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Comparing Patient Outcomes of Academician-Preceptors, Hospitalist-Preceptors, and Hospitalists on Internal Medicine Services in an Academic Medical Center

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BACKGROUND: Patient outcomes with hospitalist care have been studied in many settings, yet little is known about how hospitalist care interacts with trainee care to affect patient outcomes in teaching hospitals.

OBJECTIVES: The aim of this study was to compare patient outcomes between hospitalist-preceptors and hospitalists working alone (isolating the effect of housestaff involvement), and between hospitalist-preceptors and academician-preceptors (isolating the effect of attending type, given housestaff involvement).

DESIGN: A four-year retrospective cohort study of patients (n=13,313) admitted to all internal medicine services at an academic medical center from July 2008 to June 2012.

MAIN MEASURES: Using generalized estimating equations, we measured readmission within 30 days, hospital length of stay, cost of the index hospitalization, and cumulative cost including readmissions within 30 days.

KEY RESULTS: In the adjusted models, 30-day readmission odds were higher for academic-preceptors (OR, 1.14 [95 % CI, 1.03−1.26]) and hospitalist-preceptors (OR, 1.10 [95 % CI, 1.002−1.21]) than for hospitalists working alone. Compared with hospitalists working alone, academic-preceptors were associated with shorter length of stay (mean difference, 0.27 days [95 % CI, 0.18−0.38]), lower index hospitalization costs (mean difference, $386 [95 % CI, $192−$576]), but similar cumulative inpatient costs within 30 days of discharge. Compared with hospitalists working alone, hospitalist-preceptors were associated with shorter length of stay (mean difference, 0.34 days [95 % CI, 0.26−0.42]), lower index hospitalization cost (mean difference, $570 [95 % CI, $378−$760]), and a trend toward lower cumulative cost (mean difference, $1347 [95 % CI, $254−$2,816]).

CONCLUSIONS: Preceptor-led medicine services were associated with more readmissions within 30 days, shorter lengths of stay, and lower index admission-associated costs. However, when considering cumulative hospitalization costs, patients discharged by academician-preceptors incurred the highest cost and hospitalist-preceptors incurred the lowest cost.

KEY WORDS: quality of health care; hospitalists; academic medical centers; patient readmission; hospital costs; length of stay.
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INTRODUCTION

Many studies have investigated associations between physician models of care and inpatient outcomes.[1–7] Among these models, practice specialization in inpatient medicine has gained broad acceptance in medicine and pediatrics,[8–10] yet the impact of "hospitalist" physicians on quality of care remains unclear. A recent meta-analysis[11] reported a small but statistically significant reduction in length of stay (LOS) compared to non-hospitalists, but no cost reduction. The authors also found substantial heterogeneity among studies, suggesting that hospitalist care may improve efficiency in some settings, but not in others. Earlier systematic reviews of the quality of hospitalist care[12,13] found inconsistent effects on process and outcome measures; both reviews were generally critical of published studies because of problems such as insufficient sample sizes, failure to adjust for known confounders, failure to account for clustered data, and poorly defined comparators. For example, two studies[14,15] of hospital-level outcomes used the "presence" of hospitalists as the predictor of interest, without data on who treated each patient. Other researchers used billing volume from claims databases[16–18] to classify providers as hospitalists, which may have led to misclassification.

Hospitalists in academic medical centers (AMCs) often manage a non-academic service and also act as preceptors on an academic teaching service, but previous studies have not distinguished between these staffing models.[3,19,20]. Thus, it is not clear how preceptor type (e.g., academician versus hospitalist) and trainee care interact to affect inpatient outcomes in AMCs.

To our knowledge, no study has directly compared patient outcomes between hospitalist-led teaching services and services led by the same hospitalists without trainee involvement.

Using longitudinal electronic health records (EHR) from one large AMC, we explored the associations between three inpatient physician-staffing models—academician-preceptor, hospitalist-preceptor, and hospitalist alone (no trainees)—and patient outcomes of readmission, LOS, and cost. We minimized confounding by adjusting for demographic characteristics, comorbidities, and patient acuity. We sought to address the limitations of previous studies by accurately classifying each patient's clinical service and responsible provider (discharging physician). We compared patient outcomes between hospitalist-preceptors and hospitalists alone (i.e., isolating the effect of housestaff/trainee involvement), and between hospitalist-preceptors and academician-preceptors (i.e., isolating the effect of attending type, given housestaff involvement), hypothesizing that hospitalist teams would be associated with shorter LOS, fewer readmissions, and lower costs, with no significant effect of trainee involvement.

METHODS

Setting and Study Design

We conducted a retrospective cohort study of all internal medicine (IM) patient discharges from 1 July 2008 through 31 June 2012 at the University of California, Davis Medical Center (UCDMC), a 619-bed academic center in Sacramento. During this time, UCDMC operated nine IM physician teams—three hospitalist-alone teams, three hospitalist-preceptor teams, and three academic-preceptor teams. Hospitalist faculty (whose clinical responsibility is essentially limited to inpatient care) provide care on the hospitalist-alone and hospitalist-preceptor services, whereas academician faculty (whose responsibilities also include outpatient care and research) work only with resident trainees. With exceptions based on scheduling constraints, trainees were *quasi-randomly* assigned to academician-led and hospitalist-led services for 4-week rotations. Patient admissions were assigned to whichever team was accepting patients at that time, although hospitalist-alone teams preferentially received daytime Intensive Care Unit (ICU) transfers, which are thought to have less teaching value than other admissions.

Data Sources

Analytic data sets were constructed from multiple sources by combining data from EHR (Epic Systems; Madison, WI), finance/billing (Transition Systems Inc./Eclipsys Corporation; Atlanta, GA), and physician scheduling records. We identified all attending physicians who were assigned to an IM inpatient service during the study period; we then selected all encounters in which a patient had an order written by an IM physician (n= 25,676) and was discharged from an IM service (indicating that an internist was responsible for deciding when and how to release the patient). We excluded patients who expired during the index encounter (n=488, 1.90 %), were transferred to another acute care facility (n=199, 0.78 %), or were discharged against medical advice (n=450, 1.75 %), because these outcomes would truncate LOS and cost during the index hospitalization, and eliminate or otherwise affect the risk of readmission. We also excluded patients who remained in the hospital for non-medical reasons such as conservatorship or other social barriers to discharge (n=730, 2.84 %). For statistical reasons, we excluded encounters if fewer than 15 discharges were attributed to an individual provider (n=243). The final analytic data set included 21,025 hospital encounters.

Providers

Service type was categorized by UCDMC and the Department of Internal Medicine as hospitalist-alone, hospitalist-preceptor, and academician-preceptor. Hospitalists (n=39) are generally appointed as staff physicians and spend 18–30 weeks per year providing inpatient care. Academic-preceptors (n=58) are faculty physicians in general internal medicine or subspecialties who spend only 2–4 weeks per year on inpatient service. Nearly all hospitalists (36 of 39) had full-time clinical (non-academic) appointments and worked on both hospitalist-preceptor and hospitalist-alone services. Of the three other hospitalists, two occasionally worked as academic-preceptors and the third was a staff physician who worked only on the hospitalist-alone service. Academician-preceptors' backgrounds were more heterogeneous, ranging from junior research fellows (with no post-residency experience) to senior faculty (with > 30 years of post-residency experience). Resident trainees from the IM residency program and "rotating interns" from other programs, such as family medicine and neurology, performed clinical duties on both preceptor services. Financial incentives for individual providers or hospital departments to encourage specific patient outcomes (e.g., shorter LOS or readmission) did not differ across hospital services.

We defined a patient's service assignment based on the discharging team. For each hospital encounter, we compared the IM service assignment between billing and EHR data. Only if the service assignments were discordant did we link the discharging physician of record with scheduling information to determine his/her service assignment on the date of discharge.

Outcome Measures

We examined two primary outcomes: all-cause hospital readmission within 30 days and LOS. The time to hospital readmission was defined as the interval between the discharge date/time and the subsequent admission date/time. A readmission to any service within UCDMC was considered a readmission; patients could be discharged and readmitted more than once within the same 30-day period. LOS was calculated as the interval between the admission and the discharge time points. We also considered secondary outcome measures: the total direct cost of care during the index encounter and the cumulative inpatient cost, including all readmissions within 30 days of the index hospital discharge.

Patient-Level Adjustments

In all multivariable models, we adjusted for age, gender, sum of comorbidity categories,[21] Medicare Severity Diagnosis Related Grouper (MS-DRG) relative weight, ICU admission, weekend admission, weekend discharge, payer category, and a clustering effect for repeated patient encounters. We estimated comorbidities using Elixhauser's tool[21] with modifications; we included both principal and secondary diagnoses, and comorbidities reported on any hospital encounter in the 12-month period prior to the index hospitalization to adjust for comorbid conditions.[22] We excluded diagnoses that were not present on admission. To avoid differential ascertainment of comorbid conditions, index hospital encounters without 12 months of prior care in any setting anywhere in the UCDMC Health System were excluded (*n*=2,360).

Statistical Analysis

We computed descriptive statistics including percentages for categorical data and the mean or median (95 % CI, IQR) for continuous measures. Differences in proportions were evaluated using the Chi-square test of association, and differences between the distributions of continuous measurements were evaluated using the Kruskal-Wallis test.

We then constructed generalized estimating equations (GEE—genmod procedure in SAS) to assess the associations between three clinical service types (academician-preceptor, hospitalist-preceptor, hospitalist-alone) and two primary outcomes (readmission within 30 days and LOS) while accounting for clustering effects from patients, nested within provider.[23] The logit-link function was used to fit 30-day readmission models, whereas the identity-link with natural log-transformation was used to model LOS. Using the same adjustments, we also used GEE to model the cumulative inpatient cost for both the index hospitalization and all re-hospitalizations within 30 days of discharge. We accounted for retransformation bias by including a smearing estimator for log-transformed outcomes reported on the original scale.[24] We multiplied the population mean by the parameter estimates to calculate the absolute 30-day readmission rate, LOS, the index encounter cost, and cumulative inpatient cost.

Due to concern that associations between type of service and outcomes might be limited to certain conditions,[25] we tested interaction terms for the ten most common clinical categories (defined by AHRQ's single-level Clinical Classification Software, [Online Appendix, Table A1a]).[26] We adjusted for multiple comparisons using the linear step-up method[27] among these clinical categories. We also performed robustness analyses to evaluate the impact of eliminating the lookback period, ignoring subsequent readmissions within 30 days, excluding ICU transfers, and adjusting for season and season-teaching interactions.

All data management and analyses were conducted using SAS software, version 9.3 (SAS Institute; Cary, NC). The study protocol was approved by the Institutional Review Board at the University of California, Davis Medical Center.

RESULTS

Patient and Provider Characteristics

Our sample included 21,025 encounters involving 13,313 patients discharged from IM services at UCDMC. During the study period, the mean number of discharges per attending physician was 324 (95 % CI, 260–388). Hospitalists were responsible for more discharges than academicians, with means and medians of 213 and 118, 639 and 574, and 623 and 502 for the leaders of academician-preceptor, hospitalist-preceptor, and hospitalist-alone services, respectively.

Compared to other services, patients discharged by the hospitalist-preceptor service were slightly older, more likely to be Medicare beneficiaries, and more likely to have been admitted on a weekend (Table 1). Patients discharged by the hospitalist-alone service were more likely to have been treated in the ICU during their hospitalization (22 versus 14 %), but death rates did not differ across service types.

Univariate Analyses

The percentage of patients readmitted within 14, 30, and 60 days was 8.5 %, 14.1 %, and 22.4 %, respectively. Patients' mean and median LOS was 5.7 (95 % CI, 5.6−5.9) and 3.7 days (IQR, 2.2−6.3), and the mean and median costs for the index hospital stay were $15,738 (95 % CI, $15,336−$16,141) and $9,197 (IQR, $5,957−$16,074), respectively. The mean and median cumulative inpatient costs, including all readmissions within 30 days of the index discharge, were $19,133 (95 % CI, $18,610−$19,656) and $13,037 (IQR, $6,284−$19,790), respectively. The unadjusted results are presented in the online Appendix.

Multivariable Analyses

Overall, the hospitalist-alone service had the lowest adjusted readmission rate (12.6 % [95 % CI, 11.6−13.8 %]) and academician-preceptors had the highest adjusted readmission

Table 1. Characteristics of Internal Medicine Hospitalizations at One Academic Medical Center, 2008–2012; Outcomes by Clinical Service

Patients	Academic-preceptor (n=5,770)		Hospitalist-preceptor (n=7,300)		Hospitalist (n=7,955)	
	N or mean	Percent or 95 % CI	N or mean	Percent or 95 % CI	N or mean	Percent or 95 % CI
Age						
Mean [95 % CI]	55.5	[55.1, 56.0]	58.6	[58.1, 59.0]	56.1	[55.7, 56.5]
Gender						
Female	2,718	47.1	3,710	50.8	3,984	50.1
Race or ethnicity						
Other or mixed ethnicity	2,371	41.1	2,928	40.1	3,256	40.9
White	1,719	29.8	2,371	32.5	2,501	31.4
African American	877	15.2	1,109	15.2	1,198	15.1
Hispanic	611	10.6	690	9.5	743	9.3
Asian	181	3.1	193	2.6	241	3.0
American Indian	11	0.2	9	0.1	16	0.2
Acuity (MS-DRG weight)						
Mean [95 % CI]	1.31	[1.28, 1.33]	1.37	[1.35, 1.40]	1.42	[1.39, 1.45]
Comorbidities						
Mean number of comorbidities [95 % CI]	4.1	[4.1, 4.2]	4.3	[4.3, 4.4]	3.9	[3.9, 4.0]
Median number of comorbidities [IQR]	4.0	[2.0, 6.0]	4.0	[2.0, 6.0]	4.0	[2.0, 6.0]
Primary Payer						
Medicare	2,059	35.7	3,300	45.2	3,205	40.3
Medicaid	2,232	38.7	1,939	26.6	2,138	26.9
Private	1,381	23.9	2,001	27.4	2,528	31.8
Self pay	98	1.7	60	0.8	84	1.1
Characteristics of admission, discharge, ICU transfer and death						
ICU transfer	842	14.6	1,028	14.1	1,809	22.7
Weekend admission	1,560	7.4	1,993	9.5	1,765	8.4
Weekend discharge	1,309	6.2	1,622	7.7	1,807	8.6
Death	142	2.2	152	1.9	194	2.2
Most frequent clinical categories[26]						
Septicemia	502	8.7	835	11.4	916	11.5
Pneumonia	330	5.7	391	5.4	451	5.7
Congestive heart failure; non-hypertensive	303	5.3	408	5.6	334	4.2
Diabetes mellitus with complications	234	4.1	265	3.6	297	3.7
Skin and subcutaneous tissue infection	211	3.7	217	3.0	284	3.6
Complications of surgical procedures or medical care	148	2.6	272	3.7	246	3.1

See online Appendix, Table A1 for individual comorbidities

rate (15.5 % [95 % CI, 14.2−17.0 %]) (Table 2). The hospitalist-preceptor service had the shortest adjusted LOS (5.5 days [95 % CI, 5.4−5.6]); the hospitalist-alone service had the longest adjusted LOS (6.1 days [95 % CI, 6.0−6.1]). The hospitalist-alone service incurred the highest adjusted cost per index hospital encounter ($16,243 [95 % CI, $16,067−$16,421]) and the hospitalist-preceptor service incurred the lowest cost ($15,327 [95 % CI, $15,160−$15,497]). However, considering the cumulative inpatient cost including readmissions within 30 days, academician-preceptors were comparable to the hospitalist-alone service ($20,102 [95 % CI, $19,295−$20,940] versus $20,515 [95 % CI, $18,828−$22,352], respectively).

Adjusted GEE models confirmed that patients were more likely to be readmitted within 30 days if they were discharged by an academic-preceptor (OR 1.14 [95 % CI, 1.03−1.26]) or hospitalist-preceptor (OR 1.10 [95 % CI, 1.002−1.21]) than if

Table 2. Adjusted Patient Outcomes Reported on the Absolute Scale—30-day Readmission Rate, LOS, Index Hospitalization Cost, Cumulative Cost

Outcome	Academic-preceptor	Hospitalist-preceptor	Hospitalist-alone
30-Day readmission			
Percent readmission	15.5	14.6	12.6
95 % CI	(14.2, 17.0)	(13.4, 15.9)	(11.6, 13.8)
Length of stay*			
Days	5.63	5.50	6.06
95 % CI	(5.55, 5.71)	(5.44, 5.57)	(5.98, 6.14)
Cost of index encounter*			
US $	15,631	15,327	16,243
95 % CI	(15,463, 15,803)	(15,160, 15,497)	(16,067, 16,421)
Cumulative hospital cost within 30 days*			
US $	20,102	17,798	20,515
95 % CI	(19,295, 20,940)	(16,333, 19,396)	(18,828, 22,352)

Estimates from GEE are reported on the original scale and adjusted for age, gender, sum of comorbidity categories, MS-DRG weight, ICU admission, weekend admission, weekend discharge, payer category and a clustering effect for repeated patient and provider encounters. Cumulative cost was defined as the index encounter plus readmissions within 30 days of discharge

**We included a smearing estimator to correct for retransformation bias. Unadjusted outcomes are reported in the online Appendix, Table A2* they were discharged by a hospitalist working alone (Table 3). LOS was shorter for patients discharged from the academic-preceptor (0.27 days [95 % CI, 0.18−0.36]) and hospitalist-preceptor (0.34 days, [95 % CI, 0.26−0.42]) services than for patients discharged from the hospitalist-alone service. Index hospitalization costs were similarly lower for patients discharged from the academic-preceptor ($386 [95 % CI, $192−$576]) and hospitalist-preceptor ($570 [95 % CI, $378−$760]) services than for patients discharged from the hospitalist-alone service (Table 3). On all three of these metrics, there were no significant differences between academician-preceptor and hospitalist-preceptor services. However, hospitalist-preceptor services had lower cumulative inpatient costs than academic-preceptor services ($1,728 [95 % CI, $526−$3,002]).

After adjusting for multiple comparisons, there were no statistically significant interactions between clinical categories and service type in predicting either readmission or LOS; these results are not shown. In robustness analyses, we found negligible changes in the effect estimates when we included patients without a lookback period for ascertaining comorbidities, ignored subsequent readmissions after an initial 30-day readmission, or adjusted for season and season-teaching interactions. The adjusted differences between hospitalist-preceptor and hospitalist-alone outcomes generally diminished when ICU transfers were excluded, as shown in the online supplement Appendix A4.

DISCUSSION

In this observational study, we found that IM patients discharged by a teaching service had a modest, yet consistent increase in the odds of 30-day readmission, but lower index hospitalization cost and shorter LOS relative to patients discharged by a hospitalist working alone. These findings held regardless whether the teaching service was led by an academician or a hospitalist, suggesting that housestaff involvement may be more important than the attending physician's clinical focus in reducing LOS, lowering index hospitalization costs, and increasing readmission rates at the studied AMC. When comparing teaching services, the only significant outcome difference was that academic-preceptors incurred higher cumulative inpatient costs than hospitalist-preceptors.

Our finding that patients discharged by hospitalists working alone had significantly longer mean LOS and higher mean costs from the index hospitalization, but lower 30-day readmission rates than patients discharged by academic-preceptors, is consistent with at least two prior studies[3,28] from individual academic centers. However, this finding is inconsistent with about half of the relevant studies synthesized by White,[13] as well as a recent meta-analytic finding of no significant difference in either LOS or cost between "non-resident hospitalist" and "resident non-hospitalist" services.[11]

Our study extends prior work by showing that the cost disadvantage of hospitalist-alone care disappears when the cumulative cost from readmissions within 30 days is considered. In contrast to Chen,[29] we found evidence suggesting a tradeoff between LOS and readmission, although substantial study design differences make our findings difficult to compare. Using the 5 % national Medicare sample, Kuo and Goodwin[17] found a similar LOS-readmission tradeoff (which also offset the difference in index hospitalization costs), although they found hospitalists had lower mean LOS.

Unlike previous studies that excluded patients whose hospital stay exceeded 30 days[17] or was greater than three standard deviations from the mean,[16] we excluded patients only based on specific non-medical issues that affected how the hospital billed for care, such as conservatorship, skilled

Table 3. Adjusted Patient Outcomes on the Relative Score- 30-day Readmission, LOS, Cost Difference in Index Hospitalization, Cumulative Cost Difference (Index Encounter Plus Readmissions Within 30 days)

Outcome	Academic-preceptor vs. hospitalist-alone	Hospitalist-preceptor vs. hospitalist-alone	Academic-preceptor vs. hospitalist-preceptor
30-Day readmission			
Odds ratio	1.14	1.10	1.03
95 % CI	(1.03, 1.26)	(1.002, 1.21)	(0.93, 1.14)
p value	0.014	0.046	0.55
Length of stay*			
Difference in days	−0.27	−0.34	0.07
95 % CI	(−0.36, −0.18)	(−0.42, −0.26)	(−0.01, 0.16)
p value	<0.001	<0.001	0.10
Index hospitalization cost*			
Cost difference (US $)	−386	−570	192
95 % CI	(−576, −192)	(−760, −378)	(−8, 393)
p value	<0.001	<0.001	0.060
Cumulative hospital cost within 30 days*			
Cost difference (US $)	253	−1,347	1,728
95 % CI	(−861, 1,435)	(−2,816, 254)	(526, 3,002)
p value	0.66	0.097	0.0043

The reference group is hospitalist-alone service. Estimates from GEE are reported on the original scale and adjusted for age, gender, sum of comorbidity categories, MS-DRG weight, ICU admission, weekend admission, weekend discharge, payer category and a clustering effect for repeated patient and provider encounters. Cumulative cost was defined as the index encounter plus readmissions within 30 days of discharge. All p values reported are for these adjusted analyses

**We included a smearing estimator to correct for retransformation bias. Unadjusted outcomes are reported in the online Appendix, Table A3* nursing placement delays, and hospice care. During a hospital encounter, many physician services may participate in a patient's care and contribute to the patient's outcomes. However, the clinical decisions regarding a patient's discharge are made by the last service responsible for the patient's hospital care. Because these discharge decisions directly affect the LOS and readmission risk, we measured the service at discharge rather than the service responsible for an earlier component of care, such as the ICU service or admitting provider.[30]

The key strength of this study is that we accurately measured trainee involvement and the service type responsible for each patient discharge. Studies using claims data have typically assigned hospital encounters to provider type by the individual provider's billing volume[16,17] or percent time-on-service.[30] This approach cannot account for factors such as leave periods, non-clinical duties, or part-time employment, and it cannot distinguish hospitalist-preceptor from hospitalist-alone care. We adjusted for multiple patient-level factors, including ICU transfer and historical information on comorbidities; accounted for clustering at both the patient and physician levels; and excluded protracted hospitalizations for social reasons. Finally, we used observed cost estimates from the medical center's internal accounting system, rather than billed or allowed charges.

This study's primary limitation is that data were obtained from a single institution; the results may not be generalizable to all AMCs. Secondary limitations include confounding due to unobserved patient characteristics (e.g., social support at home) that may have differed across the three types of services. Patients are allocated to hospitalist-preceptor or academician-preceptor teams based on the date and time of admission and the on-call schedule, which should minimize such confounding. However, patients who are deemed to have low teaching value for trainees (e.g., ICU transfers) may be more frequently assigned to the hospitalist-alone service, which may contribute to unmeasured confounding in comparisons involving that service. Finally, readmissions to other acute care facilities could not be captured. This limitation could result in underestimating the odds of readmission, although it is unlikely that these missed events would bias comparisons among IM services.

CONCLUSIONS

Although we hypothesized that hospitalist teams would be associated with shorter LOS, fewer readmissions, and lower costs than academician-led teams, with no significant effect of trainee involvement, we actually found that trainee involvement was a more important driver of these outcomes. Hospitalist-preceptor and academic-preceptor teams did not differ significantly on any outcome except cumulative inpatient cost, and when ICU transfers were excluded in a robustness analysis. However, both types of teams involving residents had shorter adjusted LOS and lower adjusted cost during the index hospitalization, more 30-day readmissions, and no significant difference in cumulative inpatient cost, relative to hospitalists working alone (although these effects generally diminished when ICU transfers were excluded). Our findings suggest that trainees' eagerness to reduce their inpatient caseload (regardless of attending type), or other correlates of trainee involvement, may appear to improve efficiency, but may also have adverse consequences. Despite "between-hospital" evidence from prior studies that shorter mean LOS is not associated with higher readmission rates,[31] a "within-hospital" system of care that reduces mean LOS may be associated with more readmissions. This last finding requires confirmation with similar longitudinal data from multiple hospitals.

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Conflict of Interest: *The authors declare that they do not have a conflict of interest.*

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REFERENCES

1. **Chen LM, Birkmeyer JD, Saint S, Jha AK.** Hospitalist staffing and patient satisfaction in the national medicare population. J Hosp Med. 2013;8(3):126–31. doi:10.1002/jhm.2001.
2. **Dhuper S, Choksi S.** Replacing an academic internal medicine residency program with a physician assistant–hospitalist model: a comparative analysis study. Am J Med Qual. 2009;24(2):132–9. doi:10.1177/1062860608329646.
3. **Everett G, Uddin N, Rudloff B.** Comparison of hospital costs and length of stay for community internists, hospitalists, and academicians. J Gen Intern Med. 2007;22(5):662–7. doi:10.1007/s11606-007-0148-x.
4. **Halasyamani LK, Valenstein PN, Friedlander MP, Cowen ME.** A comparison of two hospitalist models with traditional care in a community teaching hospital. Am J Med. 2005;118(5):536–43. doi:10.1016/j.amjmed.2005.01.027.
5. **Hayward RA, Manning WG Jr, McMahon LF Jr, Bernard AM.** Do attending or resident physician practice styles account for variations in hospital resource use? Medical Care. 1994;32(8):788–94.
6. **Meltzer D, Manning WG, Morrison J, Shah MN, Jin L, Guth T, et al.** Effects of physician experience on costs and outcomes on an academic general medicine service: results of a trial of hospitalists. Ann Intern Med. 2002;137(11):866–74.
7. **Shine D, Beg S, Jaeger J, Pencak D, Panush R.** Association of resident coverage with cost, length of stay, and profitability at a community hospital. J Gen Intern Med. 2001;16(1):1–8.
8. **McMahon LF Jr.** The hospitalist movement–time to move on. New Engl J Med. 2007;357(25):2627–9. doi:10.1056/NEJMe078208.
9. **Wachter RM, Goldman L.** The emerging role of "hospitalists" in the American health care system. New Engl J Med. 1996;335(7):514–7. doi:10.1056/NEJM199608153350713.
10. **Mussman GM, Conway PH.** Pediatric hospitalist systems versus traditional models of care: effect on quality and cost outcomes. J Hosp Med. 2012;7(4):350–7. doi:10.1002/jhm.951.

11. **Rachoin JS, Skaf J, Cerceo E, Fitzpatrick E, Milcarek B, Kupersmith E, et al.** The impact of hospitalists on length of stay and costs: systematic review and meta-analysis. Am J Manag Care. 2012;18(1):e23–30.
12. **Peterson MC.** A Systematic Review of Outcomes and Quality Measures in Adult Patients Cared for by Hospitalists vs Nonhospitalists. Mayo Clin Proc. 2009;84(3):248–54.
13. **White HL, Glazier RH.** Do hospitalist physicians improve the quality of inpatient care delivery? A systematic review of process, efficiency and outcome measures. BMC Medicine. 2011;9:58. doi:10.1186/1741-7015-9-58.
14. **Jungerwirth R, Wheeler SB, Paul JE.** Association of hospitalist presence and hospital-level outcome measures among medicare patients. J Hosp Med. 2013. doi:10.1002/jhm.2118.
15. **Lopez L, Hicks LS, Cohen AP, McKean S, Weissman JS.** Hospitalists and the quality of care in hospitals. Arch Intern Med. 2009;169(15):1389–94. doi:10.1001/archinternmed.2009.222.
16. **Lindenauer PK, Rothberg MB, Pekow PS, Kenwood C, Benjamin EM, Auerbach AD.** Outcomes of care by hospitalists, general internists, and family physicians. New Engl J Med. 2007;357(25):2589–600. doi:10.1056/NEJMsa067735.
17. **Kuo YF, Goodwin JS.** Association of hospitalist care with medical utilization after discharge: evidence of cost shift from a cohort study. Ann Intern Med. 2011;155(3):152–9. doi:10.1059/0003-4819-155-3-201108020-00005.
18. **Goodwin JS, Lin YL, Singh S, Kuo YF.** Variation in Length of Stay and Outcomes among Hospitalized Patients Attributable to Hospitals and Hospitalists. J Gen Intern Med. 2013;28(3):370–6. doi:10.1007/s11606-012-2255-6.
19. **Kaboli PJ, Barnett MJ, Rosenthal GE.** Associations with reduced length of stay and costs on an academic hospitalist service. Am J Manag Care. 2004;10(8):561–8.
20. **Khaliq AA, Huang CY, Ganti AK, Invie K, Smego RA Jr.** Comparison of resource utilization and clinical outcomes between teaching and nonteaching medical services. J Hosp Med. 2007;2(3):150–7. doi:10.1002/jhm.174.
21. **Elixhauser A, Steiner C, Harris DR, Coffey RM.** Comorbidity measures for use with administrative data. Medical Care. 1998;36(1):8–27.
22. **Krumholz HM, Lin Z, Keenan PS, Chen J, Ross JS, Drye EE, et al.** Relationship between hospital readmission and mortality rates for patients hospitalized with acute myocardial infarction, heart failure, or pneumonia. JAMA. 2013;309(6):587–93. doi:10.1001/jama.2013.333.
23. **Basu A, Rathouz PJ.** Estimating marginal and incremental effects on health outcomes using flexible link and variance function models. Biostatistics (Oxford, England). 2005;6(1):93–109. doi:10.1093/biostatistics/kxh020.
24. **Duan N.** Smearing estimate—a nonparametric retransformation method. J Am Stat Assoc. 1983;78(383):605–10. doi:10.2307/2288126.
25. **Scheurer DB, Miller JG, Blair DI, Pride PJ, Walker GM, Cawley PJ.** Hospitalists and improved cost savings in patients with bacterial pneumonia at a state level. South Med J. 2005;98(6):607–10.
26. Agency for Healthcare Research and Quality. Clincial Classification Software. Available at http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp. Accessed August 8, 2014.
27. **Benjamini Y, Hochberg Y.** Controlling the false discovery rate: a practical and powerful approach to multiple testing. Journal of the Royal Statistical Society. Series B (Methodological). 1995:289–300.
28. **Palacio C, Alexandraki I, House J, Mooradian AD.** A comparative study of unscheduled hospital readmissions in a resident-staffed teaching service and a hospitalist-based service. South Med J. 2009;102(2):145–9. doi:10.1097/SMJ.0b013e31818bc48a.
29. **Chen LM, Jha AK, Guterman S, Ridgway AB, Orav EJ, Epstein AM.** Hospital cost of care, quality of care, and readmission rates: penny wise and pound foolish? Arch Intern Med. 2010;170(4):340–6. doi:10.1001/archinternmed.2009.511.
30. **Go JT, Vaughan-Sarrazin M, Auerbach A, Schnipper J, Wetterneck TB, Gonzalez D, et al.** Do hospitalists affect clinical outcomes and efficiency for patients with acute upper gastrointestinal hemorrhage (UGIH)? J Hosp Med. 2010;5(3):133–9. doi:10.1002/jhm.612.
31. **Kaboli PJ, Go JT, Hockenberry J, Glasgow JM, Johnson SR, Rosenthal GE, et al.** Associations between reduced hospital length of stay and 30-day readmission rate and mortality: 14-year experience in 129 Veterans Affairs hospitals. Ann Intern Med. 2012;157(12):837–45. doi:10.7326/0003-4819-157-12-201212180-00003.