CME

Emergency Physician and Advanced Practice Provider Diagnostic Testing and Admission Decisions in Chest Pain and Abdominal Pain

Jesse M. Pines, MD, MBA, MSCE[1,2], Mark S. Zocchi, MPH[1,3], Tamara S. Ritsema, PhD, MPH, PA-C[4], John Bedolla, MD[1,5], Arvind Venkat, MD[1,2], and for the US Acute Care Solutions Research Group

ABSTRACT

Objective: We compare utilization of diagnostic resources and admissions in emergency department (ED) patients with chest pain and abdominal pain when managed by advanced practice providers (APPs) and physicians.

Methods: We used 2016 to 2019 data from a national emergency medicine group. We compared visits managed by physicians and APPs based on demographics and observed resource utilization (labs, radiography, computed tomography) use and hospital admission/transfer, stratified by patient age. To reduce selection bias, we created inverse propensity score weights (IPWs). To estimate the average treatment effect for APP visits for each outcome, we included IPWs in a multivariable linear probability model with a dummy variable indicating treatment by an APP and used a facility fixed effect. We then estimated the average treatment effect comparing physician to APP visit for all visits and for discharged visits separately, stratified by the study outcomes. Sensitivity analyses were performed using different cohort definitions and adjusting for past medical history.

Results: In chest pain, we included 77,568 visits seen by 1,011 APPs and 586,031 visits seen by 1,588 physicians. In abdominal pain, we included 184,812 ED visits seen by 1,080 APPs and 761,230 visits seen by 1,689 physicians. For both chest pain and abdominal pain visits, physicians saw more older adult patients (55+ years) and admitted a higher percentage of visits than APPs. For chest pain, physicians saw more circulatory system diseases (70.7% vs. 58.6%); APPs saw more respiratory system diseases (17.1% vs. 9.8%). In abdominal pain, emergency physicians saw more digestive system diseases (28.5% vs. 23.3%); APPs saw more genitourinary system diseases. After matching with IPW, predicted probabilities of laboratory, radiology, and admissions either did not vary or were slightly lower for APPs compared to physicians for all outcomes. Sensitivity analyses showed similar results, including controlling for past medical history.

Conclusion: Diagnostic testing and hospitalization rates for chest pain and abdominal pain between APPs and physicians is largely similar after matching for severity and complexity. This suggests that APPs do not have observably higher use of ED and hospital resources in these conditions in this national group.

From [1]US Acute Care Solutions, Canton, OH; [2]The Department of Emergency Medicine, Allegheny Health Network, Pittsburgh, PA? [3]The Heller School for Social Policy and Management, Brandies University, Waltham, MA; [4]The Department of Physician Assistant Studies, The George Washington University School of Medicine and Health Sciences, Washington, DC; [5]and Dell Medical School, University of Texas at Austin, Austin, TX.
Received July 6, 2020; revision received October 1, 2020; accepted October 22, 2020.
This study was funded by a grant from the Physician Assistant Education Association (PAEA). The funder had no role in the design or completion of this project.
JMP has been a consultant to CSL Behring, Medtronic, Novo Nordisk, and Abbott Point-of-Care for unrelated work. The authors have no other potential conflicts to disclose.
Author contributions: JMP, MZ, TR, JB, and AV conceived this study; JMP, MZ, and AV wrote the initial draft; TR and JB contributed to substantive revisions; MZ conducted the statistical analysis and managed the data; JMP, MZ, TR, and AV all participated in obtaining funding for this study; and JMP and AV take responsibility for this study as a whole.
Supervising Editor: D. Mark Courtney, MD.
Address for correspondence and reprints: Jesse Pines, MD; e-mail: pinesj@usacs.com.
ACADEMIC EMERGENCY MEDICINE 2021;28:36–45.

ISSN 1553-2712

doi: 10.1111/acem.14161

Emergency department (ED) use of advanced practice providers (APPs), which include physician assistants (PAs) and nurse practitioners (NP), has expanded the past two decades.[1,2] According to estimates from the ED Benchmarking Alliance, 62% of EDs use APPs who evaluate approximately 30% of ED patients.[3] Some ED APPs provide support to physicians (e.g., performing procedures and triage), while others care for ED patients with either direct or indirect physician oversight.[4,5]

It is vital to understand how the expanding APP workforce impacts quality, utilization, and cost. Emergency care is increasingly complex and requires a broad knowledge of clinical medicine as well as focused content specific to emergencies.[6] APP clinical education is considerably shorter and less specialized (i.e., 2 years of general medical education) compared to ED physician education (i.e., 4 years of general medical education and 3 to 4 years of specialized graduate medical education in emergency medicine) raising concerns that the limited exposure of APPs to content and mentored supervision might lead to differences in practice and patient safety concerns. Prior work by our research team has demonstrated that in a national emergency medicine group, a care model combining increasing APP use with focused educational programs along with local emergency physician oversight had no impact on ED flow, quality of care, or outcomes but also did not provide economies of scale in staffing costs.[7]

Yet a remaining concern is that APPs may compensate for less training with increased utilization of labs, imaging, and admissions. Specifically, ordering labs, imaging, and admissions that provide no benefit to the patient (i.e., that are unnecessary). Utilization of labs, imaging, and admissions constitutes a major portion of U.S. health care spending and are areas where there is considerable variation within and among EDs.[8–11] A prior study demonstrated higher use of advanced imaging and admissions by APPs compared with physicians but did not control for patient complexity or acuity.[12]

To our knowledge, no patient-level analyses have compared resource utilization by ED APPs and physicians using methods that match on complexity and acuity or control for chief complaint. The chief complaints of chest pain and abdominal pain provide good models to study differences in resource utilization and admission since both have broad differential diagnoses and considerable clinician-level variation and are relatively common.[13–16] In this study, we compared utilization of diagnostic resources (labs and imaging) and admission decisions in ED patients matched complexity and acuity with chief complaints of chest or abdominal pain when primarily managed by APPs or emergency physicians. Given the prior literature on the topic, we hypothesized that APPs would have higher rates of test utilization and hospital admissions.

MATERIALS AND METHODS

Study Design and Setting

We conducted a retrospective observational study using 2016 to 2019 data from U.S. Acute Care Solutions, a national emergency medicine group with EDs in 18 U.S. states. We used data from ED visits seen by emergency physicians and APPs with chief complaints of chest pain or abdominal pain at hospital-based general (nonpediatric) EDs. This is a secondary analysis of an administrative data set that has been previously described.[17,18] The group employs billing and coding specialists who abstract visit data including demographics, diagnostic evaluations, procedural interventions, and disposition. Importantly for this study, the specific clinician who saw the patient—emergency physician, APP, or both—is also abstracted because this decision impacts billing. The group also receives data from hospital electronic health records (EHRs) on patient medical history when those systems can transmit the data in a continuous manner. The group maintains its own scheduling database (Tangier, Sparks, MD; and Shift Admin, Columbia, SC) for clinician hours, which is used to calculate monthly compensation for providers. We complied with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for observational studies in reporting our study results. This study was deemed exempt by the institutional review board at the Allegheny Health Network.

Selection of Participants

The sample included all ED visits of patients with a chief complaint of chest or abdominal pain that were triaged as Emergency Severity Index (ESI) level 2, 3, or 4 and seen independently by either an APP or emergency physician. Visits that were comanaged by APPs and physicians were excluded. For APPs, we analyzed PAs and NPs together as a group rather than separately because in our prior work, we detected no differences in the impact of PAs and NPs on quality of care, flow, or patient safety.[7] We excluded visits of patients who left without treatment, left against medical advice, were dead on arrival, or died in the ED. We also excluded patients triaged to ESI level 1 or 5 due to their rarity and the lack of variation in admissions in these groups. Finally, we excluded visits with a primary ICD-10 diagnosis of injury or poisoning given the narrower differential diagnosis (Data Supplement S1, Table S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.14161/full).

We also excluded visits from EDs without data on labs and diagnostic imaging. If a facility began reporting data during the study, relevant visits were included starting with the first month of reporting. We excluded chest and abdominal pain visits at facilities with fewer than 1,000 visits for these complaints over the study period or fewer than 100 such visits treated by APPs. We linked the scheduling data to the visits database and excluded ED visits seen by physicians and APPs who were not employed by the group for at least 6 months and worked less than 15 clinical hours per month. Finally, we excluded visits in facilities where APPs were not used in staffing during the ED visit month.

Chief Complaints and Covariates

Chief complaint is a "free-text" field, creating variation in documentation. We used an iterative process to standardize the assignment of chief complaints and identify visits with chest pain or abdominal pain for study inclusion.

To control for clinician and patient population variations between APPs and physicians, we identified independent variables a priori that might confound the comparison of APP and physician assessments and resource utilization based on clinical experience. Specifically, for each ED visit we identified the treating clinician's age at the visit date, sex, and years of employment with the group. We identified patient age, sex, insurance (self-pay, Medicaid, Medicare, commercial, or other), ESI level, disposition (admitted, discharged, or transferred), and body system of their primary diagnosis (using the AHRQ Clinical Classification Software [CCS] categories, multi-level 1 categories based on final primary ICD-10 diagnosis). We also identified visit time of day (12AM-6:59AM, 7AM-2:59PM, and 3PM-11:59PM), day of week, and visit year given the common scheduling of APPs during busier times in the ED (midmorning to late evening) and to address secular changes in APP utilization.

To control for patient complexity beyond AHRQ CCS categories, we examined data on past medical history documented in the EHR. Controlling for past medical history was done because APPs and physicians may see patients of differing medical complexity, which past medical history can estimate. Past medical history data were only available from a subset of facilities. We chose common past medical history elements including hypertension, diabetes, chronic obstructive pulmonary disease, congestive heart failure, cancer, asthma, or renal disease as most relevant. We could not determine the severity of past conditions, so we created dummy variables indicating their presence or absence in the EHR. Past medical history was identified using search terms in a similar process used to identify chest and abdominal pain.

For descriptive purposes, we collected data on facility-level characteristics, including annual visit volume (<20,000, 20,000–39,999, 40,000 to 59,999, 60,000–79,999, and ≥80,000), trauma-level designation (level 1 or 2), and teaching status (host facility for residency or fellowship programs whether emergency medicine or others).

All radiology and laboratory tests ordered during the visit were examined. Radiology orders were identified by linking Current Procedure Terminology (CPT) codes with the AHRQ CCS services and procedures categories, whenever possible (computed tomography [CT] scan chest, CT scan pulmonary angiography [CT-PA], CT scan abdomen/pelvis, any other CT scan, routine chest x-ray, ultrasound abdomen, any other diagnostic ultrasound, and electrocardiogram). Individual CPT codes were used when the CCS categories were not specific enough (chest x-ray one-view, chest x-ray two view, CT-PA). Laboratory orders were identified using individual CPT codes. For each visit we constructed dummy variables for each test to indicate whether the test was ordered.

Outcome Measures

For patients with chest pain, primary outcome measures were: ED visits with orders of any labs, electrocardiogram (ECG), and imaging studies (CT scans, ultrasounds, or x-rays), and hospital admissions, which defined as including transfer to other hospitals and observation admissions, stratified by patient age group (<10, 10–17, 18–54, and over 55 years) and sex. Secondary outcome measures were identified a priori as observable ways that care may vary based on evidence-based practice included: ECG ordered in patients under age 30 or 40 (potentially low yield), CT-PA ordered without D-dimer (potentially suggestive of overutilization of CT), and creatine phosphokinase/CK-MB ordered alone or with troponin in the absence of past medical history of renal disease (potentially suggestive of unnecessary test utilization and/or low yield).

Primary outcome measures with abdominal pain were as follows: any labs, ECG, and imaging studies (CT scans, ultrasounds, or x-rays)) and hospital admission stratified by patient age group and sex. Secondary outcome measures where evidence-based care may vary included: amylase ordered with or without lipase (potentially suggestive of unnecessary test utilization and/or low yield), urinalysis in male patients under age 65 (potentially low-yield), and urine or serum pregnancy test ordered in female patients ages 10–50 (quality concern if not ordered in abdominal pain).[19]

Primary Data Analysis

Descriptive statistics were used to compare patient and clinician characteristics of ED visits treated by physicians and APPs, presented as proportions or means and standard deviations (SDs). To reduce potential selection bias in the assignment of an ED visit to an APP, we created inverse propensity score weights (IPW). First, we used multivariable logistic regression to obtain, for each visit, a predicted probability (p) of being treated by an APP as a function of that visit's patient and clinician covariates, with a facility fixed effect and the visit year, month, day of week, and time of day of the visit. In all outcomes, clinician years since being hired was modeled as a quadratic function by including squared terms. For outcomes not stratified by patient age, we modeled patient age as a quadratic function as well. No other effect modifications among covariates were hypothesized. Because we included a facility fixed effect, we did not include facility characteristics (e.g., size, trauma status). We tested for multicollinearity among covariates using a variance inflation factor cutoff of 10. Using the predicted probabilities obtained from the logistic regression model, we generated IPWs for each visit. The IPWs were set equal to 1 for all visits treated by APPs and $p/(1 - p)$ for all visits treated by emergency physicians.

To estimate the effect of being treated by an APP on the outcomes of interest, we used the IPWs in a multivariable linear probability model with a dummy variable indicating treatment by an APP and a facility fixed effect. In large data sets, the linear probability model produces nearly identical results to logit or probit models, is computationally more efficient, and is easier to interpret.[20] This APP coefficient was defined as the average treatment effect in the treated and is interpreted as the change in the probability of an outcome occurring as a result of being treated by an APP. We estimated the average treatment effect in the treated for all visits and for discharged visits separately. Because past medical history covariates were only available for a subset of the facilities in the sample, we estimated the average treatment effect in the treated including and excluding past history. We present results from the larger sample (excluding past medical history) in the main text and provide the results with the patient problems in the Data Supplement S1, Tables S4–S7 and Appendix S1). Additionally, in these appendix tables, we provide results without using IPWs. For all analyses, confidence intervals (CIs) were assessed at the 95% level (significant at $p < 0.05$). However, given that we are estimating the average treatment effect in the treated in two samples (all visits and discharged visits separately) and across several outcomes within the same sample (36 total outcomes examined for abdominal pain, 62 for chest pain), we applied a Bonferroni correction for multiple comparisons and indicate significance with a "*" any estimates significant at $p < 0.0014$ (for chest pain) and $p < 0.0008$ (for abdominal pain). Data were missing for < 1% of the chest pain and abdominal pain samples; therefore, a complete case analysis was used for all multivariable and IPW analyses. All standard errors were clustered on the ED level. All analyses were performed using Stata version 16.1 (StataCorp, College Station, TX).

RESULTS

Characteristics of Study Subjects

Table 1 shows characteristics of included visits and clinicians with additional details in Data Supplement S1, Table S2. For chest pain, we included 77,568 ED visits from 83 facilities seen by 1,011 APPs and 586,031 visits seen by 1,588 physicians. For abdominal pain, we included 184,812 ED visits from 97 facilities by 1,080 APPs and 761,230 visits seen by 1,689 physicians. Included APPs were on average younger, more female, and newer in practice with the group compared to included physicians. For both chest and abdominal pain visits, physicians saw older adult patients (55+

Table 1
Characteristics of ED Visits With Chest Pain and Abdominal Pain

	Abdominal Pain				Chest Pain			
	APPs		Physicians		APPs		Physicians	
N (%)	184,812	(19.5)	761,320	(80.5)	77,568	(11.7)	586,031	(88.3)
Total clinicians	1,080	(39.0)	1,689	(61.0)	1,011	(38.9)	1,588	(61.1)
Total facilities	97				83			
Clinician characteristics								
Clinician age, mean (±SD)	37.7	(±8.8)	42.5	(±9.4)	38	(±8.8)	42.1	(±9.4)
Years since first hire, mean (±SD)	3.6	(±3.5)	5.2	(±5.0)	3.5	(±3.5)	5.1	(±4.9)
Female clinicians, %	60.8		30.1		56.9		30.8	
Patient demographics								
Female, %	69.5		65.4		58.6		53.9	
Age, mean (±SD)	36.1	(±18.4)	42.4	(±20.3)	43.2	(±19.5)	52.3	(±18.6)
Age (years), %								
<10	5.2		3.0		2.0		0.4	
10–17	6.6		4.9		4.8		1.6	
18–54	70.8		64.0		64.0		51.8	
55+	17.4		28.1		29.2		46.2	
Payer types								
Commercial	32.1		32.0		33.3		31.0	
Medicaid	35.2		29.0		28.9		20.8	
Medicare	12.9		21.1		20.7		32.8	
Self-pay	17.8		15.8		14.9		13.4	
Other	2.0		2.0		2.2		1.9	
Clinical characteristics								
ESI level								
2	2.9		7.6		30.1		47.4	
3	90.4		90.1		59.5		51.1	
4	6.7		2.3		10.4		1.5	
Admitted/transferred	10.6		23.7		24.6		40.3	

Study sample includes visits from general EDs, 2016 to 2019.
APP = advanced practice provider; ESI = Emergency Severity Index.

years) and admitted a higher percentage of visits than APPs. For chest pain, physicians saw more visits with diseases of the circulatory system (70.7% vs. 58.6%); APPs saw more diseases of the respiratory system (17.1% vs. 9.8%). In abdominal pain, emergency physicians saw more visits with diseases of the digestive system (28.5% vs. 23.3%); APPs saw more diseases of the genitourinary system (18.8% vs. 15.2%).

Table 2 shows the subset of visits with inclusion of past medical history. For both chest and abdominal pain visits, physicians saw a higher percentage of patients with patient problems, both singularly and in combination.

Main Results

The IPWs generated balance in all covariates used to estimate propensity scores. Data Supplement S1, Table S3, shows the IPW-adjusted means and proportions for APPs and emergency physicians and the raw and weighted differences.

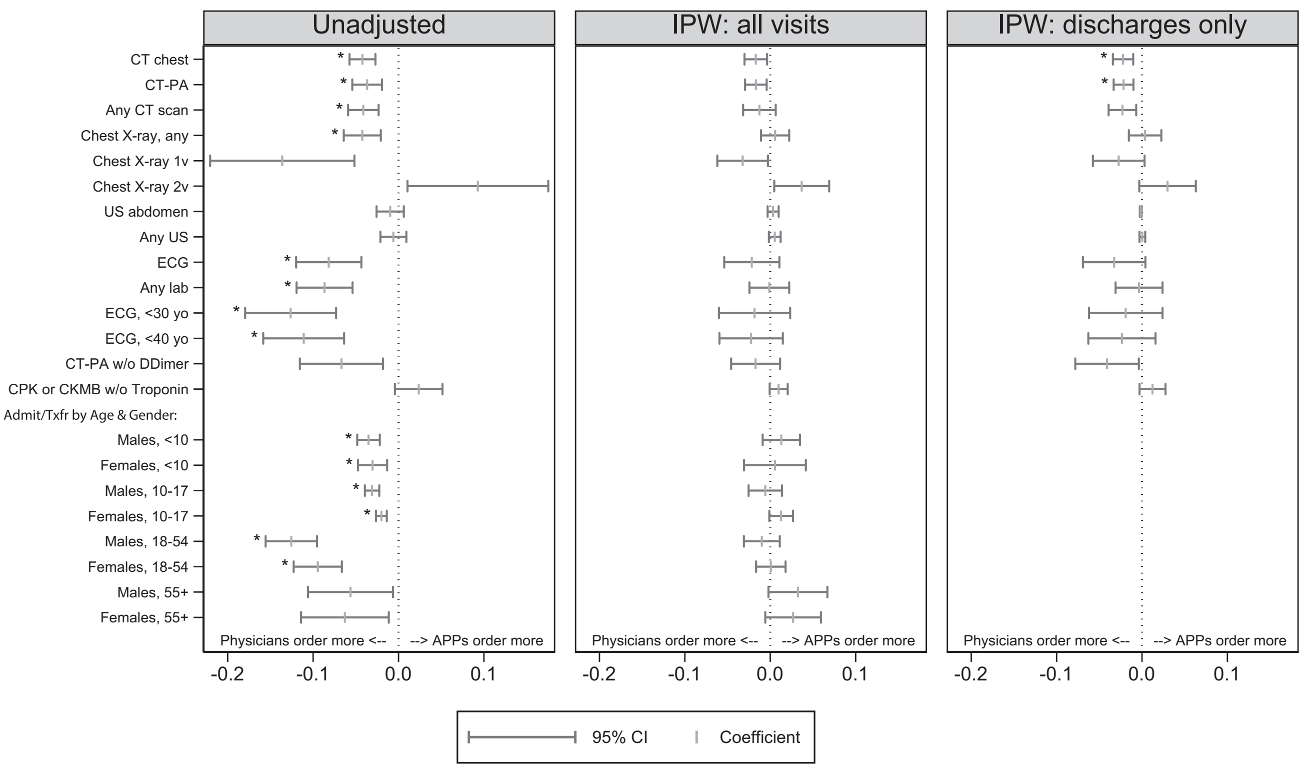
In Figures 1 and 2 we present unadjusted and IPW-adjusted average treatment effects for visits with a chief complaint of chest pain (Figure 1) and abdominal pain (Figure 2) treated by an APP. The average treatment effects can be interpreted as the change in the probability of diagnostic test being ordered or hospital admission/transfer occurring if seen by an APP relative to a physician. An average treatment effect less than 0 indicates an APP is less likely to order the test/admission while greater than 0 indicates an APP is more likely to order the test/admission. A average treatment effect of −0.1 for example would mean that an APP is 10% less likely, on average, to order that test.

For almost all outcomes examined, IPW-adjusted average treatment effects showed that being seen by an

Table 2
Past Medical History in Visits With a Complaint of Chest Pain and Abdominal Pain

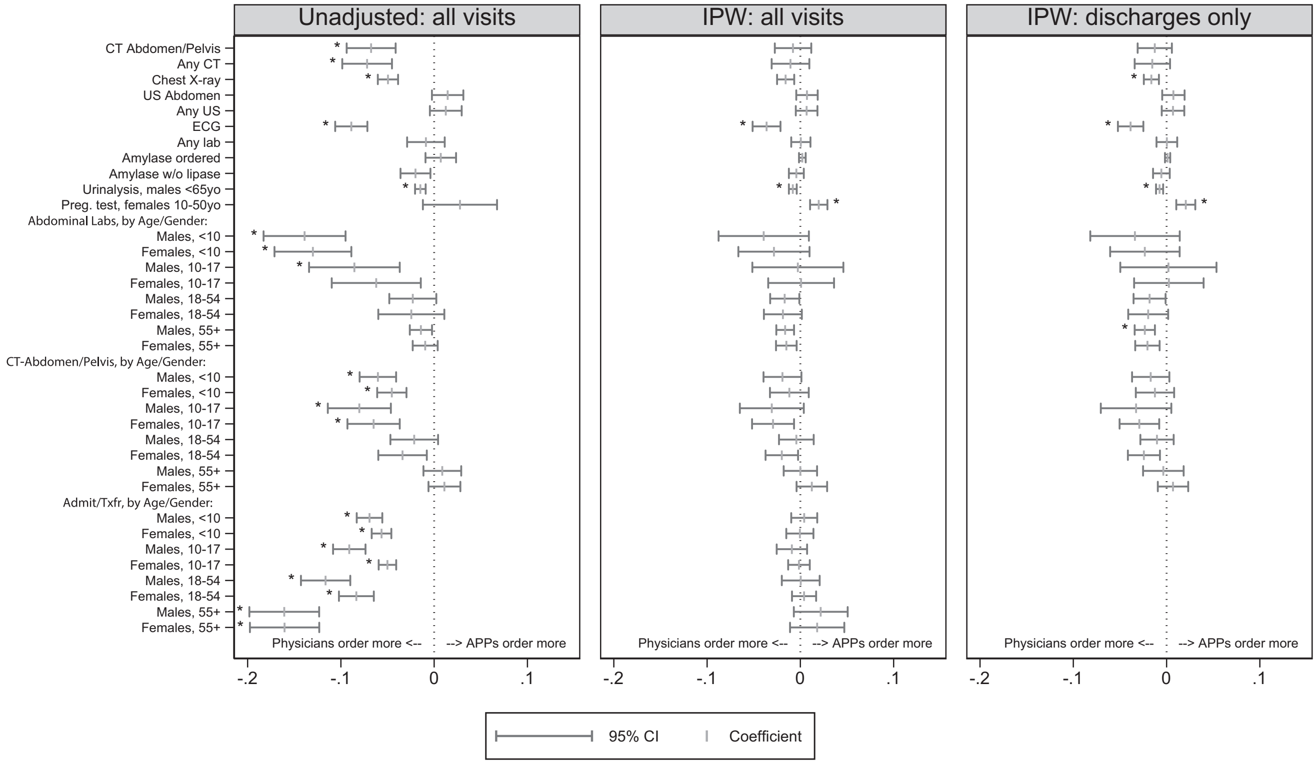
	Abdominal Pain				Chest Pain			
	APPs		Physicians		APPs		Physicians	
N (%)	107,309	(21.3)	396,099	(78.7)	42157	(12.8)	287658	(87.2)
Total clinicians	667	(41.0)	958	(59.0)	583	(40.2)	868	(59.8)
Total facilities	50				44			
Past medical history, %								
Hypertension		18.6		30.1		28.9		45.5
Diabetes		10.8		16.2		14.2		22.1
Cancer		3.6		7.0		3.6		6.0
COPD		2.2		4.4		3.9		6.8
Congestive heart failure		1.2		2.8		4.0		7.8
Asthma		11.5		12.3		11.9		11.1
Renal failure		4.8		8.3		4.5		8.1
Total past medical history, %								
None		64.7		51.2		55.1		40.0
1		23.2		27.8		27.3		30.2
2+		12.1		21.0		17.6		29.7

Study sample includes general EDs that submitted data on patient medical histories, 2016 to 2019.
APP = advanced practice provider; COPD = chronic obstructive pulmonary disease.



* = significant after adjustment for multiple comparisons (p<.0014).

Figure 1. Average treatment effect of advance practice provider (APP) management (ref: physician) on the probability of common lab, radiology, and hospital admission/transfer orders for ED patients with chest pain figure. The unadjusted differences in the left-most box represent the differences in test ordering and admission, stratified by test type and age/sex combinations, and do not account for any differences in patient population. For example, a coefficient of –0.1 means that physicians are 10% more likely to order a particular test or admit/transfer that subset of patients, while +10% means that APPs are more likely. The middle and right-most box represent this same concept (i.e., difference in probability in ordering a test or hospital admission/transfer) but using inverse probability weights (IPWs), which were used to balance clinical covariates adjusting for the differences in patient populations seen by each group. The middle box represents all visits, while the right-most box represents only discharges. Txfr = transfer; US = ultrasound.



* = significant after adjustment for multiple comparisons (p<.0008).

Figure 2. Average treatment effect of advance practice provider (APP) management (ref: physician) on the probability of common lab, radiology, and hospital admission/transfer orders for ED patients with abdominal pain figure. The unadjusted differences in the left-most box represent the differences in test ordering and admission, stratified by test type and age/sex combinations, and do not account for any differences in patient population. For example, a coefficient of –0.1 means that physicians are 10% more likely to order a particular test or admit/transfer that subset of patients, while +10% means that APPs are more likely. The middle and right-most box represent this same concept (i.e., difference in probability in ordering a test or hospital admission/transfer) but using inverse probability weights (IPWs), which were used to balance clinical covariates adjusting for the differences in patient populations seen by each group. The middle box represents all visits, while the right-most box represents only discharges. Txfr = transfer; US = ultrasound.

APP either did not vary or slightly reduced the probability of having a radiology or laboratory test ordered in comparison to physicians. This held true overall and among discharged ED visits, including models that contained past medical history (Data Supplement S1, Appendix S1). Differences that remained statistically significant after the multiple comparison adjustment were modest.

DISCUSSION

In this study we assessed whether APPs and physicians use diagnostic tests and make admission decisions differently when seeing similar patients, which has broad implications for the deployment and supervision of ED APPs. We focused on two patient chief complaints seen by both APPs and physicians: chest pain and abdominal pain. These were chosen because they are the two most common ED chief complaints: chest pain and abdominal pain accounted for 12.2 million and 6.5 million of the 139 million ED visits in 2017, respectively.[21] Chest pain and abdominal pain also have large differential diagnoses that include both severe and minor conditions and involve considerable clinical judgment, ED-based testing, and, frequently, admission to the hospital. Clinical decisions in chest and abdominal pain also differ significantly based on individual clinician factors, including malpractice fear and risk tolerance.[13–16,22–24]

The challenge in comparing APPs and emergency physicians is that within the same ED, APPs tend to work in lower-acuity areas and therefore on average evaluate lower-acuity patients. This was confirmed in our study, where APPs evaluated younger, less severely ill patients with fewer comorbidities. However, APPs did evaluate a considerable proportion of high-risk chest pain patients (30% of visits at ESI 2 compared to 48% by emergency physicians) and high-risk abdominal pain (3% at ESI 2 compared to 7% by emergency physicians). The tendency toward APPs seeing lower-acuity patient's biases toward lower testing rates by APPs based on patient factors such as acuity and comorbidities that drive differential diagnosis. Our initial unadjusted analyses did, in fact, demonstrate considerably lower testing and hospital admission/transfer rates in patients see by APPs.

However, our goal was to create a more accurate comparison of APPs and physicians. To accomplish this goal, we examined multiple subsets of visits and employed different ways to control for patient complexity and acuity, including using propensity weights, to compare diagnostic test utilization and admission rates as well as a conservative approach to assess for significance (i.e., the Bonferroni correction) given the number of outcomes modeled. Ultimately, across the varied approaches we found a broadly consistent pattern: APPs and emergency physicians largely had similar observed test utilization and admission rates after adjusting for patient characteristics, suggesting similar observed care in this national emergency medicine group. Yet, some select clinical decisions did demonstrate lower utilization among APPs, such as lower use of CT-PA without an initial D-dimer in chest pain (a potentially desirable outcome) as well as lower ECG use (a potentially undesirable outcome). These differences may reflect actual differences in approach or may be a result of residual unmeasured confounding.

Our results differ from prior work showing that ED-based APPs order more tests and that concludes that differences in training between APPs and emergency physicians result in less ability by APPs to discriminate which ED patients require testing.[12] Our study is more focused and overcomes the methodologic limitations that were ecologic (i.e., examined testing trends at the ED rather than patient level) and relied on self-reported data. It is also important to put our work in the context of the broader literature comparing APPs and physicians. Some studies have demonstrated differences in cost and utilization, while other studies have demonstrated that APPs deliver similar care and outcomes.[25–27] Unlike these prior studies, our study uses a large sample of clinicians, facilities, and visits and controls for multiple potential confounders. Therefore, we believe that our study provides a more accurate comparison of APP and physician practice patterns.

LIMITATIONS

There are several study limitations. The first is the generalizability of our results outside of chest pain or abdominal pain visits, which are only a subset of all ED visits. Resource use may differ in other conditions. We also cannot generalize outside of the national group whose data were used, which uses strategies to standardize care, including clinical management tools for all clinicians, general educational materials, and focused materials for APPs. There is also an APP training program during the first 2 years of practice. In addition, no sites in our study had unsupervised or independent APP practice. All sites have an emergency physician available for oversight if needed, so our results do not suggest that independent APP practice is appropriate because that was not directly studied. Finally, regular chart audits are conducted for quality improvement in both APP and physician cases.

Second, we do not have site-level data about how APPs are assigned cases, where APPs, physicians, and patients are physically located (i.e., fast-track or the main ED); how APPs are overseen; or specialization of APPs to particular areas (i.e., chest pain units). In general, most APP care is not directly supervised (i.e., each case is not presented to a physician). However, some EDs have local policies where APPs must present specific cases to physicians. In those cases, it is common for the physician and APP to document the case which in our prior work only occurred in 1.4% of cases.[7] In this study, those cases were excluded. In addition, in some EDs, APPs work in the main ED while in others they work only in fast-track when there is one, and in others, they may work in both areas.

A third limitation is that study outcomes were chosen based primarily on utilization (i.e., decision to order a test or admit) rather than other outcomes, such as patient experience or clinical outcomes. However, our prior exploratory work examining these outcomes did not identify differences in incident reports, 72-hour returns, or patient experience with higher use of APPs.[7]

Fourth, the IPWs generated good balance on all covariates used to estimate the propensity score but cannot account for unmeasured characteristics. Past medical history increases patient complexity but may be underreported in our data set. While we have no reason to believe underreporting would be different among APP or physician visits, we cannot rule out that more robust documentation would improve risk adjustment. In addition, while we include ESI level in propensity scores, physicians may be more likely to see patients with multiple complaints, which may add to complexity in unobservable ways.

Fifth, we used a systematic method to identify chief complaints. We may have failed to include some visits with a complaint of chest or abdominal pain, but this likelihood would not differ between APPs and physicians. Also, because complaint information was captured as free text, our method could not identify whether visits had single chief versus multiple chief complaints (e.g., chest pain, shortness of breath, and generalized weakness).

Sixth, sample sizes for the outcomes in subgroups with lower incidence (e.g., ED visits < 10 years with chest pain) may be insufficient to detect small, yet meaningful, differences. We used a large data set with few missing variables and provide 95% CIs to demonstrate the uncertainty of estimate but cannot rule out potential type II errors among some of the outcomes.

Seventh, we excluded visits seen by clinicians in practice fewer than 6 months in a facility or for fewer than 15 hours per month. While we believe the data on clinician scheduling to be highly accurate as it is used for clinician compensation, we did not validate this linkage independently.

CONCLUSION

We demonstrate that the care delivered in the ED by advanced practice providers and emergency physicians for patients matched on complexity and acuity presenting with chest pain or abdominal pain chief complaints is largely similar with respect to diagnostic test utilization and admission decisions. Future research should continue to explore the optimal use of advanced practice providers in the ED and the best ways to deploy this expanding part of the U.S. ED workforce.

The authors acknowledge Paul Dietzen, Jason Shawbell, Jesse Eterovich, and Amer Aldeen, MD, at US Acute Care Solutions for their support of this work.

REFERENCES

1. Sturmann KM, Ehrenberg K, Salzberg MR. Physician assistants in emergency medicine. Ann Emerg Med 1990;19:304–8.
2. Cooper RA, Henderson T, Dietrich CL. Roles of non-physician clinicians as autonomous providers of patient care. JAMA 1998;280:795–802.
3. Wiler JL, Welch S, Pines J, Schuur J, Jouriles N, Stone-Griffith S. Emergency department performance measures updates: proceedings of the 2014 Emergency Department Benchmarking Alliance consensus summit. Acad Emerg Med 2015;22:542–53.
4. Hooker RS, Klocko DJ, Larkin GL. Physician assistants in emergency medicine: the impact of their role. Acad Emerg Med. 2011;18:72–7.
5. Phillips AW, Klauer KM, Kessler CS. Emergency physician evaluation of PA and NP practice patterns. JAAPA 2018;31:38–43.
6. Model of the Clinical Practice of Emergency Medicine. Available at: https://www.cordem.org/globalassets/files/misc.-files/2019-em-model_website.pdf. Accessed Sep 22, 2020.
7. Pines JM, Zocchi MS, Ritsema T, Polansky M, Bedolla J, Venkat A. The impact of advanced practice provider staffing on emergency department care: productivity, flow, safety, and experience. Acad Emerg Med 2020 [Online ahead of print].
8. Papanicolas I, Woskie LR, Jha AK. Health care spending in the united states and other high-income countries [published correction appears in JAMA 2018 May 1;319(17):1824]. JAMA 2018;319:1024–39.
9. Caines K, Shoff C, Bott DM, Pines JM. County-level variation in emergency department admission rates among US Medicare beneficiaries. Ann Emerg Med 2016;68:456–60.
10. Abualenain J, Frohna WJ, Shesser R, Ding R, Smith M, Pines JM. Emergency department physician-level and hospital-level variation in admission rates. Ann Emerg Med 2013;61:638–43.
11. Pines JM, Mutter RL, Zocchi MS. Variation in emergency department admission rates across the United States. Med Care Res Rev 2013;70:218–31.
12. Aledhaim A, Walker A, Vesselinov R, Hirshon JM, Pimentel L. Resource utilization in non-academic emergency departments with advanced practice providers. West J Emerg Med 2019;20:541–8.
13. Pines JM, Hollander JE, Isserman JA, et al. The association between physician risk tolerance and imaging use in abdominal pain. Am J Emerg Med 2009;27:552–7.
14. Cotterill PG, Deb P, Shrank WH, Pines JM. Variation in chest pain emergency department admission rates and acute myocardial infarction and death within 30 days in the Medicare population. Acad Emerg Med 2015;22:955–64.
15. Kindermann DR, McCarthy ML, Ding R, et al. Emergency department variation in utilization and diagnostic yield of advanced radiography in diagnosis of pulmonary embolus. J Emerg Med 2014;46:791–9.
16. Pines JM, Isserman JA, Szyld D, Dean AJ, McCusker CM, Hollander JE. The effect of physician risk tolerance and the presence of an observation unit on decision making for ED patients with chest pain. Am J Emerg Med 2010;28:771–9.
17. Pines JM, Zocchi MS, De Maio VJ, Carlson JN, Bedolla J, Venkat A. The effect of operational stressors on

emergency department clinician scheduling and patient throughput. Ann Emerg Med 2020;76:646–58.
18. Carlson JN, Foster KM, Pines JM, et al. Provider and practice factors associated with emergency physicians' being named in a malpractice claim. Ann Emerg Med 2018;71:e4.
19. Schuur JD, Tibbetts SA, Pines JM. Pregnancy testing in women of reproductive age in US emergency departments, 2002 to 2006: assessment of a national quality measure. Ann Emerg Med 2010;55:449–57.e2.
20. Wooldridge JM. A Binary Dependent Variable: The Linear Probability Model. In: Introductory Econometrics, 6e. Boston, MA: Cengage Learning, 2016:224–9.
21. National Hospital Ambulatory Medical Care Survey: 2017 Emergency Department Summary Tables. Available at: https://www.cdc.gov/nchs/data/nhamcs/web_tables/2017_ed_web_tables-508.pdf. Accessed Sep 22, 2020.
22. Khojah I, Li S, Luo Q, et al. The relative contribution of provider and ED-level factors to variation among the top 15 reasons for ED admission. Am J Emerg Med 2017;35:1291–7.
23. Schriger DL, Menchine M, Wiechmann W, Carmelli G. Emergency physician risk estimates and admission decisions for chest pain: a web-based scenario study. Ann Emerg Med 2018;72:511–22.
24. Katz DA, Williams GC, Brown RL, et al. Emergency physicians' fear of malpractice in evaluating patients with possible acute cardiac ischemia. Ann Emerg Med 2005;46:525–33.
25. Bellon JE, Stevans JM, Cohen SM, James AE 3rd, Reynolds B, Zhang Y. Comparing advanced practice providers and physicians as providers of e-visits. Telemed J E Health 2015;21:1019–26.
26. Rymer JA, Chen AY, Thomas L, et al. Advanced practice provider versus physician-only outpatient follow-up after acute myocardial infarction. J Am Heart Assoc 2018;7:e008481.
27. Yang Y, Long Q, Jackson SL, et al. Nurse practitioners, physician assistants, and physicians are comparable in managing the first five years of diabetes. Am J Med 2018;131:276–83.e2.

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.14161/full

Data Supplement S1. Supplemental material.