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Racial and Socioeconomic Disparities in Lung Cancer Screening in the United States: A Systematic Review

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Additional supporting information may be found online in the Supporting Information section at the end of the article.

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Abstract: Nonsmall cell lung cancer (NSCLC) is the leading cause of cancer deaths. Lung cancer screening (LCS) reduces NSCLC mortality; however, a lack of diversity in LCS studies may limit the generalizability of the results to marginalized groups who face higher risk for and worse outcomes from NSCLC. Identifying sources of inequity in the LCS pipeline is essential to reduce disparities in NSCLC outcomes. The authors searched 3 major databases for studies published from January 1, 2010 to February 27, 2020 that met the following criteria: 1) included screenees between ages 45 and 80 years who were current or former smokers, 2) written in English, 3) conducted in the United States, and 4) discussed socioeconomic and race-based LCS outcomes. Eligible studies were assessed for risk of bias. Of 3721 studies screened, 21 were eligible. Eligible studies were evaluated, and their findings were categorized into 3 themes related to LCS disparities faced by Black and socioeconomically disadvantaged individuals: 1) eligibility; 2) utilization, perception, and utility; and 3) postscreening behavior and care. Disparities in LCS exist along racial and socioeconomic lines. There are several steps along the LCS pipeline in which Black and socioeconomically disadvantaged individuals miss the potential benefits of LCS, resulting in increased mortality. This study identified potential sources of inequity that require further investigation. The authors recommend the implementation of prospective trials that evaluate eligibility criteria for underserved groups and the creation of interventions focused on improving utilization and follow-up care to decrease LCS disparities. **CA Cancer J Clin 2021;71:299-314. © 2021 The Authors. CA: A Cancer Journal for Clinicians published by Wiley Periodicals LLC on behalf of American Cancer Society. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.**

Keywords: disparities, lung cancer screening, lung cancer, racial minorities, socioeconomic status

Introduction

Nonsmall cell lung cancer (NSCLC) is the leading cause of cancer deaths because most patients who have NSCLC present with stage IV disease, when cure is unlikely.[1,2] However, lung cancer screening (LCS) using low-dose chest computed tomography (LDCT)[3,4] enables the detection of NSCLC at earlier stages, leading to increased rates of resection for cure.[5,6] The National Lung Screening Trial (NLST), a US-based, randomized controlled trial, showed that 3 annual screenings using LDCT reduced NSCLC mortality by 20% and all-cause mortality by 6%.[7,8] Therefore, LCS is a critically important tool to decrease mortality from NSCLC. Accordingly, in 2013, the US Preventive Services Task Force (USPSTF) recommended annual LCS for adults aged 55 to 80 years who are: 1) current smokers with a 30 pack-year smoking history or 2) former heavy smokers

who have quit within the past 15 years.[9] Subsequently, the Dutch-Belgian LCS randomized controlled trial (Nederlands-Leuvens Longkanker Screenings Onderzoek [NELSON]),[10] which used different eligibility criteria than the NLST, found an even greater mortality benefit of LCS. On the basis of these new results, the USPSTF is updating its LCS guidelines to recommend annual screenings for adults aged 50 to 80 years who are: 1) current smokers with a 20 pack-year smoking history or 2) former heavy smokers who have quit within the past 15 years.[11]

Although the results from the NLST and the NELSON trial were exciting, neither focused on attaining significant racial or socioeconomic diversity among its participants. Indeed, 89.6% of participants in the NLST were White and of higher socioeconomic status (SES) than the general population,[8,12] and these important demographic factors were not reported for the NELSON trial.[10] As such, the results from these landmark trials may not be generalizable to other groups, such as Black and socioeconomically disadvantaged individuals, who have: 1) a higher incidence of NSCLC,[13-18] 2) higher mortality from NSCLC,[15,16,17,19,20,21] 3) lower rates of treatment,[22-30] and 4) a greater chance of being diagnosed at advanced stages of the disease.[31,32]

Eighty-five percent of lung cancers result from tobacco smoking,[33] so the finding that such strong tobacco marketing efforts were historically directed at members of marginalized and underserved communities must be highlighted,[34] especially because these same groups have the highest incidence and mortality from the disease. Therefore, assurance that members of these marginalized groups obtain life-saving LCS is a true restorative justice issue. To extend the benefits of LCS to all high-risk individuals, regardless of race/ethnicity or income, it is essential that we identify and rectify all potential sources of inequity in the LCS pipeline, from eligibility to follow-up care. For example, eligibility criteria based on a majority White, high-SES population are likely to exclude the marginalized groups at greater risk for NSCLC. There are also considerable barriers that contribute to the low participation rates (up to 16%) among individuals who are eligible for LCS, such as low referral rates by uninformed providers and uncertainty regarding the benefits of LCS.[35,36] These barriers may be magnified in the care of marginalized groups. Furthermore, support and follow-up care for individuals who are screened may differ based on patient demographics.

Thus each step from eligibility to follow-up represents an opportunity to reduce disparities in LCS and, ultimately, NSCLC outcomes. For this systematic review, our objective was to critically appraise all available studies conducted in the United States that have examined the associations of LCS outcomes with race and SES to identify known disparities as well as potential sources of inequity that require further investigation to be fully mitigated.

Methods

Search Strategy

We conducted this systematic review according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[37] Two professional medical librarians (J.D. and K.L.) searched 3 online databases: PubMed, Ovid MEDLINE, and CINAHL Plus. The librarians worked with the reviewers (A.A., G.D., and L.E.) to develop a list of keywords, Medical Subject Heading (MeSH) terms, and subject headings to identify all publications from January 1, 2010 to February 27, 2020 that examined the impact of race and/or SES on LCS. Keywords included smoking habit, cancer screening, SES, lung cancer, race, and disparities. A complete list of search terms is available (see Supporting Table 1). The literature search matrix used for PubMed was adapted for use in the other databases. No other limitations were applied to the search to avoid unintended exclusion of relevant documents.

Article Review Process

Once the articles were retrieved from each database, they were exported into a reference management software program (Covidence; Veritas Health Innovation Ltd) for study selection. This tool allowed all reviewers (A.A., G.D., L.E., and E.S.) to review the articles independently and simultaneously. In the initial screening stage, the title of each article was reviewed for topic relevance, and the abstract was reviewed for further clarification as necessary. During this screening, each article was reviewed by only 2 reviewers. Any article approved by both reviewers was deemed eligible for full-text review, whereas articles with 2 "no" votes were eliminated. Any article with one "yes" and one "no" vote was reviewed and discussed by all reviewers collectively until consensus was reached on whether it was eligible or ineligible for full-text review.

Data Abstraction

In the full-text review stage, each reviewer (2 per article) independently assessed the original research studies for eligibility according to the predefined criteria (Table 1). The same voting system used to determine full-text review eligibility was used to determine article eligibility for the systematic review. The reviewers abstracted publication, participant, and study characteristics (author, title, study type, sample size, key findings, outcomes, and themes) from each article.

Study Quality Assessment

Risk of bias was assessed using the National Heart, Lung, and Blood Institute Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.[38] This tool includes questions for evaluating potential flaws in study methods or implementation that may lead to bias and lower study

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quality and has been used in previously published systematic reviews.[39] Each question could be answered with "yes," "no," or "not reported/not applicable." On the basis of the answers, the reviewers then rated individual studies as being of "good," "fair," or "poor" quality. Studies rated "good" were considered to have the least risk of bias and to possess valid results. Studies rated "fair" were considered to have some bias but not enough to invalidate the results. Studies with a "poor" rating were considered to have a significant risk of bias. The quality of each study was rated independently by 2 reviewers (E.S. and L.E.), who then met to discuss their ratings. Discrepancies were discussed by the reviewers until consensus was reached.

Results

We identified 5169 potentially relevant citations, including 1447 duplicates, leaving 3721 studies to be screened for eligibility. Of these, 98 studies were selected for full-text review, and 21 were deemed eligible using our predefined criteria (Table 1, Fig. 1). The reasons for exclusion are documented in Table 2. Detailed study characteristics are provided in Table 3.[12,40-59]

The 21 eligible studies were evaluated, and their findings were categorized into 3 overarching themes related to steps in the LCS pipeline in which racial and socioeconomic disparities are known or are likely to exist (Table 4).[12,40-59] The disparities at each step in the pipeline negatively impact outcomes and ultimately result in disparate mortality rates (Fig. 2).[12,38,40,41,44,45,48,50,51,53,56,58-61]

LCS Eligibility

Not eligible

Seven studies (33%) investigated eligibility for screening according to the 2013 USPSTF LCS guidelines. Several studies indicated that Black smokers with or without a diagnosis of NSCLC were less likely to be eligible for LCS than their White counterparts. Han et al[49] evaluated the characteristics of smokers in younger (aged 50-54 years) and older (aged 71-80 years) individuals who were missed by the USPSTF guidelines but were selected as high-risk by the $PLCO_{m2012}$ model, a validated risk-based screening model that was shown to be more sensitive than the USPSTF criteria for lung cancer detection.[60,62,63] Han et al reported that high proportions of younger and older Black individuals were ineligible for screening by USPSTF criteria despite being high-risk according to the $PLCO_{m2012}$ model. This rate of ineligible but high-risk Black individuals was significantly greater than the rate of ineligible but high-risk White individuals.[49] In a similar study, Fiscella et al found that $PLCO_{m2012}$ criteria resulted in a statistically significant increase in LCS eligibility for Black men compared with Medicare criteria, which adopted the USPSTF smoking criteria but changed the age criterion to ages 55 to 77 years.[46] Annangi et al used the Surveillance, Epidemiology, and End Results (SEER) database to determine the frequency of early onset NSCLC in the age range from 45 to 54 years.[41] Black individuals had a significantly greater frequency of early onset NSCLC compared with White individuals.[41] However, these patients with early onset NSCLC were not eligible for LCS because they were younger than the age range defined by USPSTF guidelines.

In addition, Aldrich et al reported that the percentage of individuals eligible for LCS according to USPSTF guidelines was significantly lower among Black smokers diagnosed with NSCLC than among White smokers with NSCLC.[40] Three other studies also found that Black current and former smokers were significantly less likely to be eligible for LCS according to USPSTF guidelines because they had a shorter smoking history or longer time since quitting than required for eligibility under USPSTF guidelines.[50,52,56] Another study applied USPSTF screening criteria to 2000 patients diagnosed with NSCLC and found eligibility differences based on race as well.[61] These findings highlight the shortcomings of current USPSTF guidelines. Although the proposed updates to the USPSTF criteria may improve eligibility rates for Black individuals at high risk for lung cancer, potential gaps in eligibility remain that may limit screening for Black and other underrepresented minority individuals (Table 5).[41,50,64-68] Furthermore, innovative research methods, such as rigorous data modeling, that incorporate adequate numbers of overlooked groups are needed to address remaining gaps quickly and inexpensively and to improve our understanding of appropriate eligibility criteria for all.

The association between education and screening eligibility was evaluated in 2 studies. In their study on high-risk individuals who were missed by the USPSTF guidelines, Han et al observed that, compared with those who had higher education, a significantly higher proportion of high-risk individuals with a high school education or less were ineligible because they were younger than the recommended age range ($P < .001$).[49] In contrast, Li et al found that, compared with individuals who had a college education or higher, those who had a high school education or less were more likely to be eligible for LCS (odds ratio [OR], 1.8; 95% confidence interval [CI], 1.5-2.3). Interestingly, those authors also observed that higher household income was associated with greater eligibility.[52] This finding and the disparate results regarding the association between education and LCS eligibility require further investigation.

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TABLE 1. Inclusion and Exclusion Criteria Used for the Systematic Review

INCLUSION CRITERIA	EXCLUSION CRITERIA
Peer-reviewed literature	Gray literature (editorials, news, letter to the editor)
Published between January 1, 2010 and February 27, 2020	Published before January 1, 2010 or after February 27, 2020
Written in English	Not written in English
Study conducted in the United States only	Study conducted outside of the United States
Humans subjects only	Animal study
Participants aged 45-80 y	Participants only aged <45 or >80 y
Current and former smokers	Does not include current or former smokers
Evaluates socioeconomic and/or race-based outcomes relating to LCS	Does not evaluate socioeconomic and/or race-based outcomes relating to LCS
Study design: Cohort studies, randomized control trials, and observational studies	Case-control studies
Setting: Clinical or health care setting	Nonclinical or health care settings

Abbreviation: LCS, lung cancer screening.

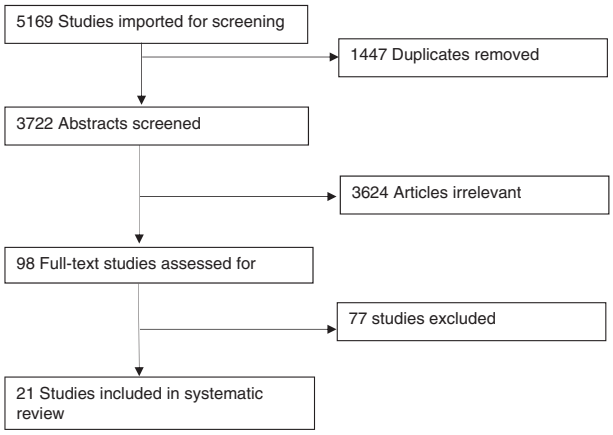

FIGURE 1. Screening Process for Articles Included in the Systematic Review. This diagram shows each step in the selection process for articles that were included in the systematic review. LCS indicates lung cancer screening; NSCLC, nonsmall cell lung cancer; SES, socioeconomic status; USPSTF, US Preventive Services Task Force.

LCS Utilization, Perception, and Utility

LCS not offered or used

Five studies (24%) evaluated whether race and/or SES impact the utilization of LCS. Three studies reported race-based differences in LCS utilization by screening-eligible patients. They found that Black participants were less likely to have been screened or to intend to be screened,[43,55] and eligible non-Black patients were 2.8 times more likely to be screened than eligible Black patients (30% vs 12%).[50] In addition, a higher annual income was significantly associated with the completion of receiving screening or the intention to receive screening.[43] A fourth study conducted in a diverse community setting (41.4% Black individuals) indicated that Black participants had a lower screening rate, comprising only 37.6% of the screened population, whereas White participants made up 46% of the screened group ($P < .001$). They also found that unscreened patients had a lower annual household income than those who were screened.[58] Specifically, the study noted that 68.4% of the screened population had an annual household income >$50,000, whereas only 59.6% of the unscreened population had the same income ($P = .022$).[58] Conversely, another study evaluated 855 patients with lung cancer who were eligible for screening (46% Black; median income by home zip code, $20,009) and did not find significant differences based on race, ethnicity, or SES, as measured by median income, between those who completed screening versus those who did not.[59] Nevertheless, there is overall compelling evidence that race-based and SES-based disparities exist in LCS utilization.

Negative perceptions/understanding of LCS

Two studies (10%) examined patient beliefs about LCS. One study did not find any correlations between sociodemographic variables and patients' perceptions about the accuracy of LCS; however, the study did find a correlation between patients' education levels and their understanding of why they were referred for LCS ($P = .01$).[48] Another study reported that, compared with non-Latinx patients, Latinx patients were more likely to believe that NSCLC can be prevented (74.6% vs 48.2%; OR, 3.07; 95% CI, 1.89-5.01), were less worried about developing NSCLC (34.8% vs 50.3%; OR, 0.44; 95% CI, 0.27-0.72), and had a greater willingness to be screened when educated about screening (90.7% vs 67%; OR, 4.79; 95% CI, 2.31-9.05).[54]

Late-stage diagnosis

Five studies (24%) investigated the impact of race and/or SES on the stage of NSCLC in those diagnosed by LCS. In an LCS community program in which 10.2% of participants were Black, 21 of the 29 cancers identified in 26 patients were stage I.[45] In addition, in a screening program that, compared with the NLST, served a greater proportion of Black participants (69.6% vs 4.5%) and current smokers (72.8% vs 48.1%), >50% of NSCLC cases were detected at stage I.[53] Su et al observed that screening affected NSCLC stage at diagnosis, with detection at an earlier stage for patients who were screened compared with those who were not; however, those authors observed no difference in stage at diagnosis based on race, ethnicity, or SES.[59] Through an analysis of the SEER database,

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TABLE 2. Reasons for Excluding Articles From the Systematic Review

NO. OF ARTICLES EXCLUDED	REASON
2	Wrong study design
17	Does not evaluate socioeconomic and/or race-based outcomes relating to lung cancer screening
13	Wrong outcomes
12	Wrong patient population
5	Gray literature (editorials, news, letter to the editor)
1	Study not conducted in the United States
1	Wrong setting

Annangi et al found that a significantly lower proportion of Black lung cancers was diagnosed at early stages (IA, IB, IIA, IIB) compared with Whites across all age groups ($P < .05$).[41] Finally, in an LCS program with a majority Black patient population (n = 231 of 275 [84%] who underwent screening), no early stage disease was found; instead, 2 patients were diagnosed with advanced-stage lung cancer.[47] Across studies, there were mixed findings regarding whether Black patients are more likely than White patients to have more advanced disease detected by LCS; however, like the NLST, most LCS studies with a higher proportion of Black participants found that early stage disease was prevalent.

Postscreening Behavior and Care

Failure to quit smoking

Three studies (14%) examined smoking behavior and cessation differences in LCS participants by race/ethnicity. Both Hispanic[49] and Black participants reported fewer pack-years of smoking compared with White participants.[46,51] Black participants were also less likely to report previous alternative tobacco use than White participants (32.6% vs 39.0%; $P = .007$) but were more likely to report menthol cigarette use (58.8% vs 20.8%; $P < .001$).[51]

Kumar et al reported that, compared with White participants, Black participants in the NLST had higher rates of smoking cessation for periods of 24 hours (52.7% vs 41.2%; $P < .001$) and 7 days (33.6% vs 27.2%; $P = .002$).[51] In addition, Black participants had slightly higher rates of participation in smoking cessation programs (7.0% vs 4.5%; $P = .03$). Higher income also was associated with a higher likelihood of 24-hour and 7-day quit attempts; however, race and income were not significantly predictive of smoking cessation success.[51]

Racial differences were also found in current smokers' preferences for receiving smoking cessation information, with White participants 4 times more likely to report a preference for digital support (social media, internet, web-based programs, and/or text messages) than face-to-face support, telephone support, or printed materials. This relation was not affected by income.[44]

Lack of follow-up care/loss to follow-up

Three studies (14%) reported on the completion of follow-up care after LCS. One study defined follow-up as undergoing either a diagnostic, invasive procedure or having imaging compared with historical images as a result of a positive screening examination.[57] The study found lower rates of follow-up in Black patients compared with White patients (82.8 % vs 89.6%; $P < .05$).[57] Another study indicated that, among 511 patients who had undergone LCS and had Lung CT Screening Reporting and Data System category 1 or 2 scores (suggesting benign findings), neither race nor insurance status had an impact on the rates of annual adherence (defined as returning for imaging within 1 year and 90 days) or any follow-up—both of which were low overall.[45] Another study that implemented an LCS program in a low-SES, predominantly Black community reported a 75% follow-up rate among individuals who had positive baseline LDCT screens but did not analyze differences by race, ethnicity, or SES.[47]

No surgery

Only one study evaluated the impact of race on surgical treatment in patients who had NSCLC detected by LCS. The authors found that Black men were 28% less likely to undergo a surgical procedure to treat NSCLC than White men.[42] No studies evaluated the impact of SES on surgical treatment.

Post-LCS mortality

Of the 2 studies (10%) that investigated the impact of race on lung cancer mortality among individuals at high risk for lung cancer, one evaluated the racial differences in outcomes within the NLST. The study indicated that Black current smokers had a 2-fold higher risk of lung cancer-specific mortality than White smokers. In addition, the study found that screening with LDCT reduced lung cancer mortality in all racial groups but more so in Black individuals (hazard ratio, 0.61 vs 0.86).[12] Similarly, all-cause mortality was 1.35 times higher in Black individuals than in White individuals; however, Black and other non-White participants had statistically significant reductions in all-cause mortality after screening with LDCT that were not observed in White participants.[12] Su et al found that screened patients had a lower lung cancer mortality rate than unscreened patients, but they did not find survival differences by race.[59] High-risk smokers in the NLST with a college education or higher had significantly lower lung cancer-specific mortality than those with a high school degree or less.[12]

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TABLE 3. Individual Study Characteristics for Articles Included in the Systematic Review

	PARTICIPANT CHARACTERISTICS				STUDY CHARACTERISTICS		
REFERENCE	AGE, Y	SEX	RACE/ETHNICITY	GEOGRAPHIC LOCATION	DATA SOURCE	SAMPLE SIZE	STUDY DESIGN
Aldrich 2019[40]	40-79	Men and women	Black, White	Southern United States	NLST, Southern Community Cohort Study	48,364	Cohort study
Annangi 2019[41]	40 to ≥85	Men and women	Black, White	United States	SEER Program from NCI; US cancer registries; CDC; NLST	486,403	Cross-sectional study
Balekian 2019[42]	55-65	Men and women	Black, White	United States	NLST	723	Cohort study
Carter-Harris 2018[43]	55-79	Men and women	Black, White	United States	Collected through community-based recruitment methods in the state of Indiana	438	Cross-sectional study
Carter-Harris 2018[44]	55-77	Men and women	Black, White	United States	Collected through community-based recruitment methods in the state of Indiana	159	Cross-sectional study
Cattaneo 2018[45]	55-80	Men and women	Black, White	Maryland	NLST; Veterans' Health Administration; Ann Arundel Medical Center patient data	1241	Cohort study
Fiscella 2015[46]	55-77	Men and women	Black, Hispanic, White	United States	National Health and Nutrition Examination Survey, PLCO	2562	Cohort study
Guichet 2018[47]	50-78	Men and women	Asian, Black, Hispanic, White	California	NLST, University of Southern California	275	Cohort study
Hall 2018[48]	55-74	Men and women	Black, White	United States	Massachusetts General Hospital, NLST	169	Cross-sectional study
Han 2020[49]	50-80	Men and women	Asian, Black, Hispanic, White	United States	National Health Interview Survey, Cancer Intervention and Surveillance Modeling Network Smoking History Generator, USPSTF, PLCO, US Census, Southern Community Cohort Study	100,000	Cohort study
Japuntich 2018[50]	55-80	Men and women	Black, White	Rhode Island, United States	Miriam Hospital, USPSTF	200	Cohort study
Kumar 2016[51]	50-74	Men and women	Black, White	United States	NLST, CDC	6813	Cohort study
Li 2019[52]	55-80	Men and women	Black, White	United States	2014 Health and Retirement Study, USPSTF	7348	Cross-sectional study
Pasquinelli 2018[53]	55-74	Men and women	Black, White	Illinois, California	NLST, University of Illinois at Chicago	500	Cohort study

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TABLE 3. (Continued)

	PARTICIPANT CHARACTERISTICS				STUDY CHARACTERISTICS		
REFERENCE	AGE, Y	SEX	RACE/ETHNICITY	GEOGRAPHIC LOCATION	DATA SOURCE	SAMPLE SIZE	STUDY DESIGN
Percac-Lima 2019[54]	50-79	Men and women	Hispanic, non-Hispanic	Massachusetts	Massachusetts General Hospital-affiliated community health centers, NLST	894	Cross-sectional study
Richmond 2020[55]	55+	Men and women	Black, White	North Carolina	US Census, Lung Cancer Screening Registry, University of North Carolina at Chapel Hill	262	Cohort study
Ryan 2016[56]	33-91	Men and women	Black, White	Maryland, United States	NCI-Maryland Lung Cancer Study, NLST, Centers for Medicare and Medicaid Services, USPSTF	1658	Cohort study
Sesti 2019[57]	55-74	Men and women	Black, White	United States	NLST	14,000	Cohort study
Steiling 2020[58]	55-80	Men and women	Asian, Black, Hispanic, White	Massachusetts, United States	Boston Medical Center Lung Cancer Screening Program, Boston Medical Center Clinical Database Warehouse, NLST, USPSTF	1325	Cohort study
Su 2018[59]	50-80	Men and women	Black, Hispanic, White	New York	Albert Einstein College of Medicine, USPSTF	855	Cohort study
Tanner 2015[12]	55-74	Men and women	Black, White	United States	NLST	53,452	Cohort study

Abbreviations: CDC, Centers for Disease Control and Prevention; NCI, National Cancer Institute; NLST, National Lung Screening Trial; PLCO, the Prostate, Lung, Colorectal and Ovarian Cancer Screening Trial; SEER, Surveillance, Epidemiology, and End Results; USPSTF, US Preventive Services Task Force.

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TABLE 4. Identified/Potential Sources of Racial and Socioeconomic Disparities in the Lung Cancer Screening Pipeline

		UTILIZATION, PERCEPTION, AND UTILITY				POSTSCREENING BEHAVIOR AND CARE		
REFERENCE	ELIGIBILITY	LCS BEHAVIOR AND UTILIZATION	PERCEPTIONS AND UNDERSTANDING	NSCLC STAGE AT DIAGNOSIS	SMOKING BEHAVIOR AND SMOKING CESSATION	FOLLOW-UP	SURGICAL TREATMENT	MORTALITY
Aldrich 2019[40]	●							
Annangi 2019[41]	●			●				
Balekian 2019[42]							●	
Carter-Harris 2018[43]		●						
Carter-Harris 2018[44]					●			
Cattaneo 2018[45]		●		●		●		
Fiscella 2015[46]	●				●			
Guichet 2018[47]				●		●		
Hall 2018[48]			●					
Han 2020[49]	●							
Japuntich 2018[50]	●	●						
Kumar 2016[51]					●			
Li 2019[52]	●							
Pasquinelli 2018[53]				●				
Percac-Lima 2019[54]			●					
Richmond 2020[55]								
Ryan 2016[56]	●							
Sesti 2019[57]						●		
Steiling 2020[58]		●						
Su 2018[59]		●		●				●
Tanner 2015[12]					●			●

Abbreviations: LCS, lung cancer screening; NSCLC, nonsmall cell lung cancer.

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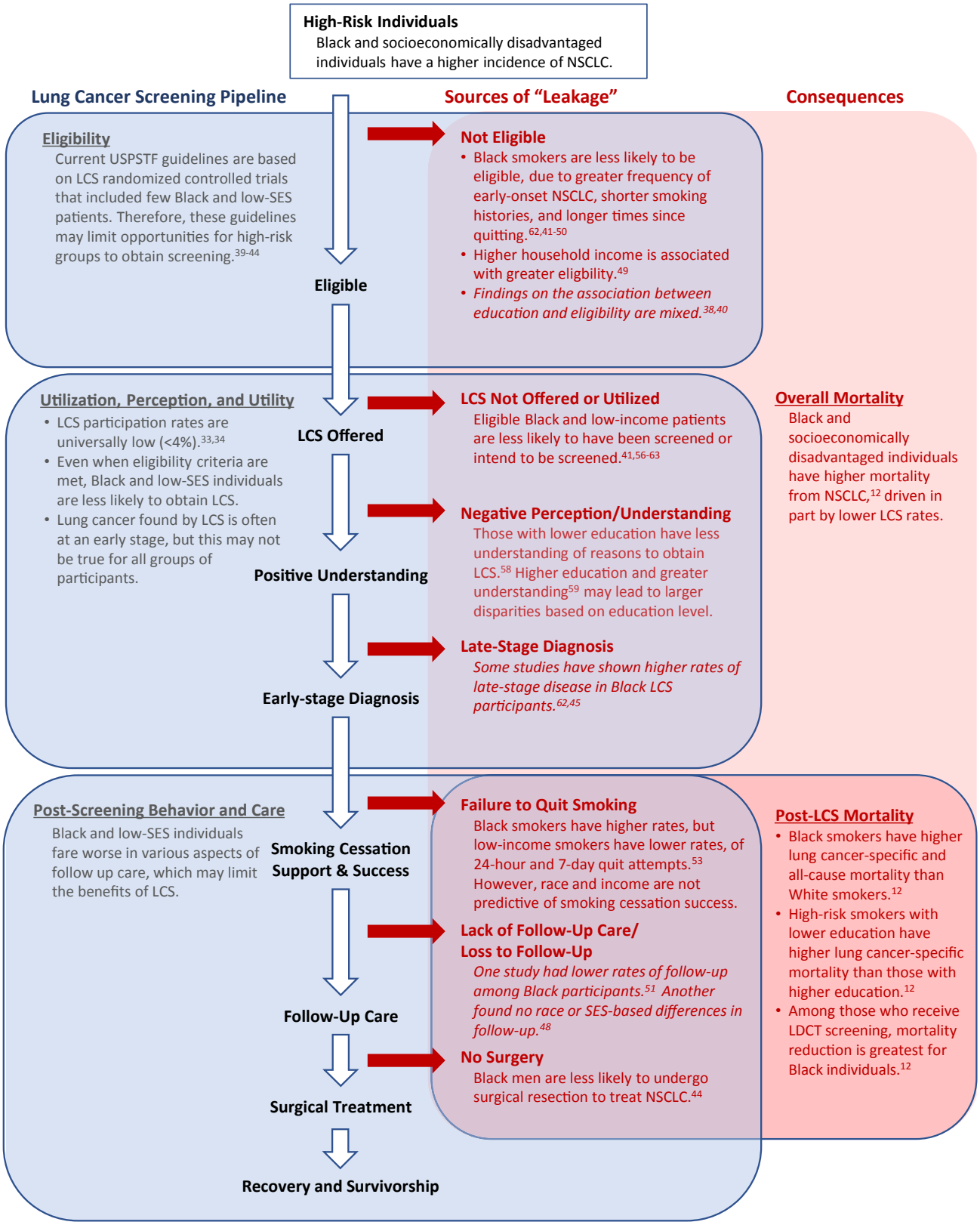

FIGURE 2. Lung Cancer Screening Pipeline. This schematic presents all reported findings captured by the systematic review. Statements in italics indicate contentious or ambiguous results. Any associations not shown were not reported or were captured by our search and thus require further study.

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TABLE 5. US Preventive Services Task Force Recommendation Updates and Remaining Gaps

	CURRENT USPSTF ELIGIBILITY RECOMMENDATIONS	NEW PROPOSED USPSTF RECOMMENDATIONS	POSSIBLE REMAINING GAPS AFTER UPDATED GUIDELINES
POPULATION	• Aged 55-80 y	• Aged 50-80 y	• Annangi et al found that 7.2% of Black patients with NSCLC were aged <50 years compared with only 4.3% of White patients with NSCLC; therefore, the new guidelines will still miss more Black vs White high-risk smokers (Annangi 2019[41])
	• 30 pack-year smoking history	• 20 pack-year smoking history	
	• Currently smoke or have quit smoking within the past 15 y	• Currently smoke or have quit smoking within the past 15 y	
RECOMMENDATION	• Annual screening for lung cancer with LDCT	• Annual screening for lung cancer with LDCT	
	• Screening should be discontinued once a person has not smoked for 15 y	• Screening should be discontinued once a person has not smoked for 15 y	• Lung cancer risk remains elevated after 15 y of cessation (Mong 2011,[64] Pinsky 2015,[65] Tindle 2018[66]); therefore, Black smokers who are more likely to have quit times >15 y may be excluded from LCS at higher rates secondary to this criterion (Japuntich 2018,[50] Stellman 2003,[67] Pasquinelli 2020[68])

Abbreviations: LCS, lung cancer screening; LDCT, low-dose computed tomography; NSCLC, nonsmall cell lung cancer; USPSTF, US Preventive Services Task Force.

Study Quality Assessment

Of the 21 studies, 18 were rated as having a low risk of bias ("good"), and 3 were rated as having some risk of bias ("fair"). Details on the risk of bias ratings are provided in Fig 3.[12,40-59]

Discussion

Racial and socioeconomic disparities are prevalent in NSCLC, as manifested by higher incidence and mortality in marginalized groups.[17,18,21] As a screening tool, LDCT has been shown to significantly decrease lung cancer mortality in high-risk patients; however, its universal underutilization limits its impact.[35,36] It is feared that the barriers to LCS utilization may be magnified by racial and socioeconomic inequities, thus further increasing the NSCLC mortality gap. It is therefore critical that we identify and address all potential sources of inequity in the LCS pipeline.

Our systematic review revealed 3 primary themes related to the steps of the LCS pipeline in which racial and socioeconomic disparities prevail: 1) eligibility; 2) utilization, perception, and utility; and 3) postscreening behavior and care. Achieving equity in lung cancer care and outcomes will require efforts to fix obvious "leaky" steps in this pipeline. It is also essential that we identify and interrogate areas in which leakage is possible but there are not yet enough data to confirm or determine how to address the problem.

Eligibility

The eligibility criteria outlined by the 2013 USPSTF guidelines are based on the landmark NLST, in which 89.6% of participants were White and of higher SES than the general population.[7] It is therefore no surprise that these criteria lack the ability to appropriately detect those who would most benefit from LCS among racial minorities and individuals with fewer socioeconomic resources.[40,49,52] Compared with White men, Black men are diagnosed with NSCLC at an earlier age, after smoking fewer cigarettes, and with longer quit times.[7,51] Consequently, significantly more Black men with NSCLC will be ineligible for LCS under current guidelines.[40,41] There is also some evidence that patients with lower education and lower household income are also less likely to be eligible for screening.[49,52] The upcoming changes to the USPSTF guidelines[11] will hopefully help narrow the noted disparities in LCS eligibility; however, there remains a need for focused studies to evaluate the impact and determine the suitability of the criteria for racial minority groups and groups of low socioeconomic position.

Utilization, Perception, and Utility

Unfortunately, even if high-risk Black individuals and individuals of lower socioeconomic position are eligible for LCS, they are still less likely to obtain the screening.[43,50,58] It is possible that a lack of knowledge among patients and their providers may affect these lower rates.[50] Raz et al found that 80% of LCS eligible smokers had never heard of LCS and that a significant proportion of smokers expressed shame and stigma as being important barriers to screening.[69] Whether these barriers are more significant in marginalized communities is understudied. In addition, a lack of awareness of USPSTF guidelines among primary care

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physicians (PCPs) has been associated with lower utilization of LDCT for screening.[70] Providers in underserved communities may experience more barriers to adherence to LCS recommendations.

Perceptions about LCS may also affect screening rates; however, Percac-Lima et al observed that Hispanic/Latinx participants had an increased willingness to be screened (ie, a more positive perception) after they were educated on lung cancer and screening options.[54] Importantly, Hall et al reported that patients with lower education were less likely to understand the reason for their referral to LCS,[48] and this lack of clarity is likely to lead to lower utilization in this group.

We also acknowledge that access is a powerful barrier that limits underserved groups from obtaining screening, as seen in other cancer studies.[71-74] Financial barriers may affect LCS utilization in marginalized groups because Medicaid does not universally cover LCS. Many individuals of low socioeconomic position are uninsured or underinsured and thus face financial hurdles that prevent them from obtaining annual LCS. Insured individuals of low SES may also experience barriers related to transportation or the inability to miss work for screening during work hours. Despite these difficulties, Pasquinelli et al revealed that, in the setting of Federally Qualified Health Centers, which serve the most marginalized and under-resourced communities, LCS can have favorable outcomes.[53] Therefore, LCS should be intentionally implemented in Federally Qualified Health Centers to ensure utilization in groups with the highest risk.

Finally, the goal of LCS is to diagnose NSCLC at an early stage, when it is curable; however, if individuals from marginalized groups are diagnosed at later stages, as some studies suggest,[47,60] then members of these groups will not experience the full benefit of screening. Because this trend would lead to lower utility of LCS among racial minority and lower SES individuals, it is critical to perform studies to further investigate this issue.

Postscreening Behavior and Care

In general, Black smokers smoke fewer cigarettes than White smokers,[51] contributing to fewer pack-years. There are also race-based differences in the experiences and behaviors of high-risk patients after receiving LCS. In the NLST, Black individuals had higher rates of short-term smoking cessation than White individuals after LCS, but sustained cessation rates were similarly low in both groups. In the same study, low-income smokers had fewer quit attempts than those who had more resources after LCS, suggesting that they benefit less from smoking cessation efforts. Therefore, there remains a need to understand which efforts are most beneficial to the most vulnerable groups.

Rates of post-LCS follow-up care may also differ by race and/or SES. Adherence represents a crucial stage in the LCS process because failure to adhere can completely undermine the benefit of LCS. One study reported lower rates of follow-up among Black participants,[57] whereas another study found no race or SES-based differences in follow-up.[45] Overall, there is a lack of clarity regarding trends in LCS adherence due to a lack of studies exploring this topic. Therefore, it is paramount that we undertake long-term studies to evaluate this issue and identify barriers to adherence as well as potential interventions.

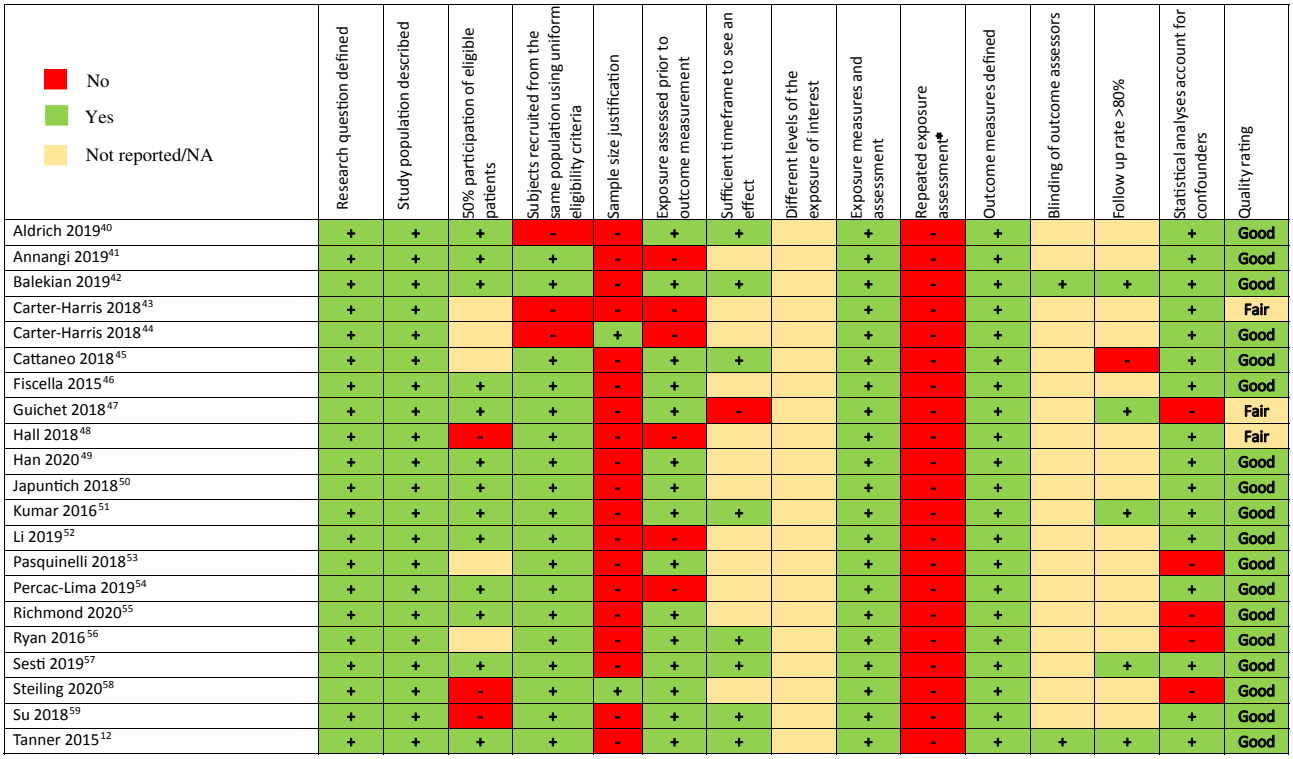
In the single study that evaluated the impact of race on surgical resection of stage I disease, Black men were less likely than White men to obtain surgery.[42] This disparity undoubtedly contributes to the significantly higher lung cancer-specific mortality rate faced by Black patients with NSCLC who are diagnosed by LCS.[12] It is also important to reiterate that Black individuals have a significantly greater reduction in lung cancer-specific and all-cause mortality after screening with LDCT.[12] This underscores the absolute need to ensure that high-risk Black individuals, in particular, obtain this life-saving examination.

Future Recommendations

The articles reviewed here have revealed multiple stages in the LCS pipeline in which marginalized patients may be excluded from the benefits of LCS, gradually worsening the disparities in NSCLC mortality among high-risk patients. Although additional studies are needed to confirm or further elucidate the potential sources of inequity in the LCS pipeline, we can begin to address some of the more obvious disparities now. We propose the following recommendations:

1. Address gaps in eligibility: Increase studies that evaluate the suitability of LCS criteria in underrepresented minority populations and communities of low socioeconomic position

Several studies have demonstrated the limits of current USPSTF LCS guidelines in capturing all individuals who could benefit from screening.[46,49,50,52,75] Specifically, smoking practices (ie, pack-years) and age requirements disqualify many high-risk Black individuals because they typically have fewer pack-years and are diagnosed with lung cancer at younger ages than the current USPSTF pack-year and age criteria.[51,76] As such, lowering the age and pack-year requirements could increase recommendations and referrals for screening among racial minority and low-income populations that are currently missed by current requirements. This approach is already garnering support, and USPSTF guidelines are being updated to include a wider age range (50-80 years) and lower pack-year smoking history (20 pack-years).[11] However, this update was based on the NELSON study, which was not based on a racially diverse cohort. Furthermore, Black smokers have longer quit times than White smokers,[50,67] and the risk of



	Research question defined	Study population described	50% participation of eligible patients	Subjects recruited from the same population using uniform eligibility criteria	Sample size justification	Exposure assessed prior to outcome measurement	Sufficient timeframe to see an effect	Different levels of the exposure of interest	Exposure measures and assessment	Repeated exposure assessment*	Outcome measures defined	Blinding of outcome assessors	Follow up rate >80%	Statistical analyses account for confounders	Quality rating
Aldrich 2019[40]	+	+	+	-	-	+	+		+	-	+			+	Good
Annangi 2019[41]	+	+	+	+	-	-			+	-	+			+	Good
Balekian 2019[42]	+	+	+	+	-	+	+		+	-	+	+	+	+	Good
Carter-Harris 2018[43]	+	+		-	-	-			+	-	+			+	Fair
Carter-Harris 2018[44]	+	+		-	+	-			+	-	+			+	Good
Cattaneo 2018[45]	+	+		+	-	+	+		+	-	+		-	+	Good
Fiscella 2015[46]	+	+	+	+	-	+			+	-	+			+	Good
Guichet 2018[47]	+	+	+	+	-	+	-		+	-	+		+	-	Fair
Hall 2018[48]	+	+	-	+	-	-			+	-	+			+	Fair
Han 2020[49]	+	+	+	+	-	+			+	-	+			+	Good
Japuntich 2018[50]	+	+	+	+	-	+			+	-	+			+	Good
Kumar 2016[51]	+	+	+	+	-	+	+		+	-	+		+	+	Good
Li 2019[52]	+	+	+	+	-	-			+	-	+			+	Good
Pasquinelli 2018[53]	+	+		+	-	+			+	-	+			-	Good
Percac-Lima 2019[54]	+	+	+	+	-	-			+	-	+			+	Good
Richmond 2020[55]	+	+	+	+	-	+			+	-	+			-	Good
Ryan 2016[56]	+	+		+	-	+	+		+	-	+			-	Good
Sesti 2019[57]	+	+	+	+	-	+	+		+	-	+		+	+	Good
Steiling 2020[58]	+	+	-	+	+	+			+	-	+			-	Good
Su 2018[59]	+	+	-	+	-	+	+		+	-	+			+	Good
Tanner 2015[12]	+	+	+	+	-	+	+		+	-	+	+	+	+	Good

FIGURE 3. Risk of Bias Assessment. This figure shows the risk of bias determination for each article included in the systematic review. *Because of the nature of the studies included in the review, the repeated exposure measurement assessment criterion is not applicable and thus was not considered in the quality rating decision. NA indicates not applicable.

lung cancer does not drop significantly for quit times >15 years.[64-66] This difference becomes important because former smokers lose eligibility once they have quit smoking for >15 years. This particular disparity is not addressed by the upcoming updates to the USPSTF guidelines. Therefore, now that randomized controlled trials have established that LCS with LDCT leads to a reduction in mortality, pragmatic designs and rigorous data modeling are required to determine which LCS criteria are most appropriate and will provide the greatest benefit to minority and low SES groups. Biomarker evaluation and the assessment of risk-prediction models should also be incorporated into early detection trials. In addition, there is not enough information available to determine whether lower education negatively affects eligibility rates. Studies and modeling focused on individuals with lower education are also required to identify individual-level factors that must be addressed to promote eligibility among high-risk populations.

2. Address gaps in utilization and utility: Implement interventions that increase PCP knowledge and adherence to guidelines and encourage discussion about screening with patients

Despite recent efforts, only 16% of eligible patients undergo LCS; therefore, LCS underutilization remains a major problem.[36] There are likely several patient-level, provider-level, and system-level barriers that need to be addressed to reduce underutilization by disadvantaged groups. Efforts to improve provider adherence to LCS recommendations must be prioritized. Raz et al observed that only one-half of PCPs were familiar with USPSTF LCS recommendations, and only 12% had referred a patient to an LCS program over the prior 12 months. The respondents explained that they had uncertainty regarding the benefits and harms of LCS as well as concerns regarding insurance coverage.[77] Thus, to increase utilization by eligible individuals, we must support the PCPs who refer patients to LDCT. Specifically, there is a need to improve providers' understanding of the LCS guidelines, the benefits of LDCT for high-risk patients, and the harms and costs of LDCT. Once this understanding is achieved, it can be passed on to patients. This lack of awareness is undergirded by the absence of endorsement of the USPSTF LCS recommendations by the American Association of Family Physicians, which has supported almost all of the other USPSTF guidelines.[78] It will be difficult for LCS utilization to increase without more engagement from the primary care community. In addition, even among PCPs who are aware of and support the USPSTF guidelines, the requirement set by the Centers for Medicare and Medicaid Services of a separate shared, informed decision-making process before performing LDCT screening is a known

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barrier to utilization that may be even more of a challenge in already underserved communities where clinicians may have even more time constraints.[79,80]

PCP-focused educational efforts, incentives for complying with USPSTF recommendations, and measurable quality metrics on the screening of high-risk patients may need to be implemented, especially in under-resourced communities where many underserved patients obtain care. In addition, discussions (eg, shared decision making) between patients and physicians can provide a space for patients to ask questions and become more comfortable with LCS, ultimately contributing to a greater likelihood of participation. This approach has been successful in the context of colorectal cancer screenings among racial and ethnic minorities.[81-83]

Creating programs and interventions that directly target barriers to LCS can also help increase screening rates. The Community Preventive Services Task Force endorses multicomponent interventions, which have been shown to increase the utilization of breast, colorectal, and cervical cancer screening services in underserved communities.[84] Multicomponent interventions increase demand for and access to cancer screening by combining ≥2 intervention approach strategies. Interventions relevant to LCS include: 1) increasing community demand for screening (eg, group education or mass media efforts), 2) increasing community access to screening (eg, addressing transportation barriers, assisting with appointment scheduling, or providing language translation services), and, as mentioned above, 3) increasing provider delivery of screening services (eg, through assessments of and incentives for provider compliance).

Several community-based interventions to increase LCS uptake have already proven successful[45,47,59] and can serve as models for future interventions to ensure that the benefits of screening reach a larger population and specifically those negatively affected by NSCLC disparities. In addition to targeting underrepresented populations and providing screening opportunities, these interventions should incorporate patient navigation.[85] Efforts to enhance statewide screening have been successful in overcoming barriers to the participation of underserved communities by leveraging networks of nurse navigators in states like Delaware. This cost-effective model resulted in reduced late-stage diagnosis and mortality and thus is worthy of consideration.[86] Screening opportunities alone may be ineffective if patients do not have the resources to traverse the unfamiliar LCS environment.

Finally, there is a significant gap in knowledge regarding the utility of LCS among Black and low-SES individuals. In particular, it is unclear whether these groups are more likely to have later stage disease at the time of diagnosis by LCS. Thus there is a need for prospective trials that over-recruit vulnerable communities to better answer this question.

3. Address gaps in follow-up care: Encourage provider discussion of follow-up options, including smoking cessation and surgery, to support patients through their treatment process

Lower rates of smoking cessation attempts among low-SES smokers may be mitigated by multilevel interventions, such as "Quit Happens,"[87] an evidence-based smoking cessation intervention for low-income populations that uses a combination of behavioral counseling and pharmacotherapy. The program has proven successful among high-risk populations and includes standardized training for program staff, allowing program adopters to adjust the program to their own needs. The program also includes several points of intervention for smokers and offers support from traditional and behavioral health providers, providing multiple avenues for patients to succeed. This approach ensures that patients have the support to continue their quit attempts if they fall short at any stage. Smoking cessation interventions should be incorporated into annual screening follow-up of LCS programs, which provide an opportunity to personalize and enhance smoking cessation guidance and can increase quitting rates.[88]

In addition to comprehensive interventions, we must conduct additional studies to fully understand the impact of race and SES on follow-up after LCS. Current studies have had mixed findings, with some reporting lower rates of follow-up among Black patients,[51] and others reporting no race-based or SES-based differences in follow-up.[45] Because a survival benefit is only obtained after 3 annual LDCT screenings, it is important to rectify any hurdles that may negatively affect follow-up. To better understand where the gaps are in follow-up, long-term prospective studies that include marginalized groups are necessary. We also recommend patient navigation and social support to help underserved patients navigate transportation, work, or family issues that may prevent compliance.

Although some studies have identified racial disparities in access to surgery among patients with lung cancer,[42,89] few solutions have been offered to improve rates of surgery among marginalized patients. Efforts to address surgical disparities in other cancers have proposed the use of both multidisciplinary management and medical advocates throughout the course of a patient's treatment.[90] These advocates can ensure proper education and help with communication between the clinical staff and the patient. Physicians and surgeons must also acknowledge that their own implicit biases can prevent patients from obtaining important care. The finding that Black patients receive lower rates of surgery indicates a difference in how

physicians manage cancer based on a patient's race, regardless of other factors, and the consequence of the resulting lapses in care is a reduction in survival among Blacks.[91] Cultural competency training and implicit/explicit bias coursework should be mandatory for every provider in medical school and as a part of continued medical education. In addition, we need a renewed focus on strengthening patient-physician relationships and communication, especially when the patient and provider are from different backgrounds.

Strengths and Limitations

We acknowledge that this study has limitations. The topics and articles included in our systematic review were limited by a paucity of literature available on LCS disparities. As such, although we acknowledge that LCS disparities may exist for other minority populations, given the scarcity of literature on other racial and ethnic minorities, we focused primarily on disparities between Black and White individuals. This study also did not focus on the disparities that women face regarding LCS. In light of the higher incidence of lung cancer in women compared with men,[92] it is remarkable that the NELSON trial included accrual of so few women in its design. Although the focus of sex-based disparities in LCS was beyond the scope of this review, the finding that women face higher incidence despite smoking fewer cigarettes[93] and are diagnosed at a younger age[94] supports the need for more inclusive research to understand LCS eligibility, utilization, and outcome differences in women. In addition, because publications on this topic are limited, most of our analysis relied on observational and secondary analysis studies. Similarly, we could only conduct a qualitative analysis because of a lack of randomized controlled trials and insufficient rigor and uniformity to perform quantitative meta-analyses.

Despite these limitations, our systematic review also has several strengths. First, to our knowledge, this is the first systematic review to investigate racial and socioeconomic disparities in LCS. Second, we intentionally analyzed and included studies from a wide spectrum of domains at each level of screening (including prescreening and postscreening). Third, most articles included in this systematic review were of good quality, as indicated by their low risk of bias. Finally, many of the articles included in this review provide templates for potential interventions and form the basis for potential policy changes to overcome disparities in LCS and, ultimately, NSCLC.

Conclusions

Our systematic review of the literature has revealed that disparities are prevalent in LCS eligibility; utilization, perception, and utility; and postscreening behavior and care. These disparities collectively cause significant NSCLC survival gaps along racial and socioeconomic lines, and greater awareness of their underlying sources is critical if we are to combat them. We recommend efforts to increase prospective trials and rigorous data modeling to evaluate the suitability of LCS eligibility criteria for underserved groups. We also believe that multicomponent interventions that increase community demand and access, as well as provider engagement, will help decrease the disparities that are currently associated with this life-saving tool. ■

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References

1. Siegel R, Naishadham D, Jemal A. Cancer statistics, 2012. *CA Cancer J Clin.* 2012;62:10-29.
2. Walters S, Maringe C, Coleman MP, et al. Lung cancer survival and stage at diagnosis in Australia, Canada, Denmark, Norway, Sweden and the UK: a population-based study, 2004-2007. *Thorax.* 2013;68:551-564.
3. Pedersen JH, Ashraf H, Dirksen A, et al. The Danish randomized lung cancer CT screening trial—overall design and results of the prevalence round. *J Thorac Oncol.* 2009;4:608-614.
4. Swensen SJ, Jett JR, Sloan JA, et al. Screening for lung cancer with low-dose spiral computed tomography. *Am J Respir Crit Care Med.* 2002;165:508-513.
5. Paci E, Puliti D, Lopes Pegna A, et al. Mortality, survival and incidence rates in the ITALUNG randomised lung cancer screening trial. *Thorax.* 2017;72:825-831.
6. Saghir Z, Dirksen A, Ashraf H, et al. CT screening for lung cancer brings forward early disease. The randomised Danish Lung Cancer Screening Trial: status after five annual screening rounds with low-dose CT. *Thorax.* 2012;67:296-301.
7. 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;365:395-409.
8. Aberle DR, Adams AM, Berg CD, et al. Baseline characteristics of participants in the randomized national lung screening trial. *J Natl Cancer Inst.* 2010;102:1771-1779.
9. Moyer VA. Screening for lung cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2014;160:330-338.
10. 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;382:503-513.
11. Young K. Draft USPSTF Recommendations Expand Lung Cancer Screening [press release]. NEJM Journal Watch; 2020. Accessed March 3, 2021. www.jwatch.org/fw116811/2020/07/07/draft-uspstf-recommendations-expand-lung-cancer-screening
12. Tanner NT, Gebregziabher M, Hughes Halbert C, Payne E, Egede LE, Silvestri GA. Racial differences in outcomes within the National Lung Screening Trial. Implications for widespread implementation. *Am J Respir Crit Care Med.* 2015;192:200-208.
13. American Cancer Society. Key Statistics for Lung Cancer. American Cancer Society; 2020. Accessed April 15, 2020. cancer.org/cancer/lung-cancer/about/key-statistics.html

15424863, 2021, 4, Downloaded from https://acsjournals.onlinelibrary.wiley.com/doi/10.3322/caac.21671, Wiley Online Library on [06/05/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

14. Meza R, Meernik C, Jeon J, Cote ML. Lung cancer incidence trends by gender, race and histology in the United States, 1973-2010. *PLoS One.* 2015;10:e0121323.
15. National Cancer Institute. Cancer Trends Progress Report. National Cancer Institute, National Institutes of Health, US Department of Health and Human Services; 2020.
16. Ward E, Jemal A, Cokkinides V, et al. Cancer disparities by race/ethnicity and socioeconomic status. *CA Cancer J Clin.* 2004;54:78-93.
17. Torre LA, Siegel RL, Jemal A. Lung cancer statistics. *Adv Exp Med Biol.* 2016;893:1-19.
18. Yu XQ, Luo Q, Kahn C, et al. Widening socioeconomic disparity in lung cancer incidence among men in New South Wales, Australia, 1987-2011. *Chin J Cancer Res.* 2017;29:395-401.
19. Greenwald HP, Polissar NL, Borgatta EF, McCorkle R, Goodman G. Social factors, treatment, and survival in early-stage non-small cell lung cancer. *Am J Public Health.* 1998;88:1681-1684.
20. Tannenbaum SL, Koru-Sengul T, Zhao W, Miao F, Byrne MM. Survival disparities in non-small cell lung cancer by race, ethnicity, and socioeconomic status. *Cancer J.* 2014;20:237-245.
21. Singh GK, Miller BA, Hankey BF. Changing area socioeconomic patterns in U.S. cancer mortality, 1950-1998: part II—lung and colorectal cancers. *J Natl Cancer Inst.* 2002;94:916-925.
22. Ebner PJ, Ding L, Kim AW, et al. The effect of socioeconomic status on treatment and mortality in non-small cell lung cancer patients. *Ann Thorac Surg.* 2020;109:225-232.
23. Hardy D, Liu CC, Xia R, et al. Racial disparities and treatment trends in a large cohort of elderly Black and White patients with nonsmall cell lung cancer. *Cancer.* 2009;115:2199-2211.
24. Margolis ML, Christie JD, Silvestri GA, Kaiser L, Santiago S, Hansen-Flaschen J. Racial differences pertaining to a belief about lung cancer surgery: results of a multicenter survey. *Ann Intern Med.* 2003;139:558-563.
25. Bach PB, Cramer LD, Warren JL, Begg CB. Racial differences in the treatment of early-stage lung cancer. *N Engl J Med.* 1999;341:1198-1205.
26. Dalwadi SM, Lewis GD, Bernicker EH, Butler EB, Teh BS, Farach AM. Disparities in the treatment and outcome of stage I non-small-cell lung cancer in the 21st century. *Clin Lung Cancer.* 2019;20:194-200.
27. Yang R, Cheung MC, Byrne MM, et al. Do racial or socioeconomic disparities exist in lung cancer treatment? *Cancer.* 2010;116:2437-2447.
28. Corso CD, Park HS, Kim AW, Yu JB, Husain Z, Decker RH. Racial disparities in the use of SBRT for treating early-stage lung cancer. *Lung Cancer.* 2015;89:133-138.
29. Cykert S, Dilworth-Anderson P, Monroe MH, et al. Factors associated with decisions to undergo surgery among patients with newly diagnosed early-stage lung cancer. *JAMA.* 2010;303:2368-2376.
30. Liu JH, Zingmond DS, McGory ML, et al. Disparities in the utilization of high-volume hospitals for complex surgery. *JAMA.* 2006;296:1973-1980.
31. Clegg LX, Li FP, Hankey BF, Chu K, Edwards BK. Cancer survival among US Whites and minorities: a SEER (Surveillance, Epidemiology, and End Results) program population-based study. *Arch Intern Med.* 2002;162:1985-1993.
32. Wong MD, Tagawa T, Hsieh HJ, Shapiro MF, Boscardin WJ, Ettner SL. Differences in cause-specific mortality between Latino and White adults. *Med Care.* 2005;43:1058-1062.
33. Warren GW, Cummings KM. Tobacco and lung cancer: risks, trends, and outcomes in patients with cancer. *Am Soc Clin Oncol Educ Book.* 2013;2013:359-364.
34. Barbeau EM, Wolin KY, Naumova EN, Balbach E. Tobacco advertising in communities: associations with race and class. *Prev Med.* 2005;40:16-22.
35. Jemal A, Fedewa SA. Lung cancer screening with low-dose computed tomography in the United States—2010 to 2015. *JAMA Oncol.* 2017;3:1278-1281.
36. Yong PC, Sigel K, Rehmani S, Wisnivesky J, Kale MS. Lung cancer screening uptake in the United States. *Chest.* 2020;157:236-238.
37. Moher D, Liberati A, Tetzlaff J, Altman DG, The PG. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. *PLoS Med.* 2009;6:e1000097.
38. National Institutes of Health; National Heart, Lung, and Blood Institute. Study Quality Assessment Tools. Accessed June 20, 2020. nhlbi.nih.gov/health-topics/study-quality-assessment-tools
39. Sedrak MS, Freedman RA, Cohen HJ, et al. Older adult participation in cancer clinical trials: a systematic review of barriers and interventions. *CA Cancer J Clin.* 2021;71:78-92.
40. Aldrich MC, Mercaldo SF, Sandler KL, Blot WJ, Grogan EL, Blume JD. Evaluation of USPSTF lung cancer screening guidelines among African American adult smokers. *JAMA Oncol.* 2019;5:1318-1324.
41. Annangi S, Nutalapati S, Foreman MG, Pillai R, Flenaugh EL. Potential racial disparities using current lung cancer screening guidelines. *J Racial Ethn Health Disparities.* 2019;6:22-26.
42. Balekian AA, Wisnivesky JP, Gould MK. Surgical disparities among patients with stage I lung cancer in the National Lung Screening Trial. *Chest.* 2019;155:44-52.
43. Carter-Harris L, Slaven JE Jr, Monahan PO, Shedd-Steele R, Hanna N, Rawl SM. Understanding lung cancer screening behavior: racial, gender, and geographic differences among Indiana long-term smokers. *Prev Med Rep.* 2018;10:49-54.
44. Carter-Harris L, Schwindt R, Bakoyannis G, Ceppa DP, Rawl SM. Current smokers' preferences for receiving cessation information in a lung cancer screening setting. *J Cancer Educ.* 2018;33:1120-1125.
45. Cattaneo SM 2nd, Meisenberg BR, Geronimo MCM, Bhandari B, Maxted JW, Brady-Copertino CJ. Lung cancer screening in the community setting. *Ann Thorac Surg.* 2018;105:1627-1632.
46. Fiscella K, Winters P, Farah S, Sanders M, Mohile SG. Do lung cancer eligibility criteria align with risk among Blacks and Hispanics? *PLoS One.* 2015;10:e0143789.
47. Guichet PL, Liu BY, Desai B, Surani Z, Cen SY, Lee C. Preliminary results of lung cancer screening in a socioeconomically disadvantaged population. *AJR Am J Roentgenol.* 2018;210:489-496.
48. Hall DL, Lennes IT, Carr A, Eusebio JR, Yeh GY, Park ER. Lung cancer screening uncertainty among patients undergoing LDCT. *Am J Health Behav.* 2018;42:69-76.
49. Han SS, Chow E, Ten Haaf K, et al. Disparities of national lung cancer screening guidelines in the US population. *J Natl Cancer Inst.* 2020;112:1136-1142.
50. Japuntich SJ, Krieger NH, Salvas AL, Carey MP. Racial disparities in lung cancer screening: an exploratory investigation. *J Natl Med Assoc.* 2018;110:424-427.
51. Kumar P, Gareen IF, Lathan C, et al. Racial differences in tobacco cessation and treatment usage after lung screening: an examination of the National Lung Screening Trial. *Oncologist.* 2016;21:40-49.
52. Li CC, Matthews AK, Rywant MM, Hallgren E, Shah RC. Racial disparities in eligibility for low-dose computed tomography lung cancer screening among older adults with a history of smoking. *Cancer Causes Control.* 2019;30:235-240.
53. Pasquinelli MM, Kovitz KL, Koshy M, et al. Outcomes from a minority-based lung cancer screening program vs the National Lung Screening Trial. *JAMA Oncol.* 2018;4:1291-1293.
54. Percac-Lima S, Ashburner JM, Atlas SJ, et al. Barriers to and interest in lung cancer screening among Latino and non-Latino current and former smokers. *J Immigr Minor Health.* 2019;21:1313-1324.
55. Richmond J, Mbah OM, Dard SZ, et al. Evaluating potential racial inequities in low-dose computed tomography

15424863, 2021, 4, Downloaded from https://acsjournals.onlinelibrary.wiley.com/doi/10.3322/caac.21671, Wiley Online Library on [06/05/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

screening for lung cancer. *J Natl Med Assoc.* 2020;112:209-214.
56. Ryan BM. Differential eligibility of African American and European American lung cancer cases using LDCT screening guidelines. *BMJ Open Respir Res.* 2016;3:e000166.
57. Sesti J, Sikora TJ, Turner DS, et al. Disparities in follow-up after low-dose lung cancer screening. *Semin Thorac Cardiovasc Surg.* 2020;32:1058-1063.
58. Steiling K, Loui T, Asokan S, et al. Age, race, and income are associated with lower screening rates at a safety net hospital. *Ann Thorac Surg.* 2020;109:1544-1550.
59. Su CT, Bhargava A, Shah CD, et al. Screening patterns and mortality differences in patients with lung cancer at an urban underserved community. *Clin Lung Cancer.* 2018;19:e767-e773.
60. Li K, Husing A, Sookthai D, et al. Selecting high-risk individuals for lung cancer screening: a prospective evaluation of existing risk models and eligibility criteria in the German EPIC cohort. *Cancer Prev Res (Phila).* 2015;8:777-785.
61. Wu GX, Goldstein L, Kim JY, Raz DJ. Proportion of non-small-cell lung cancer patients that would have been eligible for lung cancer screening. *Clin Lung Cancer.* 2016;17:e131-e139.
62. Tammemagi MC, Church TR, Hocking WG, et al. Evaluation of the lung cancer risks at which to screen ever- and never-smokers: screening rules applied to the PLCO and NLST cohorts. *PLoS Med.* 2014;11:e1001764.
63. Tammemagi MC, Katki HA, Hocking WG, et al. Selection criteria for lung-cancer screening. *N Engl J Med.* 2013;368:728-736.
64. Mong C, Garon EB, Fuller C, et al. High prevalence of lung cancer in a surgical cohort of lung cancer patients a decade after smoking cessation. *J Cardiothorac Surg.* 2011;6:19.
65. Pinsky PF, Zhu CS, Kramer BS. Lung cancer risk by years since quitting in 30+ pack year smokers. *J Med Screen.* 2015;22:151-157.
66. Tindle HA, Stevenson Duncan M, Greevy RA, et al. Lifetime smoking history and risk of lung cancer: results from the Framingham Heart Study. *J Natl Cancer Inst.* 2018;110:1201-1207.
67. Stellman SD, Chen Y, Muscat JE, et al. Lung cancer risk in White and Black Americans. *Ann Epidemiol.* 2003;13:294-302.
68. Pasquinelli MM, Tammemagi MC, Kovitz KL, et al. Risk prediction model versus United States Preventive Services Task Force lung cancer screening eligibility criteria: reducing race disparities. *J Thorac Oncol.* 2020;15:1738-1747.
69. Raz DJ, Wu G, Nelson RA, et al. Perceptions and utilization of lung cancer screening among smokers enrolled in a tobacco cessation program. *Clin Lung Cancer.* 2019;20:e115-e122.
70. Raz DJ, Wu GX, Consunji M, et al. The effect of primary care physician knowledge of lung cancer screening guidelines on perceptions and utilization of low-dose computed tomography. *Clin Lung Cancer.* 2018;19:51-57.
71. McAlearney AS, Reeves KW, Dickinson SL, et al. Racial differences in colorectal cancer screening practices and knowledge within a low-income population. *Cancer.* 2008;112:391-398.
72. Harris DM, Miller JE, Davis DM. Racial differences in breast cancer screening, knowledge and compliance. *J Natl Med Assoc.* 2003;95:693-701.
73. Vernon SW, Vogel VG, Halabi S, Jackson GL, Lundy RO, Peters GN. Breast cancer screening behaviors and attitudes in three racial/ethnic groups. *Cancer.* 1992;69:165-174.
74. Doubeni CA, Laiyemo AO, Klabunde CN, Young AC, Field TS, Fletcher RH. Racial and ethnic trends of colorectal cancer screening among Medicare enrollees. *Am J Prev Med.* 2010;38:184-191.
75. Centers for Disease Control and Prevention (CDC). Comprehensive smoke-free laws—50 largest U.S. cities, 2000 and 2012. *MMWR Morb Mortal Wkly Rep.* 2012;61:914-917.
76. Robbins HA, Engels EA, Pfeiffer RM, Shiels MS. Age at cancer diagnosis for Blacks compared with Whites in the United States. *J Natl Cancer Inst.* 2015;107:dju489.
77. Raz DJ, Wu GX, Consunji M, et al. Perceptions and utilization of lung cancer screening among primary care physicians. *J Thorac Oncol.* 2016;11:1856-1862.
78. American Academy of Family Physicians. Clinical Preventive Service Recommendation: Lung Cancer. American Academy of Family Physicians; 2013. Accessed March 3, 2021. aafp.org/patient-care/clinical-recommendations/all/lung-cancer.html
79. Wang GX, Baggett TP, Pandharipande PV, et al. Barriers to lung cancer screening engagement from the patient and provider perspective. *Radiology.* 2019;290:278-287.
80. Wender R, Fontham ET, Barrera E Jr, et al. American Cancer Society lung cancer screening guidelines. *CA Cancer J Clin.* 2013;63:107-117.
81. Dolan NC, Ramirez-Zohfeld V, Rademaker AW, et al. The effectiveness of a physician-only and physician-patient intervention on colorectal cancer screening discussions between providers and African American and Latino patients. *J Gen Intern Med.* 2015;30:1780-1787.
82. Inadomi JM, Vijan S, Janz NK, et al. Adherence to colorectal cancer screening: a randomized clinical trial of competing strategies. *Arch Intern Med.* 2012;172:575-582.
83. Mosen DM, Feldstein AC, Perrin NA, et al. More comprehensive discussion of CRC screening associated with higher screening. *Am J Manag Care.* 2013;19:265-271.
84. Community Preventive Services Task Force (CPSFT). The Community Guide. Cancer Screening: Multicomponent Interventions—Breast Cancer. CPSFT; 2020. Accessed October 26, 2020. thecommunityguide.org/findings/cancer-screening-multicomponent-interventions-breast-cancer
85. Lamanna A, Sheaffer H, Guerra C, Kochman M. Colorectal cancer screening navigation for the underserved: experience of an urban program. *Gastroenterol Hepatol (N Y).* 2016;12:547-551.
86. Grubbs SS, Polite BN, Carney J Jr, et al. Eliminating racial disparities in colorectal cancer in the real world: it took a village. *J Clin Oncol.* 2013;31:1928-1930.
87. Shishani K, Graves JM, McGowan P, Lockwood W, Nystrom M, Barbosa-Leiker C. Quit Happens: a community clinic-based, multitiered smoking cessation intervention. *Public Health Nurs.* 2019;36:813-818.
88. Park ER, Gareen IF, Japuntich S, et al. Primary care provider-delivered smoking cessation interventions and smoking cessation among participants in the National Lung Screening Trial. *JAMA Intern Med.* 2015;175:1509-1516.
89. Ezer N, Mhango G, Bagiella E, Goodman E, Flores R, Wisnivesky JP. Racial disparities in resection of early stage non-small cell lung cancer: variability among surgeons. *Med Care.* 2020;58:392-398.
90. Lineback CM, Mervak CM, Revels SL, Kemp MT, Reddy RM. Barriers to accessing optimal esophageal cancer care for socioeconomically disadvantaged patients. *Ann Thorac Surg.* 2017;103:416-421.
91. King TE, Brunetta P. Racial disparity in rates of surgery for lung cancer. *N Engl J Med.* 1999;341:1231-1233.
92. Hellyer JA, Patel MI. Sex disparities in lung cancer incidence: validation of a long-observed trend. *Transl Lung Cancer Res.* 2019;8:543-545.
93. Egleston BL, Meireles SI, Flieder DB, Clapper ML. Population-based trends in lung cancer incidence in women. *Semin Oncol.* 2009;36:506-515.
94. Cerfolio RJ, Bryant AS, Scott E, et al. Women with pathologic stage I, II, and III non-small cell lung cancer have better survival than men. *Chest.* 2006;130:1796-1802.

15424863, 2021, 4, Downloaded from https://acsjournals.onlinelibrary.wiley.com/doi/10.3322/caac.21671, Wiley Online Library on [06/05/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License