RESEARCH ARTICLE

Patient Outcomes in a Pediatric Hospital Medicine Service Staffed With Physicians and Advanced Practice Providers

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ABSTRACT

OBJECTIVES: Hospitals are employing more nurse practitioners and physician assistants on inpatient pediatric units. With this study, we compared patient outcomes in high-volume inpatient diagnoses on pediatric hospital medicine services staffed by attending physician hospitalists and residents (hospitalist and resident service [HRS]) with 1 staffed by attending physician hospitalists and advanced practice providers (HAPPS).

METHODS: A historical cohort study was implemented by using administrative data for patients admitted to HRS and HAPPS from 2007 to 2011 with asthma, bronchiolitis, cellulitis, and pneumonia with severity levels 1 and 2 for all-patient refined diagnosis-related groups. Length of stay, readmission, ICU transfer, and hospital charges were compared.

RESULTS: After controlling for clinical, demographic, and socioeconomic differences, the average probability of discharge was 10% greater each day (event ratio [ER] = 1.1 [1.06–1.14]) on HAPPS compared with HRS. By diagnosis, this trend persisted with asthma (ER = 1.07 [1.02–1.12]), cellulitis (ER = 1.2 [1.1–1.3]), and pneumonia (ER = 1.17 [1.08–1.28]) but not for bronchiolitis (ER = 0.99 [0.92–1.06]). Both 3- and 30-day readmissions were higher for HRS discharges with bronchiolitis (odds ratio = 5.9 [1.3–28.6] and 2.0 [1.3–3.3], respectively) but not for the other diagnoses. Hospital charges were 13% higher for patients on HRS than HAPPS. ICU transfers did not differ statistically.

CONCLUSIONS: Within the limitations of the design, HAPPS performed at least as well as HRS with respect to length of stay, readmissions, ICU transfers, and charges for 4 of the most common inpatient diagnoses with severity levels 1 to 2. Indicated in these results is that in this configuration, advanced practice providers on pediatric hospitalist services represent a viable model for other institutions to consider and test.

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Drs DeWolfe, Birch, Shah, Callen Washofsky, and Ms Gardner conceptualized and designed the study; Dr McCarter designed the methods used for statistical analysis and conducted the initial analyses; and all authors participated in drafting the initial manuscript, critically reviewed and revised the manuscript, and approved the final manuscript as submitted.

Over the last 2 decades, the role of advanced practice providers (APPs), specifically nurse practitioners (NPs) and physician assistants (PAs), has expanded from primary care to inpatient settings.[1–9] The impetus for increasing the presence of APPs in hospitals is multifactorial and attributed to the need to build strong health systems that promote optimal patient outcomes in the face of workforce shortages and rising health care costs.[10] One major driver has been graduate medical education reform, which reduced the number of residents in subspecialty training programs, limited resident exposure to ICUs, and restricted total resident duty hours.[10–15] Simultaneously, the Affordable Care Act has increased access to health care services in the United States such that many who were previously uninsured are now able to secure health care services.[16] In contrast, the American Association of Medical Colleges predicts a workforce shortage of ∼124 000 physicians by 2025.[17] The combination of these changes has created service gaps requiring additional providers to maintain high-quality and safe patient care. In addition to graduate medical education and health care reform, the United States spends 2.5 times more on health care than the average of high-income countries, putting additional strain on the health care system.[18] In response to the dynamic health care and education landscape in the United States, multiple governmental institutions, professional organizations, and foundations such as the Institute of Medicine, American Academy of Pediatrics, and Pew Health Professions Commission have recommended the inclusion of APPs as an integral part of new care delivery models that are focused on improving patient outcomes by providing safe, efficient, and cost-effective care.[19–24]

Historically, hospital-based APP service models have been implemented in medical and surgical subspecialty units and ambulatory clinics for which their scope of practice is limited to a narrow patient population.[1,6,9,25] Care delivery models in which APPs have been incorporated on a resident service or where the APP service works independently of residents have been studied on surgical trauma services.[7,26,27] By incorporating APPs, Christmas et al[27] demonstrated improved patient throughput and reduced length of stay (LOS) while decreasing resident service hours without affecting mortality or increasing the cost per patient. Studies in which authors evaluate APP teams in higher-acuity medical environments such as the NICU and medical ICU have revealed similar findings.[12,28–30] Furthermore, when APPs have been incorporated into an inpatient adult general medicine service, studies have revealed decreased LOS and costs with no negative effect on mortality, ICU transfers, readmissions, or patient satisfaction.[31–33] Authors of 1 additional study suggest similar results at a lesser cost for an NP team caring for pediatric inpatients at a single health system.[34] To our knowledge, this is the first study of a pediatric general inpatient service that has been used to examine a team consisting of both PAs and NPs. Moreover, no other study of a pediatric general inpatient service has been used to analyze readmissions and ICU transfer rates.

Our objective of this study was to examine the differences in patient-related outcomes between a traditional pediatric hospital medicine service staffed by attending physician hospitalists and residents (hospitalist and resident service [HRS]) and a pediatric hospital medicine service staffed by attending physician hospitalists, NPs, and PAs (hospitalist and advanced practice provider service [HAPPS]). Specific outcomes measured included LOS, 3- and 30-day readmissions, ICU transfers, and hospital charges. We hypothesized that pediatric patients with high-volume inpatient diagnoses such as asthma, bronchiolitis, cellulitis, and pneumonia admitted to HRS would have similar LOS, readmissions, ICU transfers, and hospital charges as pediatric patients admitted to HAPPS.

METHODS

Study Population and Data Collection

We used administrative data on all inpatients at a 283-bed urban, tertiary-care pediatric teaching hospital in the US Mid-Atlantic region from 2007 to 2011 in this historical cohort study. The institutional review board and the Office for the Protection of Human Subjects at the study hospital reviewed and approved the protocol.

The study included patients with severity level 1 (minor) or 2 (moderate) admitted to the pediatric hospital medicine service with any of the following 4 most common admission diagnoses as specified by all-patient refined diagnosis-related groups (APR-DRGs): asthma, bronchiolitis, cellulitis, and pneumonia between November 1, 2007 and October 31, 2011. APR-DRG severity of illness scores differentiate patients into 4 severity levels: minor (1), moderate (2), major (3), and extreme (4) primarily on the basis of the type and number of secondary diagnoses. Limiting enrollment to APR-DRG severity levels 1 and 2 was felt to better reflect the majority of admissions cared for on a general inpatient pediatric service and to be less prone to the effects of rare or complex comorbidities.[35]

LOS, readmissions, ICU transfers, and hospital charges were compared between HRS and HAPPS while controlling for APR-DRG severity level, age, sex, insurance status, and secondary clinical indicators of severity, including the percent of patients treated with continuous albuterol (asthma), oxygen (bronchiolitis and pneumonia), and incision and drainage (cellulitis). Aggregate hospital charges were taken from hospital billing data capturing hospital room and board as well as charges from the pharmacy, respiratory therapy, laboratory, and radiology departments.

Hospital Medicine Service Design: HRS Compared With HAPPS

There were 3 HRS teams and 1 HAPPS team covering the pediatric hospitalist medicine patients during the study period. The teams were constructed as shown in Table 1.

Patients from all referral sources and acuity levels were admitted to either service with the primary goal of maintaining a similar census; however, HAPPS generally admitted otherwise healthy patients with well-defined illnesses. Patients with greater complexity were preferentially admitted to HRS but were excluded in the study design on the basis of APR-DRG severity levels. HRS patients were managed on a similar inpatient medical unit with similar ancillary staff and support services as HAPPS but on a separate floor.

Statistical Methods

Sociodemographic characteristics were summarized as the mean and SD for continuous variables and as percentages for categorical variables. After first confirming adherence to the proportionality assumption, Cox proportional hazards models were used for comparison of time-to-event outcomes, including time to discharge and time to readmission between patients on HRS and HAPPS. Hazard ratios, referred herein as event ratios (ERs), reflect the relative difference in probability of an event between HRS and HAPPS groups. The relative difference in the odds (odds ratio [OR]) of ICU transfer between groups were estimated by using multiple logistic regression analyses. Comparison of the mean cost between groups was based on linear regression to implement analysis of covariance models. Each of these models controlled for patient age, insurance type, sex, APR-DRG severity of illness levels, and additional secondary indicators of clinical severity. Including each of these potential confounders in the above analyses allows us to estimate the difference between groups, removing any effects of the confounder on each outcome of interest.

Statistical significance was evaluated relative to a 2-tailed, type 1 error of $P = .05$. Because the large sample sizes in each diagnostic group provided the ability to detect relatively modest differences, we emphasized the magnitude of differences more than statistical significance.

RESULTS

Patient Demographics

Between November 2007 and October 2011, 9405 patients were admitted with asthma, bronchiolitis, cellulitis, or pneumonia. After excluding APR-DRG severity levels 3 or 4 and patients not admitted to HRS or HAPPS, a total of 6710 were included (Fig 1). Statistically significant differences ($P < .05$) were seen between patients in the HRS and HAPPS in mean age, insurance type, and severity on the basis of APR-DRGs and clinical criteria (Table 2). Patients in HRS were older and less likely to be on public insurance than those in HAPPS across all diagnoses. Except for cellulitis, which did not differ, fewer patients admitted on HRS than HAPPS were categorized as severity level 1 than 2. In addition, a higher proportion of patients on HRS required continuous albuterol for asthma and oxygen

TABLE 1 Team Structure of the HRS and HAPPS

	HRS	HAPPS
Team members during day	1 attending physician hospitalist 1 third-year pediatric resident 2 first-year pediatric residents	1 attending physician hospitalist 1 NP or PA
Team members during night	1 attending, cross-covering, physician HAPPS hospitalist responsible for staffing admissions after midnight 1 second- or third-year pediatric resident 1 first-year pediatric resident 1 attending physician hospitalist available by phone for existing service patients	1 attending physician hospitalist, also responsible for cross covering HRS service admissions after midnight
Medical students	2–4 third-year medical students 0–1 fourth-year medical student	0–1 fourth-year medical student
Additional support:	1 attending physician hospitalist responsible for staffing daytime and evening admissions	

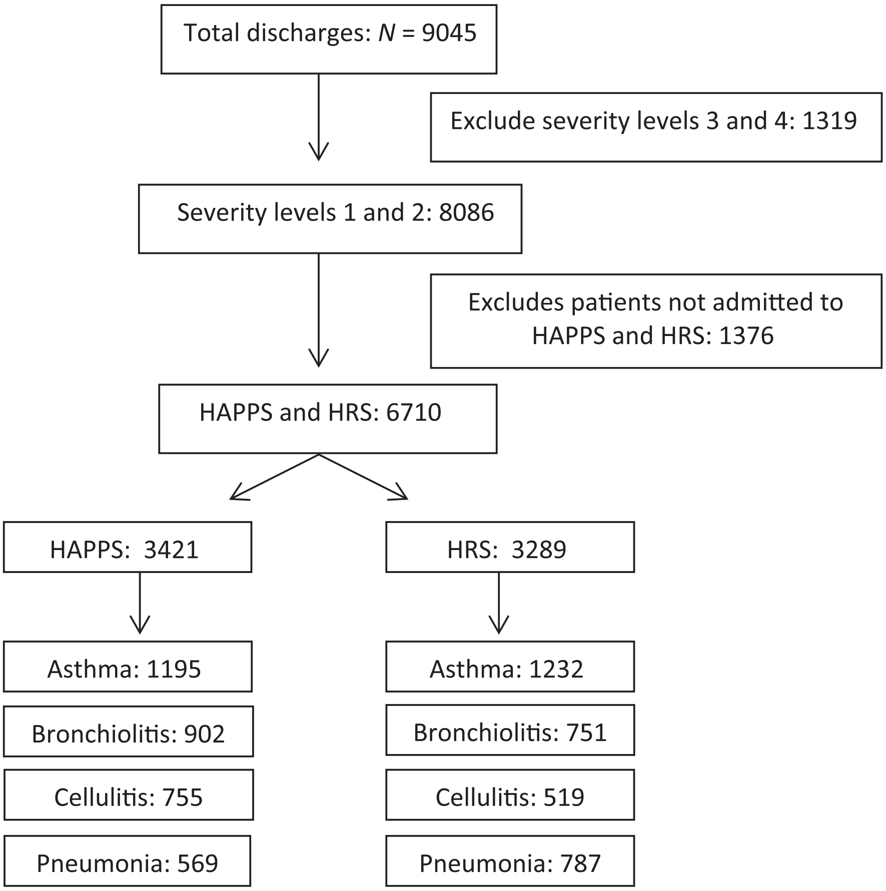

FIGURE 1 Study population determination of the HRS and HAPPS.

TABLE 2 Patient Demographics and Clinical Characteristics of the HRS Versus HAPPS, November 2007–October 2011

	Patient Demographics and Clinical Characteristics of HRS Versus HAPPS											
	Asthma, *n* = 2427			Cellulitis, *n* = 1274			Bronchiolitis, *n* = 1653			Pneumonia, *n* = 1356		
	HAPPS	HRS	*P*	HAPPS	HRS	*P*	HAPPS	HRS	*P*	HAPPS	HRS	*P*
Discharge, *n*	1195	1232	—	755	519	—	902	751	—	569	787	—
Demographics												
Mean age, y	5.5	6.2	<.05	4.6	6	<.05	0.2	0.3	<.05	2.5	3.3	<.05
Girls, *n* (%)	442 (37)	468 (38)	NS	385 (51)	254 (49)	NS	397 (44)	338 (45)	NS	273 (48)	370 (47)	NS
Medicaid, *n* (%)	848 (71)	788 (64)	<.05	559 (74)	348 (67)	<.05	731 (81)	571 (76)	<.05	393 (69)	488 (62)	<.05
APR-DRG severity level, *n* (%)												
Minor	813 (68)	727 (59)	<.05	468 (62)	306 (59)	NS	424 (47)	285 (38)	<.05	211 (37)	244 (31)	<.05
Moderate	382 (32)	505 (41)	—	287 (38)	213 (41)	—	478 (53)	466 (62)	—	358 (63)	543 (69)	—
Clinical criteria of severity, *n* (%)												
Continuous albuterol	609 (51)	715 (58)	<.05	—	—	—	—	—	—	—	—	—
Oxygen use	—	—	—	—	—	—	406 (45)	406 (54)	<.05	245 (43)	433 (55)	<.05
Incision and drainage	—	—	—	174 (23)	88 (17)	<.05	—	—	—	—	—	—

NS, not statistically significant; —, not applicable.

therapy for both bronchiolitis and pneumonia. However, more patients with cellulitis on HAPPS required incision and drainage procedures than HRS. Patient sex was similar between the 2 groups. HRS had an average daily census of 11.8 patients, whereas HAPPS had an average daily census of 9 patients. By contrast, HRS had a daytime patient-to-provider ratio of 3, and HAPPS had a patient-to-provider ratio of 4.5.

Efficiency and Quality Outcomes

Differences in LOS, 3- and 30-day readmissions, ICU transfers, and hospital charges were calculated on the basis of the total study population and by diagnosis after controlling for age, insurance status, and differences in clinical and APR-DRG severity level. There were no deaths on either service during the study period.

LOS

Patients on HRS experienced longer LOS than those on HAPPS (Fig 2). The average probability of discharge was 10% higher each day (ER = 1.1 [1.06–1.14]) on HAPPS than on HRS. By diagnosis, this trend persisted for asthma (ER = 1.07 [1.02–1.12]), cellulitis (ER = 1.2 [1.1–1.3]), and pneumonia (ER = 1.17 [1.08–1.28]). There was no statistical difference in LOS between the 2 services for bronchiolitis (ER = 0.99 [0.92–1.06]).

Readmissions

The adjusted odds of readmission within 3 days among HRS discharges approached a threefold greater adjusted odds (OR 2.7 [1.1–6.7]) compared with HAPPS discharges (Table 3). The greatest difference occurred for HRS discharges with bronchiolitis, who experienced a sixfold higher odds of 3-day readmission (OR 5.9 [1.3–28.6]). However, the odds of 3-day readmission for asthma, pneumonia, and cellulitis did not differ by service. There was a similar trend with 30-day readmissions. Overall, HRS discharges experienced twice the odds of 30-day readmission (OR = 2.0 [1.3–3.3]). By diagnosis, HRS discharges with bronchiolitis experienced more than twice the odds (OR = 2.6 [1.1–6.7]) of 30-day readmission. There was no difference in the readmissions for asthma, cellulitis, and pneumonia between the 2 services.

ICU Transfers

There was no appreciable difference in the odds of ICU transfer between the 2 services (OR = 1.6 (0.9–2.6]).

Hospital Charges

As seen in Fig 3, hospital charges for all patients on HRS were ~13% higher than on HAPPS. When analyzed by diagnosis, this trend remained statistically significant for all diagnoses. Specifically, for patients on HRS with asthma, pneumonia, cellulitis, and bronchiolitis, hospital charges were 13%, 16%, 15%, and 10% greater, respectively.

DISCUSSION

In this study, we found differences in LOS, hospital charges, and readmission rates when comparing HAPPS to HRS that persisted after controlling for differences in age, insurance type, sex, APR-DRG severity level, and additional condition-specific indicators of clinical severity. Specifically, patients were 10% more likely to be discharged each day on HAPPS than HRS, and HAPPS accrued 13% fewer hospital charges than HRS with no difference in ICU transfer. Also, patients diagnosed with bronchiolitis on HAPPS were one-sixth as likely to be readmitted within 3 days and half as likely within 30 days. Although these results are not backed by a randomized clinical trial, they can be used to lend cautious support to the potential advantage of nontraditional, complementary staffing models that capitalize on various provider types and rounding approaches within a defined patient case mix and complexity index.

Controlling for the aforementioned differences between groups, LOS was shorter on HAPPS for all 4 study diagnoses. We suspect that this may have been partly related to greater time available to devote to early day discharges on HAPPS because of a shorter rounding time and less formal

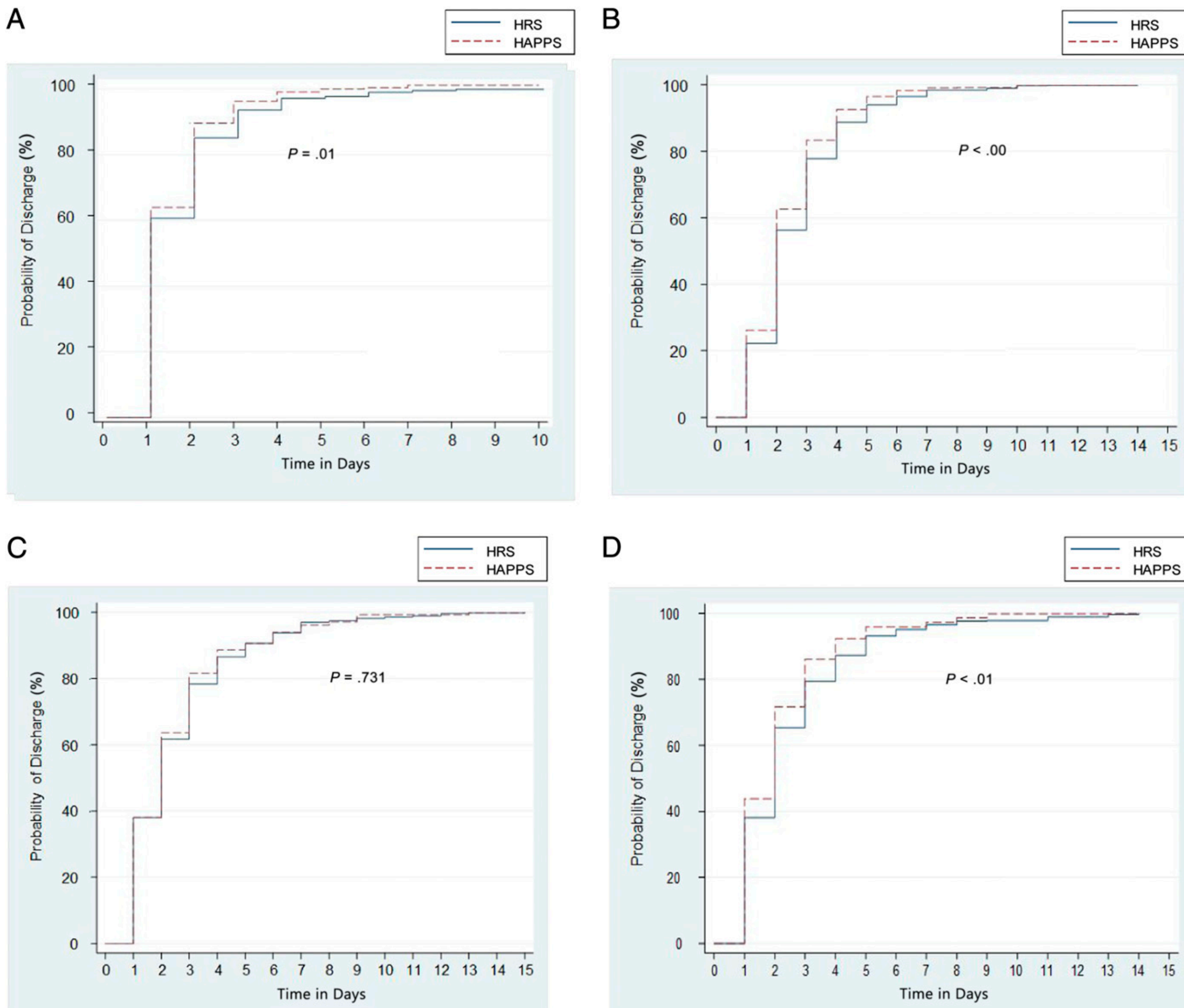

FIGURE 2 Adjusted estimates of time to discharge by diagnosis on HRS versus HAPPS. Cox proportional hazard models adjusted for differences in age, insurance type, sex, APR-DRG severity level, and additional condition-specific indicators of clinical severity. A, asthma. B, cellulitis. C, bronchiolitis. D, pneumonia.

teaching. Myers et al[9] found that more time can be dedicated to patient care and throughput in nonteaching services than in teaching services. Indeed, authors of time-motion studies of traditional teaching services have documented that up to 15% of resident or faculty time is dedicated to rounding and 28% to teaching.[36] On HAPPS, the APP rounds separately from the fourth-year student to free the other to complete patient care tasks. By contrast, on HRS, all members of the team round together. Also, the time required for conferences, supervision, feedback, and other educational activities for members of the HRS team reduces the resident and hospitalist's time directly managing patient care and facilitating early discharges.

Not controlled was the greater proportion of patients with severity level 3 and 4 managed by HRS teams and patient census. Both may also at least partly account for differences between HRS and HAPPS in average patient LOS for patients with severity level 1 and 2. The HRS model, with its team continuity and overnight coverage, allowed for care of patients with higher complexity alongside patients included within the study. The numbers and uncontrolled characteristics of patients admitted alongside our study group with diagnoses not included in our study may have demanded more attention from HRS resulting in later discharges for our study population. Similarly, the higher patient census and patient-to-hospitalist ratio on HRS may have prevented the team from discharging patients as early as on HAPPS. By contrast, the lower overall patient-to-

TABLE 3 Adjusted Odds of Readmission Within 3 and 30 Days for All Diagnoses on HRS Versus HAPPS

	HRS Versus HAPPS
	Adjusted OR (95% CI)
3-d readmission odds	
All diagnoses	2.7 (1.1–6.7)
Asthma	0.9 (1.1–6.7)
Bronchiolitis	5.9 (1.3–2.8. 6)
Cellulitis	1.1 (0.2–8.3)
Pneumonia	3.2 (0.4–27.8)
30-d readmission odds	
All diagnoses	2.0 (1.3–3.3)
Asthma	1.3 (0.6–2.6)
Bronchiolitis	2.6 (1.1–6.7)

Logistic regression was adjusted for differences in age, insurance type, sex, APR-DRG severity level, and additional condition-specific indicators of clinical severity. CI, confidence interval.

provider ratio on HRS would have resulted in more licensed providers available to focus on throughput than on HAPPS.

Consistent with the fact that hospital charges are primarily driven by LOS among our studied diagnoses, the patients on HAPPS were charged $1655 less, on average, than on HRS.[9,37–39] This finding held true for asthma, cellulitis, and pneumonia. However, in bronchiolitis, hospital charges were lower on HAPPS despite having a comparable LOS on HRS. HRS and HAPPS had similar odds of readmission among the same 3 diagnoses, but HRS had a sixfold higher readmission risk for bronchiolitis. These findings align with a study by Christakis et al[35] in which the authors found considerable variation in readmission rates, treatment approaches, and the use of diagnostic tests for inpatient bronchiolitis. Authors of other studies suggest that teams of hospitalists and/or APPs and hospitalists can lessen the variation in bronchiolitis care by relying more heavily on clinical practice guidelines.[34,40] Although our study was not designed to compare the use of diagnostic tests or therapeutics, it is possible that these factors contributed to the difference among the 2 teams in terms of hospital charges and readmissions.

Our study differed from previous studies in several aspects. To our knowledge, it is the first study used to evaluate a combined service of PAs and NPs. Each provider type has a different educational background and may have different scopes of practice on the basis of their jurisdiction (eg, legal restrictions on independent billing and prescription writing). With our findings, we expand the potential staffing options for administrators seeking to meet the unique needs of their hospital setting and system. Second, it is also the first study used to examine ICU transfers and readmissions on a general inpatient pediatric service with APPs. Evidence indicates that HAPPS was able to achieve a shorter LOS and fewer hospital charges without affecting the quality and safety of care based on similar odds of readmission and ICU transfer between HRS and HAPPS. Finally, unlike most of the existing literature, which is focused on the effect of replacing a traditional HRS with HAPPS, we studied HAPPS working separately but in parallel with a traditional HRS. As a result, we could compare similar patients and providers, unaffected by practice changes or billing patterns over time.[7,41]

There are notable limitations to our study. First, we used historical data from an institutional administrative database rather than a prospective, randomized design. Although we tried to control for differences in patient population by both the APR-DRG severity of illness measure and additional clinical markers of severity, the former measure lacks sensitivity, and the latter measure is untested. Second, we did not control for census on each team, because the difference in volume is partially offset by patient-to-provider ratios. Third, we were not able control for the potential impact of other patients with higher complexity that were not included in the study but still managed by each team. Moreover, there may have been other unaccounted confounders. Fourth, the importance of experience and on-the-job training for APPs may limit transferability to sites with lesser experienced APPs. At the end of the study enrollment period, the 2 NPs and 1 PA on HAPPS had 11 years combined of postgraduate experience in the inpatient pediatric setting and served on HAPPS as their single clinical site. Fifth, our study focused on a mixed-provider service of APPs and hospitalists caring for patients with a defined set of conditions. Authors of other studies have had more mixed results when examining APPs who treat more complex patients or work independently.[6,9,12,27,31,34,41–46]

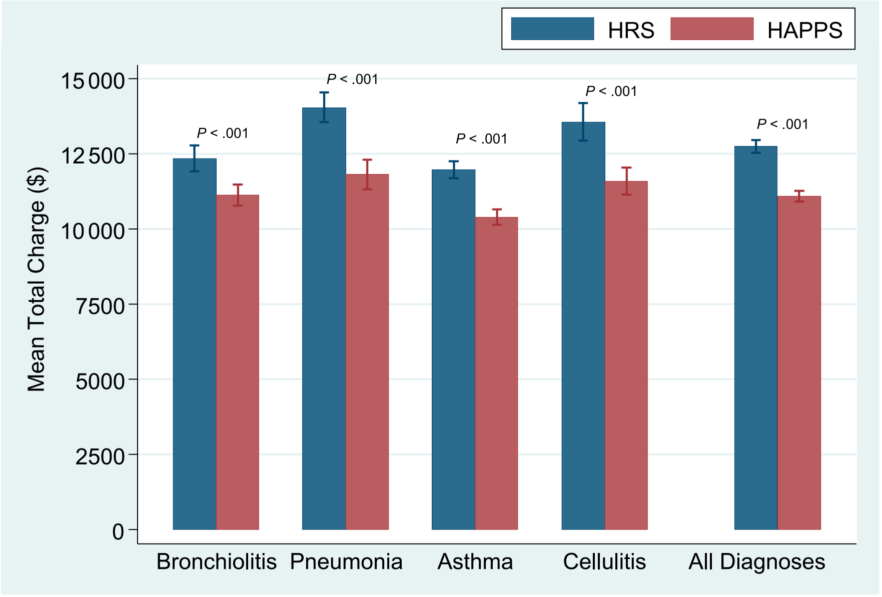

FIGURE 3 Adjusted mean and 95% confidence intervals for hospital charges among studied diagnoses on HRS versus HAPPS. A linear regression model adjusted for differences in age, insurance type, sex, APR-DRG severity level, and additional condition-specific indicators of clinical severity.

Finally, although ancillary and support services were similar for HRS and HAPPS, the teams cared for patients on different medical units. As such, there may have been variations in nursing practices that could have influenced the results.

Future study should make fuller use of concurrent prospective and experimental designs, which afford better opportunity to remove or control for sources of bias and confounding. Such designs enable explication of the factors that influence differences in outcome between service models, including staff makeup as well as the impact of teaching. More in-depth study is also required to compare the economic impact of compensation, retention, insurance reimbursement, and maximized relative value units in each model. Moreover, attention should be given to measuring additional quality and safety metrics such as achieving evidence-based and/or high-value care benchmarks, avoiding medical errors, and increasing patient and provider satisfaction.

CONCLUSIONS

At our institution, with the caveats noted above, a service staffed by hospitalists, NPs, and PAs was shown to have performed at least as well in regard to LOS, readmissions, ICU transfers, and charges for 4 of the most common inpatient diagnoses when compared with a model staffed by hospitalists and residents. Although confirmation and further study is needed, this new finding can be used to indicate that the HAPPS represents a viable service model when allied with the HRS for general inpatient pediatrics in the era of graduate medical education reform and federal initiatives related to patient safety and access to care.

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REFERENCES

1. Freed GL, Dunham KM, Loveland-Cherry C, Martyn KK, Moote MJ; American Board of Pediatrics Research Advisory Committee. Nurse practitioners and physician assistants employed by general and subspecialty pediatricians. *Pediatrics*. 2011;128(4):665–672
2. Freed GL, Dunham KM, Moran LM, Spera L; Research Advisory Committee of the American Board of Pediatrics. Resident work hour changes in children's hospitals: impact on staffing patterns and workforce needs. *Pediatrics*. 2012; 130(4):700–704
3. Moote M, Krsek C, Kleinpell R, Todd B. Physician assistant and nurse practitioner utilization in academic medical centers. *Am J Med Qual*. 2011; 26(6):452–460
4. Kleinpell RM, Ely EW, Grabenkort R. Nurse practitioners and physician assistants in the intensive care unit: an evidence-based review. *Crit Care Med*. 2008; 36(10):2888–2897
5. Hooker RS. Physician assistants and nurse practitioners: the United States experience. *Med J Aust*. 2006;185(1):4–7
6. Howie J, Erickson M. Acute care nurse practitioners: creating and implementing a model of care for an inpatient general medical service. *Am J Crit Care*. 2002;11(5):448–458
7. Oswanski MF, Sharma OP, Raj SS. Comparative review of use of physician assistants in a level I trauma center. *Am Surg*. 2004;70(3):272–279
8. Rudy EB, Davidson LJ, Daly B, et al. Care activities and outcomes of patients cared for by acute care nurse practitioners, physician assistants, and resident physicians: a comparison. *Am J Crit Care*. 1998;7(4):267–281
9. Myers JS, Bellini LM, Rohrbach J, Shofer FS, Hollander JE. Improving resource utilization in a teaching hospital: development of a nonteaching service for chest pain admissions. *Acad Med*. 2006;81(5):432–435
10. Kleinpell R, Scanlon A, Hibbert D, et al. Addressing issues impacting advanced nursing practice worldwide. *Online J Issues Nurs*. 2014;19(2):5
11. Mulvey HJ, Ogle-Jewett EA, Cheng TL, Johnson RL. Pediatric residency education. *Pediatrics*. 2000;106(2 pt 1): 323–329
12. Karlowicz MG, McMurray JL. Comparison of neonatal nurse practitioners' and pediatric residents' care of extremely low-birth-weight infants. *Arch Pediatr Adolesc Med*. 2000;154(11):1123–1126
13. Philibert I, Friedmann P, Williams WT; ACGME Work Group on Resident Duty Hours; Accreditation Council for Graduate Medical Education. New requirements for resident duty hours. *JAMA*. 2002;288(9):1112–1114
14. Iglehart JK. The ACGME's final duty-hour standards—special PGY-1 limits and strategic napping. *N Engl J Med*. 2010; 363(17):1589–1591
15. Nasca TJ, Day SH, Amis ES Jr; ACGME Duty Hour Task Force. The new recommendations on duty hours from the ACGME Task Force. *N Engl J Med*. 2010;363(2):e3
16. Patient Protection and Affordable Care Act of 2010, Pub L No. 111–148, 124 Stat 119.
17. Association of American Medical Colleges Center for Workforce Studies. Recent studies and reports on physician shortages in the US. 2012. Available at: https://www.aamc.org/download/100598/data/. Accessed August 3, 2018
18. Salmond SW, Echevarria M. Healthcare transformation and changing roles for nursing. *Orthop Nurs*. 2017;36(1):12–25
19. Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, DC: National Academies Press; 2001
20. Institute of Medicine. *The Future of Nursing: Leading Change, Advancing Health*. Washington, DC: National Academies Press; 2011
21. American Academy of Pediatrics. Committee on Hospital Care. The role of the nurse practitioner and physician assistant in the care of hospitalized children. *Pediatrics*. 1999;103(5 pt 1): 1050–1052
22. American Association of Nurse Practitioners. Nurse practitioners and team based care. 2013. Available at:

https://www.aanp.org/advocacy/advocacy-resource/position-statements/team-based-care. Accessed December 18, 2018

23. American Academy of Physician Assistants. PAs in pediatrics. 2016. Available at: https://www.aapa.org/download/37039/. Accessed December 18, 2018
24. Pew Health Professions Commission and the Center for the Health Professions. *Chartering a Course for the Twenty-First Century: Physician Assistants and Managed Care*. San Francisco, CA: Centre for the Health Professions, University of California at San Francisco; 1998
25. O'Rourke RA. The specialized physician assistant: an alternative to the clinical cardiology trainee. *Am J Cardiol*. 1987; 60(10):901–902
26. Miller W, Riehl E, Napier M, Barber K, Dabideen H. Use of physician assistants as surgery/trauma house staff at an American College of Surgeons-verified Level II trauma center. *J Trauma*. 1998; 44(2):372–376
27. Christmas AB, Reynolds J, Hodges S, et al. Physician extenders impact trauma systems. *J Trauma*. 2005;58(5):917–920
28. Carzoli RP, Martinez-Cruz M, Cuevas LL, Murphy S, Chiu T. Comparison of neonatal nurse practitioners, physician assistants, and residents in the neonatal intensive care unit. *Arch Pediatr Adolesc Med*. 1994;148(12):1271–1276
29. Gershengorn HB, Wunsch H, Wahab R, et al. Impact of nonphysician staffing on outcomes in a medical ICU [published correction appears in *Chest*. 2011;140(5): 1393]. *Chest*. 2011;139(6):1347–1353
30. Schultz JM, Liptak GS, Fioravanti J. Nurse practitioners' effectiveness in NICU. *Nurs Manage*. 1994;25(10):50–53
31. Roy CL, Liang CL, Lund M, et al. Implementation of a physician assistant/hospitalist service in an academic medical center: impact on efficiency and patient outcomes. *J Hosp Med*. 2008;3(5): 361–368
32. Cowan MJ, Shapiro M, Hays RD, et al. The effect of a multidisciplinary hospitalist/physician and advanced practice nurse collaboration on hospital costs. *J Nurs Adm*. 2006;36(2): 79–85
33. Goksel D, Harrison CJ, Morrison RE, Miller ST. Description of a nurse practitioner inpatient service in a public teaching hospital. *J Gen Intern Med*. 1993;8(1):29–30
34. Wall S, Scudamore D, Chin J, et al. The evolving role of the pediatric nurse practitioner in hospital medicine. *J Hosp Med*. 2014;9(4):261–265
35. Christakis DA, Cowan CA, Garrison MM, Molteni R, Marcuse E, Zerr DM. Variation in inpatient diagnostic testing and management of bronchiolitis. *Pediatrics*. 2005;115(4):878–884
36. Tipping MD, Forth VE, Magill DB, Englert K, Williams MV. Systematic review of time studies evaluating physicians in the hospital setting. *J Hosp Med*. 2010;5(6): 353–359
37. Zhang S, Sammon PM, King I, et al. Cost of management of severe pneumonia in young children: systematic analysis. *J Glob Health*. 2016;6(1):010408
38. Sylvester AM, George M. Effect of a clinical pathway on length of stay and cost of pediatric inpatient asthma admissions: an integrative review. *Clin Nurs Res*. 2014;23(4):384–401
39. Pelletier AJ, Mansbach JM, Camargo CA Jr. Direct medical costs of bronchiolitis hospitalizations in the United States. *Pediatrics*. 2006;118(6):2418–2423
40. Conway PH, Edwards S, Stucky ER, Chiang VW, Ottolini MC, Landrigan CP. Variations in management of common inpatient pediatric illnesses: hospitalists and community pediatricians. *Pediatrics*. 2006;118(2):441–447
41. 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):132–139
42. Carter AJ, Chochinov AH. A systematic review of the impact of nurse practitioners on cost, quality of care, satisfaction and wait times in the emergency department. *CJEM*. 2007;9(4): 286–295
43. Hughes DR, Jiang M, Duszak R Jr. A comparison of diagnostic imaging ordering patterns between advanced practice clinicians and primary care physicians following office-based evaluation and management visits. *JAMA Intern Med*. 2015;175(1):101–107
44. Mafi JN, Wee CC, Davis RB, Landon BE. Comparing use of low-value health care services among U.S. advanced practice clinicians and physicians. *Ann Intern Med*. 2016;165(4):237–244
45. Mafi JN, Landon BE. Comparing use of low-value health care services among U.S. advanced practice clinicians and physicians. *Ann Intern Med*. 2017;166(1): 77
46. Tsai CL, Sullivan AF, Ginde AA, Camargo CA Jr. Quality of emergency care provided by physician assistants and nurse practitioners in acute asthma. *Am J Emerg Med*. 2010;28(4):485–491