

The majority of patients with resectable incidental lung cancers are ineligible for lung cancer screening



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ABSTRACT

Objective: The study objective was to determine what proportion of asymptomatic patients had resectable lung cancer detected through lung cancer screening versus incidentally.

Methods: We performed a retrospective study of patients who underwent resection for lung cancer between January 2015 and December 2020. We then assessed whether asymptomatic patients with incidentally found lung cancers were eligible for lung cancer screening using the National Comprehensive Cancer Network, United States Preventive Services Task Force, Centers for Medicare & Medicaid Services, American College of Chest Physicians, American Cancer Society, and American Society of Clinical Oncology guidelines.

Results: Of 539 patients who underwent resection for primary lung cancer, 437 (81%) were asymptomatic and 355 (66%) of these patients had lung cancer found discovered incidentally. Of the 355 patients with incidentally detected lung cancer, 10 were excluded for insufficient data. Of the remaining 345 patients, 110 (32%) would have been eligible for screening using National Comprehensive Cancer Network guidelines, 65 (19%) using 2021 United States Preventive Services Task Force guidelines, 53 (15%) using 2013 United States Preventive Services Task Force guidelines, 64 (19%) using 2022 Centers for Medicare & Medicaid Services guidelines, 52 (15%) using 2015 Centers for Medicare & Medicaid Services/American College of Chest Physicians guidelines, and 45 (13%) using American Cancer Society/American Society of Clinical Oncology guidelines. Of the 280 patients who were screen ineligible by 2021 United States Preventive Services Task Force criteria, 143 patients (51%) never smoked, 112 patients (40%) quit smoking more than 15 years ago, 89 patients (32%) did not smoke at least 20 pack-years, and 44 patients (16%) were ineligible due to age.

Conclusions: The majority of asymptomatic patients with resectable lung cancers had lung cancer identified incidentally and not through lung cancer screening. Most of these patients were not eligible for screening under current guidelines. This study suggests a need for improved lung cancer screening implementation and further investigation in the identification and assessment of risk factors for lung cancer. (JTCVS Open 2023;13:379-88)

Lung cancer is the leading cause of cancer-related mortality in the United States and in the world.¹ In 2011, the National Lung Screening Trial (NLST) Research Team

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Informed written consent was waived with IRB approval because this study posed minimal risk to patients and did not adversely affect the participants' rights and welfare.

reported that for patients considered high risk for developing lung cancer, annual low-dose helical computed tomography (CT) compared with chest radiography

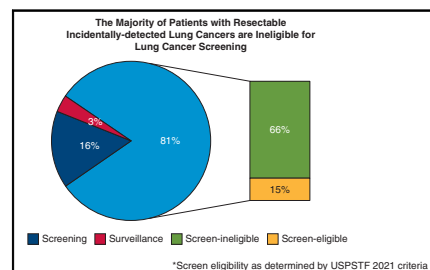
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The majority of patients with incidental lung cancers were ineligible for screening.

CENTRAL MESSAGE

There is a need for improved implementation of current lung cancer screening guidelines as well as more research to identify risk factors and methods to capture high-risk patients who are screen ineligible.

PERSPECTIVE

Lung cancer screening can significantly impact survival; however, the rate of patients across the country undergoing screening is very low. In addition, current lung cancer screening guidelines may miss certain populations who are high risk.

Abbreviations and Acronyms

ACS	= American Cancer Society
ASCO	= American Society of Clinical Oncology
CHEST	= American College of Chest Physicians
CMS	= Centers for Medicare & Medicaid Services
CT	= computed tomography
IRB	= Institutional Review Board
NCCN	= National Comprehensive Cancer Network
NLST	= National Lung Cancer Screening Trial
NSCLC	= non-small cell lung cancer
USPSTF	= United States Preventive Services Task Force

reduced lung cancer mortality by 20%.² Subsequent studies, including the Netherlands–Leuven Longkanker Screenings Onderzoek trial, have found a similar or even greater reduction in lung cancer mortality due to lung cancer screening.³⁻⁵

Since the NLST trial, the National Comprehensive Cancer Network (NCCN), United States Preventive Services Task Force (USPSTF), American Cancer Society (ACS), American Society of Clinical Oncology (ASCO), American College of Chest Physicians (CHEST), and Centers for Medicare & Medicaid Services (CMS) have each published their own guidelines for lung cancer screening.⁶⁻¹⁰ These guidelines, however, are primarily based on the inclusion criteria in the NLST trial. Advocates have argued for a more expansive screening guideline, stating that 20% of patients who are ineligible for lung cancer screening have a risk of developing lung cancer equal to or higher than the prevalence of lung cancer in the NLST cohort ($\geq 3.7\%$).^{11,12}

The objective of this study is to determine what percentage of asymptomatic resectable lung cancer cases at a single academic institution were detected incidentally. For patients whose lung cancer was incidentally detected, we investigated whether they would be eligible for screening, and if not, what factors made them ineligible.

MATERIALS AND METHODS**Patients**

We performed a retrospective evaluation of the medical records of patients who underwent resection for a primary lung cancer at the University of California, Los Angeles, from January 2015 to December 2020. Patients were identified using an institutional thoracic surgery database, and Institutional Review Board (IRB) approval was obtained to access these patients' medical charts (IRB #21-000307, approved on March 30, 2021). The need for informed written consent was waived by the IRB because this study posed minimal risk to patients and did not adversely affect the participants' rights and welfare. Histologies included in this study were adenocarcinoma, adenocarcinoma, squamous cell carcinoma,

large cell carcinoma, atypical and typical carcinoid tumors, large cell neuroendocrine carcinoma, mucoepidermoid carcinoma, pleomorphic carcinoma, and small cell carcinoma. No histologies were excluded. No types of surgical procedures were excluded. Of the patients who underwent resection for primary lung cancer, we determined whether the patients were symptomatic or asymptomatic at the time of presentation. Table E1 details the symptoms that prompted the initial CT for symptomatic patients. Asymptomatic patients were defined as patients who did not have persistent symptoms commonly associated with lung cancer, including cough, hemoptysis, dyspnea, and chest wall pain at the time of presentation to our thoracic surgery clinic. If the patient was asymptomatic, we categorized whether their lung cancer was identified through lung cancer screening, surveillance for a history of lung cancer, or incidentally. Table E2 provides the indications for the initial CT scan for the patients with incidentally detected lung cancers. For those patients who were asymptomatic and whose lung cancer was discovered incidentally, we identified whether there were sufficient data to determine if the patient would have been eligible for a lung cancer screening program through the following sets of guidelines: NCCN 2022 guidelines, USPSTF 2021 and 2013 guidelines, CMS 2022 and 2015 guidelines, ACS 2018 guidelines, ASCO 2012 guidelines, and CHEST 2021 guidelines. Data required to determine whether a patient would be eligible for screening included patient age, cigarette smoking status, pack-years smoked, and quit date (if former smoker). For our analyses, we used the age of the patient at the time of their initial consult visit. Patient's race, ethnicity, smoking status, pack-years of cigarettes smoked, and date of quitting were all identified through the electronic medical record based on patient self-report. Years since quitting was calculated based on the date of the patient's surgery. Histology and stage were determined through the pathology report generated after a patient's operation. Stage was defined as outlined by either the seventh or eighth edition of the American Joint Commission on Cancer TNM staging manual, depending on the year the patient's operation was conducted.

Screening Criteria

The screening guidelines used in this study are summarized in Table 1. Of note, the American College of Chest Physicians have a strong recommendation for annual low-dose helical CT for high-risk individuals aged 55 to 77 years with a 30 pack-year or more history of smoking and current smoker or quit within past 15 years. They also have a weak recommendation for screening those who are aged 50 to 80 years, have smoked 20 pack-years or more and either continue to smoke or have quit within the past 15 years. We have chosen to use the strongly recommended screening guideline for the purposes of this study because the weak recommendation overlaps with the current USPSTF 2021 lung cancer screening criteria.

Analysis

For those patients who were asymptomatic and whose lung cancer was discovered incidentally, we determined the percentage of patients who met each of the screening guidelines outlined in the previous section. For those patients who were screen ineligible, defined as not meeting a given screening criteria, we identified what number and percentage of patients were screen ineligible due to their age, smoking status, pack-years smoked, and years elapsed since quitting.

RESULTS

A total of 539 patients in our database underwent resection for primary lung cancer between January 2015 and December 2020. Of these, 102 patients were symptomatic, prompting imaging, whereas the remaining 437 (81%) were asymptomatic. Of the 437 asymptomatic patients, 67 (15.3%) had lung nodules discovered through lung cancer screening, 15 (3.4%) had lung nodules discovered on surveillance for a history of

TABLE 1. Comparison of screening criteria for various lung cancer screening guidelines

	Minimum age, y	Maximum age, y	Minimum pack-y	Maximum years since quitting
USPSTF 2021	50	80	20	15
USPSTF 2013	55	80	30	15
CMS 2022	50	77	20	15
CMS 2015/CHEST 2021	55	77	30	15
ACS 2018/ASCO 2021	55	74	30	15
NCCN Version 1.2022	50	N/A	20	N/A

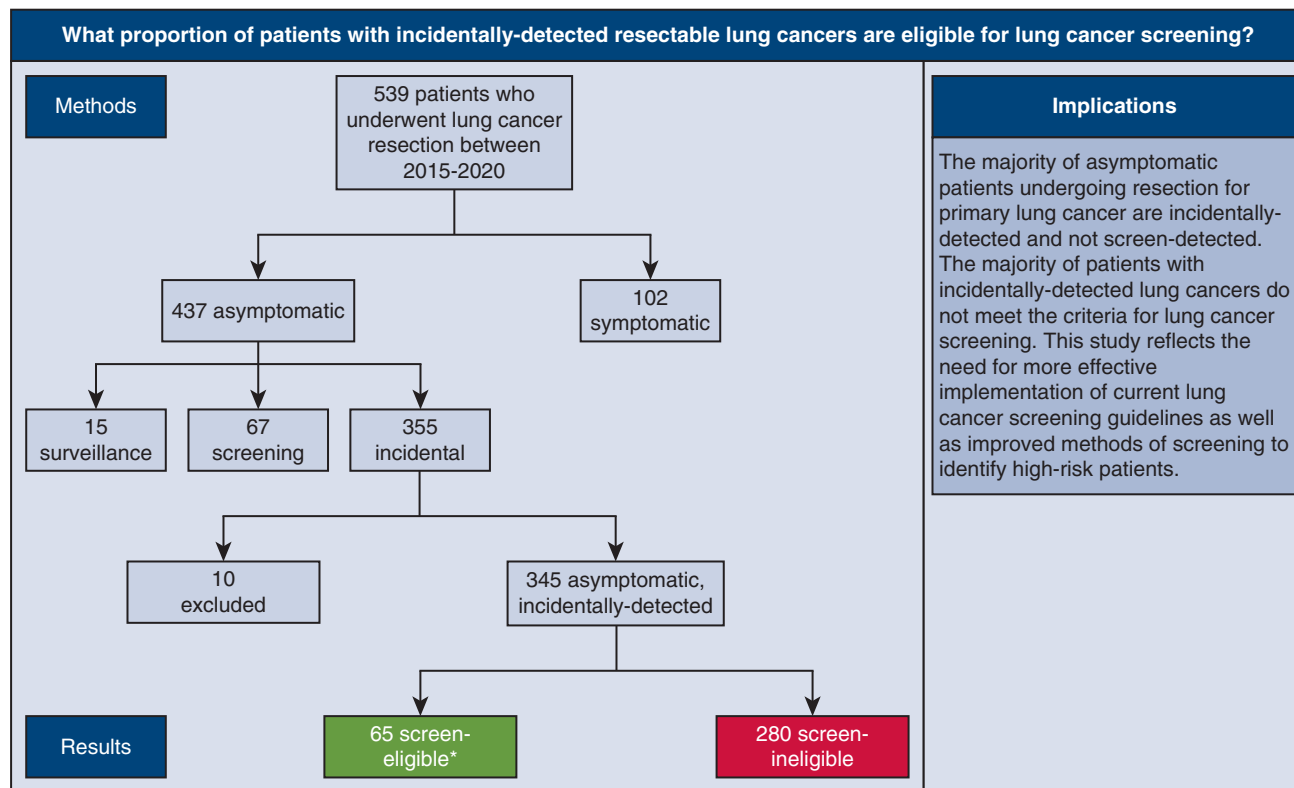
USPSTF, United States Preventative Services Task Force; CMS, Centers for Medicare & Medicaid Services; CHEST, American College of Chest Physicians; ACS, American Cancer Society; ASCO, American Society of Clinical Oncology; NCCN, National Comprehensive Cancer Network; N/A, not available.

primary lung cancer, and 355 (81.2%) had incidentally discovered primary lung cancer (Figure 1). Of these 355 patients, 10 were excluded from further analysis because of inadequate data to determine screening. The baseline demographics of the remaining 345 patients are shown in Table 2. These patients had a median age of 68 (range, 21-90) years and were predominantly female (61%, 211/345) and White, non-Hispanic (67%, 231/345). Half of these patients were former cigarette smokers (50%, 174/345) and 41% (143/345) were never-smokers, with the remaining 8% (28/345) being current smokers. The majority of these patients had adenocarcinoma (79%, 271/345) and had stage IA disease at the time of resection (59%, 204/345). On the basis of

2022 NCCN guidelines, 32% (110/345) of patients would have been eligible for screening, followed by 19% (65/345) by 2021 USPSTF criteria, 15% (53/345) by the 2013 USPSTF guidelines, 19% (64/345) by 2022 CMS criteria, 15% (52/345) by 2015 CMS/CHEST guidelines, and 13% (45/345) by ACS/ASCO guidelines. Of note, the lung cancer screening eligibility of symptomatic patients ranged from 11% to 43% (Table E3).

Screen-Ineligible Patients

Table 3 summarizes the factors for screen ineligibility based on the various screening guidelines. By applying the current 2022 NCCN guidelines, 235 patients (68%)



*Screen eligibility as determined by USPSTF 2021 criteria

FIGURE 1. Methodology and results for determining what proportion of asymptomatic patients undergoing lung cancer resection at our institution had cancer found incidentally and were ineligible for lung cancer screening.

TABLE 2. Baseline demographics of asymptomatic patients with incidentally found primary lung cancer

N = 345	
Age, y	
Median	68
Range	21-90
Gender, no (%)	
Female	211 (61%)
Male	134 (39%)
Race/ethnicity	
White, non-Hispanic	231 (67%)
Asian	55 (16%)
Hispanic	21 (6%)
Black/African American	7 (2%)
Other/not indicated	31 (9%)
Smoking status, no. (%)	
Former	174 (50%)
Never	143 (41%)
Current	28 (8%)
Histology, no. (%)	
Adenocarcinoma	271 (79%)
Squamous cell carcinoma	29 (8%)
Typical/atypical carcinoid tumors	33 (10%)
Other*	12 (3%)
Stage, no. (%)	
0	3 (0.9%)
IA1	93 (27%)
IA2	81 (23%)
IA3	30 (9%)
IB	49 (14%)
IIA	9 (3%)
IIB	49 (15%)
IIIA	16 (5%)
IIIB	7 (2%)
IIIC	1 (0.3%)
IVA	4 (1%)
Unknown†	3 (0.9%)

*Includes adenocarcinoma in situ (1), adenosquamous carcinoma (3), large cell carcinoma (1), large cell neuroendocrine carcinoma (3), mucinous carcinoma (1), small cell carcinoma (2), and spindle cell carcinoma (1). †Two patients had T1aNx, and 1 patient did not have staging information available.

were ineligible for screening. The main reason for ineligibility was smoking status, with 61% (143/235) of patients identifying as never-smokers. A total of 89 patients (38%) failed to meet the 20 pack-year smoking minimum to qualify for screening. Finally, 18 patients (8%) were younger than 50 years and therefore also did not qualify for screening.

The 280 (81%) screen-ineligible patients based on current 2021 USPSTF criteria were in this category because 6% (18/280) were younger than 50 years, 9% (26/280) were older than 80 years, 51% were never-smokers (143/280), 32% (89/280) did not meet the pack-year criteria of 20 pack-year smoking history, and 40% (112/280) of patients quit more than 15 years ago. When taking into

consideration only patients who were current or former smokers, 65% (89/137) did not meet the pack-year criteria.

By using 2013 USPSTF criteria, 85% (292/345) of asymptomatic, incidentally found patients in our study were screen ineligible. Patients were ineligible because they were younger than 55 years (14%, 40/292), older than 80 years (9%, 26/292), never-smoking (49%, 143/292), smoking less than 30 pack-years (40%, 117/292), and quitting smoking more than 15 years ago (38%, 112/292). When considering only current or former smokers, 79% (117/149) smoked less than 30 pack-years and therefore did not meet screening criteria.

According to the updated 2022 CMS screening criteria, 281 patients (81%) were screen ineligible. The most common reason for being screen ineligible was never-smoking (51%, 143/281), followed by quitting more than 15 years ago (40%, 112/281), less than 20 pack-years smoked (32%, 89/281), being older than 77 years (16%, 44/281), and being younger than 50 years (6%, 18/281).

According to 2015 CMS and CHEST lung cancer screening criteria, 85% of patients (293/345) were screen ineligible. Age less than 55 years made 14% (40/293) of patients ineligible, whereas age greater than 77 years made 15% of patients (44/293) ineligible. Less than 30 pack-years of smoking history resulted in 40% (117/293) of patients being screen ineligible. Quitting more than 15 years ago was the reason 38% (112/293) of patients were screen ineligible. Finally, 48% (140/293) of patients were ineligible because they had never smoked. After excluding never-smokers, 76% (117/153) of former and current smokers were ineligible because they did not meet the minimum threshold of 30 pack-years of smoking.

The ACS/ASCO criteria were the most exclusive, with 300 patients (87%) being ineligible under these criteria. Of these, 13% (40/300) were ineligible because they were aged less than 55 years, 24% (73/300) were ineligible because they were aged more than 74 years, 48% (143/300) were never-smokers, 39% (117/300) smoked less than 30 pack-years, and 37% (112/300) quit smoking more than 15 years ago. Of current and former smokers, 75% (117/157) were ineligible because they smoked less than 30 pack-years.

The demographics of screen-ineligible patients using the various criteria are summarized in [Table 4](#). Briefly, these patients had a median age of 67 or 68 years (range, 21-90), were predominantly female (63%-67%), were White, non-Hispanic (61%-64%), had stage IA disease (59%-61%), and had adenocarcinoma (80%-82%)

Patients Identified Through Screening

Of the 437 asymptomatic patients, 67 (15%) had a lung cancer discovered on low-dose CT screening. The median age of these patients was 69 (range 57-82) years, they were approximately equally represented between genders

TABLE 3. Factors for screen ineligibility based on various screening criteria

	NCCN	2021 USPSTF	2013 USPSTF	2022 CMS	2015 CMS/CHEST	ACS/ASCO
Screen-ineligible patients (N = 345, %)	235 (68%)	280 (81%)	292 (85%)	281 (81%)	293 (85%)	300 (87%)
Reason patients were screen ineligible (N, %)						
Age, y (younger)	18 (8%)	18 (6%)	40 (14%)	18 (6%)	40 (14%)	40 (13%)
Age, y (older)	N/A	26 (9%)	26 (9%)	44 (16%)	44 (15%)	73 (24%)
Never-smoker	143 (61%)	143 (51%)	143 (49%)	143 (51%)	140 (48%)	143 (48%)
Pack-y	89 (38%)	89 (32%)	117 (40%)	89 (32%)	117 (40%)	117 (39%)
Time since quitting	N/A	112 (40%)	112 (38%)	112 (40%)	112 (38%)	112 (37%)

NCCN, National Comprehensive Cancer Network; USPSTF, United States Preventative Services Task Force; CMS, Centers for Medicare & Medicaid Services; CHEST, American College of Chest Physicians; ACS, American Cancer Society; ASCO, American Society of Clinical Oncology; N/A, not available.

(52% male, 35/67), 69% (46/67) were White, non-Hispanic, and 60% (40/67) were former smokers. The majority had adenocarcinoma (82%, 55/67) and presented with stage IA disease (67%, 45/67) (Table 5). Five never-smoking patients were screened after patient request. Of the patients identified through the screening program, they had an average of 1.7 CT scans before being diagnosed with primary lung cancer and were followed for an average of 1.8 years before diagnosis and surgical resection.

DISCUSSION

Our single-institution, retrospective analysis revealed the majority of resected lung cancers in asymptomatic patients presenting to our thoracic surgery clinic were detected incidentally (66%, 355/539). This incidence is slightly higher than in previous studies, which have suggested the incidence of asymptomatic, incidentally discovered lung cancer in patients undergoing surgical resection for non-small cell lung cancer (NSCLC) ranges from 34% to 54%.¹³⁻¹⁶

TABLE 4. Characteristics of screen-ineligible patients

Patient characteristics	NCCN (n = 235)	2021 USPSTF (n = 280)	2013 USPSTF (n = 292)	2022 CMS (n = 281)	2015 CMS/CHEST (n = 293)	ACS/ASCO (n = 300)
Median age (range), y	67 (21-88)	68 (21-90)	68 (21-90)	68 (21-90)	68 (21-90)	68 (21-90)
Gender, female (N, %)	158 (67%)	185 (66%)	187 (64%)	185 (66%)	187 (64%)	190 (63%)
Race/ethnicity (N, %)						
White, non-Hispanic	143 (61%)	179 (64%)	186 (64%)	180 (64%)	187 (64%)	193 (64%)
Asian	46 (20%)	49 (18%)	52 (18%)	49 (17%)	52 (18%)	53 (18%)
Hispanic	14 (6%)	18 (6%)	19 (7%)	18 (6%)	19 (6%)	19 (6%)
Black/African American	5 (2%)	5 (2%)	5 (2%)	5 (2%)	5 (2%)	5 (2%)
Other/not indicated	27 (11%)	29 (10%)	30 (10%)	29 (10%)	30 (10%)	30 (10%)
Stage (N, %)						
0	3 (1%)	3 (1%)	3 (1%)	3 (1%)	3 (1%)	3 (1%)
IA1	69 (29%)	77 (28%)	81 (28%)	77 (27%)	81 (28%)	82 (27%)
IA2	54 (23%)	66 (24%)	69 (24%)	66 (23%)	69 (24%)	70 (23%)
IA3	22 (9%)	25 (9%)	26 (9%)	26 (9%)	27 (9%)	28 (9%)
IB	31 (13%)	40 (14%)	42 (14%)	40 (14%)	42 (14%)	42 (14%)
IIA	6 (3%)	7 (3%)	7 (2%)	7 (2%)	7 (2%)	7 (2%)
IIB	30 (13%)	38 (14%)	40 (14%)	38 (14%)	40 (14%)	43 (14%)
IIIA	10 (4%)	11 (4%)	11 (4%)	11 (4%)	11 (4%)	12 (4%)
IIIB	6 (3%)	7 (3%)	7 (2%)	7 (2%)	7 (2%)	7 (2%)
IIIC	1 (0.4%)	1 (0.4%)	1 (0.3%)	1 (0.4%)	1 (0.3%)	1 (0.3%)
IVA	2 (0.9%)	3 (1%)	3 (1%)	3 (1%)	3 (1%)	3 (1%)
Unknown*	1 (0.4%)	2 (0.7%)	2 (0.7%)	2 (0.7%)	2 (0.7%)	2 (0.7%)
Histology (N, %)						
Adenocarcinoma	192 (82%)	227 (81%)	235 (80%)	228 (81%)	236 (81%)	240 (80%)
Squamous cell carcinoma	7 (3%)	13 (5%)	16 (5%)	13 (5%)	16 (5%)	18 (6%)
Typical/atypical carcinoid tumors	30 (13%)	33 (12%)	32 (11%)	33 (12%)	33 (11%)	33 (11%)
Other†	6 (3%)	7 (3%)	8 (3%)	7 (2%)	8 (3%)	9 (3%)

NCCN, National Comprehensive Cancer Network; USPSTF, United States Preventative Services Task Force; CMS, Centers for Medicare & Medicaid Services; CHEST, American College of Chest Physicians; ACS, American Cancer Society; ASCO, American Society of Clinical Oncology. *Two patients categorized as T1aNx. †Other histologies include adenocarcinoma in situ, adenosquamous carcinoma, large cell neuroendocrine carcinoma, small cell carcinoma, mucinous carcinoma, and spindle cell carcinoma.

TABLE 5. Baseline characteristics of patients with lung cancer discovered through screening

	N = 67
Age, y	
Median	69
Range	57-82
Gender, no. (%)	
Female	32 (48%)
Male	35 (52%)
Race/ethnicity	
White, non-Hispanic	46 (69%)
Asian	8 (12%)
Black/African American	3 (4%)
Other/unreported	10 (15%)
Smoking status, no. (%)	
Former	40 (60%)
Never*	5 (7%)
Current	22 (33%)
Histology, no. (%)	
Adenocarcinoma	55 (82%)
Squamous cell carcinoma	6 (9%)
Other†	6 (9%)
Stage, no. (%)	
0	6 (9%)
IA1	20 (30%)
IA2	22 (33%)
IA3	3 (4%)
IB	4 (6%)
IIA	2 (3%)
IIB	6 (9%)
IIIA	4 (6%)

*Never-smokers screened per patient request. †Other histologies include adenocarcinoma in situ (3), adenosquamous (1), undifferentiated non-small cell carcinoma (1), and small cell carcinoma (1)

Furthermore, between 68% and 87% of the patients who had incidentally discovered primary lung cancer in our study would have been screen ineligible under current 2022 NCCN, 2021 USPSTF, previous 2013 USPSTF, ACS, ASCO, previous 2015 CMS, or CHEST guidelines. Previous studies of screening eligibility in patients with lung cancer have reported that screen-ineligible patients make up anywhere between 9% and 73% of the patients studied.^{12,17,18} The most common reasons patients were ineligible for screening in our study were related to smoking status (never-smoking or <20 pack-years).

A minority of patients (67/539, 12%) in our study had lung cancer discovered through lung cancer screening. Between 13% and 32% (depending on the screening criteria used) of asymptomatic patients whose lung cancers were discovered incidentally in our cohort, as well as 11% to 43% of symptomatic patients, would have been eligible for screening. Across the nation, lung cancer screening rates are exceedingly low at 6%. In California, the rates are even lower, with only 1% of high-risk patients being screened.¹⁹ Barriers to screening include sociodemographic

characteristics, financial cost, lack of knowledge, inconvenience, mistrust of the medical system, and stigma around smoking and lung cancer.²⁰ In particular, it has been noted that White patients are more likely to adhere to periodic lung cancer screening compared with patients of other races.²¹ These findings reflect the need for wider implementation of lung cancer screening programs to capture more eligible patients who could benefit from screening.

Of the patients whose lung cancers were discovered incidentally, a majority (68%-87%), would not have been eligible for screening under most currently accepted lung cancer screening criteria. Top reasons for ineligibility included nonsmoking status and age greater than the age cutoff used for screening. The incidence of lung cancer among never-smokers is increasing and may contribute to the high screen-ineligibility rate among the patients with incidentally found lung cancer in our cohort. In our study, 41% (143/345) of patients who were asymptomatic and had incidentally discovered lung cancer were never-smokers. One large retrospective study conducted by Stiles and colleagues²² found that the proportion of never-smokers diagnosed with lung cancer had increased from 16.1% from 1997 to 2006 to 26.6% from 2007 to 2016. Another study by Pelosof and colleagues²³ studying cancer registries from 3 major institutions found that there was an increase in the proportion of never-smokers being treated for lung cancer at each of these 3 institutions from 8% in 1990 to 1995 to 14.9% in 2011 to 2013. Additionally, in the United States, an estimated 17,000 to 26,000 never-smokers die of lung cancer each year.²⁴ In Taiwan, 53% of those have died of lung cancer were never-smokers.²⁵ Currently, no screening guidelines recommend screening in never-smokers. However, research has shown that factors such as indoor air pollution, occupational exposures, genetic susceptibility, and secondhand smoke may all contribute to the development of lung cancer in never-smokers.²⁴ Furthermore, certain demographics have been shown to have higher rates of lung cancer in never-smokers, such as never-smoking Asian women.²⁶ More research is required to investigate other risk and demographic factors that may be used to enhance lung cancer screening.

A significant number of patients in our study also did not meet the screening guidelines for age, with as many as 24% of patients being ineligible because of being older than the age cutoff. As the population ages, the incidence of lung cancer is predicted to increase, with 217,000 patients aged more than 65 years predicted to develop lung cancer in 2030.²⁷ However, older patients are often excluded from lung cancer clinical trials, despite data showing that older patients may still derive significant survival benefit from lung cancer resection. One such study found that in patients aged 90 years and older with stage I NSCLC, 5-year survival after surgery increased to 33.7% compared with 17.1% with nonoperative therapy and 6.2% with no therapy. Median survival with surgery was 40.5 months

compared with 10 months with no treatment.²⁸ Furthermore, the American Association for Thoracic Surgery Clinical Practice Standards Committee states that age alone should not be used as a factor to exclude a patient with stage I NSCLC from surgery. Instead, they recommend focusing on comorbidities, neurocognitive function, frailty, extent of resection, and open versus minimally invasive approach.²⁹ Taken together, these results suggest that older patients may still derive benefit from lung cancer screening. The use of age as a cutoff for screening criteria should be reexamined as the population ages. Of note, the NCCN screening guidelines do not have a maximum age limit for screening eligibility, and this resulted in an additional 45 patients in our study becoming screen eligible compared with current 2021 USPSTF guidelines.

Studies have shown that lung cancer screening guidelines may not capture specific patient populations based on ethnicity who could benefit from expanded screening criteria, such as younger, African American smokers.^{17,30,31} In response to this, in March of 2021, the USPSTF released an update to their original 2013 lung cancer screening guidelines. These updated guidelines decreased the minimum age to qualify for screening from age 55 years to age 50 years and reduced the minimum pack-years to qualify for screening from 30 to 20 pack-years.³² Likewise, in February of 2022, the CMS also expanded their criteria. However, in our study, we compared the percentage of screen-ineligible patients using the new 2021 USPSTF guidelines versus the previous 2013 guidelines. We found that only 12 additional patients (absolute percentage difference of 4%) in our cohort would have been additionally eligible for screening based on these expanded guidelines. Even in a Mississippi Delta Cohort, representing a population with a higher smoking rate than in California, Osarogiagbon and colleagues³³ demonstrated that the proportion of patients with incidentally detected lung cancers who would be considered screen eligible was 43% by 2013 USPSTF criteria and only increased to 49% by 2021 USPSTF criteria. In comparison, using the broadest criteria, the NCCN criteria, resulted in an additional 45 patients being eligible for screening compared with the 2021 USPSTF criteria in our study. This is partially due to the NCCN criteria not placing a cap on the amount of time elapsed since quitting, suggesting that the carcinogenic effects of cigarette smoking may be longer lasting than previously thought.

Although proponents have argued for the expansion of lung cancer screening guidelines, controversy exists as to what additional risk factors to include in screening criteria and whether expansion of screening guidelines may lead to more false-positive findings, unnecessary diagnostic procedures, and increased anxiety for patients. An enhanced understanding of the biology of lung cancer, especially related to specific patient populations, may introduce novel methods for screening through molecular biomarkers that could refine and expand the reach of clinical guidelines.³¹

Study Limitations

Our study is limited by its nature as a single-institution study with a cohort that is biased by our local sociodemographic factors. California has one of the lowest rates of smoking and lung cancer in the country³⁴; thus, the number of never-smoking patients in our study are likely higher than other regions. Even on a local scale, our sample does not reflect the racial makeup of Los Angeles County. In our study, 65% of our sample identified as White, non-Hispanic and 6% identified as Hispanic, whereas in Los Angeles County White, non-Hispanic individuals make up 25.3% of the population and individuals identifying as Hispanic make up 49.1% of the population.³⁵ These demographic differences between our cohort and the population of Los Angeles county may bias the overall proportion of screen-eligible patients.

In addition, this study only evaluates asymptomatic patients who were found to have resectable disease and does not provide any information, for example, regarding the incidental lung cancers that received other treatments. This study is also limited by the use of descriptive statistics that do not allow us to draw any conclusions about statistical significance. Furthermore, because we relied on self-reported tobacco use to determine pack-year smoking history, it is possible these data are inaccurate. There was also a paucity of clinical data in our records related to risk factors such as environmental/occupational exposure and family history of lung cancer; as a result, we were unable to evaluate the results of other screening guidelines, such as the American Association for Thoracic Surgery lung cancer screening criteria, which require this additional information.

CONCLUSIONS

This single-institution, retrospective study demonstrated that the majority of resected lung cancers in asymptomatic patients were incidentally detected lung cancers. Of these patients, the majority would not have been eligible for lung cancer screening under current lung cancer screening guidelines. These results demonstrate not only an increased need for more effective implementation of lung cancer screening but also improved methods of screening to identify high-risk patients who would otherwise be considered screen ineligible based on current screening guidelines.

Conflict of Interest Statement

J.M.L.: Advisory Board: AstraZeneca, Bristol Myers Squibb, Genentech, Novartis, Roche; Steering/Executive Committee: AstraZeneca, Genentech, Novartis; Research Support: Genentech, Novartis; Speaker's Bureau: Genentech; Stock: Moderna; Patent: University of California, Los Angeles. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: guidelines, lung cancer, screening

TABLE E1. Symptoms prompting computed tomography scan discovering primary lung cancer in symptomatic patients

Symptom	No. of patients (N = 102), %
Cough without hemoptysis	63 (62%)
Weight loss	7 (7%)
Hemoptysis	19 (19%)
Shortness of breath	6 (6%)
Chest pain	3 (3%)
Scapular pain	2 (2%)
Other*	2 (2%)

*Other symptoms prompting CT scan included wheezing (1) and flushing (1).

TABLE E2. Indications for computed tomography scans in asymptomatic patients with cancer discovered incidentally

Indication	No. of patients (N = 345, %)
Surveillance for other, nonlung primary cancer	25 (7%)
Staging for other, nonlung primary cancer	51 (16%)
Abnormal CXR*	21 (6%)
Infectious workup	28 (8%)
Abdominal pain workup	15 (4%)
Trauma workup	16 (5%)
Cardiac evaluation	37 (11%)
Preoperative evaluation	22 (6%)
Workup for suspected noncancer lung disease	9 (3%)
Cough that resolved†	12 (3%)
Syncope workup	7 (2%)
Back pain	5 (1%)
Endocrine workup	7 (2%)
Rule-out pulmonary embolism	6 (2%)
Neurologic workup	8 (2%)
Rheumatologic workup	4 (1%)
Other‡	45 (13%)
Unknown§	27 (8%)

CXR, Chest x-ray. *Reasons stated for patients undergoing chest x-rays included “routine” CXR during annual physical examination, surveillance for medications known to affect the lungs, and screening for tuberculosis. †By the time these patients presented to our thoracic surgery clinic, their cough had resolved. ‡Other reasons CT scans were obtained on these patients included drug monitoring, hematuria, vocal fatigue, upper-extremity numbness and tingling, transplant evaluation/monitoring, workup for obstructive sleep apnea, carotid stenosis, patient request, fatigue, weight loss, groin pain, back mass, aortic aneurysm, inguinal lymphadenopathy, follow-up for incidental findings on other scans, hiatal hernia workup, and hepatic workup. §A portion of these patients (20) were imaged at our institution for surveillance of a known lung nodule, but the original reason for CT scan discovering the lung nodule was performed at an outside institution; thus, reason for scan is unknown.

TABLE E3. Symptomatic patients who would have been eligible for screening

Screening criteria	No. of patients eligible (%, N = 100*)
USPSTF 2021	16 (16%)
USPSTF 2013	15 (15%)
CMS 2015/CHEST	13 (13%)
CMS 2022	14 (14%)
ACS/ASCO	11 (11%)
NCCN 2022	43 (43%)

USPSTF, United States Preventative Services Task Force; *CMS*, Centers for Medicare & Medicaid Services; *CHEST*, American College of Chest Physicians; *ACS*, American Cancer Society; *ASCO*, American Society of Clinical Oncology; *NCCN*, National Comprehensive Cancer Network. *Two symptomatic patients had insufficient data to determine screening eligibility.