Pulmonary Nodule Characteristics and Workup Rates

IN POPULATION OF 5.5 MILLION ACROSS SEVEN INSTITUTIONS IN NEW YORK

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1 Introduction

Pulmonary nodules (PNs) are a common incidental radiological finding[1] that can represent an underlying malignancy in 1-12% of patients[1-5]. Management of PNs can lead to early, potentially curative, interventions[2]. Radiological findings are a critical component of guidelines used to stratify nodule risk in individual patients[3,6-8], and balance the costs and risks of invasive investigations[9]. In this abstract we present radiological findings in 151,436 unique patients with PNs found in a cohort of 5.5 million patients in the NY metropolitan area using natural language processing (NLP) artificial intelligence (AI). Workup depends on radiological risk factors, though these features are not standardized in radiology reports. This study aims to describe the differences in radiology reporting and PN workup rates across seven institutions in a metropolitan city.

2 Plain Language Summary

Why did we perform this research?

PNs are abnormal growths in the lung that can represent early stage lung cancer. Patients should receive periodic workup if they have certain of risk factors. Workup is recommended to track whether the PNs become malignant over time. Unfortunately, many patients do not receive workup, and workup may vary across healthcare systems. This could be due to differences in how consistently healthcare systems capture risk factors.

How did we perform this research?

We used CLiX insight, a clinical natural language processing software, to read 20 million radiology reports and 40 million clinical notes for 5.5 million patients in the New York area. CLiX insight can understand text written by doctors and healthcare staff. This information was compared across institutions to evaluate patterns in important PN features and workup.

What were the findings of this research?

151,436 patients with PNs were found, of which 40% (60,749) had evidence of a PN in the upper lobes of lung and 35% (52,789) had a PN ≥6 mm, and both upper lung location and larger PN size indicate higher risk for malignancy. The overall workup rate in patients with PNs was 47% (71,071), but merely 36% (6,697) in patients with only radiological risk factors and no clinical risk factors found. Across institutions, there were notable variations of PN shape, shading and edges, though the evidence of PN sizing was more consistent.

What were the implications of this research?

Workup for PNs can help catch lung cancer at an earlier (and potentially curative) stage. It is important to consistently capture risk factors that indicate a patient is at higher risk for malignancy and then ensure patients receive workup. This study suggests that there are areas for improvement in follow-up care at the patient, doctor and system levels which could impact patient outcomes.

3 Methods

Study population: The study was conducted using Healthix data which captures medical records from healthcare institutions across the NY area. Key inclusion criteria were healthcare systems contributing radiology reports and medical documents to Healthix from January 2018 to February 2022. This study included 229,627 patient records for 151,436 unique adult patients (18-90 years old) that had evidence of at least one PN with a reported size (mm or cm), excluding calcified or hamartoma nodules.

Data analysis: 57,875,731 unstructured clinical documents were analyzed using CLiX insight NLP environment, which encodes unstructured patient records into Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT) and abstracts using SNOMED CT expressions, a structured combination of one or more clinical concepts to express a clinical concept. Descriptions of PN workup were abstracted including imaging with computed tomography (CT) or positron emission tomography (PET) of the chest, malignant and benign diagnoses such as lung cancer and mucoid impaction, and investigative procedures or surgery such as chest biopsy and pneumonectomy. Evidence of radiological risk factors were captured including PN spiculation, PN size ≥6mm, number of PNs ≥4, PNs in the upper lobes and PNs described as solid or part-solid. Descriptive statistics, including frequencies and percentages, of selected variables were generated. This research was fully compliant with HIPAA and other legislation protecting patient confidentiality.

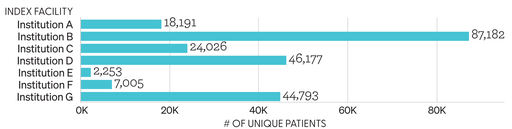
5.5M
UNIQUE PATIENTS ACROSS HEALTHIX EVALUATED FOR PULMONARY NODULES AND FOLLOW-UP

58M
RADIOLOGY REPORTS AND CLINICAL NOTES ACROSS **SEVEN** INSTITUTIONS IN HEALTHIX, A NEW YORK HEALTH INFORMATION EXCHANGE

Jan. 2018 – Feb. 2022

4 Findings

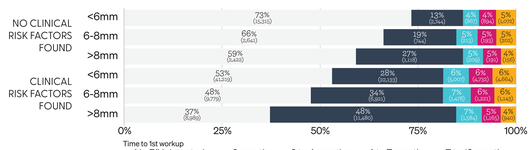
POPULATIONS WITH PNs ACROSS NY INSTITUTIONS



INCONSISTENT WORKUP RATES ACROSS PNs WITH SAME SIZE

Guidelines recommend workup for nodules ≥6mm, yet results shown below suggest workup is more likely for larger nodules and evidence of clinical risk factors

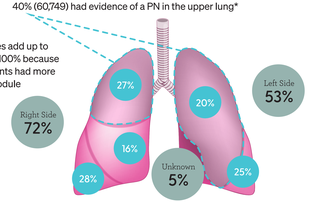
Time to 1st follow-up, by index nodule size (N = 151,436)



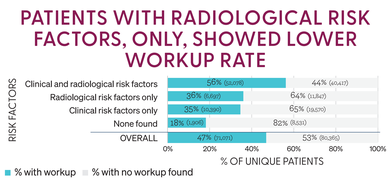
PN LOCATION DETERMINED TO ESTIMATE RISK

40% (60749) had evidence of a PN in the upper lung*

* Percentages add up to more than 100% because some patients had more than one nodule



PATIENTS WITH RADIOLOGICAL RISK FACTORS, ONLY, SHOWED LOWER WORKUP RATE

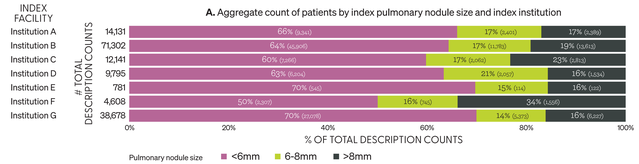


VARIATIONS IN RADIOLOGICAL FINDINGS

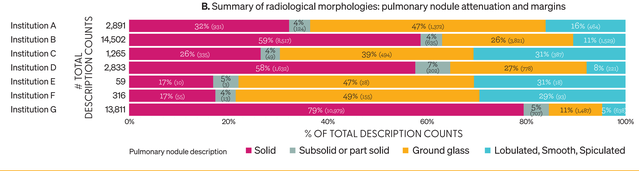
Institutional variations in PN morphology, attenuation and spiculation (N = 151,436)

Radiological characteristics were abstracted from the 20M radiology reports across the seven institutions to evaluate risk factors such as nodule size, attenuation, margin and lung location. The apparent consistent distribution for nodule size contrasts with the inconsistent distribution for attenuation and margins.

A. Aggregate count of patients by index pulmonary nodule size and index institution



B. Summary of radiological morphologies: pulmonary nodule attenuation and margins



5 Discussion

The introduction of dedicated nodule management programs has been shown to improve adherence to standardized guideline care[10], with radiology reports being a key input into PN guidelines. Studying whole populations using NLP AI in unique data sources such as Healthix has made it possible to include a greater diversity of patients and to follow patients even if they move between healthcare systems. No extrapolation is required to show the magnitude of work generated by PN finding on radiology departments. Thirty-five percent of the patients (52,789 out of 151,436) had nodules ≥6mm, putting them at medium- to high-risk for malignancy and requiring follow-up, though only 54.9% had evidence of follow-up.

These data provide evidence for under-management of nodules with respect to guidelines, for instance, 35% of nodules are greater than or equal to 6mm in size and would be expected to be followed-up regardless of guideline used. This is consistent with existing literature showing low follow-up rates[11], and is unlikely to be fully explained by the use of clinician judgment of nodule risk that some studies[12-14] have shown to be as effective as commonly used nodule risk stratification models[15-19].

This study shows relatively consistent reporting of nodule size between the radiology reports of each healthcare system, however this is still not universal. Reporting of radiological details, such as spiculation, and other inputs into nodule risk models appeared highly variable. Further studies are required to elucidate the reasons for this and whether there is a role for standardized reporting templates or better integration of radiologists into the nodule management programs.

6 Conclusions

Nodule pathways to manage patient and ensure adherence to guidelines offer the best tool to manage this risk in a repeatable, traceable and medicolegally defensible manner.

This study provides evidence that radiology reporting of PNs does not systematically include the radiological characteristics which are critical inputs to the risk stratification approaches used in clinical guidelines.

Further studies are required to elucidate the reasons for this and whether there is a role for standardized reporting templates or better integration of radiologists into the nodule management programs.

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