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Impact of a Hybrid Lung Cancer Screening Model on Patient Outcomes and Provider Behavior

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Abstract

Background: Lung cancer screening (LCS) implementation is complicated by the Centers for Medicare and Medicaid Services reimbursement requirements of shared decision-making (SDM) and tobacco cessation counseling (TCC). LCS programs can utilize different structures to meet these requirements but the impact of programmatic structure on provider behavior and screening outcomes is poorly described.

Patients and Methods: In a retrospective chart review of 624 patients in a hybrid structure, academic LCS program, we compared characteristics and outcomes of primary care provider (PCP) and specialist screened patients. We also assessed the impact of the availability of an LCS

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E.A.H., M.L.N., and S.P.M. are the guarantors of the paper. E.A.H. takes responsibility for the integrity of the data and the accuracy of the data analysis. E.A.H., M.L.N., and S.P.M. assume full responsibility for the integrity of the submission as a whole, from inception to published article. S.L.B. made substantial contributions to the study design, data collection, and writing of the manuscript. P.B.S. made substantial contributions to the study design and writing of the manuscript. A.E.B. made substantial contributions to the data analysis and interpretation and writing of the manuscript.

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specialty clinic and best practice advisory (BPA) on PCP ordering patterns using electronic medical record generated reports.

Results: During the study period of July 1, 2014 - June 30, 2018, 48% of patients were specialist screened and 52% were PCP screened; there were no clinically relevant differences in patient characteristics or screening outcomes between these populations. PCPs demonstrate distinct practice patterns when offered the choice of specialist-driven or PCP-driven screening. Increased exposure to an LCS BPA is associated with increased PCP screening orders. The addition of a nurse navigator (NN) into the LCS program increased documentation of SDM and TCC to >95% and virtually eliminated screening of ineligible patients.

Conclusions: Systematic interventions including a BPA and NN are associated with increased screening and improved program quality, as evidenced by reduced screening of ineligible patients, increased lung cancer risk of the screened population, and improved compliance with LCS guidelines. Individual PCPs demonstrate clear preferences regarding LCS that should be considered in program design.

MicroAbstract

The impact of lung cancer screening programmatic structure on provider behavior and outcomes is poorly described. Using a retrospective review of 624 patients we found that primary care providers (PCPs) demonstrate distinct practice patterns when offered the choice of specialist-driven or PCP-driven screening though no clinically relevant differences in screening population or outcome were observed.

Keywords

Lung Cancer Screening; Provider Behavior; Screening Outcomes; Nurse Navigator; Best Practice Advisory

Introduction

The goal of lung cancer screening (LCS) is to detect asymptomatic, curable, early stage disease in a large population with a low disease incidence. LCS with annual low-dose CT (LDCT) received a US Preventive Services Task Force class B recommendation¹ based on the 20% mortality reduction observed in the National Lung Screening Trial². Although the Centers for Medicare and Medicaid Services (CMS) approved LCS for high risk current and former smokers, the requirement that eligible patients undergo shared decision-making (SDM) and tobacco cessation counseling (TCC) as part of the screening process makes LCS unique among cancer screening modalities³ and markedly increases the complexity of LCS implementation.

Structurally, LCS programs generally fall into three categories⁴. Centralized programs are usually specialist driven with recruitment, SDM, and TCC performed by dedicated LCS personnel^{5, 6}. In contrast, decentralized programs depend on primary care providers (PCPs) to identify eligible patients and then perform the required SDM and TCC prior to screening⁷, though these programs often provide support in the form of electronic medical record (EMR) based tools that facilitate patient identification and radiology-generated

recommendations for management of screen-detected abnormalities. Hybrid programs contain elements of centralized and decentralized programs⁴.

Our institution took a hybrid approach to LCS. An EMR-driven best practice advisory (BPA) fires on potentially eligible patients presenting to primary care appointments. This BPA prompts PCPs to either refer patients to a pulmonologist-staffed clinic for evaluation and screening or to assess eligibility, perform SDM, then order a screening LDCT themselves (Fig. 1). Within this screening approach, we compared patient demographics, clinical characteristics, and outcomes between PCP and specialist screened patients and analyzed PCP behavior after exposure to systemic interventions designed to improve LCS implementation.

Patients and Methods

We retrospectively identified all patients who underwent a lung cancer screening CT between July 1, 2014 and June 30, 2018 at University of Colorado Hospital. Subjects were identified from the clinical database used to manage the LCS program (Primordial Design, Nuance Communications, Burlington, MA). The study was conducted in accordance with the amended Declaration of Helsinki and approved by the Colorado Multiple Institutional Review Board (COMIRB #18-0005) with waivers of informed consent and HIPAA authorization.

After identification of the study cohort, clinical and demographic data were abstracted from the radiology database or EMR. Lung cancer risk was calculated using the PLCO_{m2012} model⁸. When model variables were missing, the reference value was used to impute. Patients were classified as PCP screened if they had LCS documentation in a PCP clinic note or if their LDCT was ordered by a PCP. Patients were classified as LCS specialist screened if they were evaluated in the LCS clinic or their LDCT was ordered by a LCS clinician. Data regarding PCP LDCT orders, LCS referral orders, and unique patient BPA exposures were extracted from EMR generated reports and analyzed as described in results.

Data were analyzed using SAS 9.4 (SAS Institute Inc., Cary, NC). Descriptive statistics and univariate differences between groups were assessed using χ^2 or Fishers Exact tests for categorical variables and t-tests or Brown-Mood tests for parametric and non-parametric continuous variables, respectively. Linear relationships between BPA exposures and LCS orders and lung cancer risk scores were evaluated with Pearson and Spearman correlations.

Results

Screening populations and outcomes:

From July 1, 2014 to June 30, 2018, 624 patients were screened, approximately half by PCPs and half through the LCS clinic (Table 1). Overall, specialist screened patients had a higher 6-year lung cancer risk score that was largely driven by more extensive smoking history. Lung cancer detection and screening outcomes are shown in Table 2. No difference in cancer detection rate was observed, although there were minor differences in significant

incidental (S) findings and Lung-RADS categories between specialist and PCP screened patients.

LCS clinic utilization:

A pulmonologist-staffed LCS clinic was started in February 2015 to improve screening uptake and compliance with CMS requirements. In the first 18 months of the clinic, the majority of patients (166/253, 66%) were PCP screened, though subsequently the majority of patients (212/343, 62%) were screened through the LCS clinic (Fig. 2).

We then examined LCS clinic utilization of the 47 PCPs with at least five LCS-related orders (screening LDCT or LCS clinic referral). We characterized PCPs as “screeners” if they ordered a screening LDCT at least 67% of the time and as “referrers” if they if they ordered a LCS clinic referral at least 67% of the time. Providers who failed to meet either threshold were characterized as “dual users” (Fig. 3). Although there were no significant differences in the rates at which these three groups of providers ordered LCS, MD providers with internal medicine training were substantially more likely to be “screeners” compared to non-MD providers and family medicine trained providers (Fig. 3B).

Systematic interventions to improve LCS implementation:

To improve lung cancer screening uptake we developed a BPA that fires on patients presenting to a PCP appointment who meet CMS LCS criteria (age 55–77, 30 pack year smoking history). The BPA prompts the PCP to order a screening LDCT or refer the patient to LCS clinic; alternatively, the provider can close the BPA without action. Between July 2015 and December 2017, about 20% (276/1384) of unique patients on whom a BPA fired were screened and the BPA fired on 44% (276/624) of screened patients (Fig. 4A).

Among the 109 attending (non-resident) PCPs exposed to at least 5 unique patient BPA fires, BPA exposure was positively correlated with LCS ordering (Fig. 4B). When we compared the 15 “never screeners” (PCPs exposed to at least 5 unique patient BPA fires who never ordered a screening LDCT or LCS clinic referral) with PCPs with at least 5 LCS orders (the same 47 providers in Fig. 3A), there was no difference in provider type (APP vs MD), training (internal medicine vs family medicine), or years in practice, though “never screeners” had significantly fewer BPA exposures (10.3 ± 2.7 vs 20.5 ± 3.0 , mean $\pm$ SEM, $p=0.02$).

While nurse navigators (NN) improve screening uptake and adherence in other malignancies⁹ the role in LCS has been minimally described. We found that institution of a LCS NN into the screening program increased documentation of SDM and TCC to >95% and virtually eliminated screening of ineligible patients (Fig. 5A). This correlated with an increase in the 6-year lung cancer risk of screened patients from 1.5% to 3.3% between 2014 and 2018 (Fig. 5B).

Discussion

The hybrid design of our LCS program sets up a natural experiment that provides information about provider behavior when faced with LCS options. It also allows

comparison of PCP and specialist screened patients and facilitates the impact of systematic interventions on LCS uptake and documentation. In our LCS program, PCP and specialist screened patients were broadly similar, presumably because they are drawn from a similar demographic background (Table 1). Although the specialist screened group had slightly higher smoking exposure and hence higher lung cancer risk, these differences disappeared when we excluded 36 PCP-screened patients who were ineligible by CMS LCS criteria (not shown). Not surprisingly, given the relatively small sample size, screening outcomes and cancer detection were also similar between groups (Table 2).

Most prior descriptions of PCP preferences and knowledge regarding LCS have been derived from self-reported surveys^{10,11}. Allowing PCPs to order screening LDCT or LCS clinic referral has provided the first report of actual provider ordering patterns regarding LCS. As seen in Fig. 2, there is a clear demand for specialist-based LCS services, as once these services were established, over half of all LCS occurred through the LCS clinic. In our program, PCPs seem to largely sort into distinct groups of “screeners” who prefer to order screening LDCT (and are willing to perform SDM and TCC) and “referrers” who prefer to refer patients to LCS clinic for these services (Fig. 3A). Although 21% (10/47) of PCPs were “dual users” who order LDCT and LCS clinic referral in roughly similar proportions, these PCPs accounted for only 17% (79/453) of screening orders (Fig. 3B), raising the possibility that these providers might differentiate into screeners or referrers over time. Although we did not identify an association between years in practice and provider behavior, MDs were more likely to be screeners than APPs and internal medicine providers were more likely to be screeners than family medicine providers (Fig. 3B). It is important to note that the American Academy of Family Physicians position “that the evidence is insufficient to recommend for or against screening”, could contribute to less screening by FP training PCPs. While PCPs have reported discomfort identifying and counseling LCS patients, possibly secondary to limited LCS education^{12,13}, we did not survey PCPs to determine specific factors that might drive the observed practice patterns.

Provider targeted interventions have enhanced colorectal, cervical, breast, and prostate cancer screening^{14,15} and initial reports suggest decision support tools can improve LCS uptake¹⁶. Because we implemented a BPA early in our LCS program, we cannot effectively assess the impact on LCS volume. Although fewer than half of screened patients had a BPA fire, presumably secondary to poorly captured smoking history in the EMR^{5,17}, this observation also illustrates that PCPs identify an important fraction of screen-eligible patients in the absence of decision support tools. Furthermore, our observation that increased BPA exposure is correlated with increased screening (Fig. 4B), suggests that the BPA promotes LCS independent of individual patient identification.

Our ratio of screened patient to unique patient BPA fires was approximately 1 to 5 (276/1384, Fig. 4A). While we cannot say why individual BPA-identified patients were not screened, it is likely a complex combination of patient preference, provider interest, and medical appropriateness of screening. Additionally, while we were unable to identify specific provider characteristics associated with never ordering LCS despite multiple BPA exposures. This provider group clearly merits additional study.

Nurse navigators can enhance cancer screening uptake and improve evaluation of screen-detected abnormalities^{9,18}, though the role in LCS is less established. We found that the addition of a NN almost completely eliminated screening of ineligible patients and improved compliance with SDM and TCC requirements to >95%. The screening of ineligible patients remains a problem as LCS uptake increases^{19,20} and is potentially harmful²¹. We also observed an increase in calculated lung cancer risk over time that persists even when ineligible patients were eliminated from analysis (Fig 5B). While this cannot be solely ascribed to a NN, screening higher risk patients is associated with a markedly lower number needed to screen²².

The main limitation of this study is that its retrospective design and use of medical records as the primary data source limit the level of detail that can be obtained regarding complex medical decision making and provider behaviors. For example, we were unable to ascertain why specific patients did not undergo screening and can we address the motivations influencing a provider's decisions surrounding LCS. Additional limitations include that we were unable to identify patients who might have self-referred to either their PCP or the LCS clinic and our results may not be generalizable to community clinics that lack dedicated screening program personnel.

Conclusions

Within a hybrid LCS program, systematic interventions including a BPA and NN are associated with increased screening and improved program quality as measured by reduced screening of ineligible patients, increased lung cancer risk of the screened population, and improved documentation of SDM and TCC. PCPs demonstrate clear practice patterns regarding LCS that can inform both program design and future studies aimed at exploring the underpinnings of these behaviors.

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Abbreviations:

APP	Advanced Practice Provider
BPA	Best Practice Advisory
CMS	Centers for Medicare and Medicaid Services
EMR	Electronic medical record
LDCT	Low dose computed tomography
LCS	Lung cancer screening
NN	Nurse Navigator
PCP	Primary care provider

SDM	Shared Decision Making
TCC	Tobacco Cessation Counseling

References

1.) US Preventive Services Task Force. Screening for lung cancer. 12 2013 Available at: <https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/lung-cancer-screening>. Accessed on October 15, 2019.
2.) National Lung Screening Trial Research Team, Aberle DR, Adams AM, Berg CD, et al. Reduced lung-cancer mortality with low-dose computed tomographic screening. *N Engl J Med*. 2013 5 23;368(21):1980–91. doi: 10.1056/NEJMoa1102873. [PubMed: 23697514]
3.) Centers for Medicare & Medicaid Services. Final National Coverage Determination on Screening for Lung Cancer with Low Dose Computed Tomography (LDCT). 2015 Available at: <https://www.cms.gov/medicare-coverage-database/details/nca-decision-memo.aspx?NCAid=274>. Accessed on October 15, 2019.
4.) American Thoracic Society and American Lung Association Lung Cancer Screening Implementation Guide. Available at: <https://www.lung.org/assets/documents/lung-cancer/implementation-guide-for-lung.pdf>. Accessed on October 17, 2019.
5.) Modin HE, Fathi JT, Gilbert CR, et al. Pack-Year Cigarette Smoking History for Determination of Lung Cancer Screening Eligibility. Comparison of the Electronic Medical Record versus a Shared Decision-making Conversation. *Ann Am Thorac Soc*. 2017 8;14(8):1320–1325. doi: 10.1513/AnnalsATS.201612-984OC. [PubMed: 28406708]
6.) Mazzone PJ, Tenenbaum A, Seeley M, et al. Impact of a Lung Cancer Screening Counseling and Shared Decision-Making Visit. *CHEST* 2017; 151(3):572–578. doi: 10.1016/j.chest.2016.10.027. Epub 2016 Nov 1. [PubMed: 27815154]
7.) Janssen K, Schertz K, Rubin N, Begnaud A. Incidental Findings in a Decentralized Lung Cancer Screening Program. *Ann Am Thorac Soc*. 2019 9;16(9):1198–1201. doi: 10.1513/AnnalsATS.201812-908RL [PubMed: 31251089]
8.) Tammemägi MC, Katki HA, Hocking WC, et al. Selection Criteria for Lung-Cancer Screening. *N Engl J Med*. 2013 2 21;368(8):728–36. doi: 10.1056/NEJMoa1211776. [PubMed: 23425165]
9.) Wells KJ, Battaglia TA, Dudley DJ, et al. Patient Navigation Research Program. Patient Navigation State of the Art, or is it Science? *Cancer*. 2008 10 15; 113(8): 1999–2010. doi: 10.1002/cncr.23815. [PubMed: 18780320]
10.) Henderson LM, Jones LM, Marsh MW, et al. Opinions, practice patterns, and perceived barriers to lung cancer screening among attending and resident primary care physicians. *Risk Manag Healthc Policy*. 2017; 10: 189–195. doi: 10.2147/RMHP.S143152. eCollection 2017. [PubMed: 29403320]
11.) Khiary M, Duong DJ, Shariff-Marco F, et al. An Analysis of Lung Cancer Screening Beliefs and Practice Patterns for Community Providers Compared to Academic Providers. *Cancer Control*. 2018 Jan-Dec; 25(1): 1073274818806900. doi: 10.1177/1073274818806900. [PubMed: 30375235]
12.) Rajupet S, Doshi D, Wisnivesky JP, and Lin JJ. Attitudes About Lung Cancer Screening: Primary Care Providers Versus Specialists. *Clin Lung Cancer*. 2017 11;18(6):e417–e423. doi: 10.1016/j.clcc.2017.05.003. Epub 2017 May 10. [PubMed: 28648531]
13.) Raz DJ, Wu GX, Consunji M, et al. Perceptions and Utilization of Lung Cancer Screening Among Primary Care Physicians. *J Thorac Oncol*. 2016 11;11(11):1856–1862. doi: 10.1016/j.jtho.2016.06.010. Epub 2016 Jun 23. [PubMed: 27346412]
14.) Souza NM, Sebaldt RJ, Mackay JA, et al. CCDSS Systematic Review Team. Computerized clinical decision support systems for primary preventive care: a decision-maker-researcher partnership systematic review of effects on process of care and patient outcomes. *Implement Sci*. 2011 8 3;6:87. doi: 10.1186/1748-5908-6-87. [PubMed: 21824381]
15.) Baron RC, Melillo S, Rimer BK, et al. Task Force on Community Preventive Services. Intervention to increase recommendation and delivery of screening for breast, cervical, and

- colorectal cancers by healthcare providers a systematic review of provider reminders. *Am J Prev Med.* 2010 1;38(1):110–7. doi: 10.1016/j.amepre.2009.09.031. [PubMed: 20117566]
16.) Dowling L, Zimmerman L, Shah P, Powell L, and Dunham D. Improving Lung Cancer Screening Rates in a Primary Care Practice in Large Urban Academic Medical Center. [abstract] *JTO.* 2018; 13(10): S961.
17.) Li J, Chung S, Wei EK, and Luft HS. New recommendation and coverage of low-dose computed tomography for lung cancer screening: uptake has increased but is still low. *BMC Health Serv Res.* 2018; 18: 525. doi: 10.1186/s12913-018-3338-9. [PubMed: 29976189]
18.) Hoopes S, Weathers J, Perkins L, et al. The Importance of Nurse Navigation in Lung Cancer Screening. [abstract] *AONN+.* 2018; 9(11): 2051.
19.) Huo JH, Shen C, Volk RJ, and Shih YT. Use of CT and Chest Radiography for Lung Cancer Screening Before and After Publication of Screening Guidelines: Intended and Unintended Uptake. *JAMA Intern Med.* 2017 3 1; 177(3): 439–441. doi: 10.1001/jamainternmed.2016.9016. [PubMed: 28135349]
20.) Triplette M, Thayer JH, Pipavath SN, Crothers K. Poor Uptake of Lung Cancer Screening: Opportunities for Improvement. *J Am Coll Radiol.* 2019 4;16(4 Pt A):446–450. doi: 10.1016/j.jacr.2018.12.018. Epub 2019 Feb 15. [PubMed: 30777648]
21.) Mansoori JN, Little N, Malkoski SP. Maximizing benefits and minimizing harms of lung cancer screening: A teachable moment. *JAMA Intern Med.* 2017; 177(8):1197–1198. doi: 10.1001/jamainternmed.2017.2349. [PubMed: 28628709]
22.) Kovalchik SA, Tammemagi MC, Berg CD, et al. Targeting of low-dose CT screening according to the risk of lung cancer death. *N Engl J Med.* 2013; 369(3): 245–254. doi: 10.1056/NEJMoa1301851. [PubMed: 23863051]

Clinical Practice Points

The impact of lung cancer screening (LCS) programmatic structure on provider behavior and outcomes is unknown. In a hybrid structure LCS program that allows screening by primary care providers (PCPs) or a specialty LCS clinic there were no differences in screening outcomes. Interestingly, family medicine physicians and non-MD PCPs tended to refer patients to LCS clinic while internal medicine trained PCPs tended to perform LCS themselves. Exposure to a best practice advisory encouraging LCS was associated with an increase in LCS ordering behavior. Addition of a nurse navigator to the LCS program was associated with improved program quality as evidenced by increased documentation of shared decision making and tobacco cessation counseling and the elimination of ineligible patient screening. In aggregate, these findings demonstrate the impact of programmatic interventions and structure on LCS uptake and quality, which may be considered by existing and future LCS programs.

Figure 1: LCS workflow.

Screening can be either PCP driven or specialist driven. A NN is responsible for verifying screening eligibility, assuring SDM documentation, communicating screening results, and facilitating evaluation of screen detected abnormalities. If the NN cannot verify eligibility and SDM, patients are seen in LCS clinic prior to LDCT. The NN also facilitates management of screen-detected abnormalities. Definition of abbreviations: PCP = primary care provider; NN = nurse navigator; SDM = shared decision making; LCS = lung cancer screening; LDCT = low dose computed tomography.

Figure 2: Baseline screening volume by provider type.

LCS began at University of Colorado Hospital in July 2014 with a LCS-specific CT order designed to differentiate screening and diagnostic studies. The CMS final decision on LCS was issued in February 2015. The LCS clinic was started in February 2015. Definition of abbreviations: LCS = lung cancer screening.

Figure 4: BPA exposure increases LCS ordering.

(A) Relationship between BPA firing and LCS. Screened patients with a BPA fire had a more extensive smoking history (median 45 vs 40 pack years (IQR 40–60 vs 34–53, $p = 0.01$) and were more likely to be former smokers (54% vs 44%, $p = 0.02$). **(B)** BPA firing and LCS ordering by PCP. Each point represents a single PCP. Increase BPA exposure is associated with increased LCS behavior (Pearson $r=0.62$, $p<0.0001$). Definition of abbreviations: BPA = best practice advisory; LCS = lung cancer screening; IQR = interquartile range; PCP = primary care provider.

Figure 5: NN impact on the LCS program.

(A) Institution of a NN increases compliance with SDM, TCC, and eligibility. (B) Box and whisker plot of calculated risk score by 6 month intervals. Midline of the box is the median, lower and upper horizontal edges of box represent the 25th – 75th percentiles, whiskers indicate variability outside the lower and upper quartiles, and dots indicate outliers. Median risk score values are labeled for each 6 month interval; Spearman $r = 0.18$, $p < 0.0001$. Definition of abbreviations: NN = nurse navigator; SDM = shared decision making; TCC = tobacco cessation counseling.

Table 1.

Characteristics of patients by screening provider

	Specialist n = 299	PCP n = 325
Age, yr	64.3 (±5.7)	64.4 (±6.2)
Sex, male	168 (56.2)	187 (57.5)
Race, non-Hispanic white	247 (82.6)	274 (84.3)
Smoking status		
Current	163 (54.5)	158 (48.6)
Former	136 (46.5)	167 (51.4)
Median Pack Years (IQR)	45.0 (40.0 – 59.0)	40.0 (33.0 – 51.0)
Median 6 yr lung cancer risk, % (IQR)	3.6 (2.1 – 6.1)	2.8 (1.7 – 5.1)

Patients were classified as PCP screened or specialist screened as described in Methods. Fifty patients were evaluated in LCS clinic after the NN could not verify PCP performed SDM; these patients were classified as specialist screened. Analyzing these patients as PCP screened did not change the observed patient characteristics. Specialist screened patients had higher 6-year lung cancer risk ($p=0.004$) that was driven by a higher pack year smoking history ($p=0.0001$). Reference values were used to calculate lung cancer risk score when specific data points could not be abstracted from the EMR. Missing data elements were education level ($n=141$), family history of lung cancer ($n=131$), personal history of cancer ($n=9$), history of COPD ($n=4$), years since quit smoking ($n=9$), and body mass index ($n=3$). Data are presented as count (%), mean $\pm$ SD, or median (IQR). Definition of abbreviations: yr = year; IQR = interquartile range.

Table 2.

Screening outcomes by screening provider

	Specialist n = 299	PCP n = 325
Lung-RADS Category		
1	188 (62.9)	167 (51.4)
2	75 (25.1)	114 (35.1)
3	18 (6.0)	23 (7.1)
4	18 (6.0)	21 (6.4)
Any S finding*	95(31.8)	65 (20.0)
Coronary Calcification	60 (63.2)	37 (56.9)
Other	35 (36.8)	28 (43.1)
Any lung cancer	4 (1.3)	9 (2.8)
Early Stage	3 (75.0)	7 (77.8)
Late Stage	1 (25.0)	2 (22.2)

Lung cancer was detected in 13 of 624 (2.1%) patients. Specialist screened patients had a higher percentage Lung-RADS 1 results while PCP screened patients had a higher percentage of Lung-RADS 2 results ($p < 0.05$). Specialist screened patients also had more S findings ($p = 0.0008$). Data are presented as count (%). Definition of abbreviations: Lung-RADS = Lung CT Screening Reporting and Data System.

* Incidental findings for which further evaluation was recommended.