Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Factors influencing lung cancer screening completion following participation in shared decision-making: A retrospective study in a U.S. academic health system

Lior Rennert\textsuperscript{a,⁎}, Lu Zhang\textsuperscript{a}, Brandon Lumsden\textsuperscript{a,b}, Katon Harwood\textsuperscript{c}, Lauren Tyler\textsuperscript{d}, Morgan Ashby\textsuperscript{a}, Jeffrey W. Hanna\textsuperscript{e}, Ronald W. Gimbel\textsuperscript{a}

\textsuperscript{a}Department of Public Health Sciences, Clemson University, Clemson, SC, United States  
\textsuperscript{b}School of Mathematical and Statistical Sciences, Clemson University, Clemson, SC, United States  
\textsuperscript{c}School of Osteopathic Medicine, Campbell University, Lillington, NC, United States  
\textsuperscript{d}School of Medicine, University of South Carolina, Greenville, SC, United States  
\textsuperscript{e}Department of Radiology, Prisma Health System, Greenville, SC, United States

ARTICLE INFO

Keywords:  
Lung cancer screening  
Shared decision-making  
Prevention  
Barriers  
Multivariable analysis

ABSTRACT

Purpose: Shared decision making (SDM) between patients and designated health professionals is recommended by several professional organizations prior to lung cancer screening by low dose CT (LDCT). This study seeks to identify factors, including characteristics of patients and referring clinicians, that influence LDCT screening completion following participation in SDM.

Materials and methods: This retrospective study consisted of \( n = 171 \) patients eligible for LDCT screening and who participated in SDM between 2016 and 2017 in one of two sites in Prisma Health, an academic health care delivery system in South Carolina. Patient characteristics included age, sex, race, body mass index, marital status, insurance, smoking status and history, family history of lung cancer, SDM site, and distance to screening site. Characteristics of referred clinicians included age, sex, race, body mass index, marital status, insurance, smoking status and history, family history of lung cancer, SDM site, and distance to screening site. Characteristics of referred clinicians included age, sex, race, body mass index, marital status, insurance, smoking status and history, family history of lung cancer, SDM site, and distance to screening site. Descriptive statistics and multivariable generalized linear mixed models were used to compare effects of patient and referring clinician characteristics on LDCT completion.

Results: A total of 152 patients (89\%) completed LDCT screening after participation in SDM. SDM site (\( p = 0.02 \)), longer distances to the screening site (\( p = 0.03 \)), referrals from internal medicine clinicians (\( p = 0.03 \)), and referrals from younger clinicians (\( p = 0.01 \)) and from those with less years of experience (\( p = 0.02 \)) were significantly associated with a lower likelihood of screening completion.

Conclusions: Several factors significantly associated with screening completion were identified. This information can assist with development of interventions to improve communication and decision-making between patients, clinicians, and SDM health professionals, and inform design of targeted decision aids embedded into SDM procedures.

1. Introduction

Lung cancer is the leading cause of cancer mortality in both men and women in the United States (US), and has led to an estimated 142,670 deaths in 2019 [1]. Because the majority of lung cancer cases are diagnosed at an advanced stage, the lung cancer 5-year survival rate of 19.4\% is comparatively low to the survival rate of other cancers [2, 3]. Following the National Lung Cancer Screening Trial (NLST) report that annual screenings of low dose CT (LDCT) reduced lung cancer mortality by 20\% [4], the US Preventive Services Task Force (USPSTF) recommended annual LDCT to high-risk individuals [5]. High-risk individuals were defined as adults aged 55–80 who are current smokers or former smokers who quit within the past 15 years, with a smoking history of at least 30 pack-years. In 2015, The Affordable Care Act mandated that private insurance companies cover LDCT and the Centers for Medicare and Medicaid Services (CMS) approved the use of LDCT for high-risk individuals [6].

While LDCT lowers patient mortality, there are potential harms to the patient. These harms have been categorized into four domains: physical effects, psychological effects, financial strain, and opportunity...

\* Corresponding author at: Department of Public Health Sciences, 529 Edwards Hall, Clemson, SC 29634, United States

E-mail address: lior@clemson.edu (L. Rennert).

https://doi.org/10.1016/j.ctarc.2020.100198

2468-2942/ © 2020 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/BY-NC-ND/4.0/).
costs [7]. Specific harms include, but are not limited to, radiation, false positives, overdagnosis, and overtreatment [7, 8]. Because of the complexities of the benefits and harms of LDCT, shared decision making (SDM) is necessary to ensure that each patient can understand and weigh the potential benefits and harms associated with annual LDCT screening [9–11]. SDM is a process where a health professional and a patient can have a face-to-face conversation about the options, benefits, harms, and patient preferences of LDCT screening [12, 13]. Ultimately, the patient and health professional arrive at a shared decision that leverages the patient’s values and beliefs [13]. Several professional organizations promote SDM for lung cancer screening [14], and CMS coverage mandates participation in SDM prior to screening [5].

Support for LDCT screening is generally high [14]. However, screening uptake is comparatively low [15,16], and numerous studies found that clinician referral and patient participation in LDCT screening is influenced by both patient and clinician level barriers [17–24, 11]. Recent studies have shown that the LDCT screening rate is much higher for patients participating in SDM [9, 25–27]. While studies have examined factors that patients and clinicians consider important in the decision-making process [11, 17, 28], little is known about the factors influencing LDCT completion in this population of individuals who choose to participate in SDM. Understanding these factors is necessary for improving shared decision-making and screening rates [29].

In this paper, we examine the association between patient and referring clinician characteristics and LDCT completion following participation in SDM, across two sites in an academic healthcare delivery system in South Carolina. Knowledge of which factors influence LDCT screening in this population is important, as it can be used to improve communication between SDM health professionals, patients, and their referring clinicians, and potentially increase LDCT uptake for high-risk individuals.

2. Materials and methods

2.1. Setting, participants, and procedures

Prisma Health, formerly known as Greenville Health System (GHS) prior to 2019, is a not-for-profit academic healthcare delivery system geographically located in the Upstate of South Carolina. Prisma Health compromises of seven medical campuses, six acute care hospitals, two specialty hospitals, nine outpatient facilities and 155 affiliated practice sites. In 2015, Prisma Health launched a multidisciplinary lung cancer screening program, which was accredited with American College of Radiology (ACR).

There are two sites for SDM of lung cancer screening in Prisma Health: The Center for Integrative Oncology and Survivorship (CIOS) and the Pulmonology Clinic (Pulm). Every appointment was conducted by a designated nurse practitioner to ensure patient understanding of the LDCT screening, discuss the benefits and risks, and address any concerns the patient may have about the process. Both SDM sites used a lung cancer screening pamphlet as a decision aid. This pamphlet was developed by Prisma Health based on several national guidelines [30]. It included a basic introduction of LDCT, eligibility criteria of screening, potential benefits and risks of screening, advice on smoking cessation, and contact information for a lung cancer screening program. In addition to the pamphlet, CIOS used a Lung Nodule Information Sheet to educate the patients on how to interpret the margin, size, and density of lung nodules.

In this retrospective study, we identified LDCT eligible individuals who were referred for LDCT and participated in SDM at one of the two SDM sites in Prisma Health between February 1, 2016 and January 31, 2017. Consistent with CMS requirements, LDCT eligible individuals were defined as 55–77 years of age who are either current smokers or former smokers who have quit within the past 15 years, and have a tobacco history of 30 or more pack-years [6]. Exclusion criteria included any patients with a history of lung cancer (n = 1), patients who were self-referred (n = 2), or patients with continuous referrals (n = 4). These patients did not represent the target population of interest. The final sample consists of 171 patients who participated in SDM for lung cancer screening but have not been previously screened.

The characteristics of patients and referring clinicians, as well as LDCT completion status, were extracted from the Prisma electronic health record (EHR). The study was approved by the Prisma Institutional Review Board (IRB); informed consent was waived, and a partial Health Insurance Portability and Accountability Act waiver was granted to support data extraction.

2.2. Study measures

The primary outcome measure was a binary indicator of whether the patient completed LDCT screening (yes or no). Patient characteristics included age (55–59, 60–69, or 70–77), sex, race (Caucasian or non-Caucasian), body mass index (<25, 25–29.9, or ≥30), marital status (married or not married), insurance provider (Medicare, Medicaid, Private, or uninsured), smoking status (current smoker or former smoker), smoking history (30–39, 40–59, or 60 + pack-years), family history of lung cancer (yes or no), the site where SDM took place (CIOS or Pulm), and distance from patient’s home to LDCT site (miles). Characteristics of referring clinicians included age (30–39, 40–49, 50–59, or 60–69), sex, race (Caucasian or non-Caucasian), specialty (internal medicine, family medicine, or oncology/hematology), years of practice (<5, 5–9, 10–19, or 20 +), education level (medical doctor or osteopathic doctor (MD/DO), physician assistant, or nurse practitioner), and the status of current residency training (yes or no). The inclusion of these variables was based on existing literature, and is summarized in Supplementary Table 1.

2.3. Statistical methods

We first used descriptive statistics to compare patient-level and clinician-level characteristics by LDCT completion (yes/no). Categorical variables are reported as number (%) and compared with a chi-squared test. Exact tests were used for variables with small cell counts. Continuous variables are reported as the mean ± standard deviation and differences between the groups were testing using the Kruskal-Wallis rank test. To examine whether the effects of these variables differ by SDM site, data were stratified by SDM site and descriptive statistics are reported by site.

Multivariable generalized linear mixed effects models (GLMM) were used to analyze the joint effects of these characteristics on LDCT screening to account for dependent observations [31]. Random intercepts were used to account for correlation between patients referred by the same clinician. Given the limited sample size, the model only adjusted for variables with a p-value < 0.20 in the univariate analyses. Current smoking status was also included in the model, as this is a well-known predictor of LDCT completion [18, 29]. All categorical variables with >2 categories were dichotomized for the regression models in order to account for small cell counts. Clinician years of practice, age, and residency were included in separate models to avoid collinearity. Multiple imputation was performed to replace missing values in some of the variables. Inference is based on the parameter estimates from the GLMM corresponding to 20 imputed data sets. An interaction between each variable in the GLMM and SDM site was included to test whether the odds ratios of screening completion differed by SDM site. All analyses were conducted using the MI, GLIMMIX, and MIANALYZE procedures in SAS.

Results

The final sample consisted of 171 patients, 152 (88.8%) which proceeded to complete LDCT screening. Patient characteristics are described in Table 1. Patients referred to CIOS were more likely to
proceed with LDCT screening compared to those referred to PULM (95.7% vs 75.0%, \( p < 0.01 \)). Compared to patients who completed LDCT screening, patients who did not complete LDCT screening lived further (on average) from the imaging center where LDCT screening was performed (14.9 miles vs 22.7 miles, \( p = 0.03 \)). No other variables, including current smoking status and smoking history, were deemed statistically significant at the 0.05 level.

Characteristics of the referring clinicians are described in Table 2. There were 81 Prisma clinicians identified in the study that referred patients for LDCT screening. Each clinician referred a median of 2 patients for LDCT screening (IQR = 1 to 2, range = 1 to 19). A total of 70 clinicians (86.4%) referred four patients or less, 9 clinicians (11.1%) referred four to seven patients, and 2 clinicians (2.5%) referred at least 10. The highest number of patients referred by a clinician was 19, accounting for 11.1% of the patient sample. Patients of clinicians who were younger (30–39 years of age) were less likely to complete screening (\( p < 0.01 \)). Patients participating in SDM at PULM (95.7%) were less likely to proceed with LDCT screening compared to former smokers, this difference was not statistically significant (\( OR = 0.53, 95\% CI = 0.13 \) to 2.14, \( p = 0.38 \)). A separate model replacing clinician years of practice with clinician age concluded that patients with younger

### Table 1

| Variable                | LDCT Completion | P-value |
|-------------------------|-----------------|---------|
| Age Group               |                 | 0.71    |
| 55–59                   | 39 (22.9)       |         |
| 60–69                   | 97 (57.1)       |         |
| 70–77                   | 34 (20.0)       |         |
| Race Group              |                 | 0.72    |
| Caucasian               | 121 (73.5)      |         |
| Non-Caucasian           | 49 (26.5)       |         |
| Gender                  |                 | 1.00    |
| Male                    | 89 (52.0)       |         |
| Body Mass Index         |                 | 0.83    |
| < 25                    | 50 (29.6)       |         |
| 25–30                   | 64 (37.9)       |         |
| > 30                    | 55 (32.5)       |         |
| Marital Status          |                 | 1.00    |
| Not married             | 72 (43.6)       |         |
| Married                 | 93 (56.4)       |         |
| Insurance Provider Group|                 | 0.61    |
| Medicare                | 124 (72.9)      |         |
| Medicaid                | 15 (8.82)       |         |
| Private                 | 29 (17.1)       |         |
| Uninsured               | 2 (1.18)        |         |
| Smoking History, years  |                 | 0.33    |
| 30–39                   | 42 (24.9)       |         |
| 40–59                   | 82 (48.5)       |         |
| 60+ packs               | 45 (26.6)       |         |
| Smoking Status          |                 | 0.30    |
| Former smoker           | 58 (33.9)       |         |
| Current Smoker          | 113 (68.7)      |         |
| Family History of Lung Cancer | 112 (90.3) | 0.15    |
| No                      | 124 (77.0)      |         |
| Yes                     | 37 (23.0)       |         |
| SDM site patient referred to | 115 (67.3) | <0.01   |
| CIOS                    | 110 (95.7)      |         |
| Pulm                    | 56 (32.7)       |         |
| Distance from patient to home screening | 15.8 (12.0) | 0.03 |

### Table 2

| Variable A | Clinician | P-value |
|------------|-----------|---------|
| Age Group A|           | <0.01   |
| 30–39      | 26 (37.68)| 46 (30.3) |
| 40–49      | 17 (24.64)| 38 (25.0) |
| 50–59      | 19 (27.54)| 58 (38.2) |
| 60–69      | 7 (10.14)| 10 (6.58) |
| Race Group |           | 0.22    |
| Non-Caucasian | 9 (12.16) | 16 (9.82) |
| Caucasian | 65 (87.84)| 147 (90.2) |
| Gender    |           | 0.22    |
| Male      | 41 (50.62)| 81 (47.4) |
| Female    | 40 (49.38)| 90 (52.6) |
| Physician |           | 0.04    |
| Specialty |           |         |
| Internal  | 40 (52.63)| 98 (59.4) |
| Family    | 23 (30.26)| 47 (28.5) |
| Medicine  | 13 (17.11)| 20 (12.1) |

Note: **Boldface** indicates statistical significance (\( p < 0.05 \)). Variables. may not add to N due to missing data.

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

b Variables reported as N (%), where % represents proportion of patients included in a variable category who received, or did not receive, LDCT screening.
referring clinicians (30–39 years) were less likely to proceed with LDCT screening (OR = 0.19, 95% CI = 0.05 to 0.72, p = 0.01). Patients referred by residents were also less likely to complete screening, but this effect did not reach statistical significance (p = 0.17).

Patient and referring clinician characteristics stratified by SDM site are presented in Supplementary Tables 2 through 5. Patient characteristics were not significant predictors of screening completion when univariable analysis stratified by site (CIOS: Supplementary Table 2; Pulm: Supplementary Table 3). Effects of clinician characteristics who referred patients to CIOS and Pulm are presented in Supplementary Tables 4 and 5, respectively. In both sites, patients of younger clinicians were less likely to complete screening; however, the effect of clinician age only reached statistical significance at Pulm (p = 0.02). Similarly, patients of clinicians with less years of experience, and residents, were less likely to complete screening at both sites. However, these effects only reached statistical significance at CIOS (years of practice: p = 0.05; residency: p = 0.03). Multivariable regression analyses revealed no significant differences between the two sites in the odds ratios of patient and referring clinician characteristics on screening completion (Supplementary Table 6).

4. Discussion

Using data from an academic health system, information was collected on patients who participated in the SDM process for lung cancer screening, and their referring clinicians, in an attempt to determine factors that influence screening completion. SDM meetings conducted at the Pulmonology Clinic, longer distances from the patient’s home to the LDCT screening site, referrals from internal medicine clinicians, referrals from clinicians with less years of experience, and referrals from younger clinicians were associated with a lower likelihood of screening completion.

In this study population, 89% of patients who participated in the SDM process proceeded with LDCT screening. Previous studies have also reported a high rate of LDCT completion after SDM that is close to 90% or higher [9, 25, 26]. However, this study found that LDCT completion rates were significantly different between the two SDM sites: 95.7% in CIOS vs. 75% in Pulm. Potential reasons could be different patient populations or different procedures across the two sites. After adjusting for patient and referring clinician characteristics in our multivariable analysis, SDM site still remained a significant predictor of LDCT completion. Thus, the different SDM processes between the two sites could be a potential explanation. Variation in the SDM process has been previously reported. A recent study rated the SDM process as poor in quality due to poor communication of potential harms of screening and lack of decision aids for the patients [32], while other studies have reported the SDM process to be of high quality [9, 25].

Although our study did not evaluate the quality of the SDM process, we were able to collect some information about the SDM processes through discussions with the nurse practitioners at CIOS and Pulm. The SDM meetings at CIOS were conducted by one of two nurse practitioners, while the SDM meeting at Pulm was conducted by one nurse practitioner. In both sites, each in-person meeting took an average of 25–30 min, and covered smoking cessation, lung cancer screening benefits and risks, interpretation of screening results, and the follow-up procedure for positive screening results. Both sites used a Prisma Health Lung Cancer Screening pamphlet as a decision aid. CIOS additionally provided a Lung Nodule Information Sheet to educate patients on how to interpret the margin, size, and density of lung nodules.

A major difference in procedures between the two sites is same day screening. Very few patients receive same day screening at Pulm. Due to insurance authorization issues, most patients schedule their LDCT screening one to two weeks after participation in SDM. At CIOS, a dedicated nurse navigator works with a financial counselor to obtain prior insurance authorization as needed. As a result, most of the patients who agree to screening receive their LDCT scan on the same day of SDM. Future research should investigate the role of waiting time after participation in SDM, as it may be an important predictor of screening completion.

Due to the current Coronavirus (COVID-19) pandemic, remote SDM could be used to replace in-person SDM for patients requiring LDCT screening. This may also help address issues associated with longer waiting times. However, it is unknown whether remote SDM has the equal effect and quality as in-person SDM.

To our knowledge, our study is the first to investigate factors associated with LDCT completion in a population that has participated in SDM. In addition to SDM site, several factors associated with LDCT completion were identified. Further investigation of these factors is needed to improve the process of LDCT screening to ultimately reduce lung cancer mortality. Distance is an established barrier to diagnosis and treatment of lung cancer [33]. Yet the fact that distance remains a barrier after participation in SDM indicates a need to address this issue during or before the SDM appointment. It is unclear why patients referred by internal medicine clinicians, younger clinicians, or those with less years of experience were less likely to complete screening. While these findings warrant further investigation, they do suggest that interventions aimed at improving LDCT screening may need to target clinicians earlier in their careers and be tailored to accommodate the various clinician specialties.

While the LDCT completion rate was lower for current smokers, there was not enough evidence to conclude that current smokers were less likely to complete LDCT screening compared to former smokers. Previous research has shown that current smokers tend to have different beliefs about the risk of cancer, less understanding of screening test characteristics and benefits of early detection of cancer, and are over 3 times less likely to consider lung cancer screening [12]. One possible explanation for our findings is that patients in our study obtained a clinician referral and chose to participate in SDM, and thus represent a different population than all high-risk smokers who are simply eligible for LDCT.

Our study has several limitations. First, the high rate of LDCT completion in this population reduces the power to detect factors associated with screening completion (only 5 of 115 patients failed to complete screening at CIOS). This may explain why some of the results in the study did not reach statistical significance despite a large effect size. Furthermore, adjustments for multiple comparisons were not performed in this exploratory study. While strict adjustment for multiple comparisons is not as critical in exploratory studies, subsequent studies with pre-planned hypothesis must be conducted to confirm the observed associations found here [34].

A second limitation is an inability to identify the causes for SDM site

Table 3

| Variable | Odds Ratio | 95% CI | P-value |
|----------|-----------|-------|---------|
| Current Smoker | 0.42 | (0.10, 1.74) | 0.23 |
| Family History of Lung Cancer | 0.60 | (0.17, 2.12) | 0.42 |
| Distance from patient home to screening | 0.21 | (0.05, 0.80) | 0.02 |
| Clinician age (ref: > 40 years) | 0.19 | (0.05, 0.72) | 0.01 |
| Resident | 0.28 | (0.05, 1.69) | 0.17 |

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

For example, clinicians with less years of experience, and residents, were less likely to complete screening at both sites. However, these differences did not reach statistical significance. This finding is consistent with previous studies, which have shown that clinicians with less experience may be less likely to complete screening. Additionally, the study found that patients referred by residents were also less likely to complete screening. This may be due to several factors, including the higher workload of residents, the lack of decision aids for the patients, and the shorter length of the in-person meeting.

Using data from an academic health system, information was collected on patients who participated in the SDM process for lung cancer screening, and their referring clinicians, in an attempt to determine factors that influence screening completion. SDM meetings conducted at the Pulmonology Clinic, longer distances from the patient’s home to the LDCT screening site, referrals from internal medicine clinicians, referrals from clinicians with less years of experience, and referrals from younger clinicians were associated with a lower likelihood of screening completion.

In this study population, 89% of patients who participated in the SDM process proceeded with LDCT screening. Previous studies have also reported a high rate of LDCT completion after SDM that is close to 90% or higher [9, 25, 26]. However, this study found that LDCT completion rates were significantly different between the two SDM sites: 95.7% in CIOS vs. 75% in Pulm. Potential reasons could be different patient populations or different procedures across the two sites. After adjusting for patient and referring clinician characteristics in our multivariable analysis, SDM site still remained a significant predictor of LDCT completion. Thus, the different SDM processes between the two sites could be a potential explanation. Variation in the SDM process has been previously reported. A recent study rated the SDM process as poor in quality due to poor communication of potential harms of screening and lack of decision aids for the patients [32], while other studies have reported the SDM process to be of high quality [9, 25].

Although our study did not evaluate the quality of the SDM process, we were able to collect some information about the SDM processes through discussions with the nurse practitioners at CIOS and Pulm. The SDM meetings at CIOS were conducted by one of two nurse practitioners, while the SDM meeting at Pulm was conducted by one nurse practitioner. In both sites, each in-person meeting took an average of 25–30 min, and covered smoking cessation, lung cancer screening benefits and risks, interpretation of screening results, and the follow-up procedure for positive screening results. Both sites used a Prisma Health Lung Cancer Screening pamphlet as a decision aid. CIOS additionally provided a Lung Nodule Information Sheet to educate patients on how to interpret the margin, size, and density of lung nodules.

A major difference in procedures between the two sites is same day screening. Very few patients receive same day screening at Pulm. Due to insurance authorization issues, most patients schedule their LDCT screening one to two weeks after participation in SDM. At CIOS, a dedicated nurse navigator works with a financial counselor to obtain prior insurance authorization as needed. As a result, most of the patients who agree to screening receive their LDCT scan on the same day of SDM. Future research should investigate the role of waiting time after participation in SDM, as it may be an important predictor of screening completion.

Due to the current Coronavirus (COVID-19) pandemic, remote SDM could be used to replace in-person SDM for patients requiring LDCT screening. This may also help address issues associated with longer waiting times. However, it is unknown whether remote SDM has the equal effect and quality as in-person SDM.

To our knowledge, our study is the first to investigate factors associated with LDCT completion in a population that has participated in SDM. In addition to SDM site, several factors associated with LDCT completion were identified. Further investigation of these factors is needed to improve the process of LDCT screening to ultimately reduce lung cancer mortality. Distance is an established barrier to diagnosis and treatment of lung cancer [33]. Yet the fact that distance remains a barrier after participation in SDM indicates a need to address this issue during or before the SDM appointment. It is unclear why patients referred by internal medicine clinicians, younger clinicians, or those with less years of experience were less likely to complete screening. While these findings warrant further investigation, they do suggest that interventions aimed at improving LDCT screening may need to target clinicians earlier in their careers and be tailored to accommodate the various clinician specialties.

While the LDCT completion rate was lower for current smokers, there was not enough evidence to conclude that current smokers were less likely to complete LDCT screening compared to former smokers. Previous research has shown that current smokers tend to have different beliefs about the risk of cancer, less understanding of screening test characteristics and benefits of early detection of cancer, and are over 3 times less likely to consider lung cancer screening [12]. One possible explanation for our findings is that patients in our study obtained a clinician referral and chose to participate in SDM, and thus represent a different population than all high-risk smokers who are simply eligible for LDCT.

Our study has several limitations. First, the high rate of LDCT completion in this population reduces the power to detect factors associated with screening completion (only 5 of 115 patients failed to complete screening at CIOS). This may explain why some of the results in the study did not reach statistical significance despite a large effect size. Furthermore, adjustments for multiple comparisons were not performed in this exploratory study. While strict adjustment for multiple comparisons is not as critical in exploratory studies, subsequent studies with pre-planned hypothesis must be conducted to confirm the observed associations found here [34].

A second limitation is an inability to identify the causes for SDM site
5. Conclusions

This study fills an important gap in the literature regarding the factors that influence LDCT screening following participation in SDM. The factors associated with screening completion included the site of the SDM appointment, distance from the patient’s home to the LDCT screening site, referring clinician specialty, and referring clinician age and years of practice. SDM is a critical part of the lung cancer screening process, and is necessary to help patients understand the benefits and risks of LDCT and guide the decision on whether to proceed with screening. Findings from this real-world population of screening eligible patients who participated in SDM can be used to improve the lung cancer screening process by aiding the formulation of consistent procedures across SDM sites, informing the design of targeted decision aids, and developing interventions to facilitate communication and decision-making between patients, clinicians, and SDM health professionals.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ctarcrc.2020.100198.

References

[1] The American Cancer Society medical and editorial content team, “Key statistics for lung cancer,” 2019 https://www.cancer.org/cancer/lung-cancer/about/key-statistics.html (accessed Nov. 25, 2019).

[2] R.L. Siegel, K.D. Miller, A. Jemal, Cancer statistics, 2018: cancer Statistics, 2018, CA Cancer J. Clin. 68 (Jan(1)) (2018) 7–30, https://doi.org/10.3322/caac.21442.

[3] “Common cancer sites - cancer stat facts,” 2019 SEER. https://seer.cancer.gov/statfacts/html/common.html (accessed Nov. 22, 2019).

[4] National Lung Lung Screening Trial Research Team, Reduced lung-cancer mortality with low-dose computed tomographic screening, N. Engl. J. Med. 365 (Aug.(5)) (2011) 395–409, https://doi.org/10.1056/NEJMoa102875.

[5] V.A. Meyer/U.S. Preventive Services Task Force, Screening for lung cancer: U.S. Preventive services task force recommendation statement, Ann. Intern. Med. 160 (Mar.(5)) (2014) 330–338, https://doi.org/10.7323/M13-2771.

[6] Centers for Medicare & Medicaid Services, “Decision memo for screening for lung cancer with low dose computed tomography (LDCT) (CAG-00439 N).” 2015 [Online]. Available:https://www.cms.gov/medicare-coverage-database/details/nca-decision-memo.aspx?NCAId=274. (accessed Nov. 22, 2019).

[7] P.B. Bach, et al., Benefits and harms of CT screening for lung cancer: a systematic review, JAMA 307 (Jun.(22)) (2012) 2418–2429, https://doi.org/10.1001/jama.2012.5521.

[8] P.J. Mazzone, et al., Impact of a lung cancer screening counseling and shared decision-making visit, Chest 151 (Mar.(3)) (2017) 572–578, https://doi.org/10.1016/j.chest.2016.10.027.

[9] N.T. Tanner, G.A. Silvestri, Shared decision-making and lung cancer screening: let’s get the conversation started, Chest 155 (1) (2019) 21–24, https://doi.org/10.1016/j.chest.2018.10.013.

[10] M. Lowenstein, et al., Real-world lung cancer screening decision-making: barriers and facilitators, Lung Cancer 133 (Jul.) (2019) 32–37, https://doi.org/10.1016/j.lungcan.2019.04.026.

[11] R.S. Wiener, 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. 192 (Oct.(7)) (2015) 881–891, https://doi.org/10.1161/ajrccmcr.201508-1671ST.

[12] Y. Shieh, M. Bohnenkamp, Low-dose CT scan for lung cancer screening: clinical and coding considerations, Chest 152 (1) (2017) 204–209, https://doi.org/10.1016/j.chest.2017.03.019.

[13] S.E. Lillie, et al., What factors do patients consider most important in making lung cancer screening decisions? Findings from a demonstration project conducted in the Veterans health administration Lung Cancer 104 (Feb.) (2017) 38–44, https://doi.org/10.1016/j.lungcan.2016.11.021.

[14] A. Jemal, S.A. Fedewa, Lung cancer screening with low-dose computed tomography in the united states—2010 to 2015, JAMA Oncol 3 (Sep.(9)) (2017) 1278–1281, https://doi.org/10.1001/jamaoncol.2016.6416.

[15] M.K. Barton, Integration of lung cancer screening into practice is lacking, CA Cancer J. Clin. 65 (Aug.(4)) (2015) 255–256, https://doi.org/10.3322/caac.21282.

[16] J. Tyler as student Research Assistants for the study. Dr. Rennert receives intramural Clemson University support to fund graduate student stipend support for B. Lumsden who contributed to the statistical analyses. The study sponsor had no role in study design; collection, analysis, and interpretation of data; writing the report; and the decision to submit the report for publication.

Acknowledgements

The authors would like to thank Ginny Simmons (MPH), Stephanie Hoopes (RN), Gina Franco (MSN, NP), Jeanne Williams (NP), and Sarah Tomaszewski (NP) for their clinical insights on the shared decision-making processes at the Center for Integrative Oncology and Survivorship and the Pulmonology Clinic. The authors also acknowledge and appreciate the professional support of Ms. Karen Edwards, MS, who helped the research team navigate the institutional review board and administrative data review requirements to complete this study. Dr. Gimbel received support from the Health Sciences Center, Greenville Health System. In 2019, The Greenville Health System became Prisma Health System, Greenville, SC that provided stipend support for research assistants for the study. Dr. Rennert received intramural Clemson University support for graduate student assistance with data preparation and statistical analyses.
[22] N. Ali, et al., Barriers to uptake among high-risk individuals declining participation in lung cancer screening: a mixed methods analysis of the UK lung cancer screening (UKLS) trial, BMJ Open 5 (Jul.(7)) (2015), https://doi.org/10.1136/bmjopen-2015-008254.

[23] J. Richmond, et al., Preempting racial inequities in lung cancer screening, Am. J. Prev. Med. 55 (Dec.(6)) (2018) 908–912, https://doi.org/10.1016/j.amepre.2018.07.023.

[24] C.P. Erkmen, et al., Overcoming barriers to lung cancer screening by implementing a single-visit patient experience, Int. J. Cancer Oncol. 4 (2) (2017) Accessed: Nov. 22, 2019. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5796669/.

[25] N.T. Tanner, E. Banas, D. Yeager, L. Dai, C.H. Halbert, G.A. Silvestri, In-person and telephonic shared decision-making visits for people considering lung cancer screening: an assessment of decision quality, Chest 155 (Jan.(1)) (2019) 236–238, https://doi.org/10.1016/j.chest.2018.07.046.

[26] H.E. Modin, et al., Pack-year cigarette smoking history for determination of lung cancer screening eligibility. comparison of the electronic medical record versus a shared decision-making conversation, Annals ATS 14 (Aug.(8)) (2017) 1320–1325, https://doi.org/10.1513/AnnalsATS.201612-884OC.

[27] J.S. Goodwin, S. Nishi, J. Zhou, Y.-F. Kuo, Use of the shared decision-making visit for lung cancer screening among medicare enrollees, JAMA Intern. Med. 179 (May(5)) (2019) 716, https://doi.org/10.1001/jamainternmed.2018.6405.

[28] V.N. Simmons, J.E. Gray, M.B. Schabath, L.E. Wilson, G.P. Quinn, High-risk community and primary care providers knowledge about and barriers to low-dose computed topography lung cancer screening, Lung Cancer 106 (Apr.) (2017) 42–49, https://doi.org/10.1016/j.lungcan.2017.01.012.

[29] G.A. Silvestri, P.J. Nietert, J. Zoller, C. Carter, D. Bradford, Attitudes towards screening for lung cancer among smokers and their non-smoking counterparts, Thanas 62 (Feb.(2)) (2007) 126–130, https://doi.org/10.1136/thx.2005.056036.

[30] R.A. Smith, et al., Cancer screening in the United States, 2019: a review of current American Cancer Society guidelines and current issues in cancer screening, CA Cancer J. Clin. 69 (3) (2019) 184–210, https://doi.org/10.3322/caac.21557.

[31] G.M. Fitzmaurice, N.M. Laird, J.H. Ware, Generalized linear mixed effects models, Applied Longitudinal Analysis, 2nd ed., Wiley, Hoboken, NJ, 2012, pp. 295–453.

[32] A.T. Brenner, et al., Evaluating shared decision making for lung cancer screening, JAMA Intern. Med. 178 (Oct.(10)) (2018) 1311–1316, https://doi.org/10.1001/jamainternmed.2018.3054.

[33] M. Ambroggi, C. Biasini, C.D. Giovane, F. Fornari, L. Cavanna, Distance as a barrier to cancer diagnosis and treatment: review of the literature, Oncol. 20 (Dec.(12)) (2015) 1378–1385, https://doi.org/10.1634/theoncologist.2015-0110.

[34] A.D. Althouse, Adjust for multiple comparisons? It’s not that simple, Ann. Thorac. Surg. 101 (May(5)) (2016) 1644–1645, https://doi.org/10.1016/j.athoracsur.2015.11.024.

[35] G.X. Wang, et al., Barriers to lung cancer screening engagement from the patient and provider perspective, Radiology 290 (Jan.(2)) (2019) 279–287, https://doi.org/10.1148/radiol.2018180212.

[36] L.M. Henderson, et al., Opinions and practices of lung cancer screening by physician specialty, N. C. Med. J. 80 (Jan.(1)) (2019) 19–26, https://doi.org/10.18043/ncm.80.1.19.