Ann Surg Oncol (2014) 21:2129–2135
DOI 10.1245/s10434-014-3692-8

Annals of
SURGICAL ONCOLOGY
OFFICIAL JOURNAL OF THE SOCIETY OF SURGICAL ONCOLOGY

ORIGINAL ARTICLE – HEALTHCARE POLICY AND OUTCOMES

Differences in Perioperative Care at Low- and High-Mortality Hospitals with Cancer Surgery

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ABSTRACT

Objective. To evaluate adherence to perioperative processes of care associated with major cancer resections.

Background. Mortality rates associated with major cancer resections vary across hospitals. Because mechanisms underlying such variations are not well-established, we studied adherence to perioperative care processes.

Methods. There were 1,279 hospitals participating in the National Cancer DataBase (2005–2006) ranked on a composite measure of mortality for bladder, colon, esophagus, stomach, lung, and pancreas cancer operations. We sampled hospitals from among those with the lowest and highest mortality rates, with 19 low-mortality hospitals [(LMHs), risk-adjusted mortality rate of 2.84 %] and 30 high-mortality hospitals [(HMHs), risk-adjusted mortality rate of 7.37 %]. We then conducted onsite chart reviews. Using logistic regression, we examined differences in perioperative care, adjusting for patient and tumor characteristics.

Results. Compared to LMHs, HMHs were less likely to use prophylaxis against venous thromboembolism, either preoperative or postoperatively [adjusted relative risk (aRR) 0.74, 95 % CI 0.50–0.92 and aRR 0.80, 95 % CI 0.56–0.93, respectively]. The two hospital groups were indistinguishable with respect to processes aimed at preventing surgical site infections, such as the use of antibiotics prior to incision (aRR, 0.99, 95 % CI 0.90–1.04), and processes intended to prevent cardiac events, including the use of β-blockers (1.00, 95 % CI 0.81–1.14). HMHs were significantly less likely to use epidurals (aRR, 0.57, 95 % CI 0.32–0.93).

Conclusions. HMHs and LMHs differ in several aspects of perioperative care. These areas may represent opportunities for improving cancer surgery quality at hospitals with high mortality.

First Received: 21 February 2014;
Published Online: 8 April 2014

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INTRODUCTION

Major cancer resections are associated with considerable morbidity and mortality. Despite recent trends toward declining mortality rates overall, there remain significant differences in outcomes across hospitals.[1–3] For example, perioperative mortality rates for pancreatic cancer range from 1 to 16 %.[4] Although these data suggest that there is considerable room for quality improvement, how to best achieve this goal remains uncertain.[2,5] Among many efforts intended to reduce such variation, professional organizations, such as the American College of Surgeons, have implemented national outcomes registries aimed at providing hospitals with performance feedback. Others are pushing operative checklists designed to reduce errors and enhance teamwork in the operating room. Despite the potential benefits associated with these programs, none are designed to provide hospitals with insight on exactly how to improve outcomes.

A better understanding of how perioperative care differs at hospitals with low and high mortality may help fill this knowledge gap. Hospitals with low mortality rates may be more likely to adopt practice patterns known to be protective against adverse outcomes related to cancer surgery. Specifically, low-mortality hospitals (LMHs) may deliver more effective medical prophylaxis aimed at reducing surgical site infections (SSIs), venous thromboembolism (VTE), and cardiopulmonary complications, among the leading causes of death in this patient population.[6–8] LMHs may also be more aggressive with monitoring for hemodynamic instability, and the delivery of more effective pain control, which may lead to fewer cardiac and respiratory complications.[9–11]

In this context, we performed a national cohort study of 19 LMHs and 30 high-mortality hospitals (HMHs). This study summarizes the extent to which low- and HMHs differ in practice patterns in the management of patients undergoing major resections for bladder, colon, esophagus, stomach, lung, and pancreas cancers.

METHODS

Database and Subjects

The Commission on Cancer (CoC) National Cancer Database (NCDB) is a nationwide oncology outcomes program maintained by the American College of Surgeons and the American Cancer Society. The database represents over 1,200 cancer programs and more than 70 % of newly diagnosed cancer cases in the United States and Puerto Rico. Information on all types of cancer are prospectively tracked, analyzed, and submitted to the NCDB. The database includes information on patient, tumor, treatment, survival, and hospital characteristics.[12]

To identify the best and worst hospitals all 1,279 hospitals participating in the NCDB, 2005–2006, were identified and ranked according to a composite measure derived from operative volume and mortality for major resections of six cancers, including bladder, colon, esophagus, stomach, lung, and pancreas. Methods used to define the composite measure have been previously described in detail by our group.[13–15] Hospitals were ranked by their composite score and the highest and lowest hospitals were invited to participate. Starting at the top with very LMHs and at the bottom with very HMHs, we enrolled facilities until we reached the number implied by our sample size calculations. From among 41 very LMHs recruited, 22 declined participation. As a result, a total of 19 LMHs (unadjusted mortality 1.96 %) were enrolled in the study. Of the 77 very HMHs recruited, 47 declined to participate. Subsequently, 30 HMHs (unadjusted mortality 9.37 %) were enrolled in the study. Participating hospitals were representative of the entire gamut of the lowest and highest ranking hospitals, and even though a relatively large number of hospitals declined to participate (from both groups), those that did participate truly represent the "extremes." After the hospital selection process, onsite chart reviews were conducted at each facility. Due to inadequate data abstraction, 2 LMHS and 4 HMHs were excluded, and as a result 17 LMHs and 26 HMHs were included the analyses (Fig. 1).

Trained data abstractors performed onsite chart reviews of patients undergoing major resections for bladder, colon, esophagus, gastric, lung, and pancreas cancers (2006–2007) at the 49 participating facilities. Abstractors received training and a detailed instruction manual and data dictionary prior to the start of data collection. We maintained an open contact with abstractors in case there were any questions during the data collection process. Among hospitals with $\leq$150 patients, all records were abstracted. In higher volume hospitals with >150 patients, a random sample of up to 150 patients were selected for review to minimize data collection burden at larger hospitals. A total of 5,632 patients were included in the study, with 2,708 patients treated in LMHs and 2,924 treated in HMHs.

Investigators and hospitals were blinded to the performance status of each center. A validated data collection tool was used to capture patient level information on the receipt of 11 clinical practices related to important aspects of general perioperative care.[16] Seven of 11 measures reflected aspects of complication prophylaxis, including three related to SSIs, three related to VTE, and one related to cardiac events. In addition, we collected four variables related to perioperative hemodynamic monitoring and pain control.

Analysis

Our primary goal was to compare practice patterns at HMHs and LMHs. Risk-adjusted adherence rates, by hospital rank (HMH or LMH), were estimated using standard logistic regression. A similar model was used to obtain risk-adjusted odds ratios of receipt of specified processes of care, based on hospital rank (HMH vs. LMH). The covariates used for risk-adjustment included race, gender, age, American Society of Anesthesiologists physical status class (ASA), comorbid conditions,[17] functional status, dyspnea, ischemic heart disease, congestive heart failure, diabetes, cancer type, cancer stage and receipt of emergency surgery. All variance inflation factors were less than 10, indicating minimal correlation among the independent variables. To better estimate the effect of hospital rank on the receipt of the selected process of care, adjusted risk ratios were approximated from the adjusted odds ratios using a method adopted from Zhang and Yu.[18] All analyses were adjusted for clustering of patients within hospitals using robust estimates for the standard error.

Analyses were performed using SAS version 9.1 (SAS institute, Cary, NC) and STATA version 12 (StataCorp, College Station, TX) software. $p < 0.05$ was considered statistically significant and all tests were two-sided. The Institutional Review Board of the University of Michigan approved the study protocol.

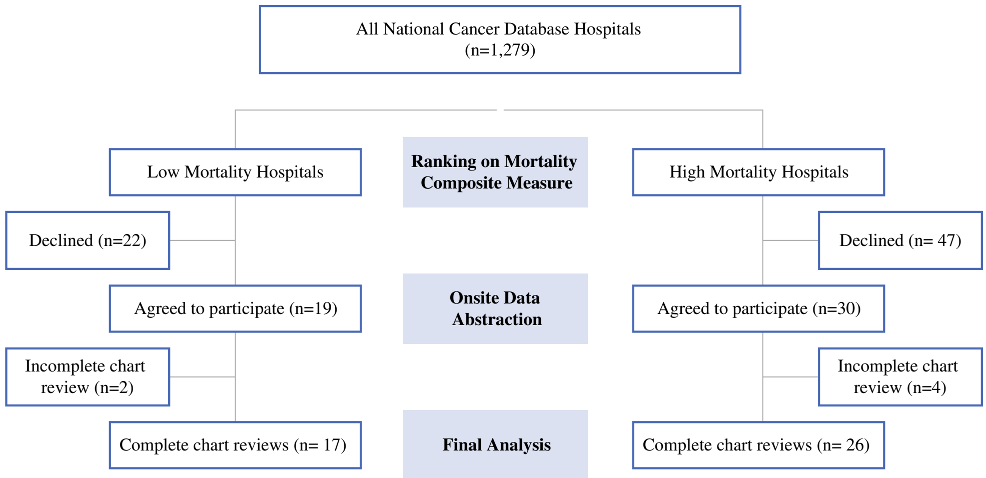

FIG. 1 Study design and hospital enrollment

RESULTS

Patient Characteristics

In general, patients treated at HMHs had greater illness severity compared to those at LMHs. HMHs had more patients with >2 comorbid conditions (22.1 vs. 16.2 %; $p < 0.001$), ASA class of 4 or 5 (13.1 vs. 5.7 %; $p < 0.001$), and patients who were dependent in regard to functional status (12.9 vs. 5.4 %; $p < 0.001$). Patients treated at HMHs were also more likely to have stage 4 cancer (12.1 vs. 9.3 %; $p < 0.001$). We observed significant differences in the types of cancer resections performed at the two groups of hospitals. LMHs performed a higher proportion of complex resections, with higher baseline risk, compared with HMHs. For example, LMH hospitals performed significantly more esophagus (6.9 vs. 1.3 %; $p < 0.001$) and pancreas (7.5 vs. 2.5 %; $p < 0.001$) resections. Colectomies represented 69.0 % of the procedures performed at HMHs. Overall, HMHs performed a higher percentage of emergency surgeries (6.3 vs. 3.3 %; $p < 0.001$). Before risk-adjustment mortality rates at low- and HMHs were 1.96 and 9.37 %, respectively. After risk adjustment, the difference in mortality rates narrowed, nonetheless, it was substantial (LMHs 2.84 % vs. HMHs 7.37) (Table 1).

Hemodynamic Monitoring and Pain Control

Compared with patients at LMHs, those undergoing treatment at HMHs were less likely to receive hemodynamic monitoring with arterial lines [adjusted relative risk (aRR), 0.30; 95 % CI, 0.17–0.47]. Overall, central venous and pulmonary artery catheters were used infrequently, and there were no measurable differences between the two hospital groups (Fig. 2). HMHs also had significantly lower rates of epidural catheter usage for postoperative pain management (aRR, 0.57; 95 % CI 0.32–0.93) (Fig. 2).

Prophylaxis Against Complications

Rates of preoperative VTE chemoprophylaxis were low overall, and did not differ significantly between high- and LMHs (aRR, 0.79; 95 % CI 0.39–1.38). However, HMHs were significantly less likely to use sequential compression devices (SCDs) before surgery, compared with LMHs (aRR 0.64 95 %CI 0.38–0.88). In the postoperative period, the adjusted rate of VTE chemoprophylaxis use was significantly lower among HMHs compared to LMHs (41.7 and 63.7 %, respectively) (aRR, 0.55; 95 % CI 0.3–0.85). The adjusted rate of postoperative SCD use was also lower among HMHs (62.8 % compared to 76.2 % in LMHs), although this did not reach statistical significance (aRR, 0.77; 95 % CI 0.47–1.01) (Table 2).

The two hospital groups were similar in their use of SSI prophylaxis (Fig. 3). There were no significant variations in the use of prophylactic antibiotics 1 h prior to incision (aRR, 0.99; 95 % CI 0.90–1.04). Both groups were also equally likely to record glucose levels on postoperative day 1 (aRR, 1.03; 95 % CI 0.89–1.09), and use hyperglycemia management protocols (aRR, 0.83; 95 % CI 0.53–1.19). However, HMHs were more likely to continue antibiotics >24 h after surgery (aRR, 1.43; 95 % CI 1.06–1.73). In terms of cardiovascular protective measures, LMHs and HMHs were indistinguishable in their continuation of β-blocker therapy in patients who were prescribed β-blockers prior to surgery (aRR, 1.00; 95 % CI 0.81–1.14).

TABLE 1 Characteristics of patients undergoing major cancer resections in low- and high-mortality hospitals

Characteristics	Low-mortality hospitals	High-mortality hospitals	*p* value
Number of patients	2,708	2,924	
Number of hospitals	19	30	
Patient characteristics			
Age, mean	67.8	69.1	<0.01
Race (black)	136 (5.0 %)	324 (11.1 %)	<0.01
Gender (female)	1,291 (47.7 %)	1,394 (47.7 %)	1.00
Comorbid conditions (>2)	440 (16.2 %)	647 (22.1 %)	<0.01
ASA class (4 or 5)	155 (5.7 %)	384 (13.1 %)	<0.01
Functional status (partially/totally dependent)	146 (5.4 %)	377 (12.9 %)	<0.01
Ischemic heart disease	464 (17.1 %)	551 (18.8 %)	0.018
Congestive heart failure	116 (4.3 %)	251 (8.6 %)	<0.01
Diabetes	456 (16.8 %)	655 (22.4 %)	<0.01
Body mass index	27.29	27.83	<0.01
Albumin	3.81	3.46	<0.01
Creatinine	1.05	1.08	<0.01
Hematocrit	36.88	34.95	<0.01
Platelets	270.30	284.54	<0.01
Emergency surgery	89 (3.3 %)	183 (6.3 %)	<0.01
Tumor characteristics			
Cancer types			
Lung	927 (34.2 %)	572 (19.6 %)	<0.01
Colon	1,006 (37.1 %)	2,019 (69.0 %)	
Esophagus	186 (6.9 %)	37 (1.3 %)	
Stomach	197 (7.3 %)	132 (4.5 %)	
Pancreas	204 (7.5 %)	72 (2.5 %)	
Bladder	188 (6.9 %)	92 (3.1 %)	
Stage			
0/I	941 (34.7 %)	980 (33.5 %)	<0.01
II	659 (24.3 %)	796 (27.2 %)	
III	531 (19.6 %)	650 (22.2 %)	
IV	252 (9.3 %)	355 (12.1 %)	
Mortality rates			
Unadjusted mortality rate	1.96 %	9.37 %	
Risk-adjusted overall mortality rate*	2.84 %	7.37 %	

ASA American Society of Anesthesiologists

* The covariates used for risk-adjustment included race, gender, age, ASA class, comorbid conditions, functional status, dyspnea, ischemic heart disease, congestive heart failure, diabetes, cancer type, cancer stage and receipt of emergency surgery

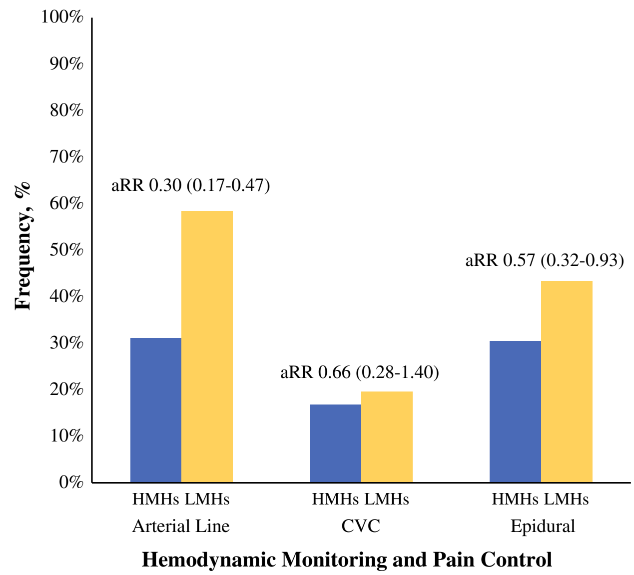

FIG. 2 Risk-adjusted rates of hemodynamic monitoring and pain control in low and high mortality hospitals. *CVC* central venous catheter

DISCUSSION

Among a nationwide sample of hospitals, we identified substantial variation in perioperative mortality for major lung, colon, esophagus, stomach, pancreas, and bladder cancer resections. The highest and lowest mortality hospitals did have different types of patients, noting greater illness severity at HMHs. The highest mortality hospitals have patients who are older and have more illnesses, and these hospitals perform more emergency surgeries.

Onsite chart reviews performed at hospitals with very low mortality and hospitals with very high mortality also revealed significant variations in perioperative practice patterns. Specifically, HMHs were less likely to use intraoperative hemodynamic monitoring, preoperative SCDs, postoperative VTE chemoprophylaxis, and epidural catheters. Conversely, HMHs and LMHs were virtually indistinguishable regarding SSI prophylaxis, including the use of antibiotics 1 h prior to incision, and cardioprotective measures, such as the continuation of β-blockers in the perioperative period. Among a small number of studies that have compared practices at hospitals according to their outcomes, this study is the most comprehensive to date and focuses on several evidence-based practices across multiple domains of perioperative care.

Other studies have similarly compared practices at hospitals with low and high rates of mortality following surgery. Perhaps the most widely recognized of these is a two-part study performed in the Department of Veterans Affairs based on its Surgical Quality Improvement Program (VAQIP). Daley et al.[19] performed site visits at hospitals with higher than expected and lower than expected mortality rates. Quality ratings were consistently higher for low outlier hospitals across seven domains of quality, and were statistically significant for overall quality of care and the availability of surgical technology and equipment. There were no significant differences regarding the collection and monitoring of performance indicators or in areas of communication and care coordination. A subsequent chart review by the same group aimed to validate the relationship between risk-adjusted outcomes and practice patterns, which did not identify measurable differences

TABLE 2 Risk-adjusted venous thromboembolism prophylaxis in low- and high-mortality hospitals

Venous thromboembolism prophylaxis	Percent of low-mortality hospitals	Percent of high-mortality hospitals	Percent of relative risk (95 % confidence interval)
Preoperative VTE prophylaxis			
Any chemoprophylaxis	29.5	24.4	0.79 (0.39–1.38)
Lovenox	2.3	9.6	–
Unfractionated heparin	25.8	14.2	–
SCDs	81.7	61.3	0.64 (0.38–0.88)
Both chemoprophylaxis and SCDs	23.3	13.7	0.49 (0.20–1.13)
Either chemoprophylaxis or SCDs	87.8	72.0	0.74 (0.50–0.92)
Postoperative VTE prophylaxis			
Any chemoprophylaxis	63.7	41.7	0.55 (0.31–0.85)
Lovenox	16.6	22.2	–
Unfractionated heparin	47.8	19.5	–
SCDs	76.2	62.8	0.77 (0.47–1.01)
Both chemoprophylaxis and SCDs	48.1	25.5	0.43 (0.21–0.78)
Either chemoprophylaxis or SCDs	91.6	78.9	0.80 (0.56–0.93)

SCD sequential compression devices, *VTE* venous thromboembolism

in adherence to processes of care between low- and high-mortality outliers.[20]

Given the nature of the study design, our analysis was not aimed at addressing casual inference between practice patterns and surgical outcomes. In our study, hospitals were enrolled based on outcomes, hence assessing relationships between processes and outcomes would be tautological. In other words, our study does not necessarily imply that specific aspects of perioperative care are responsible for differences in outcomes between the two hospital groups. However, those relationships can be considered in the context of previous literature. For example, it should not be surprising that prophylactic strategies against VTE are associated with hospital mortality. VTE, and more specifically pulmonary embolism, are among the leading causes of death among people undergoing cancer surgery.[21] There is a large body of randomized clinical trials that have examined the effectiveness of various combinations of prophylaxis and have demonstrated reduced VTE rates with pharmacologic prophylaxis in cancer patients.[22] Finally, previous hospital level studies have suggested that those with higher compliance rates with VTE prophylaxis have lower rates of VTE and mortality.[23,24]

Our findings that LMHs used hemodynamic monitoring more frequently are also consistent with the literature in this regard. A meta-analysis by Hamilton et al.[25] revealed that invasive monitoring reduced surgical mortality and morbidity among high-risk patients. It is important to note that many of the randomized controlled trials included in this meta-analysis also included interventions beyond hemodynamic monitoring, so there remain questions regarding the independent effect of monitoring alone.

Regarding the epidurals, we found that LMHs had substantially higher rates of catheter placement. Although we found that LMHs had higher rates of epidural use, the casual relationship between epidural catheters and surgical mortality remains unclear. Epidural catheters are often used for major thoracic and abdominal cancer resections because there is evidence that epidurals provide superior pain control and reduce the incidence of pulmonary complications compared to systemic opioids.[9,26–29] Although the results of a large number of clinical trials have been mixed, a meta-analysis of clinical trials among colectomy patients comparing epidural to parenteral opioids failed to identify any reduction in cardiopulmonary complications.[27] In this context, our findings suggest the possibility that the routine placement of epidurals may be a proxy of other aspects of perioperative care or hospital resources related to better outcomes.

Likewise, our null findings regarding SSI prophylaxis are consistent with what is known in this area. Although process measures regarding antibiotic prophylaxis in surgical patients have been widely accepted, numerous large population-based studies have failed to demonstrate that hospitals with high-compliance rates with Surgical Care Improvement Project SSI measures (SCIP-SSI) have lower SSI rates.[30–32] For example, Campbell et al.[30] examined practices at hospitals with low- and high-SSI rates, respectively. Low outlier hospitals were easily identified by site visitors. However, there were no measurable differences in the use of SCIP measures designed to prevent SSIs, such as the use of antibiotics 1 h prior to incision. Furthermore, because most SSIs are not fatal, it is not surprising that this process measure is not strongly linked with mortality.

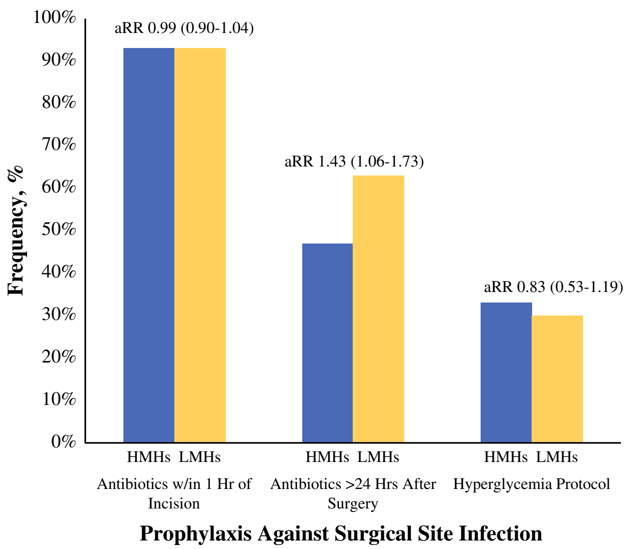

FIG. 3 Risk-adjusted rates of prophylaxis against surgical site infections in low and high mortality hospitals

With the use β-blockers, our findings that LMHs and HMHs have similar compliance rates are consistent with the current literature. The literature about the effectiveness of β-blocker administration is mixed.[33,34] Although some studies document advantages for high-risk patients,[35] subgroup analyses of broader population groups failed to confirm the benefit of perioperative β-blockers, specifically suggesting harm in low-risk patients.[34]

Our study has several limitations. First, only CoC-accredited hospitals were enrolled in the project. Hospitals participating in the NCDB are not a random sample of facilities performing cancer surgery in the United States. Even though we are examining very high- and very LMHs that demonstrate variation in illness severity, it is possible that CoC hospitals as a group are more committed to quality improvement, and that compliance rates and outcomes are not generalizable to other hospitals that provide cancer care. Second, for practical reasons, only hospitals at the extremes of mortality were sampled, thus practice patterns at the large majority of hospitals with intermediate levels of mortality are unknown. However, our findings on clinical practice patterns should be relevant across the entire spectrum of performance. Third, this study only focuses on a subset of perioperative practices and there is no doubt that many other aspects of practice, in and outside of the operating room, could help explain differences in mortality rates across hospitals.

Based on our own analysis of the National Inpatient Sample, more than 5,000 patients die annually after major cancer resections.[36] These large variations in mortality across hospitals suggest the possibility that some of these deaths could be avoided with quality improvement. Although our study does not provide definitive evidence on the effectiveness of particular practices, it does highlight several potential opportunities for further implementation and evaluation.

ACKNOWLEDGMENT This work was supported by the National Cancer Institute at the National Institutes of Health (NCI R01 CA098481 to J.D.B. and 2T32 CA009672-21 to S.L.R.).

DISCLOSURE John Birkmeyer has a financial interest in ArborMetrix, Inc., a clinical analytics company focused on hospital- and specialty-based care. The company was not involved with the study herein in any way.

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