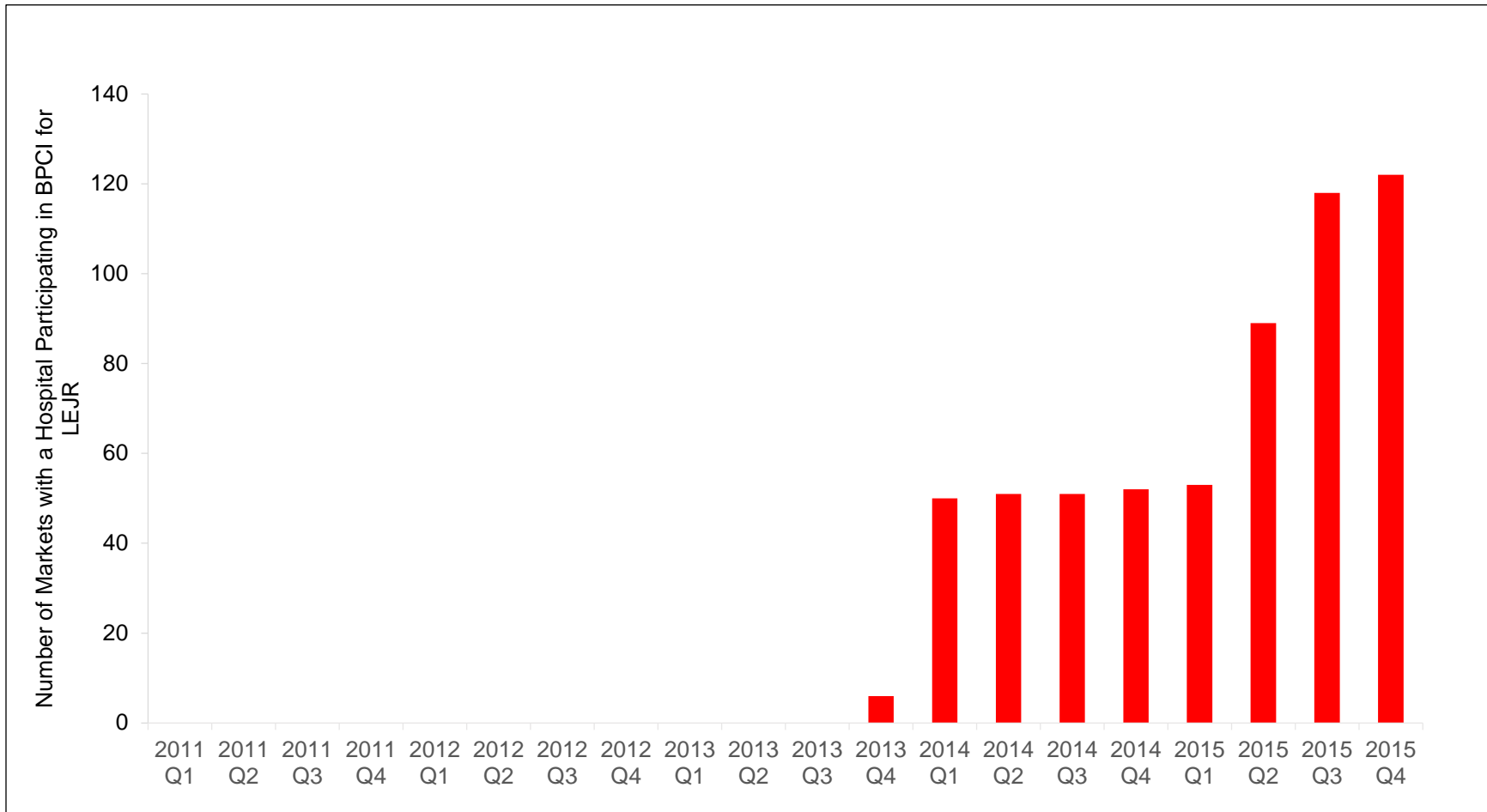
Abbreviations: BPCI, Bundled Payments for Care Improvement program by Medicare; LEJR, Lower Extremity Joint Replacement; MS-DRG, Medicare Severity-Diagnosis Related Group; ACO, accountable care organization; JCAHO, Joint Commission: Accreditation, Health Care, Certification; HHI, Herfindahl-Hirschman Index.

Pre-Period is Q1 2011 – Q3 2013. BPCI Period is Q4 2013 – Q4 2015. ^a Includes hospitals with non-zero volume for all LEJR. ^b Other race includes White, Asian, Hispanic, North American Native, and Other as defined by Medicare. ^c The variable low-median income level ZIP code is a binary variable indicating that a beneficiary resides in a ZIP code with a median income in the bottom quartile of median ZIP code income nationally. ^d Similarly, the variable low-education level ZIP code is a binary variable indication that a beneficiary resides in a ZIP code with a proportion of residents with less than a high school education that is in the top quartile among ZIP codes nationally. ^e The Elixhauser comorbidity score is an index of severity with a range of –20 to +90 with increasing scores highly correlated with in-hospital death. Uncomplicated LEJR corresponds to MS-DRG 470 and Complicated LEJR corresponds to MS-DRG 469. The patients in MS-DRG 470 underwent major joint replacement or reattachment of lower extremity without major complications or comorbidities. The patients in MS-DRG 469 underwent major joint replacement or reattachment of lower extremity with major complications or comorbidities. These MS-DRG designations reflect both complexity before the surgery as well as complications after the surgery during the same hospitalization. ^f These represent the differences in Elixhauser score between the periods. ^g High complexity is a binary variable indicating an Elixhauser comorbidity score in the top 20% of all patients receiving LEJR in our sample. ^h Market characteristics are calculated based on total procedural (episode) volume rather than based on unique patients. ⁱ Medicare Advantage penetration was determined using the Medicare Beneficiary Summary File and computing at a market –quarter level the proportion of Medicare beneficiaries enrolled in Medicare Advantage at any time during that quarter. ^j ACO penetration was determined using data from a random 20% sample of fee-for-service beneficiaries and the CMS ACO Provider-level Research Identifiable File following previously described methodology for assignment based on the plurality of primary care spending (McWilliams, J. Michael, et al. "Early performance of accountable care organizations in Medicare." *New England Journal of Medicine* 374.24 (2016): 2357-2366). ^k Hospital and skilled nursing facility concentration was determined using via the Herfindahl-Hirschman index. ^l Markets with Physician Group Practice indicates markets with a physician group practice participating in BPCI for the LEJR condition. Wilcoxon rank-sum or t-tests were used to test the differences in continuous variables and Chi-square tests for categorical variables.

eFigure 2a. Number of markets with a hospital participating in BPCI for LEJR by quarter, 2011-2015

Abbreviations: BPCI, Bundled Payments for Care Improvement; LEJR, Lower Extremity Joint Replacement.

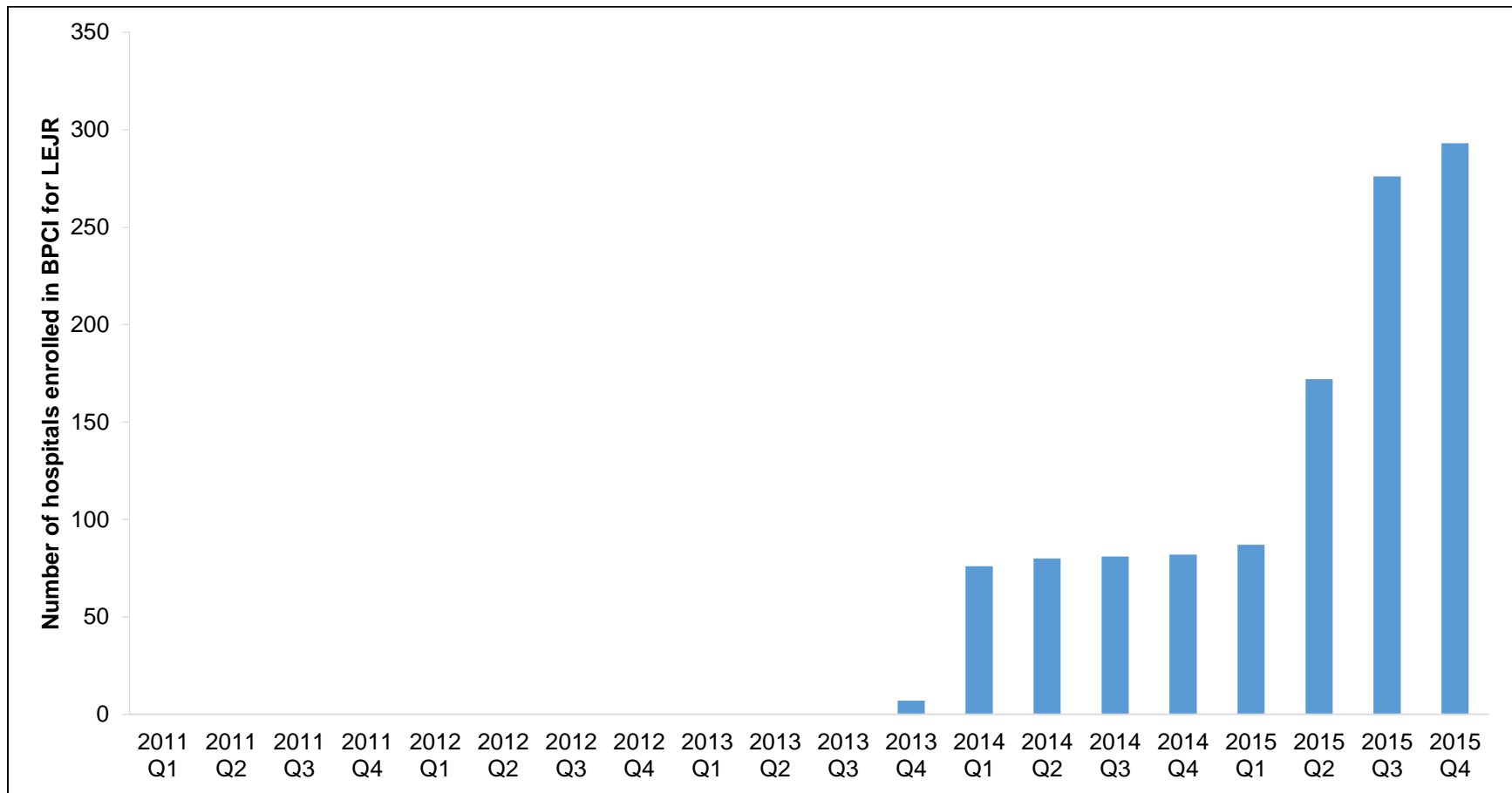
This figure illustrates the increase in the number of markets, defined as Hospital Referral Regions, with a hospital participating in BPCI for LEJR over time, with notable increases in 2014 quarter 1 and throughout 2015. There were a total of 131 markets that had a hospital participate in BPCI at any time, but due to hospitals that dropped out of BPCI the maximum number of markets with an active BPCI hospital participant in any given quarter was 122.



eFigure 2b. Number of hospitals enrolled in BPCI for LEJR by quarter, 2011-2015

Abbreviations: BPCI, Bundled Payments for Care Improvement; LEJR, Lower Extremity Joint Replacement.

This figure illustrates the increase in the number of hospitals participating in BPCI for LEJR over time, with notable increases in 2014 Quarter 1 and throughout 2015.



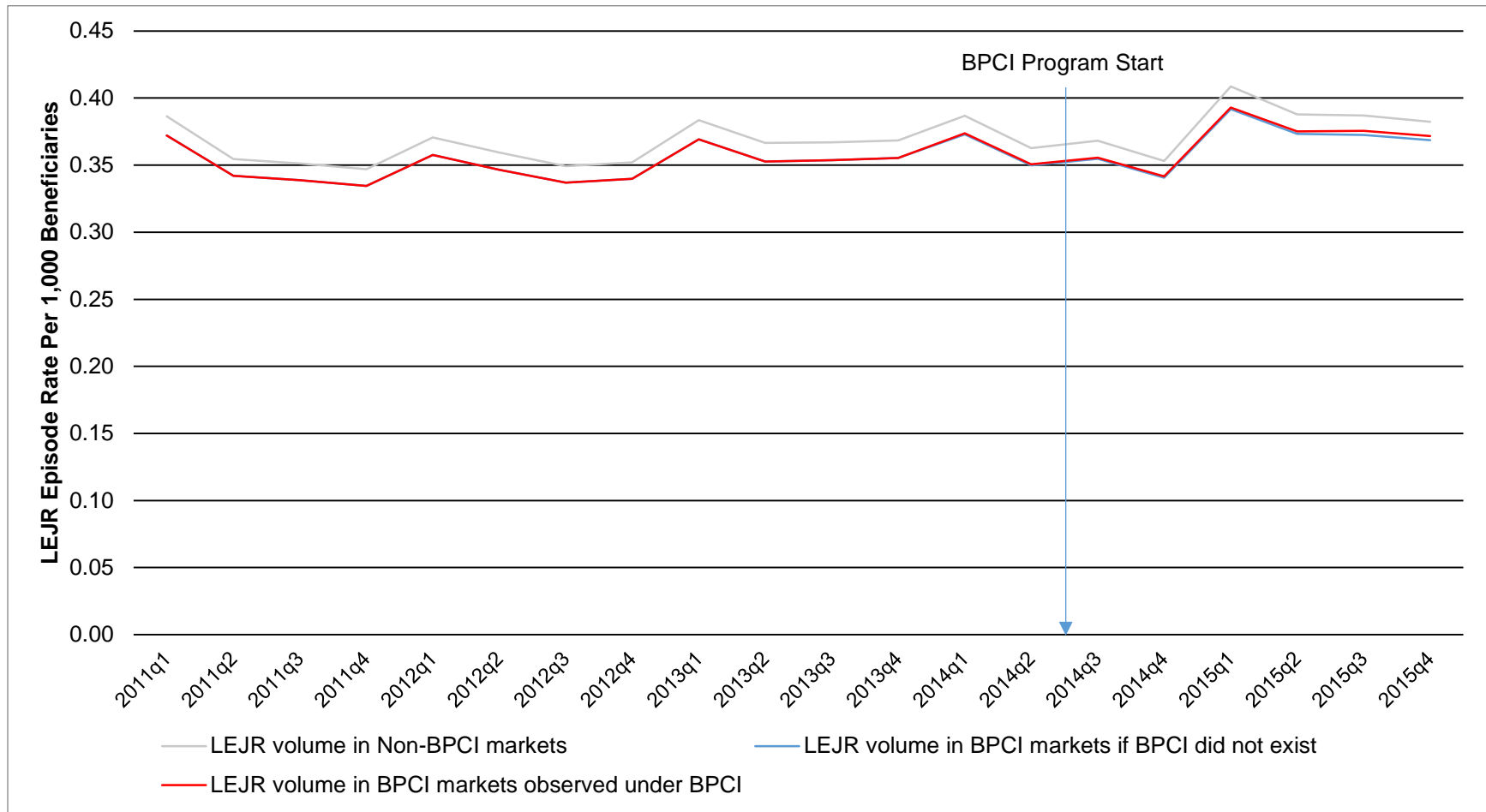
eTable 3. Changes in Lower Extremity Joint Replacement (LEJR) Market Volume Associated with BPCI Participation, 2011-2015

	Unadjusted Analysis										Adjusted Analysis	
	Non-BPCI Markets (n = 175)				BPCI Markets (n = 131)							
	Pre-Period	BPCI Period	Difference between Periods, n (%)	P-Value	Pre-Period	BPCI Period	Difference between Periods, n (%)	P-Value	Differential Change in BPCI Period for BPCI vs. Non-BPCI Markets, n (%)	P-Value	Adjusted Differential Change in BPCI vs. Non-BPCI Markets with Mean BPCI Exposure	P-Value
Market Volume per quarter												
All LEJR cases	238.3	252.4	14.1 (5.9%)	0.05	406.7	435.9	29.2 (7.2%)	0.07	15.1 (1.3%)	0.005	0.32% (95% CI -0.06% to 0.69%)	0.10
Uncomplicated LEJR cases (MS-DRG 470)	228.6	242.8	14.2 (6.2%)	0.05	390.0	419.3	29.3 (7.5%)	0.06	15.1 (1.3%)	0.002	0.39% (95% CI 0.01% to 0.77%)	0.04
Complicated LEJR cases (MS-DRG 469)	9.8	9.7	-0.1 (-1.0%)	0.69	16.8	16.7	-0.1 (-0.6%)	0.66	0.0 (0.4%)	0.73	-1.1% (95% CI -2.38% to 0.20%)	0.10

Abbreviations: BPCI, Bundled Payments for Care Improvement program by Medicare; LEJR, Lower Extremity Joint Replacement; MS-DRG, Medicare Severity-Diagnosis Related Group.

Pre-Period is Q1 2011 – Q3 2013. BPCI Period is Q4 2013 – Q4 2015. Uncomplicated LEJR corresponds to MS-DRG 470 and Complicated LEJR corresponds to MS-DRG 469. The patients in MS-DRG 470 underwent major joint replacement or reattachment of lower extremity without major complications or comorbidities. The patients in MS-DRG 469 underwent major joint replacement or reattachment of lower extremity with major complications or comorbidities. These MS-DRG designations reflect both complexity before the surgery as well as complications after the surgery during the same hospitalization. Unadjusted analysis does not control for time-varying participation or “dose” of exposure to BPCI at the market level in BPCI markets. Adjusted analysis models have market fixed effects, quarter fixed effects to adjust for the secular trend, additional time-varying covariates for market mean patient sex, age, race, and market structure controls including market size (number of beneficiaries), hospital capacity and concentration, post-acute care capacity and concentration, Medicare Advantage penetration, ACO penetration, and BPCI physician group practice (PGP) participation. Mean BPCI exposure for BPCI markets in the BPCI period was 14%. Positive values were interpreted as differential increases in volume in BPCI markets as compared to Non-BPCI markets; negative values were interpreted as differential decreases in volume in BPCI markets as compared to Non-BPCI markets.

eFigure 3. Estimated Changes in Uncomplicated LEJR Market Volume per 1,000 Beneficiaries from BPCI participation in BPCI Markets compared to Non-BPCI Markets, 2011-2015



Abbreviations: BPCI, Bundled Payments for Care Improvement program by Medicare; LEJR, Lower Extremity Joint Replacement.

Uncomplicated LEJR corresponds to MS-DRG 470, major joint replacement or reattachment of lower extremity without major

complications or comorbidities. We plotted estimated uncomplicated LEJR volume per 1,000 Beneficiaries under three scenarios: (1) *Non-BPCI*, which reflects changes in volume and spending in the absence of BPCI (i.e., underlying secular trends); (2) *BPCI without Volume Changes*, which reflects secular trends in volume plus the impact of BPCI on episode spending; and (3) *BPCI with Volume Changes*, which reflects secular trends in volume plus the impact of BPCI on both procedural volume and episode spending. A small but statistically significant difference between the BPCI with and without Volume Changes scenarios is illustrated (estimate of 0.4%, $p=0.04$).

eTable 4. Comparison of characteristics of BPCI hospitals and non-BPCI hospitals before and after propensity matching

Hospital Characteristics						
	Before Matching			After Matching		
	Non-BPCI (n=1,340)	BPCI (n=322)	Standardized Difference	Matched Non- BPCI (n=265)	BPCI (n=265)	Standardized Difference
Hospital size, mean beds	213.4	323.8	0.62	300.2	286.6	0.04
Ownership status, No. (%)						
For-profit	278.3 (20.8)	66.8 (20.8)	0.38	51.0 (19.3)	55.0 (20.8)	0.10
Not-for-profit	876.1 (65.4)	243.4 (75.6)		197.0 (74.3)	199.0 (75.1)	
Government	185.6 (13.9)	11.1 (3.5)		17.0 (6.4)	11.0 (4.2)	
Teaching status, No. (%)^a						
Major teaching	85.4 (6.4)	45.6 (14.2)	0.59	35.0 (13.2)	25.0 (9.4)	0.21
Minor teaching	560.9 (41.9)	196.5 (61.0)		139.0 (52.5)	166.0 (62.6)	
Non-teaching	693.7 (51.8)	80.0 (24.8)		91.0 (34.3)	74.0 (27.9)	
Urban-rural status, No. (%)						
Metro	963.6 (71.9)	305.8 (95.0)	0.65	248.0 (93.6)	249.0 (94.0)	0.05
Rural	87.5 (6.5)	3.0 (0.9)		2.0 (0.8)	3.0 (1.1)	
Geographic region, No. (%)						
South	572.4 (42.7)	118.5 (36.8)	0.47	117.0 (44.2)	111.0 (41.9)	0.07
Midwest	430.1 (32.1)	62.8 (19.5)		51.0 (19.3)	58.0 (21.9)	
West	209.8 (15.7)	60.8 (18.9)		55.0 (20.8)	54.0 (20.4)	

	Before Matching			After Matching		
	Non-BPCI (n=1,340)	BPCI (n=322)	Standardized Difference	Matched Non- BPCI (n=265)	BPCI (n=265)	Standardized Difference
Northeast	127.6 (9.5)	16.0 (5.0)	0.47	42.0 (15.9)	42.0 (15.9)	0.07
Annual Medicare volume, median (IQR)	4,458.3 (4,791)	7,207.0 (5,707)	0.76	6,650.9 (5,987)	6,331.2 (4,961)	0.01
Annual total facility admissions, median (IQR)	9,618.6 (10,374)	16,213.6 (12,981)	0.75	14,736.7 (13,963)	13,856.8 (11,296)	0.01
Patient mix						
Medicare utilization ratio, mean (SD)	0.5 (0.1)	0.5 (0.1)	0.02	0.5 (0.1)	0.5 (0.1)	-0.01
Medicaid utilization ratio, mean (SD)	0.2 (0.1)	0.2 (0.1)	-0.04	0.2 (0.1)	0.2 (0.1)	-0.08
% Medicare by admissions, mean (SD)	0.5 (0.1)	0.5 (0.1)	-0.14	0.5 (0.1)	0.5 (0.1)	-0.04
Hospital margin %, median (IQR) ^b	5.8 (10.4)	6.6 (9.0)	0.004	6.3 (9.5)	6.9 (9.4)	-0.01
JCAHO accreditation, No. (%)	1,072.3 (80.0)	278.5 (86.5)	0.17	225.0 (84.9)	224.0 (84.5)	-0.01
Safety-net hospitals, No. (%) ^c	329.0 (24.6)	72.9 (22.6)	-0.04	66.0 (24.9)	57.0 (21.5)	-0.08

Abbreviations: BPCI, Bundled Payments for Care Improvement program by Medicare; LEJR, Lower extremity joint replacement.

^a From the AHA Annual Survey, major teaching hospitals are those that are members of the Council of Teaching Hospitals (COTH), minor teaching hospitals are non-COTH members that had a medical school affiliation reported to the American Medical Association, and nonteaching hospitals are all other institutions. ^b Hospital Margin is calculated as the difference between total net revenue and total expenses divided by total net revenue. ^c Safety-net hospitals were defined as being in the top quartile of disproportionate share (DSH) payment percentage, using the FY2017 CMS IMPACT file.

eTable 5. Changes in Lower Extremity Joint Replacement (LEJR) Volume at BPCI participant hospitals compared to Non-BPCI hospitals, 2011-2015

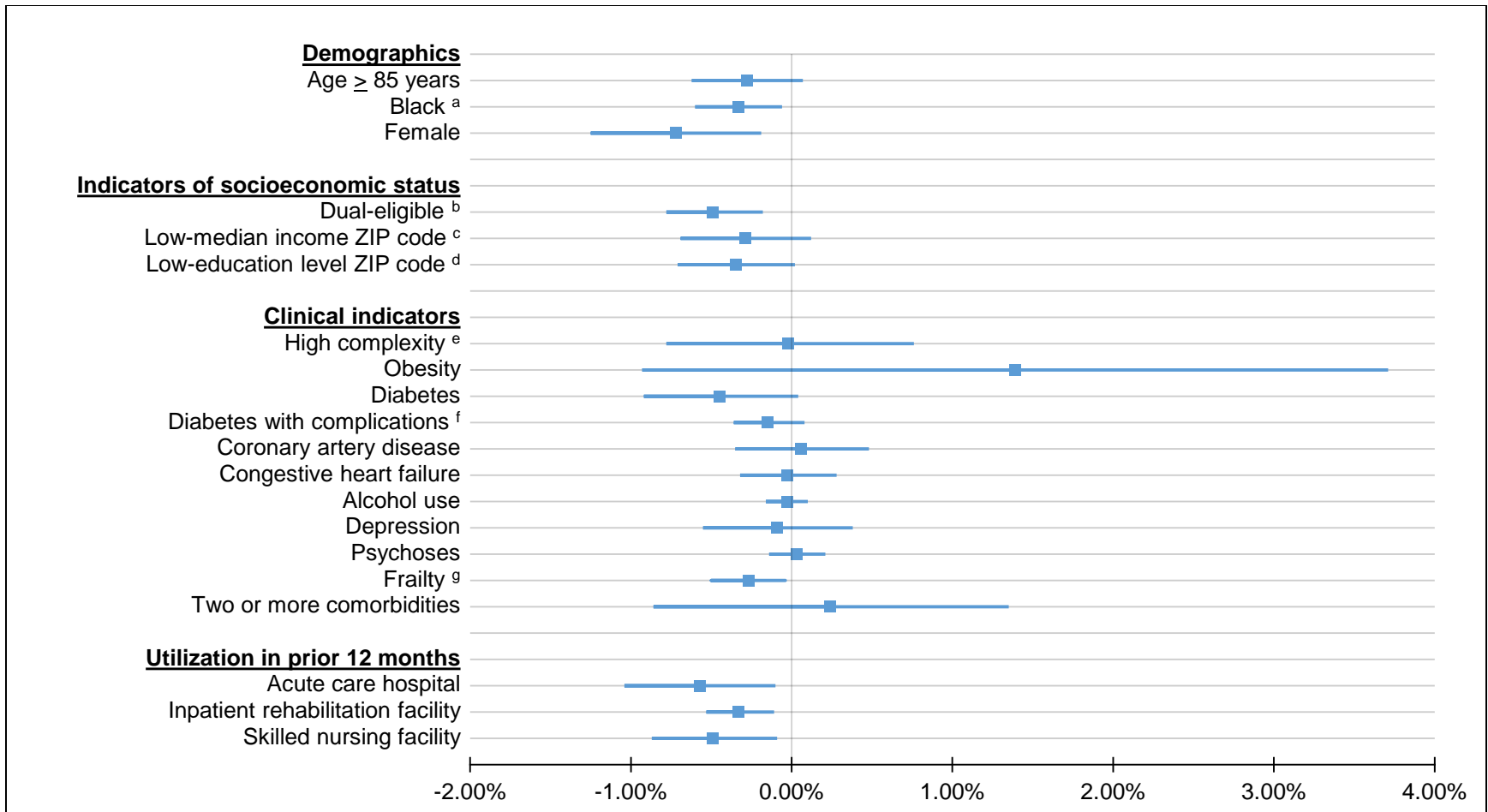
Abbreviations: BPCI, Bundled Payments for Care Improvement program by Medicare; LEJR, Lower extremity joint replacement.

Using a propensity-matched set of Non-BPCI hospitals located in Non-BPCI markets as a comparison group for BPCI participating hospitals, we analyzed the association between BPCI participation and hospital LEJR volume and separately evaluated the association with hospital LEJR market share. We repeated this analysis when comparing BPCI participating hospitals to all Non-BPCI hospitals located in Non-BPCI markets. The results demonstrated that BPCI participation is not associated with a significant increase in hospital LEJR volume or hospital LEJR market share using propensity matching. When comparing to all Non-BPCI hospitals in Non-BPCI markets without matching, the association is positive and significant.

	Comparison to Propensity Score Matched Non-BPCI Hospitals		Comparison to All Non-BPCI Hospitals	
	Adjusted differential change in BPCI Hospitals vs. matched Non-BPCI Hospitals, %	P-Value	Adjusted differential change in BPCI Hospitals vs. Non-BPCI Hospitals, %	P-Value
Market Share				
All LEJR	0.3% (95% CI -0.7% to 1.4%)	0.51	1.0% (95% CI 0.1% to 1.9%)	0.03
Hospital LEJR Volume				
All LEJR	3.1% (95% CI -4.2% to 10.3%)	0.41	9.2% (95% CI 2.4% to 16.0%)	0.008

eFigure 4. Changes in case-mix at BPCI participant hospitals compared to all Non-BPCI hospitals in Non-BPCI markets from the pre-BPCI to BPCI period

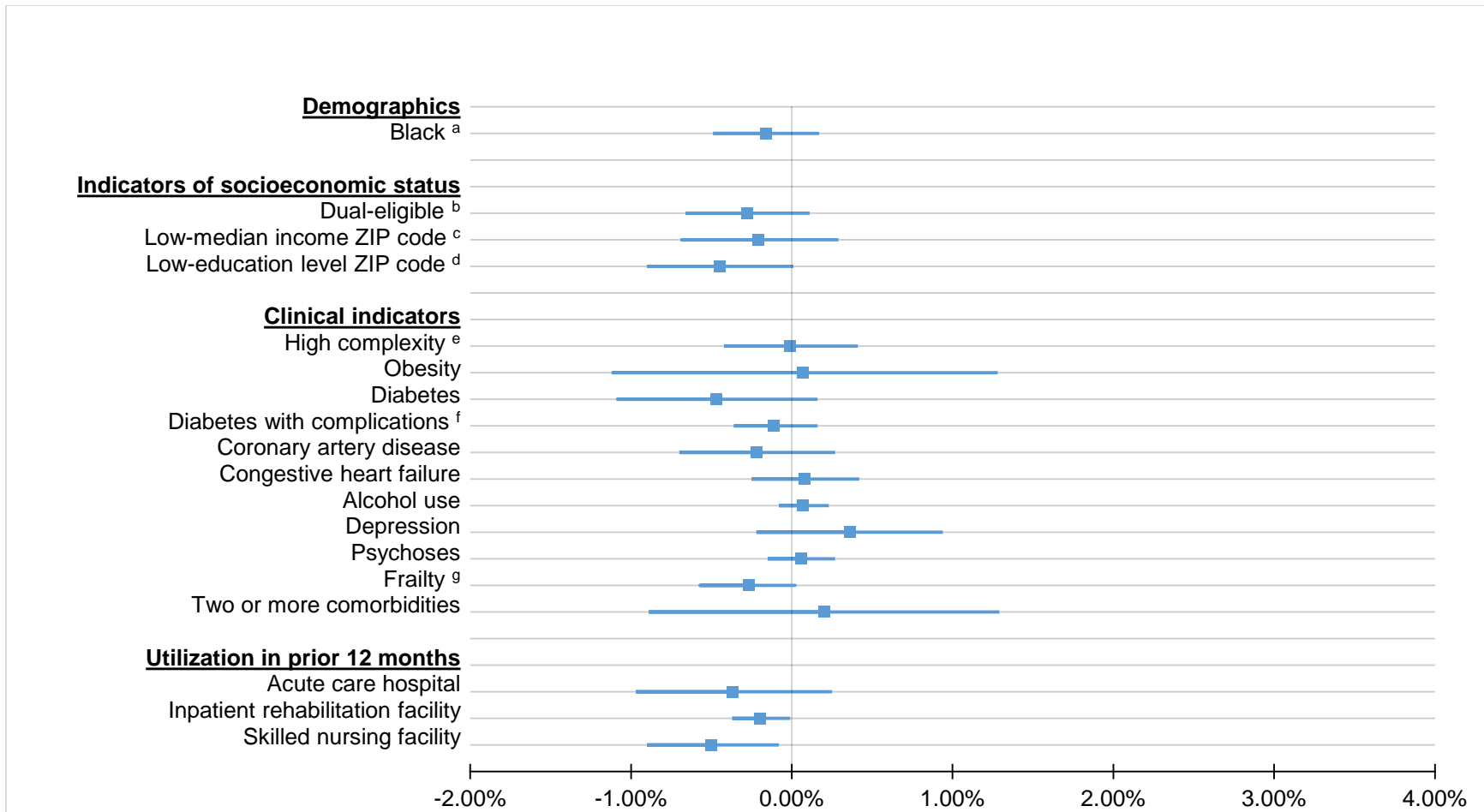
The association between BPCI participation and the change in probability of a beneficiary with each demographic, socioeconomic, clinical or utilization characteristic receiving LEJR at BPCI hospitals compared with the change at **all** non-BPCI hospitals (restricted to those in non-BPCI markets) between the pre-BPCI and BPCI periods was estimated for each characteristic with a separate difference-in-differences linear probability regression model (ordinary least squares). The estimate for each patient characteristic thus indicates the absolute difference in the probability comparing the pre-post changes at BPCI vs. non-BPCI hospitals. The propensity matching model is described in detail in eMethods 2 in the Supplement. ^{a-g} See eTable 1.



Absolute percentage point change in probability of undergoing LEJR at BPCI vs Non-BPCI hospital before vs after BPCI participation

eFigure 5. Risk-Adjusted Changes in case-mix at BPCI participant hospitals compared to all Non-BPCI hospitals in Non-BPCI markets from the pre-BPCI to BPCI period

The risk-adjusted association between BPCI participation and the change in probability of a beneficiary with each demographic, socioeconomic, clinical or utilization characteristic receiving LEJR at BPCI hospitals compared with the change at matched non-BPCI hospitals (restricted to those in non-BPCI markets) between the pre-BPCI and BPCI periods is estimated for each characteristics with a separate difference-in-differences linear probability regression model (ordinary least squares). The risk-adjusted model adds covariates at the patient level for age, sex, and Elixhauser comorbidity risk index (hence, age, sex, and the high complexity variables were not used as dependent variables). The estimate for each patient characteristic thus indicates the absolute difference in the probability comparing the pre-post changes at BPCI vs. non-BPCI hospitals. The propensity matching model is described in detail in eMethods 2 in the Supplement. ^{a-g} See eTable 1.



Absolute percentage point change in probability of undergoing LEJR at BPCI vs Non-BPCI hospital before vs after BPCI participation

eTable 6. Additional Analyses and Falsification Tests Examining the Association between BPCI Participation and Changes in Market Volume for Uncomplicated LEJR (MS-DRG 470), 2011-2015

This table demonstrates falsification tests for the positive and significant association between BPCI participation and an increase in market level volume for uncomplicated LEJR. Results were consistent with expected findings, suggesting that confounding factors or spurious correlations were unlikely to be driving the main results on uncomplicated LEJR volume changes.

All models also included market and quarter fixed effects, market level covariates as in primary analysis models, and robust standard errors.

Model	Result that would be consistent with our findings on uncomplicated LEJR	Difference-in-Differences Estimate	P-Value
Test of 'Pent up Demand' with 'post period' falsified as the year before BPCI program started	Null or not significant	0.009	0.10
Test of whether Patients Crossing Market Boundaries Explains Volume Increases	Positive significant of similar magnitude	0.04	0.001
Test of Changes in Carotid Endarterectomy Market Volume	Null or not significant	0.03	0.29
Test of Changes in LEJR Market Volume from Hip Fractures	Null or not significant	-0.01	0.69

eTable 7. The Association between BPCI Participation and Changes in Market Volume for All LEJR, stratified by ACO penetration

Abbreviations: ACO, Accountable Care Organization. Models included market and quarter fixed effects, market level covariates as in primary analysis models, and robust standard errors. The results demonstrate no differences from the primary analysis with respect to stratification by ACO market penetration.

	All		High ACO Penetration		Other ACO Penetration	
	Differential Change in Post-Period for BPCI vs. Non-BPCI Markets, n	P-Value	Differential Change in Post-Period for BPCI vs. Non-BPCI Markets	P-Value	Differential Change in Post-Period for BPCI vs. Non-BPCI Markets	P-Value
All LEJR cases	0.32%	0.10	0.29%	0.35	0.25%	0.31