

Profile of Inpatient Operating Room Procedures in US Hospitals in 2007

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Objective: To provide an overview of inpatient operating room (OR) procedures in the United States.

Design, Setting, and Patients: Healthcare Cost and Utilization Project 2007 Nationwide Inpatient Sample discharge data from a sample of US short-term, acute-care, nonfederal hospitals.

Main Outcome Measures: National volume of OR procedures overall and by type of procedure, resource use and costs, most frequent and expensive procedures, and trends.

Results: Fifteen million OR procedures were performed in 2007 (495 procedures/10 000 population). Only 26.4% of hospitalizations involved an OR procedure; however, OR-related stays were responsible for 46.8% of hospital costs (\$161 billion). Patients aged 65 years and older were 2 to 3 times more likely to experience OR procedures (eg, 1327 procedures/10 000 persons among those aged 65-84 years

vs 626 procedures/10 000 persons for those aged 45-64 years). Compared with non-OR inpatients, OR patients were less severely ill (20.5% had the highest severity of illness vs 24.6% for non-OR patients) and used more resources (\$2900/day for OR patients vs \$1400/day for non-OR patients). The 15 most expensive procedures accounted for half of all procedure-related hospitalization costs and one-fourth of total hospital costs. Volumes for 4 of the most expensive procedures increased between 1997 and 2007: 20% for percutaneous transluminal coronary angioplasty, 46% for cesarean delivery, 46% for knee replacement, and 45% for spinal fusion. The volume of percutaneous transluminal coronary angioplasty declined 20% from 2006 to 2007, compared with a 56% increase in the prior decade.

Conclusions: Procedures in the OR represent a large portion of hospital costs, and these costs are concentrated in few procedure types.

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OPERATING ROOM (OR) procedures represent the most intensive health care intervention; they are performed in a relatively short time and are highly invasive and expensive. Procedures in the OR are also a major reason for use of hospitals. Hospital care is a major portion of US health care expenditures (30.7%)¹; thus, understanding OR procedures in the hospital provides important information about how health care resources are used. Such an understanding is critical in debates about how to improve the population's health while attempting to constrain growth in health care costs.

See Invited Critique at end of article

The literature is replete with studies on individual OR procedures and relatively homogeneous groups of procedures.²⁻⁴ However, to our knowledge, there have been no published articles on the epidemiology and resource use of OR procedures in general. To fill this gap, this study

provides an overview of inpatient OR procedures in the United States. We describe the volume of inpatient OR procedures, associated resource use, the most frequent and expensive OR procedures, and trends in inpatient OR procedure use from 1997 to 2007.

METHODS

DATABASES

This study used the Nationwide Inpatient Sample (NIS)⁵ from the Healthcare Cost and Utilization Project, developed by the Agency for Healthcare Research and Quality. The NIS is a nationwide database of hospital inpatient stays, including a 20% stratified, nationally representative sample of short-term, acute-care, nonfederal hospitals.⁶ It includes inpatient records for all sampled hospitals regardless of payer. The 2007 NIS includes 1044 hospitals drawn from a sampling frame of a census of hospitals from 40 states that composed 90% of all discharges in the United States. It includes 8 million unweighted records, extrapolated to 39.5 million hospital discharges in the United States. Weighting takes into account key hospital characteristics associated with health care outcomes: region, ownership, teaching status, location, and number of beds. Estimates from the NIS are ac-

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curate and precise compared with other national data.⁶ Trend data were drawn from the 1997-2006 NIS, sampled each year to ensure representativeness.⁷ Population estimates are from the US Census Bureau and zip code-level data through a private vendor (Claritas, San Diego, California).⁸⁻¹¹

The NIS contains data on patient demographic characteristics, primary expected payer, median household income of the patient's zip code (in quartiles), rural or urban residence of the patient, census region of the hospital, type of admission, diagnoses and procedures coded using the *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)*, diagnosis-related group (DRG), discharge status, and resource use (length of stay and total hospital charges). Information is missing on a small proportion of cases, ranging from fewer than 10 cases missing length of stay (although 380 cases were excluded as outliers) to 0.3% of cases missing data on sex. The one exception is total charges, for which 2.0% of cases had missing data.

IDENTIFYING OR PROCEDURES

Up to 15 procedure codes were included on the NIS. The principal procedure was performed for definitive treatment rather than for diagnostic or exploratory purposes. If 2 procedures met this definition, the procedure most related to the principal diagnosis was considered principal. All listed procedures included all procedures performed during the same intervention or at another time during the hospitalization. The Clinical Classifications Software (CCS) categorizes *ICD-9-CM* codes into 1 of 231 clinically meaningful categories.¹² This clinical grouper summarizes information on types of procedures. Only 1 occurrence of a CCS category was counted per hospitalization because multiple codes may be used for related procedures performed during a single operation. For example, multiple codes for spinal fusion may appear on the record when multiple vertebrae were fused, but only 1 code was counted here. The CCS categories that comprised heterogeneous procedures (eg, other therapeutic OR procedures on the nervous system) were not included; however, constituent *ICD-9-CM* codes in each of these high-frequency (or high-cost) heterogeneous CCS categories were examined to determine whether single codes or homogeneous groups of procedure codes would warrant inclusion.

The OR procedures were defined using procedure classes, which categorize each *ICD-9-CM* procedure code as either major therapeutic, major diagnostic, minor therapeutic, or minor diagnostic.¹³ Major procedures are valid OR procedures according to DRGs as determined by physician panels who classified procedure codes based on whether the procedure would be performed in an OR in most hospitals.¹⁴

MEASURES OF SEVERITY OF ILLNESS AND MORTALITY

All-patient-refined DRGs provided a severity level for each case based on principal diagnosis, unrelated secondary diagnoses, procedures, and age.¹⁵ Severity levels 3 and 4 reflect multiple-organ impairment and are highly associated with resource use and risk of mortality. A count of the number of unrelated comorbidities was included as another measure of illness severity.¹⁶ Comorbidities were defined as secondary conditions unrelated to the principal reason for hospital admission, based on an approach used in both medical and surgical patients.¹⁷⁻¹⁹ In-hospital mortality was defined using hospital discharge status.

CHARGES AND COSTS

Charges represent the amount billed by the hospital and do not include professional (physician) fees billed separately from fa-

cility fees. Charges reflect the amount the hospital charged for the stay, not just the procedure, and cannot be apportioned specifically to procedures. When a case was missing charges, a value was imputed using the mean charge for all discharges with non-missing charges in the same DRG. Charges were converted to costs using cost-charge ratios based on hospital accounting reports from the Centers for Medicare and Medicaid Services in hospital cost reports.²⁰ Thus, costs represent the hospital cost of production, not reimbursed amounts or costs to consumers or payers. Aggregate costs were calculated as the sum of all costs for all hospitalizations in the United States. We examined costs for the hospitalization during which procedures were first-listed, or principal, to avoid double counting.

STATISTICAL ANALYSES

Analyses were conducted using SAS version 9.2 statistical software (SAS Institute, Inc, Cary, North Carolina), and cases were weighted to national estimates. Standard errors were calculated taking into account the clustering of patients within hospitals and the sampling design of the NIS.²¹ Differences between estimates and in trends noted in the text are statistically significant at $P < .001$ (to account for multiple comparisons) using z tests.

Data used in this study were exempt from human subjects review because no individual is personally identifiable in the data.

RESULTS

In 2007, about 15 million OR procedures were performed in US hospitals at a rate of 495 OR procedures/10 000 population. These procedures were performed during 10.4 million hospitalizations; 26.4% of all hospitalizations involved an OR procedure.

Table 1 shows details about procedure use by patient characteristics. The elderly population underwent OR procedures at rates 2 to 3 times higher than younger age groups. However, persons aged 45 to 64 years received the most procedures: 32.1% of all procedures were performed in these middle-aged patients. Of all OR procedures, 61.7% were performed in females (603 procedures/10 000 females vs 381 procedures/10 000 males). There were no significant differences in procedure rates by community median household income or by rural or urban residence of the patient. Procedure rates in the West were significantly lower than those in other regions ($P = .02$).

Patients who received OR procedures were less severely ill than non-OR patients (**Table 2**). Only 20.5% of patients who received OR procedures fell into the group with the highest severity of illness, compared with 24.6% of non-OR patients. Similarly, patients with OR procedures had fewer comorbid conditions than non-OR patients (mean, 1.5 vs 1.7 comorbidities, respectively). More than half of the patients undergoing OR procedures were admitted to the hospital electively (53.8%) compared with only 14.2% for non-OR patients. Only 1.4% of OR patients died in the hospital vs 2.1% of non-OR patients.

The mean length of hospitalization for OR-related stays (5.3 days) was significantly longer than for non-OR stays (4.3 days) ($P < .001$), and the mean cost per stay was nearly 2.5 times higher (\$15 400 for OR-related stays vs \$6300 for non-OR stays; $P < .001$). The mean costs per day reflect greater resource intensity: \$2900/day for OR-

Table 1. Hospital Stays With and Without Operating Room Procedures and the Rates per 10 000 Population Among US Acute-Care, Nonfederal Hospitals in 2007

Characteristic	Cases Without OR Procedures		Cases With OR Procedures					P Value ^c	
	Stays, No. (SE), in Thousands	% of All Non-OR Stays	Stays, No. (SE), in Thousands ^a	% of All OR Stays	Rate of Stays/10 000 Population, No. (SE)	OR Procedures, No. (SE), in Thousands ^b	Rate of OR Procedures/10 000 Population, No. (SE)		
									% of All Procedures
Overall	29 113 (583)	100.0	10 429 (264)	100.0	346 (8.8)	14 939 (400)	100.0	495 (13.2)	
Age, y									
<1	5044 (188)	17.3	80 (13)	0.8	189 (30.7)	123 (21)	0.8	288 (49.5)	<.001 ^d
1-19	1768 (90)	6.0	489 (31)	4.7	63 (4.0)	628 (45)	4.2	80 (5.7)	
20-44	6573 (178)	22.6	3181 (103)	30.5	304 (9.9)	4485 (146)	30.0	428 (13.9)	
45-64	6015 (136)	20.6	3120 (91)	29.9	407 (11.8)	4792 (149)	32.1	626 (19.5)	
65-84	7201 (140)	24.7	3076 (92)	29.5	950 (28.3)	4295 (131)	28.8	1327 (40.4)	
≥85	2485 (58)	8.5	468 (13)	4.5	850 (24.0)	600 (17)	4.0	1089 (31.0)	
Sex									
Male	12 190 (244)	41.9	4041 (113)	38.7	272 (7.6)	5666 (168)	37.9	381 (11.3)	<.001
Female	16 859 (349)	57.9	6344 (164)	60.8	415 (10.7)	9223 (249)	61.7	603 (16.3)	
Median household income of patient's zip code									
Lowest quartile	8854 (372)	30.4	2649 (112)	25.4	351 (14.9)	3761 (161)	25.2	499 (21.3)	.34
Midrange	13 608 (371)	46.7	5004 (154)	48.0	332 (10.2)	7149 (224)	47.9	474 (14.9)	
Highest quartile	5850 (383)	20.1	2512 (179)	24.1	333 (23.7)	3645 (266)	24.4	483 (35.3)	
US region									
Northeast	5767 (238)	19.8	1986 (137)	19.1	363 (25.1)	2868 (217)	19.2	524 (39.6)	
Midwest	6766 (236)	23.2	2365 (109)	22.7	356 (16.4)	3356 (157)	22.5	506 (23.6)	
South	11 284 (436)	38.8	3989 (178)	38.3	361 (16.1)	5734 (266)	38.4	519 (24.0)	
West	5296 (191)	18.2	2089 (87)	20.0	298 (12.4)	2981 (132)	20.0	425 (18.8)	.02 ^e
Patient residence									
Rural	2087 (98)	7.2	698 (43)	6.7	344 (21.2)	997 (61)	6.7	492 (30.0)	.65
Urban	25 870 (611)	88.9	9336 (260)	89.5	333 (9.3)	13 377 (389)	89.5	477 (13.9)	

Abbreviation: OR, operating room.

^aBased on any hospital stay with at least 1 OR procedure.

^bBased on all-listed procedures.

^cBased on z tests comparing stays with and without OR procedures.

^dAll age groups differ significantly from one another.

^eRates for the West are significantly lower than those for all other regions; there were no other regional differences.

related stays vs \$1400 for non-OR stays ($P < .001$). The OR-related hospitalizations cost \$161 billion in 2007. Even though OR-related stays were responsible for 26.4% of all stays and 30.4% of all days spent in the hospitals, they accounted for 46.8% of total aggregate costs for hospitalization in the United States. Patients undergoing OR procedures who died had the longest mean lengths of stay (16.5 days), the highest costs (\$53 000), and the greatest intensity of care (\$3400/day) (data not shown).

While patients covered by Medicare and Medicaid were responsible for 58.3% of non-OR hospitalizations, they accounted for less than half of all OR stays (48.7%). Similarly, among the uninsured, there were more patients without OR procedures (6.3%) than with OR procedures (4.5%). On the other hand, patients with private insurance accounted for 31.9% of non-OR stays but 42.5% of OR-related stays.

OR PROCEDURES BY BODY SYSTEM

Musculoskeletal procedures accounted for the largest proportion of all-listed OR procedures (22.8%), followed by digestive (18.6%) and cardiovascular (15.7%) procedures. Female genital (12.0%) and obstetric (12.9%) procedures accounted for a quarter of all OR procedures. Nervous system procedures accounted for 4.1% of OR procedures, while 3.9% were performed on skin. The re-

maining OR procedures were performed on urinary (2.6%), respiratory (2.6%), male genital (1.7%), hemic and lymphatic (0.9%), ear, nose, mouth, and pharynx (0.9%), endocrine (0.8%), eye (0.1%), and miscellaneous (0.3%) systems.

MOST FREQUENT OR PROCEDURES

Table 3 lists the 15 most frequent OR procedures in 2007 with their rank in 1997. These procedures account for nearly half (44.1%) of all OR procedures. All of these procedures have been frequent over time, although some have changed rank dramatically such as knee arthroplasty, hip replacement, and spinal fusion (all increasing) as well as coronary artery bypass graft (CABG) (decreasing). Cesarean deliveries were the most common (1.5 million), accounting for 9.1% of all procedures (49 procedures per 10 000 population)—more than half (53.9%) were elective admissions. Percutaneous transluminal coronary angioplasty (PTCA) and CABG were also top-ranked, totaling 972 000 procedures. About one-third of PTCAs (33.2%) and half of CABGs (48.1%) were elective.

Five musculoskeletal procedures were of high frequency (knee arthroplasty, laminectomy, hip replacement, spinal fusion, and surgical treatment of hip fracture), totaling 2.1 million procedures. As expected, few surgical hip fracture treatments were performed elec-

Table 2. Severity of Illness, In-Hospital Mortality, and Resource Use for Hospitalizations With and Without Operating Room Procedures Among US Acute-Care, Nonfederal Hospitals in 2007

Characteristic	Hospital Stays Without OR Procedures	Hospital Stays With OR Procedures	P Value ^a
Cases with severity of illness, % (SE)			
Level 1 or 2, least severe	75.4 (0.31)	79.5 (0.26)	
Level 3 or 4, most severe	24.6 (0.31)	20.5 (0.26)	<.001
Comorbidities, mean (SE), No.	1.7 (0.02)	1.5 (0.02)	<.001
Type of admission			
Elective, No. (SE)	4131 (153)	5613 (180)	<.001
%	14.2	53.8	
Nonelective, No. (SE)	24 981 (553)	4816 (153)	<.001
%	85.8	46.2	
Died in hospital, % (SE)	2.1 (0.04)	1.4 (0.03)	<.001
Length of stay, d			
Mean (SE)	4.3 (0.04)	5.3 (0.06)	<.001
Median	3	3	
Interquartile range	2-5	2-5	
First percentile	1	0	
99th percentile	36	27	
Time in hospitals, d			
Aggregate (SE), in millions	126 (3)	55 (2)	<.001
% of total	69.6	30.4	
Costs, \$			
Mean (SE)	6300 (105)	15 400 (262)	<.001
Median	4000	8800	
Interquartile range	2200-7300	4600-16100	
First percentile	300	400	
99th percentile	43 800	93 600	
Per day	1400 (21)	2900 (39)	<.001
Aggregate (SE), in billions	183 (5)	161 (5)	.002
% of total	53.2	46.8	
Expected primary payer, in thousands			
Medicare, No. (SE)	10 692 (210)	3619 (107)	<.001
%	36.7	35.4	
Medicaid, No. (SE)	6279 (244)	1384 (59)	<.001
%	21.6	13.3	
Private insurance, No. (SE)	9293 (311)	4427 (160)	<.001
%	31.9	42.5	
Uninsured, No. (SE)	1841 (105)	469 (32)	<.001
%	6.3	4.5	

Abbreviation: OR, operating room.

^aBased on z tests comparing stays with and without OR procedures.

tively (13.7%), while most knee replacements (92.7%), spinal fusions (87.1%), and laminectomies (86.6%) were elective along with approximately two-thirds of hip replacements (68.7%). Two operations on the female genital system, hysterectomy and oophorectomy, accounted for a total of 930 000 procedures (89.3% and 84.6%, respectively, were elective), while ligation of fallopian tubes was performed on 346 000 women in US hospitals (55.2% elective admissions). Three procedures associated with the digestive system, cholecystectomy (25.4% elective), appendectomy (15.0% elective), and colorectal resection (59.7% elective), were also top-ranked and totaled 1.1 million procedures. Debridement of wounds or burns accounted for 221 000 procedures (24.0% elective).

RESOURCE USE FOR SPECIFIC PROCEDURES

The most costly procedures, based on mean cost per hospitalization, tended to be relatively uncommon. Heart transplants were the most costly procedures,

with 1600 stays having a mean cost of \$131 500. Organ transplants in general tended to be among the most expensive, including bone marrow transplants (15 000 stays with a mean cost of \$85 600) and kidney transplants (14 400 stays with a mean cost of \$47 900). The most expensive procedures that were also relatively common were heart valve procedures (91 600 stays with a mean cost of \$49 500). Other top-ranking procedures in terms of the mean cost had long and intensive hospitalizations even though the procedures themselves were not expensive, such as tracheostomy (\$81 100/stay).

Table 4 ranks OR procedures based on total aggregate costs in the United States. The 15 most expensive procedures in the aggregate accounted for 51.2% of all costs associated with OR procedures and 24.0% of total hospitalization costs. Together, PTCA and CABG accounted for \$17.9 billion (10.9% of all costs for OR-related stays and 5.4% of aggregate costs for all hospitalizations). The mean cost per hospitalization with CABG as the first-listed procedure (\$35 300) was more than twice as high as that for PTCA (\$16 200). Two other heart procedures were among the top 15 most expensive because they were associated with high mean costs: heart valve procedures and insertion or revision of cardiac pacemaker, cardioverter, or defibrillator.

Four musculoskeletal procedures were among the most expensive and were of high frequency: knee arthroplasty, spinal fusion, hip replacement, and treatment of hip fracture. Together, these procedures totaled \$28.0 billion in aggregate costs (17.0% of all costs for OR-related stays and 8.3% of total hospital costs).

Cesarean delivery was the highest-frequency procedure in this list and accounted for \$7.7 billion in aggregate costs (4.7% of all costs for OR stays and 2.4% of total hospital costs). Hysterectomy accounted for \$3.8 billion.

Three digestive system procedures were also top-ranked. Nationwide, hospitalizations cost \$6.3 billion for colorectal resection, \$4.4 billion for cholecystectomy, and \$2.5 billion for appendectomy.

Finally, débridement of wounds, infections, and burns accounted for \$3.0 billion in total hospitalization costs, while amputation of a lower extremity cost \$2.1 billion even though it was not a top-ranked procedure in terms of frequency.

TRENDS IN PROCEDURE USE

As shown in the **Figure**, between 1997 and 2007, 7 of the 15 most frequent OR procedures increased significantly: cesarean delivery increased by 46%, knee arthroplasty by 46%, spinal fusion by 45%, hip replacement by 28%, PTCA by 20%, colorectal procedures by 12%, and appendectomy by 12%. On the other hand, 2 procedures declined significantly during this period: CABG decreased by 70% and oophorectomy by 20%. Between 2006 and 2007, PTCA experienced a significant reversal in its steady climb, decreasing 20% in 1 year after a 56% increase in the prior decade.

Table 3. Most Frequent All-Listed Operating Room Procedures Performed in US Acute-Care, Nonfederal Hospitals in 2007

All-Listed OR Procedure ^a	Rank in 1997	Rank in 2007	OR Procedures, No. (SE), in Thousands	% of All Procedures	Rate of OR Procedures per 10 000 Population, (SE)	Admitted on Elective Basis, % (SE)
All OR procedures			16 242 (434)	100.0	538 (14.4)	52.1 (1.0)
Cesarean delivery	1	1	1482 (65)	9.1	49 (2.1)	53.9 (2.6)
Percutaneous transluminal coronary angioplasty	3	2	722 (39)	4.4	24 (1.3)	33.2 (1.7)
Arthroplasty of knee	10	3	611 (26)	3.8	20 (0.9)	92.7 (0.8)
Hysterectomy	2	4	539 (19)	3.3	18 (0.6)	89.3 (1.0)
Laminectomy, excision of intervertebral disk	7	5	479 (23)	3.0	16 (0.8)	86.6 (1.1)
Cholecystectomy	5	6	434 (11)	2.7	14 (0.4)	25.4 (0.8)
Hip replacement	13	7	404 (18)	2.5	13 (0.6)	68.7 (1.3)
Oophorectomy	4	8	391 (14)	2.4	13 (0.5)	84.6 (1.0)
Appendectomy	9	9	377 (10)	2.3	12 (0.3)	15.0 (0.6)
Spinal fusion	17	10	368 (19)	2.3	12 (0.6)	87.1 (1.4)
Ligation of fallopian tubes	11	11	346 (15)	2.1	11 (0.5)	55.2 (2.4)
Colorectal resection	14	12	329 (9)	2.0	11 (0.3)	59.7 (1.0)
Treatment of fracture or dislocation of hip	12	13	284 (7)	1.8	9 (0.2)	13.7 (0.6)
Coronary artery bypass graft	6	14	250 (15)	1.5	8 (0.5)	48.1 (1.4)
Débridement of wound, infection, or burn	8	15	221 (7)	1.9	7 (0.2)	24.0 (0.9)

Abbreviation: OR, operating room.

^aUsing the Clinical Classifications Software,¹² which groups procedures into clinical categories.

Table 4. Most Costly First-Listed Operating Room Procedures Performed in US Acute-Care, Nonfederal Hospitals in 2007

First-Listed Procedure ^a	Rank in 2007	Aggregate Cost for Hospitalizations, \$ (SE), in Millions	% of Total	Cost per Hospitalization, Mean (SE), \$	Stays, No. (SE), in Thousands
Total for all hospital stays with OR procedures		161 025 (5414)	100.0	13 990 (257)	11 724 (301)
Percutaneous transluminal coronary angioplasty	1	10 853 (601)	6.6	16 200 (316)	668 (37)
Arthroplasty of knee	2	8946 (394)	5.5	14 800 (231)	605 (26)
Spinal fusion	3	8605 (468)	5.2	24 600 (532)	350 (18)
Cesarean delivery	4	7732 (379)	4.7	5200 (94)	1480 (65)
Coronary artery bypass graft	5	6997 (412)	4.3	35 300 (652)	199 (12)
Hip replacement	6	6625 (318)	4.0	16 500 (238)	402 (18)
Colorectal resection	7	6257 (180)	3.8	21 800 (321)	288 (8)
Insertion or revision of cardiac pacemaker, cardioverter, or defibrillator	8	5225 (289)	3.2	30 900 (659)	170 (9)
Heart valve procedures	9	4639 (364)	2.8	49 500 (925)	94 (7)
Cholecystectomy	10	4375 (113)	2.7	11 500 (139)	382 (9)
Treatment of fracture or dislocation of hip	11	3800 (115)	2.3	14 800 (277)	254 (6)
Hysterectomy	12	3768 (151)	2.3	7300 (139)	516 (18)
Débridement of wound, infection, or burn	13	2993 (112)	1.8	17 500 (408)	170 (5)
Appendectomy	14	2471 (73)	1.5	8200 (107)	301 (8)
Amputation of lower extremity	15	2123 (67)	1.3	20 200 (416)	105 (3)

Abbreviation: OR, operating room.

^aUsing the Clinical Classifications Software,¹² which groups procedures into clinical categories.

COMMENT

These findings highlight the important role that OR procedures play in US health care. This study found that roughly 5 of 100 people underwent OR procedures and about one-quarter of hospitalizations involved an OR procedure. In addition, OR-related hospitalizations accounted for nearly half the costs of inpatient hospital care in the United States.

There were major differences in procedure use by age: the elderly were 2 to 3 times more likely to undergo OR procedures than younger patients. Females had higher procedure rates than males. The West had higher rates than any other region, although no differences were found for rural vs urban patients or for patients from lower- vs higher-income communities.

This study also provides information on how OR hospitalizations differed from non-OR stays. As compared with non-OR patients, those with OR procedures were more likely to be admitted on an elective basis, were less severely ill, and had fewer comorbidities. The OR-related stays had higher resource use than non-OR stays as measured by the mean number of hospital days, mean costs per stay, and mean per diem cost. The mean cost of OR-related hospitalizations was more than twice that for non-OR hospital stays.

This study provides details on the epidemiology of OR procedures including distribution by body system and most frequent individual OR procedures. This detailed information provides insight into how the country allocates this intensive resource and can contribute to esti-

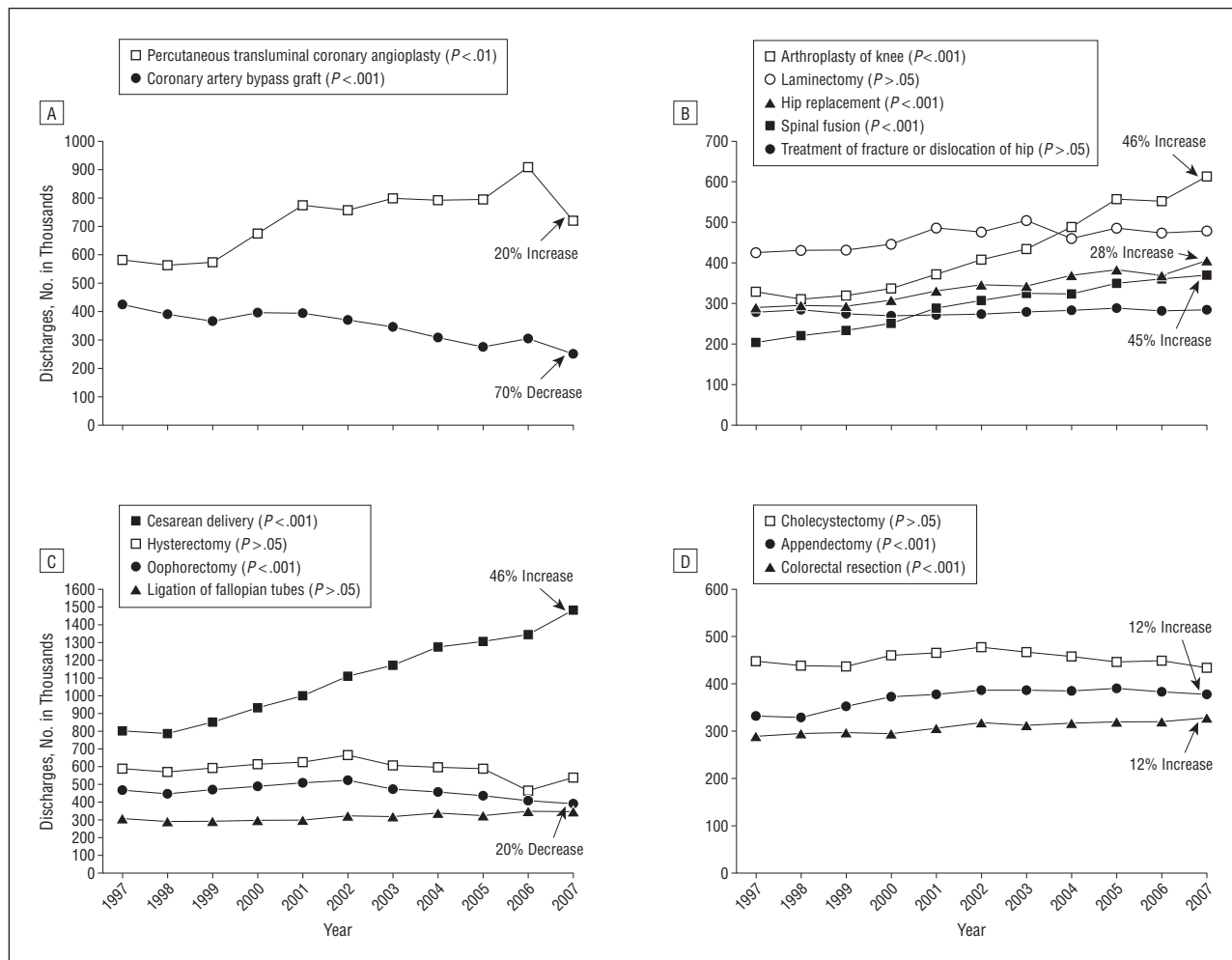


Figure. Trends in the most frequent all-listed operating room procedures in US hospitals, with significant differences between 1997 and 2007, including cardiac procedures (A), back, hip, and knee procedures (B), obstetric and gynecologic procedures (C), and gastrointestinal procedures (D).

mates of surgical workforce needs,²² especially given the declining number of surgeons during the past 2 decades.²³

The study findings suggest the importance of considering the role that OR procedures play in attempts to curb growth in health care costs. Hospital care represents the single most expensive component of US health care, and OR-related hospitalizations account for half of all hospital costs. Furthermore, these costs are concentrated in relatively few procedures—hospitalizations for the top 15 most expensive OR procedures accounted for half of all procedure-related hospitalization costs or one-fourth of all inpatient hospital costs.

Four of the most expensive procedures in the United States have undergone significant increases in volume from 1997 to 2007, ranging from a 20% increase for PTCA to increases of 46% for cesarean delivery, 46% for knee arthroplasty, and 45% for spinal fusion. In contrast, hospitalizations in general increased just 14% during this period.²⁴ From 2006 to 2007, PTCA reversed its steady rate of increase with a 20% decrease in just 1 year, perhaps reflecting evidence that PTCA has a limited effect in reducing major cardiovascular events compared with medical therapy.^{25,26} However, other procedures maintained

their trajectory, especially knee and hip replacements, spinal fusion, and cesarean delivery.

There are limitations related to the findings on cost. Costs do not include physician costs that are billed separately from the hospital bill, and they represent costs for the entire hospitalization, not solely the cost of performing the procedure. In addition, we restricted cost analysis to principal procedures to avoid double counting costs for hospitalizations that involved more than 1 OR procedure. This will underestimate costs for some types of OR procedures coded as secondary procedures. Finally, we estimated costs by applying hospital-wide cost-charge ratios to billed charges. This approach does not account for differences in service mix across types of patients or differences in markups between types of services (eg, ancillary vs routine bed unit services).

These data are based on hospital claims. Use of OR procedures is key to the amount reimbursed; thus, there is incentive to accurately record procedures in the discharge record. However, our estimate of the total number of inpatient procedures, 15 million in 2007, differs from other data sources owing to differences in definitions, sampling strategy, and completeness of reporting. The American Hospital Association Annual Survey

of hospitals estimates about 10 million procedures from community hospitals²⁷; however, multiple procedures performed in the same OR visit are counted as 1 procedure. Furthermore, the number of operations was imputed by the American Hospital Association for 25.6% of hospitals because of nonresponse (from raw data from the 2007 American Hospital Association Annual Survey of Hospitals). The National Hospital Discharge Survey for 2005 estimated 25.6 million OR procedures.²⁸ The National Hospital Discharge Survey counts all procedures meeting their definition of surgical procedures; thus, a single procedure requiring multiple codes could result in multiple counts. The National Hospital Discharge Survey definition of operations includes procedures that are not defined as OR procedures in DRGs. In our study, multiple procedures are counted during a single stay only if they are classified in different CCS categories and meet the definition of a valid OR procedure according to DRGs.

One limitation of this study is that it focuses on inpatient procedures while there has been considerable growth in outpatient procedures.²⁹ Recent multistate data indicate that about half of OR procedures occur as outpatient procedures.³⁰ However, outpatient procedures differ from inpatient procedures in that they are less invasive and require less intensive monitoring and post-operative care. As a result, mean charges for outpatient procedures were about one-fifth of those for inpatient procedures in 2003. Certain types of procedures are almost always performed on an outpatient basis, including procedures on the eye (99.3%), ear (96.3%), and nose, mouth, and pharynx (93.8%). More than half of procedures involving the skin (70.4%), digestive (66.8%), urinary (61.7%), and musculoskeletal (54.0%) systems are performed on an outpatient basis. On the other hand, procedures for some body systems are generally performed on an inpatient basis, including hemic and lymphatic (90.7%), male genital (90.7%), cardiovascular (70.6%), and respiratory (68.8%) systems. By focusing on inpatient procedures, this study highlights care that is higher risk, is more costly, and involves more resources.

These findings suggest further study using data beyond hospital administrative data examined here. For example, which of these procedures are discretionary, and could any be avoided? Is there a role for greater specialization among hospitals to improve efficiency of providing care? What findings are related to other procedures performed in the hospital but in non-OR settings? How do volumes and costs of ambulatory surgery compare? What accounts for the regional differences described here? Despite these unanswered questions, this study provides the first overall profile to our knowledge of inpatient OR procedures in the United States, including resources used and trends over time. The findings may provide insight for health care planning and reform because OR procedures represent a large portion of hospital costs and these procedure-related costs are concentrated in relatively few procedures.

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INVITED CRITIQUE

The Past and Present as Prologue to the Future

Given the current debate on health care reform, this descriptive, nonanalytical statistical overview of 10-year trends in OR procedures by Elixhauser and Andrews is timely and informative. Documenting trends in OR use, an expensive allocation of resources, provides policy makers with data to more accurately estimate future resource needs, especially costs. The specification of population trend data facilitates strategic planning with an opportunity to focus allocation of shrinking financial resources.

The data sources, population snapshot samples, and non-repetitive sampling of the same institutions do not allow an understanding of why these trends have occurred. The explicit documentation of the trends, particularly the increases in both the common procedures and the expensive and complicated procedures, provides baseline information for planning and eventually evaluating realistic and effective health care reform with respect to OR procedures in general. Used to plan and then evaluate the effects of changes, data of this sort evaluate the potential economic impact and offer insight into future specialty training needs for surgical manpower. The example of a decrease

in cardiac surgery with a corresponding increase in coronary angioplasty reflects an evolution in the practice paradigm: decreased demand for a specific intervention resulting from improved alternative approaches with an overall improvement in the management of cardiac risk. Are there other areas where similar associations can be made with improved projections for system tuning? While describing the near-current state of affairs of OR procedures and trends for the immediately preceding decade, the work provides neither causation nor insight. There is no unifying underlying hypothesis to explain the reasons for these trends, the critical underlying question if the data are to be used to affect health care reform.

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