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Patient-level factors influencing adherence to follow-up imaging recommendations

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ABSTRACT

Purpose: To determine which, if any, patient-level factors were associated with differences in completion of follow-up imaging recommendations at a tertiary academic medical center.

Methods: In this IRB-approved, retrospective cohort study, approximately one month of imaging recommendations were reviewed from 2017 at a single academic institution that contained key words recommending follow-up imaging. Age, gender, race/ethnicity, insurance, smoking history, primary language, BMI, and home address were recorded via chart extraction. Home addresses were geocoded to Census Block Groups and assigned to a quintile of neighborhood socioeconomic status. A multivariate logistic regression model was used to evaluate each predictor variable with significance set to $p = 0.05$.

Results: A total of 13,421 imaging reports that included additional follow-up recommendations were identified. Of the 1013 included reports that recommended follow-up, 350 recommended additional imaging and were analyzed. Three hundred eight (88.00%) had corresponding follow-up imaging present and the insurance payor was known for 266 (86.36%) patients: 146 (47.40%) had commercial insurance, 35 (11.36%) had Medicaid, and 85 (27.60%) had Medicare. Patients with Medicaid had over four times lower odds of completing follow-up imaging compared to patients with commercial insurance (OR 0.24, 95% CI 0.06–0.88, $p = 0.032$). Age, gender, race/ethnicity, smoking history, primary language, BMI, and neighborhood socioeconomic status were not independently associated with differences in follow-up imaging completion.

Conclusion: Patients with Medicaid had decreased odds of completing follow-up imaging recommendations compared to patients with commercial insurance.

1. Introduction

Disparities in imaging access have been described in multiple health care settings.^{1–5} For many patients, clinical questions can only be satisfactorily answered with further imaging and rates of adherence to imaging recommendations may lead to additional disparities in the use of clinical imaging. Studies have reported a wide range of adherence rates to follow-up imaging recommendations depending on an array of factors, including department of the ordering provider,² practice setting,^{2,5–7} communication between providers and patients,^{8–10} type of cancer,¹¹ insurance status,¹ patient's perception of importance,^{12,13}

race/ethnicity,^{1,11,13,14} and distance from the patient's zip code to the ordering facility.¹ There is wide variance in reported follow-up imaging adherence rates (ranging between 32% and 69%)^{2,15–18} and the influence of many patient-level factors remains poorly understood.

Delayed use of advanced imaging as well as delayed action on imaging findings have been associated with longer hospital stays, increased morbidity and mortality, and higher costs to hospital systems.^{19–24} Studies have shown poorer outcomes in Black and Hispanic patients associated with lack of early screening discussions with providers, demonstrating the complex interaction of race/ethnicity, bias, and language-discordant care.^{11,13}

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Though systems have been developed to more effectively communicate radiological findings to patients,^{25,26} and artificial intelligence has led to more precise notification and tracking systems,²⁷ the completion rate of recommendations for additional imaging remains low. The purpose of this study was to determine which, if any, patient-level characteristics were associated with differences in adherence to follow-up of radiology recommendations at a tertiary academic medical center.

2. Material and methods

The study was approved by the institutional review board, and the need for written informed consent was waived. All imaging reports which contained imaging recommendations in 2017 were identified via a database search, by searching for reports which contained one of the following key words in the “Impression” section of the imaging report: recommend, advise, and suggest. Duplicates were removed and a random sample was obtained representing approximately the number of recommendations made on average in a single month. Reports that made non-imaging recommendations (e.g. clinical correlation or labs) were excluded. Additional reports were excluded for patients who did not have subsequent clinical notes or imaging visits in the electronic medical record system over and beyond the expected time of follow-up.

Each of the remaining reports and patient electronic medical records were reviewed to determine whether the follow-up imaging recommendation occurred. If a time frame was given for less than or equal to one month after the initial study, the recommended follow-up study was determined to have occurred within the time frame if it occurred within one week of the stated time frame. If a time frame was given for more than one month after the initial study, the recommended follow-up study was determined to have occurred within the recommended time frame if it occurred within one month of the stated time frame. If no time frame was given for the follow-up imaging recommendation, then the health record was reviewed to determine whether the follow-up imaging was completed before December 31, 2019.

In cases where the imaging modality for the follow-up imaging recommendation was different than the imaging modality specified by the initial report, a board-certified radiologist with twelve years of experience determined whether the imaging study performed was appropriate for the given indication.

Age, gender, race/ethnicity, insurance, smoking history, primary language, BMI, and home address were recorded via chart extraction. Patients were subcategorized by self-identified gender (male, female), race/ethnicity (non-Hispanic White; Black/African American; Hispanic; Asian American or Native Hawaiian/Pacific Islander; Other/unknown), insurance (commercial, Medicaid, Medicare), smoking history (never, former, current), and primary language (English, Spanish, Cantonese, Mandarin, Russian, Other). Home addresses were geocoded to Census Block Groups and assigned to a quintile of neighborhood socioeconomic status (nSES) using a previously described composite measure based on statewide distribution.²⁸ Recommended test modality and ordering location were also recorded.

All statistical analyses were performed with Stata (College Station, TX). A multivariate logistic regression model was used to evaluate each predictor variable with significance set to $p = 0.05$. All of the above covariates were felt to potentially be a source of bias in imaging follow-up so all were included in the regression model.

3. Results

A total of 540,246 imaging reports were identified in the radiology database between January 1, 2017, and December 31, 2017. Of those, 13,421 imaging reports included recommendations for additional follow-up. After duplicates were removed, it was calculated that on average 1013 follow-up recommendations were made per month (accounting for 2.3% of total imaging reports). Reports that recommended

clinical correlation, labs, or other non-imaging follow-up studies were excluded as well as reports for patients who did not have subsequent clinical notes or imaging visits in the electronic medical record system over and beyond the expected time of follow-up (Fig. 1). The remaining 350 reports were then reviewed to determine whether the recommended follow-up imaging occurred.

Among the 350 imaging recommendations for patients with expected follow-up completion, 308 (88.00%) had corresponding follow-up imaging present (Table 1). Of those 308 patients, the insurance payor was known for 266 (86.36%): 146 (47.40%) had commercial insurance, 35 (11.36%) had Medicaid, and 85 (27.60%) had Medicare. In comparison, the insurance payor was known for 39 of the 42 (92.86%) patients with absent follow-up imaging: 15 (35.71%) had commercial insurance, 8 (19.05%) had Medicaid, and 16 (38.10%) had Medicare. Compared to those who had commercial insurance, patients with Medicaid had over four times lower odds of completing follow-up imaging recommendations (OR 0.24, $p = 0.03$); inversely, patients with commercial insurance had 4.18 greater odds of completing follow-up imaging recommendations when compared to patients with Medicaid ($p = 0.03$). There was no difference in odds of completing follow-up when comparing patients with Medicare to those who had commercial insurance (OR 0.63, $p = 0.38$).

One hundred seventy-two of the 308 (55.84%) patients who completed follow-up, as well as 25 of the 42 (59.52%) patients who did not complete follow-up identified as non-Hispanic White. Compared to the non-Hispanic White patients, Black/African American patients (OR 0.59, $p = 0.45$), Hispanic patients (OR 0.89, $p = 0.88$), Asian American or Native Hawaiian/Pacific Islander patients (OR 1.91, $p = 0.37$), and patients of Other Race/Ethnicity (OR 0.97, $p = 0.98$) had no difference in odds of completing follow-up imaging recommendations. Patients in the Other group self-identified as 1) American Indian or Alaskan Native, 2) as another race/ethnicity besides the ones listed previously, 3) declined to state their race/ethnicity, or 4) did not know their race/ethnicity. Odds ratios were unable to be calculated for these groups individually due to insufficient numbers.

English was identified as the primary language for 274 of the 308 (88.96%) patients who completed follow-up imaging, as well as for 39 of the 42 (92.86%) patients who did not complete follow-up imaging. Compared to primarily English-speaking patients, primarily Spanish-speaking patients (OR 3.04, $p = 0.43$), primarily Cantonese-speaking patients (OR 0.78, $p = 0.85$), and primarily Russian-speaking patients (OR 1.26, $p = 0.86$) had no difference in odds of completing follow-up imaging recommendations. Nine patients who primarily spoke Arabic, Cambodian, Hindi, Mandarin, Tagalog, Thai, or Vietnamese all completed follow-up imaging, and thus odds ratios were unable to be calculated for these groups.

One hundred six of the 308 (34.42%) patients who completed follow-up, as well as 15 of the 42 (35.71%) patients who did not complete follow-up belonged to the highest quintile of nSES (n1). Compared to patients in the highest quintile, patients in n2 (OR 0.52, $p = 0.2$), n3 (OR 1.73, $p = 0.39$), n4 (OR 3.90, $p = 0.22$), and n5 (OR 0.89, $p = 0.87$) had no difference in odds of completing follow-up imaging recommendations.

Age (OR 0.97, $p = 0.11$), self-identifying as a woman (OR 0.98, $p = 0.95$), and BMI (OR 0.99, $p = 0.71$) did not show a difference in odds between patients who completed follow-up imaging and those who did not. A former smoking history (OR 0.92, $p = 0.85$) and current smoking history (OR 1.27, $p = 0.80$) did not affect the odds of completing follow-up imaging recommendations when compared to patients with no smoking history.

Lastly, there was no difference in odds for completing follow-up when the recommended imaging study was a radiograph compared to ultrasound (OR 0.85, $p = 0.84$), CT (OR 1.22, $p = 0.76$), PET (OR 3.18, $p = 0.24$), MRI (OR 1.39, $p = 0.66$), and nuclear medicine (OR 1.16, $p = 0.93$), nor was there a difference in odds when comparing follow-up completion for those who received their initial imaging as inpatients

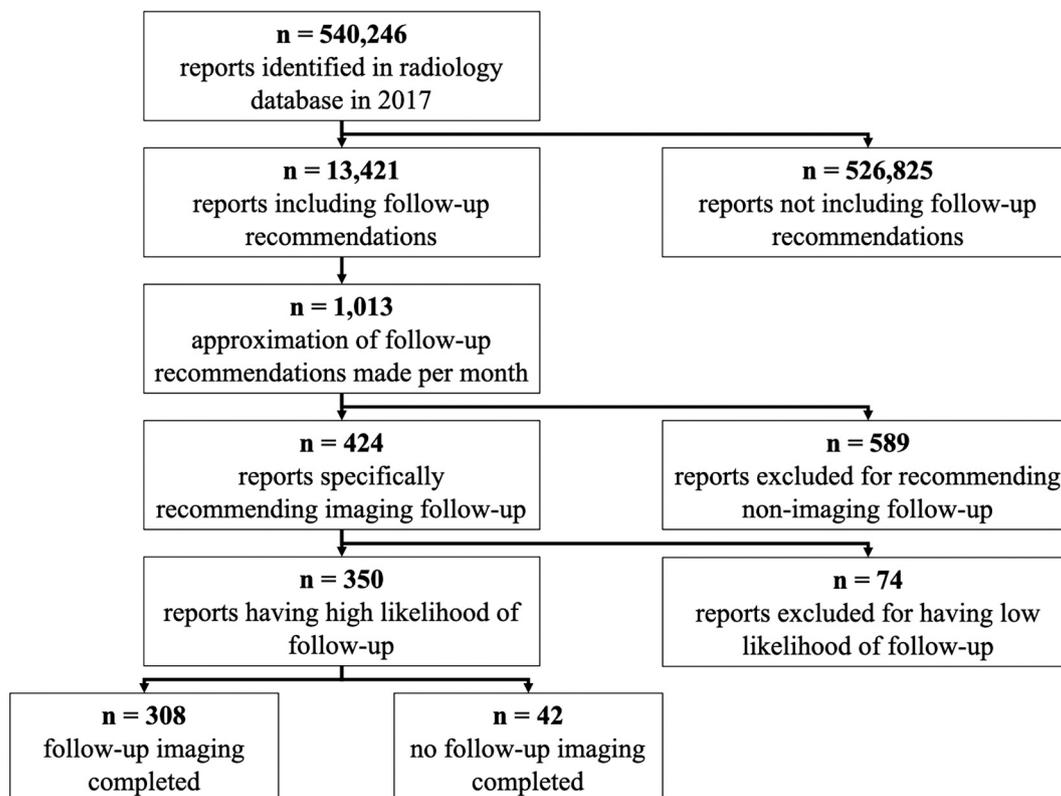


Fig. 1. Subject selection process. Total number of radiology reports and initial search string result followed by sample size analyzed and application of exclusion criteria. Likelihood was determined to be high if patients had clinical notes and imaging visits over and beyond the expected completion time frame, and low if patients did not have clinical notes and imaging visits over and beyond the expected completion time frame.

compared to those who received their initial imaging as outpatients (OR 0.41, $p = 0.09$) or in the emergency room (OR 4.01, $p = 0.23$). An odds ratio was unable to be calculated for patients who were recommended a follow-up fluoroscopy study because all 11 patients with this recommendation completed the recommended follow-up.

4. Discussion

The findings of this study suggest that patients with Medicaid had over four times lower odds of completing follow-up imaging recommendations when compared to patients with commercial insurance. No other patient-level factors contributed significantly to differences in completing follow-up imaging recommendations in the current study.

Our 2.3% rate of reports including follow-up imaging recommendation is less than other reported rates in the literature, which range between 8% and 37%,^{29–31} possibly attributable to our extraction of patient charts based off keywords instead of natural language processing or another algorithm. Upon manual review of 100 random imaging studies from 2017, 3 studies contained follow-up imaging recommendations, all of which contained one of our keywords. This resulted in a sensitivity and specificity of 100% for our chosen keywords (specifically the keyword “recommend”) and a follow-up imaging recommendation rate comparable to what we have reported in our study sample. Our results are consistent in the greater context of imaging missed care opportunities (IMCOs), defined as scheduled imaging appointments that were not performed by the expected time and date, in which Glover et al. found that insurance payor was independently associated with increased odds of an IMCO and that patients with Medicaid had the highest odds ratio of having an IMCO of 2.6.³²

Hanna et al. investigated the use of advanced imaging during emergency department visits and found disparities in advanced imaging utilization among patients receiving Medicare associated with race and

hospital setting,³³ similar to how Moser and Applegate found that patients with Medicaid received fewer imaging services in the emergency department compared to patients insured by another payor.³⁴ Several studies have attributed potential disparities in follow-up to patients on government-issued insurance overutilizing emergency services as primary care,^{1,2,5–7,35} as well as to physicians either being unaware or ignoring the American College of Radiology (ACR) Appropriateness Criteria.^{36–39} The findings of these studies and ours demonstrate the complex interplay of factors that affect patients' utilization of advanced imaging follow-up, influenced by both provider and patient-level factors. While studies have included insurance status in their analyses, there is limited research exploring factors affecting follow-up adherence rates among patients with government-issued insurance.

With such a complex interplay of factors affecting follow-up adherence rates, a multifaceted approach is needed to better understand and address these potential gaps in patient care. Multiple prior studies have developed novel automated algorithms to identify whether patients have completed recommended follow-up imaging, many with high accuracy.^{25–27,40,41} Patient communication workflows also play an important role. For example, Mannix et al. saw a significant decrease in nonadherence to follow-up recommendations when a dedicated system of communication was implemented beyond automated provider notifications that could be easily ignored, suggesting that more effort on the provider end can yield better adherence rates for patients.⁴²

To supplement better communication systems and provider workflows, case management has been shown to improve navigation of the health system for patients. Grover et al. showed how case management helped patients who frequently visit the emergency department decrease emergency department visits by 49%, decrease use of computed tomography imaging by 41%, decrease use of ultrasound imaging by 52%, and decrease use of radiographs by 38%.⁴³ Of those patients, the majority had government-issued insurance suggesting that

Table 1
Factors for all patients who received follow-up imaging recommendation.

Factor	Follow-up imaging completed		No follow-up imaging completed		Odds ratio	95% CI	p
	No.	%	No.	%			
Total	308	100	42	100			
Age (y)							
Range	0–93		27–92		0.97	[0.94, 1.01]	0.11
Median	58		61.5				
Mean	54.91		60.55				
Mean SD	19.63		14.73				
Gender							
Male	145	47.08	18	42.86	1	[1, 1]	1.00
Female	163	52.92	24	57.14	0.98	[0.43, 2.23]	0.95
Race/ethnicity							
Non-Hispanic White	172	55.84	25	59.52	1	[1, 1]	1.00
Black/African American	20	6.49	6	14.29	0.59	[0.14, 2.37]	0.45
Hispanic	39	12.66	5	11.90	0.89	[0.21, 3.80]	0.88
Asian American or NHPI ^a	50	16.23	4	9.52	1.91	[0.46, 7.91]	0.37
Other ^b	27	8.77	2	4.76	0.97	[0.19, 5.12]	0.98
Language							
English	274	88.96	39	92.86	1	[1, 1]	1.00
Spanish	11	3.57	1	2.38	3.04	[0.19, 49.39]	0.43
Cantonese	11	3.57	1	2.38	0.78	[0.57, 10.64]	0.85
Mandarin	2	0.65	0	0.00	–	–	–
Russian	3	0.97	1	2.38	1.26	[0.10, 15.37]	0.86
Other ^c	7	2.27	0	0.00	–	–	–
Insurance							
Commercial	146	47.40	15	35.71	1	[1, 1]	1.00
Medicaid	35	11.36	8	19.05	0.24	[0.06, 0.88]	0.03 ^d
Medicare	85	27.60	16	38.10	0.63	[0.23, 1.77]	0.38
Smoking history							
Never	164	53.25	20	47.62	1	[1, 1]	1.00
Former	111	36.04	19	45.24	0.92	[0.39, 2.16]	0.85
Current	16	5.19	2	4.76	1.27	[0.20, 7.96]	0.80
BMI							
Range	12.77–63.49		17.16–66.18		0.99	[0.93, 1.05]	0.71
Median	25.46		26.39				
Mean	26.32		27.34				
Mean SD	6.72		8.48				
Neighborhood SES ^e							
n1	106	34.42	15	35.71	1	[1, 1]	1.00
n2	71	23.05	13	30.95	0.52	[0.19, 1.41]	0.20
n3	52	16.88	6	14.29	1.73	[0.49, 6.07]	0.39
n4	34	11.04	1	2.38	3.90	[0.44, 33.84]	0.22
n5	36	11.69	7	16.67	0.89	[0.23, 3.46]	0.87
Modality							
Radiograph ^f	52	16.88	6	14.29	1	[1, 1]	1.00
Ultrasound	37	12.01	5	11.90	0.85	[0.18, 4.06]	0.84
CT	117	37.99	20	47.62	1.22	[0.34, 4.38]	0.76
PET	24	7.79	2	4.76	3.18	[0.46, 21.82]	0.24
MRI	61	19.81	8	19.05	1.39	[0.32, 5.95]	0.66
Nuclear Medicine	6	1.95	1	2.38	1.16	[0.06, 24.21]	0.93
Fluoroscopy ^g	11	3.57	0	0.00	–	–	–
Location							
Inpatient	72	23.38	8	19.05	1	[1, 1]	1.00
Outpatient	185	60.06	30	71.43	0.41	[0.15, 1.14]	0.09
Emergency	37	12.01	3	7.14	4.01	[0.43, 37.76]	0.23

^a NHPI=Native Hawaiian/Pacific Islander.

^b Includes American Indian or Alaskan Native, Other, Unknown, and Declined.

^c Includes Arabic, Cambodian, Hindi, Tagalog, Thai, and Vietnamese.

^d $p < 0.05$.

^e n1 = highest neighborhood socioeconomic status (nSES), n5 = lowest nSES.

^f Includes mammography.

^g Includes all interventional radiology.

case management may be most beneficial to patients with Medicare or Medicaid to help them navigate their health care efficiently.

Finally, educational initiatives exploring nuances of health insurance coverage may help create a lasting, patient-centered foundation for future radiology practices. Vijayasarithi et al. demonstrated that radiology residents lack important knowledge on the cost of commonly performed imaging studies, suggesting a need for targeted education in this area.⁴⁴ Sarwar et al. and Leddy et al. implemented a role for a resident quality improvement director and curriculum,^{45,46} which both

fulfills Accreditation Council for Graduate Medical Education and ACR noninterpretive milestones,⁴⁷ as well as guides radiology departments toward more direct patient care. Expanded education and training for residents in care coordination for patients could be an important step toward fostering improved equity in imaging utilization.

Our study had five limitations: First, we did not consider whether the radiology report was communicated to the patient by the referring provider. Second, we only included patients whom we determined were receiving their imaging care predominately at our institution to reduce

the uncertainty of patients continuing their imaging care outside our institution or truly being lost to follow-up. Third, our patient demographic data was self-reported and thus, subject to error. Fourth, there was broad agreement within our institution's radiology department that the three keywords used in our search query would result in the clearest and most direct recommendation for follow-up imaging with active language, and we acknowledge that other institutions may use different language to communicate a direct recommendation for follow-up imaging in their practice. Lastly, our sample size was limited in relying on only a one-month sample to allow for manual review of every single case.

5. Conclusion

Our research demonstrated that patients with Medicaid were less likely to complete follow-up imaging recommendations compared to patients with commercial insurance, emphasizing the need for radiology departments to better promote equitable imaging access for all patients. Without an improved understanding of which patient-level factors limit access, standardized reporting systems enabling us to provide equal care could potentially contribute to ongoing health inequities. Radiologists should be actively engaged in understanding the effects of barriers to imaging across different groups and aim to develop workflows that help to mitigate these barriers.

Author roles

All authors substantially contributed to the conception or design of the work, the writing and/or revision of the manuscript, approved the final version of the manuscript, and are accountable for the manuscript's contents.

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Statement on data access and integrity

The authors declare that they had full access to all of the data in this study and the authors take complete responsibility for the integrity of the data and the accuracy of the data analysis.

Declaration of competing interest

The authors declare no conflict of interest.

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