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Awareness and interest in lung cancer screening among current and former smokers: findings from the ITC United States Survey

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Abstract

Purpose To examine the awareness of low-dose computed tomography (LDCT) lung cancer screening among a population of current and former smokers using a nationally representative sample from the United States.

Methods Data for this study come from Wave 9 of the International Tobacco Control (ITC) United States Survey, conducted between 2013 and 2015. Among respondents age ≥ 40 ($n = 1145$), a 50% random sample were asked a series of questions pertaining to lung cancer screening. This study examines awareness and screening behaviors in relationship to demographic characteristics of respondents, health beliefs, psychosocial behaviors, and smoking behaviors. Descriptive tables and χ^2 tests were used to examine the association between those who were aware and unaware. Logistic regression analyses were conducted, stratified on respondents' smoking status. Data were weighed to be representative of the current smoking population in the US.

Results Overall, 52% of current and former smokers reported being aware of lung cancer screening. Among the group with no prior screening, 80.6% said they would take a lung cancer screening exam if recommended by their physician. In the multivariate models, former smokers had significantly greater awareness of lung cancer screening compared to current smokers [odds ratio 1.42 (95% confidence interval 1.03, 1.97)].

Conclusions Awareness of LDCT lung cancer screening was lower among current smokers compared to former smokers. Most smokers who had not ever been screened said they would have lung cancer screening if it were recommended by their physician, demonstrating the need for healthcare providers to encourage those eligible for screening to take the test.

Keywords Lung cancer screening · Smoking cessation · Health disparities · Tobacco control

Introduction

Lung cancer kills more men and women in the US compared to any other form of cancer [1]. In 2018, there will be an expected 234,030 incident cases of lung cancer, resulting in 154,050 deaths according to the Surveillance, Epidemiology, and End Results Program (SEER) [2]. Lung and bronchus cancer are expected to be responsible for over 13% of all cancer deaths in the US, with a 5-year survival rate of 18.6% [2]. One of the main reasons lung cancer remains so deadly is because it is often detected at later stages—when detected as the primary site, the 5-year survival is 56.3% [2], whereas the 5-year survival for metastatic disease drops to 4.7% [2]. Currently, 57% of all incident lung cancer is identified after it has metastasized, suggesting a significant opportunity to increase early detection [2]. Thus, lung cancer screening is premised on better prognosis if lung cancer is detected at

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earlier stages, when the disease is still localized and better treatment options are available to the patient [3, 4].

Several trials have been conducted to examine the benefits of low-dose computed tomography (LDCT) lung cancer screening among a high-risk population of smokers [5–10]. The National Lung Screening Trial (NLST) found a 20% relative reduction in deaths due to lung cancer over 8 years of follow-up among the group screened using LDCT versus chest X-ray [10]. Based largely on the results of this trial, the United States Preventive Services Task Force (USPSTF) changed its recommendation to annual screening for lung cancer among adults 55 to 80 years of age, with a 30-pack year history of smoking [6]. Former smokers who had quit smoking within the past 15 years are also eligible for this screening [6]. This 'grade B' recommendation by the USP-STF ensures that the cost of screening is covered by Medicare and Medicaid (depending on the state) and offered with no co-payment by other insurers under provisions of the Affordable Care Act [11].

Despite clear potential benefits, uptake of these new screening guidelines has been very low [12]. In 2010, approximately 3.3% of smokers who would be eligible to receive lung cancer screening using LDCT were found to have undergone the procedure [12]. In 2015, after the new guidelines were issued, only 3.9% of eligible smokers underwent lung cancer screening [12]. It is estimated that almost 7 million smokers were eligible to receive lung cancer screening in 2015, but only 262,700 individuals actually received it [12]. There was no statistically significant difference in uptake before and after the issuance of the screening guidelines. One of the reasons for low uptake of cancer screening was that smokers lacked knowledge of availability and potential benefits of lung cancer screening [12]. Other barriers to lung cancer screening included cost of the screening exam and fear of the test results [13] [14]. Huo et al. examined data from the National Health Interview Survey (NHIS) and found that between 2010 and 2015, there was a statistically significant (but small) increase in the percentage of respondents reporting a CT scan for lung cancer screening from 1.3% to 2.1% ($p < 0.001$). [15] Lung cancer screening is in the early stages of being implemented nationwide, and recent campaigns such as the "Saved by the Scan" campaign by the American Lung Association are attempting to engage with eligible current and former smokers about the benefits of lung cancer screening [16]. The state of Michigan also launched a media campaign during the winter of 2015 to increase the awareness of lung cancer screening [17]. Mass media campaigns are an effective means to increase awareness and knowledge about the screening procedure, as well as insurance coverage, to help overcome the identified barriers to adoption of lung cancer screening [16].

While several studies have documented the low awareness of lung cancer screening [12, 15], few studies have examined lung cancer screening awareness in a population of current and former smokers using nationally representative data while measuring a wide range of relevant covariates. This study examines the level of awareness of lung cancer screening and interest in screening among a representative sample of current and former cigarette smokers in the United States. Perceptions about personal well-being, perceived risk from smoking, current smoking status, and views regarding one's own health status, are likely to play a key role in promoting healthy behaviors such as cancer screening [18–25].

This study also explores how perceptions about health status, perceived health risks from smoking, smoking status, and demographic factors, are related to reported awareness and future interest in screening for lung cancer among those who have not previously been screened.

Methods

Study population

Data for this study were collected as part of the International Tobacco Control (ITC) Four Country Survey, wave 9 (August 2013–March 2015), US sample. Study recruitment used a combination of phone surveys (via random digit dialing) and web-administered surveys (through the GFK Knowledge Panel) as previously described [19, 20]. The questions on lung cancer screening were administered to a randomly selected 50% of those aged 40 or older who were current smokers (i.e., smoked at least 100 cigarettes in lifetime and smoked at least one cigarette in the past 30 days; $n = 936$) or former smokers (i.e., smoked at least a 100 cigarettes in lifetime and did not smoke in past 30 days, $n = 209$). Sixteen current smokers refused to answer the question and were excluded from the present study, for a final sample of 1129.

Measures

To measure awareness of lung cancer screening, participants were presented with this brief description of lung cancer screening: "A CT scan is similar to an x-ray, except that for this test you lie on a table that slides into a tunnel that takes a picture of the lungs. If something abnormal is found, it usually results in follow-up tests or surgery." After providing this information, participants were asked: "Have you heard of this screening test for lung cancer?" (yes/no/don't know/refused).

Participants who were aware of the lung cancer screening test were asked "Have you ever had a CT scan for lung cancer?" Participants who responded "yes" were asked "Have you had this test in the past 12 months?" Participants who responded "no" or "don't know" were asked "Would you

have a CT scan for lung cancer if it were recommended by your doctor?" For all questions, the response options were yes/no/don't know/refused. In the analyses presented here, "no" and "don't know" were combined. Fig. 1 in Appendix shows the skip patterns pertinent to the lung cancer screening questions asked of the study participants.

Correlates of awareness and interest in screening

We examined whether four classes of variables were associated with lung cancer screening awareness and interest in screening: (1) demographic characteristics (i.e., age, gender, race/ethnicity, education, and income); (2) current smoking status (current vs. former) and smoking characteristics among current smokers (i.e., amount smoked per day, level of nicotine dependence, perceived addiction to cigarettes, interest in stopping smoking, self-efficacy for stopping smoking, importance of smoking to one's life); (3) perceptions about health status and beliefs about smoking (i.e., perceived health status, health concerns generally, health damage from smoking, enjoyment of smoking, regrets about smoking); and (4) visits to the doctor in the past year. Detailed measures on variables included in the analysis are presented in Table 4 in Appendix.

Analysis

Descriptive statistics were used to examine the relationship between lung cancer screening and demographic covariates. Chi-square tests were used to assess for significant associations ($p \leq 0.05$). There are key differences among current smokers and former smokers, and some variables were only asked of current smokers. Therefore, the analysis was stratified by smoking status. Logistic regression models examined the association of each variable with awareness of lung cancer screening. Odds ratios (OR) and 95% confidence intervals (95% CI) for lung cancer screening awareness are reported separately for current smokers and former smokers. In an effort to create the most parsimonious model, only covariates which showed evidence of a bivariate association with awareness (p value ≤ 0.20 from the χ^2 testing) were considered for inclusion in the multivariate models. Analyses were conducted using IBM SPSS version 21, applying the ITC US cross-sectional sample weights so that the results could be considered to be representative of the national adult population of current and former smokers in the US.

Results

Overall 52.0% ($n = 593$) of the respondents reported having ever heard of lung cancer screening; among those who had heard of lung cancer screening, 26.9% ($n = 162$) said they

had previously been screened for lung cancer, and of those not screened, 80.6% ($n = 341$) said they would be interested in lung cancer screening if recommended by their doctor.

Table 1 shows the correlates of awareness for lung cancer screening among the overall sample, as well as stratified by smoking status. Table 2 presents the results of the multivariate logistic regression model for the overall sample, as well as stratified by smoking status.

In the combined model created for the complete sample, it was observed that former smokers had significantly greater awareness of lung cancer screening compared to current smokers [OR 1.42 (95% CI 1.03, 1.97)]. Those who were older and reported high levels of education and income were more likely to be aware of lung cancer screening, although these results were not statistically significant. With regards to health concern scale, those who were in the moderate [OR 1.47 (95% CI 1.05, 2.05)] and high category [OR 1.82 (95% CI 1.29, 2.59)] were significantly more likely to be aware of lung cancer screening compared to the reference group. Those individuals who did not know if smoking had damaged their health [OR 0.55 (95% CI 0.35, 0.85)] were significantly less likely to be aware of lung cancer screening.

Discussion

There were two key findings from this study. First, we found that awareness regarding lung cancer screening is low among current smokers—the population which is likely to have the most health gains from lung cancer screening [Table 2]. Second, when individuals who had never had a CT scan were asked if they would be receptive to having a CT scan if their doctor recommended it, the large majority (80.6%) said yes. Therefore, these data support the need for health care professionals to engage with their patients to promote lung cancer screening.

Overall, in this study, we found that 51.3% of the participants were aware of lung cancer screening (Table 1). Among those who were aware, approximately 27% reported having undergone a lung cancer screening procedure (Table 3). If this figure is calculated out of the entire study sample, this percentage drops to 14%. Even so, this rate of screening is high considering recent studies have found the prevalence of lung cancer screening to be less than 5% in the population [12, 15]. It is likely that at least some study participants were unsure of what a lung cancer screening exam entails. For example, it is possible that respondents were thinking of other types of lung exams such as chest radiography and pulmonary function testing when answering the question about whether they had ever had a lung cancer screening test. A recent focus group study found that a high degree of misconception exists about lung cancer screening [21].

Even individuals who have undergone lung cancer screening are not sure about what the process actually entails [21]. This suggests that survey questions on lung cancer screening should involve sufficient probing to ensure the validity of survey responses. Results from our study indicate there is great interest in receiving lung cancer screening. In Table 3, 80.6% of the participants who had not received lung cancer screening reported they would have the procedure if recommended by their physician. However, all screening tests have risks and benefits. Therefore, lung cancer screening may not be appropriate for everyone [7]. Future research studies should explore how participants respond if their physician recommends against lung cancer screening.

Smokers who are more dependent on cigarettes (as measured in this study by time to first cigarette) were more aware of lung cancer screening (Table 2). Smokers who view their cigarettes as more dangerous, as measured by greater level of health concern about smoking, were also more likely to be aware of lung cancer screening [OR 1.94 (95% CI 1.22, 3.08)]. Because this study was cross sectional, it is not possible to assess the causal nature of this association. It may be that individuals who have a greater level of health concern seek out information regarding lung cancer screening. However, the opposite causal account is possible: Individuals who are aware of lung cancer screening may start thinking about the risk to their health from smoking. These individuals may view their cigarettes as more harmful, and therefore, report higher levels of health concerns. Future research studies should examine the direction, as well as the impact of this association.

In the combined model (Table 2), former smokers were 42% more likely to have lung cancer screening awareness compared to current smokers after adjustment for additional covariates. Individuals who are older (55+ age group) also had significantly greater levels of lung cancer screening awareness, along with individuals in the moderate and high-level categories on health concern scale. Furthermore, individuals who said they did not know if smoking had damaged their health were significantly less likely to be aware of lung cancer screening [OR 0.55 (95% CI 0.35, 0.85)]. It may be that individuals who report "don't know" are engaging in a type of avoidance behavior by refusing to acknowledge that smoking is causing harm to their health (or caused harm in the past for former smokers) [22]. These individuals may choose to ignore messages about lung cancer screening as part of their denial about their personal health risks from smoking. Future research studies should focus on these individuals to assess if they are receptive to lung cancer screening. If they are indeed choosing to ignore messages (perhaps out of fear), strategies could be developed to engage with this group and facilitate their participation in lung cancer screening.

Previous research studies conducted so far have focused on awareness regarding the new screening guidelines among primary care providers [23, 24, 26]. Awareness regarding lung cancer screening was initially low among primary care providers, and many of them were concerned about harms due to false positives, radiation exposure, and the financial costs to participants [27, 28]. A recent study published in 2017 found that among a survey administered to primary care providers, 89% reported awareness of the lung cancer screening guidelines [24]. However, only 31% of primary care providers were accurately able to identify the age and smoking eligibility criteria [24]. It is essential that providers are given more training regarding lung cancer screening, so they are comfortable engaging in discussions with their patients. As our study found, 81% of participants would be motivated to receive lung cancer screening if their physician recommended it. Therefore, providers should be engaging in shared decision making and cessation counseling with their patients who are eligible to receive lung cancer screening.

Current smokers were the least likely group to be aware of lung cancer screening guidelines. This is an important finding because current smokers have a greater risk of developing cancer compared to former smokers suggesting important public health implications. These findings demonstrate a need for better education among current smokers so they may initiate a conversation with their health care providers regarding lung cancer screening. During the course of this conversation, they may gain important information regarding smoking cessation, since all lung cancer screening discussions should have a component of smoking cessation counseling and shared decision making [6]. Decision aids can help providers and patients discuss these options with a greater understanding [6, 25], helping to lower perceptions of fear and lead to higher-quality discussions regarding lung cancer screening [25]. One of the concerns regarding lung cancer screening has been misuse of cancer screening among participants who do not actually meet the strict eligibility criteria [15]. These 'worried well' may engage in lung cancer screening, but they would be at risk for adverse results due to overdiagnosis or the high rates of false positives [29]. Indeed, research by Huo et al. found evidence of inappropriate screening among those not meeting the eligibility criteria [15]. While lung cancer screening has been shown to be beneficial among a selected group of high-risk current and former smokers, it remains to be determined what impact messages of lung cancer screening are having on participants who may not meet the eligibility criteria.

Finally, it is important to continue to promote messages of smoking cessation among current smokers who may be eligible for lung cancer screening. While lung cancer screening does hold promise in decreasing the number of lung cancer deaths each year, the benefits of lung cancer

Table 1 Correlates of awareness for lung cancer screening

Heard of the screening test for lung cancer?			
Total	Asked of all (n = 1129)	Current smokers only (n = 920)	Former Smokers only (n = 209)
	Yes 593 (51.3)	Yes 464 (50.2)	Yes 129 (60.4)
Demographics			
Age			
40 to 54	237 (47.9)*	189 (49.7)*	48 (41.8)
55 and over	356 (52.1)	275 (50.3)	81 (58.2)
Education[a]			
Low	226 (40.2)	183 (40.4)	43 (39.2)
Moderate	240 (37.4)	189 (38.3)	51 (34.0)
High	127 (22.5)	92 (21.3)	35 (26.8)
Income[b]			
Low	201 (38.8)	165 (40.3)	36 (32.6)
Moderate	175 (29.8)	143 (30.1)	32 (28.1)
High	201 (31.4)	145 (29.6)	56 (39.3)
Ethnicity			
Non-Hispanic Caucasian	487 (80.0)	383 (83.3)*	104 (69.8)*
Other	104 (19.4)	80 (16.7)	24 (30.2)
Gender			
Female	310 (50.1)	247 (51.9)	63 (42.9)
Male	283 (49.9)	217 (48.1)	66 (57.1)
Smoking status			
Current smoker	464 (78.9)*	N/A	N/A
Former smoker	129 (21.1)		
Health beliefs and behaviors			
Describe your health			
Very good/excellent	138 (23.0)	96 (20.5)	42 (33.0)
Good	256 (42.6)	209 (44.4)	47 (36.2)
Poor or fair	195 (34.3)	157 (35.1)	38 (30.9)
Health concern scale			
Low	99 (15.5)*	87 (17.5)*	12 (8.2)*
Moderate	250 (44.6)	195 (44.9)	55 (43.3)
High	235 (39.8)	174 (37.7)	61 (48.5)
Addicted to cigarettes			
Not at all	N/A	25 (6.3)	N/A
Somewhat		147 (31.6)	
Very addicted		289 (62.1)	
Smoking has damaged your health			
Not at all	100 (17.4)*	70 (15.2)*	30 (25.8)
Just a little	201 (35.1)	159 (34.4)	42 (38.1)
A fair amount or great deal	222 (36.7)	181 (39.7)	41 (25.8)
Don't know	65 (10.8)	51 (10.7)	14 (10.3)
Worried about damage to health			
Not at all worried/little worried	N/A	228 (50.7)	N/A
Moderately or very worried		219 (49.3)	
Visit doctor since LSD[c]			
No	N/A	154 (33.6)*	N/A
Yes		309 (66.4)	

Table 1 (continued)

Heard of the screening test for lung cancer?			
Total	Asked of all (n=1129)	Current smokers only (n=920)	Former Smokers only (n=209)
	Yes 593 (51.3)	Yes 464 (50.2)	Yes 129 (60.4)
Psychosocial measures			
Enjoy smoking or enjoyed smoking[d]			
Disagree or unsure	133 (24.6)	108 (25.0)	25 (24.0)
Agree	457 (75.4)	355 (75.0)	102 (76.0)
Regret: do again, not start smoking[e]			
Disagree or unsure	113 (18.8)*	95 (19.2)*	18 (17.3)
Agree	479 (81.2)	368 (80.8)	111 (82.7)
Smoking an important part of life[f]			
Disagree or unsure	335 (59.3)*	289 (64.3)	46 (40.8)
Agree	253 (40.7)	170 (35.7)	83 (59.2)
Importance of smoking to self-perception			
Not at all important/don't know	N/A	229 (47.0)	N/A
Somewhat important		133 (31.3)	
Extremely or very important		99 (21.7)	
Sure would succeed at quitting			
Not at all/don't know	N/A	188 (38.8)	N/A
Slightly/moderately sure		199 (44.5)	
Very or extremely sure		77 (16.7)	
How hard to completely quit[g]			
Easy	N/A	82 (16.9)	N/A
A little difficult		141 (31.7)	
Very difficult		241 (51.4)	
Smoking lowered quality of life			
Not at all	N/A	153 (31.8)*	N/A
Little/fair or great deal		278 (62.4)	
Don't know		27 (5.8)	
Smoking behavior			
Cigarettes per day			
1 to 10 cigarettes	N/A	208 (44.7)	N/A
11 to 20 cigarettes		188 (43.9)	
21 or more cigarettes		58 (11.5)	
HSI: heaviness of smoking index			
Low	N/A	124 (28.9)	N/A
Mid		224 (49.7)	
High		85 (21.3)	
Time to first cigarette			
>5 min	N/A	370 (80.5)*	N/A
≤5 min		69 (19.5)	
Plan to quit smoking			
Not intending to quit/don't know	N/A	190 (41.0)	N/A
Yes—intention to quit		274 (59.0)	

Table 1 (continued)

Heard of the screening test for lung cancer?			
Total	Asked of all ($n=1129$)	Current smokers only ($n=920$)	Former Smokers only ($n=209$)
	Yes 593 (51.3)	Yes 464 (50.2)	Yes 129 (60.4)
Last time you thought seriously about quitting[h]			
Never or > 6 months	N/A	211 (47.4)	N/A
Within the last 6 months		232 (52.6)	

[a]For education: low (HS or less); moderate (some college or technical); high (completed university)

[b]For income: low (less than $30,000); Moderate (between $30,000 and $59,999); high ($60,000 or greater)

[c]Visit with the doctor since last survey date not asked of newly recruited former smokers for ITC wave 9

[d]Enjoy or enjoyed smoked (neither agree or disagree/disagree/strongly disagree/can't say) versus (agree/strongly agree)

[e]Regret: (neither agree/disagree/disagree/strongly disagree/don't know) versus (agree/strongly agree)

[f]Smoking important part of life: (neither agree or disagree/disagree/strongly disagree/don't know) versus (strongly agree/agree)

[g]How hard to quit: (Very easy/somewhat easy/neither hard nor easy/don't know) versus (somewhat hard) versus (very hard)

[h]Last time thought of quitting: (never/don't know/more than 6 months) versus within the past 6 months

*Significance at $p \leq 0.05$ as determined by χ^2 testing for awareness of lung cancer screening (aware vs. unaware)

screening do not come close to the benefits which can be achieved by smoking cessation [6, 30]. Smoking harms virtually all organs in the body, and continues to place smokers at risk for competing illnesses such as heart disease, stroke, and various other forms of cancers [30]. Therefore, it is imperative that messages of lung cancer screening do not diminish the messages of smoking cessation in any way. While there was some concern early on that lung cancer screening would be viewed by participants as a license to keep smoking [31], the majority of the evidence now suggests that screening serves as a teachable moment for smoking cessation [32–35].

A recent study conducted in 2016 by Ostroff et al. surveyed lung cancer screening sites which had pledged to follow best practices with regards to the delivery of lung cancer screening [36]. A total of 152 sites were invited to participate, out of which 93 (61%) completed the survey. It was found that while almost all the screening sites were asking patients about their smoking status (99%), only 57% were offering counseling services to promote cessation. Smoking cessation medications were only being recommended at 37% of the sites. The major barriers cited by survey participants were that patients were not motivated to quit (77%), and that patients were resistant to cessation advice and treatment (73%). Lack of available resources or referrals was cited by 24% of the survey participants and 32% said they lacked confidence in how to help patients quit smoking [36]. It is worth noting that studies conducted among patients undergoing lung cancer screening have found high rates of motivation to quit smoking [34, 37]. Lung cancer screening sites should implement smoking cessation as a well-integrated

component of their program, and they should assess participant's beliefs and views on quitting, especially with repeat lung cancer screenings [38].

Study limitations and strengths

The ITC data used in this study are a rich source of information regarding variables associated with cigarette smoking and lung cancer screening. However, using secondary data for research does pose challenges. This study was cross sectional in nature; therefore, inferences regarding causality, and the directionality of associations between exposures and outcomes, were difficult to assess. Future research studies should collect prospective data which may help elucidate several of the questions which were posed by this study. Second, our study did not have a precise measure of cigarette pack years. The lack of a precise pack year measure did not allow us to categorize our study population into lung cancer screening eligible versus non-eligible groups. The ITC survey did collect information on the heaviness of smoking (HSI) index for the study participants. This HSI measure has been established as a validated tool to examine nicotine addiction using data from prior waves of the ITC survey [39]. Over 60% of the current smokers in this study were placed in the middle to high category of the HSI index (Table 1). Thus, most of the study participants were heavily addicted to cigarettes, and it is a reasonable assumption that they would be eligible to receive lung cancer screening if they met the age criteria. A third limitation is that the questions on lung cancer

Table 2 Multivariate logistic regression models to examine lung cancer screening awareness

	Combined (N = 1074) Adjusted OR (95% CI) Model 1	Current smoker (N = 818) Adjusted OR (95% CI) Model 2	Former smoker (N = 197) Adjusted OR (95% CI) Model 3
Smoking status			
Current smoker	Ref	N/A	N/A
Former smoker	1.42 (1.03, 1.97)	N/A	N/A
Age			
40–54	Ref.	Ref.	Ref.
55+	1.31 (1.02, 1.69)	1.32 (0.95, 1.82)	1.26 (0.66, 2.40)
Education			
High school or less	Ref.	Ref.	Ref.
More than HS	1.10 (0.83, 1.45)	0.82 (0.57, 1.19)	1.51 (0.74, 3.07)
Complete university or more	1.27 (0.89, 1.81)	1.11 (0.69, 1.78)	2.34 (0.97, 5.64)
Income			
Low (less than $30,000)	Ref.	Ref.	Ref.
Moderate ($30,001–$59,999)	1.28 (0.94, 1.73)	1.19 (0.81, 1.77)	1.40 (0.62, 3.17)
High ($60,000 or more)	1.28 (0.94, 1.75)	1.18 (0.78, 1.78)	1.79 (0.82, 3.89)
Gender			
Female	Ref.	Ref.	Ref.
Male	0.94 (0.73, 1.20)	0.81 (0.58, 1.12)	0.77 (0.40, 1.46)
Ethnicity			
Everyone else	Ref.	Ref.	Ref.
Non-Hispanic Caucasians	1.06 (0.76, 1.46)	1.32 (0.86, 2.03)	0.20 (0.07, 0.61)
Time to first cigarette			
> 5 min	N/A	Ref.	N/A
≤ 5 min	N/A	1.61 (1.04, 2.48)	N/A
Health concern scale			
Low	Ref.	Ref.	Ref.
Moderate	1.47 (1.05, 2.05)	1.54 (1.00, 2.38)	2.41 (0.94, 6.20)
High	1.82 (1.29, 2.59)	1.94 (1.22, 3.08)	3.39 (1.27, 9.04)
Visit with health care provider in last year or since last survey			
No	N/A	Ref.	N/A
Yes	N/A	1.14 (0.81, 1.59)	N/A
Smoking has damaged your health			
Not at all	Ref.	Ref.	Ref.
Just a little	0.99 (0.68, 1.44)	1.11 (0.68, 1.81)	1.30 (0.52, 3.22)
Fair or great deal	1.10 (0.75, 1.60)	1.28 (0.78, 2.11)	1.78 (0.69, 4.58)
Don't know	0.55 (0.35, 0.85)	0.79 (0.43, 1.45)	0.71 (0.24, 2.10)

Variables included in Model 1: smoking status, age, education, income, gender, ethnicity, health concern scale, and smoking has damaged your health

Variables include in Model 2: age, education, income, gender, ethnicity, time to first cigarette, health concern scale, visit with health care provider in last year or since last survey, smoking has damaged your health

Variables included in Model 3: age, education, income, gender, ethnicity, health concern scale, and smoking has damaged your health

screening were asked of study participants who were aged 40 and older (52.2% of the participants in the weighted sample were between 40–54 years of age, results not shown). Since lung cancer screening is only recommended by USPSTF among those aged 55 to 80 [6], this analysis also included participants who were too young to be eligible for lung cancer screening. However, it is important to assess the knowledge and awareness in the 40–54

Table 3 Demographic factors associated with having received lung cancer screening, consider lung cancer screening if recommended by physician, or receiving lung cancer screening in past 12 months

	Ever had lung cancer screening?[a] (N=592) N (wt col%)[d]		Would you have lung cancer screening if recommended by your doctor?[b] (N=416) N (wt col%)		Ever had lung cancer screening in the past 12 months?[c] (N=162) N (wt col%)	
	Yes	No[e]	Yes	No[e]	Yes	No[e]
	162 (26.9)	430 (73.1)	341 (80.6)	75 (19.4)	82 (49.4)	79 (50.6)
Age						
40 to 54	40 (25.0)*	197 (56.5)	159 (55.6)	36 (64.1)	19 (26.2)	21 (25.8)
55 and over	122 (75.0)	233 (43.5)	182 (44.4)	39 (35.9)	63 (73.8)	58 (74.2)
Education						
Low	60 (39.5)	165 (40.4)	120 (37.6)	36 (50.0)	31 (46.7)	29 (32.3)
Moderate	63 (34.7)	177 (38.3)	145 (39.5)	27 (34.4)	37 (33.3)	25 (33.9)
High	39 (25.8)	88 (21.2)	76 (22.9)	12 (15.6)	14 (20.0)	25 (33.9)
Income						
Low	61 (42.2)	140 (37.8)	106 (35.3)	25 (43.5)	36 (40.0)	24 (35.5)
Moderate	50 (33.6)	125 (28.4)	99 (29.5)	25 (27.4)	28 (36.7)	22 (27.4)
High	45 (24.1)	155 (33.8)	129 (35.3)	23 (29.0)	16 (15.0)	29 (30.6)
Ethnicity[d]						
Non-Hispanic Caucasian	133 (75.0)	353 (81.7)	280 (80.1)	60 (87.5)	65 (68.3)*	68 (83.9)
Other	29 (25.0)	75 (17.4)	59 (18.8)	15 (12.5)	17 (31.7)	11 (16.1)
Gender						
Female	82 (50.4)	228 (50.1)	180 (47.2)	39 (59.4)	45 (51.7)	37 (51.6)
Male	80 (49.6)	202 (49.9)	161 (52.8)	36 (40.6)	37 (48.3)	42 (48.4)
Smoking status						
Current smoker	120 (74.2)	343 (80.8)	269 (78.9)	64 (89.2)	59 (71.7)	61 (80.3)
Former smoker	42 (25.8)	87 (19.2)	72 (21.1)	11 (10.8)	23 (28.3)	18 (19.7)

Participants who refused/no answer not included in χ^2 testing

[a]Only asked of those participants who had heard of lung cancer screening (593 participants asked)

[b]Only asked of those who said they had not had a scan for lung cancer screening (416 participants asked)

[c]Only asked of those who said they had ever had a CT scan for lung cancer screening (162 participants asked)

[d]Please note: actual N noted, weighted column percent presented

[e]No includes participants who selected don't know option

*Statistical significance ≤ 0.05 as a result of Chi-square testing

age group as many of these individuals will be screening eligible in the near future, so awareness of screening may impact their behavior. Gathering information among these younger participants will inform on issues regarding the public health awareness around screening and it may provide insights into barriers which may be hindering the uptake of lung cancer screening. The ITC survey did not collect measures on insurance coverage, and lack of health care access is known to be a major barrier with all forms of cancer screening [13, 23]. All the data in ITC were self-reported, which could lend itself to some aspects of social desirability bias if participants do not accurately report their responses. Finally, while the survey asked questions regarding a screening CT, there may be some misclassification if participants did not accurately distinguish between a screening and a diagnostic CT exam. A strength of this study is that it was one of the first nationally representative studies to examine the prevalence of lung cancer screening awareness. Information gained from this study can help public health campaigns target certain groups (like current smokers) with messages regarding lung cancer screening. It is important to increase the rates of lung cancer screening among eligible participants if the benefits of lung cancer screening are to be achieved on the population level.

Compliance with ethical standards

**Conflict of interest** KMC has received payment as a consultant to Pfizer, Inc., for service on an external advisory panel to assess ways to improve smoking cessation delivery in health care settings. KMC also has served as paid expert witness in litigation filed against the tobacco industry. Other authors have no conflicts of interest to declare.

Ethics approval The survey protocols and all materials, including the survey questionnaires, were cleared for ethics by Institutional Review Board, Roswell Park Cancer Institute; Medical University of South Carolina; and the Office of Research Ethics, University of Waterloo, Canada.

Appendix

See Fig. 1 and Table 4.

Fig. 1 Skip patterns associated with questions pertinent to lung cancer screening
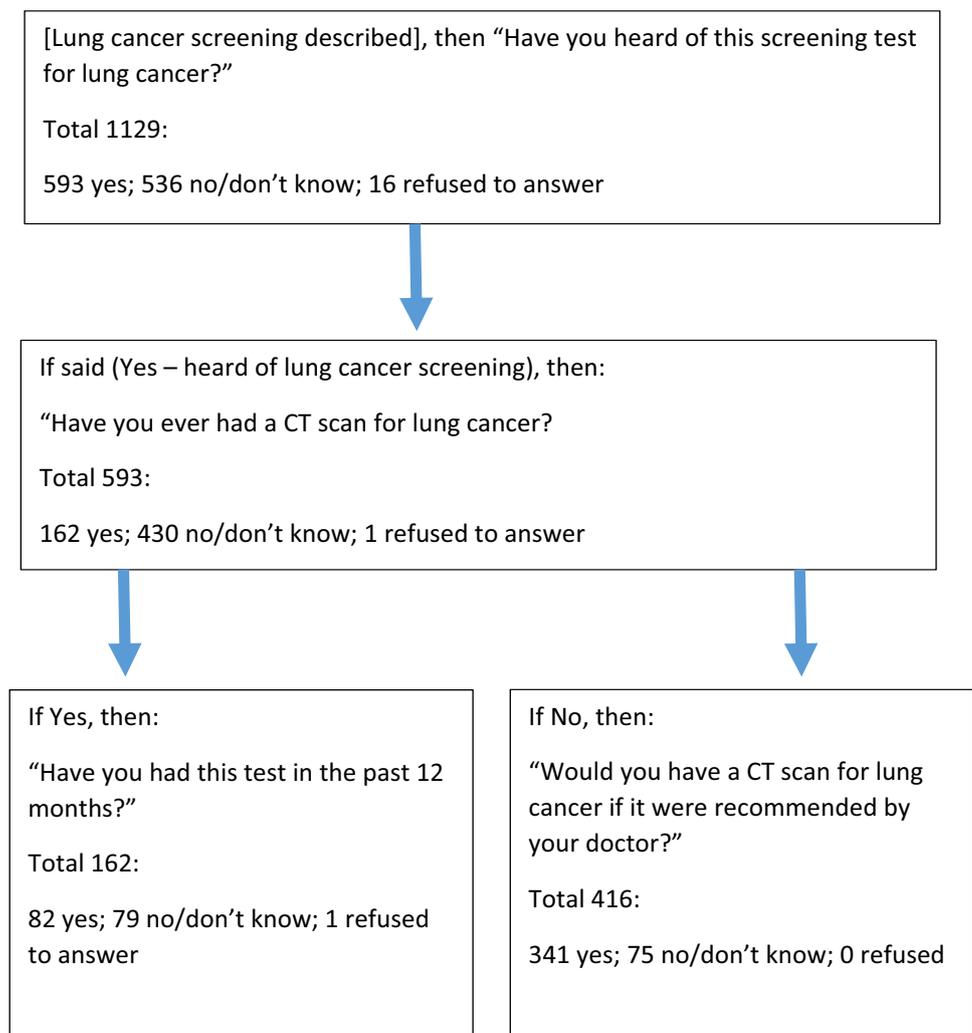
Table 4 Variables Included in the awareness of lung cancer screening analysis

Variable	Asked in survey	Parameterization
Demographics		
Age		40–54; 55 and above
Education	(Derived variable from ITC)	Low = high school or less Moderate = community college/trade school/technical school/some university High = completed university or higher
Income	(Derived variable from ITC)	Low = less than $30,000; Moderate = between $30,000 and $59,999 High = $60,000 or greater
Gender	(Derived variable from ITC)	Male; female
Ethnicity	(Derived variable from ITC)	Non-Hispanic Caucasian; everyone else
Health beliefs and behaviors		
Describe your current health	Asked of current and former smokers: "In general, how would you describe your health?"	Very good/excellent; good; poor/fair
Health concern Scale	Individual questions were asked of current and former smokers Based on the addition of points from the following questions: *(Yes = 1; no/Don't know = 0)* Smoking causes impotence Smoking causes blindness Smoking causes bladder cancer Smoking causes throat cancer Smoking causes peripheral vascular disease Smoking causes emphysema in smokers Smoking causes stroke	Low (0 to 2); Moderate (3 to 4); High (5 to 7)
Consider yourself addicted to cigarettes	Asked of current smokers: "Do you consider yourself addicted to cigarettes?"	Not at all; somewhat addicted; very addicted
Smoking has damaged health	Asked of current and former smokers: 'To what extent, if at all, has smoking damaged your health?'	Not at all; just a little; fair amount/great deal; don't know
Worried smoking will damage your health in the future?	Asked of current smokers only "How worried are you, if at all, that smoking WILL damage your health in the future?"	Not at all worried/little worried; moderately or very worried
Visit with a doctor in the past year/since last survey	*Asked of all current smokers, but new former smokers recruited for wave 9 did not receive this question* "In the last 12 months, have you visited a doctor or other health professional?"	Yes; No/don't know
Psychosocial measures		
Enjoy/enjoyed smoking	Asked of current and former smokers Participants were asked: you enjoy smoking or you enjoyed smoking	Agree/strongly agree; neither agree nor disagree/disagree/strongly disagree/can't say
Regret	Asked of current and former smokers 'If you had to do it over again, you would not have started smoking'	Agree/Strongly agree; neither agree/disagree/disagree/strongly disagree/don't know
Smoking an important part of life	Asked of current and former smokers Smoking is an important part of life Smoking was an important part of life.	Agree/strongly agree; neither agree nor disagree/disagree/strongly disagree/don't know
Importance of smoking to self-perception	Asked of current smokers only 'How important is smoking to the way you think about yourself?'	Not at all/don't know; somewhat important; extremely or very important

Table 4 (continued)

Variable	Asked in survey	Parameterization
Self-efficacy: sure would succeed at quitting	Asked of Current smokers only 'If you decided to give up smoking completely in the next 6 months, how sure are you that you would succeed?'	Not at all sure/don't know; slightly/moderately sure; very/extremely sure
How hard to completely quit smoking (belief in quitting)	Asked of current smokers only 'How easy or hard would it be for you to quit smoking if you wanted to?'	Very easy/somewhat easy/neither hard not easy/ don't know; somewhat hard; very hard
Smoking has lowered your quality of life	Asked of current smokers only 'To what extent, if at all, has smoking lowered your quality of life?'	Not at all; little/fair amount/great deal; don't know
Smoking behavior		
Smoking status	(derived variable from ITC) iFR309v	Current; former
Cigarettes per day	(derived variable from ITC based on continuous measure)	1–10; 11–20; 21 or more
HSI index (used to measure nicotine dependence)	(derived variable from ITC for current smokers) based on Number of cigarettes per day 0 to 10 cpd (0) 11 to 20 cp (1) 21 to 30 cpd (2) 31 or more cpd (3) Time to first cigarette 61 or more minutes (0) 31 to 60 min (1) 6 to 30 (2) 5 min or less (3) Combined to create an index from 0 to 6	Low (0 to 1) Mid (2 to 3) High (4 to 6)
Time to first cigarette	(derived variable from ITC based on continuous measure) "How soon after waking do you usually have your first smoke?"	≤ 5 min; > 5 min
Plan to quit smoking (intention to quit)	Asked of current smokers only "Are you planning to quit smoking…"	Not intending to quit/don't know; yes
Last time seriously thought about quitting smoking?	Asked of current smokers "When was the last time you seriously thought about quitting smoking?"	Within the last 6 months; more than 6 months ago/never/don't know

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