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Smoking-Related Health Beliefs and Smoking Behavior in the National Lung Screening Trial

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Abstract

Understanding the association between smoking-related health beliefs and smoking cessation in the context of lung screening is important for effective cessation treatment. The purpose of the current study is to explore how current smokers' self reported smoking-related health cognitions (e.g., self-efficacy) and emotions (e.g., worry) are related to cessation. This study utilized longitudinal data from current smokers (age 55–74) in a sub-study of the National Lung Screening Trial (NLST; 2002–2006; $N = 2,738$). Logistic regression analyses examined associations of cessation at last assessment with smoking-related health cognitions and emotions, demographics, and two-way interactions among smoking-related health cognition and emotion variables, gender, and age. Over 37% ($n = 1,028$) of smokers had quit at their last assessment of smoking status. Simple logistic regressions showed the likelihood of quitting was greater among participants reporting higher perceived severity of smoking related diseases ($OR = 1.17$, $p = .04$), greater self-efficacy for quitting ($OR = 1.32$, $p < .001$), and fewer perceived barriers to quitting ($OR = 0.82$, $p = .01$). Likelihood of quitting was lower among non-Hispanic Black participants (versus non-

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Conflict of Interest Statement

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Contributors

Dr. Annette Kaufman lead the writing of the manuscript, planned statistical analyses, and completed a literature review. Dr. Laura Dwyer planned and performed statistical analyses, created tables and graphs, and drafted the methods and results sections. Dr. Stephanie Land planned statistical analyses and contributed to the writing of the manuscript. Drs. William Klein and Elyse Park contributed to the writing of the paper. All authors contributed to and have approved the final manuscript.

Hispanic White participants) ($OR=0.68$, $p=.04$) and higher among older participants ($OR=1.03$, $p=.002$). Multiple logistic regression showed that participants reporting greater self-efficacy for quitting ($B=0.09$, $p=.05$), fewer perceived barriers to quitting ($B=-0.22$, $p=.01$), and who were older ($B=0.03$, $p<.01$) were more likely to quit smoking. These results suggest that, among heavy smokers undergoing lung screening, smoking-related health cognitions and emotions are associated with smoking cessation. These health beliefs must be considered an integral component of cessation in screening settings.

Keywords

lung screening; health cognition; emotion; cessation; cigarettes; smoker

1. Introduction

Lung cancer is the leading cause of cancer death among men and women in the United States [1], and 90% of lung cancers are caused by cigarette smoking [2]. The National Lung Screening Trial (NLST, 2002–2006) assigned more than 50,000 individuals ages 55–74 who were current or former heavy smokers (at least a 30 pack-year history) to screening via low-dose computed tomography (LDCT) or chest x-ray. Since the 2011 release of NLST results showing a 20% reduction of lung cancer mortality for high-risk current and former smokers screened using LDCT vs. chest x-ray [3], numerous organizations have recommended annual screening for high-risk individuals [4–7].

Although CT screening can reduce lung cancer mortality, the most important tool for reducing lung cancer risk is smoking cessation, and yet we still know very little about the nature of smoking cessation in the lung screening setting [5,6,8,9]. Some lung cancer screening studies have found an increased motivation to quit smoking and higher rates of cessation among screening trial participants compared to spontaneous cessation in the general population [10–12]. A systematic review of six empirical studies examining smoking cessation interventions within the context of LDCT lung cancer screening suggests that participation in lung screening may promote smoking cessation and present a teachable moment [13–15], particularly for those with abnormal results.

Studies have shown a statistically significant increase in rates of cessation among individuals with an abnormal LDCT scan compared to those without abnormal results [16–19]. In the Pittsburgh Lung Screening Study (PLuSS), participants whose screening results indicated abnormalities were more likely to quit smoking than those whose screening results were negative [19]. Together, this research highlights the importance of the screening context when considering smoking cessation. Nevertheless, research on the individual-level factors that may promote cessation in conjunction with screening is much more limited, even though health behavior theories and research have proposed multiple such factors as possible correlates of smoking behavior in general [20–23].

No studies to date have examined the underlying beliefs that may be associated with quitting among current smokers undergoing lung cancer screening. Numerous health behavior models, such as the Health Belief Model (HBM), posit that behavior depends on factors such

as perceived susceptibility (subjective risk of outcome), perceived severity (seriousness of outcome), self-efficacy (competence to perform behavior), perceived benefits of taking action (effectiveness of known available alternatives to reduce threat), and perceived barriers (negative aspects of health action) [24–26]. Risk perceptions can be measured many ways including *absolute risk*, defined as the perceived likelihood that the outcome will occur, and *comparative risk*, the perceived likelihood that the outcome will occur relative to that of a comparative referent like the average person. The Self-Regulation Model proposes that emotional evaluations (e.g., I am worried about getting lung cancer) also play an important role in predicting behavior [27]. Emotional responses to risk, such as worry, may be powerful predictors of behavior and could interact with more cognitively based health beliefs [28–30]. These studies examining the interactive effects among health cognitions and emotions are limited, but have shown complex associations predicting behavior.

This theoretical foundation has increased our understanding of how health beliefs are associated with health behavior. However, much of this work has been cross-sectional which does not explain how health beliefs may predict future behavior. Additionally, few studies have included comprehensive and contemporary assessments of health beliefs and examined how potential interactions between these beliefs could influence behavior. Finally, no studies have examined the longitudinal association between these multifaceted smoking-related health beliefs and cessation among a high-risk group of smokers in a large national sample.

The current study utilizes data from the NLST to examine how smoking-related health beliefs are related to smoking cessation outcomes among long-term current smokers in the screening context. Previous analyses showed that theoretical constructs such as smoking-related health cognitions and emotional constructs remained stable over time among current smokers in the NLST [23]. Based on prior research, we predict that these smoking-relevant beliefs will be associated with cessation [31,32]. The goal of this study is to better understand how these beliefs are related to smoking cessation.

2. Methods

2.1 Participants and Procedure

The purpose of NLST was to compare whether screening with LDCT vs chest x-ray reduced lung cancer-specific mortality in individuals who were at high risk of developing cancer. No smoking cessation intervention was provided to participants of NLST. At the time of recruitment, NLST participants were 55–74 years of age, current or former (quit within the past 15 years) smokers with a history of 30 pack-years or more; they had no history of lung cancer, had not been treated for any cancer within the past 5 years other than a non-melanoma skin cancer, and were not participating in any other screening or cancer prevention trial. Eight of the 23 American College of Radiology Imaging Network (ACRIN) sites participated in a sub-study to assess health cognitions and emotions related to lung screening (full description of methods in Park et al., 2009[33]). From December 2003 to March 2004, participants at these sites completed the sub-study questionnaire as part of the trial enrollment assessment. Participants who had already entered the trial were invited to complete the 12-month follow-up questionnaire. Participants' first risk perception sub-study questionnaire was utilized for this analysis. Follow-up for participants documented interval

health status at least annually through December 31, 2009 [34]. The NLST and sub-study were approved by the Institutional Review Boards at each of the participating sites and at Brown University.

2.2 Measures

Baseline Information—Participants' age, gender, race, ethnicity, and education were collected at trial enrollment. Participants' smoking history was also collected at trial enrollment. Baseline smoking status was determined by questions from both the eligibility and baseline questionnaires to maximize accuracy. In the eligibility questionnaire, participants were asked, "Have you ever smoked cigarettes?" and "Do you smoke cigarettes now?" If respondents said 'yes' to both questions, they were determined to be current smokers at baseline.

Risk Perception Sub-Study Questionnaire—The risk perception sub-study questionnaire assessed smoking-related health beliefs and was developed for long-term heavy current and former smokers in the NLST [23,33,35]. Factor structure and stability of the questionnaire has been previously reported [23]. The questionnaire includes 22 items including: absolute risk perception (4 items; e.g., "How likely do you think it is that you will develop lung cancer in your lifetime?") [36,37], comparative risk perception (6 items; e.g., "Compared to others your age and sex, what do you think is your chance of getting lung cancer in your lifetime?") [38], self-efficacy to quit (1 item; "How confident are you that you could quit smoking/stay quit for good if you wanted to?") [39], perceived benefits of quitting smoking (3 items; e.g., "In your opinion, how much would/did quitting smoking reduce your chances of getting lung cancer?") [36,40], and perceived severity (4 items; e.g., "How serious would the health consequences be if you developed lung cancer?") [41,42], and worry (4 items; e.g., "How worried are you about getting lung cancer in your lifetime?") [36,43]. Perceived barriers to quitting smoking were assessed with a stem "I have not quit smoking because..." followed by five items "I feel physically well," "I don't have the willpower/I haven't been able to quit," "I have not decided to quit," "I don't know enough about smoking cessation aids (nicotine replacement therapy, medication)," and "I don't think that smoking cessation aids are effective (nicotine replacement therapy, medication)." [41,44]

Follow-Up Smoking Status—At each participant's last assessment of smoking status, participants were asked, "Do you now smoke cigarettes (one or more cigarettes per week)?" (No/Yes). If participants reported no, they were coded as having quit smoking. Biochemical validation was not feasible in this trial, but other research suggests that self-reports of smoking cessation among lung cancer screening patients are reliable [45].

2.3 Data Analysis

Analyses were performed for sub-study participants who were current smokers at baseline ($n = 2,791$), and excluded those diagnosed with lung cancer during the study ($n = 30$) and those current smokers at baseline who did not have a follow-up smoking status ($n = 23$). The final analytic sample size was therefore 2,738. Screen result was not statistically significantly associated with smoking cessation at the end of the trial nor did it affect our findings; thus, it was not included as a covariate in this study. The outcome of interest was quitting smoking

from the first to last assessment. Smoking-related health beliefs were drawn from the risk perception questionnaire, which followed the first assessed smoking status and preceded the last assessed smoking status. Logistic regression analyses were used to examine independent and interactive associations of the following variables with likelihood of quitting: absolute risk perception, comparative risk perception, perceived severity, self-efficacy, perceived benefits of quitting smoking, perceived barriers to quitting smoking, and worry (emotion). Each of these variables was examined as an individual predictor of quit likelihood in simple logistic regressions. The full multiple logistic regression model included all smoking-related health cognition and emotion variables, all demographic variables (race/ethnicity, education, gender, age at baseline), and all possible two-way interactions among the smoking-related health cognition and emotion variables, gender, and age. We applied backward elimination of terms with $\alpha = 0.5$ [46]. All continuous predictors were mean-centered in the full logistic regression model to facilitate interpretation of conditional main effects. To interpret significant two-way interactions, we examined the odds ratios of one variable in the interaction when set at the different response options for the other variable. These levels corresponded to response options on the four-point scale used in the questionnaire (1 = not at all; 2 = sometimes/a little; 3 = often/somewhat; 4 = all of the time/extremely). Analyses were conducted with SAS 9.3 (Cary, NC).

3. Results

3.1 Sample description

Characteristics of the analytic sample ($N = 2,738$) are shown in Table 1. The sample was gender-balanced (44.3% female), predominantly non-Hispanic White (87.6%), and had a mean age of 60.8 ($SD = 4.83$) at baseline. Most participants had at least some college or a college degree (60.0%). Among this sample of baseline smokers, 1,028 (37.6%) had quit smoking at the end of the study. The mean number of days between baseline and last assessed smoking status was 2,214 (6.1 years).

3.2 Simple logistic regressions predicting quit likelihood from health cognition and emotion variables and demographics

The likelihood of quitting was higher among participants reporting higher perceived severity of lung cancer or other smoking-related diseases ($OR = 1.17$, 95% CI [1.00–1.35], $p = .04$), higher self-efficacy for quitting ($OR = 1.32$, 95% CI [1.23–1.41], $p < .001$), and lower perceived barriers to quitting ($OR = 0.82$, 95% CI [0.71–0.94], $p = .01$) (see Table 2). Likelihood of quitting was lower for non-Hispanic Blacks versus non-Hispanic Whites ($OR = 0.68$, 95% CI [0.53–0.88], $p = .04$). Likelihood of quitting was higher among older participants ($OR = 1.03$, 95% CI [1.01–1.04], $p = .002$).

3.3 Multiple logistic regression testing independent associations and interactions with quit likelihood

The multiple logistic regression analysis with backward elimination included all significant main effects and all possible two-way interactions ($n = 18$) among the smoking-related health cognition and emotion variables, gender, and age. Eighteen terms were excluded for having p -values > 0.5 (see Table 3 footnote for these variables). The final model revealed

that participants who reported greater self-efficacy (Wald $\chi^2 = 3.81$, $B = 0.09$, $p = .05$) and fewer perceived barriers to quitting (Wald $\chi^2 = 7.07$, $B = -0.22$, $p = .01$) were more likely to quit smoking. Those who were older at baseline were also more likely to quit smoking (Wald $\chi^2 = 7.93$, $B = 0.03$, $p < .01$). One interaction was statistically significant: worry X perceived benefits of quitting smoking (Wald $\chi^2 = 3.95$, $B = 0.19$, $p = .05$). We examined the conditional effects of perceived benefits of quitting at each level of worry. Greater perceived benefits of quitting were associated with a greater likelihood of quitting among individuals who worried all of the time ($OR = 1.40$, 95% CI [1.01–1.93]). For those individuals “not at all worried,” greater perceived benefits of quitting were in fact inversely associated with the likelihood of quitting ($OR = 0.78$, 95% CI [0.57–1.07]). One interaction approached significance: worry X comparative risk perception (Wald $\chi^2 = 3.57$, $B = -0.17$, $p = .06$). We examined the conditional effects of comparative risk perception at each level of worry. Comparative risk perception odds ratios were progressively smaller as worry increased: in other words, among those who were not at all worried, the likelihood of quitting was higher for those with higher comparative risk perception, whereas among those who were worried all the time, the likelihood of quitting was inversely associated with comparative risk perception.

4. Discussion

The purpose of this study was to examine how smoking-related health beliefs may be related to smoking cessation among long-term current smokers undergoing lung cancer screening in the NLST trial. Over 37% of participants reported quitting between baseline and last assessed smoking status, which is higher than estimates from even the best clinical cessation interventions [47] and reflects a cumulative quit rate in this sample. The results from the current study suggest that health beliefs are associated with smoking cessation. In bivariate analyses, participants with higher perceived severity of lung cancer, greater self-efficacy for quitting, and lower perceived barriers to quitting at baseline were more likely to quit at follow-up than their counterparts. In an adjusted multivariable model, greater self-efficacy and fewer perceived barriers to quitting remained significantly associated with quitting, but perceived severity did not.

In the adjusted model, we examined all possible two-way interactions among the smoking-related health cognition and emotion variables, gender, and age. We found two interactions, which support Leventhal’s Common-Sense Model of self-regulation [27] and are consistent with prior research showing similar complex relationships between health cognitions and worry [28–30]. Worry buffered the association between perceived benefits of quitting and cessation such that those individuals who were high in worry and perceived greater benefits of quitting had particularly higher odds of quitting smoking. A marginal interaction between worry and comparative risk perception revealed that worry attenuated the relationship between comparative risk perception and quitting such that participants who were low in worry and had high comparative risk perceptions (i.e., they perceived a higher probability of smoking-related health outcomes than others) had higher odds of quitting smoking. Thus, those who had more ‘realistic’ (higher) comparative risk perceptions were more likely to quit smoking when they had low worry. On the other hand, participants who were high in worry and had high comparative risk perceptions ironically had lower odds of quitting

smoking, consistent with a paradoxical interaction between worry and risk perception observed in other studies [28,29].

A burgeoning area of research on affective risk perception has demonstrated the importance of emotion in predicting health behavior [30,48]. The importance of intervening on affect, such as worry, in the context of lung screening may be particularly critical: for example, research has shown that one-third of current smokers reported they were afraid to find out whether they had cancer [49], which could lead to screening avoidance. A more nuanced understanding of the interactive effects of worry and cognitive risk beliefs could lead to the development of interventions to enhance communications between practitioners and patients at the time of screening in relation to smoking cessation as well. For example, individuals who worry all of the time about smoking-related health outcomes may not benefit from interventions attempting to increase comparative risk perceptions, as this synergy may prevent them from quitting (e.g., overwhelm them or lead to lower motivation to quit). By assessing cognitive and affective perceptions about quitting, lung cancer, and smoking-related diseases at the time of screening, practitioners may be better equipped to help patients quit smoking.

The nature of the dataset precluded us from examining the relationships between smoking-related health beliefs and smoking behavior changes at multiple time points. The health belief constructs were not necessarily assessed right before the quit attempt, making it difficult to establish immediate temporal precedence. Furthermore, we only tested change between baseline and last smoking status due to dataset limitations. Unlike prior research [50], screen result at any point during the trial was not statistically significantly associated with participants' last assessed smoking status nor did it affect our findings and thus was not included in our study. This may mean that screen result may initially motivate quitting attempts but may not influence long-term cessation. As this was not the focus of this study, future research may wish to explore this premise. The current study took place in a distinct context and sample; thus, the results cannot be generalized to other groups not studied here (such as smokers with fewer than 30 pack-years, younger people, and individuals who had been treated for cancer recently). Few studies have examined the format, components, dose, and timing of cessation treatment in conjunction with screening; seven NCI-funded randomized clinical trials are now addressing these issues [51].

5. Conclusions

This national study of smoking-related health beliefs and cessation among at-risk smokers in a seminal lung cancer screening clinical trial is an important contribution to the literature examining smoking behavior change in the lung cancer screening context. Our results offer insight about smoking-related health beliefs that may be important to integrate into cessation programs in lung cancer screening settings. These beliefs may be particularly important to target in messaging and cessation interventions and should be considered an integral part of these efforts.

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Highlights

- A sub-study of the National Lung Screening Trial examined smokers' health beliefs
- Greater self-efficacy and fewer perceived barriers to quitting predicted cessation
- Health beliefs are important to cessation in the screening context.

Figure 1.
Interaction from the final model predicting probability of quitting: Worry X Benefits of Quitting

Table 1Sample characteristics for baseline current smokers ($N = 2,738$)

	<i>n</i> (%)
Gender	
Male	1,525 (55.7)
Female	1,213 (44.3)
Race/ethnicity	
Non-Hispanic, White	2,399 (87.6)
Non-Hispanic, Black	308 (11.3)
Other / Unknown	31 (1.1)
Education	
Less than high school	283 (10.4)
High school graduate or equivalency	744 (27.2)
Some college	948 (34.7)
College graduate & beyond	696 (25.5)
Other	59 (2.2)
Variable	Mean (SD)
Age at baseline	60.84 (4.83)
Risk Perception Questionnaire	
Absolute risk perception ^a	3.73 (0.82)
Comparative risk perception ^a	3.65 (0.78)
Perceived severity ^a	4.51 (0.54)
Self-efficacy ^a	2.86 (1.15)
Perceived benefits of quitting ^b	3.01 (0.71)
Perceived barriers to quitting ^a	3.14 (0.59)
Worry ^b	2.54 (0.71)
Variable	<i>n</i> (%)
Last assessed smoking status	
Current smoker (did not quit)	1,710 (62.5)
Former smoker (quit)	1,028 (37.5)

^aScales range from 1 to 5;^bScales range from 1 to 4.

Simple logistic regressions predicting likelihood of quitting from health belief variables and demographics

Table 2

Predictor	<i>n</i>	<i>B</i> (<i>SE</i>)	Wald χ^2	<i>p</i>	<i>OR</i> (95% <i>CI</i>)
Absolute risk perception	2,723	0.01 (0.05)	0.09	.77	1.01 (0.92–1.12)
Comparative risk perception	2,720	−0.01 (0.05)	0.01	.91	0.99 (0.90–1.10)
Perceived severity	2,653	0.15 (0.08)	4.08	.04	1.17 (1.00–1.35)
Self-efficacy	2,630	0.28 (0.04)	59.40	<.001	1.32 (1.23–1.41)
Perceived benefits of quitting	2,649	0.10 (0.06)	3.28	.07	1.11 (0.99–1.24)
Perceived barriers to quitting	2,345	−0.20 (0.07)	7.68	.01	0.82 (0.71–0.94)
Worry	2,688	0.05 (0.06)	0.76	.38	1.05 (0.94–1.17)
Gender ^a (Female)	2,738	0.04 (0.04)	0.97	.32	1.08 (0.93–1.26)
Race/ethnicity^b (Non-Hispanic Black)	2,738	−0.30 (0.15)	4.24	.04	0.68 (0.53–0.88)
Race/ethnicity ^b (Hispanic/Other)	2,738	0.22 (0.25)	0.83	.36	1.15 (0.56–2.37)
Education ^c (Less than high school)	2,730	−0.22 (0.12)	3.60	.06	0.73 (0.54–0.97)
Education ^c (High school/GED)	2,730	0.09 (0.09)	0.99	.32	0.99 (0.80–1.22)
Education ^c (Some college)	2,730	−0.04 (0.08)	0.18	.67	0.88 (0.72–1.07)
Education ^c (Other)	2,730	0.08 (0.22)	0.12	.73	0.98 (0.57–1.69)
Age at baseline	2,738	0.02 (0.01)	9.18	.002	1.03 (1.01–1.04)

Note. Bolded numbers indicate statistically significant effects at *p* .05. Reference categories:

^a male;

^b Non-Hispanic White;

^c College.

Table 3

Interactions from the final model: Likelihood of quitting as a function of comparative risk perception and perceived benefits of quitting, at each level of worry

Predictor	OR for quitting (95% CI)
Perceived benefits of quitting	
Main Effect $p = .42$	
Interaction with Worry $p = .05$	
Worry = 1 (not at all)	0.78 (0.57–1.07)
Worry = 2 (sometimes)	0.95 (0.80–1.12)
Worry = 3 (often)	1.15 (0.97–1.36)
Worry = 4 (all of the time)	1.40 (1.01–1.93)
Comparative risk perception	
Main Effect $p = .94$	
Interaction with Worry $p = .06$	
Worry = 1 (not at all)	1.31 (0.94–1.80)
Worry = 2 (sometimes)	1.10 (0.90–1.35)
Worry = 3 (often)	0.93 (0.77–1.13)
Worry = 4 (all of the time)	0.79 (0.58–1.07)

Note. Bolded numbers indicate statistically significant effects at $p = .05$.

This table shows the interactions from the final model after backward elimination procedures, as well as associations between comparative risk perception and benefits with quitting at each level of worry. Eighteen terms were removed through backward elimination: self-efficacy X gender, absolute risk perception X comparative risk perception, comparative risk perception X gender, age X worry, absolute risk perception X perceived severity, perceived benefits X gender, absolute risk perception X self-efficacy, self-efficacy X perceived barriers, age X perceived severity, comparative risk perception X perceived benefits, age X gender, worry X perceived barriers, absolute risk perception X worry, age X comparative risk perception, comparative risk perception X self-efficacy, absolute risk perception X perceived benefits, worry X perceived severity, and age X self-efficacy. Terms in the final model were: race/ethnicity, education, gender, age at baseline, absolute risk perception, comparative risk perception, worry, perceived severity, self-efficacy, benefits, barriers, absolute risk perception X gender, absolute risk perception X age, worry X gender, worry X comparative risk perception, worry X self-efficacy, worry X benefits, severity X gender, severity X comparative risk perception, severity X self-efficacy, severity X benefits, severity X barriers, self-efficacy X benefits, benefits X age, barriers X age, benefits X barriers, absolute risk perception X barriers, comparative risk perception X barriers, and gender X barriers.