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Patient, Provider, and Practice Characteristics Predicting Use of Diagnostic Imaging in Primary Care: Cross-Sectional Data From the National Ambulatory Medical Care Survey

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Abstract

Objective: To determine imaging utilization rates in outpatient primary care visits and factors influencing likelihood of imaging use.

Methods: We used 2013 to 2018 National Ambulatory Medical Care Survey cross-sectional data. All visits to primary care clinics during the study period were included in the sample. Descriptive statistics on visit characteristics including imaging utilization were calculated. Logistic regression analyses evaluated the influence of a variety of patient-, provider-, and practice-level variables on the odds of obtaining diagnostic imaging, further subdivided by modality (radiographs, CT, MRI, and ultrasound). The data's survey weighting was accounted for to produce valid national-level estimates of imaging use for US office-based primary care visits.

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Results: Using survey weights, approximately 2.8 billion patient visits were included. Diagnostic imaging was ordered at 12.5% of visits with radiographs the most common (4.3%) and MRI the least common (0.8%). Imaging utilization was similar or greater among minority patients compared with White, non-Hispanic patients. Physician assistants used imaging at higher rates than physicians, in particular CT at 6.5% of visits compared with 0.7% for doctors of medicine and doctors of osteopathic medicine (odds ratio 5.67, 95% confidence interval 4.07–7.88).

Conclusion: Disparities in rates of imaging utilization for minorities seen in other health care settings were not present in this sample of primary care visits, supporting that access to primary care is a path to promote health equity. Higher rates of imaging utilization among advanced-level practitioners highlight an opportunity to evaluate imaging appropriateness and promote equitable, high-value imaging among all practitioners.

Keywords

Advanced practice providers; health equity; imaging utilization; primary care

INTRODUCTION

Diagnostic imaging use has a large economic footprint in the health care system and has been identified as one of the fastest growing components of outpatient testing [1]. Despite this, little is known about factors driving imaging utilization during primary care patient encounters. Previous research on primary care imaging utilization has largely focused on trends in imaging rates, most commonly in the Medicare population. This has shown rapidly rising imaging rates in the early 2000s that leveled off in the 2010s with the exception of CT, which showed more recent renewed growth [2–4]. Imaging utilization varied considerably by geographic region in ways not fully explained by population health status, suggesting that regional variation in provider practice patterns influences utilization rates [5–9]. A smaller group of studies looked at individual patient and provider characteristics predicting frequency of imaging use in the primary care setting. Provider characteristics associated with increased ordering of imaging included female sex, fewer years of experience, secondary degrees, advanced practice providers (APPs) versus doctors of medicine (MDs) and doctor of osteopathic medicine (DOs), and owning imaging equipment [10–12]. Patient characteristics predicting higher imaging rates included increased age, higher urgency of visit, higher number of comorbidities, and Black or Hispanic race or ethnicity [11,12]. The percentage of primary care visits at which diagnostic imaging was ordered has been reported to be between 1.3% and 25% [10,13,14]. However, many of these studies were performed more than a decade ago, used small local or regional samples, or were restricted to Medicare participants.

A better understanding of current diagnostic imaging utilization in the primary care setting could identify ways to promote high-value imaging and support policy makers in predicting and modeling trends in imaging utilization. Additionally, inequities have been identified in access to imaging in the emergency department with racial and ethnic minorities and socioeconomically disadvantaged patients less likely to have imaging ordered [15–18]. Because improving access to primary care has been shown to improve health disparities

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[19], it is important to understand the extent to which these inequities may persist in the primary care setting.

Therefore, the purpose of this study was to use a large, nationally representative dataset to evaluate the association between patient-, provider-, and practice-level characteristics and diagnostic imaging utilization during primary care visits in the United States. Our investigation places particular emphasis on two aims. Firstly, we examine patient race and ethnicity with the hypothesis that in contrast to the disparities observed during emergency department encounters, patients who belong to racial and ethnic minority groups will be comparably likely to have imaging tests ordered during patient encounters in the primary care setting. Secondly, we examine provider credentials with the hypothesis that APPs order imaging at higher rates than physician providers.

METHODS

Study Design

We performed a retrospective, cross-sectional, observational study using data from the National Ambulatory Medical Care Survey (NAMCS). The study design and reporting are in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines [20]. The use of publicly available, deidentified data was exempt from institutional review board review.

Data Source

The NAMCS is a nationally representative survey administered annually by the National Center for Health Statistics collecting data on office-based, outpatient encounters at nonfederal ambulatory care facilities. Data are collected by ambulatory care staff using a patient record form on a random sampling of patient visits during a randomly assigned 1-week reporting period. The survey uses a multistage probability sample design and incorporates US census data to provide weighted estimates to be nationally representative of office-based, US ambulatory care visits. As recommended by the National Center for Health Statistics, all of our analysis and reporting incorporates the weighted data. Detailed information on the survey, including the sampling design and survey instruments, is available on the National Center for Health Statistics website [21].

We used data from 2013 to 2016 and from 2018 for the analysis because processing delays with data from 2017 prevented release of the results and therefore could not be included in the analysis [22]. Data are collected and organized at the level of individual patient visits. Because the study was intended to be broadly representative of primary care encounters, all visits in which specialty was coded as primary care were included in the analysis. Within the survey design, this includes primary care visits in internal medicine, family medicine, pediatrics, and obstetrics and gynecology clinics.

Study Variables

Outcome Variables.—Our primary outcome variable was whether the patient encounter resulted in an order for any noninvasive, diagnostic imaging further subdivided and

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evaluated independently by modality (x-ray, CT, MRI, ultrasound). Because our analysis focused on diagnostic imaging, screening examinations such as mammography and bone densitometry were not included. These imaging variables reflect orders for imaging entered by clinic providers and staff as part of a patient visit but do not capture whether the imaging appointment occurred and imaging was successfully obtained.

Predictor Variables.—Key variables included a variety of patient, provider, and practice characteristics. Patient characteristics included self-reported demographics such as age, sex, insurance status (private, Medicare, Medicaid, worker's compensation, uninsured, other or unknown) and race or ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other race or ethnicity). Further disaggregation of racial and ethnic categories was not possible with this dataset. Missing data for patient race or ethnicity was imputed within the original dataset. No other variables in the analysis contained missing data.

Additionally, the presence or absence of specific patient comorbidities was recorded. Selected by consensus of the study team, these included obesity, type 2 diabetes, coronary artery disease, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, and cancer. Reason for patient visit was coded as new problem, chronic problem routine, chronic problem flare, presurgical care, postsurgical care, or preventive health visit.

Provider characteristics included provider credential either MD or DO for the physician of record and whether a nurse practitioner (NP) or physician assistant (PA) was seen as part of the visit. The NAMCS survey samples physician visits but also tracks whether the patient is seen by a PA or NP or midwife under physician supervision. Other provider variables included provider employment status (full owner, part owner, employee, or contractor) and whether the clinician was the patient's assigned primary care provider. Practice characteristics included region (Northeast, Midwest, South, or West) and rural versus urban setting based on the Centers for Disease Control and Prevention's metropolitan statistical area classification [23].

Statistical Analysis

Descriptive statistics regarding patient demographics, insurance status, comorbid conditions, and reason for visit were calculated and tabulated by patient race or ethnicity and provider type (physician or APP) given the intention of our analysis to particularly emphasize the role of these factors in imaging utilization. Number of observations and weighted counts for each column are provided.

Imaging utilization was calculated for primary care clinic visits defined as the proportion of clinic visits resulting in an order for diagnostic imaging. This was reported for any imaging modality and further subdivided by individual modality (x-ray, CT, MRI, ultrasound) with imaging utilization tabulated by the patient, provider, and practice variables described earlier. Number of observations and weighted counts are provided for each column here as well.

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For hypothesis testing on the association of these variables with imaging utilization rates, a multiple variable logistic regression analysis was performed to evaluate the association between all of these patient, provider, and practice variables and the likelihood of diagnostic imaging use, both for any imaging modality and with independent subanalyses for each specific type of imaging. Results were reported as adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Statistical significance was defined as two-sided $P < .05$ without adjustment for the number of comparisons. To further evaluate the two variables of emphasis (patient race or ethnicity and provider type), a subanalysis was done isolating adult patient visits (age ≥ 18) in family medicine or internal medicine clinic. This was to exclude pediatric and obstetric visits in which imaging modalities with radiation might preferentially be avoided. For this portion of the analysis, both adjusted and unadjusted ORs are reported for the patient race or ethnicity and provider type variables. Finally, to identify any temporal trends in imaging utilization, a logistic regression analysis was performed to assess the influence of year and imaging utilization for each modality. All statistical analyses were performed in Stata (version 17, StataCorp, College Station, Texas).

RESULTS

Summary Statistics and Univariate Analysis

The unweighted survey data included 65,501 total primary care visits. With survey weighting, this provides estimates on over 2.8 billion primary care patient encounters nationwide. Table 1 shows the descriptive patient characteristics, including age, sex, insurance status, chronic conditions, reason for presentation, and type of imaging ordered, stratified by race or ethnicity and provider type. For all patients presenting to primary care clinic visits, the mean age was 41.5 (SD 22.9) years and 61% were female. In general, compared with non-Hispanic White patients, non-Hispanic Black and Hispanic patients were younger, more likely to be female, and less likely to have private insurance although this did not pertain to those patients in the other race or ethnicity category. There were also differences in the mean number of chronic conditions that were highest for Black patients (mean of 1.3) and lowest for Hispanic patients (mean of 0.68). The distribution of other chronic conditions also varied by race or ethnicity as shown in Table 1.

Diagnostic imaging was ordered at 12.5% of all primary care clinic visits, with x-ray being the most commonly ordered (4.3% of visits) and MRI the least commonly ordered (0.8% of visits). Table 2 reports imaging utilization for each modality stratified by a variety of patient, provider, and patient factors. In general, increased imaging use was observed in older patients (peaking in the 45- to 64-year age group with slight declines thereafter) and in patients with specific comorbidities. Cancer in particular increased imaging utilization from a baseline of 12% for patients without cancer to 20% for patients with cancer. Other factors seen to influence imaging rates were patient insurance (highest in workers' compensation and Medicare), reason for visit (highest for presurgical visits), and increased imaging utilization when the patient was not seen by their own primary care provider. PAs ordered imaging at higher rates than either NPs or physicians, including CT scans in particular, which were ordered at 0.7% of physician visits, 0.5% of NP visits, and 6.5% of PA visits. This is shown graphically in Figure 1.

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Regression Modeling

The ORs for the full multivariable regression analysis are presented in Table 3. These indicate that a variety of patient, provider, and practice characteristics influence the probability of diagnostic imaging in primary care encounters even in the controlled regression model.

Patient Characteristics.—In this model, patients of racial and ethnic minorities were equally likely or more likely to have imaging ordered for them during primary care visits compared with non-Hispanic White patients. Specifically, the odds of imaging of any modality were higher for non-Hispanic Black (adjusted odds ratio [OR] = 1.26; 95% CI, 1.06–1.49) and Hispanic (adjusted OR = 1.26; 95% CI, 1.05–1.51) patients. Hispanic patients also had higher odds of radiograph (adjusted OR = 1.65; 95% CI, 1.29–2.11) and CT utilization (adjusted OR = 1.71; 95% CI, 1.19–2.47). Increasing age also increased the odds of imaging use, peaking in the 45- to 64-year age group. Female patients saw higher rates of imaging use, particularly ultrasound (adjusted OR = 1.97, 95% CI, 1.61–2.41).

Some, but not all, patient comorbidities were associated with increased imaging use. For example, patients with cancer saw higher odds of imaging predominantly driven by higher odds of CT use (adjusted OR = 2.59, 95% CI, 1.52–4.41). Patients with cerebrovascular disease had higher odds (adjusted OR = 2.53; 95% CI, 1.17–5.44) of MRI utilization. Chronic obstructive pulmonary disease was also associated with higher imaging use, in particular x-ray, but the other evaluated comorbid conditions were not.

Provider Characteristics.—Provider characteristics that significantly changed the odds of imaging utilization included whether the patient saw their own PCP and the provider's credentials. In general, imaging use was more likely when patients saw a provider other than their own PCP (adjusted OR for any imaging = 1.51, 95% CI, 1.28–1.78), although the magnitude of this difference varied somewhat by modality. A larger difference was seen between physicians and PAs. Although NPs ordered imaging at similar rates to physicians in the controlled model, PAs had 2.00 greater adjusted odds (95% CI, 1.44–2.80) of ordering imaging of any kind and 5.67 greater adjusted odds (95% CI, 4.07–7.88) of ordering CTs. Differences in imaging ordering rates are shown graphically in Figure 1.

Practice Characteristics.—The odds of ordering diagnostic imaging differed by region of the country only for CT with the Western region with lower odds of CT use than the Northeast. The odds of imaging did not differ between metropolitan statistical areas and their more rural counterparts. Practice employment model influenced the odds of imaging use but inconsistently. Overall, physician part-owner practice models showed the highest odds of imaging particularly for CT (adjusted OR = 2.06, 95% CI 1.22–3.47). It should be noted that this reflects ownership status of the practice but whether practices owned their own imaging equipment was not captured in this dataset.

The adjusted and unadjusted odds ratios for the subanalysis focusing on adult (≥18 years), nonobstetric internal medicine and family medicine clinic visits are presented in Table 4. These focus on the two predictor variables of particular interest: patient race or ethnicity and provider credentials. In general, minority patients had similar or higher odds of imaging than

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White patients, although Black patients had lower rates of MRI (adjusted OR = 0.68, 95% CI, 0.47–0.97). For provider type, compared with physician-only visits, when the patient was seen by a PA, there were higher odds of imaging across all modalities. This was the greatest for CT scans with 3.88 higher adjusted odds (95% CI, 2.94–5.12) of CT use at PA visits in the adjusted model. For visits in which the patient was seen by a NP, the odds of imaging were not significantly different from physician only visits.

There was not adequate evidence to conclude that imaging rates changed significantly by year over the study time period.

DISCUSSION

The study results suggest that multiple factors, including patient demographics, provider characteristics, and practice settings, can affect the rates of image ordering during primary care visits. However, the study found no significant racial or ethnic disparities in the use of imaging during these encounters, supporting the value of primary care access as a means to promote health equity. However, the study did reveal that APPs ordered imaging at significantly higher rates than physicians. This finding has important implications for the delivery of primary care services, particularly as the use of APPs in primary care continues to increase. The challenge will be to find ways to maintain high-quality, cost-effective care for all patients while addressing the potential overuse of imaging by some providers.

Although the appropriateness of any individual imaging examination cannot be determined from this dataset, it is concerning that higher rates of imaging use by APPS may represent overutilization. A recent working paper from the National Bureau of Economic Research [24] found that APPs—specifically NPs—in the emergency department used more resources than physicians, including the ordering of more radiologic examinations. This was associated with equal or worse patient outcomes than those of physicians, including a 20% increase in the rates of preventable 30-day hospital admission. Our study shows similar findings in the outpatient, primary care clinic setting, raising concern for how to leverage the many advantages of APP care provision without overutilization of radiologic resources. Curiously, in our study the increase in imaging use was predominantly limited to PAs rather than NPs. This may be a result of specific scope of practice or supervision patterns in the clinics within the NAMCS sample. It should be noted that in the NAMCS dataset, NPs are listed as NP or midwives although they are included in nonobstetric visits as our subanalysis indicates. Our findings demonstrate the need for further research to determine what drives higher rates of imaging and if there are particular examination types that are overutilized for little value—for example, knee MRI in older patients with osteoarthritis. If overutilization is indeed a problem, radiology can be part of the solution by providing high-quality clinical decision support tools or even being readily available for consultations on imaging appropriateness with primary care colleagues of all levels.

In contrast to studies done in the emergency department setting [17], with few exceptions our study did not identify systematically decreased rates of imaging for racial and ethnic minority patients. This supports the assertion that increasing access to primary care is a means to decrease racial and ethnic health disparities [25]. The reasons for the increased

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likelihood of imaging observed for Black and Hispanic patients is difficult to interpret without the availability of more granular data and could be further verified and evaluated on the local level. This may relate to an increased burden of comorbidities that is incompletely controlled for in the current dataset. In the subanalysis limited to adult nonobstetric visits, we did observed decreased likelihood of MRI use for Black patients compared with their White counterparts. Although the reasons for this are difficult to determine from large scale data—particularly in the context of overall equal or increased imaging use for minorities—it should not be assumed that primary care access alone is adequate to resolve all health inequities. Moreover, many minority groups may preferentially seek primary care in the emergency department or urgent care centers for a variety of reasons [26]. Improving health equity should remain a priority across health care settings.

Our study findings also showed that patients were less likely to undergo imaging when they saw their own primary care provider. This result may be due in part to differences in the nature of the visits. Urgent visits for acute medical needs often require same-day scheduling with any available provider and are more likely to require imaging. However, continuity of care has consistently shown benefit including higher patient satisfaction and reduced resource utilization [27,28]. In this context, the increased rates of imaging when continuity of care is lost are not surprising. When care fragments around imaging use, radiology has the opportunity to play a more central role in care coordination becoming a health hub rather than an ancillary service.

Other patient factors associated with increased imaging—including advancing age, female sex, and the presence of specific comorbidities such as cancer—is in keeping with the existing literature on patient variables predictive of imaging in the emergency department [29]. These factors remain predictive in the outpatient setting, and the quantitative data reported here on imaging rates by specific patient characteristics may be of use for predictive modeling of imaging utilization in specific populations.

Insurance status had little effect on the likelihood of imaging in our sample. This differs from other sources indicating that Medicaid and uninsured patients are less likely to receive imaging, particularly in the ED setting. It should be noted that only a small minority of patients in the sample (~3%) were uninsured. This reflects the selection bias in our sample of patients seen in a primary care clinic. Many patients without insurance likely do not have reliable access to primary care and would not be included in this sample.

The employment model of primary care providers was found to be a significant factor in determining imaging utilization, with full practice owners having the lowest rates. The reasons for this finding are not well understood, but it is possible that this ownership model is associated with smaller or low-resource practices. Notably, the dataset did not include information on whether practices owned their own imaging equipment. Although the study did not find a significant difference in imaging utilization between rural and metropolitan regions, there were regional variations in CT usage. The Northeast showed the highest rates of CT imaging (2.4%), and this remained significant even in the controlled regression model. This is in keeping with the existing body of literature demonstrating variability of imaging

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utilization by region [9]. A better understanding of how practice referral patterns, location of imaging sites, and equipment ownership influence imaging patterns will require future study.

Our study has a number of important limitations, predominantly related to the patient sample and data source used. In particular, there is selection bias inherent in using a sample in which all patients were seen in primary care clinic. This indicates that this group of patients all had some level of access to a primary care physician. Sociodemographic inequities including patient race or ethnicity, insurance status, neighborhood, income, and education level that prevent a patient from ever seeing a primary care physician will not be evident in this sample. Additionally, although the dataset we used is nationally representative and captures a very large number of patient encounters, the level of detail is necessarily limited. Specific diagnosis and procedure codes are not available nor is longitudinal data on patient outcomes. There may be differences in the types of patients seen by physicians versus APPs that are not documented and cannot be controlled for. Moreover, medical decision making is not documented in this summary dataset. There may be individual visits in which the documentation was done by an APP in consultation with a physician provider who may have determined the need for imaging. This could lead to an overestimate of the differences in imaging utilization between physicians and APPS. It should also be noted that this dataset captures orders placed for diagnostic imaging at the time of the physician's encounter with the patient. Additional access issues in scheduling and transportation to imaging appointments cannot be captured here. Further research, including detailed local data, is needed to better understand patient factors influencing examination access for diverse groups. Finally, the NAMCS data are only available for years before the COVID-19 pandemic, and many of the trends observed in our study may have changed with the advent of such COVID-19-era changes as telehealth, COVID-19 safety protocols, and other structural shifts in the health care system.

Our study has significant implications for promoting an equitable, just, and economically efficient health care system. The absence of disparities in imaging use for patients of racial and ethnic minorities in primary care clinics highlights the importance of ensuring access to high-quality primary care as a means of promoting health equity. However, the potential overutilization of imaging by APPs indicates a need to continue to promote high-value imaging for all. Measures—such as clinical decision support tools—to optimize the value of imaging will be necessary as the strained primary care physician workforce is increasingly augmented by other health care providers.

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REFERENCES

1. Iglehart JK. Health insurers and medical-imaging policy—a work in progress. N Engl J Med; 2009;360:1030–7. [PubMed: 19264694]
2. Hong AS, Levin D, Parker L, Rao VM, Ross-Degnan D, Wharam JF. Trends in diagnostic imaging utilization among Medicare and commercially insured adults from 2003 through 2016. Radiology 2020;294:342–50. [PubMed: 31891320]
3. Lang K, Huang H, Lee DW, Federico V, Menzin J. National trends in advanced outpatient diagnostic imaging utilization: an analysis of the medical expenditure panel survey, 2000–2009. BMC Med Imaging 2013;13:1–10. [PubMed: 23289431]
4. Levin DC, Rao VM, Parker L. Trends in the utilization of outpatient advanced imaging after the Deficit Reduction Act. J Am Coll Radiol 2012;9:27–32. [PubMed: 22221633]
5. Ip IK, Raja AS, Seltzer SE, Gawande AA, Joynt KE, Khorasani R. Use of public data to target variation in providers' use of CT and MR imaging among Medicare beneficiaries. Radiology 2015;275:718–24. [PubMed: 25658040]
6. Leape LL, Park RE, Solomon DH, Chassin MR, Kosecoff J, Brook RH. Does inappropriate use explain small-area variations in the use of health care services? JAMA 1990;263:669–72. [PubMed: 2404147]
7. Pakpoor J, Raad M, Harris A, et al. Diagnostic imaging use for the initial evaluation of low back pain by primary care providers in the United States: 2011–2016. J Am Coll Radiol 2019;16:1522–7. [PubMed: 31125539]
8. Parker L, Levin DC, Frangos A, Rao VM. Geographic variation in the utilization of noninvasive diagnostic imaging: national Medicare data, 1998–2007. AJR Am J Roentgenol 2010;194:1034–9. [PubMed: 20308507]
9. Rosenkrantz AB. Regional variation in Medicare imaging utilization and expenditures: 2007–2011 trends and comparison with other health services. J Am Coll Radiol 2014;11:45–50. [PubMed: 24075216]
10. Hughes DR, Jiang M, Duszak R. A comparison of diagnostic imaging ordering patterns between advanced practice clinicians and primary care physicians following office-based evaluation and management visits. JAMA Intern Med 2015;175:101. [PubMed: 25419763]
11. Sistrom C, McKay NL, Weilburg JB, Atlas SJ, Ferris TG. Determinants of diagnostic imaging utilization in primary care. Am J Manag Care 2012;18:e135–44. [PubMed: 22554039]
12. Rosen MP, Davis RB, Lesky LG. Utilization of outpatient diagnostic imaging. J Gen Intern Med 1997;12:407–11. [PubMed: 9229278]
13. Couchman GR, Forjuoh SN, Rajab MH, Phillips CD, Yu J. Nonclinical factors associated with primary care physicians' ordering patterns of magnetic resonance imaging/computed tomography for headache. Acad Radiol 2004;11:735–40. [PubMed: 15217590]
14. Halpern DJ, Clark-Randall A, Woodall J, Anderson J, Shah K. Reducing imaging utilization in primary care through implementation of a peer comparison dashboard. J Gen Intern Med 2021;36:108–13. [PubMed: 32885372]
15. Ross AB, Kalia V, Chan BY, Li G. The influence of patient race on the use of diagnostic imaging in United States emergency departments: data from the National Hospital Ambulatory Medical Care survey. BMC Health Serv Res 2020;20:840. [PubMed: 32894129]
16. Schrager J, Patzer R, Kim J, et al. Racial and ethnic differences in diagnostic imaging utilization during adult emergency department visits in the United States, 2005 to 2014. J Am Coll Radiol 2019;16:1036–1045. [PubMed: 31092354]
17. Shan A, Baumann G, Gholamrezanezhad A. Patient race/ethnicity and diagnostic imaging utilization in the emergency department: a systematic review. J Am Coll Radiol 2021;18:795–808. [PubMed: 33385337]
18. Al-Dulaimi R, Duong P-A, Chan BY, Fuller MJ, Ross AB, Dunn DP. Revisiting racial disparities in ED CT utilization during the Affordable Care Act era: 2009–2018 data from the NHAMCS. Emerg Radiol 2022;29:125–32. [PubMed: 34713355]
19. US Department of Health and Human Services. increase the proportion of people with a usual primary care provider–AHS-07. Available

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at: https://health.gov/healthypeople/objectives-and-data/browse-objectives/health-care-access-and-quality/increase-proportion-people-usual-primary-care-provider-ahs-07. Accessed November 11, 2022.

20. Von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Ann Intern Med 2007;147:573–7. [PubMed: 17938396]
21. National Center for Health Statistics. Ambulatory Health Care Data. Available at: https://www.cdc.gov/nchs/ahcd/index.htm. Accessed October 1, 2022.
22. National Center for Health Statistics. Notices for NAMCS and NHAMCS Public Use Data File Users. Available at: https://www.cdc.gov/nchs/ahcd/notice.htm. Accessed October 1, 2022.
23. CDC. Metropolitan statistical area classification (MSA). Available at: https://www.cdc.gov/nchs/hus/sources-definitions/msa.htm. Accessed October 1, 2022.
24. National Bureau of Economic Research. The Productivity of Professions: Evidence from the Emergency Department. Available at: https://www.nber.org/papers/w30608. Accessed November 15, 2022.
25. Starfield B, Shi L, Macinko J. Contribution of primary care to health systems and health. Milbank Q 2005;83:457–502. [PubMed: 16202000]
26. Arnett M, Thorpe RJ, Gaskin D, Bowie J, LaVeist T. Race, medical mistrust, and segregation in primary care as usual source of care: findings from the exploring health disparities in integrated communities study. J Urban Health 2016;93:456–67. [PubMed: 27193595]
27. Raddish M, Horn SD, Sharkey PD. Continuity of care: is it cost effective. Am J Manag Care 1999;5:727–34. [PubMed: 10538452]
28. Nutting PA, Goodwin MA, Flocke SA, Zyzanski SJ, Stange KC. Continuity of primary care: to whom does it matter and when? Ann Fam Med 2003;1:149–55. [PubMed: 15043376]
29. Zhang X, Kim J, Patzer RE, Pitts SR, Chokshi FH, Schrager JD. Advanced diagnostic imaging utilization during emergency department visits in the United States: a predictive modeling study for emergency department triage. PLoS One 2019;14:e0214905. [PubMed: 30964899]

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TAKE-HOME POINTS

- Patients of racial and ethnic minorities received imaging at similar or higher rates than White patients in this sample of United States primary care clinic visits.
- Physician's assistants ordered imaging—particularly CT—at rates higher than physicians.
- Patients were less likely to receive diagnostic imaging when seeing their own primary care provider.
- A variety of patient factors—including female sex, increasing age, and comorbidities such as cancer—predicted higher rates of imaging.
- Appropriateness of utilization by primary care provider type can not be determined without more granular data.

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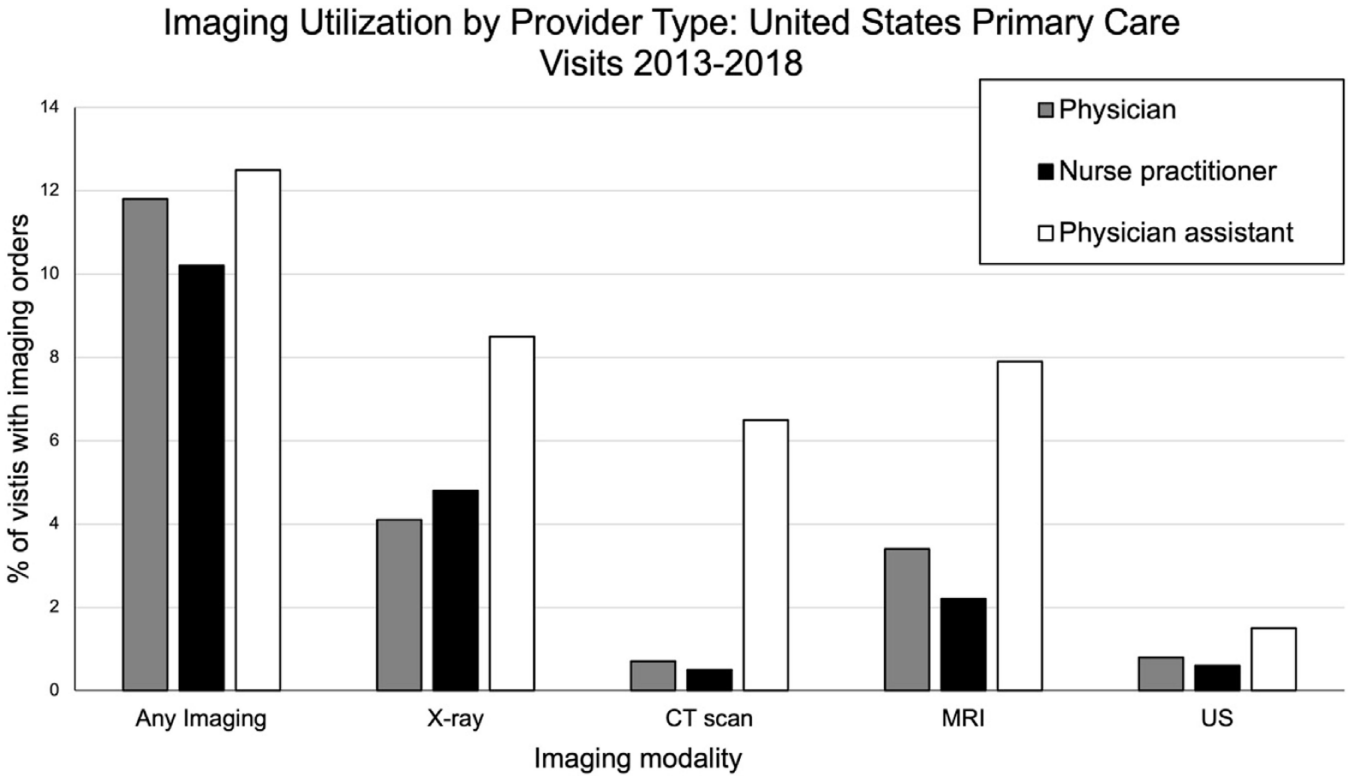

Fig. 1.
Proportion of primary care visits with imaging use by modality and provider type. US = ultrasound.

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Table 1.

Patient and visit characteristics from United States primary care visits 2013–2018 by patient race or ethnicity and provider type

Characteristic	Patient Race or Ethnicity					Provider Type		
	White	All Minority Groups	Black	Hispanic	Asian or Other	Physician	Nurse Practitioner	Physician Assistant
Unweighted count, n	46,929	18,572	6,546	8,446	3,580	61,285	1,605	2,611
Weighted count, n (millions)	1,816	1,003	298	507	197	2,619	59	141
Age (mean, SD)	44 (24)	37 (19)	39 (21)	34 (19)	42 (20)	42 (23)	36 (27)	42 (18)
Age range, % (95% CI), y								
<15	20.0 (17.8–22.4)	25.4 (21.7–29.6)	20.9 (17.2–25.2)	29.5 (24.2–35.5)	21.8 (15.3–30.1)	22 (19.3–24.3)	35 (19.5–55.4)	20 (12.3–31.7)
15–24	7.4 (6.8–8.0)	9.3 (8.1–10.8)	10.2 (8.3–12.4)	10.5 (8.8–12.5)	5.1 (0.4–7.5)	8.1 (7.4–8.9)	7.2 (4.3–11.9)	7.2 (5.3–9.7)
25–44	19.4 (17.9–20.9)	22.9 (20.6–25.4)	22.3 (19.5–25.3)	22.8 (19.7–26.2)	24.3 (18.1–31.8)	21 (19.3–22.3)	16 (10.7–22.1)	20 (19.2–22.1)
45–64	27.2 (25.8–28.7)	24.9 (22.7–27.3)	29.3 (26.1–32.7)	22.3 (19.4–25.5)	25.2 (21.3–29.6)	26 (24.8–27.6)	21 (15.0–29.0)	34 (26.3–41.8)
65–74	13.5 (12.5–14.6)	9.7 (8.1–11.4)	10.9 (8.8–13.4)	8.4 (6.6–10.7)	11.0 (7.0–16.8)	12.3 (11.3–13.3)	9.9 (6.7–14.4)	11 (8.0–14.2)
>75	12.5 (11.3–13.7)	7.7 (5.9–9.9)	6.5 (5.1–8.3)	6.5 (4.9–08.6)	12.5 (7.2–20.8)	11 (9.7–12.2)	11 (6.6–17.0)	8.1 (5.5–11.6)
Female, % (95% CI)	59.1 (57.5–60.6)	64.3 (62.1–66.4)	64.3 (60.8–67.7)	65.1 (62.0–68.1)	62.0 (57.9–65.9)	61 (59.3–62.3)	59 (53.9–63.0)	64 (58.4–69.6)
Insurance status, % (95% CI)								
Private insurance	55.4 (53.2–57.6)	47.6 (44.0–51.3)	43.1 (38.8–47.5)	44.8 (40.0–49.8)	61.7 (57.0–66.1)	52.9 (50.5–55.2)	65.0 (55.0–73.9)	43.1 (37.0–49.5)
Medicare	23.0 (21.1–24.9)	15.4 (12.9–18.2)	18.3 (15.0–22.3)	13.3 (10.7–16.4)	16.4 (10.4–24.9)	20.5 (18.6–22.5)	18.0 (12.1–25.8)	17.2 (13.6–21.6)
Medicaid	11.0 (09.8–12.4)	26.6 (22.8–30.8)	28.0 (24.0–32.5)	31.0 (25.9–36.6)	13.1 (9.0–18.7)	16.2 (14.2–18.4)	12.7 (8.1–19.4)	25.1 (17.8–34.1)
Workers' compensation	0.3 (0.1–0.5)	0.4 (0.2–0.7)	0.3 (0.1–0.8)	0.5 (0.2–1.1)	0.3 (0.0–1.5)	0.3 (0.2–0.6)	0.0 (0.0–0.1)	0.0 (0.0–0.1)
Uninsured	2.8 (2.2–3.6)	3.0 (2.4–3.6)	2.5 (1.9–3.3)	3.2 (2.5–4.1)	3.1 (1.9–5.1)	2.8 (2.3–3.4)	2.0 (1.1–3.8)	5.0 (2.7–9.2)
Unknown or other	7.4 (5.6–9.9)	7.0 (5.1–9.6)	7.8 (4.9–12.4)	7.1 (5.1–9.8)	5.5 (3.6–8.2)	7.3 (5.6–9.4)	2.2 (1.2 –4.1)	9.5 (3.3–24.5)
Chronic conditions (95% CI), % with condition								
Cancer	4.4 (3.8–5.1)	2.1 (1.7–2.6)	3.0 (2.3–4.0)	1.5 (1.1–2.0)	2.5 (1.6–4.0)	3.6 (3.1–4.1)	2.8 (1.6–4.7)	3.9 (2.3–6.3)
Cerebrovascular disease	1.7 (1.3–2.1)	0.8 (0.6–1.1)	1.2 (0.8–1.8)	0.7 (0.4–1.3)	0.5 (0.3–0.9)	1.4 (1.1–1.8)	0.9 (0.3–3.3)	1.1 (0.6–2.0)
Chronic obstructive pulmonary disease	5.1 (4.4–5.9)	2.5 (2.0–3.2)	2.9 (2.2–4.0)	2.1 (1.4–3.1)	2.9 (1.6–5.3)	4.3 (3.7–4.9)	2.7 (1.6–4.5)	3.4 (2.5–4.6)
Congestive heart failure	1.7 (1.4–2.2)	1.0 (0.6–1.5)	1.7 (1.1–2.8)	0.5 (0.3–1.0)	0.9 (0.3–2.4)	1.4 (1.2–1.8)	3.7 (1.4–9.1)	0.8 (0.4–1.9)
Coronary artery disease	5.3 (4.5–6.1)	2.7 (2.2–3.4)	3.1 (2.3–4.2)	2.5 (1.8–3.5)	2.9 (1.9–4.4)	4.4 (3.7 –5.1)	6.1 (3.5–10.6)	3.8 (2.2–6.5)
Type 2 diabetes	10.2 (9.1–11.4)	10.1 (8.8–11.7)	12.3 (10.0–15.0)	9.4 (7.5–11.7)	8.9 (7.0–11.3)	10.2 (9.1–11.4)	8.3 (5.5–12.3)	10.2 (7.8–13.2)
Obesity	9.4 (8.3–10.6)	08.9 (7.6–10.5)	12.6 (10.6–14.9)	8.5 (6.6–10.7)	4.6 (3.4–6.4)	9.2 (8.3–10.3)	11.0 (7.0–16.9)	8.2 (4.9–13.5)

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Characteristic	Patient Race or Ethnicity					Provider Type		
	White	All Minority Groups	Black	Hispanic	Asian or Other	Physician	Nurse Practitioner	Physician Assistant
Total number of chronic conditions, mean (SD)	1.2 (2.0)	0.9 (1.7)	1.3 (1.6)	0.7 (1.6)	0.7 (1.7)	1.1 (1.9)	1.2 (1.6)	1.4 (1.3)
Reason for visit (95% CI), %								
Not specified	2.1 (1.5–2.9)	2.3 (1.5–3.4)	2.1 (1.3–3.3)	2.2(01.4–03.4)	2.7 (1.1–6.4)	2.2 (1.6–3.0)	1.3 (0.6–2.9)	1.4 (0.5–3.4)
New problem	35.1 (33.3–36.9)	35.5 (32.4–38.7)	30.5 (27.7–33.4)	39.5 (35.0–44.2)	32.8 (27.4–38.7)	35.2 (33.3–37.3)	40.7 (33.4–48.4)	32.4 (28.0–37.2)
Chronic problem, routine	24.4 (22.2–26.8)	17.5 (15.7–19.4)	23.1 (20.2–26.4)	14.8 (12.6–17.3)	15.9 (12.6–19.8)	22.3 (20.4–24.4)	17.4 (11.8–25.0)	17.2 (13.0–22.4)
Chronic problem, flare-up	4.5 (4.0–5.1)	5.4 (4.4–6.7)	6.3 (4.8–8.1)	5.3 (4.1–6.8)	0.4 (2.7–7.1)	4.2 (3.8–4.8)	3.5 (2.1–5.7)	16.0 (10.8–22.9)
Presurgery	1.3 (1.0–1.6)	1.0 (0.7–1.5)	1.1 (0.8–1.7)	1.1 (0.7–1.8)	0.6 (0.3–1.2)	1.1 (0.9–1.3)	1.0 (0.9–3.9)	3.3 (1.5–7.0)
Postsurgery	6.5 (5.9–7.1)	5.8 (4.9–6.9)	6.9 (5.6–8.5)	5.5 (4.3–7.1)	4.8 (3.3–7.1)	6.1 (5.6–6.7)	6.9 (4.4–10.7)	7.7 (4.4–13.2)
Preventive care	26.2 (24.3–28.3)	32.5 (29.2–36.0)	29.9 (26.0–34.2)	31.7 (27.2–36.5)	38.8 (32.2–45.8)	29.0 (26.6–31.1)	28.3 (21.2–36.7)	22.0 (14.3–32.3)
Region								
Northeast	20.0 (18.0–22.1)	16.0 (13.2–19.2)	16.3 (12.6–20.9)	15.9 (12.5–20.1)	15.4 (1 1.2–20.9)	17.3 (15.6–19.2)	19.4 (10.8–32.3)	37.1 (23.1–53.7)
Midwest	25.3 (23.2–27.6)	10.6 (8.7–12.8)	12.7 (10.1–15.9)	8.5(6.3–11.4)	12.4(9.1–16.8)	20.3 (18.5–22.3)	34.2 (21.4–49.9)	11.4 (6.4–19.5)
South	34.3 (31.8–36.8)	44.9 (39.9–49.9)	57.0 (50.9–62.8)	44.2 (37.1–51.6)	22.4 (17.0–29.0)	38.3 (35.7–40.9)	38.9 (24.6–55.5)	34.9 (18.3–56.3)
West	20.4 (18.3–22.6)	28.5 (24.5–33.0)	13.9 (9.9–19.2)	31.4 (25.7–37.7)	49.7 (41.5–57.9)	24.1 (21.6–26.8)	7.5 (3.3–16.1)	16.5 (9.4–27.5)
Metropolitan statistical area								
Yes	85.8 (82.2–88.8)	95.4 (93.7–96.7)	95.0 (92.9–96.5)	94.8 (92.0–96.6)	97.5 (95.7–98.6)	89.2 (86.3–91.6)	91.5 (84.9–95.4)	89.0 (74.0–95.8)
No	14.2 (11.2–17.8)	4.6 (3.3–6.3)	5.0 (3.5–7.1)	5.2 (3.4–8.0)	2.5 (1.4–4.3)	10.8 (8.4–13.7)	8.5 (4.6–15.1)	11.0 (4.2–26.0)
Degree								
MD	89.0 (86.8–90.8)	94.5 (92.6–95.9)	93.9 (90.5–96.1)	94.4 (92.1–96.1)	95.5 (92.2–97.4)	91.2 (89.4–92.7)	—	—
DO	11.0 (9.2–13.2)	5.5 (4.1–7.4)	6.1 (3.9–9.5)	5.6 (3.9–7.9)	4.5 (2.6–7.8)	8.8 (7.3–10.6)	—	—
Provider type, % (95% CI)								
Physician	94.0 (92.2–95.3)	90.9 (86.9–93.8)	91.5 (86.8–94.6)	90.6 (86.7–93.4)	90.9 (82.4–95.5)	—	—	—
Nurse practitioner	2.4 (1.7–3.5)	1.5 (1.0–2.4)	1.5 (1.0–2.5)	1.6 (1.0–2.7)	1.3 (0.6–3.0)	—	—	—
Physician assistant	3.6 (2.5–5.1)	7.5 (4.8–11.7)	7.0 (4.0–11.9)	7.8(5.1–11.7)	7.8(3.5–16.5)	—	—	—
Seen by own PCP?								
Yes	76.3 (73.6–78.9)	73.5 (69.2–77.3)	73.8 (68.5–78.4)	71.8 (66.2–76.8)	77.2 (67.7–84.6)	75.5 (72.6–78.1)	76.7 (67.3–84.1)	72.1 (61.5–80.7)
No	23.7 (21.1–26.4)	26.5 (22.7–30.8)	26.2 (21.6–31.5)	28.2 (23.2–33.8)	22.8 (15.4–32.3)	24.5 (21.9–27.4)	23.3 (15.9–32.7)	27.9 (19.3–38.5)
Practice employment model								
Full owner	29.9 (26.3–33.8)	38.7 (32.9–44.7)	37.0 (30.9–43.7)	41.5 (34.0–49.4)	33.9 (23.3–46.3)	33.5 (29.6–37.6)	31.1 (19.2–46.1)	24.8 (12.1–44.1)
Part owner	28.4 (24.1–33.1)	22.5 (17.3–28.8)	21.6 (16.6–27.8)	20.1 (15.1–26.4)	30.0 (14.9–51.2)	26.2 (22.0–31.0)	17.1 (7.4–35.0)	31.6 (19.6–46.6)

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Characteristic	Patient Race or Ethnicity					Provider Type		
	White	All Minority Groups	Black	Hispanic	Asian or Other	Physician	Nurse Practitioner	Physician Assistant
Employee	39.9 (35.9–44.0)	34.4 (28.9–40.2)	39.3 (33.0–46.0)	32.8 (26.1–40.3)	30.8 (21.7–41.6)	37.8 (33.8–41.9)	50.0 (33.3–66.6)	35.3 (19.8–54.8)
Contractor	1.8 (1.2–2.8)	4.5 (2.3–8.3)	2.0 (1.1–3.7)	5.5 (2.7–11.1)	5.4 (2.0–13.4)	2.5 (1.4–4.4)	1.8 (0.7–5.1)	8.3 (2.9–21.5)

CI = confidence interval; PCP = primary care physician.

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Table 2.

Percentage of 2013 to 2018 United States primary care visits with imaging use by visit characteristic

Characteristic	Any Imaging, % (95% CI)	X-Ray, % (95% CI)	CT Scan, % (95% CI)	Ultrasound, % (95% CI)	MRI, % (95% CI)
Unweighted count, n	7,879	2,689	532	2,274	466
Weighted count, n (millions)	351	121	27	102	23
All visits	12.5 (11.4–13.6)	4.3 (3.8–4.8)	1.0 (0.7–1.2)	3.6 (3.2–4.2)	0.8 (0.7–1.0)
Age, y					
<15	2.6 (2.1–3.3)	2.1 (1.6–2.7)	0.1 (0.0–0.2)	0.3 (0.2–0.4)	0.2 (0.1–0.4)
15–24	9.3 (7.8–11.0)	3.3 (2.2–4.8)	0.2 (0.1–0.4)	5.1 (4.0–6.3)	0.7 (0.3–1.7)
25–44	14.7 (13.0–16.5)	3.5 (2.8–4.4)	0.5 (0.3–0.8)	7.4 (6.3–8.8)	0.7 (0.5–1.0)
45–64	17.6 (15.6–19.7)	5.8 (4.8–7.0)	1.8 (1.2–2.7)	3.8 (3.0–4.8)	1.3 (0.9–1.8)
65–74	16.9 (13.9–20.3)	6.0 (4.5–7.9)	1.3 (0.9–1.9)	3.0 (2.0–4.3)	1.3 (0.8–2.1)
>75	13.2 (10.9–15.8)	5.5 (4.3–7.0)	1.7 (1.1–2.6)	2.4 (1.6–3.5)	0.8 (0.4–1.6)
Sex					
Male	8.0 (7.0–9.1)	4.7 (4.0–5.5)	1.0 (0.7–1.4)	1.5 (1.2–1.9)	0.8 (0.6–1.0)
Female	15.3 (14.1–16.7)	4.0 (3.5–4.7)	0.9 (0.7–1.3)	5.0 (4.3–5.7)	0.9 (0.7–1.1)
Race or ethnicity					
White	12 (11.0–13.1)	4.2 (3.6–4.8)	0.8 (0.6–1.0)	3.0 (2.6–3.4)	0.8 (0.6–1.1)
All minority groups	13.3 (11.5–15.4)	4.5 (3.7–5.5)	1.3 (0.8–2.0)	4.8 (3.8–6.1)	0.9 (0.6–1.2)
Black	14.1 (11.7–17.0)	4.0 (3.6–4.8)	1.4 (0.70–2.9)	4.5 (3.3–6.2)	0.8 (0.5–1.4)
Hispanic	13.9 (11.5–16.6)	5.4 (4.1–7.0)	1.4 (0.8–2.2)	5.7 (4.1–7.7)	0.7 (0.5–1.1)
Asian or other	10.9 (7.5–15.4)	3.2 (2.1–4.9)	0.8 (0.3–1.9)	3.0 (1.8–5.0)	1.2 (0.5–2.8)
Insurance					
Private insurance	12.5 (11.3–13.8)	4.2 (3.5–5.0)	0.8 (0.5–1.1)	3.8 (3.1–4.6)	0.7 (0.5–0.9)
Medicare	15.0 (13.0–17.3)	5.1 (4.2–6.1)	1.5 (1.2–2.1)	3.0 (2.3–3.9)	1.2 (0.8–1.8)
Medicaid	9.5 (8.2–11.0)	3.1 (2.5–3.8)	0.8 (0.4–1.5)	4.3 (3.4–5.4)	0.8 (0.5–1.5)
Workers’ compensation	17.7 (11.3–26.4)	15.4 (9.0–24.9)	0.3 (0.1–1.6)	0.9 (0.1–5.2)	1.0 (0.3–3.2)
Uninsured	7.5 (5.3–10.5)	2.7 (1.6–4.4)	0.8 (0.2–3.2)	2.5 (1.4–4.6)	1.0 (0.4–2.8)
Unknown or other	14.0 (10.8–17.9)	5.9 (4.2–8.1)	1.2 (0.7–2.3)	3.3 (2.0–5.4)	1.0 (0.5–1.8)
Comorbidities					
Cancer no	12.2 (11.2–13.3)	4.2 (3.7–4.8)	0.9 (0.7–1.1)	3.6 (3.1–4.1)	0.8 (0.7–1.0)

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Characteristic	Any Imaging, % (95% CI)	X-Ray, % (95% CI)	CT Scan, % (95% CI)	Ultrasound, % (95% CI)	MRI, % (95% CI)
Cancer yes	19.9 (16.2–24.2)	6.6 (4.5–9.7)	4.0 (2.3–6.8)	5.0 (3.1–7.9)	0.8 (0.4–1.6)
Cerebrovascular disease no	12.4 (11.4–13.5)	4.3 (3.8–4.8)	0.9 (0.7–1.2)	3.6 (3.1–4.2)	0.8 (0.7–1.0)
Cerebrovascular disease yes	18.4 (12.3–26.6)	6.1 (3.0–11.9)	2.9 (0.9–8.8)	4.7 (2.3–9.3)	1.3 (0.7–2.6)
Chronic obstructive pulmonary disease no	12.3 (11.3–13.4)	4.2 (3.7–4.7)	0.9 (0.7–1.2)	3.6 (3.1–4.2)	0.8 (0.7–1.0)
Chronic obstructive pulmonary disease yes	16.7 (13.3–21.1)	6.9 (5.2–9.0)	1.8 (1.1–3.0)	3.8 (2.2–6.4)	0.8 (0.3–1.8)
Congestive heart failure no	12.4 (11.4–13.5)	4.2 (3.8–4.8)	1.0 (0.7–1.2)	3.6 (3.2–4.2)	0.8 (0.7–1.0)
Congestive heart failure yes	18.1 (12.3–25.7)	7.5 (4.3–12.8)	2.0 (0.5–8.2)	2.7 (1.3–5.4)	0.1 (0.0–0.4)
Coronary artery disease no	12.4 (11.3–13.5)	4.2 (3.7–4.7)	0.9 (0.6–1.1)	3.7 (3.2–4.2)	0.8 (0.7–1.0)
Coronary artery disease yes	14.8 (11.3–19.1)	6.5 (4.6–9.0)	3.4 (2.0–5.8)	2.3 (1.4–3.7)	1.2 (0.5–2.8)
Type 2 diabetes no	12.4 (11.4–13.5)	4.3 (3.8–4.8)	0.9 (0.7–1.2)	3.7 (3.3–4.3)	0.8 (0.6–1.0)
Type 2 diabetes yes	12.7 (10.6–15.2)	4.6 (3.4–6.1)	1.7 (1.0–2.7)	2.6 (1.8–3.7)	1.3 (0.7–2.2)
Obesity no	12.1 (11.1–13.2)	4.1 (3.7–4.6)	0.9 (0.7–1.2)	3.6 (3.1–4.1)	0.8 (0.6–1.0)
Obesity yes	16.1 (13.6–18.9)	5.9 (4.1–8.5)	1.3 (0.7–2.2)	4.1 (3.0–5.6)	1.2 (0.7–2.0)
Reason for visit					
Not specified	8.7 (5.4–13.8)	2.0 (1.0–3.8)	0.4 (0.2–0.8)	3.0 (1.3–6.6)	0.5 (0.1–1.8)
New problem	13.0 (11.6–14.4)	7.5 (6.5–8.6)	1.1 (0.8–1.4)	3.2 (2.6–4.1)	1.0 (0.7–1.4)
Chronic problem, routine	8.1 (7.0–9.4)	2.6 (2.1–3.3)	0.9 (0.6–1.5)	1.5 (1.1–1.9)	0.8 (0.5–1.2)
Chronic problem, flare-up	19.5 (16.2–23.4)	7.7 (5.7–10.4)	2.7 (1.7–4.3)	6.5 (4.1–10.2)	2.3 (1.6–3.3)
Presurgery	27.4 (18.8–38.1)	10.6 (6.2–17.6)	8.5 (3.3–19.9)	5.5 (2.6–11.1)	1.4 (0.5–4.4)
Postsurgery	13.2 (11.1–15.7)	2.4 (1.5–3.7)	1.1 (0.5–2.4)	4.2 (3.2–5.5)	0.7 (0.2–2.6)
Preventive care	13.5 (11.4–15.9)	1.3 (0.9–1.9)	0.3 (0.2–0.5)	5.1 (4.0–6.5)	0.3 (0.2–0.6)
Region					
Northeast	13.0 (10.5–16.0)	3.9 (2.9–5.1)	2.4 (1.3–4.5)	4.0 (2.8–5.6)	1.0 (0.6–1.8)
Midwest	12.7 (11.5–14.0)	4.9 (4.2–5.7)	1.0 (0.7–1.3)	3.1 (2.5–3.8)	0.8 (0.6–1.0)
South	12.8 (11.0–14.8)	4.1 (3.5–4.8)	0.8 (0.6–1.2)	3.6 (2.8–4.7)	0.9 (0.7–1.2)
West	12.3 (10.7–14.1)	4.3 (3.6–5.2)	0.4 (0.3–0.6)	4.0 (3.0–5.3)	0.8 (0.6–1.1)
Metropolitan statistical area					
Yes	12.5 (11.4–13.7)	4.2 (3.7–4.8)	0.9 (0.7–1.2)	3.7 (3.2–4.3)	0.8 (0.7–1.1)
No	12.1 (10.0–14.7)	5.3 (4.0–7.1)	1.6 (1.0–2.4)	2.8 (2.0–4.0)	0.7 (0.4–1.4)
Degree					
MD	12.6 (11.5–13.8)	4.3 (3.8–4.9)	0.9 (0.7–1.2)	3.8 (3.3–4.4)	0.8 (0.7–1.0)

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Characteristic	Any Imaging, % (95% CI)	X-Ray, % (95% CI)	CT Scan, % (95% CI)	Ultrasound, % (95% CI)	MRI, % (95% CI)
DO	11.1 (9.0–13.8)	4.4 (3.4–5.8)	1.2 (0.7–2.1)	1.9 (1.3–2.8)	0.9 (0.5–1.5)
Provider type					
Physician	11.8 (10.9–12.8)	4.1 (3.6–4.6)	0.7 (0.6–0.9)	3.4 (3.0–3.9)	0.8 (0.6–1.0)
Nurse practitioner	10.2 (7.7–13.5)	4.8 (2.8–8.1)	0.5 (0.2–1.1)	2.2 (1.2–3.9)	0.6 (0.3–1.4)
Physician assistant	12.5 (18.5–33.3)	8.5 (6.1–11.6)	6.5 (3.6–11.0)	7.9 (4.6–13.0)	1.5 (0.8–2.7)
Seen by own PCP?					
Yes	10.4 (9.3–11.6)	4.4 (3.9–5.0)	0.8 (0.7–1.1)	2.3 (1.8–2.8)	0.9 (0.7–1.1)
No	18.7 (16.7–21.0)	3.9 (3.0–5.2)	1.3 (0.8–2.2)	7.8 (6.6–9.2)	0.7 (0.5–1.1)
Practice employment model					
Full owner	9.8 (8.4–11.5)	2.9 (2.3–3.5)	0.6 (0.4–0.9)	3.3 (2.6–4.1)	0.7 (0.5–1.1)
Part owner	14.3 (11.7–17.2)	4.3 (3.2–5.7)	1.3 (0.7–2.4)	4.4 (3.3–5.8)	0.8 (0.5–1.1)
Employee	13.9 (12.3–15.6)	5.6 (4.7–6.5)	1.1 (0.8–1.4)	3.6 (2.8–4.7)	1.0 (0.7–1.4)
Contractor	7.3 (4.1–12.8)	4.3 (2.0–9.1)	0.9 (0.3–2.7)	0.8 (0.4–1.9)	0.4 (0.1–1.4)

CI = confidence interval; DO = doctor of osteopathic medicine; MD = doctor of medicine; PCP = primary care physician.

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Table 3.

Adjusted odds ratios for imaging use

Characteristic	Any Imaging, OR (95% CI)	X–Ray, OR (95% CI)	CT, OR (95% CI)	MRI, OR (95% CI)	US, OR (95% CI)
Race					
White	Ref				
Black	1.26 (1.06–1.49)	1.18 (0.90–1.56)	1.43 (0.83–2.46)	0.88 (0.47–1.63)	1.28 (0.96–1.69)
Hispanic	1.26 (1.05–1.51)	1.65 (1.29–2.11)	1.71 (1.19–2.47)	1.12 (0.71–1.75)	1.26 (0.92–1.73)
Asian or other	1.20 (0.97–1.50)	1.26 (0.95–1.68)	1.55 (0.63–3.80)	1.61 (0.75–3.46)	1.04 (0.64–1.69)
Age, y					
<15	Ref				
15–24	2.83 (2.18–3.66)	1.73 (1.28–2.34)	3.89 (1.27–11.92)	2.96 (1.10–7.96)	10.10 (5.73–17.91)
25–44	5.10 (4.08–6.39)	2.32 (1.79–3.02)	6.75 (2.39–19.10)	4.79 (2.08–11.01)	15.60 (9.12–26.60)
45–64	8.49 (6.72–10.70)	3.61 (2.71–4.81)	14.90 (5.40–41.4)	6.87 (2.79–16.9)	11.50 (6.61–20.12)
65–74	8.28 (6.27–10.90)	3.87 (2.70–5.54)	8.63 (2.98–24.9)	7.83 (3.24–18.9)	9.48 (5.04–17.81)
>75	6.40 (4.74–8.65)	4.52 (3.03–6.75)	8.54 (2.74–26.5)	2.62 (0.98–7.01)	8.65 (4.50–16.61)
Sex					
Male	Ref				
Female	1.88 (1.67–2.11)	0.88 (0.75–1.02)	1.12 (0.77–1.64)	1.01 (0.72–1.40)	1.97 (1.61–2.41)
Insurance					
Private	Ref				
Medicare	0.98 (0.83–1.15)	0.68 (0.52–0.88)	1.72 (1.08–2.74)	1.23 (0.81–1.87)	1.22 (0.93–1.64)
Medicaid	0.99 (0.83–1.14)	0.98 (0.77–1.26)	1.17 (0.75–1.80)	1.06 (0.61–1.83)	1.10 (0.86–1.43)
Workers’ compensation	1.51 (0.84–2.71)	3.61 (1.86–7.00)	0.50 (0.09–2.95)	1.39 (0.37–5.27)	0.22 (0.38–1.28)
Uninsured	0.78 (0.55–1.12)	0.78 (0.45–1.33)	0.49 (0.18–1.38)	1.94 (0.71–5.31)	0.93 (0.54–1.58)
Unknown or other	1.14 (0.95–1.38)	1.24 (0.98–1.58)	1.24 (0.75–2.05)	1.80 (1.02–3.17)	0.79 (0.50–1.24)
Comorbidities					
Cancer	1.45 (1.17–1.79)	1.34 (0.84–2.15)	2.59 (1.52–4.41)	1.22 (0.61–2.46)	1.33 (0.89–1.98)
Cerebrovascular disease	1.27 (0.91–1.77)	0.79 (0.50–1.23)	0.89 (0.37–2.18)	2.53 (1.17–5.44)	1.92 (0.92–3.97)
Chronic obstructive pulmonary disease	1.36 (1.06–1.74)	1.77 (1.30–2.41)	1.63 (0.86–3.06)	0.79 (0.39–1.63)	1.11 (0.67–1.84)
Congestive heart failure	1.19 (0.78–1.83)	0.735 (0.47–1.16)	0.26 (0.08–0.88)	0.09 (0.01–0.66)	1.20 (0.63–2.31)
Coronary artery disease	1.17 (0.93–1.48)	1.27 (0.83–1.93)	1.95 (1.00–3.78)	0.62 (0.30–1.27)	1.04 (0.66–1.65)

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Characteristic	Any Imaging, OR (95% CI)	X–Ray, OR (95% CI)	CT, OR (95% CI)	MRI, OR (95% CI)	US, OR (95% CI)
Type 2 diabetes	0.86 (0.74–1.00)	0.85 (0.64–1.13)	0.97 (0.58–1.60)	0.94 (0.50–1.76)	0.88 (0.64–1.21)
Obesity	1.13 (0.94–1.35)	1.01 (0.72–1.42)	0.9- (0.57–1.40)	1.34 (0.79–2.27)	1.25 (0.97–1.59)
Reason for visit					
New problem	Ref				
Chronic problem, routine	0.50 (0.43–0.58)	0.27 (0.22–0.35)	0.53 (0.32–0.89)	0.57 (0.34–0.95)	0.58 (0.43–0.79)
Chronic problem, flare-up	0.98 (0.73–1.22)	0.72 (0.53–0.97)	0.68 (0.33–1.40)	2.06 (1.21–3.52)	1.02 (0.57–1.83)
Presurgery	1.67 (1.10–2.53)	1.28 (0.75–2.21)	2.41 (1.43–4.06)	1.44 (0.42–4.98)	1.49 (0.73–3.02)
Postsurgery	1.00 (0.81–1.22)	0.36 (0.22–0.59)	0.65 (0.40–1.04)	0.31 (0.11–0.89)	1.28 (0.92–1.78)
Preventive care	1.12 (0.94–1.34)	0.22 (0.16–0.30)	0.33 (0.18–0.60)	0.52 (0.28–0.98)	1.23 (0.88–1.70)
Not specified	0.64 (0.39–1.05)	0.38 (0.21–0.68)	0.55 (0.26–1.13)	0.64 (0.15–2.82)	0.53 (0.29–0.96)
Region					
Northeast	Ref				
Midwest	0.99 (0.81–1.21)	1.29 (0.97–1.73)	0.77 (0.52–1.13)	0.71 (0.38–1.31)	0.84 (0.61–1.14)
South	1.04 (0.85–1.27)	1.19 (0.89–1.60)	0.66 (0.41–1.06)	0.87 (0.48–1.58)	0.89 (0.65–1.24)
West	0.96 (0.76–1.19)	1.14 (0.85–1.55)	0.33 (0.19–0.56)	0.75 (0.40–1.42)	0.98 (0.68–1.43)
Metropolitan statistical area					
Yes	Ref				
No	0.84 (0.70–1.03)	0.91 (0.70–1.16)	1.0 (0.54–1.83)	0.69 (0.39–1.20)	1.01 (0.68–1.50)
Degree					
MD	Ref				
DO	0.80 (0.63–1.01)	0.99 (0.76–1.28)	0.96 (0.45–2.03)	0.76 (0.45–1.28)	0.50 (0.32–0.77)
Practice employment model					
Full owner	Ref				
Part owner	1.47 (1.22–1.78)	1.47 (1.12–1.94)	2.06 (1.22–3.47)	1.23 (0.75–2.03)	0.20 (0.89–1.61)
Employee	1.38 (1.17–1.63)	1.71 (1.35–2.15)	1.32 (0.80–2.18)	1.10 (0.67–1.82)	1.17 (0.86–1.60)
Contractor	1.00 (0.67–1.51)	2.43 (1.33–4.41)	0.59 (0.08–4.22)	0.61 (0.15–2.44)	0.29 (0.12–0.67)
Seen by own PCP?					
Yes	Ref				
No	1.51 (1.28–1.78)	0.76 (0.61–0.94)	1.58 (1.13–2.22)	0.62 (0.40–0.97)	2.22 (1.64–3.00)
Provider type					
Physician	Ref				

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Characteristic	Any Imaging, OR (95% CI)	X–Ray, OR (95% CI)	CT, OR (95% CI)	MRI, OR (95% CI)	US, OR (95% CI)
Nurse practitioner	0.98 (0.71–1.35)	1.04 (0.65–1.65)	0.87 (0.41–1.82)	1.10 (0.48–2.52)	1.07 (0.63–1.81)
Physician assistant	2.00 (1.44–2.80)	1.57 (1.09–2.27)	5.67 (4.07–7.88)	1.13 (0.66–1.95)	2.23 (1.39–3.57)

Odds ratios adjusted for patient age, sex, race or ethnicity, insurance status, comorbidities, reason for visit, region of country, rural or urban status, provider degree, provider employment, provider PCP status, and provider type. CI = confidence interval; DO = doctor of osteopathic medicine; MD = doctor of medicine; OR = odds ratio; PCP = primary care physician; Ref = reference; US = ultrasound.

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Table 4.

Adjusted and unadjusted odds ratios for imaging use for nonobstetric, nonpediatric primary care visits

	Any Imaging, OR (95% CI)		X–Ray, OR (95% CI)		CT, OR (95% CI)		MRI, OR (95% CI)		US, OR (95% CI)	
Variable	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**	**Unadjusted**	**adjusted**	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**
Race										
White	Ref									
Black	1.23 (1.04–1.45)	1.37 (1.12–1.57)	1.02 (0.85–1.25)	1.09 (0.90–1.32)	1.20 (0.78–1.84)	1.31 (0.94–1.82)	0.77 (0.52–1.14)	0.68 (0.47–0.97)	1.27 (0.92–1.75)	1.37 (1.04–1.80)
Hispanic	1.17 (0.98–1.39)	1.16 (1.00–1.34)	1.12 (0.91–1.40)	1.03 (0.86–1.23)	1.07 (0.74–1.54)	1.38 (1.09–1.76)	0.90 (0.68–1.20)	0.94 (0.73–1.23)	1.81 (1.33–2.47)	1.54 (1.13–2.10)
Asian or other	1.05 (0.67–1.64)	1.41 (0.84–2.38)	0.70 (0.52–0.94)	0.90 (0.71–1.13)	0.74 (0.45–1.21)	1.22 (0.77–1.93)	1.09 (0.69–1.72)	1.13 (0.78–1.63)	1.79 (0.60–5.34)	2.43 (0.92–6.48)
Provider type										
Physician	Ref									
NP	0.99 (0.70–1.41)	1.08 (0.73–1.62)	1.31 (0.83–2.07)	1.32 (0.84–2.07)	0.90 (0.51–1.58)	0.92 (0.53–1.60)	0.85 (0.48–1.52)	1.00 (0.56–1.80)	0.81 (0.39–1.68)	1.12 (0.50–2.51)
PA	2.65 (1.93–3.63)	2.43 (1.91–3.10)	2.84 (1.99–4.05)	2.32 (1.74–3.09)	4.29 (2.69–6.86)	3.88 (2.94–5.12)	2.34 (1.40–3.94)	1.81 (1.16–2.81)	2.08 (1.22–3.56)	2.60 (1.67–4.01)

Odds ratios adjusted for patient age, sex, race or ethnicity, insurance status, comorbidities, reason for visit, region of country, rural or urban status, provider degree, provider employment, provider primary care physician status, and provider type. CI = confidence interval; NP = nurse practitioner; PA = physician assistant; Ref = reference; US = ultrasound.

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