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Short communication

The role of lung cancer risk and comorbidity in lung cancer screening use

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ABSTRACT

Although lung cancer screening (LCS) with low dose computed tomography has been shown to reduce lung cancer mortality, benefits and harms of screening vary among eligible adults. The goal of this study was to evaluate whether LCS is more commonly used among populations most likely to benefit, namely adults with high lung cancer risk and low comorbidity. In this cohort study of patients eligible for LCS, we used data from the electronic health record to evaluate the relationship between lung cancer risk, comorbidity, and receipt of LCS. We also evaluated use of diagnostic chest CT. Analyses used a nonparametric test for trend across quartiles of lung cancer risk and comorbidity. The study sample included 551 LCS-eligible adults who were followed for a mean 2.9 years (SD 1.6 years). A cumulative 190 (34 %) received at least 1 LCS, and 141 (26 %) had a diagnostic chest CT. Receipt of LCS increased across quartiles of lung cancer risk (5 per 100 person years in the lowest quartile vs 13 per 100 person-years in the highest, $p < 0.001$ for test of trend). LCS receipt decreased across increasing quartiles of comorbidity (14 vs 8 per 100 person-years, $p = 0.008$). Diagnostic CT was more common in among patient with higher levels of comorbidity (15 vs 5 per 100 person-years, $p < 0.001$). In conclusion, lung cancer screening was more commonly used in patients with greater lung cancer risk and lower comorbidity. Results suggest that both patient characteristics and use of diagnostic imaging may shape current patterns of LCS use.

1. Introduction

Early detection of lung cancer through screening with low dose computed tomography has been shown to reduce lung cancer mortality by approximately 20 % (Mortality, 2011; de Koning et al., 2020). Lung cancer screening (LCS) also has harms, including false positives requiring additional work up, incidental findings that require further evaluation, and overdiagnosis (Jonas et al., 2021). Annual screening with computed tomography is currently recommended for adults ages 50–80 who have smoked at least 20 pack-years and who are either still using tobacco or quit in the last 15 years (Krist et al., 2021). However, among screen-eligible individuals, the balance of harms and benefits varies considerably. Individuals who are at highest risk of lung cancer and have the fewest comorbidities and longest life expectancy are most likely to benefit from screening (Caverly et al., 2018; Cheung et al., 2019; Kovalchik et al., 2013).

The current paradigm for LCS emphasizes shared-decision making, in which an individual's health history and preferences are taken into account (Hoffman et al., 2021). Within this framework, patients who are most likely to benefit might be more likely to accept screening than those who are less likely to benefit. However, there are many reasons why patients who would benefit the most from screening may not actually be screened most often. Stigma and negative perceptions of screening may be barriers to screening, especially among those who are at higher risk for lung cancer (Carter-Harris et al., 2017; Ali et al., 2015). Alternatively, patients may view screening favorably, regardless of their personal risk or the balance of harms and benefits. Shared decision making visits may be of poor quality (Brenner et al., 2018). Patients with more comorbidities may more likely to be screened, perhaps because they have greater contact with the health care system (Advani et al., 2021; Rustagi et al., 2022).

The goals of this study were to evaluate lung cancer screening use in a cohort of primary care patients overall, and by level of comorbidity and lung cancer risk. We also evaluated diagnostic CT use, since receipt of diagnostic CT influences the need for subsequent screening. We hypothesized that although patients who are at higher risk for lung cancer

Abbreviations: LCS, lung cancer screening; EHR, electronic health record.

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and have lowest comorbidity may benefit most from screening, these patients may not actually be screened most commonly.

2. Methods

2.1. Cohort

This was an observational cohort study of patients at three academically-affiliated primary care practices within the Yale New Haven Health System. We included patients who were attributed to one of these three practices in the EHR and who were seen in primary care at least once between January 1, 2015, when the health system began offering LCS, and February 28, 2020, prior to the COVID pandemic. We also included patients who were not explicitly attributed to these practices in the EHR but who were seen three or more times during this period.

We included patients who were ages 55–77 (the age group for which Medicare covered LCS during the study), current smokers or former smokers who had quit within the past 15 years, and who had at least a 30 pack-year smoking history during the study period (Lung, 2021). Patients could enter the cohort if they met these criteria at any point during the study period. Patients were followed from their first primary care visit until one year after their last visit or the end of follow up, whichever came first.

2.2. Data

We used data from the electronic health record (EHR). The EHR captures key data elements including dates of primary care visits, age, comorbidities, tobacco use history, LCS ordering, LCS receipt, and receipt of diagnostic chest CT. LCS and diagnostic chest CT are denoted in the EHR with distinct procedure codes. In addition, the ordering process includes some decision support to ensure the correct CT is ordered. Tobacco use data is collected routinely during clinical visits and collection of data had been emphasized as part of a quality measure focusing on screening and treatment for tobacco use.

2.3. Covariates and outcomes

We calculated the 10-year risk of lung cancer for each eligible patient using the Bach model, which incorporates age, tobacco use, sex, and asbestos exposure (Cronin et al., 2006). Lung cancer risk estimation uses Cox models to estimates the 10 year risk of lung cancer, accounting for competing risk of mortality. Since asbestos exposure was not available but is also relatively rare, we classified all patients as having no asbestos exposure. To characterize comorbidity, we used the unweighted Elixhauser score using conditions documented at the time of data collection. The Elixhauser score is a global measure of comorbidity calculated using International Classification of Diseases diagnostic codes in the EHR. The primary outcome was receipt of LCS. We also evaluated orders for LCS, receipt of diagnostic chest CT, and receipt of any chest CT (diagnostic or screening).

2.4. Analytic approach

To characterize overall patterns of LCS use, we calculated the cumulative proportion of patients who were referred for screening, who had at least one LCS performed, and who had multiple lung cancer screening CTs during follow up. We also calculated the cumulative proportion of patients who had diagnostic chest CT but not LCS, and the proportion of patients with any chest CT (diagnostic and/or screening). For these analyses, we defined cumulative proportion as the number of patients who had had the outcome of interest (LCS, diagnostic CT, etc.) at the end of follow up out of all patients included in the cohort.

Because patients were followed for multiple years, we evaluated incidence of initial LCS ordering and diagnostic CT use per 100 person-years of observation. When evaluating incidence of LCS use, we focused on receipt of an initial screen, and we censored participants after receipt of the first instance of LCS. We then evaluated incidence of LCS and diagnostic CT by quartile of lung cancer risk, comorbidity, and the combination of lung cancer risk and comorbidity. Analyses used a nonparametric test for trend to evaluate for differences in imaging use across levels of comorbidity and lung cancer risk. Analyses used SAS 9.4 and Stata 15.0. This study was approved by the Human Investigation Committee at the Yale School of Medicine.

3. Results

We identified 7,147 patients who were between 55 and 77 years of age and who had primary care visits during the study period. Of these, 5,882 (82 %) had sufficient smoking history documented to determine screening eligibility, and 551 (9.3 %) were eligible for LCS. The mean age of these 551 screen-eligible patients was 62 years (SD 6), 52 % were male, 29 % were Black, 16 % were Latinx and 54 % were White. Most patients were insured by Medicare ($n = 336$, 61 %) followed by Medicaid ($n = 167$, 30 %) and commercial insurance ($n = 38$, 7 %). The median 10-year lung cancer risk was 5.7 % (IQR 3.5–8.1).

The mean follow-up time for patients included in the sample was 2.9 years (SD 1.6 years). Among screen-eligible patients, by the end of follow up, a total of 288 (52 %) had a LCS ordered, 190 (34 %) received at least 1 LCS, and 56 (10 %) underwent more than one LCS (Fig. 1). Overall, 141 (26 %) had a diagnostic chest CT performed but were not screened. In aggregate, 331 (60 %) of patients had any chest CT (screening or diagnostic).

Overall, the incidence of orders for LCS was 18 per 100 person-years and LCS receipt was 11 per 100 person-years. Incident orders for LCS increased across quartiles of lung cancer risk (11 per 100 person-years in the lowest quartile vs 19 per 100 person-years in the highest, $p = 0.03$ for test of trend across quartiles, Fig. 2a). By contrast, incident orders for LCS decreased across quartiles of comorbidity (22 per 100 person-years in the lowest quartile of comorbidity vs 12 per 100 person years in the highest quartile, $p < 0.001$ for test of trend across quartiles, Fig. 2a). Similarly, receipt of LCS was more common as lung cancer risk increased across quartiles (5 per 100 person years in the lowest quartile vs 13 per 100 person-years in the highest quartile, $p < 0.001$, Fig. 2b) and less common with increasing levels of comorbidity (14 vs 8 per 100 person-years, $p = 0.008$, Fig. 2b). Unlike LCS, diagnostic chest CT was more common among patients with greater comorbidity (15 per 100 person-years in the highest quartile of comorbidity vs 5 per 100 person-years in the lowest $p < 0.001$, Fig. 2c). Incidence of any chest CT (diagnostic or screening) rose with increasing lung cancer risk (12 per 100 person-years in the lowest quartile of risk vs 25 per 100 person years in the highest quartile, $p < 0.001$) but not comorbidity (Fig. 2d).

4. Discussion

We found that lung cancer screening use among patients in primary care was low overall, consistent with national reports (Fedewa et al., 2021). However, we also observed that lung cancer screening use varied considerably by patient characteristics. LCS use was indeed more common among those most likely to benefit—specifically, adults with higher lung cancer risk and lower levels of comorbidity. These findings suggest two distinct mechanisms that may influence current levels of LCS use.

First, our finding that lung cancer screening was more common among those with greater lung cancer risk suggests that patient characteristics are considered in screening decisions. A key question is whether this pattern is driven by patient preferences and values, which would be in line with the current shared decision-making paradigm, or whether it primarily reflects the beliefs, behaviors, or recommendations of clinicians alone. Understanding how lung cancer screening is offered, framed, and discussed along the continuum of lung cancer risk will be critical for ensuring all patients have the opportunity to consider

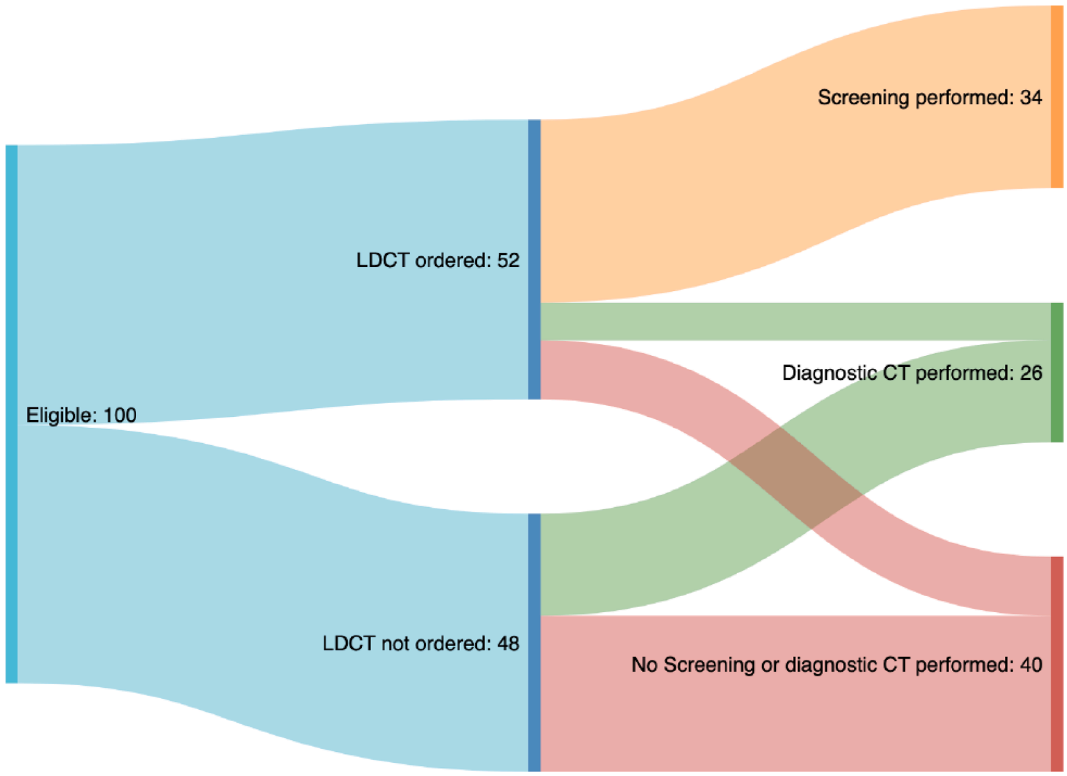

Fig. 1. Lung cancer screening use. Figure depicts cumulative lung cancer screening use over the entire study period as a percentage of screen-eligible patients.

screening.

We also observed that patients with substantial comorbidity were more likely to receive diagnostic imaging and less likely to be screened. This finding suggests that a substantial fraction of patients who meet the age and tobacco use criteria for screening may not actually be eligible for screening because they are symptomatic. Accounting for symptoms and recent use of diagnostic imaging is essential in assessing the reach of screening. Second, this finding highlights the complexity of implementing lung cancer screening in a population where symptoms and use of diagnostic imaging may be common. Evaluating symptoms, tracking prior imaging, and determining whether screening is appropriate and at what interval creates important logistical challenges to ensuring LCS is used appropriately.

Our results differ from two recent national studies which reported higher LCS use among those with greater comorbidity (Rustagi et al., 2022; Advani et al., 2021). Both of those studies, though, used self-reported data from the Behavioral Risk Factor Surveillance Survey which may not accurately distinguish between screening and diagnostic chest CT. A relative strength of our approach was use of data from the EHR, which captures actual receipt of imaging and clearly distinguishes between diagnostic and screening chest CT. A VA-based study, which did use EHR data, did not find a strong relationship between comorbidity, lung cancer risk, and LCS use, although differences in patient populations and practice settings may account for the differences in findings (Leishman et al., 2021).

Our study has limitations including use of data from a single health system, which may limit generalizability, and use of data from the electronic health record, which may have inaccuracies, particularly around tobacco use history. In particular, tobacco use history in the EHR may underestimate true tobacco exposure if patients have cut back recently, and only their current packs per day are used to calculate pack-years. The information in the EHR may also underestimate tobacco use history if patients underreport tobacco use or if changes in behavior like resumption of smoking after a period of abstinence are not noted. Use of EHR data may also contribute to inaccuracies around diagnostic vs screening CTs. Although the two procedures are distinct in the medical record, it possible that diagnostic CTs were used as screening if clinicians were uncertain about how to order screening tests or whether they would be reimbursed. Still, we believe our results contribute to the current understanding of how lung cancer screening is used in primary care. As lung cancer screening is expanded to a broader population and shared decision-making requirements are scaled back, continued evaluation of the implementation of lung cancer screening will be important (Screening for Lung Cancer with Low Dose Computed Tomography (LDCT), 2022).

5. Conclusions

We found that lung cancer screening use in primary care varies by lung cancer risk and comorbidity, raising key questions about how the current formal shared decision-making paradigm influences LCS use and the role of diagnostic imaging in shaping lung cancer screening use. Continued evaluation of LCS use, especially focusing on how patients are identified for screening, which patients are offered screening, and how patients and clinicians make decisions about screening, will be critical for understanding and improving implementation.

6. Authorship contributions

Dr. Richman contributed to study conceptualization, data collection, formal analysis, writing—original draft, visualization, and funding acquisition. Ms. Long contributed to formal analysis, data curation, visualization, and writing—review and editing. Dr. Poghosyan contributed to writing—review and editing. Ms. Sather contributed to study conceptualization and writing—review and editing. Dr. Gross contributed to study conceptualization, writing—review and editing.

7. Disclosures and Funding

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a: Incidence of LCS ordering, per 100 person-years

Quartile of Elixhauser score	Quartile of lung cancer risk: 1	2	3	4	Overall
4	4	13	16	14	12 (n=124)
3	11	21	18	20	18 (n=105)
2	13	21	26	18	19 (n=160)
1	15	22	29	25	22† (n=162)
Overall	11 (n=138)	19 (n=138)	24 (n=138)	19†† (n=137)	

Key: <=5; 6-10; 10-14; 15-19; 20-24; >=25

†p-value for test of trend across comorbidity quartiles <.001
††p-value for test of trend across lung cancer risk quartiles=.03

b: Incidence of LCS receipt per 100 person-years

Quartile of Elixhauser score	Quartile of lung cancer risk: 1	2	3	4	Overall
4	2	8	11	11	8 (n=124)
3	6	14	16	13	11 (n=105)
2	5	16	18	14	13 (n=160)
1	8	17	18	16	14† (n=162)
Overall	5 (n=138)	14 (n=138)	16 (n=138)	13†† (n=137)	

†p-value for test of trend across comorbidity quartiles .008
††p-value for test of trend across lung cancer risk quartiles<.001

c: Incidence of diagnostic chest CT receipt, per 100 person-years

Quartile of Elixhauser score	Quartile of lung cancer risk: 1	2	3	4	Overall
4	14	16	12	13	15 (n=124)
3	6	6	10	9	8 (n=105)
2	6	9	8	9	8 (n=160)
1	3	4	3	9	5† (n=162)
Overall	7 (n=138)	9 (n=138)	8 (n=138)	12†† (n=137)	

†p-value for test of trend across comorbidity quartiles <.001
††p-value for test of trend across lung cancer risk quartiles = .03

d: Incidence of any chest CT receipt, per 100 person years

Quartile of Elixhauser score	Quartile of lung cancer risk: 1	2	3	4	Overall
4	16	24	23	29	23 (n=124)
3	13	20	26	23	19 (n=105)
2	11	25	26	23	21 (n=160)
1	10	21	22	25	19† (n=162)
Overall	12 (n=138)	23 (n=138)	24 (n=138)	25†† (n=137)	

†p-value for test of trend across comorbidity quartiles=0.29
††p-value for test of trend across lung cancer risk quartiles<0.001

Fig. 2. Chest imaging by quartile of lung cancer risk and comorbidity. Panels depict the incidence of order or receipt of chest imaging (either LCS, diagnostic CT, or both) per 100 person-years.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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