Quantifying Opportunities for Hospital Cost Control: Medical Device Purchasing and Patient Discharge Planning

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In the past decade, many hospitals have covered rising costs by merging with erstwhile competitors and demanding ever-higher payment rates from insurers.[1-4] This focus on revenue growth now appears to be of declining value. Private insurers are experimenting with narrow networks and consumer cost-sharing incentives that will channel patient volume away from facilities charging the highest prices.[5,6] CMS has proposed reductions in Medicare hospital payment updates.[7,8] Many hospitals are thus finding they need to shift to a focus on cost reduction to preserve their operating margins.

The changing economic environment presents opportunities as well as challenges. Both public and private insurers are experimenting with bundled "episode-of-care" methods of payment that allow hospitals to retain the savings they achieve through cost-control initiatives.[9-12] The Medicare accountable care organization initiatives use shared-savings payment methods that reward efficiency and cost reductions achieved by hospitals.[13]

There is substantial cost variation among hospitals, after adjusting for differences in case mix, suggesting that significant savings can be obtained through adopting best practices. While cost variation across geographic regions often is due to factors outside the control of individual facilities—such as regulatory requirements and the cost of living—variations within regions are more likely to be due to factors under the control of hospital management, if it can identify and adopt best practices from neighboring facilities. This paper identifies opportunities hospital face for cost control and quantifies the potential savings. It focuses on 3 major classes of inpatient procedures: orthopedic joint replacement, neurosurgical spine fusion, and cardiac rhythm management (CRM). These procedures account for a substantial share of hospital revenues and offer important opportunities for hospital cost savings through reduced device prices and patient lengths of stay.

ABSTRACT

Objectives

To quantify the potential reduction in hospital costs from adoption of best local practices in supply chain management and discharge planning.

Study Design

We performed multivariate statistical analyses of the association between total variable cost per procedure and medical device price and length of stay, controlling for patient and hospital characteristics.

Methods

Ten hospitals in 1 major metropolitan area supplied patient-level administrative data on 9778 patients undergoing joint replacement, spine fusion, or cardiac rhythm management (CRM) procedures in 2008 and 2010. The impact on each hospital of matching lowest local market device prices and lowest patient length of stay (LOS) was calculated using multivariate regression analysis controlling for patient demographics, diagnoses, comorbidities, and implications.

Results

Average variable costs ranged from $11,315 for joint replacement to $16,087 for CRM and $18,413 for spine fusion. Implantable medical devices accounted for a large share of each procedure's variable costs: 44% for joint replacement, 39% for spine fusion, and 59% for CRM. Device prices and patient length-of-stay exhibited wide variation across hospitals. Total potential hospital cost savings from achieving best local practices in device prices and patient length of stay are 14.5% for joint replacement, 18.8% for spine fusion;,and 29.1% for CRM.

Conclusions

Hospitals have opportunities for cost reduction from adoption of best local practices in supply chain management and discharge planning.

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DATA AND METHODS

Take-Away Points

Insurers are implementing designs that channel patients toward low-price facilities. CMS has proposed payment reductions. Many hospitals must reduce costs. Three high-margin services are joint replacement, spine surgery, and cardiac rhythm management (CRM). Adopting best local practices in device purchasing and discharge planning may yield savings.

- Device prices and length of stay exhibited wide variation.
- Devices accounted for 44% of variable costs for joint replacement, 39% for spine fusion, and 59% for CRM.
- Total potential cost savings from implementing best local practices are 14.5% for joint replacement, 18.8% for spine fusion, and 29.1% for CRM.

Data

We obtained data on 9778 patients receiving acute care procedures in 10 hospitals in 1 metropolitan region in 2008 and 2010. The market is a major suburban area with 4.5 million residents. The focus on 1 market eliminates influences on hospital costs of factors outside the control of any 1 facility, such as the cost of living, and permits a quantification of potential savings from adopting local best practices.

The hospitals agreed to supply data from their patient records, operating room logs, and cost accounting systems as part of their participation in initiatives by the Integrated Healthcare Association (IHA) to improve purchasing and utilization of implantable medical devices.[14] The IHA is an association of hospitals, physician organizations, and health insurance plans in California, whose mission is enhancing quality and efficiency of care. Data were supplied by each hospital to Aspen Healthcare Metrics, a data intermediary and consulting firm that created data files to be used by IHA. Patient identifiers were removed by the hospitals prior to transferring the data.

Orthopedics, neurosurgery, and interventional cardiology were selected because they constitute high volume, revenue, and margin service lines for most hospitals. Orthopedic joint surgery is represented in this study through total primary knee and hip replacement; partial, bilateral, and revision joint procedures were excluded. Spine neurosurgery and orthosurgery are represented by lumbar and cervical spine fusion. Interventional cardiology is represented through procedures to implant pacemakers, defibrillators, and cardiac resynchronization therapy devices, which collectively are referred to as CRM devices.

The outcome of primary interest was the hospital's total variable costs for each patient's admission, as derived from the hospital's cost accounting system. This represents the direct costs of treating the patient, and does not include administrative overhead, the cost of providing charity care, and other indirect costs. The procedures included in this study represented 4.6% of the total revenue received by these 10 hospitals for patient care.[15]

We obtained the prices paid by the hospitals to device manufacturers and distributors for the implantable devices used for each patient. These prices are the sum of the amounts paid for each component of devices that have multiple components. We do not have data on brand names or device types, only on the total amount spent by the hospital. For each hospital we also measured the volume of joint replacement, spine fusion, and CRM procedures performed each year.

Patient characteristics included age, major diagnoses related to the procedure, the presence of complications, the presence of comorbidities, length of stay (LOS) in the hospital, discharge destination (home vs skilled nursing or rehabilitation facility), and insurance coverage (Medicare vs private insurance). Diagnoses for joint replacement included osteoarthritis, rheumatoid arthritis, aseptic necrosis, and fracture. Diagnoses for spine fusion included osteoarthritis, rheumatoid arthritis, fracture, intervertebral disk disorder, and spondylolisthesis. For spine patients we also measured the hospital's use of bone morphogenic protein (a biopharmaceutical cement to stimulate bone growth). For CRM, we distinguished 4 types of rhythm management devices: single and dual chamber pacemaker, pacemaker with cardiac resynchronization therapy (CRT), and implantable cardioverter defibrillator. Complications were defined by Aspen as in-hospital events found in observational studies as serious enough to require at least a 1-day LOS extension. Comorbidities were defined by Aspen in terms of secondary diagnoses associated in observational studies with at least a 1-day LOS extension.

Statistical Methods

We calculated descriptive statistics on procedure costs, device prices, LOS, and patient characteristics. We also calculated each hospital's average variable costs, device prices, and LOS.

For each of the 3 classes of procedures, we conducted multivariate regression analyses of variable costs per patient as a function of implantable device prices, patient LOS, hospital surgical volume, patient characteristics (age, diagnoses, complications, comorbidities), discharge destination, and insurance coverage. All cost and price

data were expressed as constant 2008 dollars. We also included a year dummy variable to identify procedure-specific trends in costs between 2008 and 2010.

For the joint surgery analyses we included a dummy variable indicating whether the procedure was for knee replacement (vs hip replacement). For the spine fusion we included a variable indicating whether the procedure was for lumbar fusion (vs cervical fusion). For CRM we included variables for whether the device implanted was a dual chamber pacemaker, pacemaker with CRT, or defibrillator (vs a single chamber pacemaker). The regression specifications included dummy variables for each hospital to control for facility-specific characteristics that influence variable costs beyond device prices, LOS, procedure volume, and patient characteristics. Standard errors were adjusted for heteroscedasticity.

The impact on each hospital of matching lowest local market costs in supply chain purchasing was measured by computing the difference between its price per implanted device and the lowest average price obtained by any hospital in the market. Similarly, the impact of adopting best local practices in discharge planning was measured as the difference between each hospital's LOS and the minimum LOS obtained by any local facility.

To estimate the potential cost reductions in dollar terms for each hospital, we multiplied the difference between the average price paid by the particular hospital and the lowest market price paid by any of the 10 hospitals by the coefficient on device price obtained from the regression equation. To determine the potential cost savings in discharge planning for each hospital, we multiplied the analogous LOS difference by the coefficient on LOS in each regression equation. As each of our 3 regression equations contains 2 (for joint and spine) or 4 (for CRM) subprocedures, we used the weighted price per device and weighted average LOS, where weights are the proportion of each type of subprocedure performed in each hospital.

RESULTS

Descriptive Statistics

Table 1 presents descriptive statistics on the patients undergoing each of the study procedures. Average costs range from $11,315 for joint replacement to $16,087 for CRM and $18,413 for spine fusion. There is substantial variation around these average figures, especially for spine and CRM procedures. The coefficient of variation (standard deviation divided by the mean) equals 0.221 for joint replacement, 0.574 for spine fusion, and 0.585 for CRM.

Average prices paid for implantable devices were $4771 for knee and $5534 for hip replacement; $4085 for cervical and $9326 for lumbar spine fusion; and $4984 for single chamber pacemaker, $5903 for dual chamber pacemaker, $10,220 for pacemaker with CRT, and $23,092 for defibrillator. The coefficient of variation for device prices was 0.312 for knee replacement and 0.321 for hip replacement, 0.690 for cervical spine fusion and 0.617 for lumbar spine fusion, 0.284 for single chamber pacemaker, 0.255 for dual chamber pacemaker, 0.268 for pacemaker with CRT, and 0.220 for defibrillator with CRT. Implantable devices account for 44% of procedure costs for joint replacement, 39% for spine fusion, and 59% for CRM.

The average length of patient stay was similar across the 3 sets of procedures, ranging from 3.1 to 3.8 days, but there was substantial variability across patients and facilities. The coefficient of variation for patient LOS is 0.307 for joint replacement, 0.586 for spine fusion, and 0.936 for CRM.

Multivariate Statistical Analyses

Table 2 presents multivariate regression results for the correlates of costs across the 3 procedures. Hospitals paying higher prices for implantable devices and experiencing longer LOS than nearby facilities incurred significantly higher costs per procedure than did hospitals with lower device prices and LOS.

Variability across hospitals in device prices accounted for a large share in the variability in procedure costs. A $1000 reduction in the price of the implantable device would reduce procedure costs per patient by $1160 for joint replacement, $1300 for spine fusion, and $1025 for CRM. Each additional day of patient stay increased hospital costs by $998 for joint replacement, $1570 for spine fusion, and $1254 for cardiac rhythm management procedures. Given the variability in device prices and patient LOS among nearby facilities, the scale of these illustrative reductions would be quite feasible (within 1 standard deviation).

Hospitals with high patient volumes incurred significantly lower costs per procedure than did facilities with low volumes, consistent with the literature suggesting efficiencies from scale and experience with major acute care procedures.[16,17] The effect was particularly strong for cervical and lumbar spine fusion. An additional 100 patients per year would be associated with lower average costs per patient of $548 for joint replacement, $2736 for spine fusion, and $1076 for CRM procedures. Patient demographics and case mix were associated with costs for all 3 procedures, as expected.

Table 1. Descriptive Statistics

Variable	Joint Replacement Surgery Mean (SD)	Spine Fusion Surgery Mean (SD)	Cardiac Rhythm Management Mean (SD)
Observations	6055	1846	1877
Variable costs per procedure ($)	11,315 (2498)	18,413 (10,570)	16,087 (9410)
Implantable device price ($)	5028 (1631)	7168 (5422)	9543 (7429)
Length of stay (days)	3.18 (0.98)	3.09 (1.81)	3.77 (3.53)
Annual volume (patients)	399.3 (191.5)	137.3 (45.1)	139.1 (64.3)
Medicare coverage	0.67 (0.47)	0.44 (0.50)	0.86 (0.35)
Age	69.24 (10.40)	60.11 (14.18)	77.83 (11.28)
Discharged to home	0.13 (0.34)	0.67 (0.47)	0.70 (0.46)
Complications	0.03 (0.18)	0.06 (0.23)	0.07 (0.25)
Comorbidities	0.31 (0.46)	0.20 (0.40)	0.50 (0.50)
Osteoarthritis	0.97 (0.17)	0.05 (0.22)	—
Rheumatoid arthritis	0.04 (0.19)	0.03 (0.17)	—
Aseptic necrosis	0.03 (0.16)	—	—
Fracture	0.01 (0.11)	0.03 (0.18)	—
Intervertebral disk disorder	—	0.55 (0.50)	—
Spondylolisthesis	—	0.07 (0.25)	—
Bone morphogenic protein	—	0.10 (0.30)	—
Knee replacement	0.66 (0.47)	—	—
Lumbar spine fusion	—	0.59 (0.49)	—
Dual chamber pacemaker	—	—	0.64 (0.48)
Pacemaker with cardiac resynchronization therapy	—	—	0.06 (0.23)
Implantable cardioverter defibrillator	—	—	0.20 (0.40)

Potential Cost Savings From Adopting Local Best Practices

The importance of device prices and patient LOS as potential targets for hospital cost control can be observed in their contribution to explaining total variance in variable cost per procedure (the R^2 statistic). To highlight this association, we calculated regression specifications similar to those reported in Table 2 but that excluded device price and LOS. These specifications explained 38% of the variance in procedure costs for joint replacement, 45% for spine fusion, and 70% for CRM procedures. Addition of device price to the specifications increased the variance explained by an additional 30 percentage points for joint, 32 points for spine, and 6 points for CRM procedures. The addition of both device price and patient LOS increased the percentage of variance explained to 80% for joint replacement, 80% for spine fusion, and 93% for CRM (as reported in Table 2). The hospital's performance on device purchasing and discharge planning thus accounted for one-fifth to two-fifths of its performance on variable procedure costs.

Table 3 presents the potential savings for each hospital in percentage terms. These estimates were calculated on the assumption that each hospital could reduce its price per device and patient LOS to the lowest average achieved by any facility in its local market.

The potential savings from device purchasing ranged across hospitals up to 29.3% of costs for joint replacement, 40.5% for spine fusion, and 21.1% for cardiac rhythm management. By construction, 1 hospital received no savings, as it already has implemented best local practice. The potential savings from reductions in patient LOS ranged across hospitals up to 8.8% for joint replacement, 17.7% for spine fusion, and 21.2% for CRM. The hospital with the greatest potential savings from supply chain management

Table 2. Determinants of Hospital Variable Cost per Procedure

	Joint Replacement Surgery	Spine Fusion Surgery	Cardiac Rhythm Management
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Implantable device price ($)	1.16 (0.01)[a]	1.30 (0.04)[a]	1.03 (0.03)[a]
Length of stay (days)	997.79 (21.23)[a]	1569.50 (89.57)[a]	1254.09 (43.96)[a]
Annual volume (patients)	–5.48 (0.17)[a]	–27.36 (7.04)[a]	–10.76 (7.04)[a]
Medicare coverage	220.80 (41.35)[a]	179.83 (305.87)	242.11 (201.50)
Age	–3.88 (1.97)[a]	–21.41 (11.58)	–34.12 (7.06)[a]
Discharged to home	–49.19 (43.73)	–789.91 (304.67)[a]	–486.15 (166.19)[a]
Complications	537.68 (122.08)[a]	–534.71 (569.65)	242.45 (330.16)
Comorbidities	289.42 (35.39)[a]	275.62 (399.42)	403.37 (116.28)[a]
Rheumatoid arthritis	124.36 (76.34)	1302.50 (1135.38)	—
Aseptic necrosis	–101.59 (93.19)	—	—
Fracture	493.84 (182.16)[a]	932.93 (954.66)	—
Intervertebral disk disorder	—	252.45 (237.84)	—
Spondylolisthesis	—	–176.15 (540.22)	—
Bone morphogenic protein	—	4527.06 (505.58)[a]	—
Knee replacement	423.62 (35.15)[a]	—	—
Lumbar spine	—	778.55 (321.20)[a]	—
Dual chamber pacemaker	—	—	–318.14 (220.70)
Pacemaker with cardiac resynchronization therapy	—	—	1926.64 (451.19)[a]
Implantable cardioverter defibrillator	—	—	505.51 (647.36)
Constant	3117.90 (202.01)[a]	6566.35 (1141.07)[a]	3939.12 (815.82)[a]
R^2	0.80	0.80	0.93
F–statistic	797.48[a]	211.31	836.11
Observations	6055	1846	1877

Regressions also control for hospital and year dummy variables.
Robust standard errors are in parentheses.
[a]$P \leq .05$ (2-tailed *t*-test)

was not the one facing the greatest potential savings from discharge planning. The combined potential savings from device prices and patient LOS range up to 35.2% for joint replacement, 61.8% for spine fusion, and 36.5% for CRM.

Table 4 presents procedure costs and potential savings for the 10 hospitals combined, under the assumption that all match the best local practices in supply chain management and discharge planning. Total potential savings are $9.9 million for joint replacement, $6.4 million for spine fusion, and $8.8 million for CRM. This accounts for 14.5%, 18.8%, and 29.1%, respectively, of total variable costs incurred by the 10 hospitals for these 3 procedures.

STUDY LIMITATIONS

This study should be evaluated in light of its limitations. We have data from only 10 hospitals in a single major suburban area. They cannot be fully representative of the national hospital population. Nevertheless, these facilities are similar to many community-based, nonacademic urban hospitals in terms of size, mix of nonprofit and for-profit ownership, and payer mix. We focus on 3 classes of major acute care procedures, rather than the full range of medical and surgical care offered in hospitals. Orthopedic joint replacement, spine fusion, and interventional cardiology are important sources of volume and expenditures at most acute-care hospitals, however, and must be among the targets for hospital management seeking to manage costs.

We did not have access to data that would permit insight into why particular hospitals paid higher prices for implantable devices or experienced longer patient LOS than comparable local facilities. It is possible that part of the observed variance is due not to lack of adoption of best practices but, rather, to unobserved differences in hospital

Table 3. Potential Cost Savings From Implementing Local Best Practices in Supply Chain Management and Discharge Planning

	Joint Replacement		Spine Fusion		Cardiac Rhythm Management	
Hospital	Supply Chain Savings as % of Costs	Discharge Planning Savings as % of Costs	Supply Chain Savings as % of Costs	Discharge Planning Savings as % of Costs	Supply Chain Savings as % of Costs	Discharge Planning Savings as % of Costs
1	26.4	8.8	14.1	17.7	15.3	21.2
2	29.3	5.5	50.1	11.7	16.4	12.5
3	4.0	7.2	3.9	16.2	18.2	5.3
4	19.5	6.4	40.5	16.6	19.8	11.2
5	8.9	0.8	6.9	3.8	16.9	14.3
6	6.3	5.1	2.5	11.5	0.0	10.8
7	23.7	3.8	25.0	0.0	18.8	1.5
8	5.8	0.8	10.8	7.0	14.8	6.3
9	8.9	1.3	9.4	6.3	10.1	8.0
10	0.0	3.9	5.7	5.6	21.1	8.4

Since local best practices vary by individual procedure, rather than by sets of procedures, columns contain a zero only when a hospital had the lowest supply chain cost or discharge planning cost across all procedures within each set of procedures.

Table 4. Total Incurred Procedure Costs and Potential Savings for 10 Hospitals From Adoption of Local Best Practices in Supply Chain Management and Discharge Planning

	Joint Replacement Surgery	Spine Fusion Surgery	Cardiac Rhythm Management
Total incurred costs	$68,510,369	$33,989,730	$30,195,611
Total potential savings	$9,925,039	$6,403,655	$8,794,178
Savings as % of costs	14.5%	18.8%	29.1%
Number of patients	6055	1846	1877

processes that generate offsetting improvements in quality or efficiency. It is possible, for example, that hospitals paying higher prices for device implants receive better service from the manufacturers and distributors in the form of staff training, technical support, and inventory management, which should increase efficiency and result in lower total variable costs per procedure. However, our data indicate that hospitals paying more for implantable devices incur higher, not lower, variable costs per procedure.

It is possible that the observed differences in procedure costs, device prices, and patient LOS are associated with unmeasured differences in patient outcomes. We did not find any association between device costs, patient LOS, and our measure of surgical complications, but we have no data on outcomes after discharge. It also is possible that the observed differences in costs, prices, and LOS are due to unmeasured differences among hospitals in case mix severity. We were able to adjust for many of the major case mix indicators relevant for these procedures. Interviews with executives and managers at several of the included hospitals indicated that the hospitals compete vigorously with one another for the same doctors and patients, and no interviewees believed that there were systematic differences in case mix between facilities.

DISCUSSION

This paper used detailed data from patients undergoing joint, spine, and CRM procedures in 10 hospitals within the same local market to quantify the variance in costs per procedure and 2 major contributors to those costs: prices for implantable medical devices and the length of the patient's stay. Our results permit the quantification of potential savings from improvements in hospital efficiency. According to our estimates, the adoption of best local practices in supply chain management could reduce procedure costs across hospitals by up to 29.3% for joint replacement, 40.5% for spine fusion, and 21.1% for CRM procedures. The potential savings from adoption of best practices in discharge planning and patient LOS could reduce procedure costs

across hospitals by up to 8.8% for joint replacement, 17.7% for spine fusion, and 21.2% for CRM procedures.

The potential for hospital cost savings is not limited to better management of medical device purchasing and patient LOS. Two recent case studies have highlighted the potential savings from improved patient scheduling, operating room staffing and turnaround, post surgical rehabilitation, orchestrated administration of drugs and physical therapy, and other factors.[18,19]

The challenge facing hospital management is to identify potential efficiency improvements and then actually capture them. Opportunities can be identified with the help of consultants with industry experience, including consulting firms associated with the hospitals' Group Purchasing Organizations. Many of these are now strongly focused on improving medical device procurement and pricing. Management in particular hospitals also can benefit from internal consultations with managers from affiliated facilities, one advantage of mergers and membership in multihospital delivery systems. Some hospital systems are supporting research initiatives on quality and efficiency improvement, sometimes in collaboration with health insurers and sometimes with industry associations.

The adoption and implementation of best practices can be promoted with the assistance of consultants from both inside and outside the hospital's larger organizational framework. Most important, however, is close alignment between hospital management and the medical staff physicians who make the clinical decisions that allocate resources within the organization. Efforts to improve discharge planning, reduce LOS, reduce complications, and avoid readmissions all must be led by physicians, as only they have the authority to decide what is to be done with and for each patient. Physicians also must lead hospital technology assessment committees, which decide which medical devices should be allowed into the facility, and must work closely with supply chain management on negotiating prices and conditions of service with device manufacturers.[20] Hospitals are strengthening their physician relationships through co-management agreements, joint ventures, and practice acquisition.

Hospitals are under pressure from payers to increase efficiency and reduce expenditures. Fortunately, major components of their cost structure are under hospital control if management adopts best practices from other local facilities. Imitation of local competitors is never easy. But it cannot be said that it cannot be done.

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REFERENCES

1. Melnick GA, Shen YC, Wu VY. The increased concentration of health plan markets can benefit consumers through lower hospital prices. *Health Aff (Millwood).* 2011;30(9):1728-1733.

2. Robinson J. Hospitals respond to Medicare payment shortfalls by both shifting costs and cutting them, based on market concentration. *Health Aff (Millwood).* 2011;30(7):1265-1271.

3. Cuellar AE, Gertler PJ. How the expansion of hospital systems has affected consumers. *Health Aff (Millwood).* 2005;24(1):213-219.

4. Gaynor M, Town R. The Impact of Hospital Consolidation—Update. Princeton, NJ: The Synthesis Project, The Robert Wood Johnson Foundation; 2012.

5. Robinson JC, MacPherson K. Payers test reference pricing and centers of excellence to steer patients to low-price and high-quality providers. *Health Aff (Millwood).* 2012;31(9):2028-2036.

6. Robinson JC, Brown TT. Increases in consumer cost sharing redirect patient volumes and reduce hospital prices for orthopedic surgery. *Health Aff (Millwood).* 2013;32(8):1392-1397.

7. CMS issues FY 2014 inpatient payment rule [press release]. Washington, DC: CMS; August 2, 2013. http://www.cms.gov/Newsroom/MediaReleaseDatabase/Press-Releases/2013-Press-Releases-Items/2013-08-02.html. Accessed September 21, 2013.

8. Kocher RP, Adashi EY. Hospital readmissions and the Affordable Care Act: paying for coordinated quality care. *JAMA.* 2011;306(16):1794-1795.

9. Hackbarth G, Reischauer R, Mutti A. Collective accountability for medical care — toward bundled Medicare payments. *N Engl J Med.* 2008;359(1):3-5.

10. Rastogi A, Mohr BA, Williams JO, Soobader MJ, de Brantes F. Prometheus payment model: application to hip and knee replacement surgery. *Clin Orthop Relat Res.* 2009;467(10):2587-2597.

11. Chernew M. Bundled payment systems: can they be more successful this time? *Health Serv Res.* 2010;45(5, pt 1):1141-1147.

12. Miller DC, Gust C, Dimick JB, Birkmeyer N, Skinner J, Birkmeyer JD. Large variations in Medicare payments for surgery highlight savings potential from bundled payment programs. *Health Aff (Millwood).* 2011;30(11):2107-2115.

13. Fisher ES, Shortell SM. Accountable care organizations: accountable for what, to whom, and how. *JAMA.* 2010;304(15):1715-1716.

14. Information on IHA programs, including medical device purchasing and episode-of-care payment, is available at www.iha.org.

15. Total patient care revenues for each hospital were obtained from the California Office of Statewide Health Planning and Development for 2008 and 2010. These data exclude nonpatient revenues, such as earnings off endowments, and billed but not collected charges.

16. Ho V, Aloia T. Hospital volume, surgeon volume, and patient costs for cancer surgery. *Med Care.* 2008;46(7):718-725.

17. Regenbogen SE, Gust C, Birkmeyer JD. Hospital surgical volume and cost of inpatient surgery in the elderly. *J Am Coll Surgeons.* 2012; 215(6):758-765.

18. Robinson JC. Case studies of orthopedic surgery in California: the virtues of care coordination versus specialization. *Health Aff (Millwood).* 2013;32(5):921-928.

19. Bohmer RMJ, Huckman RS, Weber J, Bozic KJ. Managing orthopaedics at Rittenhouse Medical Center. Cambridge, MA: Harvard Business School Case 607-152; June 2007. Revised March 2010.

20. Robinson JC. *Purchasing Medical Innovation.* Berkeley, CA: University of California Press. In press 2015. ■