Factors associated with poor patient recall of lung cancer screening follow-up recommendations and the association with adherence

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Abstract

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Rationale. Factors associated with adherence to recommendations after initiating lung cancer screening (LCS) are poorly understood. We sought to determine patient-level factors associated with incorrect identification of LCS follow-up recommendations, hypothesizing that incorrect recall would be associated with decreased adherence to follow-up.

Methods. We performed a cross-sectional study of patients in the University of Washington LCS registry who underwent initial LCS exam between June 2017- July 2018 (n=229). We excluded individuals with cognitive limitations and non-English speakers. Subjects were mailed a survey following initial LCS exam. Additional data was abstracted from the electronic health record and LCS registry. Participants were asked to identify the timing and next step for their follow-up, with answers corresponding to Lung-RADS recommendations. We examined associations between incorrect identification of recommended follow-up and patient-level characteristics, self-perceived benefit/harm of LCS, Lung-RADS score, and method of results communication (letter, telephone or in-person). Adherence was defined as receipt of follow-up within 90 days of recommended interval by Lung-RADS 1.0 designation. Categorical variables were compared using chi-square tests and bivariate logistic regression. Multivariable logistic regression was used to estimate associations between incorrect identification of recommendations and adherence to follow-up, adjusting for demographics (age, race/ethnicity), smoking (current vs. former), and Lung-RADS score (<3 vs ≥ 3).

Results. One-hundred two participants completed the survey (response rate 44.5%); 46 (45%) incorrectly identified their follow-up recommendation. In bivariate analyses, individuals who self-identified as male, current smokers, had lower educational attainment or lower income were less likely to correctly identify

follow-up recommendations. The method of communicating LCS results and follow-up was not associated with incorrect identification of follow-up. Those with lung-RADS scores ≥3 were less likely to correctly identify follow-up recommendations compared to those with scores <3. Overall adherence to follow-up was 62%. Despite more incorrect responses in those with lung-RADS score ≥3, the majority of these participants (15/19, 79%) were adherent with follow-up. In adjusted models, incorrect identification of LCS recommendations was associated with decreased adherence to follow-up (OR=0.37, 95% CI: 0.14-0.96).

Conclusion. This study is among the first to identify factors associated with incorrect identification of recommendations for LCS follow-up, and to find that incorrect identification is associated with less adherence to follow-up. These results can inform efforts to target improved education and navigation of LCS, potentially improving adherence.

Introduction:

Lung cancer is the leading cause of cancer-related death in the United States. Each year more people die from lung cancer than from colon, breast and prostate cancers combined.[1] Clinical trials have consistently demonstrated the benefit of longitudinal low-dose computed tomography (LDCT) based lung cancer screening (LCS) to reduce lung cancer specific mortality.[2,3] Translation of clinical trial benefits into clinical practice will necessarily require mechanisms to assure patient understanding of and adherence to often complex screening recommendations, which may include immediate tissue sampling, short term radiographic reassessment, and/or need for continued annual screening.

While adherence to LCS clinical follow-up was ~95% in the National Lung Screening Trial (NLST) and nearly 90% in the more recent Dutch-Belgian Randomized Lung Cancer Screening Trial (NELSON), emerging studies suggest it will be lower in clinical or real-world settings.[4,5] For breast, cervical and prostate cancer screening, studies have indicated that decision making interventions and standardized result communication tools increase patients' knowledge about the need for ongoing cancer screening tests and increase adherence to follow-up recommendations. [6,7] In the U.S., lung cancer disproportionally affects lower socioeconomic strata and those with lower educational level achieved.[8,9] Therefore, it is imperative to prioritize effective communication between patient and provider that emphasizes *understanding* of follow up recommendations as a critical, and best practice, step to improve adherence to subsequent procedures and annual screening.[10-12]

The development of an effective patient-centered communication tool must start with knowledge of demographic and patient-level factors associated with poor understanding of LCS recommendations. The objective of this study was to determine barriers to patient recall of LCS follow-up recommendations and determine the association of recall with ultimate adherence to follow-up.

Materials and Methods:

Screening Program and Study Population

We performed a cross-sectional analysis of participants enrolled in a Seattle-based multisite LCS program who received baseline LCS between June 2017- July 2018, and in a subsequent cohort analysis, were followed for adherence to follow-up recommendations through October 2019. Registry participants deemed eligible were mailed an informed consent and a research survey to complete following initial LDCT. The vast majority (93%) of registry participants qualified for LCS based on United States Preventative Service Task Force (USPSTF) guidelines, including: persons age 55- 80 years old who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years. Those who did not meet USPSTF criteria and who were inappropriately referred to our LCS program were included in analysis of recall of LCS recommendations but were excluded from analysis of adherence (n=7). Reminder/thank-you postcards were sent 2 weeks after the initial contact, and second packets with research surveys sent to non-responders after 4 weeks. A $10 gift card was sent as an incentive to enhance participation.[13] We excluded participants who were non-English speaking or had expressive language deficits.

The LCS program serves the University of Washington, the Seattle Cancer Care Alliance, and their affiliated hospitals and clinics including over 25 unique primary care clinics as well as Harborview Medical Center, a county safety-net hospital and its affiliated clinics. The screening program is largely decentralized, with individual providers managing screening; however, there are several key centralized elements to the program. First, upon entry into the LCS program and scheduling of the baseline CT, the patients undergo a universal phone interview where they provide a self-report of health and smoking history. Second, there is a centralized tracking database across the system which tracks screening results. This tracking system is utilized to send all patients a letter reminder when screening is due and is accessed by a dedicated nurse-practitioner who sends directed follow-up reminders to providers and patients who have high-risk imaging findings (Lung-RADS 4A or higher). All participants in the screening program over the study time period were enrolled in this study to evaluate adherence with a waiver of consent

provided by the Institutional Review Board (Fred Hutchinson Cancer Research Center, Study Protocol 9968).

Study Variables and Outcome

Participant data for survey responders were obtained primarily from self-report on the research survey and included age at initial screening, gender, race, ethnicity, family history of lung cancer, smoking history, place of residence, annual income, education level achieved, insurance status, self-identified comorbidity data, self-perceived risks/benefits of LCS, post-LDCT perception of lung cancer likelihood, healthcare literacy, trust in healthcare provider/system, and means of communicating results (letter only versus the addition of telephone or in-person encounter). Demographic information for survey non-responders was obtained from data collected at phone interview following LCS referral and scheduling but was limited compared to survey information (Supplementary Table 1). Information on ordering provider, location of LDCT, and CT characteristics were derived from the electronic health record (EHR) for both survey responders and non-responders.

We reviewed CT reports to characterize baseline LCS results. All interpretations were made by a thoracic radiologist and consistent with Lung-RADS version 1.0. Recommended follow-up was also standardized by Lung-RADS (Table 1). In the survey, participants were asked to identify the next step that was recommended to them after their last LCS CT scan from a list of multiple-choice responses. Participants could choose from 1) I do not know, 2) I do not need to return for annual LCS, 3) I should return for annual LCS CT in one year, 4) I should come back sooner than one year for a CT scan of my lungs, 5) I should have other testing for possible lung cancer or lung disease (such as PET scan, bronchoscopy, biopsy, sputum evaluation or other testing), or 6) Other (free text). Correct or incorrect recall of follow up recommendations was identified for each participant by correlating responses with Lung-RADS recommendations (Table 1). All participants who selected that they did not need to return for annual LCS or the free text options were manually reviewed for accurate understanding of follow up recommendations.

Finally, adherence to follow up recommendations was determined by review of the EHR through October 2019 for any documentation, imaging or procedures follow index LCS CT scan. We considered patients adherent if subsequent LCS occurred within 90 days of the recommended follow-up window or if they received alternative forms of follow-up, such as a diagnostic CT performed for other purposes within the follow-up window (Table 1). For non-adherent patients, the EHR was reviewed for reasons for possible non-adherence. Those who either could not be adherent (i.e. death during follow-up period), or should not be adherent (i.e. those who did not qualify for initial screening per USPSTF guidelines, or had documented proof of relocation outside of the catchment area) were excluded from the analysis of adherence (Figure 1).

Statistical Analysis

Descriptive statistics were reported using proportions (%) for categorical and dichotomous variables, and medians with interquartile range for continuous variables. For analysis, all continuous variables were categorized at clinically meaningful cutoffs where possible. Comparative results between groups that had correct and incorrect recall of LCS recommendations were obtained via chi-squared testing. We examined several potential factors associated with incorrect recall of LCS follow-up recommendations using bivariate logistic regression. Multivariable logistic regression was then used to estimate independent associations between clinical exposure variables and incorrect recall of LCS recommendations as our outcome, adjusting for age (< 65 vs ≥ 65), sex, smoking status (current vs former), education level achieved (some college vs less than college), and Lung-RADS score (< 3 vs ≥ 3), based on *a priori* hypotheses. In a separate multivariate logistic regression model, we next examined the association between incorrect recall of LCS follow-up recommendations, using this as the primary exposure variable, and adherence as the outcome, while controlling for potential confounders. Variables included in this model were based on previous patient-level sociodemographic and CT characteristics known to be associated with screening adherence, and included: age, smoking status, and Lung-RADS score (< 3 vs ≥ 3) (Triplette M, manuscript under review).

Finally, in sensitivity analyses, we examined whether associations between incorrect recall of LCS follow up recommendations and adherence differed by Lung-RADS score (< 3 vs ≥ 3), to confirm that meaningful observations in the relationships between recall of recommendations and adherence are similar among the patients with higher and lower post-test probability of lung cancer .

All statistical analyses were performed using Stata v16.0 (Stata Corporation, College Station, TX). Results were considered significant at a two-sided p-value of <0.05.

Results:

Two hundred and twenty-nine individuals received baseline lung cancer screens during the study period and were mailed the research survey. One hundred and two participants returned the survey and were included in the overall analysis (response rate 44.5%). For the analysis of adherence, 94 met criteria for inclusion (Figure 1). The median age of participants was 65 years old (Table 2). The majority were male and seventy-eight percent identified as non-Hispanic, white. Participants had a median smoking history of 50 pack-years, with a slightly higher proportion of former smokers compared to current (55% versus 45%). The majority of participant baseline scans had a Lung-RADS of 1 or 2 (81%) however many participants still perceived their individual risk for lung cancer as high (45%). Despite the centralized tracking database in our center's LCS program, only 34 subjects recalled receiving their LCS results via a letter. Twelve subjects recalled receiving a telephone call or an in-person consultation in addition to a letter, and 18 subjects could not recall the method of result delivery. Notably, survey non-responders were more likely to self-identify as black, be current smokers of tobacco, and were slightly more likely to utilize public insurance options as their primary means of payment (supplementary Table 1). Among survey responders, baseline scans resulted in a nodule/finding that resulted in lung cancer diagnosis in 1.9% (2/102) of our cohort, both at early stage.

Overall, 56 subjects (55%) successfully recalled LCS follow up recommendations. In bivariate analyses, individuals who self-identified as male, current smokers, those with lower educational

attainment (< college education versus at least some college), or lower income level (<$15,000 compared to >$50,000) were less likely to correctly recall follow-up recommendations (Table 3). Notably, neither the ordering provider specialty (Primary care specialty versus Pulmonary specialist) nor the method of communicating LCS results and follow-up recommendations were associated with incorrect recall of follow-up. We found that those with lung-RADS scores ≥3 were more likely to have poor recall of follow-up recommendations compared to those with scores <3 (Table 3). In multivariate models, current smoking (OR 2.54, 95% CI 1.01- 6.53) and Lung-RADS score ≥3 (OR 3.85 , 95% CI 1.18- 12.53) remained associated with increased odds of poor recall of follow-up recommendations while having had at least some college education (OR 0.27, 95% CI 0.10- 0.74) was independently associated with lower odds of poor recall of follow up recommendations (Table 4).

Overall adherence to follow-up was 62% in survey responders and 39% in non-responders. In adjusted models, incorrect recall of LCS recommendations was associated with decreased adherence to follow-up (OR=0.37, 95% CI: 0.14-0.96). Despite more incorrect recall of follow-up recommendations in those with lung-RADS score ≥3, the majority of the participants (15/19, 79%) were adherent with follow-up (Table 5).

Finally, we assessed Lung-RADS as an effect modifier in the relationship between recall of LCS follow-up recommendations and adherence. In those with "low risk" baseline CT's (Lung-RADS 1 and 2), poor recall of lung cancer screening follow-up recommendations remained associated with lower adherence in a multivariable model which included age, race and smoking status (OR 0.46 95% CI 0.13, 0.98). However, in those with "high risk" baseline CTs (Lung-RADS ≥ 3), correct recall of follow-up recommendations perfectly predicted adherence limiting analysis, but suggesting an association between recall and adherence in this "high risk" group as well (Table 6).

Discussion:

While several studies have focused on barriers and facilitators to the uptake of screening, longitudinal adherence to follow-up recommendations is essential to obtain the lung cancer specific mortality benefits observed in randomized studies of LCS. For example, approximately 13% of lung cancers in NLST and NELSON were diagnosed on follow-up LDCT after a normal baseline exam.[2,3] To our knowledge this is one of the first studies to affirm factors associated with patient recall of lung cancer screening recommendations and its association with follow-up adherence. In adjusted models, lower educational attainment and current smoking status were independently associated with increased odds of poor recall of follow-up recommendations, findings that should guide strategies to develop patient communication tools to the appropriate reading-level for LCS program participants. We found that poor recall was associated with decreased adherence especially among patients with low Lung-RADS score. This finding may suggest the importance of improved patient understanding/recall as one key mechanism to increase adherence, especially amongst those with "low risk" LDCT who are *most likely* to benefit from ongoing screening and *least likely* to have substantial support from cancer navigators.

Poor recall among participants with lower education level achieved and those who currently smoke may not be surprising. Lower education level achieved may directly impact patient understanding of complex medical recommendations[14,15] and may reflect associations with social disparities such as low income and poor health access that have been linked to inferior health outcomes in cancer screening previously,[16-19] and which we observed in bivariate analyses in this study. The burden of smoking and lung cancer remain disproportionately high in persons with lower education and lower socioeconomic status (SES),[20,21] and thus represent crucial populations to target for improved communication and cancer navigation. Additionally, prior studies demonstrate that current smokers may be less likely to seek out care related to lung cancer diagnosis compared to former smokers.[22-24] Qualitative studies suggest this may result from an attitude of fatalism on the part of individuals who continue to smoke regarding future lung cancer compared to former smokers who may feel more motivated to continue to make health conscious choices after making the commitment to quit smoking.[23]

Interestingly, having a higher Lung-RADS score was associated with higher odds of poor recall of follow up recommendations in fully adjusted models. This finding may reflect the increased complexity of recommendations following "high risk" LDCT, however it is notable that the observation was persistent even when answer choices allowed to be considered correct were liberalized. Alternatively, it may reflect differences in subjects who have more advanced risk at time of initial enrollment into lung cancer screening programs compared to those who have lower risk. Similar socioeconomic and health access disparities that have been shown to negatively impact outcomes in other cancer screening programs are associated with delays in initiation of cancer screening and thus more advanced stage at presentation.[25-29] Reassuringly, despite this poor recall, our findings suggest that in patients with higher Lung-RADS, recall is less associated with adherence. The majority of participants with Lung-RADS≥ 3 who incorrectly identified follow up recommendations were nonetheless adherent to follow-up, perhaps reflecting improved support for clinical navigation in those with higher risk baseline LDCT.

In our cohort, 63 subjects (62%) successfully followed up, which is far lower than trial setting[2,3]. The few studies which have examined adherence to follow-up in the context of LCS report a wide range of adherence values, with typical clinical programs reporting similar adherence to this cohort.[30-32] Studies have consistently validated the importance of effective communication between provider and patient following cancer screening to ally distress, improve patient satisfaction and increase adherence.[6,33,34] This is particularly important in LCS, where incidental findings on LDCT are common and may be associated with distress and contribute to loss to follow-up.[11,35,36] Among Veterans with incidentally detected lung nodules, confusion about results and follow-up was frequent.[34,37] High quality communication was associated with less distress, and being informed of nodule characteristics was important to patients.[34,36,38,39] Our data suggest that communication between patient and provider following index LDCT should additionally include discussion of follow-up recommendations. Though recall of these recommendations does not uniformly predict adherence we observed that it is critical step for *many* LCS

participants, especially those with low risk LDCT (Lung-RADS 1-2) who typically receive less dedicated support/navigation but who derive significant benefit from ongoing screening.

Our LCS program utilizes a tracking intervention which provides follow-up reminder letters to all patients and active reminders to patients, and their providers, with Lung-RADS 4 findings. Though previous reports have shown this to be associated with improved adherence (Triplette M, manuscript under review), interestingly in our cohort only 33% of participants recalled receiving letter. Knowledge gained from other cancer screening modalities highlight that defining a "best" communication strategy is uncertain and much context specific variability exists.[40] Regardless, this finding, along with other studies which demonstrate higher levels of adherence in programs that utilize a centralized structure, may point to the benefit of specific navigation interventions to target adherence. Our study may help guide future targets for follow-up navigation and highlights the importance of targeting groups disproportionately affected by lung cancer, including current smokers, particularly those in lower socioeconomic groups and those with lower educational achievement.

While our study is one of the first to evaluate factors associated with LCS follow up recommendations and the role this may play in adherence, this study does have several limitations. The small number of participants in our cohort restricted our ability to adjust completely for differences between subjects with or without poor recall of LCS follow-up recommendations and it is possible that residual confounding exists. The response rate of the survey was only forty-four percent. While this is an acceptable rate of return,[41] differences between responders and non-responders with regards to our outcomes could introduce bias. Non-responders were observed to have lower adherence to LCS recommendations and tended to more frequently self-identify as black, be current smokers and rely on public health insurance. Though this may limit generalizability, even amongst a group of more affluent survey respondents with higher educational levels achieved and increased levels of adherence, we have identified barriers relevant to clinical navigation of LCS that may be expected to have an even greater clinical impact among an unbiased cohort. Generalizability may also be limited by our recruitment from a

single lung cancer screening program, however, this cohort includes a broad payer mix and a safety-net populations. Reliance on surveys introduces potential for recall bias. The nearly uniform split between correct and incorrect recall of follow up recommendations may provide assurance that there was not differential misclassification based on our outcome; however, cautious inference is required. Finally, while we evaluated the EHR of non-adherent individuals for documented evidence of relocation, we cannot definitively say that they did not move, establish care outside of our system, or receive lung cancer screening elsewhere. Though this would have no impact on our primary outcome of interest, participant recall, it is possible that our estimate of adherence may be slightly lower than actual return to screening. We feel this bias would be non-differential when considering risk factors for adherence.

We have identified participants with lower educational level achieved and current smokers as particularly vulnerable populations in need of special consideration and targeting for navigation and observed that poor recall of LCS follow up recommendations was associated with decreased adherence to LCS. Though patient understanding of LCS results does not uniformly predict adherence, we suggest it is a best-practice, patient centered outcome for *many* LCS participants and may be important in improving adherence to LCS recommendations in real world clinical settings. Future studies will utilize our findings to develop education-level appropriate communication tools that work to promote understanding of LCS results and follow-up recommendations as a mechanism to derive maximum benefit from LCS programs. Finally, it is critical we explore these important relationships in increasingly diverse, real-world cohorts. A greater understanding of factors associated with adherence to LCS follow-up among populations with limitations in health access who are disproportionally impacted by lung cancer remains necessary.

Table 1. Definition of correct recall of LCS follow-up recommendations and adherence.			
Lung-RADS Category	Lung-RADS management recommendations	Correct recall of follow up recommendations per survey	Definition of adherence
1	Continue annual screening with LDCT in 12 months	I should return for annual LCS CT in one year	15-month LDCT or diagnostic CT for other purposes
2			
3	6-month LDCT	*I should come back sooner than one year for a CT scan of my lungs Or *I should have other testing for possible lung cancer or lung disease (such as PET scan, bronchoscopy, biopsy, sputum evaluation or other testing)	9-month LDCT or diagnostic CT for other purposes
4A	3-month LDCT or PET/CT		6-month LDCT or PET/CT
4B	PET/CT and/or tissue sampling		3-month PET/CT or biopsy
4X			
*Both answer choices deemed correct given subtlety in difference to LCS participants			

Figure 1: Participant Selection

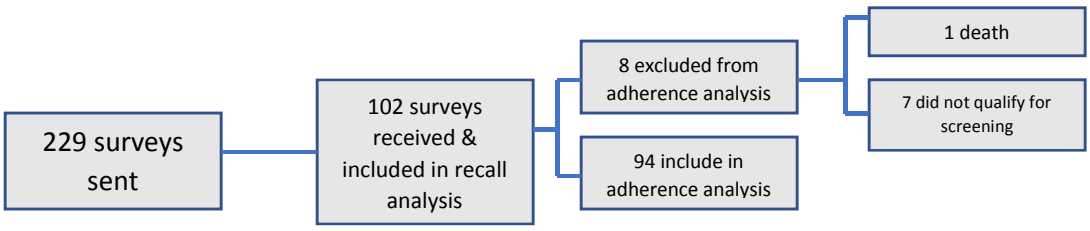

Table 2. Baseline demographic and computed tomography characteristics of participants enrolled in LCS program (June 2017- July 2018) in responders to enrollment survey (n=102)	
Patient Characteristics	
Gender – no. (%)	
Male	69 (67.6)
Female	32 (31.4)
Age, Median (IQR)	65 (61-70)
Referral/Enrollment site	
University-affiliated	49 (48.0)
Safety-net affiliated	51 (50.0)
Race– no. (%)	
White	79 (77.5)
Black or African American	12 (11.8)
Asian	7 (6.9)
Other	2 (1.9)
Ethnicity – no. (%)	
Hispanic or Latino	3 (2.9)
Non-Hispanic and non-Latino	97 (95.1)
Education achieved – no. (%)	
< high school	11 (10.7)
High school graduate	22 (21.6)
At least some college	32 (31.4)
College Graduate	37 (36.3)
Income level, annual – no. (%)€	
< $15, 000	31 (30.4)
$15,000- $50,000	22 (21.6)
> $50,000	29 (28.4)
Health insurance – no. (%)₮	
Private	19 (18.6)
Medicare/caid	61 (59.8)
Charity Care	10 (9.8)
Ordering Provider	
Primary Care specialty	92 (91.1)
Pulmonary specialist	9 (8.9)
Smoking status at enrollment – no. (%)	
Current	44 (43.2)
Former	55 (53.9)
Tobacco pack-years – median (IQR)	50 (42-60)
Eligible by USPSTF Recommendation – no. (%)	95 (93.1)
Family history of lung cancer in relative – no. (%)	20 (19.6)
Self-reported comorbidities	
Chronic Lung disease	36 (35.2)
Heart Failure	18 (17.6)
Pervious malignancy	10 (9.8)
Baseline CT characteristics	
Lung-RADS Category – no. (%)	
1	24 (23.5)
2	59 (57.8)
3	13 (12.8)
4A	3 (2.9)
4B	1 (1.0)
4X	2 (1.9)
S-findings designation– no. (% of total)	60 (58.8)
Nodules present– no. (%)	
Single	18 (17.6)
Multiple	63 (61.8)
None	21 (20.6)
Nodule size (largest) – no. (%)	
≤ 6 mm	39 (38.2)
>6 and ≤ 8 mm	12 (11.8)
>8 mm	10 (9.8)
Not specified	41 (40.2)
Nodule Characterization (largest) – no. (%)	
Solid	58 (56.9)
Semi-Solid	3 (2.9)
Ground-glass	8 (7.8)
Not specified	33 (32.4)
Mediastinal or hilar adenopathy – no. (%)	1 (0.9)
Incorrect recall of LCS follow up recommendations—no. (%)	46 (45.1)
Lung cancer diagnosis resulting from baseline scan	2 (1.9)
Any reported complications	1 (1.0)

Abbreviations: LCS= lung cancer screening; USPSTF= United States preventative service task force; CT= computed tomography; Lung-RADS= lung imaging reporting and data system; S-findings= Other findings (non-lung cancer)
€ data available for n=82
₮ data available for n=90
Missing is <5% unless otherwise noted as above

Table 3. Factors related to incorrect recall of lung cancer screening follow up recommendations among survey responders (n=102)

Variable	Correct Recall (n=56)	Incorrect Recall (n=46)	Odds Ratio (95% CI)
Age			
Age <65	26	21	Ref
Age ≥65	30	24	1.04 (0.47, 2.30)
Sex			
Male	33	36	Ref
Female	23	9	0.36 (0.15, 0.91)
Race			
White	45	30	Ref
Black	6	5	1.29 (0.36, 4.63)
Other	4	10	3.88 (1.11, 13.53)
Ethnicity			
Non-Hispanic	54	43	Ref
Hispanic	0	3	NA
Education			
Less than college	12	21	Ref
College or greater	44	25	0.34 (0.15, 0.81)
Income category			
<15K	12	19	Ref
15-50K	12	10	0.55 (0.18, 1.69)
>50K	22	7	0.21 (0.06, 0.65)
Insurance			
Private	16	3	Ref
Medicare/caid	29	32	5.71 (1.50, 21.6)
Charity	5	5	5.33 (0.93, 30.6)
Ordering Provider			
Primary care specialty	49	43	Ref
Pulmonary specialist	6	3	0.58 (0.14, 2.47)
Smoking status			
Former	35	10	Ref
Current	20	24	2.18 (1.02, 4.81)
Screening (ever for other cancers)			
No	22	27	Ref
Yes	31	20	0.55 (0.24, 1.21)
Self-perceived risk of Lung Cancer			
Low	8	5	Ref
Moderate	24	18	1.13 (0.32, 4.07)
High	22	24	1.75 (0.50, 6.14)
Self-perceived benefit from LCS			
No	7	10	Ref
Yes	49	37	0.58 (0.20, 1.72)
Self-perceived risk from LCS			
No	20	22	Ref
Yes	26	19	0.70 (0.30, 1.63)
Method of results delivery			
Letter	22	12	Ref
Telephone	6	4	1.22 (0.28, 5.20)
In-person	18	24	2.34 (0.92, 5.97)
Comorbidity data			
Heart disease			
No	18	19	Ref
Yes	4	14	2.46 (0.73, 8.31)
Lung Disease			
No	16	14	Ref
Yes	16	20	1.54 (0.58, 4.11)
Other cancer			
No	20	25	Ref
Yes	8	2	0.21 (0.04, 1.09)
Provider trust/doctor trust[Ŧ]			
No	29	19	Ref
Yes	26	28	1.59 (0.72, 3.49)
Health literacy (forms difficult)[€]			
No	27	16	Ref
Yes	28	31	1.81 (0.81, 4.04)
Family/social support[¶]			
No	28	25	Ref
Yes	27	22	0.87 (039, 1.90)
Lung-RADS			
<3	50	33	Ref
≥3	6	13	3.03 (1.04, 8.87)
S-findings			
No	21	23	Ref
Yes	36	24	0.60 (0.27, 1.32)

Abbreviations: Lung-RADS= lung imaging reporting and data system; S-findings= Other findings (non-lung cancer)

Ŧ Provider trust based on agreement or disagreement with statement "I trust doctors' decisions about which medical treatments are best"

€ Health literacy based on response to the question "How often do you have problems learning about medical problems because of difficulty with understanding written information?"

¶Social support based on response to the question "How often do you have someone like a family member, friend, or caregiver help you read clinic or hospital materials?" Likert scale with Always or often affirming family/social support

Table 4. Odds of incorrect recall of lung cancer screening follow-up recommendations in multivariable model of survey responders (n=102)		
Variable	**OR**	**95% CI**
Age		
Age <65	Ref	Ref
Age >=65	1.29	(0.49, 3.37)
Sex		
Male	Ref	Ref
Female	0.47	(0.17, 1.31)
Smoking status		
Former	Ref	Ref
Current	2.54	(1.01, 6.53)
Education		
Less than college	Ref	Ref
College or greater	0.27	(0.10, 0.74)
Lung-RADS		
< 3	Ref	Ref
≥ 3	3.85	(1.18, 12.53)
Abbreviations: Lung-RADS= lung imaging reporting and data system		

Table 5. Odds of adherence to LCS follow up recommendations following incorrect recall of LCS recommendation among survey responders (n=94)			
Variable	**Adherent (n= 54)**	**Non-Adherent (n=40)**	**OR (95% CI)**
Recall of LCS follow-up recommendation			
Correct	**32 (65.3)**	**17 (34.7)**	**Ref**
Incorrect	**22 (48.9)**	**23 (51.1)**	**0.37 (0.14, 0.96)**
Age			
<65	21 (48.2)	22 (51.2)	Ref
≥65	34 (68.0)	16 (32.0)	2.24 (0.92, 5.49)
Smoking status			
Former	28 (59.6)	19 (40.4)	Ref
Current	26 (60.5)	17 (39.5)	1.22 (0.49, 3.02)
Lung-RADS			
< 3	40 (53.3)	35 (46.7)	Ref
≥ 3	15 (79.0)	4 (21.0)	3.06 (0.84, 11.12)

Abbreviations: LCS= Lung cancer screening; Lung-RADS= lung imaging reporting and data system

Table 6. Odds of adherence to LCS follow up recommendations following incorrect recall of LCS recommendations stratified by Lung-RADS (<3 or ≥3) (n=94)				
	Lung-RADS <3 (n=75)		Lung-RADS >3 (n=19)	
Variable	**Adherent**	**Non-Adherent**	**Adherent**	**Non-Adherent**
Recall of LCS follow-up recommendation				
Correct	26 (62.0)	16 (38.0)	6 (100)	0 (0)
Incorrect	14 (42.4)	19 (57.6)	9 (69.2)	4 (30.8)
Abbreviations: LCS= lung cancer screening; Lung-RADS= lung imaging reporting and data system				

Supplementary Table 1. Baseline demographic and computed tomography characteristics of participants enrolled in LCS program (June 2017- July 2018) in non-responders to enrollment survey (n=127)	
Patient Characteristics	
	Survey Non-Responders
Gender – no. (%)	
Male	87 (68.5)
Female	40 (31.5)
Age, Median (IQR)	64 (60-67)
Referral/Enrollment site	
University-affiliated	66 (52.0)
Safety-net affiliated	61 (48.0)
Race– no. (%)	
White	91 (71.7)
Black or African American	22 (17.3)
Asian	6 (4.7)
Other	8 (6.2)
Ethnicity – no. (%)Ŧ	
Hispanic or Latino	1 (0.8)
Non-Hispanic and non-Latino	16 (12.6)
Health insurance – no. (%)	
Private	33 (26.0)
Medicare/caid	89 (70.1)
Charity Care	2 (1.6)
Smoking status at enrollment – no. (%)	
Current	85 (66.9)
Former	42 (33.1)
Tobacco pack-years – median (IQR)†	50 (41-76)
Family history of lung cancer in relative – no. (%)	17 (16.8)
Baseline CT characteristics	
Lung-RADS Category – no. (%)	
1	24 (18.9)
2	84 (66.1)
3	7 (5.5)
4A	7 (5.5)
4B	3 (2.4)
4X	2 (1.6)
S-findings designation– no. (% of total)	79 (62.2)
Nodules present– no. (%)	
Single	29 (22.8)
Multiple	73 (58.4)
None	25 (19.8)
Nodule size (largest) – no. (%)	
≤ 6 mm	71 (55.9)
>6 and ≤ 8 mm	5 (3.9)
>8 mm	9 (7.1)
Not specified	42 (33.1)
Nodule Characterization (largest) – no. (%)	
Solid	78 (61.4)
Semi-Solid	7 (5.5)
Ground-glass	9 (7.1)
Not specified	33 (26.0)
Mediastinal or hilar adenopathy – no. (%)	3 (2.4)
Lung cancer diagnosis resulting from baseline scan	3 (2.4)
Any reported complications	1 (0.8)

Abbreviations: LCS= lung cancer screening; CT= computed tomography; Lung-RADS= lung imaging reporting and data system; S-findings= Other findings (non-lung cancer)
Ŧ data only available for n=17
Missing is <5% unless otherwise noted as above

References

1. *Cancer Facts & Figures 2018.* American Cancer Society;2018.
2. de Koning HJ, van der Aalst CM, de Jong PA, et al. Reduced Lung-Cancer Mortality with Volume CT Screening in a Randomized Trial. *The New England journal of medicine.* 2020;382(6):503-513.
3. Aberle DR, Adams AM, Berg CD, et al. Reduced lung-cancer mortality with low-dose computed tomographic screening. *The New England journal of medicine.* 2011;365(5):395-409.
4. Jemal A, Fedewa SA. Lung Cancer Screening With Low-Dose Computed Tomography in the United States-2010 to 2015. *JAMA oncology.* 2017;3(9):1278-1281.
5. Nanavaty P, Alvarez MS, Alberts WM. Lung cancer screening: advantages, controversies, and applications. *Cancer Control.* 2014;21(1):9-14.
6. Briss P, Rimer B, Reilley B, et al. Promoting informed decisions about cancer screening in communities and healthcare systems. *American journal of preventive medicine.* 2004;26(1):67-80.
7. Orel SG, Kay N, Reynolds C, Sullivan DC. BI-RADS categorization as a predictor of malignancy. *Radiology.* 1999;211(3):845-850.
8. Guichet PL, Liu BY, Desai B, Surani Z, Cen SY, Lee C. Preliminary Results of Lung Cancer Screening in a Socioeconomically Disadvantaged Population. *AJR Am J Roentgenol.* 2018;210(3):489-496.
9. National Lung Screening Trial Research T, Aberle DR, Adams AM, et al. Baseline characteristics of participants in the randomized national lung screening trial. *J Natl Cancer Inst.* 2010;102(23):1771-1779.
10. Montes U, Seijo LM, Campo A, Alcaide AB, Bastarrika G, Zulueta JJ. Factors determining early adherence to a lung cancer screening protocol. *Eur Respir J.* 2007;30(3):532-537.
11. Moseson EM, Wiener RS, Golden SE, et al. Patient and Clinician Characteristics Associated with Adherence. A Cohort Study of Veterans with Incidental Pulmonary Nodules. *Ann Am Thorac Soc.* 2016;13(5):651-659.
12. Wildstein KA, Faustini Y, Yip R, Henschke CI, Ostroff JS. Longitudinal predictors of adherence to annual follow-up in a lung cancer screening programme. *J Med Screen.* 2011;18(3):154-159.
13. Rookey BD, Le L, Littlejohn M, Dillman DA. Understanding the resilience of mail-back survey methods: An analysis of 20years of change in response rates to national park surveys. *Social science research.* 2012;41(6):1404-1414.
14. Albano JD, Ward E, Jemal A, et al. Cancer mortality in the United States by education level and race. *J Natl Cancer Inst.* 2007;99(18):1384-1394.
15. Galesic M, Garcia-Retamero R. Statistical numeracy for health: a cross-cultural comparison with probabilistic national samples. *Archives of internal medicine.* 2010;170(5):462-468.
16. Hiscock R, Bauld L, Amos A, Fidler JA, Munafo M. Socioeconomic status and smoking: a review. *Annals of the New York Academy of Sciences.* 2012;1248:107-123.
17. Elmore JG, Nakano CY, Linden HM, Reisch LM, Ayanian JZ, Larson EB. Racial inequities in the timing of breast cancer detection, diagnosis, and initiation of treatment. *Medical care.* 2005;43(2):141-148.
18. Martires KJ, Kurlander DE, Minwell GJ, Dahms EB, Bordeaux JS. Patterns of cancer screening in primary care from 2005 to 2010. *Cancer.* 2014;120(2):253-261.
19. Clegg LX, Li FP, Hankey BF, Chu K, Edwards BK. Cancer survival among US whites and minorities: a SEER (Surveillance, Epidemiology, and End Results) Program population-based study. *Archives of internal medicine.* 2002;162(17):1985-1993.
20. Haiman CA, Stram DO, Wilkens LR, et al. Ethnic and racial differences in the smoking-related risk of lung cancer. *The New England journal of medicine.* 2006;354(4):333-342.

21. Jamal A, Homa DM, O'Connor E, et al. Current cigarette smoking among adults - United States, 2005-2014. *MMWR. Morbidity and mortality weekly report.* 2015;64(44):1233-1240.

22. Friedemann Smith C, Whitaker KL, Winstanley K, Wardle J. Smokers are less likely than non-smokers to seek help for a lung cancer 'alarm' symptom. *Thorax.* 2016;71(6):659-661

23. Hall MB, Vos P. Comparison of Cancer Fatalism Among Rural Smokers and Nonsmokers. *J Community Health.* 2019;44(2):215-221.

24. Silvestri GA, Nietert PJ, Zoller J, Carter C, Bradford D. Attitudes towards screening for lung cancer among smokers and their non-smoking counterparts. *Thorax.* 2007;62(2):126-130.

25. Haas JS, Earle CC, Orav JE, Brawarsky P, Neville BA, Williams DR. Racial segregation and disparities in cancer stage for seniors. *Journal of general internal medicine.* 2008;23(5):699-705.

26. Wong MD, Shapiro MF, Boscardin WJ, Ettner SL. Contribution of major diseases to disparities in mortality. *The New England journal of medicine.* 2002;347(20):1585-1592.

27. Oakley-Girvan I, Kolonel LN, Gallagher RP, Wu AH, Felberg A, Whittemore AS. Stage at diagnosis and survival in a multiethnic cohort of prostate cancer patients. *American journal of public health.* 2003;93(10):1753-1759.

28. Sassi F, Luft HS, Guadagnoli E. Reducing racial/ethnic disparities in female breast cancer: screening rates and stage at diagnosis. *American journal of public health.* 2006;96(12):2165-2172.

29. Lantz PM, Mujahid M, Schwartz K, et al. The influence of race, ethnicity, and individual socioeconomic factors on breast cancer stage at diagnosis. *American journal of public health.* 2006;96(12):2173-2178.

30. Cattaneo SM, 2nd, Meisenberg BR, Geronimo MCM, Bhandari B, Maxted JW, Brady-Copertino CJ. Lung Cancer Screening in the Community Setting. *Ann Thorac Surg.* 2018;105(6):1627-1632.

31. Gould MK, Sakoda LC, Ritzwoller DP, et al. Monitoring Lung Cancer Screening Use and Outcomes at Four Cancer Research Network Sites. *Ann Am Thorac Soc.* 2017;14(12):1827-1835.

32. Hirsch EA, New ML, Brown SP, Baron AE, Malkoski SP. Patient Reminders and Longitudinal Adherence to Lung Cancer Screening in an Academic Setting. *Ann Am Thorac Soc.* 2019;16(10):1329-1332.

33. Freiman MR, Clark JA, Slatore CG, et al. Patients' Knowledge, Beliefs, and Distress Associated with Detection and Evaluation of Incidental Pulmonary Nodules for Cancer: Results from a Multicenter Survey. *J Thorac Oncol.* 2016;11(5):700-708.

34. Slatore CG, Golden SE, Ganzini L, Wiener RS, Au DH. Distress and patient-centered communication among veterans with incidental (not screen-detected) pulmonary nodules. A cohort study. *Ann Am Thorac Soc.* 2015;12(2):184-192.

35. O'Donnell S, Goldstein B, Dimatteo MR, Fox SA, John CR, Obrzut JE. Adherence to mammography and colorectal cancer screening in women 50-80 years of age the role of psychological distress. *Women's health issues : official publication of the Jacobs Institute of Women's Health.* 2010;20(5):343-349.

36. Slatore CG, Wiener RS, Golden SE, Au DH, Ganzini L. Longitudinal Assessment of Distress among Veterans with Incidental Pulmonary Nodules. *Ann Am Thorac Soc.* 2016;13(11):1983-1991.

37. Sullivan DR, Golden SE, Ganzini L, Hansen L, Slatore CG. 'I still don't know diddly': a longitudinal qualitative study of patients' knowledge and distress while undergoing evaluation of incidental pulmonary nodules. *NPJ primary care respiratory medicine.* 2015;25:15028.

38. Wiener RS, Gould MK, Woloshin S, Schwartz LM, Clark JA. What do you mean, a spot?: A qualitative analysis of patients' reactions to discussions with their physicians about pulmonary nodules. *Chest.* 2013;143(3):672-677.

39. Wiener RS, Koppelman E, Bolton R, et al. Patient and Clinician Perspectives on Shared Decision-making in Early Adopting Lung Cancer Screening Programs: a Qualitative Study. *J Gen Intern Med.* 2018;33(7):1035-1042.

40. Williamson S, Patterson J, Crosby R, et al. Communication of cancer screening results by letter, telephone or in person: A mixed methods systematic review of the effect on attendee anxiety, understanding and preferences. *Preventive medicine reports.* 2018;13:189-195.

41. Galea S, Tracy M. Participation rates in epidemiologic studies. *Annals of epidemiology*. 2007;17(9):643-653.