AJR FOCUS ON:

Reducing Delay in Diagnosis: Multistage Recommendation Tracking

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OBJECTIVE. The purpose of this study was to determine whether a multistage tracking system could improve communication between health care providers, reducing the risk of delay in diagnosis related to inconsistent communication and tracking of radiology follow-up recommendations.

MATERIALS AND METHODS. Unconditional recommendations for imaging follow-up of all diagnostic imaging modalities excluding mammography (n = 589) were entered into a database and tracked through a multistage tracking system for 13 months. Tracking interventions were performed for patients for whom completion of recommended follow-up imaging could not be identified 1 month after the recommendation due date. Postintervention compliance with the follow-up recommendation required examination completion or clinical closure (i.e., biopsy, limited life expectancy or death, or subspecialist referral).

RESULTS. Baseline radiology information system checks performed 1 month after the recommendation due date revealed timely completion of 43.1% of recommended imaging studies at our institution before intervention. Three separate tracking interventions were studied, showing effectiveness between 29.0% and 57.8%. The multistage tracking system increased the examination completion rate to 70.5% (a 52% increase) and reduced the rate of unknown follow-up compliance and the associated risk of delay in diagnosis to 13.9% (a 74% decrease). Examinations completed after tracking intervention generated revenue of 4.1 times greater than the labor cost.

CONCLUSION. Performing sequential radiology recommendation tracking interventions can substantially reduce the rate of unknown follow-up compliance and add value to the health system. Unknown follow-up compliance is a risk factor for delay in diagnosis, a form of preventable medical error commonly identified in malpractice claims involving radiologists and office-based practitioners.

Keywords: actionable findings, delay in diagnosis, diagnostic error, follow-up, recommendation tracking

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Recommendations for follow-up imaging associated with abnormal radiology test results are present in 2–5% of all radiology reports [1, 2]. A recommendation in a radiology report implies a risk for the development of malignancy or other serious medical condition. Reported compliance with obtaining recommended follow-up imaging for an abnormal radiologic finding is highly variable (range, 29–77%) [3, 4]. Inconsistent follow-up places patients at risk for delay in diagnosis.

Delayed cancer diagnosis is associated with patient harm, increased health care costs, and malpractice claims [5–8]. A 2011 report from the American Medical Association identified communication breakdowns between radiologists, referring providers, and office-based practitioners as a significant source of medical error in the outpatient setting [9]. Communication of test results is particularly vulnerable during transitions of care, such as the transition of patients between hospital and outpatient settings, which is a common occurrence for patients of hospital-based radiology practices [10].

Malpractice lawsuits alleging failure of communication of radiologic test results are prevalent and are becoming more so [11]. Inadequate communication of abnormal radiologic test findings to the referrer is the third most common primary cause of medical malpractice lawsuits against radiologists in the United States [12]. Errors identified in malpractice claims are often multifactorial, with breakdown in communication identified as a causative factor in as many as 80% of malpractice lawsuits involving radiologists

[13]. Missed opportunities resulting in a preventable delay in the diagnosis of malignancy related to noncompliance with follow-up imaging recommendations occur for 15% of lung cancer diagnoses [5].

Although it seems reasonable to assume that tracking recommendations would lead to an increase in recommended examination completion, this has not been documented in the literature. Published studies have attempted to measure the effectiveness of electronic health record (EHR)–based alert notification systems, primarily within the U.S. Department of Veterans Affairs. A study of 1196 alerts found no statistically significant difference in the rate of proper follow-up between acknowledged and unacknowledged alerts for abnormal test results [14]. Sending EHR-based alerts to both the primary care provider (PCP) and the ordering clinician decreased the likelihood of timely follow-up, a finding that was attributed to diffusion of responsibility [15]. Missed test results have also been attributed to alert fatigue when EHR-based alerts are used [16].

Despite the increase in national attention to the problem of medical errors since publication of the Institute of Medicine's report *To Err is Human: Building a Safer Health System* in 1999 [17], millions of patients continue to be affected by preventable medical errors each year. Adopting the science of high-reliability systems into health care practice is currently a focus of the Joint Commission [18]. High-reliability systems have a goal of achieving zero patient harm. Reaching this goal requires a preoccupation with failure and the development of resilient multistep processes.

Materials and Methods

A three-stage system known as the Backstop system was developed to track recommendations for follow-up radiologic imaging studies and image-guided interventional procedures. All imaging modalities were included, with the exception of mammography. Recommendations were tracked for patients from the emergency department and inpatient and outpatient settings. Recommendations meeting the inclusion criteria included those for abnormal findings with malignant potential and vascular aneurysm. The criteria were designed to align with existing American College of Radiology white papers on incidental findings and other common recommendation guidelines, such as the Fleischner Society criteria. Both indeterminate lesions requiring further characterization and findings requiring interval follow-up were included.

Radiologists flagged reports with unconditional recommendations meeting the inclusion criteria at the time of dictation, and these reports were then entered into a custom database management system (Access, 2010 version, Microsoft) developed in house for this tracking system. Unconditional recommendations were presented in the following format: "CT chest recommended in 6 months." Conditional recommendations, such as "MRI abdomen should be considered for further characterization if warranted clinically," were not included. Each recommendation that was entered into the database management system required a specific imaging modality (or modalities) that would satisfy the recommendation plus a recommendation due date. If a range was provided for the recommendation due date, then the longest time interval was used for tracking purposes. Individual recommendations were tracked instead of patients or reports, because some reports contained more than one recommendation with distinct recommended imaging modalities and due dates.

All tracking interventions were directed to the patient's PCP. Using PCPs as the sole contact for follow-up interventions eliminated potential confusion for the clerical navigator regarding which provider was responsible for arranging follow-up. If no PCP was documented for a patient, a letter was sent directly to the patient explaining that a radiology recommendation was overdue and encouraging the patient to obtain a PCP and discuss the recommendation with him or her.

Timely follow-up was defined as completion of the recommended imaging test or procedure within the interval from 1 month before to 1 month after the recommendation due date. For example, timely examination completion for a study recommended in 6 months was obtained between 5 and 7 months after the initial study. One month after the recommendation due date, the radiology information system was queried to determine whether the recommended study had been completed or scheduled. If it was completed, this was documented, and tracking for this recommendation was closed. If it was not completed, the stage 1 intervention was performed. This intervention consisted of resending the radiology report in question to the patient's PCP along with a cover letter explaining that an outstanding recommendation had been identified. This form was then faxed back to the clerical navigator with an explanation as to why the recommendation was not performed, if such an explanation could be identified by the PCP's office staff.

One month after the stage 1 intervention was performed, the radiology information system was again queried regarding completion of the recommended study. If the study was not completed, the stage 2 intervention (a telephone call from the clerical navigator to the PCP's office staff or nurse) was performed. If no information obtained from this telephone conversation allowed us to close the tracking of this recommendation, we again queried the radiology information system the following month. For studies that still were not completed, the stage 3 intervention (a direct telephone call from the radiologist to the PCP) was performed. For any recommendation that could not be closed after this discussion, a letter was sent to the patient explaining that an overdue radiology recommendation existed and encouraging the patient to contact his or her PCP (Table 1). Satisfactory clinical closure was categorized as surgical biopsy or resection, limited life expectancy or death, and other forms of appropriate clinical management inclusive of subspecialist referral. Recommendations could be cancelled by the radiologist at any stage if additional information was obtained that eliminated the risk to the patient from the abnormal finding, most commonly identification of a remote comparison study showing lesion stability that was performed at an outside institution.

Results

A total of 879 follow-up recommendations were entered into the tracking system from February 1, 2015, to February 29, 2016. This represented 1.3% of all 69,867 diagnostic radiology studies performed in our health care system over these 13 months. A total of 589 of the 879 entered recommendations (67.0%) were tracked to completion within the time frame of this project. The remaining recommendations had due dates after the end of the study period.

TABLE 1: Tracking Intervention Timeline

Intervention	Description of Intervention	Intervention Timing
Stage 1	Resend the radiology report	1 month after recommendation due date
Stage 2	Clinical navigator makes telephone call to PCP office	2 months after recommendation due date
Stage 3	Radiologist makes telephone call to PCP	3 months after recommendation due date
Patient letter	Send letter directly to patient[a]	As soon as tracking efforts were stopped

Note—PCP = primary care provider.
[a]Letter was sent to all patients without examination completion or clinical closure.

TABLE 2: Intervention Outcomes by Stage for 589 Recommendations

Intervention Outcome	At Baseline (*n* = 589)	After Intervention(s)			
		Stage 1 (*n* = 296)	Stage 2 (*n* = 203)	Stage 3 (*n* = 64)	Aggregate (*n* = 589)
Examination completion	273 (46.3)	60 (20.3)	55 (27.1)	12 (18.8)	400 (67.9)
Completion identified in hospital radiology information system	254 (93.0)	41 (68.3)	18 (32.7)	4 (33.3)	317 (79.3)
Completion outside of hospital	0 (0.0)	15 (25.0)	33 (60.0)	7 (58.3)	55 (13.8)
Alternative imaging performed	9 (3.3)	4 (6.7)	4 (7.3)	1 (8.3)	18 (4.5)
Examination completed early	10 (3.7)	0 (0.0)	0 (0.0)	0 (0.0)	10 (2.5)
Clinical closure	4 (0.7)	25 (8.4)	45 (22.2)	18 (28.1)	92 (15.6)
Subspecialist referral or resolution	0 (0.0)	13 (52.0)	29 (64.4)	10 (55.6)	52 (56.5)
Limited life expectancy	0 (0.0)	10 (40.0)	13 (28.9)	0 (0.0)	23 (25.0)
Biopsy	4 (100.0)	2 (8.0)	1 (2.2)	0 (0.0)	7 (7.6)
Recommendation cancelled	0 (0.0)	0 (0.0)	2 (4.4)	8 (44.4)	10 (10.9)
Examination completion after patient letter was sent	2 (0.3)	1 (0.3)	5 (2.5)	7 (10.9)	15 (2.5)

Note—Data are number (%) of recommendations.

Baseline (Preintervention Stage)

For 254 of the 589 recommendations (43.1%) that were tracked and closed, the recommended study was completed at our institution in a timely manner (within a month before or after the recommendation due date) (Table 2). An additional 10 recommended studies (1.7%) were completed more than 1 month before the recommendation due date. Of these 10 examinations, seven (70.0%) did not resolve the clinical question, and generation of an additional recommendation was required. In these cases, the initial recommendation was considered closed, and a new recommendation was entered to prevent duplicate tracking of a single abnormal finding. For nine patients (1.5%), an alternative imaging study was performed that resolved the clinical question despite the imaging modality not matching the recommended imaging modality. Four recommendations were clinically closed after biopsy or resection. During data entry, 16 patients (2.7%) were identified as not having a documented active PCP. The remaining 296 recommendations (50.3%) entered the first stage of the tracking system.

Stage 1 (Resend the Report)

In the month after the stage 1 intervention was performed, a total of 60 patients (20.3%) were confirmed to have undergone imaging (Table 2). Information obtained after the stage 1 intervention allowed clinical closure for 25 recommendations (8.4%). Tracking was discontinued for eight patients (2.7%) at risk for being lost to follow-up (Table 3). The effectiveness of the stage 1 intervention inclusive of examination completion and clinical closure was 29.0% (Table 4). The remaining 203 tracked recommendations (68.6%) were advanced to stage 2.

Stage 2 (Call From Clerical Navigator to Primary Care Provider)

In the month after the stage 2 intervention was performed, a total of 55 patients (27.1%) were confirmed to have undergone imaging (Table 2). Information obtained after the stage 2 intervention allowed clinical closure for an additional 45 recommendations (22.2%). Tracking was discontinued for 39 patients (19.2%) at risk for being lost to follow-up (Table 3). The effectiveness of the stage 2 intervention inclusive of examination completion and clinical closure was 51.7% (Table 4). The remaining 64 tracked recommendations (31.5%) were advanced to stage 3.

Stage 3 (Call From Radiologist to Primary Care Provider)

In the month after the stage 3 intervention was performed, a total of 12 patients (18.8%) were confirmed to have undergone imaging (Table 2). Information obtained after stage 3 intervention allowed clinical closure for an additional 18 recommendations (28.1%). The radiologist cancelled eight recommendations (12.5%). Examination completion or clinical closure was not possible for the remaining

TABLE 3: Reasons Why Tracking Was Discontinued for 97 Patients Who Were at Risk for Being Lost to Follow-Up

Reason for Discontinuation	Timing of Discontinuation				
	At Baseline	Stage 1	Stage 2	Stage 3	Aggregate
No PCP	16 (100.0)	2 (25.0)	2 (5.1)	1 (2.9)	21 (21.6)
Patient was noncompliant	0 (0.0)	4 (50.0)	23 (59.0)	19 (55.9)	46 (47.4)
PCP was informed	0 (0.0)	1 (12.5)	9 (23.1)	14 (41.2)	24 (24.7)
Patient was not active patient of listed PCP	0 (0.0)	1 (12.5)	4 (10.3)	0 (0.0)	5 (5.2)
Out-of-network PCP	0 (0.0)	0 (0.0)	1 (2.6)	0 (0.0)	1 (1.0)
All, no. of patients/total patients (%)	16/589 (2.7)	8/296 (2.7)	39/203 (19.2)	34/64 (53.1)	97/589 (16.5)

Note—Except where indicated otherwise, data are number (%) of patients. PCP = primary care provider.

TABLE 4: Outcomes of Recommendation Tracking by Intervention Stage

Outcome	Intervention Performed		
	Stage 1 (*n* = 296)	Stage 2 (*n* = 203)	Stage 3 (*n* = 64)
Examination completion	60 (20.3)	55 (27.1)	12 (18.8)
Clinical closure	25 (8.4)	45 (22.2)	18 (28.1)
Examination completion after patient letter	1 (0.3)	5 (2.5)	7 (10.9)
Tracking stage effectiveness	86 (29.0)	105 (51.7)	37 (57.8)

Note—Data are number (%) of recommendations.

34 patients (53.1%), despite all three interventions having been performed, and these patients were at risk for being lost to follow-up (Table 3). Either these patients were identified as noncompliant with PCP efforts to obtain recommended follow-up (19) or the PCP had lost track of the recommendation and expressed intent to order the recommended imaging test now that he or she had been reminded (14). Each of these 34 patients received a letter. The effectiveness of the stage 3 intervention inclusive of examination completion and clinical closure was 57.8% (Table 4).

Letters to Patients

Letters were sent to a total of 97 patients at risk for being lost to follow-up (Table 3). Of the 97 letters sent, 15 (15.5%) resulted in examination completion at our hospital. Examination completions associated with patient letters are presented in Table 2.

Complete Tracking System

The combined multistage tracking system increased the number of recommended imaging studies completed at our hospital from 254 (43.1%) to 317 (53.8%). In addition to these 63 imaging studies completed at our hospital, after one of our three interventions was completed, eight recommended imaging studies were performed at affiliated hospitals and 15 recommended imaging studies were performed at nonaffiliated imaging centers. After intervention, six patients had an alternative imaging study performed at our institution that answered the clinical question. Fifteen patients completed recommended imaging examinations after receiving a letter from our department explaining the overdue recommendation. From the 312 recommendations for imaging studies, a total of 107 such studies (34.3%) were completed after tracking intervention was done (Table 5).

The tracking system also provided information on acceptable clinical nonimaging follow-up and imaging tests performed at other facilities before our intervention that was not available to the clerical navigator on review of our radiology information system. The number of recommendations for which an acceptable rationale for clinical closure existed increased from four recommendations (0.7%) before tracking intervention to 92 recommendations (15.6%) after intervention. These recommendations included 52 patients managed clinically (by referral to a specialist or clinical resolution), 23 who had a limited life expectancy or died, and seven patients who underwent biopsy. Ten recommendations were cancelled on the basis of additional comparison study information obtained through intervention. In addition to these 88 clinical closures, information was obtained that confirmed preintervention completion of recommended imaging for 15 recommendations at affiliated hospitals and 17 recommendations at nonaffiliated sites. Three patients were identified as having an alternative imaging test performed before intervention that answered the clinical question. Information allowing confident closure of the recommendation directly attributable to tracking intervention was identified for 123 of the 312 recommendations (39.4%) for which intervention was performed.

When information on imaging completion was combined with information obtained that led to clinical closure; the tracking system confirmed satisfactory follow-up for 507 of 589 recommendations that were closed (86.1%). The remaining 82 recommendations (13.9%) remained lost to follow-up, largely related to patient factors (Table 3). Through our tracking efforts, our health system was able to reduce the rate of patients at risk for delay in diagnosis (i.e., patients with unknown compliance plus those who were lost to follow-up) from 53.0% to 13.9% (for a 74.0% reduction).

Discussion

Despite the increasing attention given to incidental findings by the American College of Radiology, delay in diagnosis, a form of preventable diagnostic medical error commonly identified in malpractice claims involving radiologists and office-based practitioners, persists [10, 15, 19]. Communication breakdowns between hospital-based referring providers and office-based practitioners place radiologists and their patients at risk [8–10]. Given the serious or fatal harm that can be associated with a delay in the diagnosis of malignancy, a high-reliability safety-net tracking system was implemented with the goal of adding value to our health system by reducing the risk of diagnostic medical error.

A number of strategic considerations were required in the development of the Backstop tracking system, given what is, to our knowledge, the absence of a similar reported system in the literature. Because communication breakdowns are difficult to measure and eliminate, we chose to support the communication and tracking systems currently in place, performing tracking interventions only for patients without confirmed examination completion 1 month after the recommendation due date. This approach encouraged a collaborative relationship with our PCPs, whose office-based practices assisted with our interventions. We partnered exclusively with PCPs and their offices to avoid confusion regarding whether the referring hospital-based provider, subspecialist provider, or PCP was responsible for arranging the follow-up examination.

Tracking could not be performed for recommendations lacking actionable characteristics—namely, a specific imaging modality and due date. Addenda were requested and obtained for all tagged recommendations lacking specificity. This single action was 100% effective in improving this aspect of the recommendations entered into the tracking system. Tracking is also impractical for conditional recommendations because determination of whether conditional clinical

TABLE 5: Recommended Imaging Studies Completed After Tracking Interventions Were Performed

Examination	No. (%) of Imaging Studies Completed
CT	64 (59.8)
MRI	14 (13.1)
Ultrasound	21 (19.6)
Radiography	8 (7.5)
Total	107 (100.0)

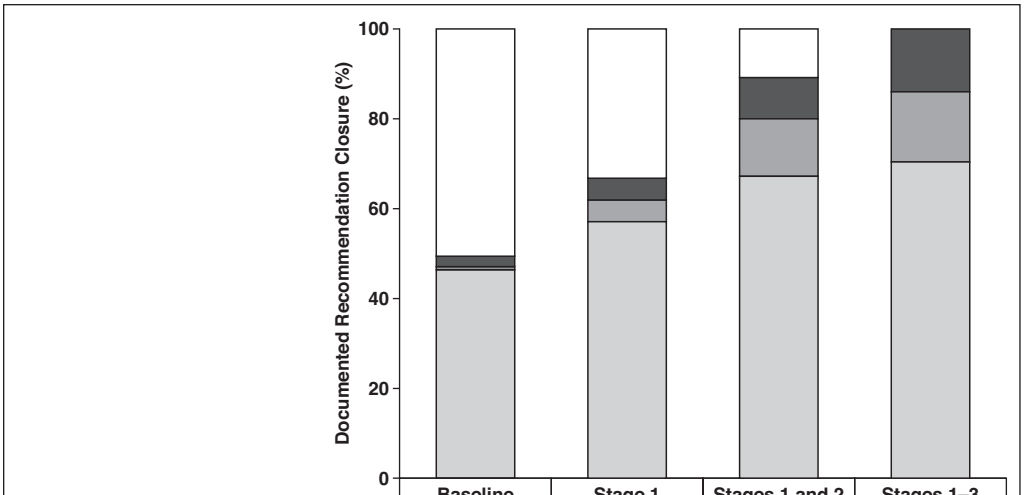
criteria have been met cannot easily be performed by non–clinical navigator staff. The risk of abnormal radiologic results associated with conditional recommendations is typically lower than that associated with unconditional recommendations.

Many referring offices used disparate EHR systems, which did not allow us to include EHR notifications in the tracking system used in this study. Development of an EHR-centric tracking system within a highly integrated health system may have altered our choice of tracking interventions. Involving patients in the tracking process aligns with a patient-centered care model and provides a low-cost mechanism to improve compliance [20]. Every patient for whom we could not document examination completion or clinical closure was informed of the outstanding recommendation via a letter.

Nonimaging or clinical follow-up of abnormal radiologic results has not been well described in the literature given the difficulty of manually obtaining this information. Through our tracking efforts, we were able to identify the relative frequency of satisfactory nonimaging closure composed of subspecialist referral, limited life expectancy or death, and biopsy (Table 3). Subspecialist referral to oncologists and surgeons accounted for 57% of nonimaging closure. Limited life expectancy (inclusive of patients receiving palliative care and deceased patients) was the only other category of clinical closure that occurred frequently (25%). Although the risk of delay in diagnosis may not be completely eliminated after PCP referral to a subspecialist, it presumably was reduced substantially, and tracking the subsequent workup was considered beyond the scope of the present study. An opportunity to identify nonclinical closure before intervention would be present in health systems that share an EHR system integrated with that of office-based providers. Examination completions performed outside of the health system and with the use of alternative imaging modalities identified by our tracking system (representing 14% and 5% of examination completions, respectively) would potentially be misconstrued as noncompliance by an automated EHR-based tracking system.

Performing the three intervention stages sequentially likely reduced the effectiveness of stage 2 and 3 interventions because of selection bias. Despite this, the effective closure rate of stage 2 (51.7%) and stage 3 (57.8%) interventions remained higher than the closure rate of the stage 1 intervention (29.0%). None of the interventions tested resulted in an effective closure rate high enough to approach a high-reliability system if used in isolation, confirming our suspicions during the design of the Backstop system. Consequently, we believe that multistage tracking systems beginning with minimally intrusive intervention and progressing to more disruptive interventions will be required to eliminate preventable medical error related to inconsistent communication between providers. Patient factors, such as lack of a PCP and noncompliance with either obtaining scheduled imaging studies or attempts to schedule office appointments to discuss actionable radiologic findings, accounted for 72% of the 13.9% of tracked patients without confirmed closure. Mailing a letter to these patients resulted in an examination completion rate of 15.5%, the lowest effective closure rate for an intervention studied. Although this rate is influenced by selection bias, it also shows that more aggressive patient contact interventions may be required to reduce risk further. Additional investigation into the specific causes of patient noncompliance, such as a lack of insurance, difficulty with scheduling or transportation, a need for translation services, medical comprehension, and cost of follow-up examinations, may prove beneficial.

From the perspective of the health system, each patient for whom examination completion or clinical management cannot be confirmed represents a risk for delay in diagnosis. The multistage tracking system developed for this study was able to reduce the rate of unknown compliance with recommendations from 53.0% to 13.9% (for a 74% reduction) by both increasing the examination completion rate and gathering information regarding clinical closure (Fig. 1). Measuring the rate of patient harm secondary to preventable delay in diagnosis is not easily performed. In our health system, the reported rate of severe patient harm events directly related to a breakdown in the communication of abnormal radiology test results during the



	Baseline	Stage 1	Stages 1 and 2	Stages 1–3
Unknown compliance (% of patients)	50.6	34.5	10.9	0.0
Lost to follow-up (% of patients)	2.4	3.6	9.3	13.9
Clinical closure (% of patients)	0.7	4.9	12.6	15.6
Examination completed (% of patients)	46.3	57.0	67.2	70.5

Fig. 1—Aggregate tracking system effectiveness. Bar graph shows that multistage tracking system developed for study achieved, with each subsequent intervention, reductions in rate of unknown compliance with recommendations. Examination completion category includes examinations performed after letters were sent, attributed to intervention stage in which they were sent.

4 years before intervention was 1.33 events per 100,000 diagnostic examinations. Using this as a baseline, risk reduction associated with our interventions can be estimated to reduce severe patient harm to 0.35 events per 100,000 diagnostic examinations. Although no adverse events related to delay in diagnosis were reported in the year subsequent to the present study, our sample size was too small to confidently confirm the estimated impact on patient harm. Implementation of a similar tracking system within a large health system over a number of years would allow more definitive assessment of risk reduction.

In addition to reducing the risk of patient harm and limiting medical legal liability, tracking recommendations resulted in the added benefit of increased fee-for-service revenue. More than 72% of additional examinations completed after tracking intervention were either CT or MRI (Table 5). The technical revenue generated from the 18.2% of examinations completed after tracking intervention was 5.2 times the labor cost of the clerical navigator position, which was the primary expense associated with the program. Most of this revenue (78.5%) was captured at our hospital, resulting in an annual return on investment that was 4.1 times greater than the labor cost, discounting the variable costs of imaging. Identifying quality initiatives that add value to both patient care and the finances of health systems is critical given the competition for limited resources available at hospitals facing shrinking operating margins.

The present study has shown the value of multistage radiology recommendation tracking to reduce preventable patient harm, reduce medical legal liability, and increase revenue. We did not attempt to validate the consistency of tracked recommendations with available guidelines. Prior research has shown high variability and inconsistency in this regard. To further increase the value added by tracking recommendations, the effectiveness of new information technology tools, such as point-of-care clinical decision support for evidence-based recommendation generation, should be investigated. It is difficult to estimate the degree to which radiologists were compliant with entering recommendations that met our inclusion criteria. Validation of the effectiveness of natural language processing to prospectively identify radiology reports with recommendations worthy of tracking may eliminate the need for radiologists to enter examinations into tracking systems and may improve the capture rate of appropriate recommendations. Randomized controlled trials testing alternative tracking methods may increase the efficiency and effectiveness of tracking efforts before more widespread adoption of the practice.

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