Original Investigation

Impact of Minimally Invasive Surgery on Medical Spending and Employee Absenteeism

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IMPORTANCE As many surgical procedures have undergone a transition from a standard, open surgical approach to a minimally invasive one in the past 2 decades, the diffusion of minimally invasive surgery may have had sizeable but overlooked effects on medical expenditures and worker productivity.

OBJECTIVE To examine the impact of standard vs minimally invasive surgery on health plan spending and workplace absenteeism for 6 types of surgery.

DESIGN Cross-sectional regression analysis.

SETTING National health insurance claims data and matched workplace absenteeism data from January 1, 2000, to December 31, 2009.

PARTICIPANTS A convenience sample of adults with employer-sponsored health insurance who underwent either standard or minimally invasive surgery for coronary revascularization, uterine fibroid resection, prostatectomy, peripheral revascularization, carotid revascularization, or aortic aneurysm repair.

MAIN OUTCOMES AND MEASURE Health plan spending and workplace absenteeism from 14 days before through 352 days after the index surgery.

RESULTS There were 321 956 patients who underwent surgery; 23 814 were employees with workplace absenteeism data. After multivariable adjustment, mean health plan spending was lower for minimally invasive surgery for coronary revascularization (−$30 850; 95% CI, −$31 629 to −$30 091), uterine fibroid resection (−$1509; 95% CI, −$1754 to −$1280), and peripheral revascularization (−$12 031; 95% CI, −$15 552 to −$8717) and higher for prostatectomy ($1350; 95% CI, $611 to $2212) and carotid revascularization ($4900; 95% CI, $1772 to $8370). Undergoing minimally invasive surgery was associated with missing significantly fewer days of work for coronary revascularization (mean difference, −37.7 days; 95% CI, −41.1 to −34.3), uterine fibroid resection (mean difference, −11.7 days; 95% CI, −14.0 to −9.4), prostatectomy (mean difference, −9.0 days; 95% CI, −14.2 to −3.7), and peripheral revascularization (mean difference, −16.6 days; 95% CI, −28.0 to −5.2).

CONCLUSIONS AND RELEVANCE For 3 of 6 types of surgery studied, minimally invasive procedures were associated with significantly lower health plan spending than standard surgery. For 4 types of surgery, minimally invasive procedures were consistently associated with significantly fewer days of absence from work.

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As growth in US medical care expenditures continues to exceed overall economic growth,[1] there has been an increasing emphasis placed on establishing the value of medical and surgical technologies. Technological innovation in medical care has played an important role on both sides of the value equation—affecting both benefits and costs. Thus far, comprehensive information about the value of many treatments has been limited, in part owing to a lack of available data. Most studies on the value of medical technology have focused on health care expenditures and clinical outcomes but have ignored other measures of benefit and cost such as the impact of medical innovation on worker productivity. Employers in particular are interested in measuring the effects of medical care on worker productivity because employers are the primary sponsors of health insurance for nonelderly employed individuals and their families, who comprise 55% of Americans.[2]

During the past 2 decades, many surgical procedures have undergone a transition from a standard, open surgical approach to a minimally invasive one using laparoscopic, endoscopic, and catheter-based techniques. The diffusion of minimally invasive surgery may have affected expenditures in terms of both the cost per procedure and the number of procedures, as has been shown for prostatectomy.[3] As minimally invasive surgery typically permits shorter hospital stays and facilitates rapid postoperative recovery,[4,5] it is likely that such procedures have affected worker absenteeism as well.

Accordingly, we sought to assess the effects of switching from standard to minimally invasive surgery on both medical care expenditures and worker absenteeism in a large national sample of patients for 6 types of surgery that have both standard and minimally invasive options. It would be difficult to generalize from only 1 type of surgery, as each has a unique set of attributes. Conversely, across the 6 types of surgery we examined, there is substantial variation in many dimensions, including the disease being treated, the specialty of the operating physician, and the level of clinical complexity. Thus, studying this group of surgery offers a broad picture of the economic effects of minimally invasive procedures.

Methods

Study Sample

We identified a sample of adults aged 18 to 64 years who were enrolled in employer-sponsored health insurance and underwent 1 of 6 types of surgery. The sample was drawn from the 2000 to 2009 Truven MarketScan Research Databases, which include insurance claims data and employer-provided absenteeism data and are collected from self-insured firms and health plans around the United States. The numbers of firms and plans contributing data increased steadily during the study period; for the 3 most recent years, data were collected from 150 firms and 21 health plans covering all 50 states and Washington, DC.

We analyzed 6 types of surgery, each with both standard and minimally invasive treatment options, listed in descending order of sample size: (1) coronary revascularization (coronary artery bypass graft surgery vs percutaneous coronary interventions); (2) uterine fibroid resection (open abdominal hysterectomy and myomectomy vs vaginal/laparoscopic hysterectomy, vaginal/laparoscopic myomectomy, and uterine artery embolization); (3) prostatectomy (radical vs laparoscopic [with or without robotic assistance]); (4) revascularization of peripheral arterial occlusive disease (open surgery vs endovascular treatment); (5) carotid revascularization (carotid endarterectomy vs carotid arterial stenting); and (6) aortic aneurysm repair (open vascular surgery vs endovascular treatment). Diagnosis and procedure codes that define each surgery cohort are listed in eTable 1 in Supplement.

Patients were included in the study cohort based on their having an insurance claim indicating receipt of one of the study's types of surgery between January 1, 2001, and December 31, 2008, accompanied by a relevant study diagnosis in the MarketScan Commercial Database. For individuals with multiple claims for a given surgery, the earliest date was selected as the index surgery date. Individuals were excluded if they did not have continuous insurance coverage in the same plan for the 12 months before and after their index surgery date or if their total spending was less than $1, which implied erroneous data (eTable 2 in Supplement).

Because absenteeism data were available only for individuals who were employees of self-insured firms, we limited the analysis of absenteeism to this subset of patients. We linked data about paid time off and short-term disability workplace absences from the MarketScan Health and Productivity Management Database. We excluded patients who had 0 days of absence, as this implied erroneous data.

Outcomes

We assessed 2 outcomes: (1) health plan expenditures on medical care, including both medical and pharmacy costs; and (2) days absent from work, including vacation, sick leave, and short-term disability. Spending was adjusted to 2009 real dollars using the general Consumer Price Index. Following prior conventions,[6] we divided the time around the procedure index date into 3 periods: baseline (−380 days to −15 days), perioperative (−14 days to +28 days), and postoperative (+29 days to +352 days). Our outcomes reflect spending and absenteeism during the combination of the perioperative and postoperative periods.

Statistical Analysis

Patient characteristics—including surgery type, age, sex, number of Elixhauser comorbidities,[7] US census region, urban vs rural residence, and health plan type—were compared in the 6-surgery pooled sample according to whether the patients had undergone standard or minimally invasive procedures, using t tests or χ tests as appropriate. Comparisons were performed for both the full sample and the subsample of patients with absenteeism data.

For each procedure cohort, we used analysis of variance to compare mean medical expenditures by receipt of standard vs minimally invasive procedures for the baseline pe-

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riod and the combination of perioperative and postoperative periods (ie, from −14 to +352 days around the index procedure date). Parallel comparisons were made for absenteeism using analysis of variance with multiple imputation, as described in the eAppendix in Supplement.[8]

To assess the independent effects of undergoing minimally invasive surgery on medical expenditures and absenteeism, for each procedure cohort we estimated a series of regression models in which the outcome was either spending or absenteeism during the perioperative plus postoperative period. The baseline-adjusted model specification controlled for the patient-specific value of the outcome (ie, spending or absenteeism) during the baseline period. This approach is preferred to modeling a change score because it explicitly accounts for preexisting differences in baseline values of spending or absenteeism among patients receiving different surgical approaches.[9] The fully adjusted model specification added controls for year of procedure and the patient's propensity score for receiving minimally invasive surgery. The propensity score was derived from a cohort-specific logistic regression of surgical approach (ie, standard vs minimally invasive) as a function of patient age, sex, 29 indicators for Elixhauser comorbidities,[7] US census region, urban vs rural residence, and health plan type. We used a propensity score rather than multivariable regression adjustment because some surgical cohorts had small samples and some comorbidities were rare. For the expenditure outcomes, we estimated generalized linear models with a log link and used the modified Park test to identify the optimal distribution for the dependent variable.[10] To facilitate interpretation of model coefficients, we converted the regression results to the original (dollar) scale by computing the average partial effect of receiving minimally invasive surgery using the method of recycled predictions.[11] Confidence intervals were calculated from a nonparametric bootstrap with 1000 iterations. For the absenteeism outcome, we estimated linear regression models with heteroskedasticity-robust standard errors. We combined multiple imputation with auxiliary information on the number of days with medical care use to address the lack of complete data for this outcome (eAppendix in Supplement).[8]

To help understand the national impact of minimally invasive surgical technology on spending and workplace absenteeism among individuals with employer-sponsored insurance, we then projected our results to the national level using a previously developed approach.[12,13] We calculated the number of individuals with employer-sponsored insurance undergoing the 6 types of surgery nationally in 2009 by counting the number of claims for each cohort in the MarketScan Commercial Database and then weighting to the national level. Data from the household component of the 2009 Medical Expenditure Panel Survey were used to estimate the number of individuals with employer-sponsored insurance nationally. To match the MarketScan data, the Medical Expenditure Panel Survey data were stratified by respondents' US census region, age group, sex, urban vs rural location, and insurance policyholder status (policyholder or spouse/dependent). For each unique combination of strata, weights were calculated as the ratio of the total number of individuals with employer-sponsored insurance (from the Medical Expenditure Panel Survey) to the total number of individuals enrolled in plans (from MarketScan). The relevant weight was then applied to each patient in each cohort based on the applicable combination of strata.

To derive the total reductions in health plan spending and absenteeism attributable to the use of minimally invasive surgery among those with employer-sponsored health insurance, we multiplied the national projection of the number of individuals in each cohort undergoing minimally invasive surgery by the regression-based estimated effect. For the absenteeism estimates, to convert from days to years we divided by 250 (assuming 50 five-day workweeks per year). We repeated the calculation using the projected number of individuals receiving standard surgery nationally in 2009 to derive the potential national reductions in spending and worker absenteeism if patients who received standard surgery had instead received minimally invasive surgery.

All analyses used Stata version 12.1 statistical software (StataCorp LP). Two-tailed $P < .05$ was considered statistically significant. This study was approved by the University of Pennsylvania Institutional Review Board.

Results

Of the 321 956 patients in the 6 procedure cohorts, 196 700 (61.1%) received minimally invasive surgery and 125 256 (38.9%) received standard surgery (**Table 1**). There were 23 814 patients in the absenteeism subsample, because absenteeism data were available only for employees of self-insured firms. Of these, 8953 (37.6%) received standard surgery and 14 861 (62.4%) received minimally invasive surgery. Patients who underwent minimally invasive procedures were more often older, were more often male, had higher numbers of comorbidities, more often lived in rural areas, and were covered by less restrictive health plans such as comprehensive and preferred provider organization plans. Patient characteristics by surgery type are shown in eTable 3 in Supplement for the overall sample and eTable 4 in Supplement for the absenteeism subsample.

During the baseline period prior to the index surgery, differences in the unadjusted levels of health plan spending and days absent for standard and minimally invasive surgery were frequently statistically significant but nevertheless qualitatively close in magnitude for most cohorts (**Table 2**). In contrast, during the combined perioperative and postoperative period, unadjusted mean health plan spending was significantly lower among patients receiving minimally invasive surgery for 3 cohorts (coronary revascularization, uterine fibroid resection, and peripheral arterial revascularization) and significantly higher for 2 cohorts (prostatectomy and carotid revascularization). Unadjusted mean days absent during the combined perioperative and postoperative period were statistically lower for patients undergoing minimally invasive surgery in 5 cohorts (all but aortic aneurysm repair).

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Table 1. Patient Characteristics

Characteristic	Full Sample, %			Absenteeism Subsample, %		
	Standard (n = 125 256)	Minimally Invasive (n = 196 700)	*P* Value	Standard (n = 8953)	Minimally Invasive (n = 14 861)	*P* Value
Surgery type						
Coronary revascularization	30.1	60.3	<.001	29.8	64.3	<.001
Uterine fibroid resection	47.2	27.2		46.3	21.9	
Prostatectomy	11.0	5.1		14.4	7.2	
Peripheral revascularization	2.8	6.5		2.6	5.8	
Carotid revascularization	7.8	0.4		5.9	0.3	
Aortic aneurysm repair	1.2	0.5		1.0	0.5	
Age, y						
Mean (SD)	50.5 (8.7)	52.1 (7.8)	<.001	48.9 (8.3)	50.8 (7.2)	<.001
Group						
18-35	4.3	2.3	<.001	5.1	2.2	<.001
36-45	21.9	16.1		25.2	17.2	
46-55	34.5	36.0		39.6	45.5	
56-64	39.3	45.6		30.1	35.1	
Sex						
Male	42.4	55.7	<.001	48.3	69.4	<.001
Female	57.6	44.3		51.7	30.6	
Comorbid conditions/patient, No.						
0	35.5	20.9	<.001	45.2	22.8	<.001
1	32.9	40.4		35.2	50.9	
2	18.3	23.9		13.9	20.4	
≥3	13.3	14.8		5.7	5.9	
US census region						
Northeast	8	8.8	<.001	14.6	14.4	<.001
Midwest	25.5	28.6		28.7	37.2	
South	55.6	51.5		44.9	37.2	
West	10.6	10.8		11	11.1	
Unknown	0.4	0.4		0.7	0.1	
Residence						
Rural	22.5	21.5	<.001	10.5	12.6	<.001
Urban	77.5	78.5		89.5	87.4	
Health plan type[a]						
Less restrictive	67.9	70.5	<.001	55.7	64.7	<.001
More restrictive	32.1	29.5		44.3	35.3	

[a] Less restrictive health plan types include comprehensive and preferred provider organization plans. All others are categorized as more restrictive, including health maintenance organization, point of service, and high-deductible health plans.

The differences in perioperative and postoperative spending and absenteeism were similar after adjustment for spending during the baseline period (**Table 3**). Mean health plan spending was significantly lower for minimally invasive surgery compared with standard surgery for coronary revascularization (−$31 418), uterine fibroid resection (−$1311), and peripheral revascularization (−$11 796) and significantly higher for prostatectomy ($1228) and carotid revascularization ($6229). Results were qualitatively unchanged when fully adjusted. Moreover, after adjusting for baseline differences in days absent, patients undergoing minimally invasive surgery missed significantly fewer days of work during the perioperative and postoperative periods compared with those undergoing standard surgery in 5 cohorts; the differences ranged from 6.3 fewer days (prostatectomy) to 37.4 fewer days (coronary revascularization). The results were similar after full adjustment, except that the difference between minimally invasive surgery and standard surgery was no longer statistically significant for carotid revascularization.

For 2009, we projected that across the 6 cohorts nationally there were 248 632 individuals with employer-sponsored health insurance who underwent standard surgery and

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Table 2. Mean Unadjusted Spending and Days Absent in the Baseline Period and Both Perioperative and Postoperative Periods

Surgery Type	Patients, No.	Baseline			Perioperative/Postoperative		
		Standard, Mean	Minimally Invasive, Mean	*P* Value	Standard, Mean	Minimally Invasive, Mean	*P* Value
Health plan spending, $							
Coronary revascularization	156 247	8908	8406	<.001	80 900	48 997	<.001
Uterine fibroid resection	112 595	4719	4661	.22	15 326	14 034	<.001
Prostatectomy	23 860	7431	7924	<.001	26 317	27 758	.001
Peripheral revascularization	16 267	22 905	19 584	<.001	64 467	51 070	<.001
Carotid revascularization	10 411	15 936	22 122	<.001	37 379	47 158	<.001
Aortic aneurysm repair	2576	16 060	18 682	.003	69 311	67 618	.60
Days absent, No.							
Coronary revascularization	12 229	30.3	28.4	.05	99.7	61.7	<.001
Uterine fibroid resection	7402	30.4	28.8	.05	61.9	50.4	<.001
Prostatectomy	2355	29.8	30.3	.72	66.4	60.4	.01
Peripheral revascularization	1100	35.9	37.1	.71	77.8	63.7	.01
Carotid revascularization	565	39.5	36.4	.76	76.6	53.0	.03
Aortic aneurysm repair	163	33.0	47.0	.09	86.8	75.6	.36

Table 3. Adjusted Differences in Perioperative and Postoperative Spending and Days Absent by Standard vs Minimally Invasive Surgery

Surgery Type	Patients, No.	Mean Difference (95% CI)	
		Baseline Adjusted	Fully Adjusted
Health plan spending, $			
Coronary revascularization	156 247	−31 418 (−32 229 to −30 636)[a]	−30 850 (−31 629 to −30 091)[b]
Uterine fibroid resection	112 595	−1311 (−1533 to −1103)[b]	−1509 (−1754 to −1280)[c]
Prostatectomy	23 860	1228 (337 to 2015)[a]	1350 (611 to 2212)[b]
Peripheral revascularization	16 267	−11 796 (−15 677 to −8497)[b]	−12 031 (−15 552 to −8717)[b]
Carotid revascularization	10 411	6229 (2886 to 9658)[b]	4900 (1772 to 8370)[b]
Aortic aneurysm repair	2576	−2723 (−8891 to 3652)[a]	−3268 (−9681 to 3242)[b]
Days absent, No.			
Coronary revascularization	12 229	−37.4 (−40.7 to −34.0)	−37.7 (−41.1 to −34.3)
Uterine fibroid resection	7402	−11.5 (−13.8 to −9.2)	−11.7 (−14.0 to −9.4)
Prostatectomy	2355	−6.3 (−10.9 to −1.7)	−9.0 (−14.2 to −3.7)
Peripheral revascularization	1100	−14.5 (−25.3 to −3.7)	−16.6 (−28.0 to −5.2)
Carotid revascularization	565	−22.8 (−43.7 to −1.9)	−21.0 (−43.7 to 1.7)
Aortic aneurysm repair	163	−15.8 (−39.8 to 8.2)	−19.2 (−47.1 to 8.8)

[a] Poisson model distribution.
[b] Gamma model distribution.
[c] Inverse gaussian model distribution.

Table 4. Health Plan Spending National Projections, 2009

Surgery Type	Patients, No.		Health Plan Spending/ Patient, $	Projected Impact, $ in Millions[a]	
	Standard	Minimally Invasive		If Standard Were Switched to Minimally Invasive	From Minimally Invasive
Coronary revascularization	70 153	266 425	−30 850	−2164	−8219
Uterine fibroid resection	134 328	175 561	−1509	−203	−265
Prostatectomy	16 626	45 571	1350	22	62
Peripheral revascularization	6968	40 123	−12 031	−84	−483
Carotid revascularization	18 357	2409	4900	90	12
Aortic aneurysm repair	2200	3108	−3268	−7	−10
Total	248 632	533 196	NA	−2346	−8904

Abbreviation: NA, not applicable.
[a] Health plan spending projected impact was calculated as the product of the number of patients and the fully adjusted health plan spending per patient.

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Table 5. Absenteeism National Projections, 2009

Surgery Type	Patients, No.		Days Absent/ Patient, No.	Projected Impact, Years Absent[a]	
	Standard	Minimally Invasive		If Standard Were Switched to Minimally Invasive	From Minimally Invasive
Coronary revascularization	70 153	266 425	−37.7	−10 582	−40 186
Uterine fibroid resection	134 328	175 561	−11.7	−6287	−8216
Prostatectomy	16 626	45 571	−9.0	−595	−1632
Peripheral revascularization	6968	40 123	−16.6	−462	−2659
Carotid revascularization	18 357	2409	−21.0	−1541	−202
Aortic aneurysm repair	2200	3108	−19.2	−169	−238
Total	248 632	533 196	NA	−19 635	−53 134

Abbreviation: NA, not applicable.

[a] Years absent projected impact was calculated as the product of the number of patients and the fully adjusted days absent per patient divided by 250 days per work year.

533 196 who underwent minimally invasive surgery. We combined these projections with our fully adjusted regression-based estimates to calculate the net impacts of minimally invasive surgery under the assumption that everyone with employer-sponsored health insurance was employed. In 2009, the use of minimally invasive procedures for the 6 types of surgery we studied was responsible for projected national reductions of $8.9 billion in health plan spending and 53 134 person-years in workplace absenteeism (**Table 4** and **Table 5**). Furthermore, if standard surgery in 2009 had been replaced by minimally invasive surgery, we projected that health plan spending would have been reduced by an additional $2.3 billion and workplace absenteeism nationwide would have been further reduced by 19 635 person-years. These findings were driven largely by coronary revascularization, which accounted for 43.1% of all cases in 2009 and had the largest reductions from minimally invasive surgery in health plan spending (mean difference, −$30 850) and absenteeism (mean difference, −37.7 days).

Comment

Across a diverse set of 6 surgery types, the net impact of minimally invasive surgery was to reduce health plan spending and workplace absenteeism. In 2009 for these 6 types of surgery, we projected nationally that the use of minimally invasive procedures reduced health plan expenditures by more than $8.9 billion and workplace absenteeism by more than 50 000 person-years, which, at the 2009 national average wage of $40 712, was worth $2.2 billion.[14] Furthermore, if minimally invasive procedures had been used for all patients undergoing any of the 6 types of surgery in the United States in 2009, spending would have decreased by an additional $2.3 billion and absenteeism by another 20 000 person-years, similarly worth $800 million. Altogether, the sum of these effects exceeds $14 billion.

The aggregate estimates mask the effects of minimally invasive procedures specific to each surgery. Minimally invasive procedures significantly reduced health plan spending for coronary revascularization, uterine fibroid resection, and peripheral revascularization but significantly increased costs for prostatectomy and carotid revascularization. Moreover, they significantly reduced workplace absenteeism for 4 types of surgery (coronary revascularization, uterine fibroid resection, prostatectomy, and peripheral revascularization) and increased it for none. These findings were robust to statistical adjustment.

Because we did not assess differences in clinical outcomes, our findings should be interpreted with caution. Regardless of their economic benefits, minimally invasive procedures clearly remain inappropriate for some patients. Nevertheless, our findings do draw attention to important differences between standard and minimally invasive surgical approaches in nonclinical outcomes. Given that inpatient lengths of stay for minimally invasive procedures were already recognized as being shorter on average than for their standard counterparts,[4,5] it is perhaps not surprising that we found that total workplace absenteeism in the year after surgery was also much lower for patients who had undergone minimally invasive procedures. The full benefit to the patient of what is measured here as reduced workplace absenteeism may extend beyond economic productivity gains to include quality-of-life advantages from faster recovery times, which were not quantified in our analysis but would be relevant for patients regardless of their employment status.

Our findings have direct relevance for health care payers. For 4 types of surgery, we found that patients receiving minimally invasive procedures had nominally if not statistically significantly lower medical spending and workplace absenteeism on average. For the other 2 types of surgery, we can calculate the ratio of spending to days absent to obtain an average effective price per reduced day of absence using the fully adjusted results in Table 3. This yields an average price of about $140 per day for prostatectomy and $300 per day for carotid revascularization; average prices from the baseline-adjusted results are about $50 higher. Basic economic theory suggests that, all else equal, an employer should prefer a minimally invasive procedure for an employee when it has both lower costs and absenteeism than its corresponding standard surgery or when its effective price is lower than the employee's wage.

The principal implication of our results for policy is that a focus on evaluating new medical technologies based on their

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clinical outcomes alone, or even an evaluation including direct medical costs, may be too narrow. Increased worker productivity is one important example of a benefit that follows from shorter surgical recovery times produced by new technologies but cannot be adequately measured using administrative claims or other data sources typically used for comparative effectiveness research. A more comprehensive accounting of the benefits and costs of medical innovation is necessary to ensure that manufacturers' research and development strategies, payers' coverage policies, and health care providers' and patients' treatment decisions are fully informed and are thus economically optimal.

Our study has several limitations. Most notable is that our data do not permit examination of clinical outcomes; our findings must therefore be interpreted in light of possible differences between standard and minimally invasive approaches in clinical outcomes. However, the standard and minimally invasive options for the 6 types of surgery chosen for this study have generally been demonstrated to produce comparable clinical outcomes. Second, patients who underwent standard procedures may have been different from those who underwent minimally invasive procedures in clinically important ways that may also have influenced spending and absenteeism. Despite our adjustment for observable factors, any omitted variable bias would likely exaggerate the benefits of minimally invasive surgery in situations where, for example, patients with more severe disease were selected for standard surgery. Third, our data and imputation strategy may have led to inaccurate measurement of absenteeism. Although there is little reason why this limitation would affect standard and minimally invasive procedures differently, it is important to recognize that data on absenteeism were available only for patients working at self-insured firms. Fourth, our national projections of the anticipated effects of switching from standard to minimally invasive surgery represent upper bounds, as they are based on unrealistic assumptions that all patients with employer-sponsored health insurance are workers and that minimally invasive surgery could have substituted for standard surgery for all patients. Fifth, our findings may not be representative of other types of surgery and our analysis was limited by the small samples of patients with absenteeism data, particularly for carotid disease and aortic aneurysm repair. Last, although we treat minimally invasive surgery uniformly, our data conceal potentially important differences among the technologies underlying various minimally invasive approaches; ideally, an individual technology should be evaluated on its own merits.

Conclusions

For 3 of 6 types of surgery studied, minimally invasive procedures were associated with significantly lower health plan spending than standard surgery. For 4 of the 6 types of surgery, minimally invasive procedures were consistently associated with significantly fewer days of absence from work. Although the effect size depends critically on the clinical setting, the net impact of minimally invasive surgery across the 6 types of surgery studied was to lower both health care spending and worker absenteeism.

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Invited Commentary

Taking a Broader Perspective on the Benefits of Minimally Invasive Surgery

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Although the clinical benefits of minimally invasive surgery are well known, the study by Epstein et al[1] in this issue of *JAMA Surgery* provides a much broader perspective. Traditional clinical research asks a relatively narrow but important question: "Is this procedure better for this patient?" Dr Epstein, a health economist at the University of Pennsylvania, and his colleagues instead ask the question, "Is the trend toward less invasive procedures better for society?" The answers to these two questions are not necessarily the same. Less invasive procedures could provide clinical benefits to patients but increase the costs to society. Indeed, in most industries outside health care, higher quality costs more.

However, in this study, the authors find that the trend toward less invasive surgery is also better for society. Using data from national health insurance claims and workplace absenteeism data, they found lower costs (to the health care payer) and fewer days absent for patients undergoing less invasive procedures. For some procedures, the results were quite dramatic, with patients undergoing less invasive procedures going back to work several weeks earlier. Importantly, they examined a broad range of technologies, including laparoscopy, robotic surgery, and endovascular therapies, which could extend the generalizability of their findings.

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There is one problem with the study design that raises questions about the accuracy of their results, however. Because the study used administrative data, there was not much clinical detail on how patients were chosen for less invasive vs standard surgery. An ideal study design to answer this question would be to randomize patients eligible for both types of procedures and assess outcomes in these 2 comparable groups. The lack of randomization in this study raises questions about whether the 2 groups are comparable.

Patients who have less invasive procedures, as opposed to traditional surgery, may be different in ways that were not measured but drive important outcomes (ie, selection bias). In this study, selection bias likely results in an overestimation of the benefits of less invasive procedures. Standard open surgical approaches are often offered to patients who have advanced disease that is not amenable to a less invasive strategy. For example, abdominal aortic aneurysms that extend to the renal arteries are often not candidates for endovascular repair. Patients undergoing these complex aneurysm repairs have much longer hospital stays that lead to complications and disability. Some of the differences in outcomes between less invasive and standard therapy in this study are likely due to such differences in patient disease.

The authors used several standard approaches for addressing selection bias. They used multivariate regression models to adjust for differences in observed variables, including propensity scores. Unfortunately, this modeling strategy cannot adjust for unobserved variables (like disease severity) and therefore does not correct for selection bias, as discussed earlier. Alternatively, the authors could have addressed this problem with a more rigorous study design. Rather than using a cross-sectional modeling strategy, they could have leveraged changes over time or differences in practice patterns to conduct an instrumental variable analysis. This method, commonly applied in economics, uses a variable that is related to treatment choice but not outcomes to create a pseudorandomization of study subjects. Used correctly, it is a powerful tool to mitigate selection bias.

While the potential for selection bias in this study is a problem, it is not a fatal flaw. Differences in patient selection account for some, but not likely all, of the benefits found with less invasive procedures. This study is also valuable because it broadens our thinking to include the societal perspective, which is not always considered in the clinical literature.

ARTICLE INFORMATION

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