Original Investigation

A Comparison of Diagnostic Imaging Ordering Patterns Between Advanced Practice Clinicians and Primary Care Physicians Following Office-Based Evaluation and Management Visits

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IMPORTANCE Little is known about the use of diagnostic testing, such as medical imaging, by advanced practice clinicians (APCs), specifically, nurse practitioners and physician assistants.

OBJECTIVE To examine the use of diagnostic imaging ordered by APCs relative to that of primary care physicians (PCPs) following office-based encounters.

DESIGN, SETTING, AND PARTICIPANTS Using 2010-2011 Medicare claims for a 5% sample of beneficiaries, we compared diagnostic imaging ordering between APC and PCP episodes of care, controlling for geographic variation, patient demographics, and Charlson Comorbidity Index scores. Provider specialty codes were used to identify PCPs and APCs (general practice, family practice, or internal medicine for PCP; nurse practitioner or physician assistant for APC). Episodes were constructed using evaluation and management (E&M) office visits without any claims 30 days prior to the index visit and (1) no claims at all within the subsequent 30 days; (2) no claims within the subsequent 30 days other than a single imaging event; or (3) claims for any nonimaging services in that subsequent 30-day period.

MAIN OUTCOMES AND MEASURES The primary outcome was whether an imaging event followed a qualifying E&M visit.

RESULTS Advanced practice clinicians and PCPs ordered imaging in 2.8% and 1.9% episodes of care, respectively. In adjusted estimates and across all patient groups and imaging services, APCs were associated with more imaging than PCPs (odds ratio [OR], 1.34 [95% CI, 1.27-1.42]), ordering 0.3% more images per episode. Advanced practice clinicians were associated with increased radiography orders on both new (OR, 1.36 [95% CI, 1.13-1.66]) and established (OR, 1.33 [95% CI, 1.24-1.43]) patients, ordering 0.3% and 0.2% more images per episode of care, respectively. For advanced imaging, APCs were associated with increased imaging on established patients (OR, 1.28 [95% CI, 1.14-1.44]), ordering 0.1% more images, but were not significantly different from PCPs ordering imaging on new patients.

CONCLUSIONS AND RELEVANCE Advanced practice clinicians are associated with more imaging services than PCPs for similar patients during E&M office visits. Expanding the use of APCs may alleviate PCP shortages. While increased use of imaging appears modest for individual patients, this increase may have ramifications on care and overall costs at the population level.

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Warnings of worsening primary care physician (PCP) shortages abound.[1-4] With fewer medical students choosing primary care,[5,6] increasing health care demand from a growing and aging population,[4] and a broad increase in access to care through the Affordable Care Act,[7] these warnings are rising in pitch. This has led to calls to fundamentally redesign primary care.[8] Many alternative models to alleviate this shortage have been proposed. A few include shifting primary care settings to nontraditional outlets such as retail clinics,[9] increasing integrated care though nurse-managed health centers and patient-centered medical homes,[10] and expanding the scope of practice for nonphysician providers.[11,12] A common theme among these models is the increased use of advanced practice clinicians (APCs), particularly physician assistants (PAs) and nurse practitioners (NPs).

Although the optimal use of APCs is still under debate,[11] recent literature reviews[13,14] report that selected patient outcomes for many specific conditions are no worse when care is managed by APCs rather than physicians. It remains to be seen whether APCs are able to deliver equivalent clinical outcomes in a broader patient population, as randomized studies covering broader ranges of conditions have largely focused on measures such as patient satisfaction and self-reported health status.[15] This is important because many new models of care seek to expand the role of APCs to serve as the initial point of contact for a full range of patient care. In this larger role, APCs' limited training and narrower expertise relative to physicians potentially increases their uncertainty when confronted with less familiar medical conditions outside of those explicitly covered by their scope of practice.

Moreover, while expanded use of APCs has been shown to reduce provider labor costs,[13,16] little is known regarding their use of related services, such as diagnostic imaging—an important tool for reducing provider diagnostic uncertainty, and where overuse may expose patients to unnecessary radiation[17,18] and offset at least some savings. Though previous randomized trials[19,20] indicate that NPs may order more tests than physicians, these studies are not generalizable, given their specific practice environments (medical clinic associated with a county hospital[19] and a Veterans Affairs Medical Center[20]), small patient panels (60 total patients across all groups),[19] and small number of participating providers (9 participating APCs).[20]

We sought to examine the use of diagnostic tests—specifically medical imaging—by APCs as a directly observable and quantifiable measure for comparing the care they provide with that of PCPs. Previous research investigating the concordance of APC and physician radiography orders in the emergency department (ED) setting found that in 34% of ED patients, APCs recommended imaging studies when physicians had not.[21] Using retrospective claims data, we were able to estimate the use of diagnostic imaging following initial evaluation and management (E&M) office visits to APCs relative to that of PCPs while controlling for patient demographics and prospective patient risk. Moreover, because we used Medicare claims data, we were able to investigate this question in context of the complex care needs of a growing elderly population that will drive much future demand for primary care services.

Methods

Study Setting

The American College of Radiology's institutional review board waived this study from institutional review. We conducted a retrospective analysis of 2010-2011 Medicare fee-for-service claims to compare rates of ordering diagnostic imaging examinations following an E&M office visit between PCPs and APCs. The 2011 Medicare 5% Limited Data Set (LDS) Physician/Supplier Part B claims file was used to identify qualifying patient episodes and imaging events. The 2010 5% LDS Inpatient file was used to calculate a comorbidity index for each beneficiary. The 5% LDS Denominator file for both years was used to determine patient eligibility for inclusion in the study and to obtain demographic information for the statistical analysis.

Patient Episode Identification

Patient episodes of care were defined as follows: E&M office visits were identified by restricting data to claims where (1) the place of service was reported as "office" and (2) the Healthcare Common Procedure Coding System code was reported as either between 99201 and 99205 (new patients) or 99211 and 99215 (established patients). Imaging events were identified as claims reporting a Berenson-Eggers Type of Service code that began with "I". Services performed by either a PCP or APC were identified using the provider specialty code reported on the claim (general practice, family practice, or internal medicine for PCP; NP or PA for APC). If an E&M visit or imaging event involved only 1 care provider on each day, it was considered a single visit. Otherwise, it was defined as multiple visits and excluded from the study.

A single E&M office visit served as the index event for qualifying patient episodes of care. To minimize inclusion of imaging events initiated by a different preceding event, an index event was included in the study sample if there were no claims of any type 30 days prior to that visit.

To minimize the potential bias in the attribution of imaging claims to index E&M visits when there are imaging claims that occur after follow-up care (such as specialty referrals), we limited analysis to the following 3 types of episodes (Figure): (1) index E&M visits with no claims of any type within 30 days following the E&M visit; (2) index E&M visits with no claims of any type within 30 days following the E&M visit other than a single nonmammography imaging event; and (3) index E&M visits with any nonimaging event(s) within 30 days following the E&M visit.

Key Variables

The primary outcome was whether an imaging event occurred following an index E&M visit. Other variables include patient age group (66-69, 70-74, 75-79, 80-84, and >84 years), sex, race (white, black, Hispanic, other/unknown), geographic variation (50 US states), urban areas as identified by the 2013 National Center for Health Statistics Urban-Rural Classification Scheme for Counties,[22] and the Charlson Comorbidity Index (CCI; score range, 0 to ≥3). The CCI is a summary score for 17 categories of conditions with assigned scores of either 1, 2, 3, or 6, depending on the risk of dying associated with the condition. We calculate this index for each beneficiary for the preceding 12 months prior to 2011 by applying established algorithms[23] on linked 2010 5% LDS Inpatient claims data.

Statistical and Sensitivity Analyses

A bivariate logistic regression model was used to examine the relationship between whether a single E&M office visit was followed by an imaging event and whether the E&M visit was performed by a PCP or APC. To adjust for potential confounders, we used a multivariable logistic regression model that adjusted for patient age group, sex, race, geographic variation (50 US states), urban location, and the CCI. We also conducted these analyses on subgroups defined by whether the imaging event was radiography (ie, "x-ray") or nonradiography imaging ("advanced imaging") and whether the E&M visit was for new or established patients.

Several analyses were performed to check the robustness of our results. We used a shortened 15-day window for claims following the index E&M visit to determine if results were sensitive to window length. Moreover, to ensure the comparability of E&M visits between PCPs and APCs (ie, that APCs in the analysis were treating similar patients as PCPs), we performed analyses after restricting episodes of care to those where the patient's condition, as reported by the *International Classification of Diseases, Ninth Revision* (*ICD-9*), code on the index E&M claim, was among the most frequent *ICD-9* codes treated by PCPs. Specifically, we considered the 0.5%, 1%, 2%, and 3% most frequently reported *ICD-9* codes treated by PCPs in E&M office visits. These codes covered between 56% and 80% of all E&M office-based claims. Fixed effects for the included *ICD-9* codes were added to the regression models to adjust for the specific clinical condition associated with the E&M visit. These analyses were then repeated under an alternative study design where episodes of care were constructed by including all claims of any type within 30 days after the index E&M claim to examine the for potential bias from excluding episodes of care that contained either multiple imaging claims or an imaging claim plus any other claims within 30 days after the index visit.

In addition, we performed analyses of episodes of care for 2 clinical conditions frequently seen by APCs: nonspecific lower back pain and acute respiratory tract infection. Because of the variation in training between NPs and PAs, we performed an analysis on all episodes of care attributed to APCs, where the independent variable of interest was whether the provider was an NP.

All analyses were performed using SAS software (SAS Institute Inc), version 9.3 for Windows. Statistical tests were 2 sided with an α level of .05.

Results

Study Sample

The 2011 5% LDS claims file contains 86 378 354 distinct line items. We first restricted the sample to beneficiaries 66 years or older in 2011, with continuous Medicare Part A and B coverage in both 2010 and 2011 and with no health maintenance organization enrollment in both years (n = 58 120 478). This ensures that patients have complete Medicare claims data throughout 2010 for calculating a Charlson Comorbidity Index. There were 8 114 207 E&M visits, of which 3 639 103 were coded as either PCPs (n = 3 311 584) or APCs (n = 327 519). Of these, there were 870 360 claims for E&M encounters with a 30-day claim-free period prior to the visit. We further removed E&M visits with multiple providers on the same day (n = 12 217). The remaining 858 143 E&M visits represent the number of eligible index E&M visits prior to constructing our episodes of care.

There were 177 266 episodes of care with no claims of any type for 30 days after the index E&M visit that met our study inclusion criteria. There were another 462 380 episodes of care with only nonimaging claims 30 days after the index E&M visit. Finally, there were 12 726 episodes of care with only a single imaging claim 30 days after the index E&M visit. Together, this produced 652 372 episodes of care that met study inclusion criteria. We further removed 1298 episodes of care because of either missing or conflicting information. This produced a final study sample of 651 074 episodes of care covering 75.9% of all eligible index E&M visits. The eFigure in the Supplement depicts the process of study sample creation.

Our robustness test using an alternative study design that included previously removed episodes of care with multiple imaging claims or an imaging claim plus any other claims within 30 days after the index E&M visit covered 99.9% (n = 857 451) of all eligible index E&M visits for this study.

Descriptive Statistics

Table 1 provides descriptive statistics of the study sample. Of the 651 074 E&M episodes of care included in the main analysis, 52 186 (8.0%) were performed by APCs and 598 888 (92.0%) were performed by PCPs. A single imaging event occurred during the 30-day follow-up window in 12 385 (1.9%) of all qualifying episodes. Of these, 8946 (72.2%) were for radiography and 3439 (27.8%) were for advanced imaging services. Advanced practice clinicians ordered imaging tests in 1350 (2.7%) of their qualifying episodes of care. Primary care physicians ordered imaging tests in 11 035 (1.9%) of their qualifying episodes of care. Of E&M visits, 59.6% were for female patients, 85.4% were for white patients, and 89.7% were for healthy patients (ie, CCI score of 0), with only 3.1% for severely ill patients. Patients of PCPs were more likely to be 75 years or older (+6.0%), male (+1.5%), nonwhite (+6.8%), from the northeast (+4.5%), urban (+13.0%), and sicker (+0.6% with CCI score >0) compared with patients of APCs.

Comparison of Imaging Rates

Because the unadjusted and adjusted results were qualitatively similar, we report only the adjusted results. **Table 2** presents adjusted estimates of the odds ratio (OR) that an APC ordered an imaging examination relative to a PCP following a qualifying E&M visit along with the predicted rate of imaging. Across the overall sample, APCs were associated with more

Table 1. Descriptive Statistics for Patients Among the Evaluation and Management Visits Included in the Study[a]

Variable	All Episodes, No. (%)	APCs, No. (%)	PCPs, No. (%)	% APC	% PCP
Qualifying E&M visits	651 074 (100)	52 186 (100)	598 888 (100)	8.0	92.0
Age category, y					
65-69	152 192 (23.4)	14 229 (27.3)	137 963 (23.0)	9.3	90.7
70-74	163 740 (25.2)	13 996 (26.8)	149 744 (25.0)	8.5	91.5
75-79	129 936 (20)	10 227 (19.6)	119 709 (20.0)	7.9	92.1
80-84	105 939 (16.3)	7458 (14.3)	98 481 (16.4)	7.0	93.0
>84	99 267 (15.3)	6276 (12)	92 991 (15.5)	6.3	93.7
Sex					
Male	262 975 (40.4)	20 372 (39)	242 603 (40.5)	7.7	92.3
Female	388 099 (59.6)	31 814 (61)	356 285 (59.5)	8.2	91.8
Race					
White	556 053 (85.4)	47 819 (91.6)	508 234 (84.9)	8.6	91.4
Black	53 193 (8.2)	2733 (5.2)	50 460 (8.4)	5.1	94.9
Hispanic	10 598 (1.6)	521 (1.0)	10 077 (1.7)	4.9	95.1
Other/unknown	31 230 (4.8)	1113 (2.1)	30 117 (5.0)	3.6	96.4
Region					
Northeast	114 872 (17.6)	7057 (13.5)	107 815 (18.0)	6.1	93.9
Midwest	150 528 (23.1)	12 720 (24.4)	137 808 (23.0)	8.5	91.5
South	277 780 (42.7)	23 358 (44.8)	254 422 (42.5)	8.4	91.6
West	107 894 (16.6)	9051 (17.3)	98 843 (16.5)	8.4	91.6
NCHS Urban-Rural Classification					
Urban	513 482 (78.9)	34 925 (66.9)	478 557 (79.9)	6.8	93.2
Rural	137 592 (21.1)	17 261 (33.1)	120 331 (20.1)	12.5	87.5
CCI score					
0	583 666 (89.7)	47 069 (90.2)	536 597 (89.6)	8.1	91.9
1	28 269 (4.3)	2200 (4.2)	26 069 (4.4)	7.8	92.2
2	18 839 (2.9)	1455 (2.8)	17 384 (2.9)	7.7	92.3
≥3	20 300 (3.1)	1462 (2.8)	18 838 (3.2)	7.2	92.8

Abbreviations: APCs, advanced practice clinicians (nurse practitioners and physician assistants); CCI, Charlson Comorbidity Index; E&M, evaluation and management; NCHS, National Center for Health Statistics; PCPs, primary care physicians.

[a] Source data: 2011 Medicare 5% Limited Data Set (LDS) Physician/Supplier Part B and Denominator files and 2010 Medicare 5% LDS Inpatient file.

imaging than PCPs (OR, 1.34 [95% CI, 1.27-1.42]), ordering 0.3% more images per episode of care.

The subgroup analysis revealed qualitatively similar results for all subgroups with the exception of new patient visits followed by either no imaging or advanced imaging. Advanced practice clinicians were associated with increased radiography orders on both new patients (OR, 1.36 [95% CI, 1.13-1.66]) and established patients (OR, 1.33 [95% CI, 1.24-1.43]), ordering 0.3% and 0.2% more images per episode of care, respectively. With regard to advanced imaging, APCs were associated with increased orders on established patients (OR, 1.28 [95% CI, 1.14-1.44]), ordering 0.1% more images, but were not significantly different from PCPs ordering imaging on new patients.

Sensitivity Analysis

The lower panel of Table 2 provides the results of our first sensitivity analysis, which redefined the window for qualifying episodes of care as 15 days after the index E&M encounter. The estimates were similar to those produced using the 30-day window.

Table 3 contains the results of our second sensitivity analysis examining only episodes of care where the index E&M encounter was among the most frequent conditions seen by PCPs and adjusted for the specific clinical condition reported by the *ICD-9* code on the claim. In all analyses, APCs were associated with more imaging than PCPs. For the 24 most common *ICD-9* codes, ie, 0.5% most frequent codes in the data, APCs ordered 0.1% more images per episode of care (OR, 1.16, [95% CI, 1.03-1.31]). In the remainder of the analyses covering the most frequent 1% (OR, 1.24, [95% CI, 1.13-1.37]), 2% (OR, 1.24, [95% CI, 1.14-1.35]), and 3% (OR, 1.23, [95% CI, 1.14-1.33]) most frequent *ICD-9* codes, APCs ordered 0.2% more images than PCPs per episode of care.

Our analyses using an alternative study design that included all claims within 30 days following the index E&M visit produced similarly significant results, though the magnitudes of the effects are reduced. No significant association was found between the ordering patterns of APCs and PCPs for nonspecific lower back pain (OR, 0.59 [95% CI, 0.53-0.66]), with a predicted rate of 0.5% more images per episode of care. Advanced practice clinicians were estimated to order 0.4% fewer images than PCPs per episode of care for acute respiratory tract infection (OR, 0.68 [95% CI, 0.51-0.90]). In the analysis comparing PAs with NPs, NPs were associated with less imaging than PAs (OR, 0.59 [95% CI, 0.53-0.66]), ordering 0.7% fewer examinations than PAs per episode of care.

Table 2. Predicted Rates and Estimated Odds Ratios of Imaging Following an E&M Visit With APCs Relative to PCPs[a]

Adjusted Estimates	No. of Episodes	Actual Rate of Imaging, %		Predicted Rate Difference, %	Odds Ratio (95% CI)	*P* Value
		PCPs	APCs			
30 d After E&M visit						
Overall	651 074	1.9	2.7	0.3	1.344 (1.267-1.424)	<.001
New patient, radiography	24 014	2.1	2.9	0.3	1.364 (1.125-1.655)	<.01
New patient, nonradiography	23 627	0.7	0.5	−0.1	0.698 (0.455-1.071)	.10
Established patient, radiography	623 621	1.3	1.8	0.2	1.329 (1.235-1.429)	<.001
Established patient, nonradiography	618 501	0.5	0.7	0.1	1.281 (1.137-1.444)	<.001
15 d After E&M visit						
Overall	696 233	2.3	3.2	0.4	1.385 (1.317-1.457)	<.001
New patient, radiography	25 413	2.7	3.7	0.4	1.367 (1.158-1.614)	<.001
New patient, nonradiography	24 439	0.9	0.7	−0.1	0.798 (0.559-1.140)	.22
Established patient, radiography	650 512	1.6	2.4	0.3	1.415 (1.329-1.507)	<.001
Established patient, nonradiography	634 558	0.7	0.9	0.1	1.211 (1.091-1.344)	<.001

Abbreviations: APCs, advanced practice clinicians (nurse practitioners and physician assistants); E&M, evaluation and management; PCPs, primary care physicians.

[a] Estimates for predicted rate difference and odds ratio are adjusted for patient age group, sex, race, state, urban, and Charlson Comorbidity Index.

Table 3. Predicted Rates and Estimated Odds Ratio of Imaging Following an E&M Visit With APCs Relative to PCPs for Most Frequent *ICD-9* Conditions Seen by PCPs[a]

Most Frequent *ICD-9* Codes, No. (% of All Codes)	Actual Rate of Imaging, %		Predicted Rate Difference, %	Odds Ratio, 95% (CI)	*P* Value
	PCPs	APCs			
Adjusted estimates					
24 (0.5)	1.3	1.5	0.1	1.163 (1.033-1.311)	.01
46 (1.0)	1.5	1.9	0.2	1.244 (1.130-1.371)	<.001
91 (2.0)	1.6	2.1	0.2	1.237 (1.136-1.346)	<.001
135 (3.0)	1.6	2.1	0.2	1.232 (1.139-1.334)	<.001
Adjusted estimates (alternative study design)					
24 (0.5)	21.9	25.3	0.1	1.179 (1.146-1.213)	<.001
46 (1.0)	23.5	27.9	0.1	1.224 (1.194-1.255)	<.001
91 (2.0)	23.9	27.4	0.1	1.181 (1.155-1.208)	<.001
135 (3.0)	24.3	27.9	0.1	1.196 (1.171-1.221)	<.001

Abbreviations: APCs, advanced practice clinicians (nurse practitioners and physician assistants); E&M, evaluation and management; *ICD-9*, *International Classification of Diseases, Ninth Revision*; PCPs, primary care physicians.

[a] Estimates for predicted rate difference and odds ratio are adjusted for patient age group, sex, race, state, urban, and Charlson Comorbidity Index. Alternative study design includes all claims that occurred within 30 days after the index E&M visit.

Discussion

We found that APCs were associated with more ordered diagnostic imaging than PCPs following an outpatient office visit. These results appear to be robust to the duration of follow-up period and the specific conditions for which patients present. Given the small differential in ordering rates (<1%), it is unlikely that this would have an impact on individual patients, though it is important at the population level. While we cannot discern whether the differential in ordering represents overuse by APCs (rather than underuse by PCPs), efforts to expand access to care by simply substituting APCs for physicians without careful imaging appropriateness mechanisms may further elevate health care costs and potentially increase unnecessary radiation exposure. Early experience with computerized order entry systems that incorporate integrated clinical decision support has demonstrated a decrease in imaging procedure growth.[24] Although some physicians have described such software tools as “a nuisance” and “not relevant,”[25] these tools may have value in normalizing APC ordering behavior to that of physicians.

Currently, considerable variation exists in the scope of practice for APCs across the US states. For example, while 33 states explicitly permit NPs to refer patients for diagnostic testing, only 20 states explicitly authorize NPs to order tests.[26] Further variation exists regarding the specific kinds of tests APCs are permitted to order, with fewer states allowing more advanced imaging.[27] Because of this variation, one way to consider the effects of increasing scope of practice for the ordering of diagnostic tests is to compare the ordering patterns for patients receiving radiography with those receiving nonradiographic tests.

Though the effects are modest, the estimated differential in ordered imaging for established patients between APCs and PCPs was twice as high for radiographs—a test for which larger numbers of APCs are authorized to order—than nonradiographs. The result is more pronounced with new patients, where APCs were not found to order differently from PCPs for advanced imaging examinations but were associated with higher rates for radiography orders. This might be explained by supervising physicians exercising stricter protocols and guidelines for APCs with new patients. Alternatively, it could signal that APCs are less thorough with new patient evaluations, which could have additional quality implications, particularly in scenarios where more aggressive care is appropriate.

Another approach to examine possible effects from increasing scope of practice is to consider the results as APCs face ever wider ranges of medical conditions. Increasing the number of clinical conditions from the 0.5% most frequently seen by PCPs to the 1% most frequent increased the odds of an APC ordering an image by 50% and doubling the rate. This was further tested by examining episodes of care from 2 clinical conditions that are routinely seen by APCs: nonspecific lower back pain and acute respiratory tract infection. Under the hypothesis that APCs order more tests for relatively less common conditions, we would expect the most frequent conditions seen by APCs to exhibit little to no difference in orders because of their extensive experience with these kinds of patients. We find this is to be the case in lower back pain episodes of care.

That APCs are associated with fewer images for patients with acute respiratory tract infection is an interesting result. One possible interpretation is that more patients with acute respiratory tract infection are quickly referred to PCPs or specialists who then order necessary imaging. Alternatively, the protocols and guidelines in place for APCs examining these patients may be sufficiently rigid that less imaging is ordered, whereas PCPs take more discretion.

In light of these results, expanding the use of APCs may have a minimal effect on imaging use to the extent that APCs are confronted with medical conditions with which they are highly familiar or have clear and rigid protocols in place. Our results indicating increasing imaging use as clinical conditions expand may be important for delivery models that greatly expand the use of APCs as the primary point of initial patient contact. Further evidence from a spectrum of both common and relatively infrequent clinical conditions may be required to adequately assess any changes in resource utilization that such an expansion may cause. Importantly, we should note that this study is focused on only one facet of care—test ordering—and not on other important aspects, such as time, responsiveness, and availability, that must be considered when expanding the use of APCs in new models of care.

There are several study limitations. This study examined retrospective claims for patients 66 years and older covered by Medicare Part B fee-for-service plan. Elderly patients covered by other plans such as Medicare managed care, Medicare Advantage, Medicare/Medicaid dual enrollees, and private plans may experience different imaging use. However, alternative payment plans should not influence the rate in which APCs order imaging tests relative to PCPs since neither group typically receives payment for such imaging. The results of this study are not necessarily applicable to nonelderly—and presumable healthier—populations, and it is always possible that APCs are more cautious than PCPs with older, sicker patients. That said, with growing elderly populations driving substantial increases in health care costs,[4] this study identifies potentially important differential ordering patterns within this population. In addition, as with any retrospective claims analysis, we are encumbered by the nuanced rules of *Current Procedural Terminology* coding. While "new" patients are by definition new to both the medical professional and the practice, "established" patients have a past relationship with the practice, but not necessarily with an individual provider. Nonetheless, we believe that our 30-preceding-day clean period minimizes confounding ordering by other providers within a practice. Also, under some circumstances work performed by APCs is coded by their supervising physician. This would create downward bias, ie, our reported estimates underestimate the magnitude APCs order relative to PCPs, if many episodes of care treated by APCs—and presumably ordering more imaging—are actually coded in the PCP reference group. Finally, while covering a large number of clinical conditions in the study, the study inclusion criteria limited the study cohort to 18.1% of all E&M visits to PCPs and 15.9% of E&M visits to APCs in the 5% LDS Carrier file, which may limit the generalizability of our results.

Conclusions

Given efforts to expand APC use as a mechanism to address anticipated PCP shortages, it is important to understand broadly the patterns of care these professionals provide. Examining the ordering patterns for diagnostic imaging by APCs and PCPs, we found that APCs were associated with more imaging services than PCPs for similar patients during E&M office visits. While the increased use of imaging appears modest for individual patients, this increase may have important ramifications on care and overall costs at the population level. This does not mean that APCs cannot serve an important, growing role in primary care access. But any such expansion must be mindful of the additional cost, safety, and quality implications it may incur. Greater PCP and APC team coordination, as some have suggested,[28,29] may produce better outcomes than merely expanding the scope of APC practice alone.

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REFERENCES

1. Petterson SM, Liaw WR, Phillips RL Jr, Rabin DL, Meyers DS, Bazemore AW. Projecting US primary care physician workforce needs: 2010-2025. *Ann Fam Med*. 2012;10(6):503-509.

2. Association of American Medical Colleges. *AAMC Physician Workforce Policy Recommendations.* Washington, DC: Association of American Medical Colleges; 2012.

3. Grover A, Niecko-Najjum LM. Building a health care workforce for the future: more physicians, professional reforms, and technological advances. *Health Aff (Millwood)*. 2013;32(11):1922-1927.

4. Phillips RL Jr, Bazemore AM, Peterson LE. Effectiveness over efficiency: underestimating the primary care physician shortage. *Med Care*. 2014;52(2):97-98.

5. Jolly P, Erikson C, Garrison G. US graduate medical education and physician specialty choice. *Acad Med*. 2013;88(4):468-474.

6. Schwartz MD. The US primary care workforce and graduate medical education policy. *JAMA*. 2012;308(21):2252-2253.

7. Huang ES, Finegold K. Seven million Americans live in areas where demand for primary care may exceed supply by more than 10 percent. *Health Aff (Millwood)*. 2013;32(3):614-621.

8. Porter ME, Pabo EA, Lee TH. Redesigning primary care: a strategic vision to improve value by organizing around patients' needs. *Health Aff (Millwood)*. 2013;32(3):516-525.

9. Cassel CK. Retail clinics and drugstore medicine. *JAMA*. 2012;307(20):2151-2152.

10. Auerbach DI, Chen PG, Friedberg MW, et al. Nurse-managed health centers and patient-centered medical homes could mitigate expected primary care physician shortage. *Health Aff (Millwood)*. 2013;32(11):1933-1941.

11. Iglehart JK. Expanding the role of advanced nurse practitioners—risks and rewards. *N Engl J Med*. 2013;368(20):1935-1941.

12. Chen PG-C, Mehrotra A, Auerbach DI. Do we really need more physicians? responses to predicted primary care physician shortages. *Med Care*. 2014;52(2):95-96.

13. Newhouse RP, Stanik-Hutt J, White KM, et al. Advanced practice nurse outcomes 1990-2008: a systematic review. *Nurs Econ*. 2011;29(5):230-250, quiz 251.

14. Laurant M, Reeves D, Hermens R, Braspenning J, Grol R, Sibbald B. Substitution of doctors by nurses in primary care. *Cochrane Database Syst Rev*. 2005;(2):CD001271.

15. Mundinger MO, Kane RL, Lenz ER, et al. Primary care outcomes in patients treated by nurse practitioners or physicians: a randomized trial. *JAMA*. 2000;283(1):59-68.

16. Roblin DW, Howard DH, Becker ER, Kathleen Adams E, Roberts MH. Use of midlevel practitioners to achieve labor cost savings in the primary care practice of an MCO. *Health Serv Res*. 2004;39(3):607-626.

17. Fazel R, Krumholz HM, Wang Y, et al. Exposure to low-dose ionizing radiation from medical imaging procedures. *N Engl J Med*. 2009;361(9):849-857.

18. Mettler FA Jr, Thomadsen BR, Bhargavan M, et al. Medical radiation exposure in the US in 2006: preliminary results. *Health Phys*. 2008;95(5):502-507.

19. Flynn BC. The effectiveness of nurse clinicians' service delivery. *Am J Public Health*. 1974;64(6):604-611.

20. Hemani A, Rastegar DA, Hill C, al-Ibrahim MS. A comparison of resource utilization in nurse practitioners and physicians. *Eff Clin Pract*. 1999;2(6):258-265.

21. Seaberg DC, MacLeod BA. Correlation between triage nurse and physician ordering of ED tests. *Am J Emerg Med*. 1998;16(1):8-11.

22. Ingram DD, Franco SJ. 2013 NCHS Urban-Rural Classification Scheme for Counties. *Vital Health Stat 2*. April 2014;(166):1-73.

23. Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care*. 2005;43(11):1130-1139.

24. Sistrom CL, Dang PA, Weilburg JB, Dreyer KJ, Rosenthal DI, Thrall JH. Effect of computerized order entry with integrated decision support on the growth of outpatient procedure volumes: seven-year time series analysis. *Radiology*. 2009;251(1):147-155.

25. Bowen S, Johnson K, Reed MH, Zhang L, Curry L. The effect of incorporating guidelines into a computerized order entry system for diagnostic imaging. *J Am Coll Radiol*. 2011;8(4):251-258.

26. Christian S, Dower DOE. Chart overview of nurse practitioner scopes of practice in the United States. Center for the Health Professions, University of California, San Francisco. 2007. http://futurehealth.ucsf.edu/Content/29/2007-12_Overview_of_Nurse_Practitioner_Scopes_of_Practice_In_the_United_States_Chart.pdf. Accessed March 5, 2014.

27. Christian S, Dower DOE. Overview of nurse practitioner scopes of practice in the United States—discussion. Center for the Health Professions, University of California, San Francisco. 2007. http://futurehealth.ucsf.edu/Content/29/2007-12_Overview_of_Nurse_Practitioner_Scopes_of_Practice_In_the_United_States_Discussion.pdf. Accessed March 5, 2014.

28. Grumbach K, Bodenheimer T. Can health care teams improve primary care practice? *JAMA*. 2004;291(10):1246-1251.

29. Doherty RB, Crowley RA; Health and Public Policy Committee of the American College of Physicians. Principles supporting dynamic clinical care teams: an American College of Physicians position paper. *Ann Intern Med*. 2013;159(9):620-626.