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Examining patient, provider, and health system characteristics that influence lung cancer screening following the 2021 USPSTF guidelines

By

LUCY RIOS

DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Public Health Sciences
in the

OFFICE OF GRADUATE STUDIES

of the

UNIVERSITY OF CALIFORNIA

DAVIS

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2026

Acknowledgements

Para La Comunidad

Con La Comunidad

En La Comunidad

As a researcher, we are taught to rely on data to predict outcomes. In my case, statistics might suggest that I would not receive a doctorate, given that I am a first-generation Latina Scholar born and raised in Oakland, CA. Yet, despite a non-linear academic trajectory, I am proud of every version of myself that has led me to this moment, achieving the milestone of being part of the 1% of individuals with a doctorate, and becoming a *Doctora* Rios. I am committed to applying the knowledge I have gained to giving back to the communities that have given so much to me.

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Abstract

Background: Lung cancer remains the leading cause of cancer deaths in the United States despite evidence demonstrating that lung cancer screening (LCS) using low-dose computed tomography (LDCT) can reduce mortality through early detection. In 2021, the United States Preventive Services Task Force (USPSTF) expanded LCS eligibility criteria to increase access to screening among high-risk eligible individuals. However, limited research has examined the early implementation of the revised guidelines and the multilevel factors influencing LCS uptake following the expansion of the guidelines. The purpose of this dissertation was to examine barriers, facilitators, and factors associated with LCS uptake and completion following implementation of the 2021 USPSTF guidelines.

Methods: This dissertation utilized a mixed-methods approach across three studies. Chapter 1 consisted of a Consolidated Framework for Implementation Research (CFIR) guided literature review examining multilevel determinants (patient, provider, health system levels) influencing LCS uptake between 2021 and 2024. Three online databases were searched for studies examining barriers and facilitators to LCS among individuals meeting the 2021 USPSTF guidelines.

In Chapter 2, interviews were conducted among University of California Davis Health (UCDH) patients who had received an LCS, those who were eligible but had not received an LCS, and primary care team members (PCTM) who provide services to LCS-eligible patients. A rapid qualitative analysis was done to examine the study results.

Lastly, Chapter 3 consisted of a retrospective review of UCDH electronic health records (EHR). Multivariable generalized linear mixed methods were used to examine associations between

patient and provider-level characteristics and screening completion. Analysis was performed using SAS for academic purposes.

Results: Thirty-one of nine hundred eighty-six unique articles (3%) met the inclusion criteria for Chapter 1. Findings identified salient constructs across CFIR domains, including but not limited to racial disparities, challenges in the LCS continuum, and implementation strategies to improve screening uptake. Thirty-five interviews with UC Davis Health (UCDH) LCS eligible patients who had not received LCS (n = 11), patients who had received LCS (n = 12), and primary care team members (n = 12) were conducted for Chapter 2. At a patient level, participants emphasized the need for improved clinic workflows, patient-centered educational materials, and multifaceted approaches to educational delivery. Lastly, of the 2,665 unique patients referred to LCS a total of 1,798 patients (67%) completed LCS during the study period for Chapter 3. Increased odds of screening completion were observed among patients aged 70-80 years and those identifying as Asian, whereas provider-level characteristics were not significantly associated with screening adherence after adjustment.

Conclusion: Collectively, the findings from the dissertation demonstrated that improving LCS uptake following the 2021 USPSTF guidelines requires multilevel strategies addressing patient, provider, and health system barriers. This work provides early insights into implementation efforts and offers recommendations on opportunities to improve equitable access to LCS, strengthen the LCS continuum, and increase early detection among high-risk individuals.

Introduction

Since the early 1950's, lung cancer has been the leading cause of cancer death among men in the United States, and it became the leading cause of cancer death among women in 1987. [1] Cigarette smoking is the leading risk factor responsible for 86% of all lung cancer deaths among older adults.[2] Other risk factors include exposure to radon and hazardous chemicals such as asbestos, uranium, arsenic, cadmium, chromium, nickel, etc.[3] Prior to 2013, there was no reliable method to detect lung cancer at an early stage, contributing to the high mortality rates. Pivotal studies such as the Early Lung Cancer Action Project, the National Lung Cancer Screening Trial (NLST), and the Dutch-Belgian randomized lung cancer screening trial (NELSON) provided the evidence to demonstrate the ability of low-dose computed tomography (LDCT) as a tool to detect early-stage lung cancer among high-risk individuals and improved survival.[4–8] As a result, by the end of 2013, the United States Preventive Services Task Force (USPSTF) updated their LCS guidelines to Grade B, indicating that there is a high or moderate certainty that the net benefits outweigh the risks for LCS.[9] The initial 2013 USPSTF guidelines identified high-risk eligible individuals for lung cancer as people between the ages of 55-80 years old who were current or former smokers and had at least a 30 pack-year history of smoking.[10]

In 2019, the USPSTF commissioned a systematic review and collaborative modeling studies from the Cancer Intervention and Surveillance Modeling Network (CISNET) to evaluate the 2013 guidelines and to develop recommendations to improve them.[11,12] The systematic review consisted of 223 articles published through May 2019 and assessed: 1) accuracy of LCS with LDCT and the benefits and harms, 2) the benefits of screening by subgroup (e.g., sex), or "by the number or frequency of LDCT scans and whether the harms associated with screening and the evaluation of lung nodules differ with the use of Lung-RADS, International Early Lung

Cancer Action Program (I-ELCAP), or similar approaches", 3) "whether the use of risk prediction models identified adults at higher risk or lung cancer mortality improves the balance of benefits and harms of screening compared with the use of trial eligibility criteria or variants of the 2013 USPSTF recommendation criteria." Additionally, the CISNET studies provided information on the optimal ages at which to commence and conclude LCS among eligible patients. The results of both studies led to updates to USPSTF LCS guidelines on March 9, 2021, which lowered the age of high-risk individuals from 55 to 50 and the minimum pack-year history from 30 to 20.[13] The number of years quit for former smokers remained at 15 years.

Updates to the guidelines are projected to reduce the mortality rate for lung cancer by expanding access to early detection for high-risk individuals.[14] Although the 2021 USPSTF guidelines have substantially expanded eligibility for LCS, less is known about how these updated recommendations have been implemented in clinical settings during the early years following their release. In addition, examining barriers and facilitators to LCS implementation between 2021 and 2024 is important for understanding the early impacts of the updated guideline and for identifying factors that may influence screening recommendations and completion. Assessing factors at the patient, provider, and health system levels is essential, as successful implementation of LCS requires efforts across these levels. Therefore, this dissertation examines multilevel barriers and facilitators associated with LCS uptake following the implementation of the 2021 USPSTF guidelines.

References

1. Lung Cancer Trends Brief | American Lung Association. Accessed March 24, 2025. https://www.lung.org/research/trends-in-lung-disease/lung-cancer-trends-brief

2. Ezenwankwo E, Nguyen DT, Akpabio IU, Eberth JM. Expanding reach, enhancing capacity: embracing the role of primary care in lung cancer screening and smoking cessation in the United States. *Lancet Reg Health Am*. 2024;38:100870. doi:10.1016/j.lana.2024.100870

3. American Lung Association. Lung Cancer Causes & Risk Factors. Accessed May 26, 2026. https://www.lung.org/lung-health-diseases/lung-disease-lookup/lung-cancer/basics/what-causes-lung-cancer

4. 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*. 2011;365(5):395-409. doi:10.1056/NEJMoa1102873

5. de Koning HJ, van der Aalst CM, de Jong PA, et al. Reduced Lung-Cancer Mortality with Volume CT Screening in a Randomized Trial. *N Engl J Med*. 2020;382(6):503-513. doi:10.1056/NEJMoa1911793

6. Black WC, Gareen IF, Soneji SS, et al. Cost-effectiveness of CT screening in the National Lung Screening Trial. *N Engl J Med*. 2014;371(19):1793-1802. doi:10.1056/NEJMoa1312547

7. Fathi JT, Barry AM, Greenberg GM, et al. The American Cancer Society National Lung Cancer Roundtable strategic plan: Implementation of high-quality lung cancer screening. *Cancer*. 2024;130(23):3961-3972. doi:10.1002/cncr.34621

8. Henschke CI, McCauley DI, Yankelevitz DF, et al. Early Lung Cancer Action Project: overall design and findings from baseline screening. *Lancet*. 1999;354(9173):99-105. doi:10.1016/S0140-6736(99)06093-6

9. Grade Definitions | United States Preventive Services Taskforce. Accessed March 26, 2025. https://www.uspreventiveservicestaskforce.org/uspstf/about-uspstf/methods-and-processes/grade-definitions

10. Archived: Lung Cancer: Screening | United States Preventive Services Taskforce. Accessed March 24, 2025. https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/lung-cancer-screening-december-2013

11. Jonas DE, Reuland DS, Reddy SM, et al. *Screening for Lung Cancer With Low-Dose Computed Tomography: An Evidence Review for the U.S. Preventive Services Task Force*. Agency for Healthcare Research and Quality (US); 2021.

12. Jonas DE, Reuland DS, Reddy SM, et al. Screening for Lung Cancer With Low-Dose Computed Tomography: Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. *JAMA*. 2021;325(10):971-987. doi:10.1001/jama.2021.0377

13. Krist AH, Davidson KW, Mangione CM, et al. Screening for lung cancer: US preventive services task force recommendation statement. *JAMA*. 2021;325(10):962-970. doi:10.1001/jama.2021.1117

14. Darden ME, Hoagland A. Lung cancer screening and USPSTF recommendations. *JAMA Netw Open*. 2025;8(2):e2458916. doi:10.1001/jamanetworkopen.2024.58916

Chapter 1 | Multi-level Determinants and Strategies Influencing Lung Cancer Screening Uptake in the United States Following the 2021 USPSTF Guideline Expansion: A CFIR Guided Literature Review

Abstract

Background: The 2021 United States Preventive Services Task Force (USPSTF) guidelines have expanded eligibility for lung cancer screening (LCS) among high-risk patients. However, LCS in clinical practice remains low despite early screening recommendations using low-dose computed tomography (LDCT). Several patient, primary care team (PCT) members, and health system-level approaches have been proposed to increase LCS rates and mitigate disparities. Such approaches include increasing LCS awareness through educational materials, developing LCS programs, incorporating shared decision-making (SDM) aids, and conducting media campaigns. The aim of this literature review is to understand how multilevel factors influence the implementation and uptake of LCS following the 2021 USPSTF guidelines, and which strategies have been employed to improve LCS rates among high-risk eligible patients.

Methods: Three online databases were searched for research articles on barriers and facilitators to LCS among eligible patients meeting 2021 USPSTF guidelines in the US between 2021 – 2024. The Consolidated Framework for Implementation Research (CFIR) was used to organize literature findings, and recommendations were organized at the patient, primary care team, and health system levels.

Results: Thirty-one of nine hundred eighty-six unique articles (3%) met the inclusion criteria. There was a variation in methods of included studies, including mixed methods (n=5), qualitative (n=10), and quantitative (n =16). Salient constructs under each domain included: Individual

Level - racial disparities, barriers, and facilitators to LCS; Inner Level - LCS continuum, and resource allocations; Outer Level- collaborations, and resource allocation; Innovation: dual eligible patients, and medical transportation programs; and Implementation Level - educational material content, decision aids, and content delivery.

Conclusion: The updated 2021 USPSTF LCS guidelines have substantially expanded eligibility criteria, benefiting high-risk eligible individuals, such as adults aged 50-54, women, and racial and ethnic minorities. This expansion has not only increased the number of high-risk eligible individuals but also spurred efforts to improve LCS uptake. As the guidelines have evolved, so must the approaches used to reach and engage these populations.

Keywords: Lung Cancer Screening, Strategies, Implementation Science, Literature Review

1. Introduction

On March 9, 2021, the United States Preventive Services Task Force (USPSTF) updated its lung cancer screening (LCS) guidelines, lowering the age of high-risk individuals from 55 to 50 and the minimum pack-year history from 30 to 20.[1] The number of years quit for former smokers remained at 15 years, and the recommended screening tool continued to be low-dose computed tomography (LDCT). As a result, these updates have nearly doubled the number of individuals who are eligible for LCS.[2,3] Three key outcomes emerged following the updates to LCS guidelines: an increase in the number of eligible individuals, and persistent disparities by sex, race, and ethnicity. The estimated number of eligible high-risk individuals went from 8 million to 14.5 million, of whom 50% are estimated to currently smoke.[1] Additionally, the updated guidelines increased the number of eligible women by 78%[4] and racial and ethnic minoritized populations.[5,6,7] Unfortunately, despite the increase in racial and ethnic minorities, there continue to be significant disparities by sex, race, and ethnicity.[8] Studies have linked these disparities with social determinants of health such as access to healthcare, economic status, insurance coverage, and level of education.[9]

Evidence demonstrating the benefits of early detection of lung cancer via LDCT has been endorsed by most professional organizations and lung cancer advocacy groups.[10] However, LCS uptake among eligible patients has remained low, indicating that multilevel barriers may not yet be fully understood or adequately addressed. Nationally, an estimated 226,650 new lung cancer cases and 124,730 lung cancer deaths were predicted for 2025.[11] The American Lung Association (ALA) has estimated that 20% of lung cancer deaths for eligible patients meeting the USPSTF guidelines could be prevented by undergoing annual lung cancer screenings (LCS) via

low-dose computed tomography (LDCT) scan.[12] The 2025 ALA report also estimated that only 16% of eligible patients undergo annual screenings nationally.[12]

To increase LCS screening rates, it is important to have a strong understanding of the barriers and facilitators that influence LCS uptake. Although the 2021 USPSTF guidelines expanded eligibility for LCS, the uptake remains low. The purpose of this literature review is to understand how multilevel factors at the patient, primary care team (PCT) member, and health system levels influence the uptake of LCS following the 2021 USPSTF guidelines, and which strategies have been employed to improve LCS rates among eligible individuals.

2. Methods

This review synthesized studies assessing barriers and facilitators to lung cancer screening (LCS) uptake among patients eligible under the 2021 USPSTF guidelines. Barriers were defined as challenges that impeded either the PCT from recommending LCS to eligible patients or patients from opting to undergo screening. Facilitators were defined as factors that supported PCTs in making LCS recommendations or reduced barriers to LCS uptake, including strategies shown to increase LCS uptake. Additionally, this review examined multilevel factors influencing LCS, including barriers and facilitators at the patient, primary care team, and health system levels, recognizing that screening uptake is shaped by interactions across these levels rather than by single factors.

Three academic search engines were used to conduct the literature review: PubMed, Scopus, Web of Science, and Google Scholar. A university librarian worked with the author to develop a list of keywords, MeSH terms, and subject headings to find all publications from March 9, 2021, to December 31, 2024, that examined barriers and facilitators to LCS. Search terms included “lung cancer screening,” “barrier,” “facilitator”, and related terms. A full list can

be found in Appendix A. The literature search matrix included the following categories: Author, Publication Year, Title, Journal, Location, Objectives, Design, Setting/Year of Study, Sample, Methods, Main Findings, Secondary Findings, Strengths, Source, and Notes. (Table 1)

2.1 Framework

The Consolidated Framework for Implementation Research (CFIR*)* served as the guiding framework for analyzing the literature included in this review. CFIR is a metatheoretical framework commonly used to examine determinants that influence the implementation of a single intervention within a specific context.[13,14] In contrast, this review used CFIR as an organizing framework to synthesize evidence from multiple studies evaluating strategies to improve LCS uptake following USPSTF guideline updates, from the perspectives of different stakeholders, including patients, PCTs, and health systems. The review drew on the five CFIR domains: Intervention, Outer Setting, Inner Setting, Individual Characteristics, and Process of Implementation to organize and interpret the findings. (Table 2) Lastly, applying CFIR enabled a structured synthesis of how factors at the patient, PCT, and health system levels influence LCS implementation and uptake. In this way, the framework is considered multi-level, as it recognizes that successful implementation of LCS programs requires addressing factors at all three levels. By organizing the findings using CFIR, this review illustrates how factors across levels interact and identifies points where intervention strategies can be targeted to improve equitable uptake of lung cancer screening (LCS).

2.2 Selection Criteria

Studies that examined individuals meeting USPSTF 2021 guidelines for LCS, or healthcare providers involved in LCS programs or referrals, were included. Additionally, studies discussing barriers and facilitators to LCS at the patient, PCT, or health system levels were

included. Studies involving individuals who did not meet the 2021 USPSTF LCS screening recommendations were excluded. Conference abstracts, reviews, and protocols were also excluded. Lastly, studies conducted outside the U.S., published in a language other than English, or with full-text articles unavailable were also excluded from the review. (Figure 1)

2.3 Article Review Process

All articles were retrieved from each database and exported to Lean Library Workspace[15], a reference management software for study selection. This tool allowed the author to review all the titles, abstracts, and full texts, and to create tags and notes on one platform. In the initial review stage, titles and abstracts of each article were reviewed to ensure they met the inclusion criteria. Articles that met the initial review stage underwent a secondary review stage, during which the author reviewed the full text and excluded articles that did not meet the inclusion criteria.

2.4 Synthesis of Findings

Descriptive data were coded using Lean Library Workspace during the second review stage of the articles. Codes were used to identify overarching themes related to barriers and facilitators, as well as successful strategies for LCS. Themes were organized using the five domains from the CFIR: Individual Level, Inner Level, Outer Level, Innovation Level, and Implementation Level.[16] (Table 2) Using this framework to organize findings will help to identify key influences on implementation from the perspective of multiple stakeholders: LCS eligible patients, PCT, and health system levels.

3. Results

There were 986 unduplicated articles identified for the initial review and screening for eligibility. Upon completion of the initial review, 216 articles were identified for further

examination. Of these, 179 articles were removed during secondary review, leaving 31 articles that met the review guidelines. (Figure 1; Table 1).

3.1 Individual Level

CFIR defines the individual-level domain as the roles and characteristics of individuals involved in implementing, delivering, and/or receiving an innovation.[13,14] In this review, individual-level findings focused on the characteristics, perceptions, and decision-making process among high-risk eligible patients for LCS. The two constructs identified as most salient in this domain were: racial disparities in LCS eligibility and uptake, and sociodemographic, psychological, and behavioral factors. Gender differences were also identified as a theme, with women less likely to meet LCS screening eligibility criteria. Strategies addressing these disparities, including approaches relevant to dual-eligible populations, are discussed in section

3.1.1 Racial Disparities

All reviewed articles identified racial and ethnic disparities in LCS, with several noting that these disparities may persist or become more visible following the implementation of the updated guidelines. Although the revised guidelines expanded screening eligibility, persistent inequities in LCS uptake remained evident, particularly among Black, Hispanic, American Indian, and Alaska Native (AI & AN) populations.[17,18] Under the new guidelines, Black individuals, particularly men, who experience disproportionately higher LCS incidence and mortality in the US, were more likely to become newly eligible for screening. However, despite expanded eligibility, they remained less likely to undergo LCS when recommended.[17,19] Similarly, Hispanic men continue to demonstrate low screening rates. One study emphasized the importance of disaggregating Hispanic subgroups, noting Cuban and Puerto Rican men have

nearly twice the lung cancer incidence and mortality rates compared to Mexican men, attributed to the cultural practice of smoking cigars.[20]

American Indian and Alaska Native (AI & AN) communities also experience poor cancer outcomes driven by a complex interplay of socio-economic, environmental, and structural factors.[19,21,22] Across multiple studies, mistrust of the healthcare and scientific systems was identified as a barrier, rooted in a long history and ongoing systematic oppression.[23,24,25,26] In a qualitative study (n =34), historical and contemporary racism were cited as significant contributors to systemic mistrust, which led to hesitancy toward engaging in medical procedures such as LCS or lung cancer treatment.[25] One study involving interviews with Black Veterans (n = 10) reported that participants perceived experiences of racism during their clinical encounters, including being accused of misusing medication, having their pain tolerance not being taken seriously, and feeling treated like a "test tube."[27] These negative experiences contributed to feelings of dismissal and frustration, ultimately discouraging future participation in screenings or treatment.[27] One recommendation to rebuild trust and improve engagement is to incorporate principles of community-based participatory research (CBPR), which emphasizes collaboration with the community in the design and implementation of interventions.[23] For example, one study described how tribal communities often consult tribal leaders and partner with Elder programs when developing LCS health initiatives.[23] Overall, the reviewed literature focused on identifying strategies to increase LCS uptake among racial and ethnic minorities, including the development and evaluation of culturally tailored interventions.

3.1.2 Sociodemographic, Psychological, and Behavioral Factors

At the individual level, barriers and facilitators influencing LCS recommendations and participation included sociodemographic, psychological, and behavioral factors.

Sociodemographic factors referred to the social and demographic characteristics of eligible patients and healthcare providers. At the patient level, commonly reported sociodemographic barriers included level of education[10,28], language[29], transportation [24,25,29] and cost.[20,23,29,30,31] Providers also reported that patients frequently raised these factors as barriers during clinical encounters.[32,33] Sociodemographic facilitators at the patient level included expanded eligibility criteria (e.g., age criteria) and family support – particularly when patients consulted them about screening decisions.

Psychological factors refer to the eligible patient's or providers' perception of LCS, based on their knowledge, attitudes, and beliefs. At a patient level, these factors included fear of limited or inaccurate knowledge about LCS, and misconceptions about the screening process.[20,21,24, 25,29,31,32,33] Stigma [24,29,33,34,35] particularly related to smoking and fear of receiving a positive diagnosis were also frequently cited as barriers.[20,25,29,32,34,36] For instance, a patient survey (n = 54) found that 58% of the respondents reported lacking knowledge about LCS eligibility.[31] Another phone survey indicated that patients who did not complete LCS were less likely to have a family history of lung cancer.[37] Conversely, a study found that individuals with prior challenging personal or familial health experiences, including cancer diagnosis or deaths, were more receptive to LCS.[34] Despite having limited awareness of LCS, a salient facilitator at this level was patients' knowledge of risk factors, including environmental factors.[19, 21,22, 24,29,33,34,35] Additionally, at this level, providers discussed the complexities of determining patient eligibility as a barrier to recommending a patient.[36,38,39, 40,41] One study recommended improving educational tools for providers and enhancing electronic health record (EHR) systems with automated prompts based on updated smoking history to facilitate assessment.[39]

Lastly, behavioral barriers referred to the actions and habits of eligible individuals or providers that influenced decisions regarding LCS. Patient-level behavioral barriers included their smoking history [24,29,33,34,35] and competing priorities such as chronic illness or life stressors[29]. Despite these barriers, patients consistently identified PCT recommendations as the most influential factor in their decision to undergo LCS.[20,23,25,29,42,43] However, PCTs reported that time constraints during visits often prevented them from assessing LCS eligibility - especially when patients presented with multiple urgent health concerns.[36,38,41,44]

3.2 Inner Level

CFIR defined the inner level domain as the setting in which the innovation is implemented.[13,14] In this review, inner-level findings focused on how internal structures, workflows, resources, and strategies within the healthcare systems shape the delivery of LCS. Two prominent themes emerged at this level. The first focused on the LCS continuum, spanning from eligibility identification through follow-up. The second centered on resource allocations, including the availability and allocation of organizational resources supporting LCS implementation.

3.2.1 LCS Continuum

The LCS continuum encompassed several key stages, including patient eligibility verification, shared decision making (SDM), LCS, and follow-up, specifically annual screening. The main barrier in the LCS continuum included identifying eligible patients using guideline criteria. A central challenge at this stage included inaccurate smoking histories documented in the patient's EHR.[30,43] To improve the identification of eligible patients, two strategies have been highlighted in the literature: provider-facing reminders and in-reach strategies. Provider-facing reminder strategies included tools that served as cues to action, prompting healthcare providers

to verify patients' eligibility. Integrating these reminders into the EHR has been proposed as a promising solution. However, multiple studies have raised concerns about alert fatigue among PCTs, which could affect the intervention's effectiveness.[24,39,45]

In-reach strategies involved leveraging healthcare team members, including nurses, to identify eligible individuals and connect them with evidence-based care.[44] This approach is particularly valuable as patients have reported a preference for engaging in LCS discussions with trusted members of the healthcare team. Recent updates to the guidelines have allowed non-physician health professionals to conduct shared decision-making (SDM) conversations with patients, encouraging the implementation of team-based care models. One potential approach is the nurse-driven model, which has been shown to increase LCS participation.[44] In one pilot study (n = 237), a nurse-led, patient-centered population health intervention included scheduled telehealth visits focused on LCS. In this study, population health nurses performed a pre-visit chart review and evaluated LCS opportunities among patients with overdue cancer screenings.[44] At the pre-visit chart review stage, 44.7% (n= 106) of the individuals were identified as LCS eligible after undergoing smoking-related assessments with the nurse, and 58.7% completed their screening.[44]

The Centers for Medicare and Medicaid Services requires shared decision-making (SDM) using a decision aid before referring an eligible patient for screening.[1] Telehealth has emerged as a useful strategy for conducting (SDM) appointments, particularly given the time constraints reported by healthcare providers.[38,34] Studies have shown that effective SDM discussions can significantly increase LCS uptake.[32] In one post-implementation qualitative survey, 100% of participants rated their SDM experience as “very helpful”, and 67% reported “very likely” to seek LCS in the future.[46] Tailoring SDM conversations to meet the needs of a given community

was also recommended.[25] For example, one study suggested incorporating discussions about community cultures and patient concerns about how their ancestors, families, and friends have historically been treated by the health system to build and improve trust.[25]

Patient nonadherence to annual LCS emerged as a barrier in the LCS continuum. One clinical trial found that only 26% of patients attended the first LCS appointment, but this increased to 43% among those with a prior screening.[47] Another study reported that even when LCS programs were available and accessible, more than a third of patients who were referred did not undergo screening.[48]

Multiple studies have noted that having patients schedule their own appointments contributes to the complexities of LCS adherence.[38] Scheduling follow-up appointments for patients in advance has been proposed as a strategy to improve adherence to annual LCS screening. One study reported that 24% of participants with a follow-up appointment received LCS. Another recommended strategy was to "pulling" patients into follow-up care by automatically submitting an LCS request on their behalf, rather than "pushing" them to schedule their own appointments.[28] These strategies demonstrate the importance of investing in developing strategies that promote both initial and annual screenings.

3.2.2 Resource Allocations

Understanding the availability and distribution of LCS resources, including financial, technological, and human resources to support LCS implementation, emerged as a salient theme in the literature. Given the number of healthcare staff required to support the LCS continuum, multiple studies emphasized the need to balance resource allocation and cost management. Therefore, institutional support from hospital and site administrators is essential to the success and sustainability of LCS programs.[23,30,40,43] Human resources included individuals who provide

support at any stage of the LCS continuum included but not limited to referring healthcare providers, support staff, personnel for patient scheduling, trained technologist, radiologist, oncologist, etc. This consideration is particularly important for Federally Qualified Health Clinics (FQHCs), which serve medically underserved populations and often operate with more limited resources compared to larger health systems.[42] One recommendation included providing funding for healthcare providers and staff, which in turn would reduce health inequalities and increase patient access and engagement.[42] This would include investing in the expansion of the existing healthcare SafetyNet and healthcare staff training. For example, peer or lay navigators were found to be both cost-effective and well-received by eligible patients.[43] Similarly, one study found that investing in community health workers (CHWs) and patient navigators increased screening participation.[42,35] CHWs were particularly effective in supporting historically marginalized groups to participate in the LCS continuum, demonstrating both economic and cultural value.[40] Additional investment in PCT education targeting high-risk patients about LCS has also been recommended.[42] However, limited funding can result in limited staff capacity and training opportunities.[49] Limited funding may impact the implementation and sustainability of LCS programs.[23,33]

Other infrastructure investments to improve LCS rates included technological resources – particularly low-dose computed tomography (LDCT) scanners and EHR integration. A limited number of LDCT scanners may hinder LCS's ability to meet demand, especially if many patients are identified at once. This challenge is particularly concerning in areas with cancer center deserts. The literature defines cancer center deserts as geographic areas with limited or no access to comprehensive cancer centers or LCS facilities.[23] Rural areas often experience having cancer center deserts, especially in areas where American Indian and Alaskan Natives (AI/AN) reside.

One study demonstrated that rurality is positively associated with longer distances as well as a decreased likelihood of having a cancer screening center within 200 miles.[50] In many Indian Health Service facilities without access to LDCT scanners, patients were referred outside their healthcare system and often required approval for reimbursement, creating additional barriers.[23]

Effective implementation also relied on optimizing EHR systems, particularly for eligibility verification, referral tracking, and care coordination. Several studies emphasized the need for health systems to invest time and resources in improving the technological infrastructures.[33] Barriers to implementing an LCS program frequently include insufficient resources to effectively navigate and manage the LCS continuum of care.[52] Before commencing a LCS program, studies recommend conducting an assessment of organizational readiness to employ LCS practices in conjunction with their tobacco control programs, given that limited funding could impact the overall LCS program and sustainability.[52]

3.3 Outer Level

CFIR defined the outer level domain as the setting in which the inner setting exists.[13,14] In this review, outer-level findings captured external influences beyond the health system that affected access to and uptake of LCS, as well as strategies shown to address barriers at this level. Additionally, at this level, articles discussed recommended strategies for effectively engaging LCS-eligible populations that are traditionally hard to reach. The two constructs identified as most salient in this domain were collaborations and website information.

3.3.1 Collaborations

Collaborations among healthcare systems, community-based organizations (CBOs), and academic institutions were recommended to increase access to LCS and education. One major benefit of this approach is that organizations outside healthcare systems provide specialized

services to eligible individuals. Therefore, these collaborations can support the initial identification of eligible patients who have a history of smoking or chronic diseases.[21,52] One study by the American Cancer Society discussed the importance of providing educational information about local LCS centers in spaces outside health systems where eligible individuals access services.[10]

An untapped group of potentially eligible LCS individuals are those who utilize Tobacco Quitline's. A randomized controlled trial comparing two methods of providing LCS educational material (Print = 152, Web = 146) found that providing educational tools during Quitline calls increased LCS rates among eligible individuals.[7] Another study, which conducted a pre-post survey (n= 38), found that individuals who accessed the tobacco Quitline were receptive to smoking cessation and to receive educational information about LCS.[53] Given that Quitline recommendations are often referred to patients by their PCT during a routine visit (where they often do not have time to also assess LCS eligibility), this collaboration could help to address that barrier in making the linkage.[45] One potential challenge discussed in implementing a joint screening-cessation program included further exacerbating LCS disparities due to barriers to smoking cessation.[24,49]

Partnering community organizations that provide services to individuals with substance use disorders and chronic illnesses were recommended given that they are trusted members and experts to those patients given experiences.[25] Organizations included Local Mental Health Authorities (LMHA), Alcoholics Anonymous (AA), Narcotics Anonymous (NA), Non-nicotine substance use disorders (SUDs), and people with human immunodeficiency viruses (HIV).[52,54] One study discussed how it is important to partner with organizations that serve patients with

substance use disorders, given that they are more likely to smoke, making them at a higher risk for lung cancer.[52]

Another group that is at high-risk of substance abuse and at a higher risk for lung cancer compared to the general population are individuals with HIV.[54] In a survey with 11 providers, major barriers to discussing LCS with this population included prioritizing addressing their high levels of medical comorbidities and competing issues such as substance abuse, mental health, and economic stability.[38] One challenge when working with this population is that current USPSTF guidelines do not provide specific guidance on LCS for patients with comorbidities, other than to stop screening if they develop a health issue that substantially limits an individual's life expectancy or ability to receive surgical treatment.[42]

3.3.2 Website Information

Health system dissemination of information about lung cancer and patients' access to that information through organizational websites were reported as factors influencing LCS. While the role of websites is not to provide all information required during an SDM appointment, they are meant to provide the necessary information to advise an eligible individual on eligibility and the steps to obtain a screening, which could be discussed during their SDM.[33] Two of the studies reviewed assessed the accuracy of LCS eligibility information based on 2021 USPSTF guidelines in health system websites, and found a lag in updated guideline dissemination. The first study was a cross-sectional study (n = 151) aimed to assess the eligibility criteria and information available on LCS program websites for both health professionals and eligible patients using website data pulled in March 2021.[33] One hundred fifty-one of the websites included information on LCS eligibility, and only 14.5% had updated information about age to meet the updated USPSTF guidelines, and no websites had updated information regarding

smoking history.[33] This study also found that 15.2% of websites featured an online assessment tool for users to determine eligibility, and 30.5% of the websites used multimedia (e.g. short videos and podcasts) to present LCS information. Having interactive ways in which eligible individuals can engage with LCS information (including using patient portals) was important for in-patient engagement and self-efficacy [32] The second study was also a cross-sectional review of US websites providing LCS recommendations one year after the 2021 USPSTF guidelines (n = 99) and found that 17-32% of websites providing information on LCS guidelines had not been updated.[55] Both studies demonstrate a need for health systems to have routine monitoring of their websites to eliminate outdated information regarding LCS eligibility.[33,55] While investing time and resources in updating website information is important, given that studies have shown that patients turn to the internet for information and resources about LCS, there are still concerns about digital literacy and internet access, particularly in rural areas.[24, 34, 35]

3.4 Innovations

CFIR defines the innovation domain as the "thing being implemented".[13,14] In this review, innovation-level findings captured newly developed or adapted approaches aligned with the 2021 USPSTF guidelines, designed to increase LCS uptake, particularly those not widely implemented under the prior guidelines. The most salient construct within this domain included dual-eligible patients and medical transportation programs.

3.4.1 Dual Eligible Patients

Throughout these studies, the concept of "teachable moments," which leveraged successful health innovation to increase LCS, was used to employ novel interventions.[28,31] This included studies with dual-eligible individuals. Innovations to address transportation barriers were also employed.

Given that the updated USPSTF guidelines have led to an increase in newly eligible females compared with originally eligible females (50.1% vs. 44.1%), there is a need for gender-targeted outreach and communication.[19, 56] One newly explored innovation considering dual-eligible patients used electronic health records of women undergoing mammography screening to identify potentially eligible patients for LCS.[31] A one-year (2022-2023) prospective study which assessed patient perceptions, knowledge, and attitudes about lung cancer and LCS before engaging in dual screening, as well as evaluating the feasibility and acceptability of program implementation.[31] Survey results (n = 54) from this study found that 87% of the patients expressed interest in combined breast and lung screening, and 84% were likely or very likely to undergo dual screening again.[31] In addition, another study discussed that given that women are more likely to attend their annual screenings more regularly, they may be counseled for screenings more frequently and may have an increased comfort level with screening.[19]

Another group of dual-eligible patients to consider is patients who access care through the emergency department (ED), given that they are at a higher risk of LCS than the general population.[28,57] ED patients are also less likely to be recommended if eligible, as they may lack a healthcare provider or be underinsured.[28,57] For these reasons, one study decided to conduct a randomized controlled trial (n = 303) aimed at determining feasibility and providing estimates for ED-based interventions to increase LCS. This was done by randomizing patients into one of two interventions: 1) basic referral for LCS and 2) basic referral plus text messaging among LCS-eligible patients meeting the USPSTF 2021 guidelines.[28] Study results found that 24% of participants with follow-up data received LCS. Additionally, the intervention significantly improved normative perceptions of LCS among participants ($p = 0.015$).[28] This study also found

that ED Directors would support this type of intervention as long as it does not negatively impact patients or providers.[28]

3.4.3 Medical Transportation Programs

Transportation was a commonly reported barrier to accessing LCS among eligible patients, particularly those with low socioeconomic status and those living in rural areas.[24,28] Given the success of mobile mammography, one study explored this model by using a mobile unit dedicated to LCS. In September 2021, a West Virginia LCS mobile unit provided screenings in 37 of 42 counties without immediate access.[58] Between September 2021 and July 2022, 725 LCS were completed across 74 screening site visits.[58] Of these screenings, 13.8% were clinically significant and required follow-up from LDCT, in which six of them ended up being diagnosed as lung cancer.[58] One challenge reported to consider when employing mobile units discussed in the literature included taking into consideration proximity to a specialist for treatment in the event of a positive result.[59] A participant from a focus group discussed how they overcame this barrier for American Indian and Alaska Native Communities in Washington State through their tribal clinic or "Elder programs".[23] Participants in this focus group noted that their tribal clinic had invested in vehicles and drivers to transport their patients to screening appointments or specialists, which was especially important in the event that a specialist was located outside the state.[59]

3.5 Implementation

CFIR defines the implementation domain as the activities and strategies used to implement the innovation. In this review, implementation-level findings captured strategies for developing and disseminating educational materials to increase LCS uptake. The two constructs identified as most salient in this domain were educational materials content and content delivery.

3.5.1 Educational Materials Content

LCS educational content included the importance of incorporating culturally tailored, health literacy level, and relevance to target populations. Eligible patients reported wanting educational materials.[27,29,32,60] While many of the studies discussed the need to develop educational materials to increase LCS knowledge for eligible patients, one focus group (n = 23) found that eligible patients wanted information in order to gain empowerment in their decision-making.[34] Part of the empowerment process included debunking misconceptions, including beliefs that lung cancer is contagious or caused by worry or emotional distress.[29] Patients and providers in various studies also discussed the importance of incorporating scientific evidence into educational materials.[38] Implementing a balance between practical information in the educational materials and brevity was important for engaging eligible patients with the materials.[19,24] In addition, studies highlighted the importance of tailoring information to different groups, depending on their needs. Recommendations included making information available to address the following needs: literacy levels, multiple languages, geographical needs, culturally sensitive messaging, chronic illnesses, and ableism.[24,34,43, 54]

3.5.2 Decision Aids

The most important educational material discussed in the literature was the use of LCS decision aids. An LCS decision aid (DA) is an educational tool that provides evidence on the risks and benefits of LCS and the screening process to help eligible patients make a well-informed decision.[34,54] These tools were shown to be presented in various modalities such as videos, brochures, and interactive platforms, and could be used to facilitate conversations between healthcare providers and eligible patients.[33] One study discussed the importance of being thoughtful in the DA design as it can impact utilization of both healthcare providers and

eligible patients.[54] This included having personalized messaging as well as taking into account preferences in communication channels.[34] New approaches have included incorporating online DAs into the healthcare system, as this has been shown to empower eligible patients to engage in conversations with primary care physicians prior to their visits.[33] In addition to increasing LCS knowledge and encouraging conversations with healthcare providers, using a digital format to disseminate information can help to provide timely education and may be an instrumental strategy to improving early detection.[33,34] Using DAs has been shown to standardize healthcare provider-patient discussions about LCS and lead to more patient-centered decisions, which have ultimately led to an increase in LCS uptake.[34, 36]

3.5.3 Content Delivery

Content delivery included the methods and avenues through which LCS educational material was being disseminated.[20,21,34,40] This included ensuring comprehensive LCS information was accessible.[33] Avenues of dissemination included print, video, online platforms, and information delivered by various stakeholders, such as physicians, community health workers, and other PCTs. The literature highlighted the importance of delivering tailored LCS educational materials across multiple modalities rather than a single format. Although the information was delivered to patients in different ways, the information presented remained consistent.[24] One RCT comparing two methods (print versus web) of providing LCS materials (print n = 152, web n =146) reported that by four months, more participants (eligible patients) had read the print materials (75%) than used the web (61%) option.[7] Audience reach was not the only thing that improved; so was LCS uptake. The results in the Webster study also demonstrated that 42.8% (Print) and 43.8% (Web) of participants underwent SDM, scheduled an LCS appointment, or completed an LCS appointment.[7] Having a blend of print and web

information seemed to be important, given patients' comfort level with technology.[34] In one study, interviewing Asian American patients noted that while sharing information virtually can make it more accessible to some patients, not all patients are comfortable with accessing information online.[29] Other studies indicated the importance of also sharing hard-copy information, including at community events and fairs.[20,23] Recent approaches have explored the delivery of LCS virtual messaging within the clinical space.[24,32,34] A national survey (n = 6252) found that individuals who accessed online patient portals (OR, 4.25;95%, CI, 1.67, 10.81; P, .003) and those with a history of current (vs. Former) smoking (OR, 3.15; 95% CI, 1.21, 8.19; P,.019) were more likely to discuss LCS with their healthcare provider.[32] While implementing digital approaches has shown to be an asset, a limitation to consider when using this approach is the LCS eligible patients' comfort level in navigating and accessing the internet.[29]

4. Discussion

The studies reviewed in this literature review highlight the importance of understanding the multilevel factors at the patient, PCTM, and health system levels that influence LCS referral and uptake. We classified barriers and facilitators to these factors into five domains: individual, outer, inner, innovation, and implementation. Findings from this review help us to provide recommendations on how to improve LCS rates at a health system, PCT, and patient levels. (Table 3)

4.1 Health System Level Recommendations

Health system-level barriers identified in the literature underscore the need to prioritize structural reforms and cross-sector collaborations with LCS. This included the need for LCS to

become a Healthcare Effectiveness Data and Information Set (HEDIS) quality measure, to build partnerships with CBOs, and to maintain the website.

4.1.1 Healthcare Effectiveness Data and Information Set

While none of the studies reviewed included innovations that tested the impact of incorporating a HEDIS measure into LCS referrals, several highlighted the absence of such a measure as a significant barrier to provider referrals. This aligns with the American Cancer Society National Lung Cancer Roundtable (ACSNLCR) strategic plan, which identifies the lack of a population health metric for LCS as a key challenge and recommends developing a HEDIS measure to address this gap.[10] It is important to note that the recommended USPSTF cancer screenings meet grade A and B (breast, cervical, colorectal, and lung), and LCS is the only one that does not have a HEDIS measure. The inclusion of HEDIS metrics for other cancer screenings has been associated with improved quality care, increased screening rates, reduced disparities, financial incentives (e.g., higher reimbursement rates), and enhanced patient education and engagement.[61,62] Progress toward developing an LCS-specific HEDIS measure is underway. In 2022, the National Committee for Quality Assurance (NCQA) initiated development of a HEDIS measure for LCS.[63]Although this measure has not yet been approved, progress toward improving LCS has been made through the Tobacco Screening & Cessation Intervention HEDIS metric. This metric was approved as a new measure in June 2025 and is scheduled to commence measurement in 2026.[64] This measure is expected to indirectly support LCS efforts by improving the identification of screening-eligible individuals through standardized documentation of tobacco use in a patient's electronic medical record (EMR). Future research should explore the potential impact of the Tobacco Use Screening and Cessation Intervention measure on LCS uptake.

4.1.2 Collaborations with Community-Based Organizations

A promising strategy for identifying high-risk populations was fostering collaboration between health systems and Community Based Organizations (CBOs). CBOs often serve populations in need by offering a range of services that help fill gaps in traditional healthcare.[65] To date, discussions on the role of CBOs in LCS have largely focused on community health workers and their contributions to patient education.[66,67] This aligns with the ACSNLCR recommendation to partner with stakeholders, including CBOs, to educate the public about LCS in order to address the challenge of stigma and self-stigmatization among current and former smokers.[10] This review suggests that CBOs can play a broader role beyond education by helping to identify eligible, high-risk individuals from priority populations, such as those who access substance use disorders and chronic illnesses, given their expertise in working with these populations. Implementing this approach is particularly important for LCS, given that, unlike other cancer screenings, whose eligibility relies on age and sex, LCS also includes behavioral risk factors.[28] This review also discussed the importance of modifying educational materials to meet the needs of the population served by the CBOs. Future studies should examine partnerships between health systems and CBOs serving high-risk populations to provide further evidence of this approach's effectiveness in improving LCS access and participation.

4.3 Website Maintenance

This review found the need to ensure that health system websites sharing information about LCS are up to date with guidelines. Several studies have found that both patients and providers access online resources for cancer screening information. This was consistent with the findings of this review. Future studies should consider continuing to validate the information and tools on health system websites are accurate and gathering information from users to incorporate.

4.2 Provider Level Recommendations

Provider level barriers found in the review demonstrated the need to strengthen LCS delivery through training and tailored tools. This included the importance of incorporating provider trainings and leveraging PCTs other than primary care providers to verify eligibility and conduct SDM.

4.2.1 Primary Care Provider Barriers

Receiving an LCS referral by a primary care provider was identified as the primary facilitator for screening uptake, while the absence of recommendation served as a key barrier. However, primary care providers continue to face significant challenges including not having a well-defined LCS workflow, insufficient time during patient visits to assess for LCS eligibility and go through SDM during a visit due to the complexities of LCS eligibility verification and competing health priorities. Previous studies have also attributed these barriers to limited knowledge about LCS guidelines.[68,69] This is consistent with the ACSNLCR recommendation to incorporate clinical staff training to address PCT knowledge gaps in hopes of increasing referral volume.[10] Findings from this review suggest that in addition to guideline specific training, cultural competency training should be integrated to equip PCTs with the skills to conduct effective, trust building conversations with patients from diverse backgrounds. As the review noted, addressing racial and ethnic disparities in LCS requires not only improved communication but also confronting structural racism and reducing discomfort that some patients may feel when interacting with the healthcare system.

4.2.2 Patient Navigation

One recommendation identified in this review to reduce the burden on PCPs for eligibility verification and SDM is to share these responsibilities with non-physician PCTs. For

example, identifying eligible LCS patients was frequently cited in the literature as a challenge, often due to inaccurate or incomplete smoking histories in the EHR. This finding is consistent with other studies which have documented discrepancies, such as implausible changes in their record (e.g., going from "current smoker" to never smoker").[70] One strategy used to address this challenge was the deployment of patient navigators or other PCTs. This review found that one-on-one patient interactions to identify and verify eligible patients have shown promise compared with relying solely on patient EHRs. Patient navigation, in particular, has been demonstrated to be an effective intervention in helping to reduce cancer disparities and increase cancer screening rates.[71]

4.2.3 CMS SDM guidelines

Under the current CMS guidelines, qualified non-physician PCTs, such as physician assistants, nurse practitioners, or clinical nurse specialists, can conduct SDM with a patient and place a screening order. While this expansion has helped ease some of the logistical challenges associated with SDM, many CMS commenters suggested removing the requirement altogether to reduce administrative burden, which could create a barrier to screening.[72,73] Future studies should investigate how administrative requirements contribute to delays in LCS and explore workflow models that balance efficiency with patient-centered care.

4.3 Patient Level Recommendations

Patient-level barriers found in the literature demonstrated the need to reduce disparities through targeted outreach and tailored engagement strategies. Strategies at the patient level targeted hard-to-reach eligible LCS individuals and culturally tailored interventions that directly addressed knowledge gaps, structural barriers, and sociocultural influences.

4.3.1 Dual Eligible Patients

In an effort to target high-priority populations, some of the studies in this review conducted their outreach by identifying dual-eligible patients who meet LCS eligibility criteria. Dual eligible patients that were discussed in the review were a part of the following three categories: 1. Behavioral and recovery support needs, 2. Patients with Human Immunodeficiency Virus (HIV) 3. Acute care, and 4. Preventive and population health services. (Table 4)

4.3.1.1 Behavioral and Recovery Support Needs

This review found that individuals with behavioral and recovery support needs, such as those who access mental health services, Alcoholics Anonymous (AA), Narcotics Anonymous (NA), and substance use disorder (SUD), often meet LCS eligibility. Current studies under behavioral and recovery support predominantly focused on individuals who qualify for or access smoking cessation programs, given how closely linked they are to one another. In part, this is due to the National Cancer Institute's Smoking Cessation at Lung Examination (SCALE) Collaboration, which has focused on studying treatment methods to determine best practices for tobacco use in high-risk populations.[74] Findings from these studies have helped demonstrate that this linkage can serve as a catalyst for behavioral change, maximizing the reduction in lung cancer mortality.[75–77] Within these populations, this review found that partnerships with Quitlines to provide educational resources have been effective in increasing LCS participation. Given the promise shown by linking LCS with tobacco cessation initiatives, future research should continue to explore similar strategies for other high-risk behavioral groups with strong associations to smoking, such as heavy drinking (strongly related to smoking) and the use of narcotics (higher rates of smoking compared to the general population).[10,52,78,79]

4.3.1.2 Acute Care

An untapped population of dual-eligible individuals explored in one of the studies in the review was those who accessed the ED. Individuals who are overrepresented in the ED include non-white, Hispanic ethnicity, lower education levels, and underinsured – making it an ideal location to address LCS disparities.[28,83–86] Findings from this study indicated that ED-based intervention improved normative perceptions of LCS, and participants who received educational text messages showed increased LCS uptake. Other studies have indicated that the long wait times of ED visits could be leveraged to provide information about LCS.[87] Future studies should explore ways in which to incorporate LCS-eligible, SDM, and educational materials during wait times, and ways in which to address barriers to appointment coordination while not impacting current ED workflows.

4.3.1.3 Preventive and Population Health Services

Preventive and population health services patients in the review consisted of LCS-eligible breast and lung cancer screening patients. Given the increase in the number of newly eligible females due to the expansion of LCS guidelines, one innovation highlighted in the review was the use of electronic health records from females undergoing mammography to identify potentially eligible patients. In 2023, the CDC reported 79.8% of women aged 50-74 had a mammography within the past two years. The use of mammography vans has helped to increase the number of breast cancer screenings and remove barriers to reach priority populations. Previous studies have also demonstrated that the use of mobile screening units provides significant benefits, particularly by increasing access, potentially reducing costs in areas with cancer center deserts, and serving as a valuable data-collection hub for insights into cancer screening patterns and needs within priority populations.[88–90] However, limitations of mobile

cancer screening units include lower adherence to follow-up recommendations for abnormal or inconclusive results, and susceptibility to equipment breakdowns and technical issues (e.g., due to weather conditions).[91–93] One study in the review surveyed patients' interest in combined breast and lung cancer screening, indicating that they were very likely or likely to undergo dual screening again, which is a prime example of how leveraging strategies could help increase screening rates. Future studies should continue to partner with other successful screening types and assess uptake and or implement successful strategies from those screenings.

4.3.2 Culturally tailored interventions

Despite the expansion of guidelines for individuals who meet LCS eligibility criteria and insurance coverage requirements, adoption of LCS has remained slow.[48] One strategy suggested to address this issue is to incorporate culturally tailored interventions. Culturally tailored interventions discussed in this review considered language, literacy levels, geographic location, and other health conditions, while still incorporating scientific evidence when developing educational materials or tailored interventions for patients. This aligns with the American Association for Cancer Research recommendation, which also suggests culturally tailored materials and interventions, as they have been shown to reduce disparities and increase screening rates.[71] An additional benefit of incorporating culturally tailored educational materials and interventions for patients, as discussed in this review, is that it empowered them to discuss LCS and make decisions for themselves, an essential attribute when deciding whether to get screened. Future studies should incorporate principles of CBPR when developing their educational materials and designing interventions with patients. By involving patients, there is a greater likelihood of patient reception and adoption.

4.4 Strengths and Limitations of the Study

To the best of my knowledge, this literature review is among the first to comprehensively examine successful strategies at the patient, PCT, and health system levels using the USPSTF 2021 guidelines. The author assessed studies conducted using quantitative and qualitative methodologies, which offered a comprehensive understanding of the barriers and facilitators to LCS referral and or uptake. However, this review had several limitations: (1) I did not review the grey literature (information produced outside of publications), (2) political and economic system-level papers were not included, and (3) the review was conducted by one individual. To address this limitation, a list of inclusion and exclusion criteria (reviewed by the university librarian) was used for both the initial and secondary reviews. During the secondary review, a list of exclusion rationales was created to track the reasons for excluding articles.

5. Conclusion

This review identified the barriers and facilitators to LCS uptake at the patient, healthcare provider, and health system levels after the implementation of the updated 2021 USPSTF guidelines for LCS. Additionally, this review identified successful strategies that meet the updated guidelines and have led to an increase in LCS uptake. Based on CFIR, the author was able to identify key influences at five domains- individual, inner, outer, innovation, and implementation, which suggested the need for a combination of population-based education and targeted interventions to ensure the completion of LCS. Findings from the current literature can inform future implementation strategies for LCS pilots and trials, as well as future LCS programs, ultimately helping to improve LCS uptake, equity, and early detection of lung cancer.

References

1. Krist AH, Davidson KW, Mangione CM, et al. Screening for lung cancer: US preventive services task force recommendation statement. JAMA. 2021;325(10):962-970. doi:10.1001/jama.2021.1117

2. Richman IB, Prasad TV, Gross CP. Lost to follow up?: A qualitative study of why some patients do not pursue lung cancer screening. Prev Med Rep. 2022;29:101909. doi:10.1016/j.pmedr.2022.101909

3. Landy R, Young CD, Skarzynski M, et al. Using prediction models to reduce persistent racial and ethnic disparities in the draft 2020 USPSTF lung cancer screening guidelines. J Natl Cancer Inst. 2021;113(11):1590-1594. doi:10.1093/jnci/djaa211

4. Henderson LM, Su I-H, Rivera MP, et al. Prevalence of lung cancer screening in the US, 2022. JAMA Netw Open. 2024;7(3):e243190. doi:10.1001/jamanetworkopen.2024.3190

5. Narayan AK, Chowdhry DN, Fintelmann FJ, Little BP, Shepard J-AO, Flores EJ. Racial and ethnic disparities in lung cancer screening eligibility. Radiology. 2021;301(3):712-720. doi:10.1148/radiol.2021204691

6. Meza R, Jeon J, Toumazis I, et al. Evaluation of the Benefits and Harms of Lung Cancer Screening With Low-Dose Computed Tomography: A Collaborative Modeling Study for the U.S. Preventive Services Task Force. Agency for Healthcare Research and Quality (US); 2021.

7. Webster M, Whealan J, Williams RM, et al. The tobacco quitline setting as a teachable moment: The Educating Quitline Users About Lung (EQUAL) cancer screening randomized trial. Transl Behav Med. 2023;13(10):736-747. doi:10.1093/tbm/ibad049

8. Reduce the lung cancer death rate — C-02 - Healthy People 2030 | odphp.health.gov. Accessed March 26, 2025. https://odphp.health.gov/healthypeople/objectives-and-data/browse-objectives/cancer/reduce-lung-cancer-death-rate-c-02

9. Cancer Disparities - NCI. Accessed March 26, 2025. https://www.cancer.gov/about-cancer/understanding/disparities

10. Fathi JT, Barry AM, Greenberg GM, et al. The American Cancer Society National Lung Cancer Roundtable strategic plan: Implementation of high-quality lung cancer screening. Cancer. 2024;130(23):3961-3972. doi:10.1002/cncr.34621

11. Lung Cancer Statistics | How Common is Lung Cancer? | American Cancer Society. Accessed April 25, 2024. https://www.cancer.org/cancer/types/lung-cancer/about/key-statistics.html

12. State of Lung Cancer | Key Findings | American Lung Association. Accessed April 25, 2024. https://www.lung.org/research/state-of-lung-cancer/key-findings

13. Gale RC, Wu J, Erhardt T, et al. Comparison of rapid vs in-depth qualitative analytic methods from a process evaluation of academic detailing in the Veterans Health Administration. Implement Sci. 2019;14(1):11. doi:10.1186/s13012-019-0853-y

14. Breimaier HE, Heckemann B, Halfens RJG, Lohrmann C. The Consolidated Framework for Implementation Research (CFIR): a useful theoretical framework for guiding and evaluating a guideline implementation process in a hospital-based nursing practice. BMC Nurs. 2015;14:43. doi:10.1186/s12912-015-0088-4

15. Sciwheel Website – Sciwheel. Accessed January 21, 2025. https://support.sciwheel.com/hc/en-gb/sections/16727187882909-Sciwheel-Website

16. Damschroder LJ, Reardon CM, Widerquist MAO, Lowery J. The updated Consolidated Framework for Implementation Research based on user feedback. Implement Sci. 2022;17(1):75. doi:10.1186/s13012-022-01245-0

17. Kathuria H, Wiener RS. Toward racial equity in lung cancer screening eligibility. J Clin Oncol. 2024;42(17):2001-2004. doi:10.1200/JCO.24.00351

18. Park JA, Pham D, Yalamanchili S, Twardus S, Suzuki K. Developing technologies and areas of interest in lung cancer screening adjuncts. J Thorac Dis. 2024;16(2):1552-1564. doi:10.21037/jtd-23-1326

19. Hutchings H, Aspiras O, Dawadi A, et al. Willingness for Lung Cancer Screening: Disparities Among Informed, Screening-Eligible Individuals. Annals of Thoracic Surgery Short Reports. 2024;2(2):161-165. doi:10.1016/j.atssr.2023.11.013

20. Alaniz-Cantú EI, Goodwin K, Smith L, et al. Understanding the perceived benefits, barriers, and cues to action for lung cancer screening among Latinos: A qualitative study. Front Oncol. 2024;14:1365739. doi:10.3389/fonc.2024.1365739

21. Gudina AT, Kamen C, Mattick LJ, et al. Knowledge and beliefs about lung cancer screening among Black individuals at high risk: a qualitative approach. Transl Lung Cancer Res. 2024;13(8):1877-1887. doi:10.21037/tlcr-24-269

22. Arrieta O, Arroyo-Hernández M, Soberanis-Piña PD, et al. Facing an un-met need in lung cancer screening: The never smokers. Crit Rev Oncol Hematol. 2024;202:104436. doi:10.1016/j.critrevonc.2024.104436

23. Welch AC, London SM, Wilshire CL, et al. Access to lung cancer screening among american indian and alaska native adults: A qualitative study. Chest. 2024;165(3):716-724. doi:10.1016/j.chest.2023.10.025

24. Boatman D, McCauley-Hixenbaugh L, Starkey A, Allen A, Kennedy-Rea S. A new communication approach to encourage lung cancer screening action in rural eligible populations. PEC Innovation. 2024;4:100298. doi:10.1016/j.pecinn.2024.100298

25. Richmond J, Fernandez JR, Bonnet K, et al. Patient lung cancer screening decisions and environmental and psychosocial factors. JAMA Netw Open. 2024;7(5):e2412880. doi:10.1001/jamanetworkopen.2024.12880

26. Lloyd SJ, Levy KA, Boyd AS, Fathi JT. Leveraging Patient Advocacy and Faith-Based Partnerships to Educate, Activate, and Prepare Black Communities to be Screened for Lung Cancer. Chest. December 5, 2024. doi:10.1016/j.chest.2024.11.030

27. Barker AM, Wiener RS, Crocker D, et al. "You Are the Key": A co-design project to reduce disparities in Black veterans' communication with healthcare providers. Patient Experience Journal. 2023;10(3):27-35. doi:10.35680/2372-0247.1816

28. Adler DH, Wood N, Fiscella K, et al. Increasing uptake of lung cancer screening among emergency department patients: A pilot study. J Emerg Med. 2024;67(2):e164-e176. doi:10.1016/j.jemermed.2024.03.034

29. Lei F, Chen W-T, Brecht M-L, Zhang Z-F, Lee E. Health beliefs toward lung cancer screening among Chinese American high-risk smokers: Interviews based on Health Belief Model. International Journal of Nursing Sciences. 2022;9(3):378-388. doi:10.1016/j.ijnss.2022.06.005

30. Núñez ER, Slatore CG, Tanner NT, et al. National survey of lung cancer screening practices in veterans health administration facilities. Am J Prev Med. 2023;65(5):901-905. doi:10.1016/j.amepre.2023.05.005

31. Yue T, Wong L-Y, Jani C, et al. Combined Breast and Lung Cancer Screening Among Dual-Eligible Women: A Descriptive Study. J Surg Res. June 10, 2024. doi:10.1016/j.jss.2024.05.024

32. Nourmohammadi N, Liang THP, Sadigh G. Patient-Provider Lung Cancer Screening Discussions: An Analysis of a National Survey. Clin Lung Cancer. 2024;25(4):e189-e195.e2. doi:10.1016/j.cllc.2024.02.008

33. Dodd RH, Zhang C, Sharman AR, Carlton J, Tang R, Rankin NM. Assessing Information Available for Health Professionals and Potential Participants on Lung Cancer Screening Program Websites: Cross-sectional Study. JMIR Cancer. 2022;8(3):e34264. doi:10.2196/34264

34. Tiase VL, Richards G, Taft T, et al. Patient Perspectives on a Patient-Facing Tool for Lung Cancer Screening. Health Expect. 2024;27(4):e14143. doi:10.1111/hex.14143

35. Tan NQP, Lowenstein LM, Douglas EE, et al. The TELEhealth Shared decision-making Coaching and Navigation in Primary carE (TELESCOPE) intervention: a study protocol for delivering shared decision-making for lung cancer screening by patient navigators. Res Sq. April 22, 2024. doi:10.21203/rs.3.rs-4254047/v1

36. Morgan O, Schnur JB, Diefenbach MA, Kale MS. Physician preferences for an electronic lung cancer screening decision aid. Am J Manag Care. 2024;30(6 Spec No.):SP445-SP451. doi:10.37765/ajmc.2024.89551

37. Wong L-Y, Choudhary S, Kapula N, et al. Barriers to completing low dose computed tomography scan for lung cancer screening. Clin Lung Cancer. 2024;25(5):424-430. doi:10.1016/j.cllc.2024.04.014

38. Triplette M, Brown MC, Snidarich M, et al. Lung Cancer Screening in People With HIV: A Mixed-Methods Study of Patient and Provider Perspectives. Am J Prev Med. 2023;65(4):608-617. doi:10.1016/j.amepre.2023.05.001

39. Quezada JJ, Avenido AR, Jia S, et al. Assessing Providers' knowledge about and barriers to lung cancer screening. Cancer Treatment and Research Communications. 2024;41:100850. doi:10.1016/j.ctarc.2024.100850

40. Núñez ER, Ito Fukunaga M, Stevens GA, et al. Review of interventions that improve uptake of lung cancer screening: A cataloging of strategies that have been shown to work (or not). Chest. 2024;166(3):632-648. doi:10.1016/j.chest.2024.04.019

41. Lowenstein M, Karliner L, Livaudais-Toman J, et al. Barriers and facilitators to lung cancer screening: A physician survey. Am J Health Promot. 2022;36(7):1208-1212. doi:10.1177/08901171221088849

42. Ezenwankwo E, Nguyen DT, Akpabio IU, Eberth JM. Expanding reach, enhancing capacity: embracing the role of primary care in lung cancer screening and smoking cessation in the United States. Lancet Reg Health Am. 2024;38:100870. doi:10.1016/j.lana.2024.100870

43. Chudgar NP, Stiles BM. Building a lung cancer screening program. Thorac Surg Clin. 2023;33(4):333-341. doi:10.1016/j.thorsurg.2023.04.008

44. Jansen E, Bolivar J, Auguste S, et al. Population health nurse–driven lung cancer screening. NEJM Catal. 2024;5(5). doi:10.1056/CAT.24.0002

45. Domalaon K, Valerio C. Family physician education and barriers to promoting smoking cessation: A multiservice investigation. Mil Med. September 24, 2024. doi:10.1093/milmed/usae429

46. Wong L-Y, Yue T, Aghagoli G, et al. Harnessing opportunity: pilot intervention to improve lung cancer screening for women undergoing breast screening mammography. JTO Clinical and Research Reports. 2024;5(6):100671. doi:10.1016/j.jtocrr.2024.100671

47. Luce C, Palazzo L, Anderson ML, et al. A pragmatic randomized clinical trial of multilevel interventions to improve adherence to lung cancer screening (The Larch Study): Study protocol. Contemp Clin Trials. 2024;140:107495. doi:10.1016/j.cct.2024.107495

48. Bade B, DeRycke E, Kunitomo Y, et al. "Lost to Follow-Up?" Barriers to Lung Cancer Screening Adherence in US Veterans. AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE. 203(9).

49. Salloum RG, Braithwaite D. Expansion of Guideline-Recommended Lung Cancer Screening Eligibility: Implications for Health Equity of Joint Screening and Cessation Interventions. J Thorac Oncol. 2022;17(1):13-15. doi:10.1016/j.jtho.2021.10.005

50. Peña MA, Sudarshan A, Muns CM, et al. Analysis of geographic accessibility of breast, lung, and colorectal cancer screening centers among american indian and alaskan native tribes. J Am Coll Radiol. 2023;20(7):642-651. doi:10.1016/j.jacr.2023.04.007

51. Pignone M, Chang P, Kluz N, et al. Achieving equitable lung cancer screening implementation in a texas safety net health system. Am J Prev Med. 2025;68(2):227-235. doi:10.1016/j.amepre.2024.09.016

52. Britton M, Chen TA, Martinez Leal I, et al. Lung Cancer Screening Eligibility and Referral Practices in Texas Organizations Serving People with Substance Use Disorders. Cancers (Basel). 2023;15(7). doi:10.3390/cancers15072073

53. Thomas AG, Chelala L, King AC, Chung JH. Impact on patient attitudes towards lung cancer screening and smoking cessation with radiology consultation: Pilot survey project. Curr Probl Diagn Radiol. 2024;53(3):377-383. doi:10.1067/j.cpradiol.2024.01.006

54. Brown MC, Snidarich M, Budak JZ, et al. Adaptation of a tailored lung cancer screening decision aid for people with HIV. CHEST Pulmonary. 2024;2(3). doi:10.1016/j.chpulm.2024.100044

55. Makurumidze G, Solomon G, Solomon N, Bayou Y, Dako F. Cross-sectional review of US websites providing lung cancer screening recommendations following the 2021 US Preventive Services Task Force updates. Clin Imaging. 2023;99:1-4. doi:10.1016/j.clinimag.2023.03.012

56. Yell N, Eberth JM, Alberg AJ, et al. Comparison of the characteristics of the population eligible for lung cancer screening under 2013 and population newly eligible under 2021 US Preventive Services Task Force recommendations. Cancer Causes Control. 2024;35(9):1233-1243. doi:10.1007/s10552-024-01880-6

57. Cairns C, Kang K. National Hospital Ambulatory Medical Care Survey: 2020 Emergency Department Summary Tables. Centers for Disease Control and Prevention; 2022. doi:10.15620/cdc:121911

58. Allen AR, Hazard-Jenkins HW, Boatman D, et al. Addressing Lung Cancer Health Disparities in West Virginia: An Academic-Industry Collaboration Model. J Health Care Poor Underserved. 2022;33(4S):173-179. doi:10.1353/hpu.2022.0165

59. Welch AC, Wilshire CL, Gilbert C, Gorden JA. Distance Between Indian Health Affiliated Clinics and Lung Cancer Screening Sites Suggest Structural Barriers in Access to Lung Cancer Screening in American Indian and Alaska Native Communities in Washington State. AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE. 203(9).

60. Martin JF, Kane GC, Shusted CS, Barta JA. Implementation of High-Quality Lung Cancer Screening: Impact of Centralized vs. Decentralized Processes. Popul Health Manag. 2024;27(4):291-293. doi:10.1089/pop.2023.0266

61. Simple Healthkit SA. HEDIS Measures 2025: How to Improve Healthcare Plan Performance . HEDIS Measures 2025: How to Improve Healthcare Plan Performance. February 28, 2025. Accessed December 3, 2025. https://www.simplehealthkit.com/2025/02/28/hedis-measures/#:~:text=The%20Healthcare%20Effectiveness%20Data%20and,employers%20prioritize%20high%2Dperforming%20plans

62. Tong, Hill, and Artiga MT Latoya Hill, and Samantha Artiga. Racial Disparities in Cancer Outcomes, Screening, and Treatment. KFF.org. February 3, 2022. Accessed December 3, 2025. https://www.kff.org/racial-equity-and-health-policy/racial-disparities-in-cancer-outcomes-screening-and-treatment/#:~:text=Research%20shows%20that%20the%20overall,and%20delays%20in%20diagnostic%20evaluation.

63. Smith RA. MEASURING LUNG CANCER SCREENING UPTAKE. Published online December 5, 2022. Accessed December 3, 2025. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nlcrt.org/wp-content/uploads/Smith-Measuring-Lung-Cancer-Screening-Uptake.pdf

64. Kolinski B. Tobacco Cessation HEDIS Measure Planned for MY 2026. NCQA. December 6, 2025. Accessed December 3, 2025. https://www.ncqa.org/blog/tobacco-cessation-hedis-measure-planned-for-my-2026/

65. CDC Foundation. Making a Difference Where It Matters Most. Making a Difference Where It Matters Most. Accessed December 5, 2025. https://www.cdcfoundation.org/community-based-organizations

66. Williams LB, Looney SW, Joshua T, McCall A, Tingen MS. Promoting Community Awareness of Lung Cancer Screening Among Disparate Populations: Results of the cancer-Community Awareness Access Research and Education Project. Cancer Nurs. 2021;44(2):89-97. doi:10.1097/NCC.0000000000000748

67. Conners A. Early Detection and Screening: The Magic of Community Health Workers. J Oncol Navig Surviv. 2020;11(10).

68. 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. 2018;11:93-99. doi:10.1016/j.pmedr.2018.05.013

69. Hoffman, Reuland, Volk R Daniel S, Robert. The CMS Requirement for Shared Decision Making for Lung Cancer Screening. JAMA. May 23, 2024.

70. Polubriaginof F, Salmasian H, Albert DA, Vawdrey DK. Challenges with Collecting Smoking Status in Electronic Health Records. AMIA Annu Symp Proc. 2017;2017:1392-1400.

71. American Association for Cancer Research. Disparities in Cancer Screening for Early Detection. Accessed December 5, 2025. https://cancerprogressreport.aacr.org/disparities/chd20-contents/chd20-disparities-in-cancer-screening-for-early-detection/

72. Hampton T. Medicare covers lung cancer screening for certain beneficiaries. JAMA. 2015;313(12):1199. doi:10.1001/jama.2015.1655

73. American Lung Association. Lung Cancer Screening Billing Guide .

74. Lang AE. Update on the national cancer institute's smoking cessation at lung examination collaboration trials. Chest. 2024;165(6):1302-1306. doi:10.1016/j.chest.2023.12.016

75. Taylor KL, Williams RM, Meza R, Smith P, Murray RL. Reducing lung cancer mortality by providing smoking cessation support in the lung cancer screening setting: missed opportunities and lessons learned on both sides of the atlantic. J Thorac Oncol. 2025;20(7):847-855. doi:10.1016/j.jtho.2025.03.030

76. Djuric O, Giorgi Rossi P, Ivanciu EC, et al. Motivation, acceptability and attitudes toward lung cancer screening among persons who attend a tobacco cessation program: A multicenter survey in Italy. Prev Med Rep. 2023;35:102272. doi:10.1016/j.pmedr.2023.102272

77. Deros DE, Hagerman CJ, Kramer JA, et al. Change in amount smoked and readiness to quit among patients undergoing lung cancer screening. J Thorac Dis. 2021;13(8):4947-4955. doi:10.21037/jtd-20-3267

78. Repp B, Jamieson P, Sun C, Takata Y. Alcoholism and risk of lung cancer in observational studies: A systematic review. Curr Dev Nutr. 2022;6:944. doi:10.1093/cdn/nzac067.064

79. Jenkins WD, Rose J, Molina Y, et al. Cancer Screening among Rural People Who Use Drugs: Colliding Risks and Barriers. Int J Environ Res Public Health. 2022;19(8). doi:10.3390/ijerph19084555

80. Russell S. Exploring why people with HIV have a higher lung cancer risk. Fred Hutch Cancer Center. Accessed December 5, 2025. https://www.fredhutch.org/en/news/center-news/2018/12/hiv-lung-cancer.html

81. Altekruse SF, Shiels MS, Modur SP, et al. Cancer burden attributable to cigarette smoking among HIV-infected people in North America. AIDS. 2018;32(4):513-521. doi:10.1097/QAD.0000000000001721

82. Sigel K, Pitts R, Crothers K. Lung malignancies in HIV infection. Semin Respir Crit Care Med. 2016;37(2):267-276. doi:10.1055/s-0036-1578803

83. CDC. Screening for Lung Cancer. October 15, 2024. Accessed December 5, 2025. https://www.cdc.gov/lung-cancer/screening/index.html

84. Brown ML, Klabunde CN, Cronin KA, White MC, Richardson LC, McNeel TS. Challenges in meeting Healthy People 2020 objectives for cancer-related preventive services, National Health Interview Survey, 2008 and 2010. Prev Chronic Dis. 2014;11:E29. doi:10.5888/pcd11.130174

85. Abar B, Dalawari P, Ogedegbe C, Santoro-Terray L, Adler D, Bradley K. Identifying cancer screening adherence in the emergency department utilizing research associates. J Emerg Med. 2020;59(6):894-899. doi:10.1016/j.jemermed.2020.07.013

86. Adler D, Abar B, Wood N, Bonham A. An intervention to increase uptake of cervical cancer screening among emergency department patients: results of a randomized pilot study. J Emerg Med. 2019;57(6):836-843. doi:10.1016/j.jemermed.2019.07.021

87. Adler, Abar, Chiao D Beau, Elizabeth Yu. Emergency department-based cancer screening interventions. Emergency Cancer Care. 2022;1(3).

88. De Mil R, Guillaume E, Launay L, et al. Cost-Effectiveness Analysis of a Mobile Mammography Unit for Breast Cancer Screening to Reduce Geographic and Social Health Inequalities. Value Health. 2019;22(10):1111-1118. doi:10.1016/j.jval.2019.06.001

89. Salmani H, Ahmadi M, Shahrokhi N. The impact of mobile health on cancer screening: A systematic review. Cancer Inform. 2020;19:1176935120954191. doi:10.1177/1176935120954191

90. Winn S. Mobile mammography clinic increases access to lifesaving breast cancer screening. March 31, 2025. Accessed December 5, 2025. https://health.ucdavis.edu/nursing/news/headlines/obile-mammography-clinic-increases-access-to-lifesaving-breast-cancer-screening-/2025/03#:~:text=The%20mobile%20clinic%20also%20serves,Shadi%20Shakeri%20(right)%20participated.

91. Stanley E, Lewis MC, Irshad A, et al. Effectiveness of a mobile mammography program. AJR Am J Roentgenol. 2017;209(6):1426-1429. doi:10.2214/AJR.16.17670

92. Trivedi U, Omofoye TS, Marquez C, Sullivan CR, Benson DM, Whitman GJ. Mobile mammography services and underserved women. Diagnostics (Basel). 2022;12(4). doi:10.3390/diagnostics12040902

93. Vang S, Margolies LR, Jandorf L. Mobile mammography participation among medically underserved women: A systematic review. Prev Chronic Dis. 2018;15:E140. doi:10.5888/pcd15.180291

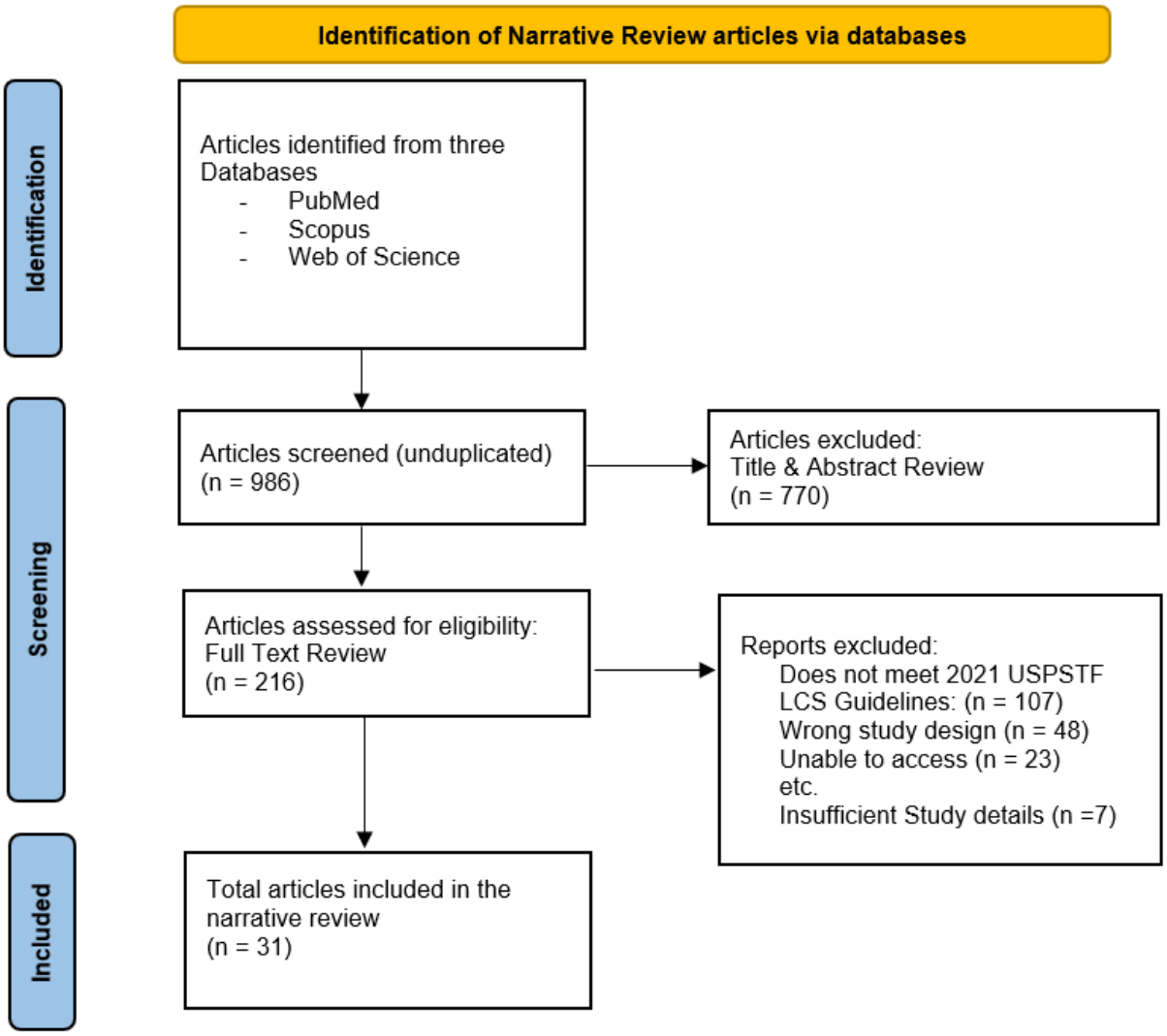
Appendices

Appendix A. Research Database Search Strategy

Database	Search Strategy
PubMed	(("lung cancer screen*"[tiab] OR ("Early Detection of Cancer"[MAJR] AND "Lung Neoplasms/diagnosis"[MAJR])) AND ("Health Services Accessibility"[Mesh] OR barrier*[tiab] OR access*[tiab] OR facilitator*[tiab] OR uptake[tiab] OR implement*[tiab]) AND English[lang]) AND (("2021/01/01"[Date - Publication] : "3000"[Date - Publication]))
Scopus	(TITLE-ABS-KEY ("lung cancer screen*") AND TITLE-ABS-KEY (barrier* OR access* OR facilitator* OR uptake OR implement*)) AND PUBYEAR > 2020 AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (DOCTYPE , "ar"))
Web of Science	(TI=("Lung Cancer" NEAR/3 Screen*) OR AB=("Lung Cancer" NEAR/3 Screen*)) AND (TI=(barrier* OR access* OR facilitator* OR uptake OR implement*) OR AB=(barrier* OR access* OR facilitator* OR uptake OR implement*)) AND PY=2021-2024 AND Article (Document Types) and English (Languages) and USA (Countries/Regions)

Figures

Figure 1. CONSORT diagram on the identification of literature review articles



Tables

Table 1. Literature Review Matrix

Author	Purpose	Study Period	Study Design
Alaniz-Cantú et al.	To understand the perceived benefits, barriers, and cues to action for lung cancer screening among Latinos.	2023	Qualitative Research
Allen et al	Partners from national, state, and community positions combine the services and science needed to develop a mobile lung cancer screening program.	2021	Quant - Report
Bandi et al.	To understand the prevalence of eligible US individuals being up to date with recommended lung cancer screening (LCS) in 2022?	2023-2024	Quantitative Research
Barker et al.	To describe a codesigned intervention to empower Black veterans to talk with providers, using SDM for LCS as an exemplar.	2020-2021	Qualitative Research
Boatman et al.	To develop an effective communication approach to encourage lung cancer screening action within rural screening-eligible populations.	2022-2023	Quantitative Research
Britton et al.	To examine the LCS eligibility and referral practices among organizations that serve individuals with non-nicotine substance use disorders.	2021	Qualitative Research
Brown et al.	To understand if SDM decision aid be adapted to include HIV-specific measures with input from both people with HIV and their providers?	2021-2022	Qualitative Research

Dodd et al.	To assess whether eligibility criteria for potential screening participants were up-to-date on these websites following the latest updates to the USPSTF recommendation.	2021	Quantitative Research
Domalaon et al.	This survey assessed the U.S. military Family Medicine physicians' training in smoking cessation resources during residency and practice, and identified barriers to screening to inform future recommendations for more consistent resource delivery within the military health care system.	2022	Qualitative Research
Gudina et al.	To explore the knowledge and beliefs of Black individuals at high risk regarding LCS.	2022	Quantitative Research
Gunn et al.	To examine the ongoing impact of COVID-19 on cancer screening we undertook The Dartmouth NH/VT Cancer Collaborative population-based two-state panel survey administered online in February/March 2022. We	2022	Quantitative Research
Hutchings et al.	To educate screening-eligible White and Black American women and men and to measure subsequent willingness to obtain screening.	2022-2023	Quantitative Research
Jasen et al.	Our goal was to leverage the expertise of RNs working at the top of their license to create a seamless, patient-centered intervention to increase LCS rates.	2022	Qualitative Research

Lei et al.	To explore health beliefs toward lung cancer screening with low dose CT among Chinese American high-risk smokers.	2021-2022	Qualitative Research
Makurumidze et al.	To investigate whether online websites have been updated to reflect the recent USPSTF guidelines that expanded the recommended age and smoking pack-years for LCS.	2022	Mixed-Methods
Matthews et al.	To examine knowledge and attitudes about lung health promotion (smoking cessation and lung cancer screening) among Black male smokers in a large Midwestern city in the United States	2021	Quantitative Research
Nourmohammadi et al.	To assess the prevalence of patient-provider discussion about LCS and determine its associated factors.	2022	Quantitative Research
Núñez et al.	To compare the utilization of these key components across centralized, hybrid, and decentralized LCS programs.	2021	Cross-Sectional
Peña et al.	To (1) evaluate the distances between AI/AN tribes and cancer screening centers and (2) assess whether persistent poverty and rurality are associated with reduced geographic access to cancer screening centers among AI/AN tribes.	2021	Quantitative Research
Quezada et al.	To assess knowledge about LCS and barriers to ordering LDCT from the viewpoint of primary care and pulmonology providers in academic and community settings.	2023	Quantitative Research

Rehman et al.	To better understand the system, provider, and patient-level barriers to LCS.	2023-2024	Qualitative Research
Richmond et al.	To understand if environmental, psychosocial, and modifying factors influence patient decisions to undergo screening for lung cancer.	2021-2022	Quantitative Research
Tan et al.	To evaluate the effectiveness of the intervention and its implementation potential, compared with an enhanced usual care arm.		Quantitative Research
Thomas et al.	To improve patient attitudes towards adherence to LCS and smoking cessation in a largely black community. We developed a novel patient-radiologist consultation for patients scheduled for LCS.	2022	Qualitative Research
Tiase et al.	To explore patient perspectives on the usefulness of the current provider-focused tool and to understand the information needs for a patient-facing version to facilitate LCS SDM.	2022-2023	Mixed-Methods
Triplette et al.	To understand the perspectives on LCS among people with HIV and their providers.	2021	Mixed-Methods
Webster et al.	To conduct a randomized trial to compare two methods of providing LCS education to Maryland Tobacco Quitline (MTQ) callers in order to assess whether this setting may serve as a teachable moment for LCS-eligible individuals.	2021-2022	Qualitative Research
Welch et al.	To understand how American Indian and Alaska Native adults perceive and use LCS.	2021	Mixed-Methods

Wong et al.	To assess the barriers to completing LDCT in a cohort of patients who were determined eligible for LCS.	2022	Mixed-Methods
Wong et al.	To combine patient self-referral with eligibility identification by providers as a two-pronged approach to increase rates of LCS among eligible women.	2022-2023	Quantitative Methods
Yues et al	To assess patient perceptions, knowledge, and attitudes about lung cancer and LCS before and after engaging in this initiative.	2022 - 2023	Mixed-Methods

Table 2. Domain Definitions

CFIR Domain	Definition	Constructs
Individual Level	Characteristics, perceptions, and decision-making process of high-risk-eligible patients for LCS, with a focus on personal, cultural, socioeconomic, and behavioral factors influencing their screening behaviors.	• Racial Disparities • Barriers & Facilitators to LCS
Inner Level	Organizational characteristics and internal processes influence how LCS was delivered within the health care settings.	• LCS Continuum • Resource Allocations
Outer Level	External influences that affect access to and uptake of LCS. Recommended strategies to effectively engage LCS eligible populations who are traditionally hard to reach.	• Collaborations • Website Information
Innovations	New or adapted interventions or approaches designed to increase LCS uptake.	• Dual Eligible Patients • Medical Transportation Programs
Implementation	Methods through which educational materials were successfully developed and disseminated to increase LCS uptake.	• Educational Materials Content • Decision Aids • Content Delivery

Table 3. Multi-level Recommendations to Improve Lung Cancer Screening Uptake

Health System Level	Primary Care Team Level	Patient Level
• Make LCS a HEDIS quality measure to drive PCT accountability • Partner with CBOs to enhance outreach and identification of high-risk individuals • Launch transportation support to improve access to screenings – particularly in cancer center deserts • Ensure website information and tools are up to date with USPSTF guidelines	• Train PCTs on LCS guidelines and how to address stigma and racial disparities • Allow PCTs other than primary care providers to conduct SDM • Integrate LCS prompts into routine care workflows • Have discussion aids and materials available for PCTs to go over and or share with patients.	• One-to-one patient verification on LCS eligibility • Develop culturally tailored educational materials and interventions • Address structural barriers • Provide targeted outreach to dual-eligible patients

Table 4. Dual Eligible Patients

Category	Health Topic/Groups
Behavioral & Recovery Support Needs	Mental Health, Alcoholics Anonymous, Narcotics Anonymous, Non-nicotine substance use
Chronic & Infectious Conditions	HIV
Acute Care	Emergency Department
Preventative & Population Health Services	Breast Cancer Screening, Smoking Quitlines

Chapter 2 | "Everybody knows that smoking causes lung cancer, but nobody really knows about lung cancer screening": A Rapid Qualitative Analysis of Patient and Primary Care Team Perspectives

Abstract

Background: Lung cancer screening (LCS) using low-dose computed tomography (LDCT), as well as abstinence from smoking, can reduce lung cancer mortality; however, screening is underutilized. The study aimed to identify patient and health system-centered factors that lead to participation in LCS. By interviewing LCS-eligible patients (both screened and unscreened) and primary care team members, we were able to better understand barriers, facilitators, and contextual factors for LCS. Findings informed the implementation of a comparative effectiveness intervention trial that included a patient decision aid and screening navigation.

Methods: Stakeholder interviews were conducted with University of California Davis Health (UCDH) patients (screened and unscreened) and primary care team members. The Consolidated Framework for Implementation Research (CFIR) guided both data collection and analysis. Interviews were audio-recorded, transcribed verbatim, and analyzed using a rapid direct content analysis approach. Summarized transcript data were organized into master templates, and findings were coded and mapped to the five CFIR domains: innovation, inner setting, outer setting, individuals, and implementation process.

Results: 35 stakeholder interviews with LCS-eligible patients who had not received LCS (n = 11), patients who had received LCS (n = 12), and primary care team members (n = 12). Across all participant groups, participants identified several opportunities to improve LCS uptake and

adherence. First, they emphasized the need for additional patient education to increase understanding of the risk and benefits of LCS and to clarify the screening process. Second, participants noted that educational materials should be disseminated through multiple communication channels rather than relying exclusively on electronic patient portals. Third, there was a strong preference for brief, personalized messages written in plain language and information. Lastly, participants underscored the importance of improving clinic workflows to streamline LCS referrals and promote adherence to recommended screening appointments.

Conclusions: Findings confirmed the need for patient educational materials and for incorporating a primary care team member to conduct individualized patient eligibility verification, provide patient decision aids, and support the facilitation of the LCS process. These findings were used to develop a MyChart web intervention, which was tested as one of two intervention arms in the trial.

1. Introduction

Lung cancer is the leading cause of cancer death in the United States (U.S.).[1] While abstaining from smoking is key to reducing lung cancer deaths, as tobacco use is the leading preventable cause, early detection is also crucial.[2] Advancements in technology have made it possible to detect lung cancer early using low-dose computed tomography (LDCT). Despite having a tool for early detection, only 16% of eligible patients receive a lung cancer screening (LCS) in the U.S.[3] Trials such as the National Lung Screening Trial (NLST) and the Nederland-leuvens Longkanker Screening Onderzoek (NELSON) provided the evidence needed for the United States Preventive Services Task Force (USPSTF) to recommend using LDCT screening as the primary method for LCS to reduce lung cancer mortality in high-risk populations in 2013.[4–6] Prior to LDCT for LCS, the Centers for Medicare and Medicaid Services requires a counseling and shared decision-making (SDM) visitas a condition of reimbursement.[7-10] This visit includes a discussion of the potential benefits and harms of LCS, the importance of adherence to annual screening, and smoking cessation counseling or support for maintaining smoking abstinence.[7-10] The updated 2021 USPSTF defines high-risk populations as individuals between the ages of 50 and 80 years who have a 20-pack-year smoking history and currently smoke or have quit within the past 15 years.[11] Limited awareness of LCS, concerns about out-of-pocket costs, access to screening facilities, stigma, and lack of provider recommendations have been shown to be some of the most common barriers to LCS.[12–16] Developing interventions to raise LCS awareness and encourage uptake among eligible patients is needed to address the existing low screening rates and increase early detection, especially in states like California, which rank amongst the lowest for LCS.[17] Additionally, developing targeted interventions for underrepresented racial/ethnic minorities that experience lung cancer disparities is important, as

certain populations experience a greater burden of lung cancer, including higher morbidity and mortality, compared with Non-Hispanic White populations.[18,19]

Understanding barriers at the patient, primary care team, and health system levels is necessary to improve referral, uptake, and participation rates. Using LCS decision aids that provide essential information about LCS and incorporating patient navigators to verify patient LCS eligibility have been shown to remove LCS barriers by increasing LCS awareness and alleviating provider burden.[20,21] One study demonstrating the importance of incorporating web-based interventions and patient navigators used Epic Healthy Planet, an EHR software, to create custom reports to determine "care gaps," including LCS, and incorporated nonphysician pre-visit planners to identify LCS eligible patients and initiate SDM, which helped to increase adherence by 212%.[21]

In addition to understanding barriers and facilitators through patient and primary care team perceptions, it is important to incorporate their feedback into current workflows to improve LCS rates. Studies have shown that incorporating feedback from populations of interest is essential to developing strategies that align with their preferences and enhance their likelihood of learning, which is essential in their SDM processes, and ultimately their screening behaviors.[22,23] Findings from this study were used to inform the implementation of a patient-facing web-based intervention at two ambulatory clinics (Rancho Cordova and Elk Grove) at University of California Davis Health (UCDH).

2. Methods

Interviews were conducted with three stakeholder groups at UCDH: eligible patients who received LCS, eligible patients who did not receive LCS, and primary care team members

(PCTMs), including physicians, medical assistants, and vocational nurses. Interviews were conducted between December 2022 to May 2023 by two members of the research team and were audio-recorded. Interviews lasted approximately 20 - 60 minutes and were conducted via Zoom or telephone. Verbal informed consent from each participant was obtained at the beginning of each interview. Upon completion of interviews, patients received a $25 VISA gift card, and PCTMs received a $40 VISA gift card, for their time. Data collection continued until thematic saturation was reached with no new themes emerging from subsequent interviews. This study was reviewed and approved by the University of California, Davis Institutional Review Board (IRB 1937769-1).

2.1 Inclusion & Exclusion Criteria

The inclusion criteria consisted of: (1) UCDH PCTMs who provide services to patients ages 50-80, and (2) UCDH patients who met LCS eligibility according to the USPSTF guidelines. The exclusion criteria consisted of: (1) patients who do not speak English or Spanish, (2) patients aged 49 and younger. (3) Non-UCDH PCTMs, and (4) patients not eligible for LCS.

2.2 Recruitment

Targeted recruitment strategies were implemented separately for PCTMs and patients. The study was advertised for both patients and PCTMs via StudyPages (a recruitment webpage used in UCDH clinical trials) and a press release (published in February 2023).

2.2.1 Primary Care Team Members

PCTM recruitment included: (1) UCDH directory; (2) Slicer Dicer, a data extraction tool in EPIC (UCDH electronic health record system), which was used to identify a list of the top 10

UCDH referring LCS primary care providers; (3) UCDH ambulatory clinic study presentation; (4) and snowball sampling. As part of the targeted recruitment strategy, invitation emails were sent to PCTMs, and those who responded were scheduled for interviews.

2.2.2 Patients

The targeted patient recruitment strategy involved using EPIC to compile a list of eligible patients from the UCDH Carmichael clinic. Purposeful sampling of racial minorities (African American or Black, American Indian or Alaska Native, Asian, Hispanic/Latino, and Native Hawaiian or Pacific Islander) was prioritized to gain insights into how to reduce disparities among these populations. Participants were identified based on race and ethnicity documented in the EHR. Participants were recruited over the phone and were scheduled for an interview at the time and location of their preference.

2.3 Rapid Qualitative Analysis

This study used rapid qualitative analysis (RQA), a systematic and team-based approach commonly used in implementation research to efficiently generate actionable findings while maintaining methodological rigor. Unlike traditional qualitative analysis, which often involves line-by-line coding of full transcripts and an inductive process that may take several months to complete, RQA uses structured templates and a deductive framework to rapidly synthesize key findings across interviews.[24] RQA was particularly appropriate for this study, given that the findings were intended to inform the development of education materials and pre-implementation activities within a relatively short timeframe. Prior studies have demonstrated that rapid deductive CFIR analysis does not compromise rigor and uses fewer resources while yielding similar results.[24–27] (Appendix A)

2.3 Conceptual Framework

The Consolidated Framework for Implementation Research (CFIR*)* served as a comprehensive guide for developing the interview guide, data collection methods, and analysis process for the rapid qualitative analysis (RQA) of interviews. CFIR is a metatheoretical framework that helps identify key influences on implementation from the perspectives of multiple stakeholders. This framework was well-suited to assessing barriers and facilitators to LCS, given its flexibility and adaptability in identifying key factors at the patient, PCTM, and health systems levels.[25,28] Unlike other frameworks, CFIR evaluates context by identifying existing or potential barriers to successful implementation.[29] Using CFIR was essential in this context, as the outcomes were used to provide valuable insights for creating educational resources and informing interventions to promote LCS for eligible patients.

Study interview guides and analysis encompassed the key constructs of the five CFIR domains: Outer Setting, Inner Setting, Individual Characteristics, Intervention, and Process of Implementation to describe the themes that were found most salient. The outer setting encompassed external factors beyond UCDH that may influence implementation outcomes. The inner setting refers to organization characteristics and contextual features that affect the integration of interventions into existing workflows. Individual level factors include the knowledge, attitudes, beliefs, and behaviors of those involved in implementation. Finally, the implementation process encompassed the planning, execution, and evaluation activities undertaken to facilitate successful adoption and sustainability of an intervention.

2.4 Interview Guides

Three semi-structured interview guides, one for each informant category, were developed with probing questions. The questions were developed based on: 1) existing qualitative studies

with validated questions exploring the barriers and facilitators to LCS, and 2) questions aimed at intervention development.

2.3.1 Patients

Patient interview guides included questions about their experiences and perceptions of LCS. This included barriers or hesitancy to accessing LCS, such as physical and psychological, as well as facilitators and motivators towards LCS uptake. Additionally, to consider patient-level factors that influence LCS behavior, such as socioeconomic status, cultural beliefs, and prior healthcare experiences, I incorporated components of the Health Belief Model (HBM) into the interview questions.[30,31] HBM questions accounted for individuals' perceived severity, perceived susceptibility, perceived benefits, perceived barriers, cue to action, and self-efficacy towards LCS.[31] Additionally, questions for eligible patients who had received an LCS explored their reasons and motivators for forgoing LCS. I also sought their advice on strategies for educational materials to encourage eligible patients who had not been screened. Questions for eligible patients who had not received LCS explored why they had not been screened and what information they would need to make an informed decision.

2.3.2 Primary Care Team Members

The PCTMs interview guide included questions that highlighted institutional and structural barriers. Questions for PCTMs helped gain insight into the current process for making an LCS recommendation. Interviews with PCTMs were used to help identify areas for improvement. Additionally, given that PCTMs are the LCS recommenders, I sought to understand what they perceived as barriers and facilitators reported by their patients during visits.

2.5 Analysis

All interviews were audio-recorded, transcribed verbatim, and uploaded to Dedoose [qualitative research software] to conduct a rapid direct content analysis in which responses were coded and mapped across CFIR domains (RQA).[32] All identifiable information was redacted from the transcripts. To maintain confidentiality, data were recoded and de-linked from individuals' identities.

CFIR was utilized to organize the coding, analysis, and summary of results. The data analysis team consisted of five individuals: four coders and one senior investigator who assisted in resolving coding discrepancies and achieving consensus. The analysis team reviewed the transcripts using a deductive approach to map themes and codes to one of the five CFIR domains. The RQA consisted of five steps:

Step 1: I developed three interview guides, one for each interview type. (More information can be found in 2.4)

Step 2: I created a templated summary table for the research team to populate with data from the interview transcripts. To construct the templated summary table, the analysis team took each CFIR-based interview guide and constructed an excel sheet which included: CFIR domains, domain definition based on CFIR website, study specific definition of the CFIR domain which were modified and agreed upon among analysis team, interview questions associated with each domain, example quotes, to illicit key examples to describe the domain, key summaries, that will describe main takeaways, and recommendations, on how to address barriers. (Appendix B)

Step 3: The interviews were conducted by two members of the analysis team and transcribed verbatim.

Step 4: Using the transcribed data from the interviews (Step 3), the analysis team split into two pairs and randomly divided the interviews in half. Each researcher coded transcripts (in Dedoose) using the templated summary table and created "individual summaries" of each interview.

Step 5: Commonly occurring themes were identified for each of the three participant types by comparing summaries across groups. Each pair of coders reviewed the corresponding individual summaries and presented them to the rest of the analysis team.

Step 6: The analysis team combined transcripts by interview type to create 35 "Individual Summaries".

Step 7: Coders and the senior researcher meet on a weekly basis virtually to review "individual summaries", reconcile, refine, and define themes, codes, and categories, and to resolve disagreements.

Step 8: At the end, there were three "Master Summaries" that represented each interview type. This process also involved reaching consensus on quotes that best represented the barriers and facilitators within each domain for each group. Findings were presented to the Enhancing Lung Cancer Screening for Eligible Patients through human centered approach (ELFE) patient advisory board (composed of UCDH patients interviewed for this study) to confirm the results of the final data analysis.

3. Results

A total of 35 interviews were conducted: PCTMs (n = 12), Eligible Patients who received LCS (n = 12), and Eligible patients who did not receive LCS (n = 11). All interviews were conducted in English. Of the 23 patients who participated in the interviews, the majority were

women (67%). Most of the patients were non-Hispanic White (61%), followed by Hispanic or Latino (13%), Decline to State (13%), Other (8.7%), and African American or Black (4.3%). Of the 12 PCTMs, a slight majority were women (54.5%). The majority of the occupation type of PCTMs consisted of clinicians (58%) - including primary care providers, a clinic director, and a former clinic director. Non-clinicians (42%) included a medical assistant, a nurse, and a radiology physicist. (See Table 1)

The definition of barriers in this study included factors that created challenges to referring or undergoing an LCS appointment. Alternatively, the definition of facilitators were factors that enhanced the likelihood of referring a patient to LCS or of uptake.

3.1 Outer Setting

All participants indicated that external infrastructure and factors within the outer setting domain affect LCS referrals and uptake. The research team identified three constructs within this determinant as themes that were most salient in the interviews: (1) quality metrics; (2) media campaign; and (3) healthcare access.

3.1.1. Quality Metrics:

The absence of LCS as a required measure in the Healthcare Effectiveness Data and Information Set (HEDIS) was identified as a primary barrier. PCTMs reported that not having LCS as a required HEDIS measure limited its prioritization compared to cancers for which screening is mandated. PCTMs shared that HEDIS measures play an important role in identifying gaps in care and informing strategies for improvement. Therefore, they suggested that not having the LCS HEDIS measure potentially led to missed opportunities for early detection

and that significant increases in LCS recommendations would occur once LCS became a mandated metric.

> *"Until lung cancer screening is one of those metrics it's just going to be hey you could do this but no one's measuring it. And I think, to me those system level changes will drive a lot of provider and clinic behavior more so than educating them."*

(Interview #35, PCTM)

3.1.2 Media Campaigns

The interviews revealed the need to improve current media campaigns to better communicate the benefits of LCS to all audiences, while also serving as a valuable tool for raising awareness. All participants described how the media has raised awareness of other cancers, yet current LCS media strategies have not been as effective: *"people have heard about pap smears and mammographs, you know, and PSA for prostate cancer, but for most patients, LDCT for lung cancer screening is a brand-new foreign concept."* (Interview # 30, PCTM) Patients who watched commercials on lung cancer shared that current LCS advertisements use fear tactics - "*having a big impact on kids*" by showing "*their [older adult] vocal cords were gone due to all the smoking."* (Interview # 10, Patient Participant Not Screened) Patients described that promoting lung cancer in this way could be seen as a self-induced problem, resulting in stigma.

Patients also discussed how the media's portrayal of smoking over the years influenced their smoking behaviors. Some patients mentioned that prior to the ban of smoking in public spaces, earlier media representations portrayed smoking as "*cool to do*" (Interview #14, Patient Participant Screened) – causing them to feel guilt for smoking. Informants also described how current media depictions of LCS can cause a lack of social compassion compared to other

cancers. All participant types compared the positive, community-focused messaging and bright colors used for breast cancer materials to the darker colors used in lung cancer, depicting *"everything is black, like a black lung...they don't show lung cancer walks, or ribbons...there are people who have never smoked and have lung cancer also".* (Interview #34, PCTM) One potential solution discussed by all participant types was to incorporate positive messaging in the media was to collaborate with celebrities on public service announcements, as they can be champions to help raise awareness, encourage participation, and destigmatize getting screened- "*giving a face to it [lung cancer] and make it more relatable*" (Interview #3, PCTM).

3.1.3 Healthcare Access

Insurance coverage and transportation were seen as the two salient themes under healthcare access. All participants emphasized insurance coverage for LCS as a decisive factor influencing their decision to undergo screening. The majority of patients screened reported their screening was covered by their insurance as a preventative care service; however, some indicated that they were required to pay a portion of the cost. One noted the importance of verifying the potential cost of screening, given that it could vary by year. Although cost was not reported as a barrier for eligible patients who received screening, removing the cost of a screening was a priority for them, given that it could be a barrier for others in their community.

Transportation was also identified as a barrier to LCS uptake, with the distance between the clinic where the referral was made and the screening facility hindering access. PCTMs noted that although the institution provided services to patients in both urban and rural areas, all LDCT scanners were located in urban areas. PCTMs reported that this has led many eligible patients not screened to avoid making the trip, opting instead to receive their LCS at a health system closer to home: *"Some older patients don't even want to travel out of this area, so they'll go to a different*

health system which has some imaging that's close by." (Interview # 3, PCTM) Patient participants who screened and transported themselves to their appointments described traffic as a barrier. This was due to ongoing construction in their counties and within UCDH, causing detours and longer travel times to their appointments. A facilitator for getting screened, described by PCTMs and patient participants, included having someone provide interpersonal support (e.g., nursing facility staff and family members) to help them get to their appointments.

3.2 Inner Setting

At the inner setting, all participants identified both barriers and facilitators to LCS across key components of the LCS workflow. The workflow was defined as the process set in place, consisting of a series of tasks performed by a PCTM to support an eligible patient through the LCS process: (1) addressing visit priorities, (2) eligibility stage, (3) SDM, (4) referral process, and (5) annual screening.

3.2.1 Visit Priorities

The limited time available to a clinician during a routine visit was identified as the most significant barrier to making LCS referrals. Clinicians reported spending between 7 and 10 minutes with each patient, which led to prioritizing more urgent issues during the visit. "*Patients will come in with multiple complaints, and we may only have ten minutes to handle like six things, so the screening often goes to the bottom of the list*." (Interview #3, PCTM) PCTMs reported that, given the age of eligible patients, visit priorities included checking blood pressure, cholesterol, hypertension, and depression. While some PCTMs discussed allocating time during their visit to ask patients about their smoking history, if a patient disclosed that they were a

current smoker, they would prioritize getting them into a smoking cessation program versus checking for LCS eligibility. One PCTM stated:

> *"If I had a choice on what to say to someone who's a current smoker, then I'm going to talk about how to help them quit smoking, it will not just help with lung cancer, it's going to help heart attacks, it's just going to help overall."*
>
> (Interview #35, PCTM)

Two reasons for this decision, according to the interviews, included: 1) the complexities of determining LCS eligibility and 2) PCTM knowledge that smoking is a leading cause for other health concerns and cancers aside from lung cancer. Some PCTMs noted using *"unofficial shortcuts"* to "*bypass*" the logistical process and save time when making an LCS referral, as *"the process takes minutes rather than seconds"* (Interview #35, PCTM), in contrast to referrals for other cancers.

3.2.2 Determining Eligibility

During the eligibility stage, one of the key challenges reported by PCTMs was identifying eligible patients. PCTMs reported that relying on the patient to accurately disclose their smoking history is a challenge, given that they might not be able to recall exact periods of time when they have smoked, or their patient's preference not to disclose their smoking history. One PCTM mentioned using their sense of smell as a cue to ask patients about their smoking history. *"If I smell that there is smoke in the room, I will definitely address it."* (Interview #34, PCTM). Having an accurate smoking history in a patient's EMR is necessary, as current strategies reported involve utilizing a patient's EMR to assess eligibility. This is done by

reviewing the patients' smoking history and inputting the information into the pack-year calculator, which is embedded into the EMR system. PCTMs reported that, while this method was valuable, the process needs to be streamlined.

> *"I think having just more upfront accessible information of here's the criteria, that's easy to see so I can't, I don't have to dig around and remember them like oh shoot, tell me how many pack years and how long ago is 15 years like they smoked in the past, how many years, just easy to find information regarding that would be helpful."*
>
> (Interview #1, PCTM)

PCTMs suggested implementing alerts within the EMR to notify clinicians when a patient becomes eligible based on their medical records. The rationale behind this suggestion was the demonstrated success of other cancer screenings that utilize this approach. Alternatively, some PCTMs discussed how implementing alerts could exacerbate the existing alert fatigue: *"They want to put more and more stuff [alerts] on there [EHR]... so the docs just blow past the alerts as well."* (Interview #2, PCTM)

3.2.3 Shared Decision Making (SDM)

The workflow for placing an LCS referral, as described by the participants, consisted of the following components: SDM, order submission, insurance coverage verification, and appointment scheduling. Patient participants who were screened reported receiving information about the risks and benefits of LCS, but often left the SDM meeting without understanding or remembering what the screening actually involved. Overall, patient participants who were screened stated that having a conversation with their PCTM allowed them to use the information

from the visit to make their decision about whether to get screened. One patient described this experience as*: "It [SDM] was a very non-pushy thing to the point where it really left the ball in my court."* (Interview #9, Patient Participant Screened)

3.2.4 Referral Process

Part of the referral process included verifying insurance coverage. PCTMs who referred eligible patients for LCS discussed challenges with timely LCS screenings due to the wait time between the referral and appointment scheduling. One PCTM shared: *"Sometimes people do fall through the cracks of the scheduling because there is a lag as to when the test is ordered and when the insurance approves it."* (Interview #4, PCTM). The lack of communication within the health system often placed the responsibility on the patients to follow up on their own. Patient participants screened reported receiving calls during work hours to schedule a screening, making it difficult to schedule an appointment if they couldn't answer. Patient participants recommended to *"make sure that scheduling is quick and easy because that might prevent a person from, you know, if they're having any frustration with getting things scheduled then might deter them."* (Interview #11, Patient Participant Not Screened). In addition, patient participants screened indicated that the existing long wait times caused some stress.

> *"I had to continue to ask my doctor for them to get a hold of me, and that it took several months before they got a hold of me, that I was really interested in getting this done because I was a little bit nervous about it".*
>
> (Interview # 8, Patient Participant Screened)

As a result of the limited, streamlined process, PCTMs shared that they sometimes had to repeat the referral process during patients' routine visits because they had not been contacted to schedule a radiology appointment.

3.2.5 Screening

Despite delays in scheduling a screening, patient participants emphasized the actual screening process as *"a very easy, quick test that could save your life."* (Interview # 15, Patient Participant Screened). Additionally, one patient participant screened emphasized how accessible the screening was for individuals in wheelchairs compared to other cancer screenings: *"I was able to get from the wheelchair up to the table to lay on it [LDCT scanner]. I don't have any problem doing that."* (Interview #16, Patient Participant Screened) Overall, patients who had been screened shared that after going through the process once, the annual appointments became "*less dreading"* because they knew what to expect, and they thought it was a good idea for their "*own peace of mind".* (Interview #14, Patient Participant Screened)

3.2.6 Follow-up appointment

Interviews with screened patient participants revealed challenges in attending annual LCS appointments. One barrier at the follow-up stage was that patients were not receiving reminders for their annual screenings. Patient participants screened reported that, unlike other cancer screenings with automatic annual reminders, LCS often relies on patient self-motivation. For instance, some patient participants screened reported reminding PCTMs to submit a referral, which then led to scheduling an appointment. Patient participants screened also mentioned that annual reminders for other health-related screenings served as a cue to action, promoting them to

"add that [LCS] to my annual list of things I'm at the greatest risk of and need to be look at." (Interview #9, Patient Participant Screened)

3.3 Individual Characteristics

Patients' individual characteristics have been shown to influence their decision to be screened for lung cancer. One construct was identified under this domain: knowledge and understanding of LCS.

3.3.1 Knowledge and Understanding of LCS

Patients' knowledge and understanding of LCS significantly influenced their decision to undergo screening. The majority of patients reported having limited knowledge about lung cancer and were unaware that screening options existed until discussing them with their PCTMs. All patients indicated being aware of the link between smoking and lung cancer, but very few knew that a screening existed or its benefits. A PCTM reported that despite efforts*, "Everybody knows that smoking causes lung cancer, but nobody really knows about LCS."* (Interview # 35, PCTM). Some patient participants were not screened and did not share accurate smoking history with their PCTMs due to *"feeling bad for not being able to quit smoking."* Patient participants screened reported that their smoking history impacted their decision to undergo LCS, influencing whether they wanted to know their results or avoid them. Some patient participants not screened chose not to receive the screening because they preferred not to know that they had lung cancer. One eligible patient participant shared:

"I didn't want to know. I had this fear of, like, well, now you're gonna tell me that I have it [lung cancer], and then I'm gonna live this messed up life thinking. OK, well, I'm gonna die, you know? And so I didn't wanna know. I'd rather just live"

(Interview # 28, Patient Participant Not Screened)

Alternatively, a patient participant screened shared: "*I guess the older I get, the more I'm like tell me the truth, while I can get better*" (Interview #13, Patient Participant Screened).

Other factors influencing patients' refusal to be screened included concerns about radiation exposure and the risk of false positives. PCTMs shared that they addressed patient participants' concerns regarding radiation by explaining the differences between an LDCT and other radiation exposures (e.g., MRI).

Motivating factors for undergoing LCS included having previously received other cancer screenings and having a family history of cancer. PCTMs reported that patients who had gotten screened for other cancers were likely to also undergo LCS after recommending. One patient participant screened shared "*After my sister and brother-in-law had passed of lung cancer, I was motivated to get that done."* (Interview #15, Patient Participant Screened) Patients shared that having a family history of cancer emphasized the importance of early detection through screening given that it has either helped their family members get treatment earlier on or could have benefited if caught earlier. Alternatively, PCTMs noted that patients with a history of declining other cancer screenings, were less likely to undergo LCS. *"It's a small minority that just aren't interested in any screenings and it's not just lung cancer screening, it's all of them."* (Interview # 25 PCTM)

3.4 Innovation

The innovation domain encompassed participants recommendations for delivering educational materials through MyChart (UCDH online patient portal powered by Epic, also known as MyUCDavisHealth) to increase awareness and uptake of LCS among eligible patients. The results under this domain focused on understanding patients' experiences using MyChart, identifying what works well, and addressing existing challenges to inform the design of a future intervention.

3.4.1 MyChart Intervention

All the patients interviewed reported using MyChart and stated that it was an "*easy to navigate*" platform with all of their health information in one location. Patients reported using MyChart to schedule and/or cancel appointments, check for upcoming visits, order or view medications and test results, review visit notes, and communicate with their PCTMs. All participants recommended using MyChart to send patients educational flyers or short videos.

One area of concern raised by PCTMs about using MyChart to deliver educational materials included accessibility challenges, such as limited Wi-Fi, issues with portal activation, and patients' comfort navigating the portal. These concerns were based on observations PCTMs made in previous projects that used MyChart to deliver educational information. PCTMs also reported that eligible patients would forget their MyChart password or that they spent time with patients, teaching them how to access it by phone.

3.5 Implementation Process

The implementation domain was defined as the set of strategies to consider when developing educational materials. Within this domain, I report on participants' preferences for the content, delivery, and distribution of educational materials. Considerations recommended by participants for developing educational materials included age and comfort level with technology.

3.5.1 Content

The content recommendations deemed important to incorporate in LCS educational materials consisted of a combination of written and visual information. All participants indicated that eligibility criteria, risks, benefits, coverage or cost, and the length of LCS were valuable information to include in writing. The importance of incorporating visuals when possible was recommended by all patients because *"explaining it [LDCT] and seeing it are two different things."* (Interview #14, Patient Participant Screened) Given that patients did not know what an LDCT scanner looked like until their visit, both patients and PCTMs recommended including an image.

3.5.2 Delivery Mode

The different modalities recommended for delivering educational materials included educational flyers, brochures, posters, videos, testimonials, and patient portals.

"The patient might not be as fluent with MyChart, so a handout to start would be good at the doctor's office... in my opinion, the first place to start [to learn about LCS] *would be with the primary care physician."*

(Interview # 14, Patient Participant Not Screened)

To ensure patient engagement, all participants indicated the importance of developing educational materials written for various reading levels. Additionally, patients emphasized that while scientific information is important, writing it in laymen terms would help them retain information. PCTMs recommended saving the detailed information for the SDM appointment and *sending "concise, shorter messaging to the patients that feels a little more personal... or else it will feel like spam."* (Interview #1, PCTM) Another PCTM noted that the *"longer it [MyChart message] was, the more people didn't read it."* (Interview #3, PCTM) Lastly, while patients felt comfortable receiving information in English, they recommended making information accessible in multiple languages to remove language barriers for limited English proficient patients. PCTMs are encouraged to use the "read message" function in MyChart to track which patients opened the message.

3.5.3 Distribution

All participants recommended distributing patient educational materials both in hard copy and digitally, acknowledging that relying solely on one method of distribution presents challenges. Hard copy materials included: flyers, brochures, and posters. PCTMs recommended placing hard copy materials in the waiting rooms – making it easy for 1) a patient to see and grab while they wait for their visit to commence, or 2) for a PCTM to hand out to their patient when

discussing LCS. PCTMs also recommended having posters with updated LCS guidelines and referral workflow placed in staff rooms or hallways for PCTMs to quickly reference.

Distributing educational materials digitally was also recommended to share information with patients and PCTMs. Digital materials included LCS information available via quick response (QR) codes, a website, a patient portal, and emails. All participant types reported that having information available digitally would be beneficial to eligible patients, especially for those who misplace the hard copy they receive during their visit. Additionally, PCTMs discussed the benefits their colleagues would gain from receiving LCS information via email, such as updates on guidelines and workflows, or a list of potentially eligible patients with upcoming routine check-up appointments. (See Appendix C)

4. Discussion

This study broadly examined barriers and facilitators to LCS at an academic health institution while gaining insights into 1) the lung cancer screening process, and 2) developing a MyChart web-based intervention to distribute educational materials. To the best of my knowledge, this is the first study to explore LCS barriers and facilitators at an academic institution with the intent to co-design a MyChart intervention using the updated 2021 USPSTF guidelines. The patient and PCTM interviews provided a multi-level perspective into barriers and facilitators to LCS as well as unique insights into patient-centered approaches to educational materials. Within these interviews, I sought to understand barriers and facilitators at the outer, inner, individual, innovation, and implementation levels to improve the clinic workflow and to inform the development of educational materials based on salient findings.

Using key informant interviews, that were identified salient factors that contributed to barriers and facilitators to LCS uptake. The three main factors that were identified from the interviews included: (1) The need for more education to raise awareness on lung cancer and LCS. (2) Modes of delivery for eligible patient education need to be multifaceted and not just reliant on electronic patient portals. (3) Improving clinic workflows and communication is needed for referral and screening adherence.

All participants reported having limited awareness of LCS eligibility and the process, which contributes to the low number of eligible patients who are referred or screened. This finding is consistent with the existing literature, which reports the influence LCS knowledge has on LCS referral and uptake. In a recent study using data from the Health Information National Trends Survey (n = 6,252), 19% of eligible patients indicated they had never heard of LDCT, and only 9.4% had discussed getting screened with their provider within the past year.[33] Another study used semi-structured interviews (n = 20) to understand the perceived benefits, barriers, and cues to action for LCS among individuals meeting USPSTF guidelines and reported that 70% of their participants were unaware of LCS, and 90% did not know they were eligible for a screening.[34] My study found that clinician recommendations were fundamental for patients to get screened. Previous literature has acknowledged the critical role clinicians play in LCS as well as the challenges they face in assuming this responsibility, including being up to date with guidelines. One study in California, which assessed clinician knowledge about LCS via a survey (n =32), found that none of their participants correctly identified all CMS eligibility criteria, with an average knowledge score of 6.6 ± 1.1 out of 9 questions, demonstrating that provider knowledge of guidelines remained limited.[35] Another PCT survey (n=250) found that less than half of the PCTs were aware of the USPSTF recommendations.[36] This study identified gaps in

knowledge in the LCS workflow among PCTMs, which demonstrate the need to develop multilevel educational resources to increase awareness for them as well.

Although patients in this study reported using MyChart and were generally receptive to receiving educational materials through the patient portal, both patients and PCTMs highlighted the limitation of relying exclusively on a digital platform to disseminate information. These findings suggest that access to a patient portal does not necessarily translate into equitable engagement with educational resources. This interpretation is supported by a National Poll on Health Aging (n = 2,563). Which found that although 78% of adults aged 50-80 reported having access to a patient portal, comfort using the technology was lower among non-Hispanic Black and Hispanic older adults, individuals with annual household incomes below $60,00, and those reporting fair or poor physical health.[37,38] Together, these findings underscore the potential for patient portals to inadvertently widen existing disparities if implemented as the sole method of delivering educational materials.

The findings also highlight the importance of adopting multimodal approaches to patient education that accommodate varying levels of digital literacy, access to technology, language proficiency, and health literacy. Consistent with recommendations from other cancer screening interventions, combining digital resources with printed educational materials and other communication strategies may improve accessibility and patient engagement.[23,39,40] Incorporating multiple dissemination methods may be particularly important for reaching populations that experience barriers to digital health technologies and ensuring that implementation efforts promote equitable access to LCS decision aids.

In addition to mailing educational materials, PCTMs emphasized the importance of identifying patients individually, given the inaccuracies in documenting smoking history within their EMR. Prior studies have shown patient navigators as leaders in addressing cancer disparities, especially among vulnerable populations, due to their ability to provide individualized, one-on-one support to patients. Results from a systematic review indicated that patient navigators could improve LCS rates, follow-up compliance, time to treatment initiation, and patient satisfaction.[41] Implementing multifaceted strategies in communicating LCS education can help to ensure information is accessible to all patients.

Enhancing clinic workflow and communication for LCS was a prevalent factor identified as a critical need across all stages: (1) addressing visit priorities, (2) eligibility stage, (3) shared decision making (SDM), (4) referral process, and (5) annual screening. The literature demonstrates that these challenges were not unique to this study, given the complexity of LCS guidelines and the need for multilevel factors during implementation. One study suggests assessing readiness for implementing the LCS program, including staff time, leadership support, training resources, and access to technology to ensure workflow success.[42] These challenges match the results in this study, which indicated the need to update patients' smoking histories in the EMR, addressing PCTM-LCS wait time intervals, and automating LCS annual screening reminders. Similar to other studies, the PCTMs in this study reported inaccurate patient smoking history in the EMR. A cross-sectional study evaluating 16,874 patients meeting 2021 USPSTF screening criteria using EHR data found that 80% of patient records had inaccuracies in pack-year calculations.[43] One potential solution for updating information has been to implement patient navigators to verify information on a patient-by-patient basis.[21] This study also found the need to address PCTM-LCS appointment wait time intervals. To my knowledge, limited studies

have reported on the wait time between when an eligible patient was referred to LCS and when they complete their screening. International guidelines recommend a 14–day maximum interval from when a PCTM makes a referral to a patient's first LCS appointment. [44] [45,46] A European scoping review (n=128) reported an overall median of 7 days and distributions largely meeting guidelines for PCT-LCS intervals. This study demonstrated the need for a standard PCT-LCS appointment interval in a clinic setting, which can alleviate patients' experiences of feeling stress and anxiety, given the possibility of receiving a positive result, which participants reported. Lastly, adherence to the LCS annual screening for those with negative screenings was also emphasized as a challenge by PCTMs. While most of the challenges to LCS adherence reported in the literature focus on low screening rates due to patients' limited knowledge or awareness about annual screening, lack of insurance cover, transportation, and management of other health concerns, my study found that a major barrier was not receiving a notification that they were due, and the inability to schedule an appointment.[47,48] Adopting a stepwise approach to implementing structural strategies could help address workflow challenges while maintaining the flexibility to make necessary improvements.[29]

4.1 Strengths and Limitations

While this study provides valuable insights into barriers and facilitators to LCS, it is important to acknowledge certain limitations that may have influenced the findings. The sample size of 35 interviews may be considered modest, thus limiting the generalizability of this study's findings. However, prior studies have shown that saturation, with no additional themes emerging, is often reached between 9 – 17 interviews.[49] In this study, saturation was assessed separately for each informant type through an iterative review of interview data conducted throughout data collection. Saturation was reached after approximately 8 patient interviews and 7 PCTM

interviews, as no new themes emerged in subsequent interviews. Additional interviews were conducted to confirm saturation and ensure adequate representation of perspectives across participants. Additionally, the results reported are based on the views of a specific group of individuals, and their experiences are not representative of the entire U.S. population. Instead, they offer a broad overview of the barriers and facilitators faced by patients and PCTMs within an academic health system, which can serve as a starting point for future research. Despite efforts to purposefully sample racial minorities, the majority of the patients interviewed identified as White. This may reflect the demographic composition of the UCDH's patient population. Furthermore, given that UCDH is an academic health system that provides LCS only to insured patients, future studies should explore barriers and facilitators to LCS among eligible individuals who seek care in a non-academic setting and evaluate the applicability of the recommendations identified in this study.

Despite the limitations, the strengths of this study included obtaining insights from three types of informants rather than just one participant type, providing us with a health system view of barriers and facilitators to LCS recommendations and uptake. Data saturation was assessed separately for each informant type through ongoing transcript review and discussions during research team data analysis meetings. This coincides with prior studies, which have reported that they commonly reach saturation between 10-12 interviews.[49,50] Additionally, this study incorporated elements of the Health Belief Model (HBM) into the CFIR framework when designing the interview questions to explore individual participant type perceptions of the benefits and barriers to LCS, cues to action, and self-efficacy. This allowed for a deeper understanding of individuals' beliefs while simultaneously examining broader implementation factors that influence screening uptake. The integration of HBM into the CFIR framework

provided a more holistic understanding of LCS implementation and supported in generating actionable recommendations across patient, PCTM, and health system levels.

5. Conclusion

This study demonstrated that while patients are aware that smoking causes lung cancer, many were unaware of the availability of a screening for early lung cancer detection, highlighting a critical need for targeted patient educational resources. The findings revealed the need for multi-level interventions at both PCTMs and patient levels to remove barriers to LCS recommendations and uptake. While findings from this study align with prior studies, my research adds to the growing body of literature. This study enabled participants to describe their experiences and provide recommendations for an intervention via MyChart. Future research should explore barriers and facilitators at both the PCTM and patient levels, integrating these insights into interventions such as decision aids and patient navigators to streamline and support the LCS process. Findings from this study were used to inform pre-implementation efforts designed to optimize the implementation of a patient decision aid and screening navigation intervention in a future implementation study.

References

1. Lung Cancer Statistics | How Common is Lung Cancer? | American Cancer Society. Accessed April 25, 2024. https://www.cancer.org/cancer/types/lung-cancer/about/key-statistics.html

2. Reducing Risk for Lung Cancer | Lung Cancer | CDC. Accessed December 20, 2024. https://www.cdc.gov/lung-cancer/prevention/index.html

3. State of Lung Cancer | Key Findings | American Lung Association. Accessed April 25, 2024. https://www.lung.org/research/state-of-lung-cancer/key-findings

4. Pinsky PF, Church TR, Izmirlian G, Kramer BS. The National Lung Screening Trial: results stratified by demographics, smoking history, and lung cancer histology. *Cancer*. 2013;119(22):3976-3983. doi:10.1002/cncr.28326

5. Ru Zhao Y, Xie X, de Koning HJ, Mali WP, Vliegenthart R, Oudkerk M. NELSON lung cancer screening study. *Cancer Imaging*. 2011;11 Spec No A:S79-84. doi:10.1102/1470-7330.2011.9020

6. Sharma D, Newman TG, Aronow WS. Lung cancer screening: history, current perspectives, and future directions. *Arch Med Sci*. 2015;11(5):1033-1043. doi:10.5114/aoms.2015.54859

7. Cochrane AL, Holland WW. Validation of screening procedures. *Br Med Bull*. 1971;27(1):3-8. doi:10.1093/oxfordjournals.bmb.a070810

8. Nishi SPE, Lowenstein LM, Mendoza TR, et al. Shared Decision-Making for Lung Cancer Screening: How Well Are We “Sharing”? *Chest*. 2021;160(1):330-340. doi:10.1016/j.chest.2021.01.041

9. Wiener RS, Gould MK, Arenberg DA, et al. An official American Thoracic Society/American College of Chest Physicians policy statement: implementation of low-dose computed tomography lung cancer screening programs in clinical practice. *Am J Respir Crit Care Med*. 2015;192(7):881-891. doi:10.1164/rccm.201508-1671ST

10. Wood DE, Kazerooni E, Baum SL, et al. Lung cancer screening, version 1.2015: featured updates to the NCCN guidelines. *J Natl Compr Canc Netw*. 2015;13(1):23-34; quiz 34. doi:10.6004/jnccn.2015.0006

11. Krist AH, Davidson KW, Mangione CM, et al. Screening for lung cancer: US preventive services task force recommendation statement. *JAMA*. 2021;325(10):962-970. doi:10.1001/jama.2021.1117

12. Lowenstein M, Karliner L, Livaudais-Toman J, et al. Barriers and facilitators to lung cancer screening: A physician survey. *Am J Health Promot*. 2022;36(7):1208-1212. doi:10.1177/08901171221088849

13. Leopold KT, Carter-Bawa L. Barriers to Lung Cancer Screening Access from the Perspective of the Patient and Current Interventions. *Thorac Surg Clin*. 2023;33(4):343-351. doi:10.1016/j.thorsurg.2023.04.003

14. Reihani AR, Ahari J, Manning EP, Cain HC, Bade BC, Zimmerman HG. Barriers and facilitators to lung cancer screening in the United States: A systematic review of the qualitative literature. *J Health Soc Sci*. 2021;6(3):333-348.

15. Cavers D, Nelson M, Rostron J, et al. Understanding patient barriers and facilitators to uptake of lung screening using low dose computed tomography: a mixed methods scoping review of the current literature. *Respir Res*. 2022;23(1):374. doi:10.1186/s12931-022-02255-8

16. Lin Y-A, Hong YT, Lin XJ, Lin JL, Xiao HM, Huang FF. Barriers and facilitators to uptake of lung cancer screening: A mixed methods systematic review. *Lung Cancer*. 2022;172:9-18. doi:10.1016/j.lungcan.2022.07.022

17. California Ranks Worst Among All States for Lung Cancer Treatment, According to New Report | American Lung Association. Accessed September 30, 2024. https://www.lung.org/media/press-releases/solc-2022-ca

18. Haddad DN, Sandler KL, Henderson LM, Rivera MP, Aldrich MC. Disparities in lung cancer screening: A review. *Ann Am Thorac Soc*. 2020;17(4):399-405. doi:10.1513/AnnalsATS.201907-556CME

19. State of Lung Cancer | Racial and Ethnic Disparities | American Lung Association. Accessed January 10, 2025. https://www.lung.org/research/state-of-lung-cancer/racial-and-ethnic-disparities

20. Jansen E, Bolivar J, Auguste S, et al. Population health nurse–driven lung cancer screening. *NEJM Catal*. 2024;5(5). doi:10.1056/CAT.24.0002

21. Chak EW, Cortez-Toledo E, Luna R, et al. Electronic population health tools enhance preventive care for older adults. *Am J Med*. 2022;135(7):840-843. doi:10.1016/j.amjmed.2021.12.015

22. Daudelin DH, Ruthazer R, Kwong M, et al. Stakeholder engagement in methodological research: Development of a clinical decision support tool. *J Clin Transl Sci*. 2020;4(2):133-140. doi:10.1017/cts.2019.443

23. Barker AM, Wiener RS, Crocker D, et al. "You Are the Key": A co-design project to reduce disparities in Black veterans' communication with healthcare providers. *Patient Experience Journal*. 2023;10(3):27-35. doi:10.35680/2372-0247.1816

24. Nevedal AL, Reardon CM, Opra Widerquist MA, et al. Rapid versus traditional qualitative analysis using the Consolidated Framework for Implementation Research (CFIR). *Implement Sci*. 2021;16(1):67. doi:10.1186/s13012-021-01111-5

25. Gale RC, Wu J, Erhardt T, et al. Comparison of rapid vs in-depth qualitative analytic methods from a process evaluation of academic detailing in the Veterans Health Administration. *Implement Sci*. 2019;14(1):11. doi:10.1186/s13012-019-0853-y

26. Taylor B, Henshall C, Kenyon S, Litchfield I, Greenfield S. Can rapid approaches to qualitative analysis deliver timely, valid findings to clinical leaders? A mixed methods study comparing rapid and thematic analysis. *BMJ Open*. 2018;8(10):e019993. doi:10.1136/bmjopen-2017-019993

27. Watkins DC. Rapid and rigorous qualitative data analysis. *Int J Qual Methods*. 2017;16(1):160940691771213. doi:10.1177/1609406917712131

28. Breimaier HE, Heckemann B, Halfens RJG, Lohrmann C. The Consolidated Framework for Implementation Research (CFIR): a useful theoretical framework for guiding and evaluating a guideline implementation process in a hospital-based nursing practice. *BMC Nurs*. 2015;14:43. doi:10.1186/s12912-015-0088-4

29. Overview. Consolidated Framework for Implementation Research. Accessed December 23, 2024. https://cfirguide.org/evaluation-design/overview/#:~:text=The%20CFIR%20is%20a%20framework,of%20evaluation%20you%20are%20conducting.

30. Alyafei A, Easton-Carr R. The health belief model of behavior change. In: *StatPearls*. StatPearls Publishing; 2025.

31. Abraham C, Sheeran P. The health belief model. In: Ayers S, Baum A, McManus C, et al., eds. *Cambridge Handbook of Psychology, Health and Medicine*. Cambridge University Press; 2001:97-102. doi:10.1017/CBO9780511543579.022

32. Home | Dedoose. Accessed May 12, 2024. https://www.dedoose.com/

33. Nourmohammadi N, Liang THP, Sadigh G. Patient-Provider Lung Cancer Screening Discussions: An Analysis of a National Survey. *Clin Lung Cancer*. March 2, 2024. doi:10.1016/j.cllc.2024.02.008

34. Alaniz-Cantú EI, Goodwin K, Smith L, et al. Understanding the perceived benefits, barriers, and cues to action for lung cancer screening among Latinos: A qualitative study. *Front Oncol*. 2024;14:1365739. doi:10.3389/fonc.2024.1365739

35. Quezada JJ, Avenido AR, Jia S, et al. Assessing Providers' knowledge about and barriers to lung cancer screening. *Cancer Treatment and Research Communications*. 2024;41:100850. doi:10.1016/j.ctarc.2024.100850

36. Raz DJ, Wu GX, Consunji M, et al. Perceptions and utilization of lung cancer screening among primary care physicians. *J Thorac Oncol*. 2016;11(11):1856-1862. doi:10.1016/j.jtho.2016.06.010

37. Hassol A, Walker JM, Kidder D, et al. Patient experiences and attitudes about access to a patient electronic health care record and linked web messaging. *J Am Med Inform Assoc*. 2004;11(6):505-513. doi:10.1197/jamia.M1593

38. AGE A. Use and Experiences with Patient Portals Among Older Adults.

39. Pignone M, Harris R, Kinsinger L. Videotape-based decision aid for colon cancer screening. A randomized, controlled trial. *Ann Intern Med*. 2000;133(10):761-769.

40. Robichaux C, Anderson M, Freese R, Stately A, Begnaud A. Lung cancer screening outreach program in an urban native american clinic. *J Prim Care Community Health*. 2023;14:21501319231212310. doi:10.1177/21501319231212312

41. Shusted CS, Barta JA, Lake M, et al. The case for patient navigation in lung cancer screening in vulnerable populations: A systematic review. *Population Health Manag*. 2019;22(4):347-361. doi:10.1089/pop.2018.0128

42. Allen CG, Cotter MM, Smith RA, Watson L. Successes and challenges of implementing a lung cancer screening program in federally qualified health centers: a qualitative

analysis using the Consolidated Framework for Implementation Research. *Translational and Behavioral Med*. 2021;11(5):1088-1098. doi:10.1093/tbm/ibaa121

43. Kukhareva PV, Caverly TJ, Li H, et al. Inaccuracies in electronic health records smoking data and a potential approach to address resulting underestimation in determining lung cancer screening eligibility. *J Am Med Inform Assoc*. 2022;29(5):779-788. doi:10.1093/jamia/ocac020

44. Malalasekera A, Nahm S, Blinman PL, Kao SC, Dhillon HM, Vardy JL. How long is too long? A scoping review of health system delays in lung cancer. *Eur Respir Rev*. 2018;27(149). doi:10.1183/16000617.0045-2018

45. BTS recommendations to respiratory physicians for organising the care of patients with lung cancer. The Lung Cancer Working Party of the British Thoracic Society Standards of Care Committee. *Thorax*. 1998;53 Suppl 1(Suppl 1):S1-8. doi:10.1136/thx.53.suppl_1.s1

46. www.cancer.org.au/assets/pdf/lung-cancer-optimal-cancer-care-pathway.pdf.

47. Sakoda LC, Gould MK. Facilitating Adherence to Annual Screening for Lung Cancer: Are Program-Level Interventions Enough? *Chest*. 2022;162(1):8-10. doi:10.1016/j.chest.2022.03.019

48. Holman A, Kross E, Crothers K, Cole A, Wernli K, Triplette M. Patient perspectives on longitudinal adherence to lung cancer screening. *Chest*. 2022;162(1):230-241. doi:10.1016/j.chest.2022.01.054

49. Hennink MM, Kaiser BN, Marconi VC. Code saturation versus meaning saturation: how many interviews are enough? *Qual Health Res*. 2017;27(4):591-608. doi:10.1177/1049732316665344

50. Guest G, Bunce A, Johnson L. Are Enough?: An Experiment with Data Saturation and Variability. *Field methods*. 2006;18(1):59-82. doi:10.1177/1525822X05279903

APPENDICIES

Appendix A. Differences between Rapid Qualitative Analysis & Traditional Qualitative Analysis

Method	Analysis Steps
Rapid Qualitative Analysis (RQA)	Step 1: Transcribe Interviews Step 2: Define study domain and create summary templates. Step 3: Randomly designate transcripts for initial review among the analysis team. Step 4: Each reviewer will summarize the designated transcripts using a domain template. Step 5: Consolidate transcript summaries with the analysis team: review summaries and matrices to identify key points, potential themes, the quality and consistency of data collection, and directions for further data collection and analysis.
Traditional Qualitative Analysis	Step 1: Transcribe Transcripts Step 2: In-depth line-by-line coding: either manually or by using software such as Dedoose. Step 3: Compare codes with the analysis team, organize codes, and organize them into agreed-upon categories. Step 4: Agree with the research team on themes based on categories and create a codebook.

Appendix B. CFIR Definitions

Domain	Definition	Interview Question
Outer Setting	Participants indicate external infrastructure and factors (individuals) influencing their decision to get screened for lung cancer.	Primary care team members • What are the main reasons for refusal? Patients • What made you decide to get lung cancer screening? • Did you/would you talk about your decision to have LCS (or ask advice) from a significant other, family member, or friend before deciding to go ahead with it? • Have you considered having LCS in the past and then decided to put it on hold? Why?
Inner Setting	Participants described existing LCS infrastructures, protocols, or experiences with the referral and screening process.	Primary care team members • Have you ever counseled a patient towards LCS? • What is your clinic's current practice for LCS? • What information do you typically give your patients about LCS? • How do you handle patients who are eligible for screening but prefer not to screen? How are LCS refusals handled? • Are there any differences in how you approach different populations (ethnicity, SES, educational level) and why? • Have you or your clinic used any particular strategies or particular educational tools that have resulted in more patients opting in to get LCS? Patients • When your provider recommended LCS to you, what was your response?
Individual	1) Participant attitudes, knowledge, and beliefs pertaining to lung cancer screening. Including their motivations or barriers to getting screened.	Primary care team members: • Do you have any concerns about recommending LCS to your patients? • Do you think patients have an accurate idea of the risks and benefits of getting an LCS? • How do you determine whether or not your patient wants to undergo LCS? Eligible patients who received LCS: • What made you decide to get LCS?

		• What were you hoping to learn through getting a LCS? • Was it difficult or easy for you to make your decision about LCS? <u>Eligible patient who did not receive LCS:</u> • Do you know there is a test to screen for LCS? • Have you considered having a LCS in the past and then decided to put it on hold? Why? • How likely would you be to get LCS?
Innovation	1. Recommendations on how to use MyChart to deliver educational material regarding LCS before a patient meets with a PCTM 2. Strategies on how to increase LCS awareness. 3. Recommendations on how to improve current practices.	<u>Primary care team members</u> • What information do you think patients need to know in order to decide getting screened for LCS? • We are planning on using MyChart (also known as MyUCDavisHealth) to deliver educational material regarding LCS before meeting with a pre visit planner, what recommendations do you have in making this intervention successful? • How can we help you educate your patients about LCS? <u>Patients</u> • Are you familiar with MyChart (also known as MyUCDavisHealth)? Do you use MyChart? • Do you have recommendations on how to increase LCS awareness?
Implementation Process	1. PCTMs decision making as to who or when to refer a patient to LCS. 2. Training or information PCTMs receive pertaining to LCS.	<u>Primary care team members:</u> • How do you determine which of your patients are eligible for LCS? • How can we help you educate your patients about LCS?

Appendix C. Domain, Summary Finding, Recommendation

Domain	Summary Findings	Recommendations
Innovation	• MyChart is a web-based tool already used by most patients to keep track of their health history and future appointments. • Developing multiple forms of educational materials is imperative, given that not everyone has or is comfortable using technology.	• Incorporate LCS into the "To Do List" feature on MyChart to remind patients of annual LCS • Use MyChart to send personalized messages from PCTMs, including educational materials: emails, flyers, posters, or videos.

Outer Setting	• LCS is not a HEDIS measure, therefore not prioritized by PCTMs.
	• There is a need for LCS media campaigns.
	  - Current efforts use "fear tactics" to promote smoking cessation and lung cancer.
	• Challenges in health access: including insurance and transportation.
		• Support the National Committee for Quality Assurance efforts to make LCS a HEDIS quality measure.
		• Develop a media campaign borrow successful strategies from other cancer screening efforts.
		• Promote health coverage information during SDM
		• Invest in an LDCT scanner in a rural area.
		  - Develop MOUs with other clinics/ health systems in the area to communicate when a screening is done at their facility.

Inner Setting	• Missing universal workflow • Incorrect smoking history in EMR • PCTM's time barrier	• Update patient smoking history in EMR. • Support patients in scheduling LCS appointments in a timely manner. • Send annual appointment reminders
Individual	• Limited LCS knowledge prior to discussing with PCTMs. • Barriers = Risk of radiation exposure and false positives • Facilitator = Undergoing other screenings and having a family history of cancer.	• Develop a visual aid that can show patients what to expect on the day of the appointment.

Implementation Process	• Do not rely on one method of education distribution.
	  - Recommendations to develop educational materials in hard copy and digital formats.
	• Educational material should include written and visual information.
	  - Written: eligibility, cost, and length of screening
	  - Visual: An image of an LDCT scanner
	• Messaging should come from the primary care provider.
	• Information should be in layman's terms and concise.
		• Develop an outreach strategy on educational materials that meets the needs of patients.
		• Keep track of unopened messages on MyChart.
		  - Mail a hard copy if the message is not opened.
		• Space out bulk messaging so that EPs can be seen in a timely manner.

Tables

Table 1. Characteristics of patient and primary care team member participants

Patient Characteristics	Number	Percent
Sex		
Female	16	67%
Male	7	33%
Race/Ethnicity		
African American	1	4.3%
Hispanic or Latino	3	13%
White	14	61%
Other	2	8.7%
Decline to State	3	13%
Patient Group		
Eligible patient who received Lung Cancer Screening	12	52%
Eligible patient who did not receive Lung Cancer Screening	11	48%
Primary Care Team Member Characteristics		
Sex		
Female	7	58%
Male	5	42%
Occupation		
Clinician	7	58%
Non-Clinician	5	42%

Figures

Figure 1. Conceptual Framework: Consolidated Framework for Implementation Research

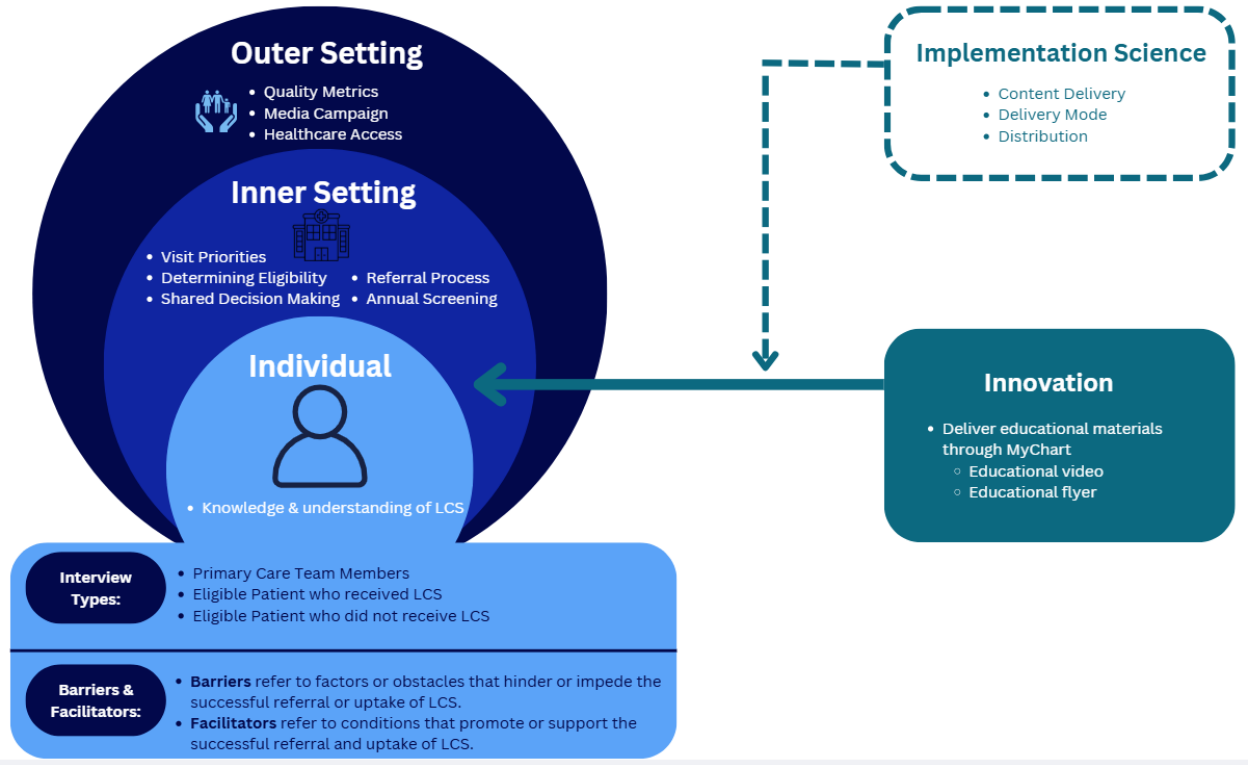
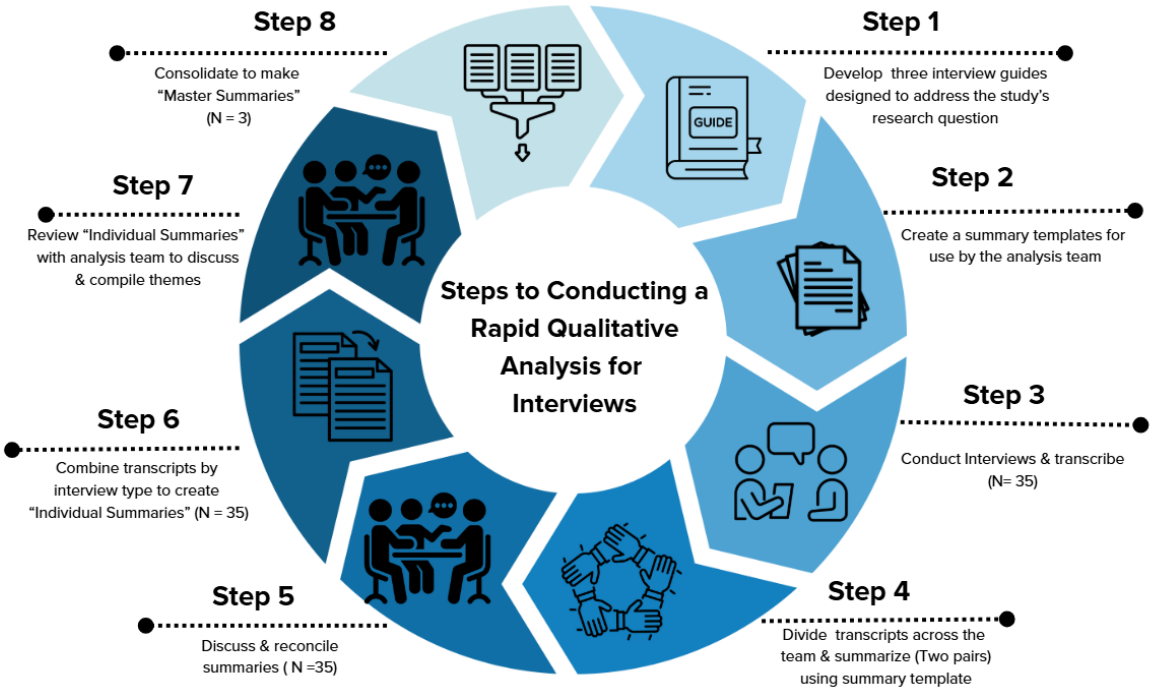


Figure 2. Steps to Conducting a Rapid Qualitative Analysis for Interviews



Chapter 3: Patient and provider factors associated with patient adherence to lung cancer screening between 2021-2024: A retrospective review of Electronic Medical Records

Abstract

Background: Lung cancer remains the leading cause of cancer-related death in the United States, driven in part by late-stage diagnosis, persistent tobacco use, socioeconomic and geographic barriers to care, and underutilization of low-dose computed tomography (LDCT) screening. Following updates to the 2021 United States Preventive Services Task Force (USPSTF) guidelines, a larger population is now eligible for lung cancer screening (LCS). This study aimed to identify factors associated with completion of LDCT screening after referral, including characteristics of eligible patients and referring providers documented in the electronic medical record under the expanded 2021 USPSTF guidelines.

Methods: This retrospective study included 2,665 patients referred for LCS at the University of California, Davis Health (UCDH) between 2021 and 2024. Patient-level characteristics included age, sex, race/ethnicity, smoking status, insurance type, marital status, referral type, and distance from patient residence to the screening facility. Referring provider-level variables available in the electronic medical record included sex, specialty, and years in clinical practice. Descriptive statistics were used to characterize the study population, and multivariable generalized linear models were used to identify factors associated with completion of LCS following referral. Analyses were performed using SAS (Academic version).

Results: Of the 2,665 patients referred for lung cancer screening, 1,798 patients (67.0%) completed LCS during the study period. Patients were predominantly non-Hispanic White (73.10%), male (51.11 %), aged 60-69 years (42.55%), married (51.82%), publicly insured

(71.41%), and former smokers (61.80%). Most patients received an LCS referral during a routine office visit (65.74%). A sequential modeling approach using generalized linear mixed models (GLIMMIX) was used to assess the relative contribution of patient- and provider-level characteristics to LCS completion. Model 1 included patient-level characteristics only, while Model 2 additionally incorporated referring provider characteristics. In adjusted analyses, LCS completion was more likely among patients aged 70-80 (OR = 2.62, 95% CI: 1.77, 3.88; p <.0001), those identifying as Asian (OR= 2.09, 95% CI: 1.31, 3.33; p = 0.002), and those with referral type classified as other/unknown (OR= 1.49, 95% CI: 1.21, 1.85; p=<.0002). Referrals from providers with more than 20 years of clinical practice were also associated with higher odds of screening completion; although, this association did not reach statistical significance (OR = 1.31, 95% CI: 0.91, 1.90; p = 0.15).

Conclusions: This study identified several patient-level factors associated with LCS completion following referral during the first four years following implementation of the 2021 USPSTF screening guidelines. The findings suggest that demographic and referral-related characteristics may influence screening completion among eligible patients and highlight potential disparities in understanding these early patterns of guideline implementation can inform targeted outreach, patient navigation, and other evidence-based strategies aimed at improving screening completion and promoting equitable access to lung cancer screening services.

Keywords: lung cancer screening; low-dose computed tomography (LDCT); screening adherence; health disparities; patient-level factors; provider characteristics; cancer prevention; USPSTF guidelines

1.0 Introduction

For decades, lung cancer has been the leading cause of cancer death in the United States (U.S). In a recent report by the American Lung Association, they reported that lung cancer accounts for 22% of deaths in the U.S.[1,2] To address this burden, multiple strategies, including smoking cessation, early detection, and timely treatment, are needed, with lung cancer screening (LCS) using low-dose computed tomography (LDCT) recommended for eligible individuals. In an effort to improve early detection of lung cancer, the United States Preventive Services Task Force (USPSTF) updated its LCS guidelines on March 9, 2021. Under the revised recommendations, individuals aged 50 to 80 years with a ≥20 pack-year smoking history who currently smoke or have quit within the past 15 years are eligible for screening.[3] As a part of broader efforts to reduce lung cancer mortality, low-dose computed tomography (LDCT) remains the recommended screening modality for eligible high-risk individuals.[4] These updates were informed by evidence demonstrating that expanded eligibility would improve early detection and survival among high-risk groups.[5–7] The revised criteria nearly doubled the eligible screening population,[1,6] were projected to increase early detection by approximately 30%, [6,8] and were estimated to prevent an additional 30,000 to 60,000 lung cancer deaths annually.[6] Despite the expansion of these guidelines, screening uptake remains low, with only 1 in 5 eligible adults in the U.S. undergoing LCS.[9]

LCS uptake is critical for early detection and reducing lung cancer mortality.[10] Receipt of a referral for LCS has been identified as a key facilitator of screening completion.[11] The referral process typically involves identifying potentially eligible patients, verifying eligibility, engaging in shared decision making (SDM), and placing a screening order. Given that smoking

is the primary risk factor for lung cancer, accurate assessment of smoking history plays a vital role in determining LCS eligibility.

Potentially eligible patients are identified through review of smoking history in the electronic health record (EHR) or during a clinical encounter. Eligibility is verified through pack-year calculations, defined as the number of packs smoked per day multiplied by the number of years smoked, and is typically performed by healthcare providers or other members of the care team.

Once eligibility is established, patients participate in an SDM visit to discuss the risks and benefits of screening and make an informed decision. If a patient consents to screening, their provider places a referral. While a patient may receive an LCS referral, screening uptake is not always guaranteed. Studies have shown that approximately 46-62% of patients complete their LDCT within 90 days of a referral.[10,12]

Determinants of LCS uptake are influenced by multilevel factors. At the patient level, prior studies have identified sociodemographic and behavioral influences on screening adherence. Sociodemographic characteristics associated with higher LCS participation include being White[13], male, married, being insured, and residing in closer proximity to screening facilities. Behavioral factors also play a significant role: individuals who are former smokers[14] and those who attend routine health visits are more likely to adhere to LCS when receiving a recommendation from a provider. On the other hand, provider-level factors for LCS uptake upon referral are less known. Existing literature has mostly focused on provider attitudes toward LCS.[15]

This chapter examines patient-level factors and selected referring provider characteristics associated with completion of low-dose computed tomography (LDCT) screening following referral among individuals eligible for lung cancer screening at the University of California, Davis Health (UCDH) between 2021 and 2024. By identifying factors associated with screening completion during the early years following implementation of the expanded 2021 USPSTF guidelines, this study provides insight into patterns of screening adherence and may inform targeted interventions to improve participation in lung cancer screening among high-risk individuals.

2.0 Materials and Methods

2.1. Study Population and Setting

Electronic health records (EHRs) from the University of California, Davis Health (UCDH) were queried to identify patients referred for lung cancer screening (LCS) between 2013 and 2024 (N=16,114). Given that the objective of this study was to examine factors associated with screening completion following the implementation of the 2021 USPSTF lung cancer screening guidelines expansion, analyses were restricted to referrals between March 2021 and December 2024. This study was conducted within the UCDH health system, which includes 17 primary care clinics serving communities throughout the greater Sacramento region, with clinic locations in: Auburn, Carmichael/Citrus Heights, Davis, Elk Grove, Folsom, Rancho Cordova, Rocklin; Roseville, and Sacramento (multiple locations). Patients referred for screening could complete low-dose computed tomography (LDCT) screening at one of the three UCDH imaging facilities, all located in Sacramento, CA. This study was approved by the UCDH Institutional Review Board (IRB ID: 2198602-1). The requirement for informed consent was waived because the study involved retrospective review of existing electronic health record data.

Eligible patients included individuals referred to LCS at UCDH between March 2021 and December 2024 who met the 2021 USPSTF screening eligibility criteria. Consistent with the USPSTF recommendations, eligible individuals were defined as adults aged 50-80 years who were current smokers or former smokers who had quit within the past 15 years and had a tobacco smoking history of at least 20 pack-years.[3] Screening referrals and screening completion were identified using electronic health record order code "CT lung screening". Referring providers were defined as UCDH clinicians who placed an LCS referral during the study period. Providers were defined as UCDH referring clinicians during the study period. From an initial cohort of 16,114 referral records identified between 2013 and 2024, exclusions were applied sequentially. Records were excluded if the referral occurred before implementation of the 2021 USPSTF guideline expansion (n = 9,019), if the referral-to-screening interval was negative (n = 1,812), if the record was identified as a duplicate (n = 2,341), or if the patient did not meet the USPSTF age eligibility criteria (n = 277). The final analytic sample consisted of 2,665 unique patients referred for LCS.

To ensure a single analytic observation per patient, the interval between the referral date and screening data was calculated in days. Records with negative referral-to-screening intervals, indicating that the documented screening date preceded the referral date, were excluded because they likely reflected data entry errors or inconsistencies in the electronic health record. The dataset was then sorted by patient medical record number (MRN) and encounter date, and duplicate records were removed. For patients with multiple referrals, the most recent referral and associated screening information were retained for analysis. This process resulted in one unique observation per patient.

Provider-level data characteristics were obtained from multiple sources, including the UCDH electronic health record (EHR) system, the National Plan Provider Enumeration System (NPPES)[16], and publicly available UCDH provider biography webpages, which are updated annually. For providers without available biography pages, supplemental information (predominantly the year of graduation) was obtained via a Google search. Provider data were primarily derived from the ProcedureOrderFact table, an EHR database table that captures information related to ordered clinical procedures. This table was used to identify the provider associated with the LCS referral, with the billing provider selected as the primary provider of record due to its completeness relative to other provider fields. Both provider and patient tables were linked to the ProcedureOrderFact table to ensure accurate attribution of the ordering provider. This study focused specifically on providers responsible for initiating referrals rather than those performing the screening. Demographic data include provider's sex, specialty, clinician type and years practiced. Years in practice were calculated by subtracting the provider's year of medical school graduation from the year in which the referral was made.

2.2. Variables

Patient-level factors included sociodemographic and behavioral characteristics. Sociodemographic variables included age (50-54, 55-59, 60-69, and 70-80), sex (Male/Female), Race/Ethnicity (non-Hispanic White, African American (AA)/Black, American Indian/ Alaskan Native AIAN, Asian, Hispanic, Other, and Unknown); marital status (Married, Not Married, Unknown); insurance (Private, Public), and distance from their home to a screening location (miles). Behavioral factors, which are patients' habits or life choices, include smoking status (Current Smoker, Former Smoker, or Never Smoker/Unknown) and referral type, which refers to the reason for attending a clinical visit (Routine Office Visit, Urgent/Acute Care, or

Other/Unknown). Provider-level factors included sex (male, female), specialty (Medical Subspecialty, Primary Care, Other/Unknown), and years of practice at the time of referral (<5, 5-9,10-20, >20). Primary care providers included physicians specializing in family medicine, family practice, general practice, and internal medicine, as well as advanced practice providers (e.g., nurse practitioners and physician assistants). Providers with multiple specialty designations that included a primary care specialty were classified primary care. A complete description of variable coding, recategorization procedures, and corresponding classifications, based on the literature, is provided in Appendix A.

2.3 Statistical analysis

Descriptive analyses were conducted to characterize the study population and referring providers according to lung cancer screening (LCS) completion status (completed vs. not completed). Categorical variables are presented as frequencies and percentages, and differences between groups were assessed using Pearson's chi-squared test.

To evaluate factors associated with screening completion, multivariable mixed-effects logistic regression models using the GLIMMIX procedure in SAS. Because patients were clustered within referring providers, a provider-specific random intercept was included to account for potential within-provider correlation and obtain valid estimates of association. Fixed effects included patient- and provider-level characteristics hypothesized a priori to influence completion based on existing literature and findings from preceding dissertation chapters.

Results are presented as adjusted odds ratios (ORs) and corresponding 95% confidence intervals (CIs). Statistical significance was assessed using two-sided tests with an alpha level of 0.05.

A sequential modeling strategy was used to examine the relative contribution of patient- and provider-level characteristics to screening completion. Model 1 included only patient-level characteristics: age, sex, race/ethnicity, smoking status, insurance type, marital status, referral type, and distance from the patients' residence to the closest UCDH screening facility. Model 2 additionally incorporated provider-level characteristics, including sex, specialty, and years of clinical experience at the time of referral. Comparison of these nested models allowed for evaluation of whether the inclusion of available provider characteristics improve the explanation of variation in screening completion beyond patient-level factors alone.

All analyses were conducted using SAS (Academic Version; SAS Institute, Cary, NC).

3.0 Results

The final analytic sample comprised 2,665 patients referred for lung cancer screening (LCS) between March 2021 and December 2024, of whom 1,798 (67.5%) completed LDCS after referral. Table 1 summarizes patient characteristics stratified by LCS completion status. Overall, the study population was predominantly non-Hispanic White (73.10%), followed by Hispanic (7.05%), African American/Black (6.12%), Asian (5.07%), Other (5.25%), and Unknown race/ethnicity (3.41%). Most patients were male (51.11%), aged 60-69 years (42.55%), married (51.82%), publicly insured (71.41%), and former smokers (61.80%). Most referrals were initiated during routine office visits (65.74%), whereas referrals originating from urgent or acute care encounters were less common (e.g., emergency department referrals, telehealth visits).

Bivariate analyses revealed significant differences in lung cancer screening (LCS) completion across several patient characteristics (Table 1). Patients who completed screening differed significantly from those who did not with respect to age ($p < .0001$), race/ethnicity ($p <$

.0001), marital status (p < .0001), insurance type (p = .0003), smoking status (p < .0001), and referral type (p = .0074). In contrast, screening completion did not differ significantly by patient sex (p = .73) or distance from the patient's residence to the screening facility (p = .12), although patients who did not complete screening resided farther from the screening site on average than those who completed screening (37.15 vs. 25.04 miles, respectively). Compared to patients who did not complete LDCT screening, patient age (<.0001), race/ethnicity (<.0001), marital status (<.0001), insurance type (0.0003), smoking status (<.0001), and referral type (0.0074) were significantly associated with LCS uptake. However, patients who did not complete their screening lived further (on average) from the imaging center where LCS was performed (25.04 miles vs 37.15 miles, p = 0.12). There were no significant differences in patient sex (0.7347) or distance from the patient's home to the screening.

Characteristics of referring providers who referred at least one patient for LCS are described in Table 2. A total of 488 UC Davis Health providers referred at least one patient for LCS during the study period. The median number of referrals per provider was 1 (IQR: 1–4), with referral counts ranging from 0 to 54 patients. Providers were predominantly female (59.84%), practiced primarily in primary care specialties (79.51%), and had more than 20 years of clinical experience. When comparing LCS completion among patients referred by providers with different characteristics, provider sex (p = 0.84) and specialty (p = 0.13) were not significantly associated with screening completion. However, years in practice were significantly associated with screening completion (p = 0.002).

Table 3 presents the results of the multivariable mixed-effects logistic regression model examining the association between patient-level characteristics and LCS completion. After adjustment for all covariates, several patient characteristics remained significantly associated

with screening completion. Patients aged 70-80 had significantly higher odds of completing screening compared with patients aged 50–54 years (OR = 2.68, 95% CI: 1.81–3.96). Similarly, patients whose referral type was categorized as other/unknown were more likely to complete screening than those referred during a routine office visit (OR = 1.47, 95% CI: 1.28–1.88).

In contrast, African American/Black patients had significantly lower odds of LCS completion compared with non-Hispanic White patients (OR = 0.53, 95% CI: 0.38–0.76). Lower odds of screening completion were also observed among patients with unknown marital status compared with married patients (OR = 0.25, 95% CI: 0.13–0.47) and among patients categorized as never smokers/unknown relative to former smokers (OR = 0.61, 95% CI: 0.51–0.74). Collectively, these findings suggest that demographic, behavioral, and referral-related characteristics were important predictors of screening completion following referral. Non-significant factors of LCS completion in this table included being female compared to male (OR = 1.02, 95% CI:0.85-1.23), and having private insurance (OR= 0.85, 95% CI: 0.68-1.06).

Table 4 presents the results of the multivariable mixed-effects logistic regression model incorporating both patient- and provider-level characteristics associated with LCS completion following referral. Compared with the patient-only model (Table 3), the inclusion of provider characteristics led to minimal changes in the observed patient-level associations. After adjustment for all patient- and provider-level covariates, patients aged 70-80 had significantly higher odds of completing screening compared with patients aged 50–54 years (OR = 2.62, 95% CI: 1.77–3.88). Asian patients were also more likely to complete screening than non-Hispanic White patients (OR = 2.09, 95% CI: 1.31–3.33). In addition, patients whose referral type was categorized as other/unknown had higher odds of screening completion compared with those referred during routine office visits (OR = 1.49, 95% CI: 1.21–1.85). These findings indicate that

patient-level characteristics remained important predictors of screening completion even after accounting for available provider characteristics.

Conversely, African American/Black patients were significantly less likely to complete lung cancer screening than non-Hispanic White patients (OR: 0.55, 95% CI: 0.39, 0.78). Similarly, patients with unknown marital status (OR = 0.26, 95% CI: 0.13–0.49) and those classified as never smokers/unknown had lower odds of screening completion compared with married patients and (OR = 0.61, 95% CI: 0.51–0.74) had lower odds of screening completion compared with married patients and former smokers, respectively.

4.0 Discussion

Using electronic health records (EHR) data from patients referred for LCS between March 2021 and December 2024 within a large academic health system, this study examined patient- and provider-level factors associated with completion of LDCT screening following implementation of the 2021 USPSTF guideline expansion. Overall, 67.5% of referred patients completed LCS during the study period. In a multivariable analysis, patients aged 70-80 years, Asian race/ethnicity, and referral types categorized as other/unknown were associated with her odds of screening completion, whereas African American/ Black race, unknown marital status, and never smoker/unknown smoking status were associated with lower odds of completion. Provider characteristics demonstrated a limited association with screening outcomes. These findings suggest that patient-level factors continue to play an important role in screening adherence following referral and identifying populations that may benefit from targeted interventions to improve LCS completion.

Although several patient-level characteristics were independently associated with screening completion, the provider characteristics examined in this study contributed little additional explanatory value. The persistence of associations with age, race/ethnicity, smoking status, marital status, and referral type after adjustment suggests that factors operating at the patient level may be particularly important determinants of screening completion following referral. These findings underscore the need to better understand barriers to screening adherence among populations with lower completion rates. Instead, barriers related to access, health literacy, social support, competing priorities, perceptions of lung cancer risk, or engagement with the health system may continue to influence whether patients complete screening. Understanding and addressing these barriers may be critical for improving LCS and reducing disparities.

Approximately two-thirds of patients referred for LCS completed screening following referral. This completion rate is lower than those reported in several prior studies, which have documented higher completion rates following referral.[17–19] However, many of these previous studies were conducted under the 2013 USPSTF screening guidelines and frequently evaluated more selective patient populations, such as individuals who completed a shared decision-making (SDM) visit prior to referral. For example, a one-year retrospective study conducted within an academic health system (n =171) reported that 89% of referred patients completed LCS after participating in an SDM visit. In contrast, the present study evaluated all eligible patients who received an LCS referral during the early years following the implementation of the 2021 USPSTF guideline expansion, regardless of documented SDM participation. This broader inclusion likely provides a more representative estimate of real-world screening completion by capturing greater heterogeneity in referral pathways, patient engagement, and follow-through after referral. More broadly, these findings suggest that referral alone may not be sufficient to

ensure screening completion and highlight the need for additional strategies, such as patient navigation, follow-up outreach, and care coordination, to support patients through the screening process. Findings from Chapter 2 identified difficulty reaching scheduling staff and long wait times for LCS appointments among patients from the same health system as important barriers to screening completion. Chapter 1, proposed patient navigation as a potential strategy to address barriers amongst patients who had been referred by supporting eligible patients through multiple steps of the screening process, including facilitating SDM, assisting with appointment scheduling, and helping to overcome logistical barriers that may delay or prevent screening completion. Collectively, these findings demonstrate that successful implementation of the 2021 USPSTF guidelines requires multilevel strategies beyond referral alone and implementing multilevel strategies that support patients throughout the LCS continuum.

At the patient level, increasing age was associated with a greater likelihood of LCS completion, with patients aged 55–80 years demonstrating higher screening completion compared with those aged 50–54 years. One possible explanation is that individuals aged 50-54 only recently became eligible for screening under the 2021 USPSTF guideline expansion and, therefore, may not yet be fully integrated into routine LCS identification and referral workflows.[3] These study results are consistent with a recent cross-sectional analysis of the 2024 Behavioral Risk Factor Surveillance System dataset (n = 26,104), which reported substantially lower rates of up-to-date LCS among individuals aged 50-54 (11.3%) compared with older eligible age groups.[20,21] Together, these findings suggest that expansion of screening eligibility alone may not be sufficient to achieve comparable screening completion across all eligible age groups, especially the newly eligible individuals. Additional research is needed to understand factors that

may influence screening completion among newly eligible individuals, including awareness of updated guidelines, perceptions of lung cancer risk, and engagement with their health home.

The lower completion observed among younger eligible adults highlights the need for targeted implementation strategies to improve identification, referral, and follow-through in this population. Prior studies, including Chapter 1 of this dissertation, have highlighted the importance of multilevel approaches, including system-level interventions such as automated EHR-based eligibility prompts, provider-focused strategies designed to increase awareness of updated screening guidelines, and patient-centered outreach and navigation programs to support screening engagement among newly eligible individuals. [22] Potential recruitment strategies as suggested in Chapter 1 include checking eligibility among dual eligible patients, such as patients during their mammography visits, or collaborating with community-based organizations that provide services to underserved communities.

In addition to age-related differences, this study identified significant variation in LCS completion across racial and ethnic groups. Compared with non-Hispanic White patients, several racial/ethnic minority populations demonstrated differences in screening completion. Although the study population was predominantly non-Hispanic White, these findings are consistent with a broader body of literature documenting persistent racial and ethnic disparities in LCS access and utilization. For example, a systematic review of 26 studies examining racial inequalities in LCS eligibility and access in the U.S reported that Black, Hispanic, and Asian populations frequently experienced lower eligibility rates and reduced access to screening compared to White populations.[23] Prior literature has attributed these disparities to multiple factors, including differences in healthcare access, awareness of screening eligibility, and provider recommendations. More importantly, these inequities persist despite evidence that some racial

and ethnic minority groups experience disproportionality, higher lung cancer morbidity, and mortality. [24–26] Together, these findings highlight the need for targeted, equity-focused interventions to improve LCS access, referral practices, and patient engagement among historically underserved populations.

In contrast to patient-level factors, provider characteristics, including sex, specialty, and years in practice, were not significantly associated with LCS completion after adjusting for patient characteristics. These null findings should be interpreted in the context of several considerations from the study. First, the provider-level measures available in the electronic health record were limited and did not capture factors previously identified as important determinants of LCS implementation, such as provider knowledge of screening guidelines, attitudes toward screening, communication practices, competing clinical priorities, or familiarity with eligibility criteria. Second, the study cohort was restricted to patients who had already received an LCS referral. Consequently, the analysis may not fully capture provider-level barriers that influence earlier stages of the screening pathway, including the identification of screening-eligible patients and the decision to recommend and refer for screening. Together, these factors may have reduced variability in provider-related influences and limited the ability to detect associations between provider characteristics and screening completion following referral. These findings suggest that, among patients who have already been referred for screening, variation in LCS completion may be more strongly influenced by patient-level and broader health system factors than by the provider characteristics examined in this study.

However, both prior literature and findings from Chapters 1 and 2 of this dissertation indicate that provider- and system-level factors remain important determinants of LCS implementation earlier in the screening pathway. For example, a mixed-methods systematic

review of 36 studies published between 2013 and 2020 identified provider knowledge, attitudes toward screening, competing clinical priorities, and familiarity with screening guidelines as important barriers to identifying and referring eligible patients for LCS. Consistent with these findings, primary care team interviews conducted in Chapter 2 highlighted several challenges with LCS implementation. Participants reported that the absence of LCS as a Healthcare Effectiveness Data and Information Set (HEDIS) quality measure reduced organizational prioritization of screening efforts relative to other preventive services. These findings suggest that policy-level incentives may play an important role in promoting LCS implementation and highlight the need for future research examining policy-related barriers and facilitators. Primary care team members also described challenges associated with assessing smoking history and determining screening eligibility, noting that these processes often required substantially more time than other preventive screening recommendations. Participants suggested that more systematic approaches to documenting and leveraging smoking history could facilitate the identification of eligible patients while simultaneously informing other smoking-related health interventions. Similarly, findings from Chapter 1 suggested that assessment of LCS eligibility could potentially be integrated into tobacco cessation services, such as Quitlines, creating additional opportunities to identify screening-eligible individuals outside of routine primary care visits. Future studies should explore strategies to assess LCS eligibility during smoking cessation counseling and tobacco treatment encounters, rather than relying predominantly on routine office visits.

Collectively, these findings suggest that provider-related barriers may be most influential during the identification and referral stages of the screening process, which were not directly captured in the present analysis of screening completion following referral. Future studies should

therefore evaluate the full population of screening-eligible patients, including those who were never referred for screening, and incorporate more comprehensive provider-level measures to better characterize provider influences on screening identification, referral practices, and downstream screening completion. Additionally, future research should examine policy-level facilitators, including the role of quality performance measures such as HEDIS, and evaluate workflow innovations that integrate LCS eligibility assessment across clinical and tobacco cessation settings.

5.0 Limitations

Several limitations should be considered when interpreting the findings. First, the analysis relied on electronic health records (EHRs), which are subject to potential misclassification and incomplete documentation. In particular, LCS completion may have been underestimated if patients completed low-dose computed tomography (LDCT) outside UCDH (i.e., other unaffiliated healthcare facilities) and those records were not captured within the EHR. However, given the limited number of sites where an LDCT is performed, the likelihood of substantial misclassification of screening completion is expected to be low.

Second, smoking history may be more susceptible to measurement error, as it depends on both accurate patient self-report and consistent clinical documentation. Factors such as smoking-related stigma, recall challenges (particularly among older adults), and variability in how smoking history is recorded within the EHR may contribute to inaccuracies. For example, smoking information may be documented within free-text clinical notes rather than standardized EHR fields, potentially reducing data consistency and completeness.

Thirdly, although the analysis adjusted for several patient- and provider-level characteristics, other important determinants of LCS completion were not available within the EHR dataset. Unmeasured factors such as socioeconomic status, health literacy, transportation barriers, language preference, patient perceptions of screening, provider communication practices, and health system navigation support may also influence screening completion.

Fourthly, this analysis was restricted to patients who had already received an LCS referral. As a result, the study may not have fully captured provider influences that occurred earlier in the screening process, including identifying LCS eligible patients, assessing eligibility, and recommending screening.

Finally, although our analysis utilizes EHR data and controlled for patient and provider characteristics, we were unable to account for other factors that may influence LCS completion, including patient health literacy, transportation access, socioeconomic barriers, perceptions of screening, provider communication practices, and health system factors such as appointment availability and care coordination. Future studies should incorporate multilevel measures to better understand barriers and facilitators influencing LCS completion.

5.0 Conclusion

Over a three-year period, more than half of the patients referred received an LCS. Several patient-level factors were associated with screening completion, including patients' age, race/ethnicity, and referral type, whereas provider-level characteristics were not significantly associated with screening completion after adjustment for patient factors. Receiving an LCS referral is an important step in the screening process because it generally indicates that screening eligibility has been assessed and screening has been discussed with the patient. Despite receiving

a referral, LCS completion is not guaranteed, and understanding factors associated with failure to complete screening after referral is essential for improving LCS completion and reducing gaps in screening participation.

In this study, among patients who had already received an LCS referral, patient-level factors were the primary predictors of screening completion, whereas provider characteristics available in the EHR were not significantly associated with completion after adjustment. Specifically, higher completion was observed among patients with certain demographic and clinical characteristics, including age, race/ethnicity, smoking status, marital status, and referral type. These findings suggest that, within the screening process stages following a patient's referral, variation in completion is more strongly influenced by patient-level factors than by the provider characteristics measured in the study. However, receipt of a referral does not guarantee screening completion, and identifying determinants of post-referral adherence is essential for improving the effectiveness of LCS programs.

This study contributes to the growing literature on LCS implementation by focusing specifically on screening completion after receiving a referral in the context of the 2021 USPSTF guideline expansion. The findings demonstrate that screening completion remains suboptimal even among referred patients and that patient-level factors are strong predictors of completion in this stage of care. These results suggest that efforts to improve LCS should focus on barriers occurring after referral, particularly among newly eligible individuals and populations that experience lower completion rates. Targeted strategies such as patient navigation, culturally tailored education, and improved documentation and use of smoking history in the EHR may help address these barriers. Furthermore, future research should focus on identifying barriers that

occur after an individual is referred and evaluating interventions designed to support screening completion among referred patients.

References

1. Krist AH, Davidson KW, Mangione CM, et al. Screening for lung cancer: US preventive services task force recommendation statement. *JAMA*. 2021;325(10):962-970. doi:10.1001/jama.2021.1117

2. U.S. Preventive Services Task Force. Lung cancer screening: recommendation statement. *Ann Intern Med*. 2004;140(9):738-739. doi:10.7326/0003-4819-140-9-200405040-00014

3. USPSTF Recommendations Development Process | United States Preventive Services Taskforce. Accessed March 12, 2025. https://www.uspreventiveservicestaskforce.org/uspstf/about-uspstf/task-force-resources/uspstf-recommendations-development-process

4. Henderson LM, Su I-H, Rivera MP, et al. Prevalence of lung cancer screening in the US, 2022. *JAMA Netw Open*. 2024;7(3):e243190. doi:10.1001/jamanetworkopen.2024.3190

5. Liu Y, Halpern MT, Volk RJ, Shih Y-CT. Characteristics of the Newly Eligible Population under Two Recent Updates of Lung Cancer Screening Recommendations. *Cancer Prev Res (Phila Pa)*. 2025;18(6):365-373. doi:10.1158/1940-6207.CAPR-24-0465

6. Marshall RC, Tiglao SM, Thiel D. Updated USPSTF screening guidelines may reduce lung cancer deaths. *J Fam Pract*. 2021;70(7):347-349. doi:10.12788/jfp.0257

7. Ritzwoller DP, Meza R, Carroll NM, et al. Evaluation of Population-Level Changes Associated With the 2021 US Preventive Services Task Force Lung Cancer Screening Recommendations in Community-Based Health Care Systems. *JAMA Netw Open*. 2021;4(10):e2128176. doi:10.1001/jamanetworkopen.2021.28176

9. Bandi P, Landy R, Star J, Kratzer TB, Smith RA, Jemal A. Lung Cancer Deaths Prevented and Life-Years Gained From Lung Cancer Screening. *JAMA*. November 19, 2025. doi:10.1001/jama.2025.19798

10. Neslund-Dudas C, Tang A, Alleman E, et al. Uptake of Lung Cancer Screening CT After a Provider Order for Screening in the PROSPR-Lung Consortium. *J Gen Intern Med*. 2024;39(2):186-194. doi:10.1007/s11606-023-08408-9

11. Belachew SA, Bizuayehu HM, Diaz A, Garvey G. Facilitators and barriers of lung cancer screening participation: umbrella and systematic review of the global evidence. *BMC Public Health*. 2025;25(1):2993. doi:10.1186/s12889-025-23808-8

12. Sifri R, Indictor A, Myers R. Increasing Lung Cancer Screening Referral/Order and Completion Rates in Primary Care through Patient Outreach. In: *Screening, Prevention,*

and Health Promotion. American Academy of Family Physicians; 2025:7635. doi:10.1370/afm.23.s1.7635

13. Aredo JV, Choi E, Ding VY, et al. Racial and Ethnic Disparities in Lung Cancer Screening by the 2021 USPSTF Guidelines Versus Risk-Based Criteria: The Multiethnic Cohort Study. *JNCI Cancer Spectr*. 2022;6(3). doi:10.1093/jncics/pkac033

14. Wu F-Z, Wu Y-J, Chen C-S, Yang S-C. Impact of Smoking Status on Lung Cancer Characteristics and Mortality Rates between Screened and Non-Screened Lung Cancer Cohorts: Real-World Knowledge Translation and Education. *J Pers Med*. 2022;12(1). doi:10.3390/jpm12010026

15. Rajupet S, Doshi D, Wisnivesky JP, Lin JJ. Attitudes about lung cancer screening: primary care providers versus specialists. *Clin Lung Cancer*. 2017;18(6):e417-e423. doi:10.1016/j.cllc.2017.05.003

16. NPPES NPI Registry. Accessed May 1, 2026. https://npiregistry.cms.hhs.gov/help/help-home

17. Rennert L, Zhang L, Lumsden B, et al. Factors influencing lung cancer screening completion following participation in shared decision-making: A retrospective study in a U.S. academic health system. *Cancer Treatment and Research Communications*. 2020;24:100198. doi:10.1016/j.ctarc.2020.100198

18. Mazzone PJ, Tenenbaum A, Seeley M, et al. Impact of a Lung Cancer Screening Counseling and Shared Decision-Making Visit. *Chest*. 2017;151(3):572-578. doi:10.1016/j.chest.2016.10.027

19. Tanner NT, Banas E, Yeager D, Dai L, Hughes Halbert C, Silvestri GA. In-person and Telephonic Shared Decision-making Visits for People Considering Lung Cancer Screening: An Assessment of Decision Quality. *Chest*. 2019;155(1):236-238. doi:10.1016/j.chest.2018.07.046

20. Burus T, McAfee CR, Knight JR, Mullett TW, Hull PC. Lung cancer screening prevalence and changes in 2024. *JAMA Intern Med*. April 27, 2026. doi:10.1001/jamainternmed.2026.0493

21. Núñez ER, Ito Fukunaga M, Stevens GA, et al. Review of interventions that improve uptake of lung cancer screening: A cataloging of strategies that have been shown to work (or not). *Chest*. 2024;166(3):632-648. doi:10.1016/j.chest.2024.04.019

22. Reese TJ, Schlechter CR, Kramer H, et al. Implementing lung cancer screening in primary care: needs assessment and implementation strategy design. *Transl Behav Med*. 2022;12(2):187-197. doi:10.1093/tbm/ibab115

23. Yambao Yang Y, McNamara C, Stuckler D. Racial inequalities in eligibility and access to lung cancer screening: systematic review of United States studies. *BMC Public Health*. 2025;25(1):3978. doi:10.1186/s12889-025-24761-2

24. Antigua-Made A, Nguyen S, Rashidi A, Chen W-P, Ziogas A, Sadigh G. Lung cancer screening completion among patients using decision aids: a systematic review and meta-analysis. *Cancer Causes Control*. 2025;36(9):871-885. doi:10.1007/s10552-025-01987-4

25. Wang GX, Baggett TP, Pandharipande PV, et al. Barriers to Lung Cancer Screening Engagement from the Patient and Provider Perspective. *Radiology*. 2019;290(2):278-287. doi:10.1148/radiol.2018180212

26. Kunitomo Y, Bade B, Gunderson CG, et al. Evidence of Racial Disparities in the Lung Cancer Screening Process: a Systematic Review and Meta-Analysis. *J Gen Intern Med*. 2022;37(14):3731-3738. doi:10.1007/s11606-022-07613-2

Tables

Table 1. Characteristics of Participants by Lung Cancer Screening Status (2021–2024)

Characteristic	Total (N=2665)	Screened (n= 1,798)	Not Screened (n=867)	P value
		n%	n%	
Age (years)				**<.0001**
50-54	161 (6.04)	82 (4.56)	79 (9.11)	
55-59	248 (9.31)	148 (8.23)	100 (11.53)	
60-69	1134 (42.55)	744 (41.38)	390 (44.98)	
70-80	1122 (42.10)	824 (45.83)	298 (34.37)	
Sex				0.7347
Male	1362 (51.11)	923 (51.33)	439 (50.63)	
Female	1303 (48.89)	875 (46.67)	428 (49.37)	
Race/Ethnicity				**<.0001**
White	1948 (73.10)	1341 (74.58)	607 (70.01)	
AA/Black	163 (6.12)	89 (4.95)	74 (8.54)	
Asian	135 (5.07)	108 (6.01)	27 (3.11)	
Hispanic	188 (7.05)	131 (7.29)	57 (6.57)	
Other	140 (5.25)	84 (4.67)	56 (6.46)	
Unknown	91 (3.41)	45 (2.50)	46 (5.31)	
Marital Status				**<.0001**
Not married	1223 (46.27)	975 (54.23)	427 (49.25)	
Married	1381 (51.82)	806 (44.83)	406 (46.83)	
Unknown	51 (1.91)	17 (0.95)	34 (3.92)	
Insurance Type				**0.0003**
Private	762 (28.59)	475 (26.42)	287 (33.10)	
*Public	1903 (71.41)	1323 (73.58)	580 (66.90)	
Smoking Status				**<.0001**
Current	127 (4.77)	89 (4.95)	38 (4.38)	
Former	1647 (61.80)	1186 (65.96)	461 (53.17)	
Never Smoker/Unknown	891 (33.43)	523 (29.09)	368 (42.45)	
Referral Type				**0.0074**
Routine Office Visit	1752 (65.74)	1149 (63.90)	603 (69.55)	
Urgent/Acute Care	131 (4.92)	87 (4.84)	44 (5.07)	
Other/Unknown	782 (29.34)	562 (31.26)	220 (25.37)	
Distance from the patient's home to the screening	30.12 (166.39)	25.04 (130.19)	37.15 (207.03)	0.12

Note: **Boldface** indicates statistical significance ($p<0.05$).

[a] % represents the proportion of patients included in each category of sociodemographic characteristics,

[b] % represents the proportion of patients within a variable category who received, or did not receive, LCS.

[c] Variables reported as mean (SD); otherwise as N (%).

Table 2. Characteristics of Referring Providers by Lung Cancer Screening Status (2021–2024)

Variable			Lung Cancer Screening				
			No[b]		Yes[b]		
	Total[a] (N=2,665)	Provider[a] (n=488)	N	Column %	N	Column %	P-Value
Sex							0.84
Male	1213 (45.52)	196 (40.16)	397	45.79	816	45.38	
Female	1452 (54.48)	292 (59.84)	470	54.21	982	54.62	
Specialty							0.13
Primary Care	2439 (91.52)	388 (79.51)	784	90.43	1655	92.05	
Medical Subspecialty	144 (5.40)	61 (12.50)	48	5.54	96	5.34	
Other/Unknown	82 (3.08)	39 (7.99)	35	4.04	47	2.61	
Years Practiced							**0.02**
<5	253 (9.49)	93 (19.06)	91	10.50	162	9.01	
5-9	557 (20.90)	138 (28.28)	194	22.38	363	20.19	
10-20	733 (27.50)	119 (24.39)	254	29.3	479	26.64	
>20	1122 (42.10)	138 (28.28)	328	37.83	794	44.16	

Note: **Boldface** indicates statistical significance (p<0.05).

[a] Variables reported as N (%), where % represents proportion of patients included in each category of the variables each category of the variable.

[b] Variables reported as N (%), where % represents the proportion of patients within a variable category who received, or did not receive, LCS.

Table 3. Adjusted Multivariable Regression Analysis of Patient-Level Characteristics Associated With Lung Cancer Screening Completion

Variable	Odds Ratio*	95% CI	P value
Age in years (*ref: 50-54*)			
55-59	1.56	(1.02-2.40)	**0.04**
60-69	1.92	(1.33-2.77)	**0.0005**
70-80	2.68	(1.81-3.96)	**<0.0001**
Sex (*ref: Male*)			
Female	1.02	(0.85-1.23)	0.81
Race/Ethnicity (*ref: Non-Hispanic White*)			
Hispanic	1.15	(0.81-1.63)	0.44
Non-Hispanic Asian	2.07	(1.30-3.30)	**0.002**
Non-Hispanic Black	0.53	(0.38-0.76)	**0.0005**
Non-Hispanic Other	0.65	(0.44-0.94)	**0.03**
Unknown	0.56	(0.35-0.89)	**0.001**
Marital Status (*ref: Married*)			
Not married	0.84	(0.70-1.01)	0.07
Unknown	0.25	(0.13-0.47)	**<0.0001**
Insurance Type (*ref: Public*)			
Private	0.85	(0.68-1.06)	0.14
Smoking Status (ref: Former)			
Current	0.91	(0.60-1.38)	0.65
Never Smoker/Unknown	0.61	(0.51-0.74)	**<0.0001**
Referral Type (ref: Routine Office Visit)			
Urgent/Acute Care	1.06	(1.19-1.81)	0.76
Other/Unknown	1.47	(1.28-1.88)	**<0.0004**

*Adjusted odds ratios (ORs), corresponding 95% confidence intervals (CIs), and p-values for factors associated with lung cancer screening (LCS) completion. Bolded values indicate statistical significance at $p < 0.05$.

Table 4. Adjusted Multivariable Regression Analysis of Patient- and Provider-Level Characteristics Associated With Lung Cancer Screening Completion

Variable	Odds Ratio (OR)	95% CI	P- value
Age in years (*ref: 50-54*)			
55-59	1.57	(1.02-2.41)	**0.04**
60-69	1.89	(1.31-2.73)	**0.0007**
70-80	2.62	(1.77-3.88)	**<.0001**
Sex (*ref: Male*)			
Female	1.01	(0.84-1.21)	0.95
Race/Ethnicity (*ref: Non-Hispanic White*)			
Hispanic	1.15	(0.81-1.64)	0.42
Non-Hispanic Asian	2.09	(1.31-3.33)	**0.002**
Non-Hispanic Black	0.55	(0.39-0.78)	**0.0009**
Non-Hispanic Other	0.66	(0.44-0.94)	**0.03**
Unknown	0.56	(0.45-0.96)	**0.01**
Marital Status (*ref: Married*)			
Not married	0.86	(0.71-1.03)	0.11
Unknown	0.26	(0.13-0.49)	**<.0001**
Insurance Type (*ref: Public*)			
Private	0.84	(0.67-1.05)	0.12
Smoking Status (ref: Former)			
Current	0.90	(0.59-1.37)	0.61
Never Smoker/Unknown	0.61	(0.51-0.74)	**<.0001**
Referral Type (ref: Routine Office Visit)			
Urgent/Acute Care	1.06	(0.71-1.59)	0.77
Other/Unknown	1.49	(1.21-1.85)	**<.0002**
PCP Sex (*ref: Male*)			
Female	1.02	(0.81-1.28)	0.87
Specialty (*ref. Primary Care*)			
Medical Subspecialty	0.92	(0.60-1.41)	0.70
Other/Unknown	0.81	(0.48-1.36)	0.43
Years Practiced (*ref. <5*)			
5-9	0.89	(0.61-1.31)	0.57
10-20	1.07	(0.74-1.57)	0.71
>20	1.31	(0.91-1.90)	0.15

Table displays the odds ratio of LCS completion, corresponding 95% confidence intervals (CI), and p-values. Note: **Boldface** indicates statistical significance ($p < 0.05$).

Appendix A. Recategorizing Variable

Variable Name	Old Category	SAS CODE	New Categories
Age in years	55-80 continuous	/*Recoded Patient Age*/ if 50 <= Age <= 54 then new_age = "50-54"; else if 55 <= Age <= 59 then new_age = "55-59"; else if 60 <= Age <= 69 then new_age = "60-69"; else if 70 <= Age <= 80 then new_age = "70-80";	55-59 60-69 70-80
Race/Ethnicity	Race: African American or Black American Indian or Alaska Native Asian Native Hawaiian or other Pacific White Other Unable to respond Unavailable or unknown Ethnicity: Hispanic or Latino Not Hispanic or Latino Declined to state Unspecified	if new_ethnicity = "Hispanic or Latino" then race_eth = "Hispanic"; else if new_ethnicity = "Non-Hispanic" then do; if new_race = "White" then race_eth = "Non-Hispanic White"; else if new_race = "African American or Black" then race_eth = "Non-Hispanic Black"; else if new_race = "Asian" then race_eth = "Non-Hispanic Asian"; else race_eth = "Non-Hispanic Other"; end; else race_eth = "Unknown";	Hispanic Non-Hispanic White Non-Hispanic Asian Non-Hispanic Black Non-Hispanic Other Unknown
Marital Status	Married Divorced Separate Single Widowed		Married Not Married Unknown
Insurance	MEDICAREFFS MEDI-CAL FFS MCARE RISK PLNS(HMO) MCAL MANAGED CARE CHAMPUS (MILITARY) WORKERS COMPENSATION OTHER INSURANCE" OTHER SPONSOR PEND MCAL/CMSP/CMISP PPO/HMO INS PLANS	if insurance in ("MEDICAREFFS","MEDI-CAL FFS","MCARE RISK PLNS(HMO)","MCAL MANAGED CARE", "CHAMPUS (MILITARY)", "WORKERS COMPENSATION","OTHER INSURANCE","OTHER SPONSOR","PEND MCAL/CMSP/CMISP", "") then new_insurance = "Public"; else if insurance = "PPO/HMO INS PLANS" then new_insurance = "Private";	Public Private
Smoking Status	Every day Some Days Light Smoker Heavy Smoker Smoker	if Smoke in ("Every day", "Some Days", "Light Smoker", "Heavy Smoker","Smoker,C") then new_smoke = "Current Smoker";	Former Current Never Smoker/Unknown

	Former Smoker Never Smoker Unknown	else if Smoke = "Former" then new_smoke = "Former Smoker"; else new_smoke = ("Never Smoker/Unknown"); /*else new_smoke = "Unknown";*	
Referral Type	OFFICE VISIT OFFICE VISIT CO OFFICE VISIT LO MEDICARE ANNUAL MYC ANNUAL WELL PHYSICAL WELCOME TO MEDI WELL WOMAN Health Education Classes NEW NEW PATIENT OPE HOSPITAL / ED D SAMEDAY URGENT TRANSFER MYC VIDEO VISIT TELEPHONE VISIT UCD E-VISIT Consultation and Visits MRI/CAT Scan PROCEDURE PREOP Unspecified	if RefType in ("OFFICE VISIT", "OFFICE VISIT CO", "OFFICE VISIT LO","MEDICARE ANNUAL", "MYC ANNUAL WELL","PHYSICAL","WELCOME TO MEDI","WELL WOMAN", "Health Education Classes","NEW", "NEW PATIENT OPE") then new_reftype = "Routine Office Visit"; /*else if RefType in ("NEW", "NEW PATIENT OPE") then new_reftype = "New Patient Visit";(moved to routine office visit)*/ /*else if RefType in ("MYC VIDEO VISIT", "TELEPHONE VISIT", "UCD E-VISIT") then new_reftype = "Telehealth";(combined with other/unknown)*/ /*else if RefType in ("Consultation and Visits", "MRI/CAT Scan", "PROCEDURE","PREOP") then new_reftype = "Specialty/ Diagnostic/ Procedure";(combined with other/unknown)*/ else if RefType in ("HOSPITAL / ED D", "SAMEDAY","URGENT") then new_reftype = "Urgent/Acute Care"; else if Reftype in ("*Unspecified", "TRANSFER","MYC VIDEO VISIT", "TELEPHONE VISIT", "UCD E-VISIT","Consultation and Visits", "MRI/CAT Scan", "PROCEDURE","PREOP") then new_reftype = "Other/Unknown";	Primary Care Routine Office Visit Urgent/Acute Care Other/Unknown
*Specialty	FAMILY MEDICINE FAMILY PRACTICE GENERAL PRACTICE GENERAL PRACTICE, FAMILY PRACTICE INTERNAL MEDICINE GENERAL PRAXTICE INTERNAL MEDICINE GENERAL PRACTICE, INTERNAL MEDICINE, HOSPITALIST EMERGENCY MEDICINE	if PCPspec in ("FAMILY MEDICINE", "FAMILY PRACTICE","GENERAL PRACTICE","GENERAL PRACTICE, FAMILY PRACTICE","INTERNAL MEDICINE","GENERAL PRAXTICE, INTERNAL MEDICINE", "GENERAL PRACTICE, INTERNAL MEDICINE, HOSPITALIST", "EMERGENCY MEDICINE, INTERNAL MEDICINE","CARDIOLOGY,CARDIOVASCULAR DIS, CARDIAC	Primary Care Medical Subspecialty Other/Unknown

	INTERNAL MEDICINE CARDIOLOGY,CARDIOVA SCULAR DIS, CARDIAC ELECTROPHYS, INTERNAL MEDICINE FAMILY PRACTICE, FAMILY PRACTICE FAMILY PRACTICE, GERIATRIC PSYCHIATRY GASTROENTEROLOGY, INTERNAL MEDICINE HEMATOLOGY,HEMATOL OGY/ONCOLOGY, INTERNAL MEDICINE INTERNAL MED/PSY INTERNAL MEDICINE INTERNAL MEDICINE, GENERAL PRACTICE INTERNAL MEDICINE,INFECTIOUS DISEASE INTERNAL MEDICINE,PMR,GENERAL PRACTICE,SPORTS MEDICINE INTERNAL MEDICINE, RHEUMATOLOGY NEPHROLOGY,INTERNAL MEDICINE OBSTETRICS & GYNECOLOGY, INTERNAL MEDICINE OSTEO MANIPULAT MED, FAMILY PRACTICE PSYCHIATRY,FAMILY PRACTICE PSYCHIATRY, INTERNAL MEDICINE PULMONARY DISEASE, CRITICAL CARE MED, INTERNAL MEDICINE NURSE PRACTITIONER NURSE PRACTITIONER, PSYCHIATRY PHYSICIAN ASSISTANT ALLERGY & IMMUNOLOGY CARDIOLOGY CARDIOVASCULAR DIS ENDOCRINOLOGY/META BO	ELECTROPHYS, INTERNAL MEDICINE","FAMILY PRACTICE, FAMILY PRACTICE","FAMILY PRACTICE, GERIATRIC PSYCHIATRY","GASTROENTEROLOGY , INTERNAL MEDICINE","HEMATOLOGY,HEMATOL OGY/ONCOLOGY, INTERNAL MEDICINE", "INTERNAL MED/PSY","INTERNAL MEDICINE","INTERNAL MEDICINE, GENERAL PRACTICE","INTERNAL MEDICINE,INFECTIOUS DISEASE","INTERNAL MEDICINE,PMR,GENERAL PRACTICE,SPORTS MEDICINE","INTERNAL MEDICINE, RHEUMATOLOGY", "NEPHROLOGY,INTERNAL MEDICINE","OBSTETRICS & GYNECOLOGY, INTERNAL MEDICINE","OSTEO MANIPULAT MED, FAMILY PRACTICE","PSYCHIATRY,FAMILY PRACTICE","PSYCHIATRY, INTERNAL MEDICINE","PULMONARY DISEASE, CRITICAL CARE MED, INTERNAL MEDICINE","NURSE PRACTITIONER", "NURSE PRACTITIONER, PSYCHIATRY", "PHYSICIAN ASSISTANT") then new_pcpspec= "Primary Care"; else if PCPspec in ("ALLERGY & IMMUNOLOGY", "CARDIOLOGY", "CARDIOVASCULAR DIS", "ENDOCRINOLOGY/METABO", "GASTROENTEROLOGY", "HEMATOLOGY", "HEMATOLOGY/ONCOLOGY", "INFECTIOUS DISEASE", "NEPHROLOGY", "PULMONARY DISEASE", "PULMONARY DISEASE, CRITICAL CARE MED", "PULMONARY DISEASE, CRITICAL CARE MED, SLEEP MEDICINE", "RHEUMATOLOGY","CARDIOTHORACI C SURG", "THORACIC SURGERY", "ORTHOPAEDIC SURGERY, HAND SURGERY, OTHO", "UROLOGY","Osteopathic Physician and Surgeon", "Physician and Surgeon",	

	GASTROENTEROLOGY HEMATOLOGY HEMATOLOGY/ONCOLOGY INFECTIOUS DISEASE NEPHROLOGY PULMONARY DISEASE PULMONARY DISEASE, CRITICAL CARE MED PULMONARY DISEASE, CRITICAL CARE MED, SLEEP MEDICINE RHEUMATOLOGY CARDIOTHORACIC SURG THORACIC SURGERY ORTHOPAEDIC SURGERY, HAND SURGERY, OTHO UROLOGY Osteopathic Physician and Surgeon Physician and Surgeon SURGERY EMERGENCY MEDICINE emergency Medicine CRITICAL CARE MED	"SURGERY", "EMERGENCY MEDICINE", "emergency Medicine", "CRITICAL CARE MED") then new_pcpspec = "Medical Subspecialty"; */else if PCPspec in ("CARDIOTHORACIC SURG", "THORACIC SURGERY", "ORTHOPAEDIC SURGERY, HAND SURGERY, OTHO", "UROLOGY","Osteopathic Physician and Surgeon", "Physician and Surgeon", "SURGERY", "EMERGENCY MEDICINE", "emergency Medicine", "CRITICAL CARE MED") then new_pcpspec = "Surgical Specialty";/* */else if PCPspec in ("DIAGNOSTIC RADIOLOGY", "INTERVENTIONAL RADIOLOGY", "RADIATION ONCOLOGY", "RADIOLOGY ONCOLOGY") then new_pcpspec = "Radiology/ Imaging";/* */else if PCPspec in ("NURSE PRACTITIONER", "NURSE PRACTITIONER, PSYCHIATRY", "PHYSICIAN ASSISTANT") then new_pcpspec = " Advanced Practice Provider (APP)";/* else new_pcpspec = "Other/Unknown";	
Years Practiced (referral Date)	Continuous	if PCPyrsprac < 5 then new_PCPyrsprac = "<5"; else if 5 <= PCPyrsprac < 10 then new_PCPyrsprac = "5-9"; else if 10 <= PCPyrsprac <= 20 then new_PCPyrsprac = "10-20"; else if PCPyrsprac > 20 then new_PCPyrsprac = ">20"; else new_PCPyrsprac = "Unknown"; run;	<5 5-9 10-20 >20

*Variables show up in the way it was presented in the dataset.

Conclusion

This dissertation provides important insights into the early implementation of the 2021 USPSTF LCS guideline expansion and the multilevel factors influencing screening uptake during the first four years following its release. Together, the findings from the three dissertation chapters demonstrate that the expansion of eligibility alone is insufficient to increase LCS participation and that improving LCS uptake requires coordinated efforts across patient, provider, and health system levels.

Chapter 1 synthesized literature published between 2021 through 2024 (n = 31) to identify multilevel barriers, facilitators, and implementation strategies influencing LCS uptake following the 2021 United States Preventive Services Task Force (USPSTF) guideline expansion. Through these studies, we found that the expansion led to an increase in the number of individuals eligible for LCS and strategies aimed at increasing LCS uptake. This review was guided by the Consolidated Framework for Implementation Research (CFIR). The review demonstrated that screening uptake is influenced at patient, provider, and health system levels; therefore, multi-level strategies are recommended to increase screening rates.

Chapter 2 provided patient and primary care team (PCT) perspectives on barriers and facilitators to LCS through a rapid qualitative analysis of interviews (n= 36). Findings revealed the need to increase awareness and knowledge of LCS among both patients and PCTs. Additional barriers reported included stigma, limited resources, competing priorities, workflow limitations, and challenges identifying eligible individuals. Recommendations to improve LCS uptake in this chapter included patient navigation, patient-centered educational materials, and recommendations for a web-based intervention.

Finally, Chapter 3 examined patient and provider factors associated with LCS completion following a recommendation to get screened, using electronic medical record data from 2021-2024. Findings demonstrated that patient-level factors, including age and race/ethnicity, were significantly associated with screening completion, whereas provider characteristics were not independently associated with adherence after referral. Therefore, these findings could imply that demographic and referral related characteristics may influence screening completion among eligible patients and may contribute to inequities in LCS completion. Understanding impacts on following the 2021 USPSTF guideline expansion can guide the development of evidence-based approaches to improve screening completion and access to LCS.

Given the high mortality rates associated with lung cancer, there remains an urgent need to strengthen the implementation of evidence-based screening programs following the 2021 USPSTF guideline expansion. By using a mixed-methods approach, this dissertation addressed important gaps in the literature by evaluating early implementation experiences, identifying barriers and facilitators to screening uptake, and examining factors associated with screening adherence in a clinical setting. The findings from this work provide evidence supporting the development of patient-centered, provider-informed, and health system-level interventions to improve equitable access to LCS and reduce lung cancer mortality among high-risk populations.