Effects of Physician Experience on Costs and Outcomes on an Academic General Medicine Service: Results of a Trial of Hospitalists

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Background: Hospitalists may decrease costs and improve outcomes in hospitalized patients, but existing evidence is limited and has not identified mechanisms for such effects.

Objective: To study the costs and outcomes for patients on an academic general medicine service assigned to teams led by hospitalists and nonhospitalists.

Design: Cohort study.

Setting: Academic general medicine service.

Patients: 6511 patients admitted to the hospital from July 1997 through June 1999.

Intervention: All patients admitted every fourth day were assigned to 1 of 2 hospitalists caring for inpatients 6 months each year or 1 of 58 nonhospitalists caring for inpatients 1 to 2 months each year.

Measurements: Length of stay; inpatient costs; and 30-, 60-, and 365-day mortality.

Results: Patients assigned to hospitalists (24.8%) and nonhospitalists (75.2%) did not differ in age, race, sex, diagnosis mix, or Charlson index score. In year 1, average adjusted length of stay was 0.29 day shorter for patients cared for by hospitalists than by nonhospitalists (95% CI, −0.66 to 0.06 day; $P = 0.06$); in year 2, average adjusted length of stay was 0.49 day shorter for patients cared for by hospitalists (CI, −0.79 to −0.15 day; $P = 0.01$). Average adjusted costs were not significantly reduced for hospitalists compared with nonhospitalists in year 1 but were reduced by \$782 in year 2 (CI, −\$1313 to −\$187; $P = 0.01$). When years 1 and 2 were combined or when year 1 was analyzed alone, 30-day mortality was not significantly different for hospitalists and nonhospitalists; however, 30-day mortality was 4.2% for hospitalists compared with 6.0% for nonhospitalists in year 2 (CI for difference, 1.8 percentage points [−3.6 to −0.1 percentage points]; $P = 0.04$) and the adjusted relative risk was 0.65 (CI, 0.44 to 0.96; $P = 0.03$). In multivariate analyses, resource use decreased with the physician's cumulative experience in caring for a patient's primary diagnosis. Mortality showed a similar pattern.

Conclusions: Hospitalist care was associated with lower costs and short-term mortality in the second but not the first year of hospitalists' experience. Disease-specific physician experience may reduce resource use and improve patient outcomes; in addition, it may be an important determinant of the effectiveness of hospitalists.

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In many countries, patients hospitalized with general medical problems are usually cared for by physicians who specialize in inpatient care (1–3). In the United States, primary care physicians have often served this role historically. However, in recent years, there has been a surge of interest in the care of inpatients by "hospitalists"—physicians who devote at least 25% of their time to the care of hospitalized patients (4).

Key to the growth of hospitalist medicine has been the belief that hospitalists are better suited to contain costs and maintain or improve patient outcomes. Although several recent studies support this belief (5–7), only two had research designs that assigned patients to hospitalists or nonhospitalists without taking into account clinical criteria. Wachter and colleagues showed cost savings but could not demonstrate improved outcomes (5). Moreover, many of the "hospitalist" physicians in that study practiced inpatient medicine for only 1 or 2 months per year. Kearns and colleagues found no effect on either costs or outcomes (8).

These disparate results highlight our limited understanding of the mechanisms by which hospitalists may affect medical care costs or outcomes. Thus, it is difficult to know whether the results of these or other studies are generalizable to other settings. One hypothesis is that the hospitalist's experience in the inpatient setting may be an important determinant of improvements in costs and patient outcomes. Indeed, numerous reports in the literature support a relationship between volume and outcomes for surgeons and some medical specialists (9, 10), but this relationship has never been demonstrated in inpatient general medical care. Benefits of care provided by hospitalists might also result from intrinsic differences in practice style; provision of more focused physician clinical leadership through the development of practice guidelines; or greater emphasis on inpatient care, such as special efforts to see patients on the day of admission. Hospitalists may also have broad effects on practice patterns in the institutions in which they operate by providing a pool of highly experienced inpatient clinicians to whom other physicians (including housestaff) can turn for advice. Understanding the importance of these factors is crucial to the design, evaluation, and improvement of hospitalist programs.

We report the results of a 2-year trial that compared hospitalist care to care by traditional academic internists on the general medicine service at the University of Chicago. In addition to examining the effects of hospitalists on both costs and outcomes, we focused on whether greater overall experience and disease-specific experience with hospitalized patients are important determinants of the effects of hospitalists on costs and patient outcomes.

METHODS

In July 1997, a hospitalist service was established within the general medicine service at the University of Chicago. The goals of the service were to improve the educational environment and contain costs. Two general internists in practice for 2 and 10 years, respectively, agreed to serve as an inpatient attending physician for 6 months of the year, alternating with each other every month between the inpatient service and a shared ambulatory general medicine practice. The 58 nonhospitalist physicians had an average of 9 years of experience after residency (median, 7 years [range, 0 to 34 years]), and 24 had subspecialty training. The hospitalists were not given specific instructions or incentives to alter their practice patterns but were aware that resource utilization, patient outcomes, and housestaff satisfaction were being studied. The hospitalist team alternated in a 4-day call cycle with 3 teams led by traditional academic internists who served as inpatient attending physician 1 or 2 months per year. The 4-day call cycle was arranged so that all patients admitted on each day were assigned to the on-call team (except for the first four patients admitted on weekdays before 5 p.m.). The four excluded patients were assigned to the "short-call" team for that day, which was on day 3 of its call cycle at the time. Thus, all patients were assigned to teams according only to their position in the call cycle, without regard to whether the attending physician was a hospitalist or nonhospitalist.

To minimize hospitalist fatigue, all weekend days on the hospitalist service were covered by the pool of traditional general internists, except when the hospitalist team had been on call the day before. The traditional attending physicians had no weekend days off when they were on-service. Nonhospitalists generally had scheduled ambulatory clinics on weekday afternoons, whereas hospitalists did not have clinic with the expectation that they would be more available to see patients on the day of admission. Attending physicians worked with a single housestaff team in blocks of 2 or 4 weeks. Housestaff and attending physicians were assigned primarily according to requests for which months they would be on-service and without any knowledge of the specific attending physician or housestaff with whom they would be paired. Also, housestaff were assigned to teams so that each house officer had a mix of hospitalist and nonhospitalist attending physicians over the year. Occasionally, a house officer was perceived to require additional oversight; when this occurred (fewer than 3 or 4 of 48 monthly rotations yearly), the residency program director assigned the house officer to an attending physician who she believed might provide better supervision. Housestaff wrote all patient orders. The University of Chicago's Institutional Review Board approved this study.

Study Sample and Data Collection

We studied 6511 patients admitted to the general medicine service from 1 July 1997 through 30 June 1999. Hospital administrative data provided information on age, race, primary and secondary diagnoses, length of stay, and costs. Costs were assessed by using an activity-based accounting system produced by Transitions Systems, Inc. (currently owned by Eclypsis Corp., Delray Beach, Florida). Physician fees were not included. Length of stay was defined as the number of days from when a patient was admitted to the general medicine service to his or her discharge from the hospital, even when the patient was transferred to another service before discharge.

Hospitalized patients were asked to consent to a 15-minute interview to collect detailed health and socioeconomic information and contact information for a follow-up telephone interview 1 month after discharge. We tried to identify proxy respondents for patients unable to complete or consent to the interview. Of the 6511 admitted patients, 4119 (63%) were approached for interviews; 941 (14%) were not approached for interviews because the patient had an admission within the previous 60 days and 1451 (22%) were not approached for interviews because the patient was discharged or had died. Of the 4119 patients approached, 3866 (94%) agreed to be interviewed (including 12% by proxy) and 253 (6%) declined to be interviewed. Similar percentages of patients completed interviews on the hospitalist and nonhospitalist services.

We assessed mortality at 30, 60, and 365 days after admission by linking to the Social Security Death Index (11, 12). A telephone survey of patients or designated proxies who agreed to be interviewed was done at least 1 month after discharge to assess rehospitalization, emergency department use, reported physical function, and patient satisfaction. Of the 3866 patient interviews performed in the hospital, 1-month follow-up surveys were completed for 2768 (72%).

Patient satisfaction with the hospitalization and the care provided by the attending physician was assessed by

Context

Despite the growing number of hospitalist physicians in the United States, evidence about their effect on outcomes of care is limited.

Contribution

This observational study suggests that patients cared for by hospitalists had shorter hospital stays, lower costs, and lower short-term mortality compared with patients cared for by nonhospitalists. These differences became evident only in the second year of the hospitalist program, suggesting that hospitalists' skills improve with additional clinical experience.

Cautions

Because the study included only two hospitalist physicians at one hospital, readers should be cautious about generalizing the findings to other settings.

–The Editors

Table 1. **Characteristics of Patient and Attending Physician at Admission***

Characteristic	Nonhospitalist Service	Hospitalist Service	*P* Value for Difference
Patients, *n (%)*	4898 (75.2)	1613 (24.8)	
Mean age, *y*	58	58	>0.2
Women, %	61	63	0.11
African-American, %	82	83	>0.2
Diagnosis-related group weight	1.15	1.19	>0.2
Charlson Comorbidity Index score	2.64	2.69	>0.2
Primary diagnosis (ICD-9-CM code), %			
Asthma (493.20, 493.90–493.91)	7.80	7.94	
Pneumonia (486)	6.02	6.08	
Congestive heart failure (428.0)	3.16	3.47	
Urinary tract infection (599.0)	2.78	3.60	
Sickle-cell disease (282.62)	2.89	2.91	
Hypovolemia (276.5)	2.29	2.11	
Cellulitis of the leg (682.6)	2.02	1.80	
COPD (491.21)	1.92	1.36	>0.2
Venous thrombosis (453.8)	1.61	1.55	
Acute pancreatitis (577.0)	1.37	1.05	
Gastrointestinal bleeding (578.9)	1.10	1.55	
Aspiration pneumonitis (507.0)	1.20	1.18	
HIV with opportunistic infection (042)	1.20	0.80	
Systemic lupus erythematosus (710.0)	1.12	0.93	
Hypertensive renal disease with renal failure (403.91)	1.08	0.87	
Other	62.43	62.80	
Weekend admission, %	23	23	>0.2
Attending physicians			
Experience in study period to date, *n cases*	64	410	<0.001
Disease-specific experience in study period to date, *n cases*	2.4	10.1	<0.001
Sees patient on day of admission, %	27	35	<0.001
Weekday admission	27	38	<0.001
Weekend admission	27	24	>0.2

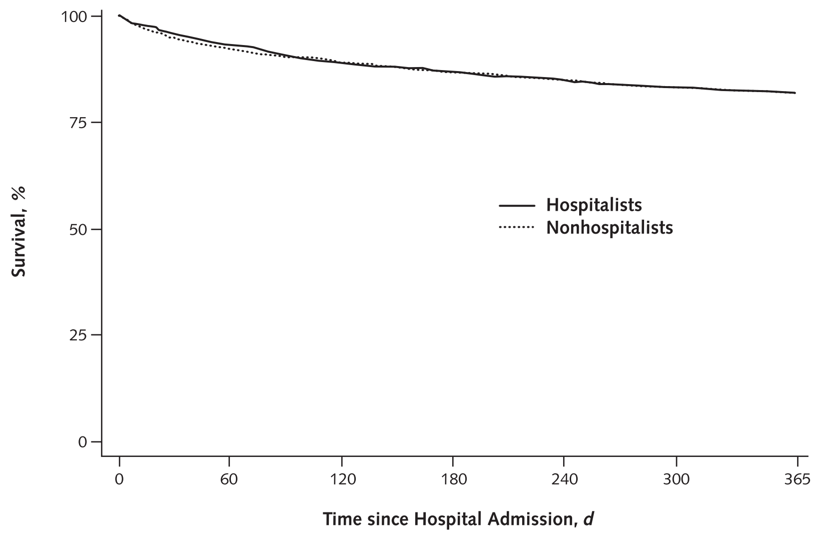
* COPD = chronic obstructive pulmonary disease; ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification.

using questions from the Picker-Commonwealth patient satisfaction survey (13, 14). Health status was assessed by using the self-rated health status and health limitation questions of the Medical Outcomes Study 12-Item Short Form (SF-12) (15). Rehospitalization and emergency department utilization were assessed by respondent recall of all emergency department visits and hospitalizations during the month after discharge (16). We measured case mix by using diagnosis-related group (DRG) weights and measured comorbidity by using a claims-based Charlson Comorbidity Index with a 1-year look-back (17–19). Provider experience was measured by counting the total number of cases and the total number of cases with the same diagnosis (measured by 3-digit International Classification of Diseases,

Table 2. **Length of Stay and Costs**

Variable	Year 1	Year 2	Difference Between Year 2 and Year 1	*P* Value for Difference
Length of stay, *d*				
Nonhospitalists	4.97	4.60	−0.37	0.03
Hospitalists	4.93	4.06	−0.87	0.01
Difference between hospitalists and nonhospitalists	−0.04	−0.54		
P value for difference	>0.2	0.02		
Adjusted length of stay, *d*				
Nonhospitalists	5.03	4.59	−0.44	0.01
Hospitalists	4.74	4.10	−0.64	0.01
Difference between hospitalists and nonhospitalists	−0.29	−0.49		
P value	0.06	0.01		
Total costs, $				
Nonhospitalists	8295	8765	470	0.19
Hospitalists	9072	8005	−1067	0.10
Difference between hospitalists and nonhospitalists	777	−760		
P value	0.13	0.13		
Adjusted total costs, $				
Nonhospitalists	8701	8801	100	>0.2
Hospitalists	8648	8019	−629	0.05
Difference between hospitalists and nonhospitalists	53	−782		
P value	>0.2	0.01		

Figure. **Kaplan–Meier survival curves for patients cared for by hospitalists and nonhospitalists.**



Patients on hospitalist service, *n*	1613	1501	1435	1392	1363	1334	1311
Patients on nonhospitalist service, *n*	4898	4510	4344	4236	4148	4059	3985

Ninth Revision, Clinical Modification [ICD-9-CM] code) that the attending physician had cared for during the study period up to and including the patient's date of admission.

Statistical Analysis

We used Stata software, version 7.0 (Stata Corp., College Station, Texas), for all statistical analyses. We examined differences in baseline health and demographic characteristics of the patients assigned to hospitalists and nonhospitalists and for differences between hospitalist and nonhospitalist characteristics (such as experience) using *t*-tests for continuous variables and exact binomial tests for binary variables. We tested for differences in length of stay, costs, mortality, emergency department utilization, and readmission by using *t*-tests, with corrections for clustering of patients by attending physician. We used the Pearson chi-square to test for differences in physical function and patient satisfaction. We compared length of stay, costs, and outcomes for the first and second year to assess changes over time.

We also assessed the effects of hospitalists using regression models in which the dependent variables were length of stay, costs, or mortality and the explanatory variables were an indicator variable for hospitalist attending physician, DRG weight of primary diagnosis, Charlson Comorbidity Index score, weekend admission, age in years, ethnicity, and whether the patient was admitted directly to the general medicine service or transferred from another service (transfer status). To account for the non-negativity and skewed distribution of costs and length of stay and to avoid heteroscedasticity in simple least-squares models, we used generalized linear models of length of stay and costs, assuming that the effects of the covariates were proportional (that is, a logarithmic link function) (20, 21). We used the residual diagnostic methods described by Manning and Mullahy (21) to determine that error structure in these generalized linear models was best described by a γ distribution. To address clustering of patients by attending physicians, we did the statistical tests based on robust standard errors (22), with cluster correction for the attending physician. These regression analyses were used to estimate length of stay and costs; we controlled for DRG weight, Charlson Comorbidity Index score, race, age, weekend admission, and transfer status. Statistical tests and confidence intervals for these adjusted values were calculated by using the bootstrap method (23). Logistic regression analyses were done for 30-, 60-, and 365-day mortality. These regressions controlled for DRG weight, Charlson Comorbidity Index score, race, age, weekend admission, and transfer status and included cluster corrections for attending physician.

To explore the mechanism by which hospitalists might affect patient outcomes, we expanded these regression analyses to include overall and disease-specific attending experience during the study period at the time of a patient's admission. The overall experience variable allowed us to test whether costs and outcomes were affected by the attending physician's cumulative experience during the study period, irrespective of diagnosis. The disease-specific experience variable allowed us to test whether the physician's cumulative experience with the patient's diagnosis during

Table 3. **Effects on Mortality**

Variable	Years 1 and 2			Year 1		
	30-Day	60-Day	365-Day	30-Day	60-Day	365-Day
Unadjusted mortality						
Nonhospitalist, %	5.4	7.9	18.6	4.7	6.9	17.4
Hospitalist, %	4.6	6.9	18.7	5.1	7.1	18.8
Difference (95% CI), *percentage points*	−0.8 (−2.1 to 0.4)	−1.0 (−2.5 to 0.5)	0.1 (−2.1 to 2.3)	0.4 (−1.4 to 2.1)	0.2 (−1.9 to 2.2)	1.4 (−1.7 to 4.5)
P value	0.20	0.21	>0.2	>0.2	>0.2	>0.2
Relative risk (hospitalist vs. nonhospitalist)						
Unadjusted relative risk (95% CI)	0.84 (0.65 to 1.09)	0.87 (0.69 to 1.08)	1.01 (0.87 to 1.16)	1.07 (0.74 to 1.56)	1.02 (0.74 to 1.41)	1.10 (0.89 to 1.36)
P value	0.20	0.21	>0.2	>0.2	>0.2	>0.2
Adjusted relative risk (95% CI)	0.82 (0.62 to 1.08)	0.85 (0.68 to 1.07)	1.00 (0.85 to 1.17)	1.04 (0.70 to 1.55)	0.99 (0.71 to 1.40)	1.09 (0.87 to 1.37)
P value	0.11	0.17	>0.2	>0.2	>0.2	>0.2

the study period affected costs or outcomes. To interpret the estimates of the effects of case counts as the percentage effect of a doubling of experience on the outcome in question, we measured the case count variables as the natural log of the case counts. To avoid possible confounding of the effects of disease-specific physician experience by the effects of diagnoses with many patients, we also included indicator variables for the 60 largest primary diagnoses, as defined according to the 3-digit ICD-9-CM code. To more precisely control for seasonal effects and time trends that could affect both services, we included an indicator variable for each month in the study in these regressions.

Role of the Funding Source

The funding sources played no role in the design, conduct, or reporting of the study or the decision to submit the manuscript for publication.

RESULTS

Characteristics of the Hospitalist and Nonhospitalist Services

Of the 6511 patient admissions to the general medicine service, 4898 (75.2%) were assigned to 1 of the 58 nonhospitalists and 1613 (24.8%) to 1 of the 2 hospitalists. Consistent with the assignment of patients to these services in accordance with the call cycle rather than by clinical criteria, patients admitted to these services were very similar in demographic characteristics, mix of primary diagnoses, diagnosis-related group weight, and Charlson Comorbidity Index score (**Table 1**).

Because hospitalists spent more time on the inpatient service over the study, their average overall and disease-specific experience was greater than that of nonhospitalists (**Table 1**). Hospitalists saw 35% of patients on the day of admission, whereas nonhospitalists saw 27%. This difference was the result of the hospitalists' greater likelihood of seeing patients admitted weekdays on the day of admission; hospitalists were not more likely than nonhospitalists to see patients admitted on weekends on the day of admission.

Effects on Length of Stay and Costs

Over the study period, adjusted average length of stay was 4.78 days on the nonhospitalist service and 4.46 days on the hospitalist service (difference, −0.32 day [CI, −0.61 to −0.03 day]; $P = 0.03$). Adjusted average length of stay was reduced by only 0.29 day for hospitalists compared with nonhospitalists in year 1 (CI, −0.66 to 0.06 day; $P = 0.06$), but the difference increased to 0.49 day by year 2 (CI, −0.79 to −0.15 day; $P = 0.01$) (**Table 2**). This difference occurred despite a 0.44-day decrease in adjusted length of stay on the nonhospitalist services between years 1 and 2. The increase in the difference between the hospitalist and nonhospitalist services between year 1 and the difference between them in year 2 was not statistically significant in either of the adjusted analyses (difference, 0.20 day [CI, −0.30 to 0.65 day]; $P = 0.23$) or unadjusted analyses (difference, 0.50 day [CI, −0.11 to 1.08 day]; $P = 0.11$). However, there was a trend toward increasing differences in both analyses.

Over the 2 years, adjusted average costs were $8746 on the nonhospitalist service compared with $8320 on the hospitalist service (difference, −$426 [CI, −$912 to −$31]; $P = 0.03$). As with length of stay, the difference in average costs between the services in year 1 was not statistically significant, but the mean cost for hospitalists was reduced by $782 compared with nonhospitalists in year 2 (CI, −$1313 to −$187; $P = 0.01$). Compared with the pattern for length of stay, the increase in the difference in costs between the hospitalist and nonhospitalist services between years 1 and 2 was more significant in both the adjusted analyses (difference, $729 [CI, −$166 to $1642]; $P = 0.06$) and the unadjusted analyses (difference, $1537 [CI, $126 to $2948; $P = 0.03$).

Effects on Outcomes

Table 3 shows unadjusted and adjusted effects on mortality. Unadjusted analyses show no statistically significant effects on mortality over the 2 years combined, al-

Table 3—**Continued**

Year 2		
30-Day	**60-Day**	**365-Day**
6.0	8.8	19.8
4.2	6.8	18.6
−1.8 (−3.6 to −0.1)	−2.0 (−4.1 to 0.01)	−1.2 (−4.2 to 1.9)
0.04	0.07	>0.2
0.68 (0.47 to 0.98)	0.76 (0.56 to 1.02)	0.93 (0.76 to 1.13)
0.04	0.07	>0.2
0.65 (0.44 to 0.96)	0.74 (0.54 to 1.01)	0.92 (0.74 to 1.14)
0.03	0.06	>0.2

though there are trends toward lower mortality at both 30 and 60 days that are no longer apparent at 365 days. These reductions in short-term mortality are shown graphically through Kaplan–Meier survival curves (**Figure**). By examining mortality by year, we can see that these findings are the result of the combination of no effect on mortality in the first year but about 2–percentage point decreases in the absolute probability of mortality at 30 and 60 days in the second year that are statistically significant.

Results were similar in the adjusted analyses of mortality. These analyses show trends toward lower mortality for hospitalist service patients at 30 days (adjusted relative risk, 0.82; $P = 0.11$) and 60 days (adjusted relative risk, 0.85; $P = 0.17$) over the 2 years. As in the unadjusted results, the adjusted results reflect the lack of significant effects in year 1 but large and statistically significant effects at 30 days (adjusted relative risk, 0.65; $P = 0.03$) and 60 days (adjusted relative risk, 0.74; $P = 0.06$) in year 2. In-hospital mortality and 30-day readmission, emergency department use, self-reported health status, and patient satisfaction did not differ significantly in either year or over the 2 years combined. However, the trend over the 2 years favored hospitalists in almost all measures (**Table** 4).

Effects of Experience on Length of Stay, Costs, and Mortality

Table 5 presents the regression analyses of length of stay, costs, and mortality. We used basic models controlling for primary diagnosis with DRG weight and indicator variables for the 60 largest diagnoses, secondary diagnoses with Charlson Comorbidity Index scores, and time trends by using month-specific dummy variables. We found that patients in the hospitalists' services had an 8.0% shorter length of stay, 4.6% lower costs, and a trend toward 18% (relative risk, 0.82) and 14% (relative risk, 0.86) lower relative risk for 30- and 60-day mortality, respectively. Including measures of overall and disease-specific experience eliminates the independent effects of hospitalists. Only the effects of disease-specific experience on resource use are statistically significant; a doubling of previous case volume decreased length of stay by 4.4% and costs by 5.1%. There was also a tendency toward decreased mortality with increasing disease-specific experience, but this decrease was not statistically significant at 30, 60, or 365 days.

DISCUSSION

Our primary conclusions are that hospitalists decreased resource use and short-term mortality and that improvements increased over time in association with disease-specific experience. Although we found more modest differences in year 1 of our study, by year 2, the hospitalists reduced average adjusted length of stay by almost 0.5 day, average adjusted costs by $782, and adjusted mortality at 30 and 60 days by 37% and 28%, respectively. Other outcomes, such as hospital readmission, emergency department visits, and self-reported health status, showed trends toward improvement, although these did not reach statistical significance. Our results provide important evidence to support the use of hospitalists to reduce inpatient resource use while maintaining or even improving outcomes.

Because our findings reflect the experience of a small number of clinicians at one institution, it is important to compare them with the two studies described earlier (Wachter and colleagues; Kearns and colleagues) that examine patients assigned to hospitalists without respect to clinical criteria. Kearns and colleagues compared the use of

Table 4. **Effects on Patient Outcomes**

Service	In-Hospital Mortality Rate (*n* = 6511)*	30-Day Readmission Rate (*n* = 2672)*	30-Day Emergency Department Visit Rate (*n* = 2659)*	30-Day Reported Health Status† (*n* = 2765)	Overall Patient Satisfaction† (*n* = 2689)
	←— *n (%)*	——	——→		
Nonhospitalist	109 (2.2)	245 (12.2)	164 (8.2)	2.73	4.08
Hospitalist	31 (1.9)	71 (10.8)	50 (7.6)	2.78	4.08
Difference in means (95% CI)	−0.3 (−1.1 to 0.5)	−1.4 (−4.2 to 1.4)	−0.6 (−3.0 to 1.8)	0.05 (−0.05 to 0.15)	0.002 (−0.09 to 0.09)
P value‡	>0.2	>0.2	>0.2	0.2	>0.2

* Differences are expressed as percentage points.
† Measured on a scale of 1 to 5; 1 = poor, 5 = excellent.
‡ *t*-test was used for *P* values for in-hospital mortality rate, 30-day readmission rate, and 30-day emergency department visit rate. Chi-square test was used for *P* values for 30-day reported health status and overall patient satisfaction.

new hospitalists with annual hospitalist case volumes similar to those in our study. Of note is the consistency between the lack of resource savings in year 1 in our study and the lack of savings suggested by Kearns and colleagues (8). The resource savings noted in year 2 of our study were similar to the 0.6-day shorter length of stay and $770 reduction in costs found by Wachter and colleagues (5). It is unclear why our initial savings were lower but our later savings were similar to those found by Wachter's team. We suggest two possible explanations for the greater initial savings at the University of California. First, Wachter and colleagues more carefully selected hospitalists for their underlying practice styles. Second, discontinuities of care were present in our system because of the hospitalist weekend coverage system. Although our hospitalist program may not have been as initially effective as the University of California program, our hospitalists were eventually able to achieve similar resource savings. A possible reason for this is that our study lasted 2 years and the University of California study lasted only 1 year. In addition, both of our hospitalists attended 6 months annually, whereas several of the University of California hospitalists attended for less than the 25% minimum proposed definition for hospitalists.

Even more striking than the substantial cost savings in our study are the large and significant reductions in mortality at 30 and 60 days in year 2. Although the increases in survival in our study are present for only a modest period after discharge, they may be important to both patients and their families. To our knowledge, this is the first study without observable differences in the baseline characteristics of patients cared for by hospitalists and nonhospitalists to show statistically significant reductions in mortality. It will be important to confirm these findings in future studies with more patients, clinicians, and institutions. Our results add credence to findings of improved outcomes in a recent nonrandomized study of hospitalists (24).

Because only two hospitalists were involved in our study, questions must be raised about the generalizability of our results. It would be helpful, then, to examine the effects of the individual hospitalists, but the number of patients cared for by each hospitalist was too small to permit a precise estimate of the effects for each hospitalist. This problem is complicated because of the differences between the 2 years and the resulting need to examine each hospitalist separately in each year of the study. In year 1, we found no difference in either resource utilization or mortality for either hospitalist. In year 2, we were still able to see trends toward shorter length of stay, lower costs, and lower mortality for each of the hospitalists; however, these trends did not consistently reach statistical significance by standard criteria. Of note, one of the two hospitalists had a stronger tendency toward lower resource utilization, whereas the other had a stronger tendency toward lower mortality. These findings support the need for future studies with larger numbers of hospitalists.

Our study includes only two hospitalists, but they rapidly accumulated experience leading to substantial variation in overall and disease-specific experience variables. These variables provide insight into mechanisms by which hospitalists may influence outcomes. Resource savings increased over time in relation to disease-specific experience. We also found a trend in which the improvements in mortality over time for hospitalists relative to nonhospitalists were associated with increased disease-specific experience. To the extent that changes in mortality over time are not associated with increased disease-specific experience, it will be important to determine why these changes occurred. One hypothesis is that the hospitalist's overall experience and greater physical presence on the wards led to greater awareness of clinical instability and more timely transfer of unstable patients to the intensive care unit, regardless of clinical diagnosis. Further work should test this and other hypotheses about mechanisms for effect on mortality.

Whether the effects of hospitalists on costs and outcomes is a result of overall or disease-specific experience, our findings suggest that even experienced clinicians, such as our hospitalists, can benefit from greater disease-specific experience. Such "volume–outcomes" relationships for providers have been demonstrated for a wide range of surgical procedures (9, 25, 26) and for treatment of patients with HIV infection in an ambulatory setting (10). However, we believe that our study is the first demonstration of

Table 5. **Multivariate Analysis of Effects on Length of Stay and Costs***

Variable	Length of Stay		Total Costs	
	Basic Model	Model with Experience Variables	Basic Model	Model with Experience Variables
	←———	%		———→
Hospitalist	−8.0‡ (−12.8 to −3.2)	0.03 (−7.1 to 7.1)	−4.6† (−9.6 to 0.4)	0.1 (−5.9 to 7.8)
Total cases to date		−1.8 (−4.4 to 9.3)		−0.2 (−2.5 to 2.2)
Cases to date with same three-digit ICD-9-CM code		−4.4‡ (−7.8 to −0.9)		−5.1§ (−9.1 to −1.1)

* Percentage effect on outcome variable of hospitalist variable or doubling of experience variables. 95% CIs are given in parentheses. All regressions also include month-specific indicator variables, three-digit ICD-9-CM–specific indicator variables for the primary diagnosis, natural log of diagnosis-related group weight, Charlson Comorbidity Index, patient age, race (African-American vs. other), and indicator variables for weekend admission and whether patient was admitted directly to the general medicine service or transferred to the service from another service. ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification.
† $P < 0.10$.
‡ $P < 0.05$.
§ $P < 0.01$.

this relationship for hospitalized general medicine patients. Moreover, because patients were assigned to attending physicians without consideration of their diagnoses, our findings are not subject to the criticism often made of volume-outcomes relationships—that such associations may occur if providers with lower costs or better outcomes attract larger numbers of patients (9, 25). The volume-outcomes relationship that we observed seems to be a result of the effects of experience on outcomes rather than the reverse.

Given the diversity of diagnoses treated by general internists, our findings about the importance of disease-specific experience highlight many challenges for general internal medicine. These challenges have importance that extends beyond hospitalists. Because no single diagnosis represents more than a small percentage of the admissions treated by general internists, the development of a few critical pathways or practice guidelines is unlikely to be as effective in general internal medicine as it is in specialty practices. If, indeed, patient volume is important, the greater use of hospitalists is one way to increase the experience of physicians caring for hospitalized patients. However, provider experience might also be increased by encouraging clinicians with little inpatient exposure to increase their clinical inpatient work or by focusing general internal medicine practice on fewer diagnoses with greater referral to subspecialists. Our study cannot assess the merits of these options but does suggest the potential value of exploring them and the importance of considering disease-specific experience in evaluating such approaches.

Costs and outcomes improved primarily in the second year of our study, suggesting that hospitalist programs are most likely to be beneficial when staffed by experienced physicians. This is an important concern because the recent rapid growth in the use of hospitalist physicians has created a relative shortage of experienced hospitalists. This problem is compounded by the fact that many hospitalist positions are designed to be transient and staffed by recent residency graduates. Long-term career development paths are unclear. At our medical center, we have addressed this challenge by using some of the financial savings generated by hospitalists to support protected time for promoting the long-term career development of our hospitalists. The hospitalists use this protected time to work on hospital systems improvements and to pursue academic research agendas.

When overall and disease-specific experience are controlled for (**Table 5**), the direct effects of hospitalists are greatly reduced, suggesting that these factors are largely responsible for the effects of hospitalists. Other factors, such as the selection of physicians with resource-conscious practice styles similar to those of hospitalists and aspects of experience or effort that were not captured by our analyses (such as subspecialty training and years since residency) may also contribute to these effects. The finding that resource savings for hospitalists that existed at the beginning of the study were substantially smaller during the second year suggests that selection of resource-conscious physicians may explain some but not most of our results. Including measures of physician subspecialty training and years since residency in our analyses did not change the effects of experience. Although hospitalists were more likely than nonhospitalists to see patients on the day of admission, this difference decreased from 15% in year 1 to 3% in year 2 ($P = 0.01$ for change in difference), suggesting that greater effort to see the patient on the day of admission does not explain the advantages of hospitalists over nonhospitalists in resource use or outcomes in year 2.

Another possible explanation of the effects of hospitalists is that the hospitalists were more likely to benefit from the development of critical pathways. However, there were only two active pathways on our general medicine service during the study period—for treating pneumonia and for treating deep venous thromboses with low-molecular-weight heparin. Excluding patients with these conditions from our analysis did not substantially alter the findings.

Hospitalists may have also influenced how other clinicians, including housestaff, care for patients. If so, our analysis may underestimate the total benefits of hospitalists. Because we know the assignment of attending physicians to housestaff for each month, it may be possible to track such effects in future analyses. In our analysis, the reduction in length of stay between years 1 and 2 for patients cared for by nonhospitalists may reflect the influence

Table 5—**Continued**

30-Day Mortality		60-Day Mortality		365-Day Mortality	
Basic Model	Model with Experience Variables	Basic Model	Model with Experience Variables	Basic Model	Model with Experience Variables
←———	———	——— % ———	———	———	———→
0.82 (0.62 to 1.09)	0.96 (0.65 to 1.42)	0.86 (0.68 to 1.09)	0.97 (0.70 to 1.34)	1.01 (0.86 to 1.19)	1.06 (0.84 to 1.32)
	0.95 (0.84 to 1.08)		0.96 (0.86 to 1.07)		1.02 (0.94 to 1.10)
	0.95 (0.75 to 1.19)		0.96 (0.79 to 1.17)		0.92 (0.81 to 1.06)

of hospitalists on housestaff who worked with nonhospitalists. However, the reduction in length of stay could also reflect a secular decline for other reasons. Our estimates of the effects of hospitalists may also underestimate their true effects because house officers perceived to be not as strong as others were occasionally assigned to attending physicians (such as hospitalists) perceived to be stronger.

Because our study is based on a small number of hospitalists at only one institution, it is important to attempt to replicate these findings with more clinicians and institutions. Future studies could help reveal whether physician characteristics, such as subspecialty training, influence costs or outcomes and could further refine understanding of how experience affects costs and outcomes. Moreover, although our findings and those from Wachter and colleagues support the potential for savings by hospitalists in an academic general medicine service, future work should also study hospitalists in community settings. Hospitalists may offer fewer advantages in such settings to the extent that they displace patients' primary care physicians, who might provide better care because of their ongoing relationship with the patient. However, because housestaff are generally not present for 24-hour coverage in community settings, the greater physical presence of hospitalists might be more important in community hospitals than in teaching hospitals.

Finally, although we found statistically significant reductions in mortality at 30 and 60 days and trends toward improvement in almost all other outcome measures, the relative infrequency of adverse outcomes leaves considerable uncertainty about our estimates of effects on outcomes. All previous studies of hospitalists (5–7) have the same limitation, which again indicates the need for larger studies to evaluate the effects of hospitalists.

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