Original Research Article

Missed Opportunities? An Observational Analysis of Lung Cancer Screening Utilization Amongst Patients With Lung Cancer

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Abstract

Lung cancer (LC) is the leading cause of cancer-related deaths worldwide. The U.S. Preventive Services Task Force (USPSTF) and National Comprehensive Cancer Network (NCCN) recommend annual low-dose CT chest (LDCT) for LC screening in high-risk adults who meet appropriate criteria, which primarily focus on age and smoking history. Despite this, screening rates remain low and patients with LC are typically diagnosed at a later stage.

We conducted a single-center retrospective analysis of patients with an established diagnosis of lung cancer to evaluate if screening guidelines were appropriately followed before the cancer diagnosis.

Patients diagnosed with LC between 2016 and 2019 were included in the analysis. Charts were reviewed for demographics, detailed smoking history, as well as histology and stage of LC. Associations between categorical factors and screening were examined using the chi-square test. Associations between continuous and ordinal factors and screening were examined using the Mann–Whitney test.

A total of 530 charts were reviewed, of which 52% met NCCN criteria and 35% met USPSTF criteria. Only 4.0% and 4.8% of patients who met NCCN and USPSTF criteria, respectively, underwent screening. There was a significant association between staging at diagnosis and screening with LDCT. All the patients who had screening CT scans were diagnosed at localized stages of lung cancer in both NCCN and USPSTF groups compared to 49.1% and 48% in eligible subjects that did not undergo screening, respectively.

Our study showed that despite established guidelines for LC screening and insurance coverage, a vast majority of screening-eligible LC patients have never had LDCT. We found that patients who underwent screening as per guidelines were diagnosed at earlier stages of the disease. Ongoing efforts to increase awareness and adherence to LC screening guidelines are needed to improve early detection and reduce LC mortality.

Keywords

lung cancer, cancer screening, early diagnosis, tobacco control, metastasis

Introduction

Lung cancer (LC) is the leading cause of cancer death in men and women in the United States (U.S.)[1] and accounts for 27% of all cancer deaths nationwide.[2] Tobacco smoking is implicated as the causative factor in 85% of lung cancer cases.[3] LC is diagnosed at advanced stages in 56% of cases.[4] The five-year overall survival is directly proportional to the stage at diagnosis: 55% for early-stage and less than 20% for advanced LC.[3,4] Other malignancies such as prostate, breast, and colorectal cancer carry a five-year survival of 99%, 89%, and 65%.[2]

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Prospective studies evaluating the role of different screening methods started in the 1970s. Studies initially investigated the role of sputum cytology, results of which were not promising. Later studies evaluated the use of chest X-ray (CXR) as a screening method, but this strategy was also not found to be beneficial.[5,6] Finally, in the 2000s, prospective, randomized-controlled studies, such as the National Lung Screening Trial (NLST) and The Dutch–Belgian Randomized Lung Cancer Screening Trial (NELSON) trials, showed a significant mortality reduction benefit and increased rates of early-stage diagnosis (stage IA and stage IB) of LC when using low-dose CT (LDCT) chest.[7,8] These findings led organizations to create guidelines for lung cancer screening with LDCT in 2014.

In 2011 and 2013, the National Comprehensive Cancer Network (NCCN) and the United States Preventive Services Task Force (USPSTF) recommend LC screening with annual LDCT for 3 years in high-risk adults who meet the eligibility criteria. The NCCN11 classifies high-risk patients as those ages 55–74 with ≥30 pack-year history of smoking with <15 years since smoking cessation; or ≥20 pack-year history of smoking, and additional risk factors that increase the risk of lung cancer to >1.3%, which include: family history of lung cancer, personal history of other malignancy, history of COPD or pulmonary fibrosis, radon exposure, occupational exposure, and/or second-hand smoking exposure.[9] The USPSTF13 recommended annual screening for lung cancer in adults aged 55–80 years with ≥30 pack-year smoking history, current smokers, or those that had quit within 15 years.[10] In 2021, USPSTF broadened their screening guidelines to include a younger starting age of 50 years and lesser pack-year history of smoking of ≥20 with hopes of capturing more high-risk individuals. This is thought to be promising for high-risk patients and its recommendation was also adapted by organizations including the American Cancer Society.[11,12]

Despite clear data and organizations supporting LC screening, studies have shown that the screening rates remain low nationally and LC is still often diagnosed at advanced stages, avoiding their candidacy for surgical resection and curative intent. One study conducted with data from 2015 reported that only 2% of screening eligible subjects was screened.[13] Another study evaluated the national screening tendencies of eligible individuals. The screening rates were 3.3% in 2016, 3.4% in 2017, and 5.0% in 2018 which highlight the underutilization of the screening guidelines.[14] Nevertheless, data assessing the effects of low LDCT uptake in patients with lung cancer is not available. To understand the impact of missed opportunities for detecting early-stage cancers with screening, we conducted an observational study to understand the LC screening patterns in eligible patients before their diagnosis of lung cancer. To our knowledge, no previous studies quantifying a missed opportunity in patients that have eventually been diagnosed with lung cancer have been published in the literature.

Methods

Study Description

We conducted a single-center observational study in an outpatient Academic Center. We reviewed the charts of consecutive patients with an established diagnosis of LC at the Northwell Health Cancer Institute between 2016 and 2019. Charts were reviewed for demographics, detailed smoking history at the time or before the screening, family history, history of previous malignancy, radon exposure, occupational exposure (carcinogens targeting the lungs include arsenic, chromium, asbestos, nickel, cadmium, beryllium, silica, diesel fumes, coal smoke, and soot), and/or second-hand smoking exposure. The patient's visits with Internal Medicine, Pulmonary, Cardiothoracic Center, and Oncology were reviewed to seek the information that was not available or recorded in the patient's profiles. Additionally, radiographic imaging to assess for referrals to Northwell's American College of Radiology designated lung cancer screening center and the execution or lack thereof of lung cancer screening, as well as the pathology, to understand the histology and stage of lung cancer at diagnosis were reviewed.

The primary endpoint of this study was to assess the LDCT screening rates in NCCN and/or USPSTF eligible subjects before or at the time of screening, and before their LC diagnosis. Secondary endpoints were the following: To assess whether stage at diagnosis differed between patients who did and did not undergo screening with LDCT before their LC diagnosis of LC; to evaluate whether there was a correlation between race, ethnicity, or gender and rates of screening; to assess the difference in screening rates between current smokers and former smokers.

Statistical Methods

Subjects were considered to have fulfilled LC screening criteria if they met eligibility according to NCCN11 and/or USPSTF13 LC screening guidelines. Those who did not meet either of the criteria were considered screening ineligible. Subjects who had missing information that was required for determining eligibility for either or both of the criteria were not categorized and excluded from the analysis.

All analyses were carried out separately for each screening criteria (NCCN11 and USPSTF13). The association between each categorical demographic and clinical factor and referred for screening (yes/no) was examined using the chi-square test or Fisher's exact test, as appropriate. The association between each continuous demographic and clinical factor and referral for screening (yes/no) was examined using the Mann–Whitney test. The association between referred for screening and stage at diagnosis was examined using the Mann–Whitney test.

Table 1. Baseline Characteristics and Characteristics at Diagnosis.

	Smokers N (%)	Never Smokers N (%)
Frequency	432 (82.0)	98 (18.0)
Baseline characteristics		
Gender		
Male	231 (55.1)	27 (27.6)
Female	188 (44.9)	71 (72.4)
Race		
African American	65 (15.1)	18 (18.4)
White	295 (68.5)	40 (40.8)
Asian	26 (6.0)	29 (29.6)
Other	45 (10.4)	11 (11.2)
Ethnicity		
Hispanic or Latino	25 (5.8)	6 (6.1)
Non-Hispanic or Latino	392 (91.0)	87 (88.8)
Other	14 (3.2)	5 (5.1)
Primary language		
English	399 (92.6)	78 (79.6)
Other	32 (7.4)	20 (20.4)
Characteristics at diagnosis		
Stage at diagnosis		
Stage I	58 (13.4)	17 (17.4)
Stage II	50 (11.6)	6 (6.1)
Stage III	111 (25.7)	16 (16.3)
Stage IV	213 (49.3)	59 (60.2)
Classification		
Adenocarcinoma	252 (58.3)	84 (86.6)
Squamous cell carcinoma	68 (15.7)	6 (6.2)
Small cell carcinoma	74 (17.1)	1 (1.0)
Other	38 (8.9)	6 (6.2)

Results

Charts of 530 subjects were reviewed, of whom 432 were current or former smokers and 98 had no history of smoking. Baseline characteristics are shown in Table 1.

Among the population with a history of smoking, 55.1% were males and 44.9% were female. Whites were the most prevalent race, accounting for 68.5% of the subjects. African Americans, Asians, and others comprise 15.1%, 6.0%, and 10.4%, respectively. Only 5.8% of subjects identified as Hispanic or LatinX, whereas 91.0% and 3.2% identified as non-Hispanic or LatinX, or other. The subjects were more frequently former smokers (71.5%), of which 62.7% had quit within 15 years or less. More than half of the subjects (64.3%) had a 30 or more pack-year history of smoking. Detailed information on the smoking history is shown in Table 2.

NCCN11 Criteria

Among the 530 total charts reviewed, there were three patients with insufficient data to determine fulfillment of screening criteria. 52.4% (276) subjects met NCCN eligibility criteria for screening. Only eleven (4.0%) of the subjected that met NCCN LC screening eligibility criteria underwent LDCT (95% exact CI: 2.0%, 7.0%). Of the eleven subjects, ten (90.9%) were male and one (9.1%) was female. The median age at LC diagnosis was 69 years and 70 years for the subjects that did and did not receive screening. Six (54.5%) of the subjects that underwent LDCT identified as White, whereas two (18.2%), two (18.2%), and one (9.1%) identified as African American, Asian, and other, respectively. None identified as Hispanic/LatinX. Of the eligible subjects that underwent LDCT, 63.6% were current smokers and 36.4% were former smokers (Table 3). An association between screening and age, gender, race, and ethnicity could not be evaluated due to the low sample size of individuals that underwent LDCT for screening.

It was possible to analyze localized (stages I–III) vs metastatic disease (stage IV), and a significant association was found between LDCT screening and stage at diagnosis. As detailed in Table 3, all of the patients that underwent LDCT as screening modality presented at stages I–III at diagnosis. A total of 50.9% of the subjects that did not undergo LDCT screening presented with Stage IV at diagnosis (95% exact CI: −.2%, 56.3%; P=.0010) (Figure 1).

In addition to the subjects that underwent LDCT, nineteen additional subjects had other screening modalities. The majority of the 30 total patients that had some type of screening underwent a suboptimal screening modality. Only 36.7% LDCT, whereas 23.3% (7) underwent chest x-ray, and 43.5 (13) had a standard-dose CT scan. 151 subjects did not meet NCCN eligibility criteria of which 4.0% (6) underwent any screening modality. A total of .7% were screened with LDCT (95% exact CI: .02%, 3.6%) as shown in Table 4.

Of the 276 patients that fulfilled eligibility criteria in this group, 78% (215) had documentation of Primary care physicians (PCPs). Of the individuals that underwent LDCT, PCPs placed 81.2% of the LDCT order referrals, while pulmonologists placed the remainder. Of the eleven patients in this group who underwent LDCT for screening, 54.5% (6) had the order placed only once, 9.1% (1) received an LDCT order every six months, 27.3% (3) had LDCT orders placed annually for 2 years, and 9.1% (1) received LDCT order referral annually for 3 years. Two (50.0%) of the four patients who received annual LDCT order referrals underwent LDCT scans yearly, while the other 50.0% (2) did not. We attempted to capture the shared decision-making conversations between patients and physicians for patients who received an LDCT order and did not undergo screening but documentation was often not provided in the medical records; therefore, the reasons are still unclear. After LDCT, all patients received a referral to a Pulmonologist and/or Cardiothoracic Surgeon. Also, further workup was recommended for all patients, of which 90.9% (10) eventually underwent biopsy.

Only 9% (24/265) of the NCCN11 screening eligible patients that did not undergo LDCT had screening discussions with their PCPs documented in the electronic medical records.

Table 2. Smoking history.

Smoking status	N (%)
Current	123 (28.5)
Former	309 (71.5)
Pack-year history	
0–19	91 (21.3)
20–29	62 (14.5)
≥30	275 (64.3)
Quit within how many years (former smokers)	
≤ 15 years	193 (62.7)
> 15 years	115 (37.3)
History of chronic lung disease	
Yes	150 (34.8)
No	281 (65.2)
Personal history of other malignancy	
Yes	116 (26.9)
No	315 (73.1)
Family history of lung cancer	
Yes	91 (21.2)
No	340 (78.9)
History of second-hand smoke or chemical exposure[a]	
Yes	16 (3.9)
No	160 (39.4)
Unknown	230 (56.7)

[a]Chemical exposure is defined as: radon, asbestos, and occupational exposures such as carcinogens targeting the lungs include arsenic, chromium, asbestos, nickel, cadmium, beryllium, silica, diesel fumes, coal smoke, and soot.

Table 3. Characteristics of eligible subjects that underwent screening.

	Underwent LDCT Screening		
	NCCN Eligible N (%)	**USPSTF Eligible N (%)**	***P*-value**
Gender			
Male	10 (90.9)	9 (100)	
Female	1 (9.1)	0 (0)	
Race			
African American	2 (18.2)	1 (11.1%)	.9732
White	6 (54.5)	5 (55.6%)	
Asian	2 (18.2)	2 (22.2%)	
Other	1 (9.1)	1 (11.1%)	
Ethnicity			
Hispanic or Latino	0 (0)	0 (0)	
Non-Hispanic or Latino	11 (100)	9 (100)	
Smoking status			
Current	7 (63.6)	7 (77.8)	.4923
Former	4 (36.4)	2 (22.2)	
Stage at diagnosis			
Stages I–III	11 (100)	9 (100)	.0010
Stage IV	0 (0)	0 (0)	

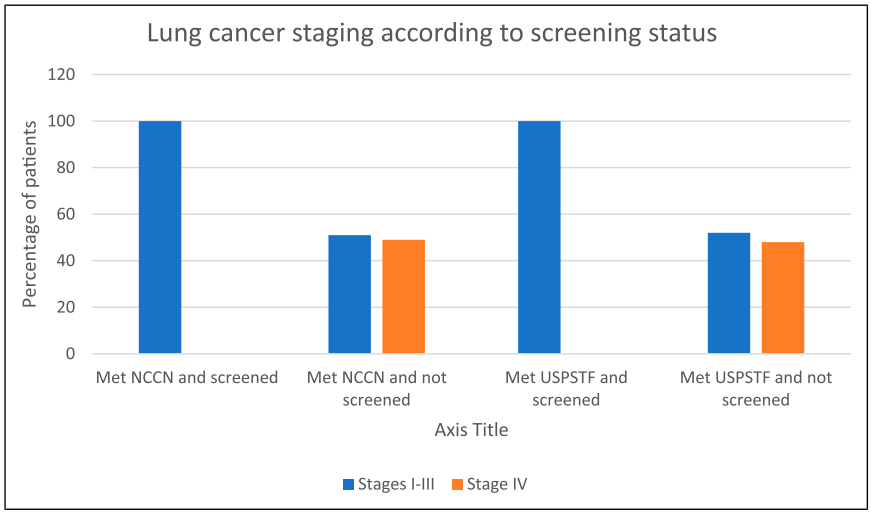

Figure 1. Lung cancer staging according to screening status.

Table 4. Eligible and ineligible subjects that did and did not undergo any type of screening modality.

	Underwent Any Type of Screening Modality		
	Yes N (%)	No N (%)	*P*-value
Met NCCN eligibility criteria			.0142
Yes	30 (10.9)	246 (89.1)	
No	6 (4.0)	145 (96.0)	
Met USPSTF eligibility criteria			.0031
Yes	24 (12.9)	162 (87.1)	
No	12 (4.9)	231 (95.1)	

USPSTF13 Criteria

Among the 530 reviewed subjects, there was one patient with insufficient data to determine fulfillment of screening criteria. A total of 35.1% (186) of subjects met USPSTF lung cancer screening eligibility criteria. Only 9 (4.8%) of the eligible subjects underwent LDCT (95% exact CI: 2.2%, 9.0%), all (100%) of which were male and none (0%) were female. The median age at lung cancer diagnosis was 69 years and 68.5 years for the subjects that did and did not receive screening, respectively. Five (55.6%) of the subjects that underwent LDCT identified as White, whereas one (11.1%), two (22.2%), and one (11.1%) identified as African American, Asian, and other, respectively. None identified as Hispanic or LatinX (Table 3). Of the eligible subjects that underwent LDCT, 77.8% were current smokers and 22.2% were former smokers. An association between screening and age, gender, race, and ethnicity could not be evaluated due to the low sample size of individuals that underwent LDCT for screening.

There was a significant association between the stage at diagnosis and LDCT screening. As shown in Table 3, all of the patients that underwent LDCT as screening modality presented at stages I–III at diagnosis. A total of 52% of the subjects that did not undergo LDCT screening presented with Stage IV at diagnosis (95% exact CI: −.2% to 56.7%; P=.0010) (Figure 1).

In addition to the subjects that underwent LDCT, fifteen patients underwent other screening modalities. More than one-half of the 24 subjects that received any type of screening underwent a suboptimal screening modality. Only 37.5% (9) received LDCT, whereas 20.8 (5) underwent chest x-ray, and 41.7% (10) had a standard-dose CT scan. As shown in Table 4, 245 subjects did not meet USPSTF screening criteria of which 4.9% (12) underwent any screening modality. A total of 1.2% were screened with LDCT (95% exact CI: 2.2%–9.0%).

Of the 186 patients in this group, 77.4% (144) had documentation of having a PCP, while 4.3% (8) did not have one and for 18.3% (34) it was not known. For the patients that underwent screening, PCPs placed 77.8% of the LDCT orders, while pulmonologists placed the remainder. Of the nine patients in this group who underwent LDCT, 55.5% (5) had the LDCT order made only once, whereas 33.3% (3) had LDCT orders placed annually for 2 years, and 11.1% (1) received annual LDCT orders for 3 years. One (33.3%) of the four subjects that had LDCT orders placed more than once underwent annual screening, whereas two (66.75%) did not receive LDCT despite having an annual order placed. It is unknown if the remaining subject (33.3%) with an LDCT order placed yearly underwent annual screening at an outside institution or not at all. We attempted to capture the shared decision-making conversations between patients and physicians for patients who received an LDCT order and did not undergo screening, but documentation was often not provided in the medical records; therefore, the reasons are still unclear.

Table 5. Tendencies for NCCN and USPSTF screening eligibility.

	Screening Eligible		
	Yes	**No**	***P*-value**
NCCN	276	151	.0001
USPSTF	186	243	

After LDCT, all patients received a referral to Pulmonary Medicine and/or Cardiothoracic Surgery. Also, further workup was recommended for all nine patients, of which 88.9% (8) eventually underwent biopsy.

Only 11% (19/177) of the USPSTF13 screening eligible patients that did not undergo LDCT had screening discussions with their PCPs documented in the electronic medical records.

Subject Eligibility According to USPSTF21 Criteria

The new USPSTF21 LC screening guidelines recommendations led us to perform a subset analysis to understand how many subjects would have fulfilled USPSTF21 eligibility criteria. If the USPSTF21 had been implemented at the time of determining screening eligibility for the subjects in this study that were eventually diagnosed with lung cancer, 45.7% (242/530) of subjects would have been eligible for lung cancer screening compared to 35.1% (P=.00012) under USPSTF13.

Discussion

A vast literature exists to support how lung cancer screening is being under-utilized in the United States.[13,14] However, to our knowledge, our study is the first one to assess the trends for lung cancer screening uptake and quantify the missed opportunities of individuals before their lung cancer diagnosis. Contrary to other studies which analyzed subjects eligible for screening, our cohort of patients were individuals with lung cancer that were retrospectively assessed for LC screening prior to their diagnosis if fulfilling the NCCN11 and/or USPSTF13 eligibility criteria. Our data revealed concerning suboptimal rates of screening in high-risk individuals, where only a very small number (4.0% and 4.8%) of the patients were eligible for screening according to NCCN11 and USPSTF13 underwent LDCT.

With solid data from large randomized studies establishing beyond doubt that low-dose CT scans improve overall mortality[7,8], there is limited information at this time regarding the utilization and effectiveness of the aforementioned guidelines in the general population. Our findings add to emerging data showing low adherence to screening since the implementation of lung cancer screening recommendations and quantify the missed opportunities in high-risk individuals that are diagnosed with lung cancer. Our data also showed an association between staging at diagnosis and screening in both USPSTF and NCCN groups, where screened subjects had significantly higher tendencies of early detection. Interestingly, in our study, we found subjects have higher rates of meeting NCCN rather than USPSTF screening eligibility (Table 5). This could be due to more rigid eligibility criteria by USPSTF guidelines than NCCN, which allows for a wider age range and a lower pack-year history, in addition to taking into account personal history of other malignancy, family history, and occupational exposure. This gap is expected to close with the new approved USPSTF 2021 LC screening guidelines,[15] which could potentially capture an additional 18 533 eligible individuals.[11] Such impact was seen in our subanalysis, which found significantly increased eligibility rates when implementing USPSTF21 compared to the USPSTF13. However, as it has been described in the literature, eligibility is not equally proportionate to individuals screened. Therefore, ongoing educational efforts will be of paramount importance to prioritize and promote LC screening uptake with hopes of improving the overall poor survival rates from a diagnosis of LC. Another observation worthy of concern found in our study is the disparities in the screening uptake according to gender and ethnicity, where 91% and 100% of the NCCN11 and USPSTF13 eligible subjects that underwent LDCT screening were male, and the rates for LDCT screening in the Hispanic population were zero.

Our study has several limitations due to its retrospective nature and small sample size. This study determined screening eligibility based on the fulfillment of expressed criteria in NCCN and USPSTF guidelines. However, it did not examine patient symptoms or other comorbidities that would adversely affect patients' ability to undergo baseline evaluation, treatment of screening-detected findings, or continue the annual LDCT when referred. In addition, some variables were not recorded in the record of several patients (3 in the NCCN group and 1 in the USPSTF group), rendering us unable to determine eligibility in those subjects in the analysis. However, given the very small sample of individuals, we do not believe this would impact the overall results. Another limitation is that we were unable to record the insurance information for each patient since our electronic medical record only captures insurance at the time of registration into our system and not what patients had previously. We are aware that patients with LDCT covered by insurance would be expected to have higher screening rates but we were, unfortunately, unable to obtain that information. Nevertheless, our study not only found suboptimal LDCT screening patterns in eligible subjects but also found the vast majority of the

patients that underwent screening had the incorrect screening modality, such as CXR and/or other types of CT scans. Despite guidelines recommending yearly screening for at least 3 years, in our study half of the patients in each group who received an initial referral for screening did not receive a follow-up referral and only underwent a screening modality once, at baseline.

One of the barriers to screening, as noted in prior studies, is physicians' lack of knowledge of LC screening guidelines. In our study, of the 56 patients in this study whose charts recorded data on having screening discussions with providers, only 24 (42.9%) acknowledged having had such a discussion. In a previously reported study involving patients seen in a New York City outpatient clinic, one of the main barriers for screening was physicians' lack of knowledge of screening eligibility guidelines.[16] An educational initiative targeting PCPs and resident physicians involving PowerPoint presentations at various settings yielded a notable positive change, with follow-up analysis performed after the educational program showing an improved screening adherence from 27% to 78% ($P < .0001$) and a decrease in referral rates for patients that did not meet criteria for screening.[17] Concerning findings suggesting lack of physician knowledge about screening eligibility that extrapolated from our study are the use of the wrong screening modality in eligible individuals as well as LDCT implementations in ineligible individuals. One study found that 8.5% of eligible patients underwent a CXR for screening compared to 4.4% that had LDCT. Additionally, this study also found that the number of ineligible individuals screened exceeded the screening rates of eligible individuals according to USPSTF criteria.[18] Therefore, continued education of PCPs regarding data to support lung cancer screening and choosing the right person to undergo screening is of paramount importance. In addition to physician-targeted education, system-level initiatives may improve adherence to screening guidelines. One such intervention is instituting timely reminders via clinical tools (ie, electronic health records) when a patient meets eligibility criteria. In addition, delegating various tasks to personnel within the screening program, such as reviewing referrals and scheduling screening tests, may decentralize the screening process and improve outcomes. Several studies have shown that such strategies can be efficacious in improving adherence to screening guidelines.[19]

In conclusion: A vast majority of LC patients who fulfill the criteria for LC screening have never undergone LDCT prior to their cancer diagnosis, highlighting the magnitude of a missed opportunity. Additionally, the number of ineligible patients that underwent screening and the amount eligible patients that underwent the wrong screening modalities are highly concerning. Furthermore, the rates for screening in eligible women and Hispanics in our study were almost non-existent and highlight gender and racial/ethnic disparities within the health care system that need attention, improvement, and further investigation. We believe that the new proposed LC screening guidelines will be a positive step in capturing more high-risk individuals, especially women and racial/ethnic minorities. However, fulfilling eligibility criteria is not the only method that will improve overall LC screening uptake because eligible individuals are not equivalent to screened individuals. Our responsibility as physicians is that every eligible patient undergoes annual LDCT screening for at least 3 consecutive years. Therefore, ongoing education initiatives targeting both physicians as well of patients are imperative to continue to promote early detection and improve the overall mortality from lung cancer.

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Coral Olazagasti is the corresponding author who was responsible for creating the study protocol, assisting in data collection, writing the introduction and methods section, editing the manuscript, and creating manuscript submission.

Author contributions

Matthew Ehrlich assisted in data collection and the writing of the manuscript.
Nina Kohn had full access to the data and was responsible for all the statistical analyses of the data.
Karen Aviles and Aldane Hoilett assisted in the study design, data collection, and writing the abstract.
Nagashree Seetharamu overlooked the study and assisted with manuscript proofread.

Declaration of conflicting interests

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Ethical statement

Our study did not require an ethical board approval because it did not contain human or animal trials.

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