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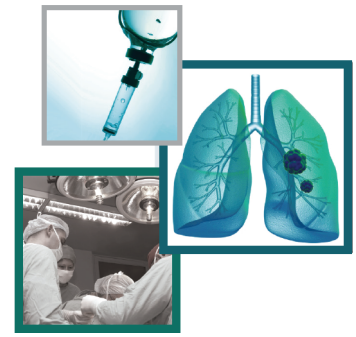
Lung Cancer Management



Implementing physician education to increase lung cancer screening uptake

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Aim: Lung cancer (LC) is the leading cause of cancer-related deaths worldwide. The US Preventive Services Task Force and National Comprehensive Cancer Network recommend annual low-dose computed tomography (LDCT) for eligible adults. We conducted a study to assess physician LDCT referral patterns. **Methods:** The study was divided into a pre-, intervention, and post-intervention periods. The intervention was a LC screening educational series. We evaluated rates of LDCT screening referrals during pre- and post-intervention periods. **Results:** In the pre-intervention period, 75 patients fulfilled US Preventive Services Task Force and/or National Comprehensive Cancer Network criteria and 27% underwent LDCT. In the post-intervention period, 135 patients fulfilled either screening criteria of whom 61.5% underwent LDCT. **Conclusion:** In our study, educational lectures improved compliance significantly and should be used as tool for primary care providers to effectively increase LDCT screening referrals.

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Keywords: early detection • lung cancer • physician education • quality improvement • screening • tobacco

Lung cancer is the most common cause of cancer in both men and women and the leading cause of cancer deaths worldwide, accounting for almost 25% of all cancer deaths [1]. The American Cancer Society estimates a total of 236,740 new cases of lung cancer with 130,180 deaths from lung cancer in the USA in 2022 [1]. The lifetime risk for lung cancer in a man is 1/15 and 1/17 for women [1]. The incidence for smokers are higher than these, as it has been established that smoking is the main cause of lung cancer and contributes to 80% of lung cancer deaths in women and 90% in men [2].

Lung cancer is typically diagnosed at advanced stages and carries a high mortality rate, with a 5-year survival rate of only 18% [3]. Due to high mortality rate and the historical improvement of breast and colon cancer outcomes because of screening, lung cancer screening trials were developed back in the 1970s to assess the benefit of screening tools for lung cancer. Initial trials were conducted using sputum cytology and chest x-rays and did not show any significant mortality reduction or early diagnosis of lung cancer [4–6].

In the 1990s, the Early Lung Cancer Action Project (ELCAP) was conducted in the USA to evaluate the use of annual low-dose computed tomography (LDCT) in subjects at high risk for lung cancer. The study detected lung cancer in 27 participants (2.7% [1.8–3.8]) by CT and seven (0.7% [0.3–1.3]) by chest radiography. A total of 23 of the 27 participants in the LDCT arm that were found to have lung cancer were diagnosed with stage I disease (2.3% [1.5–3.3]) and 26 were resectable [7]. Later in the early 2000s, other prospective studies were conducted to assess the role of LDCT for screening that also revealed promising findings with lung cancer screening. The Lung Screening Study (LSS) revealed that LDCT was twice as effective as chest radiography in detecting lung cancer [8]. It also showed that 48% of lung cancers detected by LDCT screening were diagnosed at stage I. Later studies done in USA and Europe, such as NLST and NELSON, confirmed the survival benefit of screening with LDCT. The NLST showed a 20% relative reduction in mortality in patients that were screened with LDCT compared with

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chest radiography [9]. Similarly, the NELSON study found a 26% mortality rate reduction in men and 39% in women. In NELSON, 50% of the cancers diagnosed in the screening arm were early stage [10].

Based on the data strongly supporting lung cancer screening, the National Comprehensive Cancer Network (NCCN) and the US Preventive Services Task Force (USPSTF) and created screening guidelines for high-risk patients in 2011 and 2013, respectively. While both these guidelines focus on high-risk groups, there are some differences in the screening criteria. USPSTF recommended annual screening for lung cancer in adults aged 55–80 years who have a 30 pack-year smoking history, are current smokers or have quit within 15 years [11]. The NCCN classified 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 including: family history of lung cancer, personal history of other malignancy, history of chronic obstructive pulmonary disease or pulmonary fibrosis, radon exposure, occupational exposure and/or smoking exposure that increased the risk of lung cancer to >1.3% [12]. The goal of screening is to detect the disease at earlier stages which allows for curative surgical resection and increasing overall cure rates in patients with lung cancer. Unfortunately, despite these clear recommendations, the adherence to screening guidelines and LDCT implementation remains low in the United States. In hopes of capturing more high-risk individuals, the USPSTF expanded their eligibility criteria and updated their screening recommendations in March 2021, lowering the starting age to 50 (formerly 55) and including subjects with a ≥20 (formerly 30) pack-year history of smoking [13].

We conducted a quality improvement study to assess the compliance in an outpatient Internal Medicine practice and evaluate the barriers for referring and performing LDCT. We hypothesized by providing an educational program, overall physician compliance with lung cancer screening referrals would increase.

Methods

Study description

This was an IRB-approved single institution study conducted at an inner-city, academic outpatient internal medicine practice in Manhattan (NY, USA).

The study was divided into three time periods: pre-intervention, intervention, and post-intervention. During the pre-intervention period we reviewed the charts of every current or former smoker individual that was seen at the practice by a medical resident, attending physician or mid-level providers during the months of January to March 2016. The intervention period was an educational program that served as a quality improvement project, conducted between April and December 2016. The educational program was given as part as a quality improvement project, however, in attempts to minimize bias, the providers were not aware that there would be a follow-up, post-intervention analysis. The program consisted of 60-minute PowerPoint presentations discussing the incidence and mortality of lung cancer, the history of lung cancer screening. Studies dating back to the 1970s were discussed, including the Memorial Sloan Kettering Study and John Hopkins study which assessed the use of sputum cytology and chest x rays without any evidence of mortality benefit. Also included was the emerging data from the LSS showing promising finding with the use of LDCT as screening modalities, later confirmed with larger phase 3 prospective studies such as NLST and Nelson studies whose data was also discuss in detail during the presentations, as these revealed a mortality benefit with LDCT for screening. Additional information including the proposed guidelines that were pertinent during said lectures as well as importance of shared-decision making was discussed during this program. The lectures were provided by one of three physicians: the chief of the Pulmonary Division, who served as the supervisor attending overlooking the quality improvement project, and two resident-physicians that were leading the study initiative. Each resident had mandatory didactic, where attendance was taken, on Thursday mornings prior to clinic during their ambulatory block which consisted of two weeks of ambulatory clinic every 6 weeks. Every resident physician that worked in the clinic received the presentation twice, on two separate didactic conferences spaced out by 16–20 weeks.

Approximately, only 2-3 (from a total of 10) of attending physicians working the clinic participated in the educational program, as their attendance was voluntary and not required. No mid-level providers took participation in the intervention. During the post-treatment period, we reviewed the charts of every current or former smoker individual that was seen at the practice by a medical resident, attending physician or mid-level providers during the months of January to March of 2017, For both pre- and post-intervention period, information including demographics, detailed smoking history, family history, history of other personal malignancies, history of chronic lung disease, or previous chemical exposure was recorded. For each period, we assessed the USPSTF and/or NCCN

screening eligibility for each subject and detailed whether eligible subjects underwent LDCT for lung cancer screening or not.

The primary end point of this study was to determine if the rates for screening in subjects who fulfilled NCCN and/or USPSTF eligibility criteria increased after education was provided to physicians. Secondary end points included: To assess the tendencies for screening according to ethnicity, gender; To evaluate the relationship between smoking status and screening.

Statistical methods

For both the pre and post intervention, subject information as described above was obtained to assess screening eligibility for according to USPSTF and/or NCCN guidelines. In each period (pre, post), subjects were categorized as fulfilling either USPSTF and/or NCCN eligibility criteria for lung cancer screening, or not fulfilling any criteria at all. All analyses were restricted to subjects who had sufficient information available to determine whether they fulfilled either criterion.

The Mann-Whitney test was used to examine whether there was an association between age and study period. For each categorical factor, the chi-square test, (or Fisher's exact test, as appropriate), was used to examine the association between that factor and study period. Analyses for screening were carried out separately for subjects who fulfilled criteria, and for those who did not.

Multivariable logistic regression models were used to examine the association between screening rates and period (pre-intervention, post-intervention). Gender and ethnicity (Hispanic, non-Hispanic) were included in each model to examine whether screening rates differed accorded to gender or ethnicity. All possible interactions between period, gender and ethnicity were explored.

Results

The charts of 1627 subjects were reviewed during all periods. Results of the comparisons of demographic and clinical factors are summarized in Table 1.

Pre-intervention

The pre-intervention period took place in a three-month time-point from January to March of 2016. During this period 677 charts were reviewed. It was possible to determine eligibility USPSTF and/or NCCN screening criteria in 121 of the subjects. The remaining subjects had incomplete documentation in their electronic medical records, mainly pertaining to the subjects' smoking history. The mean patient age in the pre-intervention assessment was 62 years. Of all, 45% of the patients were female and 55% men. Of the patients reviewed, 46% were Hispanic and 54% were non-Hispanic (Whites, African American, Asian, other). Data was not available to identify specific races and/or ethnicities) (Table 1).

In the pre-intervention analysis, 73% of the patients were physically seen by resident physicians, whereas 22% were seen by attending physicians and 5% by mid-level providers. Most patients (87%) were current smokers. More than half (54%) of the subjects were heavy smokers with an average of ≥20 cigarettes daily, and 90% had a smoking history of over 30 years (Table 1).

A total of 62% of the subjects fulfilled USPSTF and/or NCCN eligibility criteria for screening and 38% were ineligible per both USPSTF and NCCN screening guidelines. Only 27% of the patients that fulfilled either screening eligibility underwent LDCT, as seen in Table 2. Table 3 depicts how 85% of the subjects that were ineligible for both screening criteria underwent LDCT despite not fulfilling either screening guidelines.

Post-intervention

The post-intervention period took place in a three-month period from January to March of 2017. Following physician education, 950 patient visits were reviewed. It was possible to determine whether subjects fulfilled criteria in 163 subjects due to incomplete data in the remaining subjects. The mean age in the post-intervention analysis was 62 years. Of these patients, 48% were female and 52% were male. Like the pre-intervention analysis, 48% were Hispanic and 52% were non-Hispanic (Whites, African American, Asian, other). Data was not available to identify specific races and/or ethnicities (Table 1).

In the post-intervention analysis, 76, 23 and 1% of the patients were physically seen by resident, attendings, and mid-level providers, respectively. A total of 66% of the patients were current smokers. Half of the subjects (50%) were heavy smokers with an average of ≥20 cigarettes, and 90% had a smoking history of over 30 years (Table 1).

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Table 1. Baseline characteristics.

	Pre-intervention (n = 121), n (%)	Post-intervention (n = 163), n (%)	p-value
Median age (years)	62.0	62.0	0.7479
Gender:			
Male	67 (55.4%)	85 (52.1%)	0.5900
Female	54 (44.6%)	78 (47.9%)	
Ethnicity:			
Hispanic	56 (46.3%)	78 (47.9%)	0.7930
Non-Hispanic	65 (53.7%)	85 (52.1%)	
Smoking status:			
Current	105 (86.8%)	108 (66.3%)	<0.0001
Former	16 (13.2%)	55 (33.7%)	
Number of cigarettes[†]:			
0–9	30 (25.0%)	12 (7.5%)	<0.0001
10–19	25 (20.8%)	67 (42.1%)	
≥20	65 (54.2%)	80 (50.3%)	
Duration of smoking (years)[‡]:			
0–29	10 (210.0%)	16 (10.1%)	0.9869
≥30	90 (90.0%)	143 (89.9%)	
Family history of lung cancer:			
Yes	8 (6.6%)	19 (11.7%)	0.1518
No	113 (93.4%)	144 (88.3%)	
Personal history of other malignancy:	10 (8.3%)	10 (6.1%)	0.4879
Yes	111 (91.7%)	153 (93.9%)	
No			
History of chronic lung disease:			
Yes	31 (25.6%)	37 (22.7%)	0.5865
No	90 (74.4%)	126 (77.3%)	
Fulfilled US Preventive Services Task Force or National Comprehensive Cancer Network high-risk criteria for screening:	75 (62%)	135 (82.8%)	<0.0001
Yes	46 (38%)	28 (17.2%)	
No			

[†]Unknown: 1 (0.1%) pre-intervention; 4 (2.5%) post-intervention.
[‡]Unknown: 21 (17.4%) pre-intervention; 4 (2.5%) post-intervention.

Table 2. Screening in subjects who fulfilled US Preventive Services Task Force and/or National Comprehensive Cancer Network criteria (n = 210).

	Screened		Adjusted odds ratio[†] (95% CI)	p-value
	Yes, n (%)	No, n (%)		
Period:				<0.0001
– Pre	20 (26.7)	55 (73.3)	Reference	
– Post	83 (61.5)	52 (38.5)	4.60 (2.45–8.63)	
Gender:				0.4491
– Male	57 (52.8)	51 (47.2)	Reference	
– Female	46 (45.1)	56 (54.9)	0.80 (0.45–1.43)	
Hispanic:				0.1596
– No	61 (52.1)	56 (47.9)	Reference	
– Yes	42 (45.2)	51 (54.8)	0.65 (0.36–1.18)	

[†]The outcome was screening = yes. Therefore, an odds ratio >1 indicates higher odds of screening.

In the post-intervention period, 83% of subjects fulfilled USPSTF and/or NCCN eligibility criteria for screening and 17% were ineligible under both criteria. As seen in Table 2, 61% of the eligible subjects underwent LDCT. Table 3 depicts how 39% of the screening ineligible underwent LDCT in the post-intervention period.

Table 3. Screening in subjects who did not fulfill US Preventive Services Task Force nor National Comprehensive Cancer Network criteria.

	Screened		Adjusted odds ratio† (95% CI)	p-value
	Yes, n (%)	No, n (%)		
Period:				0.0002
– Pre	39 (84.8)	7 (15.2)	Reference	
– Post	11 (39.3)	17 (60.7)	0.10 (0.03–0.34)	
Gender:				0.9447
– Male	32 (72.7)	12 (27.3)	Reference	
– Female	18 (60.0)	12 (40.0)	0.96 (0.30–3.08)	
Hispanic:				0.1937
– No	24 (72.7)	9 (27.3)	Reference	
– Yes	26 (63.4)	15 (36.6)	0.45 (0.14–1.50)	

†The outcome was screening = yes. Therefore, an odds ratio <1 indicates lower odds of screening.

Table 4. Screening in subjects who fulfilled and did not fulfill criteria (because of the overlap of the criteria, all patients that fulfilled US Preventive Services Task Force criteria also fulfilled National Comprehensive Cancer Network criteria, but not *vice versa*).

	Screened, n (%)	Not screened, n (%)	Adjusted odds ratio† (95% CI)	p-value
Fulfilled USPSTF criteria:				<0.0001
Pre-intervention	20 (27.0%)	54 (73%)	4.83 (2.53–9.19)	
Post-intervention	78 (62.4%)	47 (37.6%)		
Fulfilled NCCN criteria:				<0.0001
Pre-intervention	20 (27.0%)	54 (73.0%)	4.69 (2.49–8.84)	
Post-intervention	83 (62.4%)	50 (37.6%)		
Did not fulfill USPSTF:				0.0002
Pre-intervention	39 (83.0%)	8 (17.0%)	0.15 (0.05–0.41)	
Post-intervention	16 (42.1%)	22 (57.9%)		
Did not Fulfill NCCN criteria:				0.0001
Pre-intervention	39 (83.0%)	8 (17.0%)	0.11 (0.04–0.35)	
Post-intervention	11 (36.7%)	19 (63.3%)		

†The outcome was screening = yes. Therefore, an odds ratio >1 indicates higher odds of screening.
NCCN: National Comprehensive Cancer Network; USPSTF: US Preventive Services Task Force.

Comparison of screening pre- & post-intervention

For each logistic regression model examined, all possible interactions between period, gender and ethnicity were included in the model, but as none were significant, they were removed. Therefore, only models with main effects were examined.

The analysis of screening rates in patients fulfilling either criteria, is detailed in Table 3, and shows the comparison between the subjects who fulfill USPSTF and/or NCCN and were screened and also those who did not fulfill criteria and were screened in both pre- and post-intervention periods. Notably, the tendencies for screening had a significant increase in those that fulfill USPSTF and/or NCCN criteria after the educational intervention, from 27% to 61.5% for those fulfilling USPSTF and/or NCCN criteria (adjusted OR 4.60, $p < 0.0001$). The rates for screening for those who did not fulfill either USPSTF or NCCN screening criteria significantly decreased post the educational intervention from 85% to 39% (adjusted OR 0.11, $p < 0.0002$) (Table 3).

Table 4 provides the results separated by USPSTF criteria and NCCN criteria.

Discussion

Throughout the years, data has demonstrated how screening with low dose CT scan has been shown to reduced mortality in patients that fulfill high risk criteria for lung cancer. While different organizations, including USPSTF and NCCN have established guidelines for screening recommendations and coverage of services by Medicare, Medicaid, and most commercial insurances exists, studies have shown how the rate of eligible patients that undergo screening remains low to date. A study evaluated the percentage of eligible smokers who reported LDCT screening (within 1 year) from 2010-2015. It revealed that only 3.9% of patients underwent screening in 2015 following

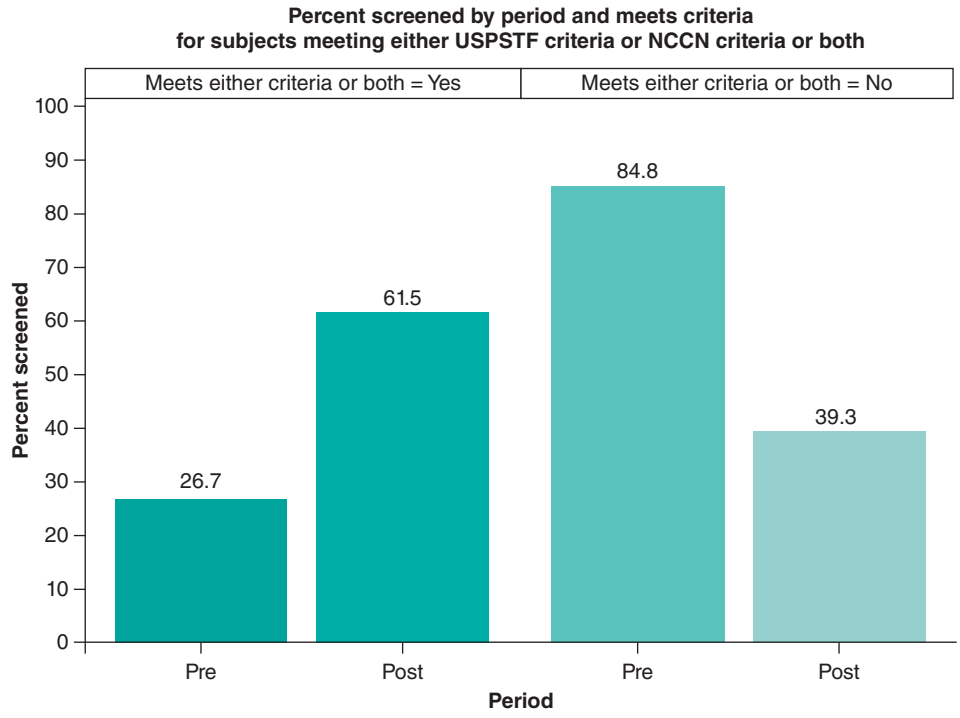

Figure 1. Percentage screened by period for subject fulfilling either or both criteria US Preventive Services Task Force or National Comprehensive Cancer Network Criteria (n = 74).
NCCN: National Comprehensive Cancer Network; USPSTF: US Preventive Services Task Force.

the 2013 USPSTF recommendations for annual screening, compared with 3.3% in 2010 [14]. Fortunately, the screening uptake has improved throughout the years, though the rates of LDCT uptake remain suboptimal. A study used the 2017 Behavioral Risk Factor Surveillance System (BRFSS) to determine the LDCT screening uptake across ten states and found that 14.4% of eligible individuals had undergone LC screening within 12 months of the assessment. The study found disparities in screening according to state and insurance. States such as Florida having higher rates of screening uptake compared with others such as Nevada, 18.1%versus 6.5% respectively ($p = 0.03$). Also, screening implementation was higher among individuals with insurance compared with uninsured subjects (15.2% vs 4.0%, $p < 0.001$) [15]. A study by Williams R, *et al.* used the 2019 BRFSS to assess the use of lung cancer screening in 2019 in 41,544 individuals with a smoking history. The study found that 20.7% of the eligible subjects underwent lung cancer screening in 2019 [16].

To understand the practices at a national level, a survey of PCPs was performed in 2019 to assess the perception and practices of low dose CT lung cancer screening, where 75% agreed that the benefits of LDCT screening outweigh the risks [17]. However, only 50% believed there is enough evidence suggesting that screening reduces mortality (50%) [17]. Common barriers reported in that study were prior authorization requirements (57%), lack of insurance coverage (53%), and coverage denials (31%) [18] Oftentimes, physicians are unaware that LDCT for screening are covered by Medicare and Medicaid services [18]. However, contrary to general belief, comprehensive lung cancer screening registry (LCSR) is considered a metric for reimbursement from Medicare and Medicaid services [19]. Another study conducted a patient and provider survey in an academic medical center to assess the tendencies for lung cancer screening. The study found that 80% of the patients that responded the survey where adherent to screening and believed that the technology is accurate, early detection useful, and they trusted their providers. Of the providers that answered the questionnaire, 89% reported being aware of the USPSTF recommendations for lung cancer screening. However, only 31% of then answered age and smoking eligibility criteria correctly [20].

Like the findings from previously published data, as mentioned above, our study found that there was suboptimal adherence to established low dose CT lung cancer screening guidelines, which was predominantly due to unfamiliarity with the screening criteria. However, our study revealed that after providing PowerPoint educa-

tional lectures to primary care physicians and Internal Medicine residents, compliance with lung cancer screening increased significantly, and screening of those patients that did not fulfill criteria decreased.

There were several limitations to our study. Only 18% of the patients in the pre-intervention arm and 17% in the post-intervention arm were evaluable for screening eligibility, as majority of our patients did not have enough data in the electronic medical system to determine eligibility. Another limitation to our study is that we did not obtain a post-intervention survey to assess the practitioner's level of comfort and knowledge of the guidelines after the education was received. Lastly, although we can infer that the improvement in the rates of screening referral and uptake was due to the educational program provided, we cannot officially correlate the changes in the referral patterns to the educational program due to the retrospective nature of the study and the fact that other compounding factors could have contributed to the changes in numbers.

Despite the above, and as seen in Figure 1, we believe that the education provided was potentially a great tool to promote lung cancer screening implementation and further prospective studies will be key in assessing this relationship. Nevertheless, it is our duty as physicians to continue to promote and advocate for lung cancer screening to for our high-risk patients. Data has shown that NSCLC survival is directly related to stage at diagnosis [21]. Patients with stage IA may have a 5-year survival rate of approximately 75% with surgery, which quickly declines with increasing stage at diagnosis [22].

Conclusion

In conclusion, lung cancer screening is an imperative tool to combat the poor outcomes and overall prognosis of lung cancer that is largely due to advanced staged at diagnosis. A follow-up study that examines these questions would offer valuable information in the national and international quest to reduce lung cancer suffering and death by increasing uptake of LCS.

Summary points

- Lung cancer (LC) is the leading cause of cancer-related deaths worldwide.
- We conducted a study to assess physician referral patterns and barriers for low-dose CT (LDCT).
- The study was divided into a pre-intervention, intervention, and post-intervention periods.
- The intervention was a lung cancer screening educational series, which consisted of lectures provided to physicians staffing an Academic medicine clinic in New York.
- We evaluated rates of LDCT screening referrals among eligible patients during the pre- and post-intervention periods.
- In the pre-intervention period, 27% of the eligible subjects underwent screening.
- In the post-intervention period, 61.5% of eligible subjects underwent LDCT.
- In our study, educational lectures improved compliance significantly and should be used as tool for primary care providers to effectively increase LDCT screening referrals.

Author contributions

All authors contributed to the study design and putting together the manuscript.

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Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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References

1. Key Statistics for lung cancer. American Cancer Association (2022). www.cancer.org/cancer/lung-cancer/about/key-statistics.html
2. Office of the Surgeon General (US); Office on Smoking and Health (US). *The Health Consequences of Smoking: A Report of the Surgeon General.* Centers for Disease Control and Prevention, Atlanta, GA, USA (2004).
3. Lung Cancer Screening. *J. Natl Compr. Canc. Netw.* 16(4), 412–441 (2018).
4. Melamed MR, Flehinger BJ, Zaman MB, Heelan RT, Perchick WA, Martini N. Screening for early lung cancer. Results of the Memorial Sloan-Kettering study in New York. *Chest* 86, 44–53 (1984).
5. Tockman MS. Survival and mortality from lung cancer in a screened population: the Johns Hopkins study. *Chest* 89, S324–S325 (1986).
6. Oken MM, Hocking WG, Kvale PA *et al.* Screening by chest radiograph and lung cancer mortality: the Prostate, Lung, Colorectal, and Ovarian (PLCO) randomized trial. *JAMA* 306(17), 1865–1873 (2011).
7. Henschke CI, McCauley DI, Yankelevitz DF *et al.* Early Lung Cancer Action Project: overall design and findings from baseline screening. *Lancet* 354(9173), 99–105 (1999).

• **Landmark study that uses low-dose CT as a screening modality and found mortality benefits for lung cancer. The findings of this study were what led organizations to extrapolate the criteria for lung cancer screening, as well as support lung cancer screening recommendations with LDCT.**

8. Gohagan J, Marcus P, Fagerstrom R, Pinsky P, Kramer B, Prorok P. Baseline Findings of a randomized feasibility trial of lung cancer screening with spiral CT scan vs chest radiograph: the lung screening study of the National Cancer Institute. *Chest* 126(1), 114–121 (2004).

• Landmark study that uses LDCT as a screening modality and found mortality benefits for lung cancer. The findings of this study were what led organizations to extrapolate the criteria for lung cancer screening, as well as support lung cancer screening recommendations with LDCT.

9. National Lung Screening Trial Research Team, Aberle DR, Adams AM *et al.* Reduced lung-cancer mortality with low-dose computed tomographic screening. *N. Engl. J. Med.* 365(5), 395–409 (2011).

• Landmark study that uses LDCT as a screening modality and found mortality benefits for lung cancer. The findings of this study were what led organizations to extrapolate the criteria for lung cancer screening, as well as support lung cancer screening recommendations with LDCT.

10. Ru ZY, Xi X, de Koning HJ, Mali WP, Vliegenthart R, Oudkerk M. NELSON lung cancer screening study. *Cancer Imaging* 11(1A), S79–S84 (2011).

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11. Moyer VA. on behalf of the US. Preventive Services Task Force. Screening for lung cancer: U.S. Preventive Services Task Force recommendation statement. *Ann. Intern. Med.* 160, 330–338 (2014).
12. Lung Cancer Screening. Wood DE, Kazerooni EA, Aberle D *et al.* NCCN Guidelines® Insights: Lung Cancer Screening, Version 1.2022. *J Natl Compr. Canc. Netw.* 20(7), 754–764 (2022).
13. Lung Cancer: Screening. U.S. Preventive Services Task Force (2021). www.uspreventiveservicestaskforce.org/uspstf/recommendation/lung-cancer-screening
14. Jemal A, Fedewa SA. Lung cancer screening with low-dose computed tomography in the United States-2010 to 2015. *JAMA Oncol.* 3(9), 1278–1281 (2017).
15. Zahnd WE, Eberth JM. Lung cancer screening utilization: a behavioral risk factor surveillance system analysis. *Am. J. Prev. Med.* 57(2), 250–255 (2019).
16. Williams RM, Li T, Luta G. Lung cancer screening use and implications of varying eligibility criteria by race and ethnicity: 2019 Behavioral Risk Factor Surveillance System data. *Cancer* 128(9), 1812–1819 (2022).
17. Eberth JM, McDonnell KK, Sercy E *et al.* A national survey of primary care physicians: perceptions and practices of low-dose CT lung cancer screening. *Prev. Med. Rep.* 11, 93–99 (2018).
18. Ersek JL, Eberth JM, McDonnell KK *et al.* Knowledge of, attitudes toward, and use of low-dose computed tomography for lung cancer screening among family physicians. *Cancer* 122(15), 2324–2331 (2006).
19. Kale MS, Wisnivesky J, Taioli E, Liu B. The landscape of US lung cancer screening services. *Chest* 155(5), 900–907 (2019).
20. Duong DK, Shariff-Marco S, Cheng I *et al.* Patient and primary care provider attitudes and adherence towards lung cancer screening at an academic medical center. *Prev. Med. Rep.* 6, 17–22 (2017).
21. Goldstraw P, Crowley J, Chansky K *et al.* The IASLC Lung Cancer Staging Project: proposals for the revision of the TNM stage groupings in the forthcoming (seventh) edition of the TNM classification of malignant tumours. *J. Thorac. Oncol.* 2, 706–714 (2007).
22. Rami-Porta R, Ball D, Crowley J *et al.* The IASLC Lung Cancer Staging Project: proposals for the revision of the T descriptors in the forthcoming (seventh) edition of the TNM classification for lung cancer. International Staging Committee., Cancer Research and Biostatistics., Observers to the Committee., Participating Institutions. *J. Thorac. Oncol.* 2(7), 593–602 (2007).