CME

The Impact of Advanced Practice Provider Staffing on Emergency Department Care: Productivity, Flow, Safety, and Experience

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ABSTRACT

Objectives: We examined emergency department (ED) advanced practice provider (APP) productivity and how APP staffing impacted ED productivity, safety, flow, and experience.

Methods: We used 2014 to 2018 data from a national emergency medicine group. The exposure was APP coverage: APP hours as a percentage of total clinician hours at the ED-day level. Multivariable regression was used to assess the relationship between APP coverage and productivity outcomes (patients/clinician hour, relative value units [RVUs]/clinician hour, RVUs/visit, and RVUs/salary-adjusted hour), flow outcomes (length of stay and left without treatment), safety (72-hour returns, incident reports), and experience (Press-Ganey scores), adjusting for patient and facility characteristics.

Results: In 13.02 million patient visits in 105,863 ED-days across 94 EDs from 2014 to 2018, nurse practitioners and physician assistants managed 5.4 and 18.6% of visits independently, 74.6% by emergency physicians alone, and 1.4% jointly. APP visits had lower RVUs/visit (2.8 vs. 3.7) and lower patients/hour (1.1 vs. 2.2) compared to physician visits. Higher APP coverage (by 10%) at the ED-day level was associated with lower patients/clinician hour by 0.12 (95% confidence interval [CI] = −0.15 to −0.10) and lower RVUs/clinician hour by 0.4 (95% CI = −0.5 to −0.3). There was no impact of increasing APP coverage on RVUs/salary-adjusted hour or RVUs/visit. There was also no effect of increasing APP coverage on flow, safety, or patient experience.

Conclusion: In this group, APPs treated less complex visits and half as many patients/hour compared to physicians. Higher APP coverage allowed physicians to treat higher-acuity cases. We found no economies of scale for APP coverage, suggesting that increasing APP staffing may not lower staffing costs. However, there were also no adverse observed effects of APP coverage on ED flow, clinical safety, or patient experience, suggesting little risk of increased APP coverage on clinical care delivery.

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The use of advanced practice providers (APP)—physician assistants (PA) and nurse practitioners (NP)—in U.S. emergency departments (ED) has expanded considerably in recent years.[1,2] According to the National Hospital Ambulatory Medical Care Survey in 2016, one in six and one in eight ED visits involved a PA or NP respectively, compared to one in 12 and one in 18 in 2008.[3] In 2017 and 2018, >12,500 PAs and > 8,000 NPs identified their practice as emergency medicine.[4] In some EDs, APP roles have expanded from low-acuity patients and performing simple procedures to also treating higher acuity, more complex illness.[5]

Rising APP use in emergency medicine is driven both by economics and by workforce needs.[6] APPs receive lower pay compared to emergency physicians and may be cost-effective.[7] However, this assumes that relative APP-to-physician productivity exceeds relative pay differentials, accounting for revenue differences for APP-only visits that are billed at approximately 85% of physician rates.[8] It also assumes that adding APPs does not diminish care quality. In addition to reducing costs, APPs may also be used when emergency physician recruitment is a challenge in rural or socioeconomically disadvantaged areas.[9] In some EDs, APPs may be used in place of emergency physicians where ED volumes cannot sustain a market-appropriate physician hourly rate.

Despite widespread ED APP use, relatively little data exist that compare productivity, safety, flow, or measured patient experience in care rendered by APPs relative to emergency physicians. Much of the literature on APP productivity and quality exists outside emergency medicine with mixed results. Some studies report notable differences: APPs prescribe more antibiotics for upper respiratory tract infections during e-visits[10] and provide less guideline-concordant care to diabetics.[11] Other studies find that in the Veterans Administration, APP-managed complex patients have lower costs than physician-managed patients.[12] Within emergency medicine, the literature primarily includes descriptive studies of single EDs or ecological studies that use national sample data.[13] The paucity of ED APP studies—particularly across multiple practice locations—is driven by the difficulty in reliable attribution of APP cases which are typically signed and billed under the names of emergency physicians. To our knowledge, no multicenter studies have examined APP care in a large sample of EDs with reliable data on care attribution to specific clinicians.

In this study, we examine the productivity of APPs compared to emergency physicians and its impact on ED operations. We focus on how productivity metrics change with higher APP staffing. We also examine the impact of APP staffing on ED flow, clinical safety, and patient experience.

METHODS

Study Design and Setting

We conducted a planned secondary analysis of 2014 to 2018 ED data from a national emergency medicine group. This data set has been described previously.[14] Briefly, billing and coding specialists abstract ED data from electronic charts, including patient demographics, elements of visit timing (e.g., patient arrival and departure time), ED diagnosis, relative value units (RVUs) generated, the ED clinician rendering care, and visit disposition, into a data set. The group uses centralized scheduling with two software packages—Tangier (Sparks, MD) and Shift Admin (Columbia, SC)—to record clinician hours, which are used for compensation and is verified for hour attribution to specific clinicians. The clinical data set was combined with scheduling data to establish actual hours worked and care delivered by clinicians during each ED day, which was the primary unit of analysis. This study received approval by the institutional review board at Allegheny Health Network Research Institute.

Selection of Participants

We included general EDs (where average patient age is ≥18 years) staffed by this group at any point between January 1, 2014, and December 31, 2018. The final data set included 105,863 ED days in 94 EDs in 19 states. A table of the study population, including totals after each exclusion, is available in Data Supplement S1 (available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.14077/full).

APP Use

There was variation in how this group used APPs over the study period. In most cases, APPs treated patients independently, with available physician input when questions arose in real time. There was a requirement for emergency physician consultation by APPs in some EDs if the patient had a high-risk complaint, abnormal vital signs, or abnormal radiology or laboratory results. However, policies regarding APP responsibilities and assignments varied. In many EDs, APPs also conducted patient call-backs, worked as a clinician-in-triage, or performed simple procedures (e.g., laceration repairs). When developing clinician schedules, 2 hours of APP time was considered equivalent to one emergency physician hour. For example, if an ED were to substitute APP for physician hours, 20 hours of APP coverage would equal 10 physician hours.[15]

Methods of Measurement

Since variation in APP use existed across EDs as well as within EDs during the study period, our goal was to assess how differential use of APPs affected our study outcomes. For our study, the primary exposure APP coverage was measured at the ED day-level and defined as the proportion of total clinician hours staffed by APPs in a 24-hour period at a given ED.

We also computed several patient acuity and case-mix measures at the ED day-level to measure the complexity/severity of patients treated to adjust for confounders to our study outcomes. These included: total visits, % visits over age 65, % female visits, % visits admitted or transferred, % visits by triage severity (Emergency Severity Index [ESI]), % visits with computed tomography (CT), % visits with a mental health primary diagnosis (based on the Agency for Healthcare Research and Quality clinical software described below), % visits with a critical procedure (endotracheal intubation [Current Procedural Terminology {CPT} 31500], chest tube [CPT 32550 or 32551], central line placement [CPT 36555 or 36556], arterial line placement [CPT 36220], lumbar puncture [CPT 62270], and conscious sedation [CPT 99143, 99144, 99145, 99148, 99149, or 99150]), and % patients with critical care time (CPT 99291 or 99292). ED characteristics included annual visit volume (<30,000, 30,000–59,999, and ≥ 60,000), trauma designation (Level 1 or 2), teaching status (host ED for residency or fellowship programs), and location (metropolitan vs. nonmetropolitan/census region).[16,17] We also examined the visit case-mix of APPs and emergency physicians using the Agency for Healthcare Research and Quality Clinical Classification Software (CCS) for primary ICD-9-CM and ICD-10-CM codes.[18]

Productivity Outcomes

Productivity measures were our primary study outcomes also measured at the ED day-level and included patients treated per hour (APP and physician combined), RVUs per hour, RVUs per visit, and RVUs per the relative salary paid for an hour. Patients per hour were calculated by dividing the total number of patient departures by the total number of individual hours staffed in an ED on a given day. RVUs per hour were calculated similarly. RVUs per visit were calculated using total patient departures in the day as the denominator. RVUs per salary-adjusted hour was used to assess whether there were economies of scale for APP staffing and was calculated based on the relative hourly clinical pay of APPs versus physicians with a ratio of 0.42 across the study period in this group.

ED Flow Outcomes

To measure ED flow (i.e., throughput), patient length of stay (LOS) was calculated as the total time in the ED from arrival to departure. LOS was averaged at the ED day-level for both admitted and discharged patients. We also calculated the 90th percentile of LOS for each ED day to assess the differential effect of APP staffing on days with particularly long LOS. Finally, we calculated the proportion of visits that left without completion of treatment (LWOT), which included left without being seen, left without treatment complete, or left against medical advice.

Safety: 72-hour Return Outcomes

A unique study patient identifier was used to determine if a patient returned to the same ED within 72-hours after the ED discharged the patient home. At the ED day-level, we calculated the proportion of 72-hour returns and the proportion of 72-hour returns that resulted in hospital admission. Patients that returned within 1 hour of ED discharge were not considered a 72-hour return.

Exploratory Outcomes: Incident Reports and Patient Experience

We examined two exploratory outcomes in a subset of the EDs that collected these data. The first exploratory outcome was incident reports during the years 2015 to 2018. Incident reports involved visits flagged based on the threat of litigation (i.e., a letter from an attorney or otherwise brought to the attention of risk management in this group). The rate of incident reports (n = 128 over the study) were studied at the ED level and were classified as APP-related incidents or physician-only incidents. The second exploratory outcome was ED Press-Ganey (PG) percentile rank as a measure of patient experience measured at the ED month-level. The PG survey is a commonly used survey of patient satisfaction in U.S. health care settings. The percentile rank given to an individual ED is based on how that ED ranks relative to all other EDs ranked in that month.

Primary Data Analysis

We used descriptive statistics to compare visits treated and EDs staffed by different levels of emergency physicians and APPs. We reported proportions (%), means with standard deviations (SD), and medians with interquartile ranges (IQRs). We compared the case mix of visits treated by all clinicians, as well as those treated independently (emergency physician only, NP only, or PA only) or in combination (physician and APP).

Our primary data analysis used multivariable linear regression models with cluster robust standard errors to estimate the effect of APP coverage on study outcomes (productivity, flow, and safety). We used both fixed-effect and random-intercept models to account for the panel data structure (i.e., ED days clustered within EDs). To adjust for potential confounders, we included the patient, acuity, and case-mix covariates described earlier as well as dummy variables for day of week, month, and year. In random-intercept models, we also included time-invariant ED characteristics (trauma center status, teaching hospital, average ED annual census, rural vs. nonrural status, and geographic region).[19,20] The random-intercept and fixed-effect models produced nearly identical coefficients and standard errors. We present the results of the random-intercept model in the main text and the fixed-effect model in Data Supplement S1. A small proportion of visits were treated by both APPs and physicians (1.4%). For these visits, we split the RVUs generated by the visit evenly between the physician and the APP. Multiple imputation was used for some missing acuity covariates. To do this, we created 10 imputed data sets using a multivariate normal (MVN) distribution as the imputation algorithm. With sufficient sample size, simulation studies have found that a MVN distribution produces reliable estimates even when the normality assumption is violated.[21]

Exploratory Analyses

For our analysis of incident reports, we used logit and ordinary least squares (OLS) linear regression to estimate the effect of APP coverage on the probability of an incident and total incidents, controlling for total visits treated and trauma center status. We included all EDs that began contracts with this staffing group beginning in 2015 (n = 44). Due to limitations related to how the incident report data were collected, EDs with contracts prior to 2015 could not be included (n = 45).

We also examined the effect of APP coverage on PG percentile ranks using OLS regression and simple descriptive statistics. We used monthly PG data from 2014 to 2017 because this group largely stopped collecting PG data after that time period. For this analysis, EDs with fewer than 12 months of PG data (or completely missing PG data) were excluded (n = 51). A total of 34 EDs and 1,114 ED-months were included in the final analysis. Comparisons of EDs included and excluded in both exploratory analyses are available in Data Supplement S1. All analyses were conducted with Stata version 16.1 (StataCorp, College Station, TX).

RESULTS

In 13,024,216 visits in 94 EDs, NPs and PAs respectively treated 5.4 and 18.6% of visits independently, while 1.4% were treated by both physicians and APPs. Most visits (74.6%) were treated by physicians independently. The mean (±SD) number of visits treated by physicians independently was 3.7 (±1.5) RVUs/visit compared with 2.8 (±1.1) RVUs/visit for NPs and 2.7 (±1.1) RVUs/visit for PAs. Comparing case mixes, APPs were less likely to treat patients >65 years; admitted patients; ESI level 1 to 3 encounters (i.e., higher-acuity cases); visits with a CT scan; and patients diagnosed with circulatory diseases, mental illness, endocrine diseases, and symptom-defined conditions (e.g., abdominal pain). APPs were more likely to treat musculoskeletal, skin, and subcutaneous tissue and respiratory conditions (Table 1).

On average, EDs were staffed with 61.6% physician hours, 8.6% NP hours, and 29.9% PA hours. Large EDs (60,000+ annual visits) had higher proportions of PA and NP coverage than smaller EDs. Teaching hospitals and trauma centers had similar PA coverage, but less NP coverage than nontrauma and nonteaching hospitals. Compared to metro hospitals, rural hospitals had significantly less PA coverage while NP coverage was about the same.

Physician assistants independently treated 1.1 patients/hour (95% confidence interval [CI] = 1.0 to 1.3), NPs independently treated 1.1 patients/hour (95% CI = 1.0 to 1.2), and emergency physicians independently treated 2.2 patients/hour (95% CI = 2.2 to 2.3). Physicians generated an average of 8.5 RVUs/hour (95% CI = 8.1 to 8.8) compared to 3.1

Table 1
Comparison of Visits Seen by Emergency Physicians, NPs, and PAs

	Visit Seen By:				
	All Clinicians	Physician Only	NP Only	PA Only	Both Physician and PA/NP
Total visits	13,024,216	9,721,637	698,889	2,425,705	177,985
Row %	100%	74.6	5.4	18.6	1.4
Mean RVUs/visit	3.6	3.8	2.7	2.8	3.4
(±SD)	(±1.5)	(±1.5)	(±1.1)	(±1.1)	(±1.5)
Median LOS/visit (discharged patients)	164	185	123	125	158
(IQR)	(103–247)	(119–271)	(81–182)	(82–187)	(107–231)
Patient characteristics, %					
Over 65	20.1	23.5	9.3	9.4	22.2
Female	55.9	56.2	55.7	55.7	46.6
Disposition, %					
Discharged	74.9	68.6	94.1	93.7	84.2
Admitted	19.7	24.7	4.4	4.6	13.7
Transfer	1.4	1.8	0.2	0.2	1.3
AMA	1.1	1.2	0.8	0.8	0.5
LWOT	2.1	2.7	0.4	0.6	0.0
ED death/DOA	0.2	0.2	0.0	0.0	0.3
Other	0.6	0.9	0.0	0.0	0.0
ESI level, %					
1	0.9	1.1	0.0	0.1	2.3
2	15.6	20.0	3.4	3.5	12.4
3	50.1	58.4	26.8	27.5	40.5
4	30.2	18.3	63.6	62.4	42.2
5	3.3	2.2	6.1	6.5	2.6
Critical care time, %					
CPT 99291	5.3	7.1	0.4	0.4	5.3
CPT 99292	0.2	0.3	0.0	0.0	0.4
Procedures, %					
CT scans	18.3	21.0	9.7	10.0	19.5
Critical procedures	0.6	0.7	0.0	0.0	5.2
Condition categories (primary diagnosis), %					
Infectious and parasitic diseases	2.3	2.2	2.7	2.6	1.6
Neoplasms	0.3	0.3	0.1	0.1	0.1
Endocrine, nutritional, and metabolic diseases and immunity disorders	2.7	3.3	1.3	1.2	1.3
Diseases of the blood and blood-forming organs	0.8	1.0	0.3	0.3	0.3
Mental illness	3.5	4.2	1.2	1.3	0.9
Diseases of the nervous system and sense organs	7.2	7.3	7.0	7.2	3.6
Diseases of the circulatory system	10.8	13.2	3.2	3.4	6.7
Diseases of the respiratory system	11.9	11.6	13.5	13.0	6.1
Diseases of the digestive system	7.0	7.4	6.1	6.0	3.2
Diseases of the genitourinary system	7.0	7.4	5.9	6.0	2.3
Complications of pregnancy, childbirth, and the puerperium	2.2	2.4	1.9	1.9	0.6
Diseases of the skin and subcutaneous tissue	3.3	2.5	5.5	5.4	10.6
Diseases of the musculoskeletal system and connective tissue	7.5	5.9	12.8	12.7	3.5
Congenital anomalies	0.0	0.0	0.0	0.0	0.0
Certain conditions originating in the perinatal period	0.1	0.1	0.1	0.0	0.0

(Continued)

Table 1 (continued)

	Visit Seen By:				
	All Clinicians	Physician Only	NP Only	PA Only	Both Physician and PA/NP
Injury and poisoning	19.3	15.2	30.0	30.2	55.8
Symptoms, signs, and ill-defined conditions and factors influencing health status	10.1	11.2	6.8	7.4	3.0
Residual codes, unclassified, all E codes [259. and 260.]	3.9	4.8	1.4	1.4	0.5

CPT codes used for critical procedures are available in Data Supplement S1.
AMA = against medical advice; CPT = Current Procedural Terminology; DOA = died on arrival; ESI = Emergency Severity Index; IQR = interquartile range; LOS = length of stay (minutes); LWOT = left without treatment; NP = nurse practitioner; PA = physician assistant; RVU = relative value unit.Source: The authors' own analysis.

by NPs (95% CI = 2.7 to 3.5) and 3.0 by PAs (97% CI = 2.7 to 3.3; Table 1).

For the outcome of patients/hour at the ED day-level, a 10-percentage-point increase in APP coverage was associated with a −0.12 (95% CI = −0.15 to −0.10) change in overall patients per clinician hour. The effect on increasing APP coverage on patients treated by physicians independently per physician hour was smaller, but positive (0.05, 95% CI = 0.02 to 0.09). For patients treated by APPs independently, a 10-percentage-point increase in APP coverage decreased patients per APP hour by −0.14 (95% CI = −0.19 to −0.09) at an ED day-level (Table 2 and Figure 1).

There were also small, but significant effects of increasing APP coverage on RVUs/hour at the ED day-level. A 10-percentage-point increase in APP coverage was associated with lower overall RVUs/hour by −0.4 (95% CI = −0.5 to −0.3). For patients treated by physicians independently, RVUs/physician hour increased slightly by 0.3 (95% CI = 0.2 to 0.4), while the effect on RVUs/APP hour for patients treated by APPs independently declined slightly by −0.3 (95% CI = −0.4 to −0.2). However, when we examined the effect of APP coverage on RVUs per salary-adjusted hour, we found no significant effect (0.03, 95% CI = −0.07 to 0.12). There was no overall effect on RVUs/visit and very small effects on physician and APP RVUs/visit. For LOS, LWOT, and 72-hour returns, we did not find any significant effect of increasing APP coverage after adjusting for acuity and ED characteristics (Table 2 and Figure 1).

For incident reports, there were no significant associations for total and APP-involved incidents with increasing APP coverage after controlling for total visit volume and trauma center status. For PG site percentile ranks, there were also no significant associations with APP coverage after controlling for visit volume, patient acuity, and ED characteristics (Table 3).

DISCUSSION

To our knowledge, ours is the first study that examined the impact of ED APP staffing on productivity, flow, safety, and experience. This is relevant from a

Table 2
Estimated Effect of a 10-percentage-point Increase of APP Coverage on Measures of ED Performance

	Coefficient	[95% CI]
Patients/hour		
All clinicians	−0.127*	[−0.151, −0.104]
Physicians	0.053*	[0.024, 0.083]
APPs	−0.136*	[−0.183, −0.089]
RVUs/hour		
All clinicians	−0.439*	[−0.519, −0.359]
Physicians	0.316*	[0.213, 0.418]
APPs	−0.308*	[−0.425, −0.192]
RVUs/salary-adjusted hour†	0.047	[−0.047, 0.141]
RVUs/visit		
Overall	0.005	[−0.006, 0.016]
Physician	0.052*	[0.035, 0.07]
APP	0.043*	[0.011, 0.074]
Log LOS		
Mean discharged	0.005	[−0.008, 0.018]
Mean admitted	0.023*	[0.001, 0.044]
90th percentile	0.008	[−0.004, 0.02]
% 72-hour returns		
All returns	0.021	[−0.081, 0.123]
Admitted returns	0.038	[−0.034, 0.11]
% LWOT	−0.067	[−0.16, 0.026]

N = 105,863 ED-days in 94 EDs.
APP = advanced practice provider; LOS = length of stay (minutes); LWOT = left without treatment; RVU = relative value unit.
*95% CI does not cross zero.
†Salary-adjusted clinician hours consider APP hours 42% that of a physician hour. Regression model includes a random intercept for the ED and is adjusted for acuity and ED characteristics.

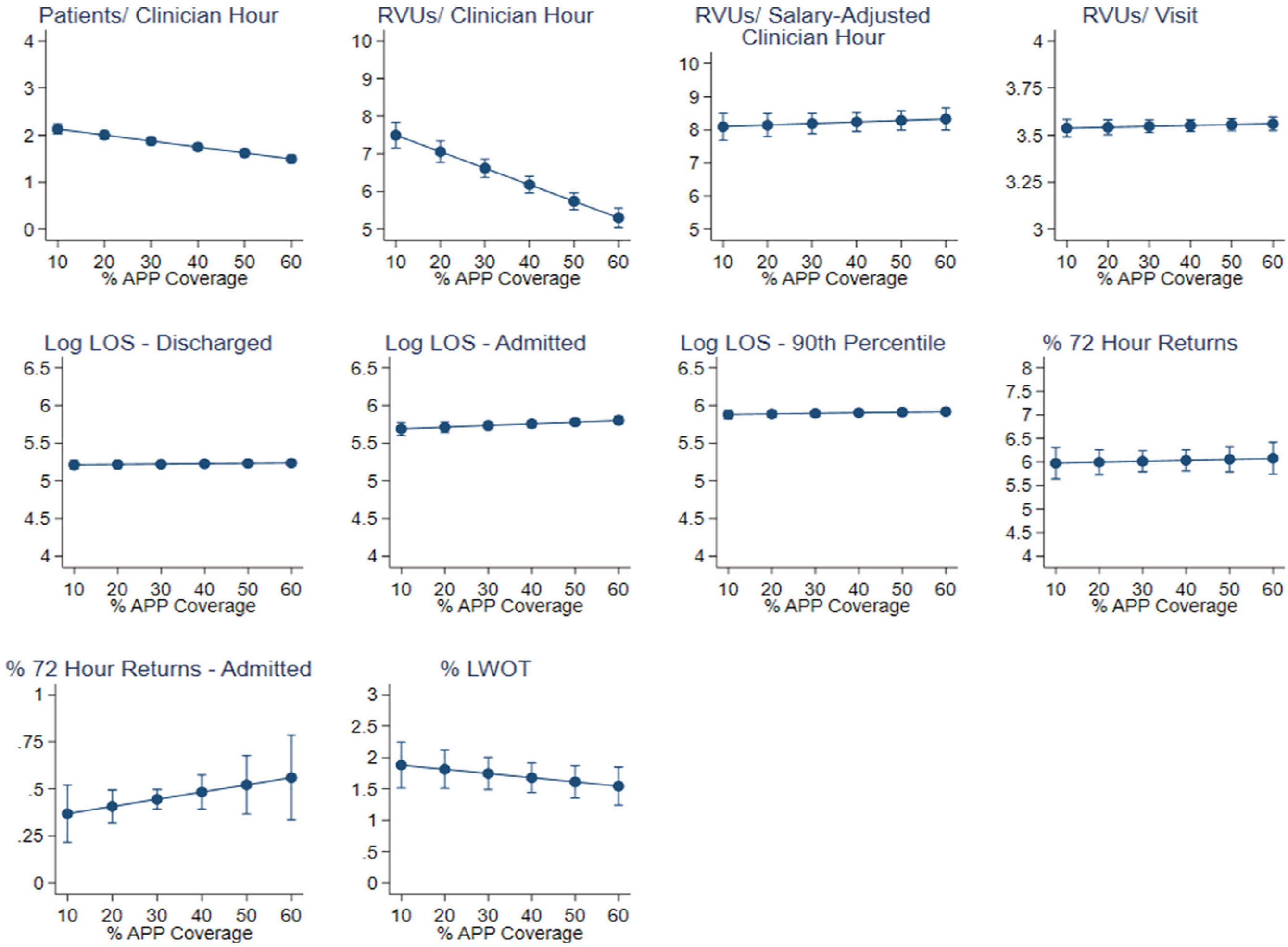

Figure 1. Linear prediction of % APP coverage on study outcomes in 94 emergency departments. APP = advanced practice provider. LOS = length of stay (in minutes); LWOT = left without treatment; RVU = relative value unit.

Table 3
Exploratory Analysis of the Estimated Change Associated With a 10-percentage-point Increase of APP Coverage on Safety Incidents and Patient Experience

	(1)		(2)		(3)	
	APP-involved Incidents		All Incidents		Press-Ganey Site Percentile Rank	
	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI
APP coverage	0.386	[−0.103 to 0.876]	−0.151	[−0.393 to 0.091]	−2.317	[−5.943 to 1.309]
Total visits (in 1000s)	−0.004	[−0.010 to 0.003]	−0.008*	[−0.015 to −0.002]	3.048	[−3.359 to 9.456]
Trauma center	0.636*	[0.006 to 1.266]	0.398	[−0.418 to 1.214]	−2.911	[−20.497 to 14.675]
Unique EDs	*44*		*44*		*37*	
Observations	*44*		*44*		*1,130*	

All EDs included in the exploratory analyses contained at least 12 months of data. Model 3 includes additional patient acuity and ED characteristics and a random intercept for the ED.
APP = advanced practice provider.
*95% CI does not cross zero.

health policy perspective given the expanding use of APPs in EDs and in U.S. health care in general. We found that APPs see approximately half of the number of independent cases as physicians and evaluate lower-acuity patients, resulting in lower RVUs/hour. However, APPs did independently evaluate small numbers of critically ill patients. There were no substantial differences in the practice patterns of PAs versus NPs.

Higher proportions of APP to physician coverage had minimal impact on overall ED productivity, measured as RVUs per visit across all ED clinicians. Some slight reductions in productivity were observed related to the reduction in patients per clinician hour and lower RVUs per clinician hour with higher APP coverage. These findings were likely due to the staffing model, where two APP hours are added for each physician hour based on administrative considerations.[14] Therefore, with higher APP coverage, there were more overall clinician hours. Higher APP coverage also increased the average RVUs per visit for both APPs and physicians, as both groups evaluated higher acuity cases. This seems somewhat paradoxical, yet can be explained: at low coverage levels, APPs evaluated low-acuity cases while higher APP coverage allowed them to evaluate some higher severity patients leaving physicians to focus on the most acutely ill.

Nevertheless, when we examined the cost-effectiveness of higher APP coverage, specifically with respect to RVUs per salary-adjusted hour, we found no significant economies of scale. These findings demonstrate that the relative clinical pay allocated to APPs compared to physicians is reflective of observed workload measured in billable services, at least in the way that APPs are used within this group. We did not account for the lower revenue typically generated from APP-only cases nor the impact of APP productivity from nonbillable activities (e.g., triaging patients), both of which impact cost-effectiveness.

No association between either LOS or LWOT in adjusted models was found, suggesting no observable effect of APP coverage on ED flow, which is an important indicator of ED quality.[22] Prior work using ecological ED-level data from the Emergency Department Benchmarking Alliance demonstrated that ED APPs have higher utilization rates of ED testing, which may increase LOS.[15] However, in this study we did not observe any LOS effect. Future patient-level analyses are needed to more definitively explore the impact of APPs on ED LOS. There was also no significant effect of APP coverage on clinical quality, as measured by 72-hour returns, 72-hour returns with admissions, and incident reports, nor on patient experience. However, given the limitations of the available safety and PG data, these findings should be considered exploratory.

LIMITATIONS

There are several study limitations. The first is the generalizability of our results. This national group employs several strategies to standardize care. There is wide dissemination of clinical management tools for high-risk complaints and a 24/7 mechanism in place for real-time questions if, for example, consultants outside the group recommend deviations from protocols. There are also regular chart audits conducted locally and nationally for quality improvement purposes for both physician and APP cases. There are educational resources for all clinicians with focused materials for APPs. Finally, the group has an internal training program for APPs to enhance their emergency care–specific skills over their first 2 years with the group if new to practice. Therefore, we cannot generalize our findings to other groups that do not have similar mechanisms in place.

Second, we had limited data at the local site about the various ways APPs are used. Because APPs perform many functions, our data underestimate APP patients per hour and may overestimate physician patients per hour, particularly in cases where an APP performed a function that was not directly recorded (e.g., triage). Additionally, we did not measure the variation in local practices with respect to how individual APPs interact with physicians and how APP oversight is implemented.

Third, we were limited in our outcomes, particularly for clinical quality metrics. While 72-hour returns with or without admissions are commonly used to identify cases that require additional chart review, they are not independently recognized as valid measures of clinical quality and safety.[23] To overcome this limitation, we added an exploratory measure—incident reports—which includes high-risk situations and assessed the ecological association between APP staffing and these reports. Incident reports are also limited because there is variation across sites whether visits reach the level of an incident in reporting. While both of these analyses did not show significant findings, our conclusions are limited by our data. Other, more in-depth chart reviews of a large proportion of cases or stratification by provider type based on objective ED quality metrics may yield different findings.

Fourth, because this was a very large, fixed sample for our main outcomes, we did not conduct a priori analyses to estimate our power to find differences in outcomes. We report the uncertainty of our estimates with 95% CIs primarily that were larger particularly for the exploratory outcomes. Therefore, we cannot definitively that there is "no difference"—particularly in the exploratory outcomes, only that we were unable to detect a significant difference given the sample size limitations.

Finally, we used ED month-level PG data in an exploratory analysis that found no relationship between APP staffing and PG ED percentile ranks. Given the considerable limitations of PG data to differentiate patient experience across sites as demonstrated in previous work as well as the limited sample, this analysis should be interpreted with caution.[24]

CONCLUSION

Our study suggests that advanced practice providers can be effectively integrated into EDs with staffing models accounting for the lower productivity of advanced practice providers compared to physicians with no apparent negative impact on ED flow, clinical quality, or patient experience. Greater levels of advanced practice provider coverage appear to allow physicians to care for higher-acuity cases while also allowing advanced practice providers to care for a lower, but significant number of patients requiring hospital admission and other critical care services. While advanced practice providers are currently utilized primarily for low-acuity cases, the finding of advanced practice providers independently evaluating critically ill ED patients suggests the potential for enhanced use of advanced practice providers in EDs. However, advanced practice provider use did not result in economies of scale given the higher productivity of physicians even when accounting for their similarly higher salary. As advanced practice provider use in emergency medicine continues to increase nationwide, implications for advanced practice provider training and processes to assure high-quality care should be considered.

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Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.14077/full

Data Supplement S1. Appendix.