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Reference-Based Benefits for Colonoscopy and Arthroscopy: Large Differences in Patient Payments Across Procedures but Similar Behavioral Responses

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Abstract

This study examines how reference-based benefits (RBB) affect patient out-of-pocket payments across outpatient procedures. The California Public Employees' Retirement System (CalPERS) implemented RBB asymmetrically for outpatient procedures in 2012, only applying RBB to outpatient procedures performed in a hospital outpatient department (HOPD), and not applying RBB to outpatient procedures performed in a lower cost ambulatory surgery center. Using claims data (2009–2013) on arthroscopy and colonoscopy services, we found that for colonoscopy, CalPERS patients paid an average of 63.9% ($p < .01$) more for HOPDs than ambulatory surgery centers in 2012. For arthroscopy, no statistically different cost sharing was found on average. However, high-priced HOPDs were 17.3% and 17.9% less likely to be chosen by CalPERS patients in 2012 for colonoscopy and arthroscopy, respectively. These magnitudes increased in 2013 to 25.2% and 24.2% less, respectively. Overall, responsiveness to RBB with regard to the most expensive HOPDs was similar despite varying cost sharing by procedure.

Keywords

reference pricing; cost sharing; difference-in-differences

Introduction

In recent years, employers and insurers have begun experimenting with innovative benefit designs that seek to reduce health care costs. Among these innovative designs, reference-based benefits (RBB), or reference pricing, has been used by some employers to encourage

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the use of less expensive facilities. Under RBB, insurers establish a contribution limit under which they will provide full coverage, requiring the patient to pay the entire difference between this limit and any charges above this limit.

The California Public Employees' Retirement System (CalPERS) is one of the early adopters of RBB. CalPERS first applied RBB in 2011 to knee and hip replacement surgery. After successfully implementing this program for 1 year, CalPERS extended the RBB program in 2012 to three categories of outpatient procedures: colonoscopy, cataract surgery, and arthroscopy. Each of these procedures were selected because there was a substantial dispersion in provider prices without corresponding evidence that higher priced providers provided higher quality care, a common situation in health care (Hussey, Wertheimer, & Mehrotra, 2013). All three of the outpatient procedures to which RBB was applied can be performed safely and effectively at lower priced ambulatory surgery centers (ASCs), and all of these services are "shoppable" in that they are nonemergency procedures whose outcomes are not compromised if a patient delays the procedure to take the time to compare providers (Robinson, Brown, & Whaley, 2015).

New Contribution

The CalPERS RBB program, as applied to outpatient care, has been studied as to its mean effect on outpatient expenditures and facility choice (Robinson, Brown, & Whaley, 2015; Robinson, Brown, Whaley, & Bozic, 2015; Robinson, Brown, Whaley, & Finlayson, 2015), and as to its effects on the variation of outpatient expenditures across the distribution of outpatient expenditures (Aouad, Brown, and Whaley, 2018). However, since the CalPERS RBB program is applied asymmetrically, applying to care received in a hospital outpatient department (HOPD), but not to care received in an ASC, the extent to which patients who chose a HOPD chose more expensive or less expensive HOPDs, and whether any such behavior is heterogeneous across procedures is unknown.

This article fills this gap by examining the effects of the CalPERS RBB program on mean patient payments for patients who choose a HOPD, and whether the effect of RBB on the choice of more expensive or less expensive HOPDs is heterogeneous across procedures. We also examine the effect of the varying levels of additional out-of-pocket payments on the use of high-priced providers among CalPERS patients after the implementation of RBB. To do so, we develop an estimation approach that uses nonlinear difference-in-differences (DID) regressions. To our knowledge, this is the first article that uses this approach to estimate nonlinear DID regressions with multiple posttreatment periods.

Conceptual Framework

Reference pricing (or RBB) is a reimbursement strategy designed to make consumers sensitive to their medical choices by increasing the consumer's marginal cost when they choose medical goods or services that are known to be more expensive but which do not significantly vary in quality. Reference pricing may be overlaid on top of traditional cost-sharing approaches, such as deductibles and coinsurance. In such a situation, the reference price is the maximum price that an insurer will pay within a given category of medical goods or services. If a consumer chooses a medical good or service whose price falls at or below

the reference price, they only pay their usual deductible and coinsurance. If they choose a medical good or service whose price falls above the reference price, they pay the usual deductible and coinsurance and any difference between the actual price of the medical good or service and the reference price. The actual price of the medical good or service is negotiated between the insurer and the provider, putting an upper limit on the amount of this difference that a consumer may have to pay (unlike the situation with indemnity insurance where no such upper limit was present). However, this difference is considered an exclusion of coverage and does not apply to either the deductible or to any annual maximum out-of-pocket limit.

In the present context, CalPERS focused on three procedures: colonoscopy, arthroscopy, and cataract surgery, all of which can be safely performed in two different settings with no known quality differences. One setting, a HOPD, is generally more expensive than the other setting, an ASC.

Under its RBB initiative, CalPERS established an RBB limit of $1,500 for colonoscopy, $2,000 for cataract surgery, and $6,000 for arthroscopy. This was overlaid over the pre-RBB cost-sharing structure of deductibles and coinsurance. Under the RBB initiative, patients who chose to receive care in an ASC were subject to their usual deductible and coinsurance (with the exception of preventive colonoscopy that did not require cost sharing under the Affordable Care Act) and were not subject to RBB, regardless of the ASC's price. In contrast, patients who choose to receive care in a HOPD were subject to their usual deductible and coinsurance and were also subject to pay any difference between the price of the service and the reference price.

Mathematically, if the reference price is r, the deductible is d, and the coinsurance rate is α, then individuals who select a HOPD with a price p are subject to reference pricing, and their out-of-pocket costs will be as follows:

$$(d + \alpha(r - d) + (p - r)) \text{ if } p > r > d \tag{1}$$

$$(d + \alpha(p - d)) \text{ if } r \geq p > d \tag{2}$$

$$p \text{ if } p \leq d \tag{3}$$

Individuals who alternatively choose an ASC with a price p' are not subject to reference pricing, and their out-of-pocket costs will always be as follows:

$$(d + \alpha(p' - d)) \text{ if } p' > d \tag{4}$$

$$p' \text{ if } p' \leq d \tag{5}$$

Method

Data and Measures

CalPERS covers approximately 1.4 million enrollees, of whom approximately 225,000 are enrolled in its self-insured Preferred Provider Organization (PPO) product, which is administered by Anthem Blue Cross (Robinson, Brown, & Whaley, 2015). Beginning in January of 2012, all CalPERS enrollees covered by the Anthem PPO product were subject to reference pricing limits if they received services in a high-price HOPD rather than a low-price ASC. We thus obtained individual-level claims data from CalPERS for all enrollees undergoing arthroscopy, colonoscopy, or cataract surgery from January 2009 to December 2013. The data cover a 5-year period, including 3 years prior to and 2 years after the implementation of RBB. The treatment group is made up of enrollees in CalPERS Anthem Blue Cross PPO insurance, who have received colonoscopy or arthroscopy. We constructed a comparison group of California enrollees who were covered by PPO products issued by the same insurance carrier (Anthem Blue Cross) but was not subject to RBB. Because Anthem negotiates the actual payment for its membership, market prices for procedures performed in any given hospital or ASC are identical for CalPERS enrollees and non-CalPERS enrollees.

Our analysis includes patients aged 18 to 64 years who resided in California and received their procedure in California. Patient cost sharing was measured by the payments made by patients, which is the sum of deductibles, coinsurance, and copayments, including any noncovered portion, the bulk of which is due to reference pricing. We also obtained data on each patient's sex, comorbidity status (as measured by the Charlson Comorbidity Index), service date, the particular hospital referral region within which they resided, and whether they were exempt from RBB, (Charlson, Pompei, Ales, & MacKenzie, 1987). Hospital referral regions are included to control for variation in market structure across the state (Trustees of Dartmouth College, 2015). Month of service, derived from service date, is included to control for the timing during the calendar year of a procedure, which will affect the amount of deductible paid. Exemption status from the RBB program is included since CalPERS exempts patients from the RBB program if they have special clinical needs that require delivery of their procedure in a HOPD, or if there is no ASC within 30 miles of the patient's home address.

While CalPERS applied RBB to three different outpatient procedures, colonoscopy, arthroscopic surgery, and cataract surgery, we do not include cataract surgery in this study because only 2.5% of HOPDs operated below the CalPERS RBB contribution limit of $2000 for cataracts, and none of these HOPDs were priced less than or equal to $500 below the RBB limit. Given the very small number of HOPDs priced below the RBB limit, there were not sufficient data to reliably estimate the causal effect of the RBB program on the use of less expensive HOPD providers (many parameters in the model were simply not estimable).

Statistical Analysis

We estimated DID ordinary least squares models to determine the patient out-of-pocket cost-sharing differences between patients who selected a HOPD and patients who selected an ASC for their procedure. Nonlinear generalized linear models with a log link and a gamma

distribution are presented in the appendix for comparison purposes. We also estimated DID logistic regression models to analyze the probability of patients selecting a HOPD over an ASC in a lower price range or a higher price range, considering a variety of marginal out-of-pocket price differences between HOPD-allowed charges and the RBB limit. Specifically, all HOPDs were divided into four subgroups based on their prices in 2011 (the year prior to the implementation of the RBB program) and the RBB limit: Providers in the "below reference-price" group charged at least $500 below the RBB limit; the "near reference-price" group includes providers who charged less than $500 below the RBB limit; providers in the "above reference-price" group charged no more than $500 above the RBB limit; and the "high-price HOPD group" priced at least $500 above the RBB limit. We select the $500 cutoffs to ensure an adequate number of both ASCs and HOPDs in each price group. We also apply $300 and $700 cutoffs for sensitivity purposes to determine the robustness of our model specification.

All regressions included controls for sex, age, Charlson comorbidity index, exemption from the RBB program, hospital referral region, and month indicators. Arthroscopy equations additionally controlled for type of arthroscopy (knee vs. shoulder), and colonoscopy equations additionally controlled for type of colonoscopy (diagnostic vs. screening, noninterventional vs. interventional, and the combination of screening and interventional).

Identification in the DID approach is often based on the "parallel trend" assumption. To relax the parallel trend assumption in our linear DID model of patient cost sharing, we followed the approach used by Bell, Blundell, and Van Reenen (1999) and Li, Hurley, DeCicca, and Buckley (2014) and modeled differential trends between the comparison and treatment groups, which consists of including treatment group time interactions for the preimplementation periods.

For our choice model, we estimated DID logistic models in which we also allowed for differential trends between the comparison and treatment groups. Logistic DID models are special cases of nonlinear models that use interaction terms to estimate the treatment effect on the treated (Puhani, 2012). For interaction terms in nonlinear models, it is improper to interpret the treatment effects directly from the estimated coefficients (Karaca-Mandic, Norton, & Dowd, 2012). Rather, the mathematical expressions for the cross-partial derivatives must be determined to compute the average of the cross-partial derivatives over all observations in the data set.

When there is only one interaction term involved in the nonlinear model to be estimated, the correct cross-partial derivatives can be computed easily with existing statistical software (Karaca-Mandic et al., 2012). However, it is less straightforward to determine the correct cross-partial derivatives when there are multiple interaction terms. Estimating nonlinear models with multiple interaction terms is important to test the parallel trends assumption and to examine differential treatment effects over time. We followed the discussion made by Karaca-Mandic et al. (2012) and used a more general Stata command. We present our syntax and formulae in the appendix. All standard errors were clustered at the facility level for all models. All analyses were performed using Stata 15.

Results

Impacts on Patient Cost Sharing

Table 1 presents descriptive statistics. The average patient cost sharing for colonoscopy among Anthem patients is greater than the average patient cost sharing among CalPERS patients for all years over the study period. Prior to the RBB intervention, over the years 2009 to 2011, the annual differences in average patient cost sharing for colonoscopy between the Anthem and the CalPERS group ranged from $351.81 to $480.98. After the implementation of reference pricing, however, the patient cost-sharing difference declined slightly relative to its level in 2011 to $240.38 in 2012 and $381.16 in 2013, mostly attributable to the sharp increases in patient cost sharing for CalPERS enrollees who selected high-priced HOPDs, as shown in Figure 1(B) whose cost shares fall into the top 5% (95th percentile). For non-CalPERS Anthem enrollees, the patient cost sharing below the 90th percentile essentially stayed flat, whereas there was a moderate increase for the 5% (95th percentile) as shown in Figure 1(A).

Similar patterns were observed for arthroscopy. For patients undergoing arthroscopy, the annual difference in average patient cost sharing between non-CalPERS Anthem enrollees and CalPERS enrollees ranged from $81.20 to $438.44, over the years 2009 to 2011, prior to the intervention. The corresponding figure was $289.39 in the first year after the intervention, in 2012, and $254.23 in the second year, in 2013, as shown in Table 1. Figure 1 furthers shows the comparison of the cost sharing for the two groups when broken down into percentile rankings. Patient cost sharing remained flat for most enrollees (below the 90th percentile) for both the Anthem group (Figure 1C) and the CalPERS group (Figure 1D). The 95th percentile of both groups saw similar increases in their responsibility of cost sharing. However, the 90th percentile of non-CalPERS Anthem enrollees only experienced a slight increase, whereas the cost sharing for the 90th percentile of CalPERS enrollees (Figure 1D) almost doubled.

Regression analyses of patient cost-sharing difference between CalPERS enrollees and non-CalPERS Anthem enrollees, accounting for patient and market factors, are presented in Table 2. In the 2 years prior to implementation of RBB, the average financial responsibilities for colonoscopy were not statistically different ($p \leqslant .05$) between CalPERS members and non-CalPERS Anthem enrollees. However, in the first year after the RBB initiative, in 2012, the average patient cost sharing for CalPERS members increased substantially. The DID parameter of 0.494, when adjusted with the standard adjustment for log-linear equations, $(100 \cdot (\exp(0.494) - 1))$ ($p \leqslant .05$) implies that CalPERS patient responsibility was 63.9% greater than Anthem patients in 2012. The difference in patient responsibility between the two groups shrank 49.3% ($49.3 = 100 \cdot (\exp(0.401) - 1)$) ($p \leqslant .05$), in the second year of the RBB implementation for colonoscopy.

For patients undergoing arthroscopy prior to the RBB initiative, the average financial responsibilities were not statistically different ($p > .05$) between Anthem enrollees and CalPERS enrollees in 2009, but they were substantially greater for CalPERS enrollees in 2010 with a difference of 23.2% ($23.2 = 100 \cdot (\exp(0.209) - 1)$) ($p = .01$). But unlike colonoscopy patients, the patient cost-sharing obligation differences did not change for

CalPERS patients with the implementation of RBB. The average out-of-pocket cost sharing for CalPERS patients receiving arthroscopy after the RBB program was not statistically greater than that for Anthem patients in either 2012 or 2013.

Impacts on Patient Choice

Our aim here is to estimate whether the RBB initiative leads to less use of HOPDs at different price points. In other words, does the RBB initiative lead to less use of HOPDs, even when there is no additional marginal patient cost relative to using ASCs, and how much less are HOPDs used relative to ASCs as the portion of the price above the reference grows? Tables 3 and 4 present the regression coefficients we obtained by fitting a logistic DID model on the use of HOPDs for colonoscopy and arthroscopy, respectively, considering different price points.

As shown in Table 5, for colonoscopy, after adjustment for nonlinearity of the logistic DID model, the average predicted conditional probability of selecting HOPDs in the group just above the reference price, RP ⩽ Price ⩽ (RP + $500), was no longer statistically different among CalPERS and Anthem enrollees (compare the same column in Table 3). In contrast, HOPDs priced near the reference price limit, (RP − $500) ⩽ Price < RP, were 10.2% less likely to be selected by CalPERS patients in the first year after the implementation of RBB. This effect further increased in the second year of the RBB program, leading to a 12.9% difference in HOPD use. Likewise, the use of high-price HOPDs, Price > (RP + $500), was 17.3% and 25.2% lower in CalPERS patients in 2012 and 2013, respectively.

Similarly, CalPERS patients were also less likely to receive their arthroscopy in a HOPD setting after the implementation of RBB. The average probability of selecting a HOPD in the lowest price category, Price ⩽ (RP − $500), was 6.7% to 9.0% lower among CalPERS enrollees compared to rates of use by Anthem enrollees after the implementation of RBB. The corresponding figures were even greater for the highest price HOPDs, Price > (RP + $500), with an 18.0% to 24.2% difference. There is, however, no statistically significant difference in the use of HOPDs just above the reference price, RP ⩽ Price ⩽ (RP+$500), among Anthem and CalPERS enrollees when we take the nonlinearity of the model in to account. The appendix describes the technical information on how these models were estimated.

Robustness checks using $300 and $700 rather than $500 are presented in Tables 6 and 7. The results are very similar to the results using $500.

Discussion

Implementation of RBB in California has been associated with statistically significant reductions in insurer payments. RBBs for outpatient procedures led to $1.3 million, $2.3 million, and $7 million reductions in CalPERS's payments for cataract surgeries, knee and shoulder arthroscopy, and colonoscopy, respectively (Robinson, Brown and Whaley, 2015; Robinson, Brown, Whaley, & Bozic, 2015; Robinson, Brown, Whaley, & Finlayson, 2015). However, RBB may expose employees to avoidable, but substantially greater, out-of-pocket expenses for these services if they select HOPDs. This study analyzed the application of

RBBs to shoulder or knee arthroscopy and colonoscopy, focusing on the cost-sharing obligations for CalPERS patients.

On average, cost-sharing obligations for CalPERS members were statistically higher for colonoscopy, but not for arthroscopy, after the implementation of RBB. The increased cost-sharing responsibility for CalPERS patients was attributable to the use of highly priced HOPDs in the postperiod as suggested in Figure 1. However, even for colonoscopy, the increase in out-of-pocket spending was attenuated in the second year of the program. This result suggests that, on average, CalPERS enrollees are able to navigate themselves through the RBB program and avoid greater out-of-pocket expenses by becoming more likely to choose ASCs over HOPDs over time as found in previous research for cataract surgery, colonoscopy, and arthroscopy (Robinson, Brown, & Whaley, 2015; Robinson, Brown, Whaley, & Bozic, 2015; Robinson, Brown, Whaley, & Finlayson, 2015).

Relatedly, the contribution limits CalPERS set for arthroscopy and colonoscopy provided adequate leeway to CalPERS enrollees to avoid the extra cost sharing imposed by the RBB program. CalPERS enrollees were allowed to use any ASC for these services without any RBB surcharges, regardless of the ASC's price. Also, the RBB limits for knee and shoulder arthroscopy and colonoscopy were comparable to the average HOPD price levels in the market. The contribution levels were set high enough to cover the prices charged by at least 17% of HOPDs. By visiting HOPDs priced below the contribution limit, CalPERS enrollees were not subject to the additional surcharges imposed by RBB.

To better understand the cost-sharing changes before and after the RBB implementation, we proceeded to examine whether CalPERS patients on average likely understood the RBB program and made informed decision to protect themselves from extra cost-sharing responsibility. If on average they were informed, we expected that the greatest decline of use would be observed in high-price HOPD settings, followed by less expensive HOPDs. Our analyses of patient choice between high-priced and low-priced providers for colonoscopy and arthroscopy fail to reject the hypothesis of informed patient decision making. For these two procedures, highly priced HOPDs were less likely to be selected by CalPERS patients after the implementation of RBB, and the effect was similar among the most expensive HOPDs for both procedures. Specifically, for both colonoscopy and arthroscopy in 2012, the highest priced HOPD group, Price > (RP + $500), experienced a 17% to 18% decrease in the likelihood of being chosen by a CalPERS patient. This difference became even greater in the second year, with decreases of 24% to 25%. The results we report in this article are based on a cutoff level of $500. We also conducted robustness checks using different price cutoffs: $300 and $700. The estimates of HOPD choices after the RBB program at various cutoffs ($300, $500, $700) were consistent, suggesting that our findings are not sensitive to the arbitrary cutoff point we selected.

Our findings of less use of high-priced HOPDS after the implementation of RBB suggest that CalPERS enrollees were on average aware of the additional out-of-pocket costs associated with using HOPDs. Moreover, patient responsiveness to increased cost-sharing obligations was similar across different procedures.

Our findings also show that, on average, patients were less sensitive to small increases in out-of-pocket cost sharing, as CalPERS enrollees did not choose differently for facilities priced slightly above the RBB limit after the implementation of RBB. Substantial changes in hospital market share were only observed for hospitals that priced at least $500 above the RBB limit. This suggests that price sensitivity varies with out-of-pocket responsibilities. Future implementation of RBB should explore the price sensitivity at different price levels. An in-depth understanding of the variation of price sensitivity would allow policy makers to set optimal contribution levels in order to maximize the effectiveness of the program.

We also illustrated that the numeric calculation of the interaction effect with adjustment for nonlinearities can be substantially different from the coefficients on the interactions in nonlinear models. For instance, in our DID model of the facility choice for colonoscopy in the category of prices just above the reference price (RP ⩽ price ⩽ (RP + $500), the interaction terms of CalPERS with both year dummies in the postperiod were statistically significant at the 0.05 levels. However, the numeric computation of the average cross-partial derivative over all observations suggested that the difference in the marginal effect between the Anthem and CalPERS group was in fact statistically insignificant. This suggested that the statistical significance of cross-partial derivative cannot be directly inferred from the regression coefficients. Conclusions merely based on regression coefficients of interaction terms in nonlinear models can therefore be misleading. Greater attention should be paid to this issue by applied researchers.

Our findings should be interpreted in light of their limitations. The choice data on colonoscopy and arthroscopy implied that, on average, CalPERS enrollees were aware of the RBB program and the associated higher cost-sharing obligation if they selected a HOPD. We did not have data on whether they unknowingly incurred high costs above the reference price.

Our measures of the cost-sharing amounts were limited to the costs they were responsible for based on the billed amount. We did not have data on the amount patients actually paid for the services as hospitals may waive some of the cost-sharing obligations to remain competitive in the market (Robinson, Brown, & Whaley, 2015).

Research to date has found that RBB has saved CalPERS $10.6 million in the form of lower insurer payments using the mechanism of shifting some of the financial responsibilities to patients, where patients generally face no quality differences by choosing lower priced facilities. It has been estimated that approximately $19 billion dollars could be saved nationally by expanding RBB to only eight classes of procedures (Robinson, Brown, & Whaley, 2017). Additional education on the quality similarities between HOPDs and ASCs may be helpful in influencing even more patients to switch from HOPDs to ASCs for procedures subject to RBB.

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Appendix (Part 1):: Estimating Difference-in-Differences Models with GLM

To show the impact of estimating Table 2 when using GLM (with a log link and a gamma distribution) rather than using OLS (with a logged dependent variable), we present the table below of results that are estimated using GLM with a log link and a gamma distribution.

Table A1.

Difference-in-Differences Estimates of Mean Patient Cost Sharing When Choosing a HOPD Over an ASC in California.

	Colonoscopy	Arthroscopy
CalPERS × 2013	0.373***	0.067
	(0.076)	(0.100)
CalPERS × 2012	0.472***	−0.014
	(0.075)	(0.100)
CalPERS × 2010	0.005	0.208**
	(0.027)	(0.086)
CalPERS × 2009	−0.026	0.052
	(0.033)	(0.117)
CalPERS	−0.165***	1.282***
	(0.042)	(0.093)
Year 2013	−0.095**	−0.006
	(0.038)	(0.078)
Year 2012	−0.090***	−0.008
	(0.022)	(0.060)
Year 2010	0.029	−0.202**
	(0.044)	(0.091)
Year 2009	0.096	−0.244**
	(0.063)	(0.107)
Screening procedure	−5.371***	
	(0.090)	
Intervention procedure	0.115***	
	(0.039)	
Screening procedure with intervention	−0.044	
	(0.045)	
Male	0.056***	0,170***
	(0.018)	(0.028)
Charlson comorbidity index	−0.026***	−0.485***
	(0.010)	(0.054)
Age		
30–39	−0.014	0.080
	(0.026)	(0.071)
40–49	0.010	0.082
	(0.026)	(0.073)

	Colonoscopy	Arthroscopy
50–59	−0.012	−0.072
	(0.032)	(0.072)
60–64	−0.017	−0.274***
	(0.041)	(0.077)
Knee arthroscopy		0.211***
		(0.044)
Observations	312,620	64,438

GLM with log link and gamma distribution as dependent variable; Hospital Referral Region indicators and month dummies included, but not reported. Standard errors in parentheses, robust SEs, clustered at provider level.

*$p<0.1$

**$p<0.05$,

***$p<0.01$(two-tailed test)

Appendix (Part 2):: Estimating Marginal Effects for Year × Treatment Interactions in Non-linear models

As an example of how Tables 5 was generated, we provide the following Stata syntax for the colonoscopy portion of the table:

> logit hopd pers2013 pers2012 pers2010 pers2009 CalPERS y2013 y2012 y2010 y2009 screening_colo intervention intervention_screening male wcharlsum i.agecat rp_exempt i.month i.hrrnum_patient if procedure == “colonoscopy” & delta_RP_cat==‘i’, robust cluster(PROV_ID)

where *hopd* is a binary variable indicating the use of a HOPD, *y2013 y2012 y2010 y2009* represent years, *CalPERS* is an binary variable representing the treatment group, and *pers2013 pers2012 pers2010 pers20* are year × treatment interaction terms, *screening_colo* is a binary variable indicating screening colonoscopies, *intervention* is a binary variable indicating interventional colonoscopies, *intervention_screening* is a binary variable indicating colonoscopies that included both screening and interventional components, *male* is a binary variable indicating the male sex, *wcharlsum* is the Charlson Comorbidity Index, *i.agecat* is a set of age categories and *i.month* is a set of month dummies, *rp_exempt* is a binary variable indicating exemption from the RBB program, and *i.hrrnum_patient* is the set of Hospital Referral Regions in which each patient lives. The variable ‘i’ is a local variable representing various out-of-pocket cost sharing difference categories.

Merely looking at the coefficients presented in Tables 3 and 4, one may conclude that for colonoscopy, the average predicted conditional probability of selecting HOPDs priced near the reference price limit (RP ⩽ Price ⩽ (RP+$500) after the implementation of RBB was statistically lower for CalPERS patients. One may also conclude that the decline in HOPD use among CalPERS enrollees becomes larger the higher the price charged by HOPDs above the reimbursement limits, since the corresponding coefficients increased in its absolute magnitudes as we move to the right.

However, as shown in Table 5, to correctly interpret the RBB effect on the use of HOPDs, we express associations between the implementation of RBB and the use of HOPDs in terms of marginal effects, incorporating the nonlinearity of the estimates in our logistic regression (Karaca-Mandic, Norton and Dowd, 2012). As suggested by Karaca-Mandic et al, we used the Stata command "predictnl" and write out the formula of the difference in two derivatives evaluated for CalPERS and for Anthem enrollees. For example, to estimate the difference in marginal effect of RBB on CalPERS and Anthem enrollees in 2013, the formula is as follows:

```
predictnl phat13 = 1/(1+exp(- (xb() - _b[y2013]*y2013-_b[treatment]*treatment-
_b[pers2013]*pers2013 + _b[y2013]+_b[treatment]+ _b[pers2013]))) - ///

1/(1+exp(- (xb() - _b[y2013]* y2013-_b[treatment]*treatment-
_b[pers2013]*pers2013 + _b[treatment]))) - ///

(1/(1+exp(- (xb() - _b[y2013]* y2013-_b[treatment]*treatment-
_b[pers2013]*pers2013 + _b[y2013]))) - ///

1/(1+exp(- (xb() - _b[y2013]* y2013-_b[treatment]*treatment-
_b[pers2013]*pers2013)))) if e(sample), se(phat13_se) p(phat13_p)
```

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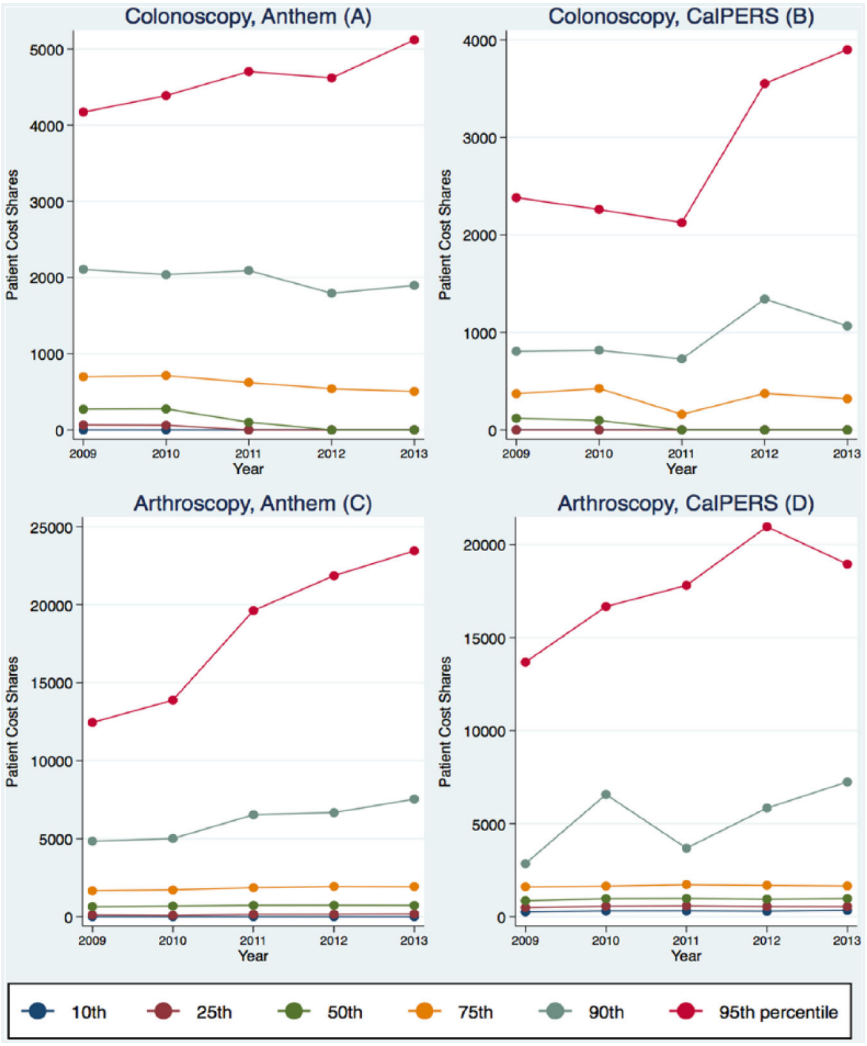

Figure 1.
Patient cost sharing by percentile.

Table 1.

Descriptive Statistics.

	Year				
Procedure	**2009**	**2010**	**2011**	**2012**	**2013**
Colonoscopy					
Mean patient responsibility					
Anthem	858.30	944.46	993.40	931.18	1110.30
CalPERS	506.49	576.48	512.42	690.80	729.14
Difference	−351.81	−367.98	−480.98	−240.38	−381.16
Mean number of comorbidities					
Anthem	0.13	0.13	0.13	0.12	0.12
CalPERS	0.14	0.14	0.13	0.12	0.13
Percent male					
Anthem	0.47	0.47	0.47	0.47	0.47
CalPERS	0.45	0.44	0.44	0.44	0.43
Mean age (years)					
Anthem	52.50	52.61	52.67	52.72	52.91
CalPERS	54.42	54.69	54.83	54.66	54.89
HOPD share					
Anthem	0.29	0.29	0.27	0.27	0.29
CalPERS	0.33	0.33	0.34	0.26	0.25
Number of procedures					
Anthem	52,769	52,045	53,678	56,462	58,626
CalPERS	7,912	7,997	8,188	7,862	7,081
Arthroscopy					
Mean patient responsibility					
Anthem	2118.95	2202.79	2846.24	3047.97	3150.42
CalPERS	2037.75	2486.75	2407.80	2758.58	2896.19
Difference	−81.20	283.96	−438.44	−289.39	−254.23
Mean number of comorbidities					
Anthem	0.07	0.08	0.8	0.08	0.08

	Year				
Procedure	**2009**	**2010**	**2011**	**2012**	**2013**
CalPERS	0.10	0.11	0.09	0.08	0.11
Percent male					
Anthem	0.56	0.55	0.55	0.54	0.54
CalPERS	0.49	0.48	0.46	0.46	0.45
Mean age (years)					
Anthem	49.41	49.97	50.20	50.20	50.41
CalPERS	53.87	53.77	53.87	54.14	54.37
HOPD share					
Anthem	0.32	0.30	0.30	0.29	0.29
CalPERS	0.36	0.34	0.33	0.28	0.25
Number of procedures					
Anthem	14,853	15,539	15,949	16,320	16,926
CalPERS	2,016	2,082	2,256	2,206	2,030

Note. CalPERS = California Public Employees' Retirement System; HOPD = hospital outpatient department.

Table 2.

Difference-in-Differences Estimates of Mean Patient Cost Sharing When Choosing a HOPD Over an ASC in California.

Variables	Colonoscopy	Arthroscopy
CalPERS × 2013	0.401***	0.023
	(0.090)	(0.104)
CalPERS × 2012	0.494***	−0.059
	(0.088)	(0.105)
CalPERS × 2010	0.005	0.209**
	(0.027)	(0.086)
CalPERS × 2009	−0.026	0.053
	(0.033)	(0.117)
CalPERS	−0.165***	1.282***
	(0.042)	(0.093)
Year 2013	−0.095**	−0.006
	(0.038)	(0.078)
Year 2012	−0.090***	−0.008
	(0.022)	(0.060)
Year 2010	0.029	−0.202**
	(0.044)	(0.091)
Year 2009	0.096	−0.245**
	(0.063)	(0.107)
Screening procedure	−5.371***	
	(0.090)	
Intervention procedure	0.115***	
	(0.039)	
Screening procedure with intervention	−0.045	
	(0.045)	
Male	0.056***	0.170***
	(0.018)	(0.029)
Charlson Comorbidity Index	−0.026***	−0.485***
	(0.010)	(0.054)
Age (years)		
30–39	−0.014	0.080
	(0.026)	(0.071)
40–49	0.010	0.082
	(0.026)	(0.074)
50–59	−0.012	−0.071
	(0.032)	(0.072)
60–64	−0.017	−0.274***

Variables	Colonoscopy	Arthroscopy
	(0.041)	(0.077)
RP exempt	−0.183*	0.313
	(0.108)	(0.197)
Knee arthroscopy		0.211***
		(0.044)
Observations	312,620	64,438

Note: HOPD = hospital outpatient department; ASC = ambulatory surgery center; CalPERS = California Public Employees' Retirement System; RP, reference price. Ordinary least squares with ln(consumer payment) dependent variable; hospital referral region and month indicators included but not reported. Standard errors in parentheses, clustered at the provider level.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

Table 3.

Difference-in-Difference Estimates of HOPD Choices for Colonoscopy (Logit Coefficients).

	Price ⩽ (RP − $500)	(RP − $500) ⩽ Price < RP	RP ⩽ Price ⩽ (RP + $500)	Price > (RP + $500)
CalPERS × 2013	−0.112	−0.982***	−1.082***	−1.567***
	(0.260)	(0.259)	(0.378)	(0.223)
CalPERS × 2012	0.116	−0.776***	−0.473**	−1.006***
	(0.309)	(0.245)	(0.211)	(0.117)
CalPERS × 2010	−0.442	0.0484	0.472***	−0.129
	(0.360)	(0.183)	(0.157)	(0.0848)
CalPERS × 2009	−0.323	0.0210	−0.0690	−0.0933
	(0.304)	(0.253)	(0.167)	(0.105)
CalPERS	0.243	0.283*	0.0982	0.0943
	(0.386)	(0.159)	(0.233)	(0.140)
Year 2013	0.249	−0.176*	0.286	−0.0734
	(0.237)	(0.0905)	(0.419)	(0.0929)
Year 2012	0.149	−0.0812	0.0288	−0.0309
	(0.227)	(0.0789)	(0.199)	(0.0520)
Year 2010	−0.236	0.319**	−0.0485	0.185*
	(0.242)	(0.143)	(0.115)	(0.102)
Year 2009	−0.120	0.424*	0.270**	0.196
	(0.201)	(0.223)	(0.125)	(0.140)
Screening	−0.120	−0.209***	−0.148	−0.0141
	(0.301)	(0.0751)	(0.238)	(0.0906)
Intervention	0.224	0.0820	−0.0258	−0.174
	(0.334)	(0.160)	(0.153)	(0.108)
Screening with intervention	0.0160	−0.130	0.0995	0.147**
	(0.141)	(0.0970)	(0.123)	(0.0745)
Male	0.0700	0.168***	−0.0843*	−0.000806
	(0.0866)	(0.0516)	(0.0509)	(0.0397)
Charlson Comorbidity Index	0.0232	0.125**	0.0359	0.149***

	Price ⩽ (RP − $500)	(RP − $500) ⩽ Price < RP	RP ⩽ Price ⩽ (RP + $500)	Price > (RP + $500)
	(0.0656)	(0.0490)	(0.0473)	(0.0323)
Age (years)				
30–39	0.258**	0.227*	−0.311	−0.281***
	(0.126)	(0.131)	(0.293)	(0.0678)
40–49	0.449*	0.127	−0.325	−0.522***
	(0.268)	(0.137)	(0.264)	(0.114)
50–59	0.585*	0.0519	−0.181	−0.503***
	(0.320)	(0.157)	(0.241)	(0.145)
60–64	0.426	0.00649	−0.228	−0.399***
	(0.332)	(0.179)	(0.299)	(0.153)
N	136,263	27,432	25,614	99,909

Note. HOPD = hospital outpatient department; RP = reference price; CalPERS = California Public Employees' Retirement System. Hospital referral region indicators and month dummies included but not reported. Standard errors in parentheses, clustered at the provider level.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

Table 4.

Difference-in-Difference Estimates of HOPD Choices for Arthroscopy (Logit Coefficients).

	Price ⩽ (RP − $500)	**(RP − $500) ⩽ Price < RP**	**RP ⩽ Price ⩽ (RP + $500)**	**Price > (RP + $500)**
CalPERS × 2013	−0.601***	−0.677	−4.838***	−1.435***
	(0.183)	(0.468)	(0.924)	(0.254)
CalPERS × 2012	−0.442***	0.291	−2.328***	−1.008***
	(0.156)	(0.484)	(0.632)	(0.164)
CalPERS × 2010	−0.0000823	1.096***	0.0816	−0.108
	(0.150)	(0.417)	(0.440)	(0.156)
CalPERS × 2009	0.232	1.258***	0.0403	−0.150
	(0.152)	(0.470)	(0.334)	(0.141)
CalPERS	0.184	−1.040***	0.484	0.154
	(0.125)	(0.370)	(0.481)	(0.119)
Year 2013	0.133	−0.107	0.683***	−0.166*
	(0.142)	(0.194)	(0.222)	(0.0872)
Year 2012	0.0774	0.191	0.581***	−0.114
	(0.0887)	(0.160)	(0.186)	(0.0801)
Year 2010	−0.0619	−0.377*	−0.0827	0.135
	(0.0715)	(0.200)	(0.234)	(0.107)
Year 2009	−0.0173	−0.192	−0.0411	0.202
	(0.0971)	(0.325)	(0.361)	(0.123)
Male	−0.0547	0.172	−0.251***	0.0286
	(0.0353)	(0.123)	(0.0564)	(0.0382)
Charlson Comorbidity Index	0.222***	0.204	0.287*	0.142*
	(0.0502)	(0.153)	(0.157)	(0.0731)
Knee arthroscopy	0.347**	1.231	0	0.167
	(0.148)	(0.988)	(.)	(0.217)
Age (years)				
30–39	0.163**	−0.308	0.941**	0.109

	Price ⩽ (RP − $500)	(RP − $500) ⩽ Price < RP	RP ⩽ Price ⩽ (RP + $500)	Price > (RP + $500)
	(0.0717)	(0.346)	(0.418)	(0.114)
40–49	0.109	−0.308	0.347	0.0207
	(0.0805)	(0.388)	(0.497)	(0.154)
50–59	0.122	−0.0627	0.0943	−0.0884
	(0.0958)	(0.381)	(0.489)	(0.166)
60–64	0.151	−0.401	−0.288	0.00907
	(0.107)	(0.369)	(0.372)	(0.169)
N	38,451	2,732	1,583	20,393

Note. HOPD = hospital outpatient department; RP = reference price; CalPERS = California Public Employees' Retirement System. Hospital referral region indicators and month dummy included but not reported. Standard errors in parentheses, clustered at the provider level.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

Table 5.

Marginal Effects After Adjusting for the Use of Interaction Terms in a Nonlinear Difference-in-Differences Model.

	Price ⩽ (RP − $500)	**(RP − $500) ⩽ Price < RP**	**RP ⩽ Price ⩽ (RP + $500)**	**Price > (RP + $500)**
Colonoscopy				
CalPERS × 2013	−0.001	−0.129**	−0.094	−0.252***
	(0.003)	(0.058)	(0.064)	(0.073)
CalPERS × 2012	0.002	−0.102**	−0.039	−0.173***
	(0.003)	(0.053)	(0.031)	(0.045)
CalPERS × 2010	−0.004	0.005	0.034	−0.023
	(0.005)	(0.024)	(0.025)	(0.016)
CalPERS × 2009	−0.003	0.001	−0.006	−0.017
	(0.004)	(0.033)	(0.013)	(0.019)
Arthroscopy				
CalPERS × 2013	−0.090**	−0.077	−0.322	−0.242***
	(0.041)	(0.076)	(0.208)	(0.078)
CalPERS × 2012	−0.067**	0.033	−0.200	−0.180***
	(0.033)	(0.061)	(0.158)	(0.059)
CalPERS × 2010	0.001	0.127	0.007	−0.020
	0.024	(0.097)	(0.046)	(0.031)
CalPERS × 2009	0.039	0.145	0.004	−0.029
	(0.028)	(0.108)	(0.034)	(0.029)

Note. RP = reference price; CalPERS = California Public Employees' Retirement System.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

Table 6.

Marginal Effects Estimates After Adjusting for the Use of Interaction Terms in a Nonlinear Difference-in-Differences Model.

	Price ⩽ (RP − $300)	**(RP − $300) ⩽ Price < RP**	**RP ⩽ Price ⩽ (RP + $300)**	**Price > (RP + $300)**
Colonoscopy				
CalPERS × 2013	−0.002	−0.138**	−0.181*	−0.279***
	(0.003)	(0.061)	(0.100)	(0.077)
CalPERS × 2012	0.001	−0.107**	−0.044	−0.188***
	(0.004)	(0.051)	(0.046)	(0.050)
CalPERS × 2010	−0.003	0.005	0.063	−0.028*
	(0.006)	(0.018)	(0.050)	(0.017)
CalPERS × 2009	−0.005	0.014	0.007	−0.022
	(0.006)	(0.031)	(0.017)	(0.019)
Arthroscopy				
CalPERS × 2013	−0.104**	−0.044	__[a]	−0.256***
	(0.044)	(0.101)	__[a]	(0.079)
CalPERS × 2012	−0.071**	0.052	−0.415	−0.206***
	(0.033)	(0.087)	0.314	(0.063)
CalPERS × 2010	−0.004	0.101	__[a]	−0.027
	0.023	(0.108)	__[a]	(0.031)
CalPERS × 2009	0.040	0.160	__[a]	−0.028
	(0.027)	(0.154)	__[a]	(0.028)

Note. RP = reference price; CalPERS = California Public Employees' Retirement System.

[a]Not estimable due to range being too narrow.

*$p < .1$.

**$p < .05$.

***$p < .01$.

Table 7.

Marginal Effects Estimates After Adjusting for the Use of Interaction Terms in a Nonlinear Difference-in-Differences Model.

	Price ⩽ (RP − $700)	**(RP − $700) ⩽ Price < RP**	**RP ⩽ Price ⩽ (RP + $700)**	**Price > (RP + $700)**
Colonoscopy				
CalPERS × 2013	0.000	−0.054**	−0.118*	−0.246***
	(0.001)	(0.027)	(0.064)	(0.068)
CalPERS × 2012	0.000	−0.043*	−0.062	−0.173***
	(0.001)	(0.024)	(0.038)	(0.049)
CalPERS × 2010	−0.001	−0.001	0.023	−0.032*
	(0.003)	(0.012)	(0.021)	(0.018)
CalPERS × 2009	−0.002	0.012	−0.006	−0.004
	(0.003)	(0.015)	(0.013)	(0.016)
Arthroscopy				
CalPERS × 2013	−0.077**	−0.023	−0.378**	−0.227***
	(0.038)	(0.048)	(0.192)	(0.076)
CalPERS × 2012	−0.067**	0.045	−0.201**	−0.172***
	(0.033)	(0.058)	(0.093)	(0.058)
CalPERS × 2010	−0.029	0.129	−0.082	−0.008
	0.024	(0.083)	(0.051)	(0.029)
CalPERS × 2009	0.011	0.120	−0.035	−0.027
	(0.024)	(0.083)	(0.054)	(0.029)

Note. RP = reference price; CalPERS = California Public Employees' Retirement System.

*$p < .1$.

**$p < .05$.

***$p < .01$.