HEALTH CARE REFORM

Comanagement of Surgical Patients Between Neurosurgeons and Hospitalists

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Background: Shared management of surgical patients between surgeons and hospitalists (comanagement) is increasingly common, yet few studies have described its effects.

Methods: Retrospective, interrupted time-series analysis of data collected from adults admitted to a neurosurgery service at our university-based teaching hospital between June 1, 2005, and December 31, 2008. Data regarding length of stay, costs, inpatient mortality rate, and 30-day readmission rate were collected from administrative sources; patient and caregiver satisfaction was assessed through surveys. We used multivariable models to estimate the effect of comanagement on key outcomes after adjusting for secular trends and patient-specific risk factors.

Results: During the study period, 7596 patients were admitted to the neurosurgery service: 4203 (55.3%) before July 1, 2007, and 3393 (44.7%) after comanagement began. Of those admitted during the postimplementation period, 988 (29.1%) were comanaged. After implementation of comanagement, no differences were found in patient mortality rate, readmission, or length of stay. No consistent improvements were seen in patient satisfaction, but strong perceived improvements occurred in care quality reported by nurses and nonnurse health care professionals. In addition, we observed a reduction in hospital costs of $1439 per admission.

Conclusions: Implementation of a hospitalist comanagement service had little effect on patient outcomes or satisfaction but appeared to reduce hospital costs and improve health care professionals' perceptions of care quality. As comanagement models are adopted, more emphasis should be placed on developing systems that improve patient outcomes.

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MANY OF THE SAME forces that have driven the growth of hospital medicine and the subspecialization of inpatient care have affected perioperative medicine. Increasing patient age and greater comorbid illness, shifts of simpler procedures from inpatient to outpatient settings, and, in teaching hospitals, limitations on house staff duty hours have sped the development of medical-surgical comanagement systems, in which surgeons and internists (generally hospitalists) codirect nonsurgical aspects of inpatient perioperative care.[1-3]

For editorial comment see page 1965

Few published studies[1,4] describe comanagement's effect on costs and outcomes. The few data describing comanagement models come from a handful of academic centers and have focused on patients undergoing orthopedic surgical procedures. These studies suggest a modest reduction in complications after joint replacement surgery but few other salutary effects on outcomes of arthroplasty or hip fracture.

The limited data supporting comanagement has led 2 authors[2] to suggest that the model should be adopted slowly or in a targeted fashion (eg, in caring only for patients with highly complex medical needs). Despite these cautionary notes, the demand for comanagement is increasing and with it the growth of hospital medicine.[5]

Our study aimed to understand the effect of a hospitalist-led comanagement service for selected patients undergoing neurologic surgery. We determined the effect of comanagement on patient outcomes, such as mortality rate, readmission, costs, and length of stay, and on patient satisfaction and impressions of health care professionals.

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METHODS

SITES AND PARTICIPANTS

Our data were collected from patients admitted to the Neurological Surgery Service at the University of California, San Francisco (UCSF) Medical Center, a 550-bed, university-based hospital. Patients in our study were aged 18 years or older during the study period and were admitted to the neurosurgery service in the 25 months before and the 18 months after July 1, 2007, the date on which a hospitalist-neurosurgery comanagement service (comanagement on neurosurgery service [CNS]) was implemented (36 months total). We also collected data from a control group of patients aged 18 years or older admitted for major noncardiac surgery at our hospital during this same period; these data were used to create a concurrent control group and to account for potential secular trends.

NEUROSURGERY SERVICE STRUCTURE BEFORE CNS IMPLEMENTATION

Before implementing the CNS, patient care for neurosurgical patients (average census of 40-50 patients) was provided by surgical attending physicians, 5 residents (only 1 of whom was not in the operating room), 3 pharmacists, and 4 to 5 nurse practitioners assigned to attend specific surgical patients. Before the CNS began, residents, pharmacists, and nurse practitioners shared order-writing responsibilities; management of acute issues was the responsibility of the cross-covering resident. Consultations for subspecialty medical care were made at the discretion of the surgical services, and general medical consultation from hospitalists was sought infrequently, most often for managing acute deteriorations rather than ongoing medical problems.

STRUCTURE OF THE CNS

Beginning July 1, 2007, a hospitalist was available every day (from 7:30 AM to 7:30 PM) to actively comanage patients on the neurosurgery service. The CNS was implemented as a response to changes in care—primarily a reduction in the availability of physicians for ward patients—which resulted from resident duty hour reductions. Less neurosurgery resident availability led to the perception that care quality might have been compromised, although no empirical data were available to support that perception.

The hospitalist began the day by screening the neurosurgery service patient rosters for newly admitted patients who met prespecified criteria for comanagement. Prespecified criteria included a history of coronary artery disease, congestive heart failure, serious arrhythmias, chronic obstructive pulmonary disease, chronic kidney disease, ischemic stroke, diabetes mellitus requiring insulin therapy, or long-term anticoagulation therapy. Comanagement was also offered if the neurosurgical staff or hospitalist thought the patient was at risk for complications based on other clinical factors. This triage process produced an average daily census of 13 to 16 comanaged patients, approximately one-third of the total neurosurgical census. Nighttime coverage for comanaged patients was provided by the neurosurgery house staff, with backup from moonlighting internal medicine physicians covering for other services.

Seven hospitalists rotated through the CNS; these hospitalists rotated on non-CNS services (ie, general medical ward services) during other times during their academic year but had no additional responsibilities while on the CNS. When making rounds on comanaged patients, the hospitalist ordered diagnostic or therapeutic interventions or consultations as needed, with the exception of orders for invasive procedures and anticoagulant or antiplatelet therapies that had been approved by neurosurgical staff beforehand. Management of surgical and perisurgical issues was left to the neurosurgery service. Hospitalists were also available to address questions and concerns from nurses, nurse practitioners, and neurosurgical house officers about neurosurgical patients not being comanaged.

DATA

Sources of data for this study included UCSF administrative data, physician billing records, and a commercial patient satisfaction survey vendor (Press Ganey, South Bend, Indiana). Administrative data sources (Transition Systems International, Boston, Massachusetts) were used to collect information regarding patient demographics, age, comorbidities, procedure type, length of stay, costs, and mortality rate. We collected administrative data from June 1, 2005, to December 31, 2008—25 months before CNS and 18 months after CNS implementation.

Physician billing data were combined with administrative data to identify which patients had received medical consultation during hospitalization. These data were screened manually to determine whether a patient had been seen by a hospitalist consultant acting in a general medicine consultation capacity (before July 1, 2007) or as a comanager (after July 1, 2007).

Press Ganey provided data from a standard patient satisfaction survey administered by telephone between 10 and 30 days after hospitalization. Surveys contain patient identifiers that can be used to link responses to individual patient hospitalizations. Press Ganey surveys contain elements of the Hospital Care Quality Information From the Consumer Perspective standard surveys[6] and are commonly used for patient satisfaction assessment in hospitals.

We also surveyed a convenience sample of nursing and physician health care professionals on the CNS 6 months before and 6 months after CNS implementation. Surveys were administered in the context of nursing unit and neurosurgery departmental meetings. Nurses included all nurses on the core neurosurgical care units. Health care professionals included neurosurgery attending physicians, residents, and other staff (such as nurse practitioners and clinical pharmacists) who would have direct experience with the CNS.

OUTCOME VARIABLES

We examined patient mortality rate in the hospital, defined by discharge status in our administrative database. Readmission was defined to include all patients who had repeat admissions to the UCSF within 30 days of discharge. Length of stay and costs are standard components of Transition Systems International administrative data. Patient and health care professional survey data were coded as categories (with a score of 1 representing very poor and 5 very good), allowing us to analyze these responses as continuous scores.

STATISTICAL ANALYSIS

Our analytic approach estimated the effects of the CNS, adjusting for neurosurgical patient characteristics and controlling for background trends in our key outcomes using data for other major noncardiac surgical patients at the UCSF. Because hospitalists' reach potentially included all patients on the neurosurgery service, our analytic plan focused on service-level changes (and not simply patients who were actively comanaged).

This process began by characterizing patients on the neurosurgery service using unadjusted methods. We used χ^2 tests to compare categorical variables between preimplementation and postimplementation periods. We used *t* tests for between-period comparisons of continuous variables.

We then built multivariable models, using generalized estimating equations to account for clustering at the surgeon level and adjusting for covariates outlined in the eAppendix (http://www.archinternmed.com). Logistic models were used for mortality rate and readmissions, gamma generalized linear models with log link function for length of stay and costs, and a proportional odds model for the ordinal patient satisfaction scale. Covariates were selected for inclusion in multivariable models based on their statistical association with the outcome in question at $P \leq .05$.

We then tested interrupted time-series models, under which the mean trajectory in each group is assumed to follow a linear secular trend in the preimplementation period, to "jump" at the time of implementation, and then to follow a different linear trend in the postimplementation period. Hypothesizing that there may have been a learning curve in the CNS, we also augmented the basic interrupted time-series model to allow for different linear trends in the first (months 1-9) and second (months 10-18) portions of the postimplementation period. However, we found no persuasive evidence of trends within periods in either group or of between-group differences in trend. Accordingly, our final analysis used simpler, more powerful "difference of differences" models, in which the change in mean outcome levels after implementation in the CNS was compared with concurrent changes in the control group, which was composed of noncardiac surgical patients. This quasiexperimental analysis controls for background trends and differences in patient-level characteristics. Because patient satisfaction data were only available for the CNS, we were only able to assess adjusted within-group changes in these outcomes and could not compare trends in satisfaction in the CNS group with those in the noncardiac surgical group.

RESULTS

PATIENT CHARACTERISTICS

A total of 7596 patients were admitted to the neurosurgery service during the study period: 4203 (55.3%) before July 1, 2007, and 3393 (44.7%) after CNS implementation (**Table 1**). Because of our large sample size, we were able to detect small but statistically significant differences in many patient characteristics between preimplementation and postimplementation periods. We observed no difference in the proportion of patients who received subspecialty consultation before or after CNS implementation.

EFFECTS OF CNS ON PATIENT OUTCOMES, LENGTH OF STAY, AND COSTS

No unadjusted differences were found in patient mortality rate, length of stay, or total costs after implementation. After adjusting for patient characteristics and background trends and accounting for clustering at the physician level, no statistically significant differences were found in mortality rate, readmission, or length of stay. There was a moderate decrease in adjusted hospital costs after implementation (adjusted cost ratio, 0.94; range, 0.88-1.00), equivalent to a savings of $1439 per admission (**Table 2**).

PATIENT SATISFACTION AFTER IMPLEMENTATION

One thousand four hundred fifty-six patients (19.2%) provided telephone survey data, 810 (19.3%) in the preimplementation period and 646 (19.0%) in the postimplementation period (**Table 3**). Satisfaction in both periods was generally high, with mean scores uniformly higher than 4 (good). After adjustment in multivariable models, there were statistically significant increases in the odds for a higher score in the comanagement cohort for 3 questions: the degree to which staff responded to concerns, the cheerfulness of the hospital, and the degree to which staff addressed patients' emotional needs. After adjustment, the overall rating of the hospital experience and the likelihood of recommending the hospital were no longer significant.

NONNURSING AND NURSING HEALTH CARE PROFESSIONAL SURVEYS

Thirty-one surveys were distributed to nonnurse health care professionals (18 in the before group and 13 in the after group) and all (100%) were completed. The results were uniformly supportive of the CNS (**Table 4**), with the strongest positive changes being associated with perception of improved attention to medical issues during hospitalization (mean score of 2.9 before CNS and 4.8 after, $P < .001$) and at discharge (mean score of 2.7 before CNS and 4.4 after, $P < .001$).

Sixty-five nursing surveys were distributed: 31 before implementation and 34 after, with 100% response rates in both periods. The nurses were experienced; the average nurse completing the survey had worked at the UCSF for 11 years. Perceptions of the CNS's effect on patient care were also uniformly positive, with strongest positive change again being seen on questions regarding treatment of medical issues during hospitalization (**Table 5**).

SECONDARY ANALYSES (NOT PRESENTED)

To test the robustness of our results, we also performed a series of preplanned secondary analyses. When we compared outcomes of all patients who had consultation in the pre-CNS period with patients who received comanagement after implementation, comanaged patients had lower adjusted readmission risk, length of stay, and costs. We then compared adjusted outcomes of comanaged patients with noncomanaged patients in the postimplementation period; not surprisingly, these analyses suggested substantially higher costs among comanaged patients compared with those whose needs were not deemed complex enough for those patients to warrant comanagement. Finally, we tested whether any changes were suggestive of a learning curve in the 18 months after CNS implementation. In adjusted models, no significant differences were found in any of our key outcomes in months 1 to 9 compared with months 10 to 18 after implementation.

Table 1. Patient Characteristics

Characteristic	No. (%) of Patients[a] Before CNS Implementation (n=4203 [55.3%])	After CNS Implementation (n=3393 [44.7%])	*P* Value for Preimplementation vs Postimplementation
Age, mean (SD), y	53.1 (15.6)	54.0 (15.6)	.01
Female sex	2207 (52.5)	1723 (50.8)	.13
Race			
White	3039 (72.3)	2354 (69.4)	.05
Black	166 (4.0)	163 (4.8)	
Asian	325 (7.7)	273 (8.0)	
Other or missing	673 (16.0)	603 (17.8)	
Ethnicity			
Hispanic	495 (11.8)	390 (11.5)	.21
Non-Hispanic	3501 (83.3)	2805 (82.7)	
Missing	207 (4.9)	198 (5.8)	
Most common diagnosis-related groups			
1, 2–Craniotomy	1529 (36.4)	1152 (34.0)	.03
496–Combined anterior-posterior spinal fusion	184 (4.4)	190 (5.6)	.01
520–Cervical spinal fusion	188 (4.5)	141 (4.2)	.50
528–Intracranial vascular procedure with principal diagnosis of hemorrhage	190 (4.5)	118 (3.5)	.02
500–Back and neck procedures except spinal fusion	181 (4.3)	117 (3.4)	.06
Payer status			
Medicare	1292 (30.7)	1150 (33.9)	.02
Medicaid/Medi-Cal	554 (13.2)	456 (13.4)	
Private	2067 (49.2)	1572 (46.3)	
Other	290 (6.9)	215 (6.3)	
Spouse	2411 (57.4)	1923 (56.7)	.55
Admission source			
Emergency department	984 (23.4)	725 (21.4)	.06
Outside hospital	425 (10.1)	379 (11.2)	
Direct admission or other	2794 (66.5)	2289 (67.5)	
Discharge to			
Home	3207 (76.3)	2576 (75.9)	.16
Skilled nursing facility	110 (2.6)	118 (3.5)	
NA (dead)	104 (2.5)	88 (2.6)	
Other	782 (18.6)	611 (18.0)	
APR risk of mortality			
1	2978 (70.9)	2257 (66.5)	<.001
2	691 (16.4)	640 (18.9)	
3	366 (8.7)	318 (9.4)	
4	168 (4.0)	178 (5.2)	
Comorbid diseases			
Hypertension	1368 (32.6)	1205 (35.5)	.007
Chronic pulmonary disease	429 (10.2)	348 (10.3)	.94
Fluid or electrolyte disorders	246 (5.9)	374 (11.0)	<.001
Diabetes mellitus	420 (10.0)	316 (9.3)	.32
Hypothyroidism	281 (6.7)	256 (7.5)	.15
Paralysis	244 (5.8)	207 (6.1)	.59
Obesity	211 (5.0)	144 (4.2)	.11
Deficiency anemia	119 (2.8)	173 (5.1)	<.001
Metastatic cancer	117 (2.8)	77 (2.3)	.16
Renal failure	66 (1.6)	100 (3.0)	<.001
Congestive heart failure	80 (1.9)	73 (2.2)	.44
Consultation			
General medicine consultation	160 (3.8)	NA	NA
Comanagement	NA	988 (29.1)	NA
Other consultation	346 (8.2)	282 (8.3)	.90

Abbreviations: APR, All Patient Refined Diagnosis Group; CNS, comanagement on neurosurgery service; NA, not applicable.
[a] Data are given as number (percentage) of patients unless otherwise indicated. Percentages may not total 100 because of rounding.

COMMENT

Implementation of a hospitalist-led comanagement service for neurosurgical patients did not have an effect on mortality rate, readmission, length of stay, or many standard measures of patient satisfaction. However, implementation by the CNS was associated with cost savings of more than $1400 per hospitalization

Table 2. Mortality Rate, Readmission, Length of Stay, and Costs Before and After CNS Implementation

	Before CNS Implementation	After CNS Implementation	Change After CNS Implementation (95% CI)[a]
Mortality, %	104 (2.47)	88 (2.59)	0.97 (0.65-1.05)
Readmission after 30 days, %	277 (6.59)	192 (5.66)	0.83 (0.65-1.05)
Length of stay, median (IQR), d	5 (3.8)	5 (3.8)	0.97 (0.92-1.03)
Total costs, median (IQR), $	23 867 (15 133-40 966)	24 533 (15 881-41 943)	0.94 (0.88-1.00)

Abbreviations: CI, confidence interval; CNS, comanagement on neurosurgery service; IQR, interquartile range.
[a] Values represent overall change in outcome in the 18 months after implementation compared with the precomanagement period. For mortality rate and readmission, the values are adjusted odds ratios; for length of stay and total costs, the values are adjusted rate ratios.

Table 3. Responses to Patient Satisfaction Surveys Before and After CNS Implementation[a]

Response	Mean Score Before CNS Implementation (95% CI) (n=810)	Mean Score After CNS Implementation (95% CI) (n=646)	Adjusted OR (95% CI) for Increasing Satisfaction Score After CNS Implementation
Time physician spent with you	4.17 (4.10-4.24)	4.23 (4.15-4.30)	1.07 (0.96-1.19)
Physician's concern for questions and worries	4.42 (4.36-4.49)	4.46 (4.39-4.53)	1.01 (0.84-1.22)
How well physician kept you informed	4.31 (4.24-4.39)	4.38 (4.31-4.46)	1.09 (0.93-1.28)
Friendliness and courtesy of physician	4.62 (4.57-4.67)	4.63 (4.57-4.69)	1.02 (0.81-1.29)
Skill of physician	4.84 (4.80-4.87)	4.82 (4.78-4.86)	0.84 (0.65-1.07)
Overall rating of residents and interns	4.50 (4.44-4.55)	4.53 (4.46-4.59)	1.08 (0.88-1.32)
Degree to which you were made to feel welcome by staff	4.51 (4.46-4.56)	4.55 (4.50-4.60)	1.09 (0.91-1.31)
Staff concern for privacy	4.38 (4.33-4.44)	4.40 (4.34-4.47)	1.06 (0.87-1.29)
Staff sensitivity to inconvenience that health problems and hospitalization can cause	4.33 (4.27-4.39)	4.35 (4.28-4.41)	0.99 (0.81-1.21)
How well was your pain controlled?	4.44 (4.38-4.50)	4.46 (4.40-4.52)	0.97 (0.75-1.25)
Degree to which staff addressed emotional needs	4.22 (4.15-4.29)	4.31 (4.24-4.38)	1.17 (1.02-1.35)
Degree to which staff addressed spiritual needs	4.27 (4.16-4.37)	4.28 (4.19-4.38)	1.04 (0.82-1.33)
Response to concerns and complaints made during your stay	4.15 (4.07-4.22)	4.25 (4.18-4.33)	1.16 (1.04-1.30)
Staff effort to include you in decisions about treatment	4.30 (4.23-4.37)	4.35 (4.28-4.42)	1.06 (0.91-1.25)
Staff's sensitivity and responsiveness to your special individual needs	4.29 (4.22-4.36)	4.35 (4.28-4.42)	1.08 (0.87-1.34)
Extent to which you or your family was informed about medications you received	4.33 (4.26-4.39)	4.35 (4.28-4.42)	0.99 (0.86-1.14)
Confidence that the hospital was doing what it could to prevent a medical mistake	4.48 (4.42-4.54)	4.52 (4.46-4.58)	1.03 (0.85-1.24)
Overall cheerfulness of hospital staff	4.38 (4.32-4.44)	4.43 (4.37-4.49)	1.14 (0.96-1.34)
How well staff worked together to care for you	4.46 (4.40-4.52)	4.53 (4.47-4.59)	1.13 (0.93-1.38)
Likelihood of recommending this hospital to others	4.57 (4.52-4.63)	4.64 (4.59-4.70)	1.18 (0.93-1.48)
Overall rating of care given in hospital	4.55 (4.49-4.60)	4.61 (4.55-4.66)	1.14 (0.90-1.43)

Abbreviations: CI, confidence interval; CNS, comanagement on neurosurgery service; OR, odds ratio.
[a] Survey responses were graded on a 1- to 5-point scale, with 1 indicating very poor and 5 indicating very good.

and improved staff and physician perception of safety and quality of care.

Comanagement of surgical patients is increasingly common, although few empirical data support its effectiveness in improving patient outcomes. Previous studies[1,4] examining hospitalist involvement in orthopedic surgical patients suggested small reductions in minor complications of surgery; hospitalist involvement in care of patients with hip fracture did not improve outcomes. Although our results mirror the findings of those previous studies, our observation of reduced costs is novel, to our knowledge. The finding of lower costs associated with the CNS parallels that of an earlier study[7] of hospitalist programs, which found reductions in costs without clear improvements in clinical outcomes or reduced use of specialty consultants. Although the cost reduction in our study is small in relative terms (6.X%), it is large in absolute terms ($1439 per case). If applied to comanaged patients, the CNS would save $1 520 000, representing a major return on investment for the CNS, whose support costs totaled $750 000 during the same period.

The CNS's lack of effect on mortality rate or readmission may be because these outcomes are uncommon or because the involvement of hospitalists does not affect factors that may be more powerful determinants of outcome in neurosurgical patients. Unlike medical patients, neurosurgical patients are most often admitted for elective or semiurgent procedures or transferred immediately for emergency surgery. As a result, hospitalists may have little effect on elective patients with a low risk of complications or those whose outcomes are largely determined by their emergent neurosurgical problem. It is also possible that the CNS affected patient outcomes other than mortality rate, such as complications of care. Although our data do not permit us to detect these events, surveys of nursing and nonnursing caregivers suggest improved perceptions of quality of care.

Lack of effect on mortality rate, satisfaction, or readmission may represent an opportunity to refine the CNS model to maximize its effectiveness. The effects of consultation models on quality of care and outcomes are generally weak,[8] leading 2 authors[9] to suggest that the frame-

Table 4. Impressions of Nonnursing CNS Service Caregivers

Question or Statement	Average Response Before CNS Implementation	Average Response After CNS Implementation	*P* Value
I have adequate supervision or backup when caring for a patient's medical problems	3.0	4.6	<.001
I receive adequate education and training in perioperative medicine	3.4	4.1	.07
The amount of time I spend providing medical care does not impair my ability to provide surgical care	3.0	4.3	.01
I can easily and promptly reach a physician who can address my concerns or questions about a patient's medical problems	3.2	4.7	<.001
I am satisfied with the level of communication and collegiality with the hospitalist	3.5	4.8	<.001
Overall, neurosurgery patients receive high-quality care for their medical problems	3.3	4.6	<.001
Patients' medical problems are promptly recognized and appropriately addressed	2.9	4.8	<.001
Sick or clinically deteriorating patients receive adequate assessment and attention with regard to their medical problems	3.4	4.7	<.001
Medical problems are adequately addressed when patients are discharged	2.7	4.4	<.001
The presence of a hospitalist improves care for neurosurgery patients	NA	4.9	NA
The presence of a hospitalist makes it easier for me to do my job	NA	4.8	NA

Abbreviations: CNS, comanagement on neurosurgery service; NA, not applicable.

Table 5. Impressions of Nursing CNS Service Caregivers

Question or Statement	Average Response Before CNS Implementation	Average Response After CNS Implementation	*P* Value
I am satisfied with the level of communication and collegiality between nurses and the neurosurgery service	3.2	4.1	<.001
I can easily and promptly reach a physician when I have concerns or questions about a patient's medical problems	3.1	4.2	<.001
I understand the care plan for my patient's medical problems	3.4	4.1	<.001
Overall, neurosurgery patients receive high-quality care for their medical problems	3.3	4.2	<.001
Patients' medical problems are promptly recognized and appropriately addressed	3.1	4.2	<.001
The physician responding to my concern about a medical problem is able to adequately address my concern	3.0	4.3	<.001
Sick or clinically deteriorating patients receive adequate assessment and attention from the neurosurgery service or the hospitalist with regard to their medical problems	3.1	4.6	<.001
Medical problems are adequately addressed when patients are discharged or leave the unit	2.9	4.0	<.001
The presence of a hospitalist improves care for neurosurgery patients	NA	5.0	NA
The presence of a hospitalist makes it easier for me to do my job	NA	4.8	NA

Abbreviations: CNS, comanagement on neurosurgery service; NA, not applicable.

work for care of surgical patients with medically complex needs should be shifted toward a comanagement paradigm. A previous study[10] of comanagement in surgery and intensive care units used models in which surgeons and internists performed rounds together, which was logistically difficult to do on our service. There may be opportunities to improve the model's effectiveness by more proactively screening and treating patients before and after surgery[10] or by applying comanagement to only the patients at highest risk.

Our study has many limitations. We focused on outcomes that are important but relatively lacking in sensitivity to compare patients before and after CNS implementation. Having said that, cost, length of stay, and satisfaction data were available for enough patients to provide strong statistical power. Our cost data lack specific information regarding which areas of practice (eg, laboratory, pharmacy, radiology) were responsible for cost reductions. Our study, which identified comanaged patients through billing systems, could not discern the intensity or extensiveness of the services provided and may have missed differences in some important outcomes or covariates (eg, functional status and bleeding risk). Because we relied on administrative data for risk adjustment, it is also possible that we failed to fully account for subtle biases related to patient or operative factors. Few of our major patient factors changed over time, lessening the likelihood of this problem. There was a moderate reduction in overall case volume during the study period. However, our methodologic approach would have accounted for any secular trends introduced by a less busy service. Although anecdotal evidence and our survey results suggest that the CNS was extraordinarily well received by nurses, pharmacists, and residents, we have no data to describe its effect on patient safety, safety culture, resident duty hour adherence, or residents' workload. Our findings of cost savings were small in relative terms and are potentially prone to type 1 (false-positive) error. However, the magnitude of the cost savings (adjusted rate ratio, 0.94) is similar to that seen for length of stay (adjusted rate ratio, 0.97), although length of stay did not meet tests of statistical significance. Our focus on service-level outcomes may have underestimated the true effect of comanagement because most patients did not, in fact, receive active comanagement. However, we believe this approach is correct because it is conservative and because hospitalists provided direct care to patients and indirect advice regarding other patients. Finally, because our study was based at a single academic center, our results may not be directly applicable to other settings, such as nonteaching hospitals, where comanagement models are typically thought to be more common.

If the cost savings and health care professional satisfaction results we found are confirmed in other studies, comanagement, particularly by hospitalists, is likely to continue to increase even if its effect on patient outcomes is small. In some circumstances, the main motivation for the implementation of comanagement systems will be coverage requirements, such as when comanagement systems are used to compensate for reduced resident availability in teaching hospitals. However, our data strongly suggest that physician and nursing perceptions of patient safety and work satisfaction may be important drivers. Whether the catalyst for a comanagement system is cost reduction, coverage needs, or something else, future research should focus on ways to improve efficiency and clinical outcomes.

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