BMJ Open Quality

Process improvement for follow-up radiology report recommendations of lung nodules

Philip S Lim,[1] Doron Schneider,[2] Jonathan Sternlieb,[2] Michel Taupin,[1] Nicholas Sich,[3] Joan Dian,[1] Eileen Jameson,[4] Bryan Frambes,[5] Sharon Taylor[5]

To cite: Lim PS, Schneider D, Sternlieb J, *et al*. Process improvement for follow-up radiology report recommendations of lung nodules. *BMJ Open Quality* 2019;**8**:e000370. doi:10.1136/bmjoq-2018-000370

► Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/bmjoq-2018-000370).

Received 1 March 2018
Revised 29 March 2019
Accepted 10 April 2019

[1]Department of Radiology, Abington Hospital, Jefferson Health, Abington, Pennsylvania, USA
[2]Department of Medicine, Abington Hospital, Jefferson Health, Abington, Pennsylvania, USA
[3]Department of Surgery, Abington Hospital, Jefferson Health, Abington, Pennsylvania, USA
[4]Abington Hospital, Jefferson Health, Abington, Pennsylvania, USA
[5]Healthcare Administrative Partners, Media, Pennsylvania, USA

Correspondence to
Dr Philip S Lim;
philip.lim@jefferson.edu

ABSTRACT

In the modern healthcare system, there are still wide gaps of communication of imaging results to physician and patient stakeholders and tracking of whether follow-up has occurred. Patients are also unaware of the significance of findings in radiology reports. With the increase in use of cross-sectional imaging such as CT, patients are not only being diagnosed with primary urgent findings but also with incidental findings such as lung nodules; however, they are not being told of their imaging findings nor what actions to take to mitigate their risks. In addition, patients at high risk for developing lung cancer often obtain serial CT scans, but tracking these patients is challenging for the clinician. In order to advance quality improvement goals and improve patient outcomes, we developed a custom application and business process for radiology practitioners that mines available healthcare data, identifies patients with lung nodules in need of follow-up imaging, notifies the patient and the primary care physician via mail, and measures process efficacy via executed follow-up screenings and captured patient condition.

This integrated analytics and communication process increased our average rate of patient follow-ups for lung nodules from 26.50 in 2015 to 59.72% in 2017. 17.18% of these patients had new lung nodules or worsening severity of lung findings detected at follow-up. This new process has added missing quality and care coordination to an at-risk patient population.

Problem Communication of imaging results and follow-up recommendations to patients and primary care providers (PCPs) is a challenge for healthcare systems. In addition, tracking whether a patient's follow-up has been completed is another significant gap in care coordination. Patients are often unaware of or cannot even understand the significance of radiology findings or follow-up recommendations reported after imaging procedures. In addition, patients may not have a primary physician listed at time of imaging if the first encounter is in the emergency room (ER) or if their primary care physician or specialist works in a different electronic health record platform. Communication of imaging results to different healthcare providers is challenging with the myriad of existing electronic health record systems that often lack interoperability with other clinical entities. Description of lung nodules in radiology reports can vary widely if a standardised lexicon is not used. Moreover, follow-up recommendations by radiologists can be varied for certain size lung nodules because an individual's risk factors to develop lung cancer may not be known at the time of dictation.

Approximately 500 000 radiology imaging procedures are interpreted and performed annually by a single private group of 33 radiologists located at a 665-bed regional referral centre and at a 140-bed acute care community hospital, both located in the suburbs of a major metropolitan city. Management of this volume of patients in the health system can be overwhelming to nurse navigators, and there is usually no system in place for primary care physicians to follow-up lung nodules found unexpectedly on inpatient images. The goal of this project was to develop a better automated tracking method and communication tool to reduce the likelihood that needed follow-up studies are missed by patients and clinicians.

BACKGROUND

The Fleischner Society guidelines for follow-up of incidentally noted pulmonary nodules are widely accepted and firmly established with updates recently published.[1 2] Approximately 10% of chest CT imaging studies report incidental pulmonary nodules that have follow-up imaging recommendations in patients who had CT pulmonary angiographic studies ordered from the emergency department.[3] However, actual follow-up imaging in these patients has been reported to be only about 29% if the 'impression' section had explicit follow-up recommendations but decreased to 0% if the follow-up recommendation was located only in the 'findings' section of the radiology report rather than in the 'impression' section. Others have reported variability in compliance which depended on the patient status as an outpatient (63%), ER (15%) or inpatient (27%) at the time of their initial CT scan, impacting adherence to follow-up imaging recommendations.[4]

Follow-up of high-risk patients in lung cancer screening programme who are referred within institutions that have shared decision-making among stakeholders, programme navigators, dedicated database management and standardised discharge protocols has been reported as high as 85.7%,

but adherence to follow-up of patients referred from outside institutions is unknown.[5]

MEASUREMENT

There is an existing Health Level-7 interface between the Radiology Information System (RIS) and the billing company whose primary function is revenue cycle management. The billing company's expertise and resources can be used to augment the often-limited information technology (IT) and care coordination resources at many large health systems.

The transactions from the RIS send patient demographics (ADT) and result information (ORU) to the billing company's interface engine. Development of a data analytics programme within an independent billing company which can analyse the text of radiology reports, track patients and their follow-up studies, and communicate follow-up requests via letters is a logical resource. The billing company's expertise and resources can be used which can be created to augment the often-limited IT and care coordination resources at many large health systems.

Radiology reports over a 6-month period from June to December 2015 were reviewed to establish our baseline follow-up rate. If the patient had a follow-up chest CT study after the initial CT study, then the follow-up was noted to be complete. Follow-up of imaging findings was 26.50% in 2015. After we designed new interventions described below, we subsequently measured the follow-up of incidental findings in radiology reports.

DESIGN

Monthly meetings with a larger multidisciplinary team included two physician patient safety officers, a radiology administrative director, a physician who served as chief medical information officer, a champion radiologist, a surgical resident and a senior hospital administrator. This group designed the process of letter notification to the PCP and patient and identified what clinical radiological follow-up was to be queried for 'proof of concept'. Lung nodule(s) due for follow-up was chosen as the primary focus since this scenario has the most widely accepted, evidence-based recommendations.

A smaller working group consisted of the champion radiologist and an analyst with IT and nursing experience (the latter employed by the billing company) who met weekly to review identified cases. Initially, a commercially available Natural Language Processing (NLP) system was used to identify which cases were overdue for follow-up based on the radiologist's recommendations in the clinical imaging report. Early concept testing through weekly reviews of new cases proved that manually sorting through and finding studies with lung nodules was impractical and labour intensive. As a result, a custom application was soon developed that queried patients with lung nodules, looked for associated follow-up indicators, and then assigned the follow-up due date. When a patient was overdue for follow-up imaging, a notification letter was first sent to the patient's primary care doctor and then, after a 2-week delay, a notification letter was sent to the patient (online supplementary file). This allowed a window for discussion between the primary physician and the patient. The patient's radiology record was then queried for evidence of a return visit.

The ORU transaction contains the ordering physician along with the order information, location and the result. In inpatient and ER visits, the ordering physician will most likely not be the PCP, so letters were sent to patients only for these visit types. Patient letters are very generic and worded to be non-alarming. The letters tell the patient of a finding which may need follow-up and are given instructions to contact their PCP. If they do not have a PCP, the hospital number is in the letter to help them find a PCP. In outpatient visits, the ordering doctor may be a specialist and not the primary care doctor. The physician letter contains a checklist along with the fax number to the billing company. The PCP can fax information back to the billing company to allow communication from the PCP to be entered back into the clinical analytics system.

The radiology champion met with the primary care physicians and their office managers at monthly meetings to educate them about these follow-up letters that they and their patients would be receiving in the mail. The Chief Medical Officer strongly emphasised that the PCP would be responsible for determining if follow-up imaging would be needed after review of the patient's risk factors and clinical history, even if the PCP was not the one ordering the original imaging study. The PCP was the most central care coordinator best equipped at managing patient problem lists and orchestrating needed follow-up since the PCP had the most complete clinical history and relationships with referring specialists.

STRATEGY

PDSA Cycle 1: In the NLP commercial software, we could identify the radiology reports that were overdue for follow-up based on data from 2016. However, we also realised the laborious work needed to track the patients, opting instead to use an export into Excel spreadsheets from the NLP which contained the full report and other key elements needed for tracking. Functions were built in the excel spreadsheet using a variety of words that would ultimately identify patients with lung nodules. The export only contained NLP identified reports with follow-ups detected as overdue.

PDSA Cycle 2: As we began taking exports from older studies, we realised that the Excel spreadsheets became quite voluminous with multiple patients and that access to prior reports and their time stamps was needed. We also needed to reference the report data exported from the NLP with data from the billing system to get addresses for the patients and the PCPs. This was done manually in spreadsheets with lookup functions. At this point, a computer programmer was hired to automate this process

of gathering all radiology reports and create a database to track letters sent. The first set of 148 letters from the manual work was sent during this cycle and included letters for patients with overdue studies from September 2016 to January 2017.

PDSA Cycle 3: The first iteration of the custom designed analytics system was used to review radiology reports and significantly decreased the time requirement of reviewing and assigning intervals for follow-up. At the time, the software was still using the exported data from the NLP which only included overdue studies. Once brought into the new system, the profile logic in the customised analytics system was applied to data mine the overdue reports for the lung profiles. It became apparent that a 2-week delay needed to be implemented after the due date to reduce instances of patients returning for follow-up during the same period when reminder letters were being mailed. Each major iteration of the analytics system yielded an improvement in matching logic efficiency and thereby a decrease in average letters sent to less than 100 per month.

PDSA Cycle 4: Automation of Lung-RADS report follow-up due dates was implemented to enhance system intelligence and reduce the number of cases which needed to be reviewed. The Lung-RADS categories 1 through 4 were used to calculate the due date and to automate closing when the patient returned for follow-up. We further enhanced the software by tracking which lung nodules had resolved, improved or worsened at the time of follow-up. With our tracking of clinical conditions such as worsening of lung finding at follow-up imaging, we could identify patients who returned for follow-up with new lung nodules so that they could be placed in a separate category within the analytics system as patients who are at higher risk.[6]

PDSA Cycle 5: The customised software, now called a clinical analytics system, was enhanced by adding patient centric risk factors listed in radiology reports to the user interface, such as a cigarette icon to easily identify smokers, and also by highlighting patients who were under 35 years of age. The extraction and presentation of some of the risk factors as icons helped with clinical decision-making during manual review, when due dates would be assigned by Fleischner guidelines. After adding multiple prior radiology reports into the programme, review of prior studies became much easier to access. In addition, the ability to edit follow-up dates of subsequent imaging was added to the software. This development proved especially helpful when the patient presented for previous or subsequent visits for the same nodule or for screenings where visit intervals did not match recommended guidelines.

PDSA Cycle 6: The word profiles which were highly accurate were ranked in levels and the highest levels used to automate closure of cases that returned for follow-up. The radiology database was expanded to encompass data mining of reports dating back to 2015 since this was the year when we began our lung cancer screening programme. At this time, over 1 million studies were added to the software, which slowed letter sending while we performed testing. In July of 2017, we sent 43 letters, but by the months of August through October we were averaging over 250 letters sent per month. We found that during this upload of data, running our lung profiles first and then running overdue follow-ups resulted in a much higher volume of patients identified as needing follow-up for lung nodules. We also began adding more filter functions to the web-based user interface to enhance analytics capabilities. These filters could identify how the follow-up due date was determined, whether a patient letter or a PCP letter was sent, who the dictating radiologist was, and the place of service.

PDSA Cycle 7: We refined our follow-up profiles to include searching for follow-up terminology within a certain word count. This once again increased the number of follow-ups that were overdue through 2015. Until then, it took about 2 hours each week to identify when Fleischner patients needed to come back and to verify that follow-up was not already completed before sending letters. The software has been further enhanced so that the system generates a formatted export and emails it to the personnel who perform the mail merge, with letters going out the same day. In November and December, the number of mailed letters began decreasing again due to the testing and refinement of the new dictated follow-up logic. At this time, the system output averaged over 200 letters sent per month.

RESULTS

Overall, our results showed an increase in patients who returned for follow-up (table 1).

As improvements were made to the clinical analytics system, the volume of identified reports with overdue follow-up increased as did the identification of completed follow-up studies. Figure 1 shows the year over year increase in follow-up completed (85.66%) and follow-up overdue (28,28%) in years 2016–2017. 2015 data was imported into the analytics system starting from April 2015.

The PCP notification letter contains a feedback checklist to complete, which the provider faxes back to the billing company and the information on the fax is entered into the analytics system. Originally, the PCP feedback was stored in a single field (Report Status); however, when PCPs began to fax letters back, it was realised that a second field (Tracking Status) was needed to track

Table 1 Overview of results from April 2015 through 2017

Year	Overdue	Completed	% Follow-up completed
2015	702	186	26.50
2016	2535	1046	41.26
2017	3252	1942	59.72

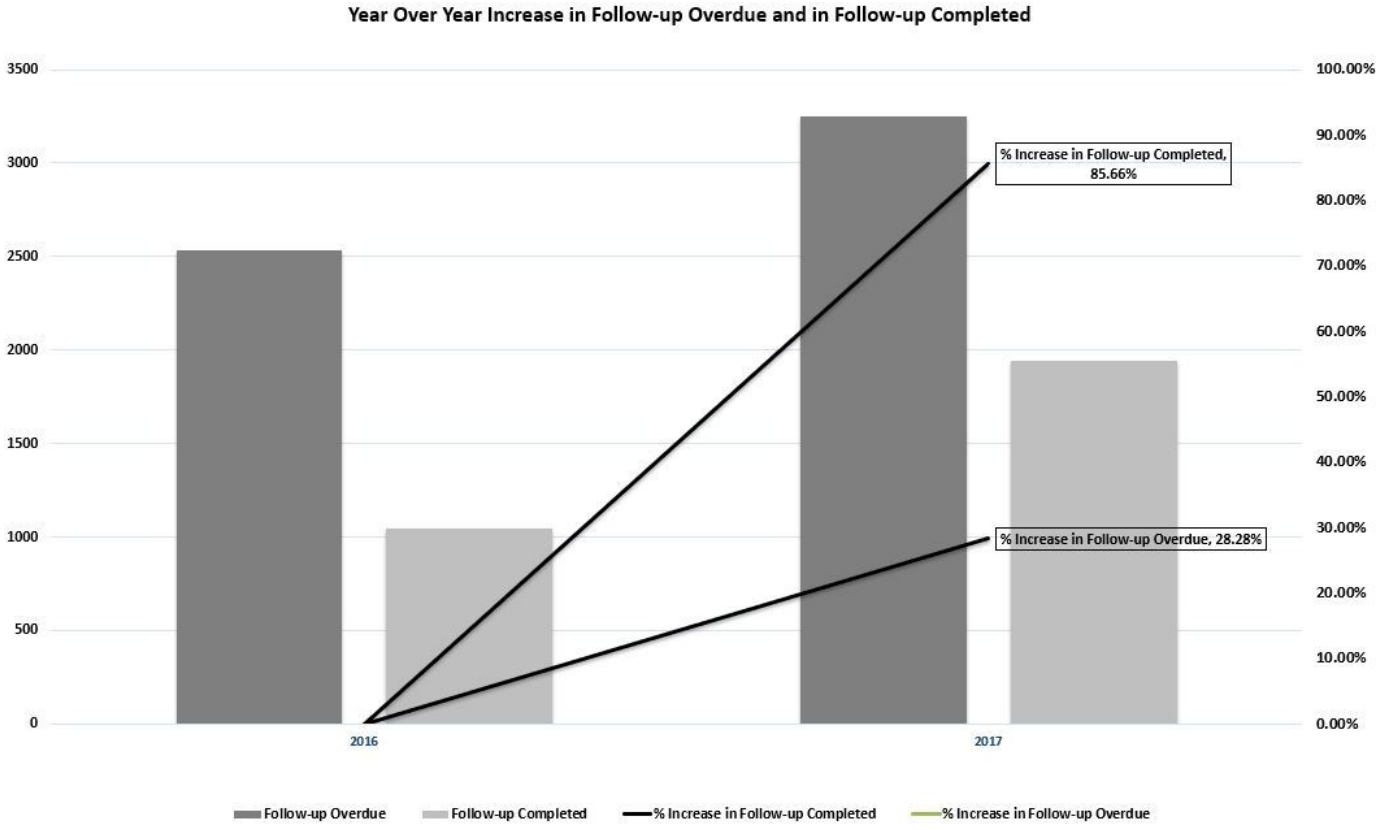

Figure 1 Year over year increase in follow-up.

feedback. For example, a report can have a 'Report Status' of 'Open' and the 'Tracking Status' of 'Exam ordered'. This report would not go to 'Follow-up completed' until the patient returned for follow-up imaging. Categories of feedback listed on the PCP letters included: patient declined, patient deceased, resolved symptoms, PCP will contact patient, imaging performed elsewhere, imaging not covered by insurance, follow-up completed, imaging exam ordered, not clinically relevant, and no documentation provided by the PCP. Figure 2 shows the breakdown of categories and responses by the PCP which were faxed back to the billing company.

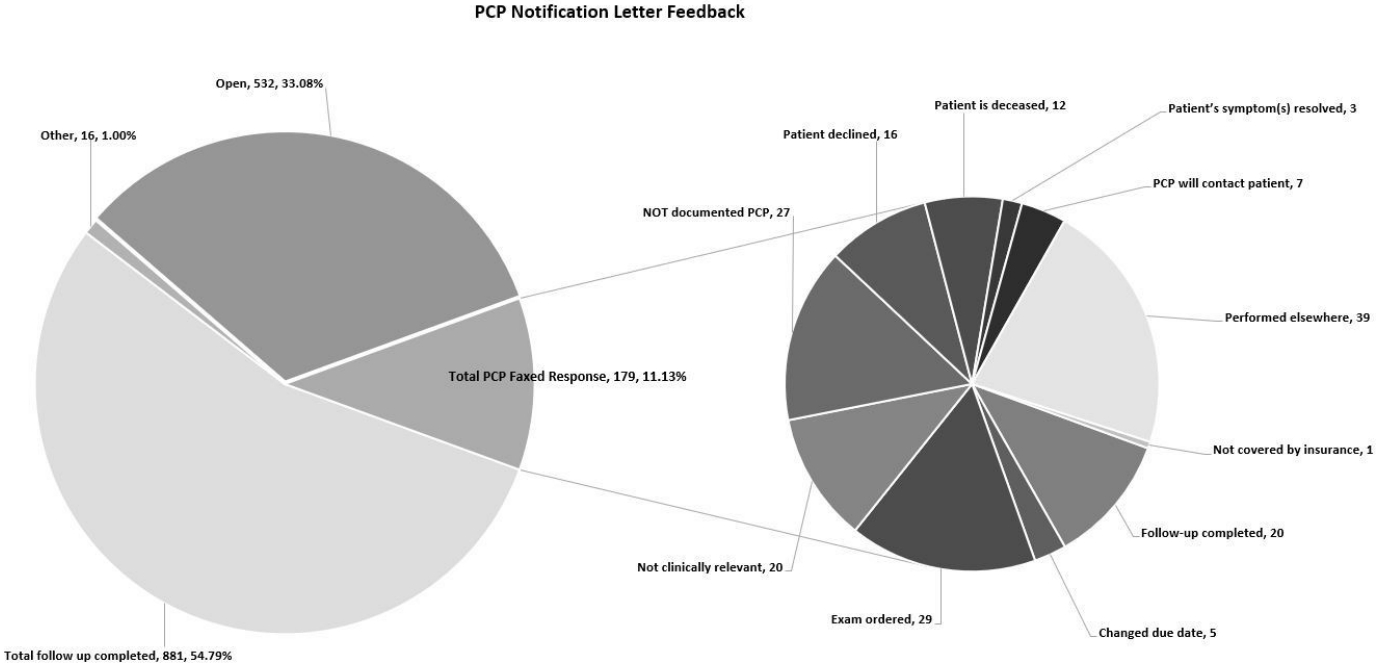

Figure 2 PCP letter feedback. PCP, primary care provider.

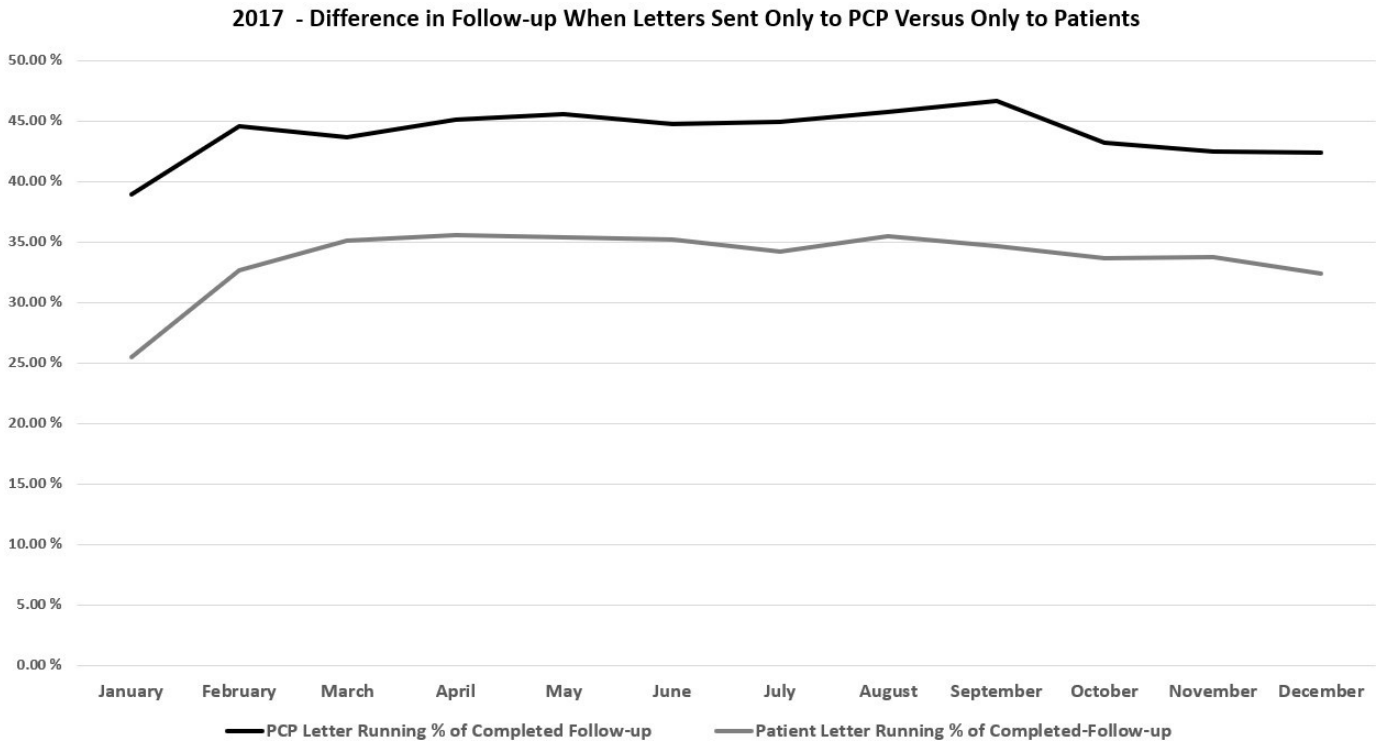

Figure 3 2017 Difference in follow-up when letters sent only to PCP versus only to patients. PCP, primary care provider.

For outpatients, the billing company has the PCP address and the patient address. However, for ER patients and inpatients, the ordering doctor is not usually the patient's PCP. The follow-up completed numbers were also measured by using the PCP letter send date or the patient letter send date to find which method of notification was more effective. The average return of patients improved by 10% when letters were sent to the PCP as compared with being only sent to the patient as shown in figure 3.

Patient's condition at time of follow-up was a manual data entry effort. Figure 4 lists the conditions of the patients at follow-up imaging: worsening, improved, new abnormality, new lung nodule, resolved, stable, and cannot determine. Most patients were stable (69.85%), and 8.42% improved or had resolution of lung findings. However, 6.16% of patients had new lung nodules, 4.21% had new non-lung findings and 11.02% had worsening of their conditions.

LESSONS AND LIMITATIONS

When we first started the lung nodule tracking programme, we believed that a commercially available NLP would be the sole answer to this issue. We quickly discovered that the complexity of tracking interval follow-ups in order to communicate the information with patients and their primary care physicians efficiently rendered the NLP software quite limited in its ability to achieve our objectives. We realised that, since all radiology reports, patient demographics and primary physician contact information was centrally located, a customised, internally developed software solution was the only path for us to utilise our resources wisely.

Acceptance by primary care physicians of the notification letter was a challenge but more easily accomplished after meeting the office managers and PCP administrative meetings. Many of these physicians never knew that their patients had radiology findings that needed follow-up, and some were resistant to take on this responsibility of addressing the situation since they did not order the initial study. Enlisting the aid of senior leadership to convince the primary care physician to take on this role was essential in order to close existing communication gaps at the root of the problem. For example, some of the studies were ordered when the patient was an inpatient, and communication of the radiology report to the primary care physician was often non-existent.

Another limitation of this project was the lack of direct input of patient stakeholders on this process improvement. However, there were patient advocates at the monthly PCP meetings, and these patient advocates suggested including letters translated into different languages for non-English-speaking patients.

We gained knowledge on critical trends by utilising the filters on the user interface to perform analysis and graph the data. We observed many patients who returned prior to the expected due date for follow-up. Some of these patients presented in the Emergency Department for a different reason for a CT study of the chest and dictated a follow-up of lung nodule based on comparison of the original study. This information rarely makes it back to the primary care doctor, who would then send the patient

for follow-up within the interval of the first study, thereby causing the patient to present twice when once may have been enough.

We were also seeing patients with a history of smoking who have a small nodule that has no follow-up dictated. During an earlier study, the patient was assigned a Lung-RADS category. This knowledge helped identify gaps in obtaining adequate history from the referring clinician. A recent article discovered that new lung nodules in patients enrolled in the National Lung Screening Trial were at higher risk for developing lung cancer.[6] As a consequence, we quickly adapted our analytics to identify and closely track this unique subset of high-risk patients.

We have also observed that there are patients who are followed regularly by a pulmonologist or their PCP. We have built a flag in the system to mark any such patient record so that, if they are being followed routinely, we will not send letters unless they miss a follow-up by a 6-month period of time.

We have seen speech recognition templates in radiology reports which list a series of different follow-up guidelines for different lung nodule sizes, giving us false queries. Simplification of dictation templates to include only pertinent follow-ups rather than an exhaustive list of nodule sizes and their corresponding follow-up intervals would remedy this problem. Our analysis affirms the potential for speech recognition errors that require optimisation and diligent proofreading; for example, a 'for millimetre lung nodule' in the radiology report is really a '4 mm lung nodule'.

The fact that the radiology reports were not standardised was a core hurdle of this initiative. Standardisation of transcription has been discussed previously in the literature.[7–9] In our opinion, it would be very challenging to standardise the clinical judgements of a diverse group of physicians who have had different training and habits. For example, some reports had follow-up recommendations in the Impressions section rather than the Findings section of the report. Adding to the challenge of speech recognition is the reality of synonyms used for 'nodule' in reports, such as 'opacity', 'density' and 'mass'. To write a programme based on only searching through the 'Findings' or body section of a radiology report, or only searching through the 'Impression', would be wasteful in our situation. Waiting for doctors to standardise the way they describe findings will not allow us to deliver care improvement solutions to our patients at the urgent pace mandated. Adoption of dictionary-constrained lists could be helpful but might impact workflow and practitioner acceptance.

New speech recognition software now offers templates for description and follow-up recommendations which can help homogenise reporting; this is a valuable tool if radiologists embrace this technology. The other, more nimble line of thinking is to mine for data and continue to identify ways that the radiologist can improve the

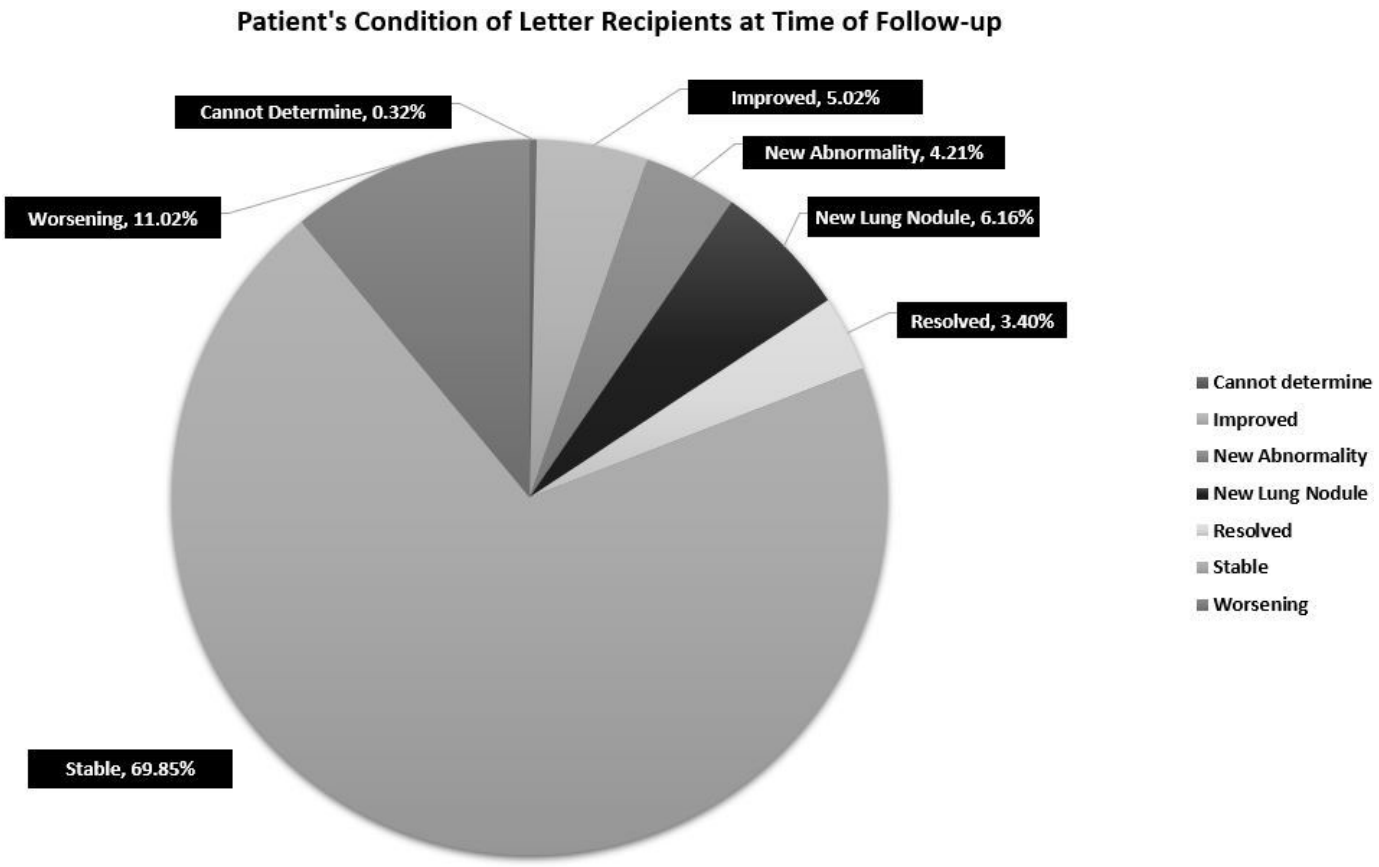

Figure 4 Conditions of letter recipients at follow-up.

dictation while we pursue a parallel solution path of continual system development, analysis and refinement. We used a version of Agile XP Programming methodology to create our lung nodule follow-up module. By using this methodology, we learnt much about our data, such as the style of reporting and described findings, and were thus able to test small iterations over a short period of time.

CONCLUSION

The project team was able to develop customised analytics algorithm to improve markedly the follow-up of lung nodules by data mining the texts of radiology reports and linking the identified cohort of patients and primary care physicians to close the loop with follow-up communication. This process has reduced the risk of missing potentially important clinical information for the patient and clinician alike and has allowed our clinical navigators to focus on higher-risk patients rather than spending resources on tracking lower-risk incidental findings.

In the future, we plan to improve sustainability by launching a portal to enable more clinical personnel to access their patient data. We are also in the process of updating our Speech Recognition software to improve our speech profiles and effectively utilise the templating description of incidental findings and follow-up recommendations. Expansion of the identification and tracking of all other non-lung incidental findings are underway via testing of new word profiles for accuracy. This combination of tactics will likely achieve a much higher rate of follow-ups completed in a more efficient manner, further closing the 40% gap that still exists.

Acknowledgements Chris Rosa, Kelly Frace and Richard Morris for their help with proofreading and with creating the tables and figures. Jane Knox and Brian Effron for their administrative support.

Contributors Authors: PSL and ST are responsible for overall content as guarantor. PL, BF, ST were responsible for conducting and reporting. DS, JS, MT, NS, JD, EJ were responsible for planning.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. MacMahon H, Austin JHM, Gamsu G, *et al*. Guidelines for management of small pulmonary nodules detected on CT scans: a statement from the Fleischner Society. *Radiology* 2005;237:395–400.
2. , Naidich DP, Goo JM, *et al*. Guidelines for management of incidental pulmonary nodules detected on CT images: from the Fleischner Society 2017. *Radiology* 2017;284:228–43.
3. Blagev DP, Lloyd JF, Conner K, *et al*. Follow-up of incidental pulmonary nodules and the radiology report. *J Am Coll Radiol* 2014;11:378–83.
4. Bhinder S, Abduljalil N, Houston S, *et al*. Lung nodule follow-up at an academic center: a revealing quality study. *Chest* 2014;146.
5. Alshora S, McKee BJ, Regis SM, *et al*. Adherence to radiology recommendations in a clinical CT Lung Screening program. *Journal of the American College of Radiology* 2018;15:282–6.
6. Pinsky PF, Gierada DS, Nath PH, *et al*. Lung cancer risk associated with new solid nodules in the National Lung Screening trial. *American Journal of Roentgenology* 2017;209:1009–14.
7. Dutta S, Long WJ, Brown DFM, *et al*. Automated detection using natural language processing of radiologists recommendations for additional imaging of incidental findings. *Annals of Emergency Medicine* 2013;62:162–9.
8. Oliveira L, Tellis R, Qian Y, *et al*. Identification of incidental pulmonary nodules in Free-text radiology reports: an initial investigation. *Stud Health Technol Inform* 2015;216.
9. Pham A-D, Névéol A, Lavergne T, *et al*. Natural language processing of radiology reports for the detection of thromboembolic diseases and clinically relevant incidental findings. *BMC Bioinformatics* 2014;15.