EMPOWERING PATIENTS FOR SHARED DECISION MAKING
IN LUNG CANCER SCREENING VIA TEXT MESSAGES

A Master’s Thesis Presented

By

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Master of Science in Clinical Investigation

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Abstract

Background: Shared decision-making (SDM) counseling for lung cancer screening is recommended by multiple professional societies and mandated by the Center for Medicare and Medicaid Services since lung cancer screening has both benefits and risks. However, uptake of SDM counseling as well as lung cancer screening itself remain low. We sought to develop educational text messages about lung cancer screening as an innovative implementation intervention tool to promote patient-provider discussion about lung cancer screening.

Methods: After the study team drafted educational text messages about lung cancer screening, informed by existing decision aids, participants who had had lung cancer screening were recruited and asked to review and edit text messages. After that, participants eligible for lung cancer screening without the previous screening experience were recruited and were asked to select the messages to be included in this text message intervention. The final set of 14 text messages were delivered to the participants both with and without the previous lung cancer screening over a period of 14 days. Participants completed a telephone survey assessing their reactions to the messages after receiving the last message.

Results: We successfully involved twelve participants with lung cancer screening experience and eleven lung cancer screening eligible participants without previous screening experience in the development of educational text messages about lung cancer screening. After one participant withdrew, 22 participants received text messages and completed the survey regarding the messages. Most participants (18 of 22) reported reading all 14 text messages, however most recommended sending fewer
messages (median recommended number of messages = 10). Participants found the educational text messages informative. Only four participants reported the text messages triggered anxiety and two reported text messages disrupted their daily activities. Participants perceived the text messages would empower patients to discuss lung cancer screening with their providers.

**Conclusion:** Participants generally supported the use of educational text messages about lung cancer screening to increase patients’ awareness and promote patient-provider discussion. Engaging patients in the development and evaluation of text messages elicited helpful feedback that will inform the content of the messages to be delivered via this lung cancer screening text messages intervention.

**Key words:** shared decision-making, lung cancer screening, text message, co-production
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List of Third Party Copyrighted Material

All materials (Figures, Tables, Appendices…etc.) in this thesis represent original work.
**List of Abbreviations:**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>NLST</td>
<td>National Lung Screening Trial</td>
</tr>
<tr>
<td>LDCT</td>
<td>Low-dose computed tomography</td>
</tr>
<tr>
<td>CMS</td>
<td>Center for Medicare and Medicaid Services</td>
</tr>
<tr>
<td>SDM</td>
<td>Shared decision-making</td>
</tr>
<tr>
<td>DA</td>
<td>Decision aid</td>
</tr>
<tr>
<td>BRFSS</td>
<td>Behavioral Risk Factor Surveillance System</td>
</tr>
<tr>
<td>AHRQ</td>
<td>Agency for Healthcare Research and Quality</td>
</tr>
<tr>
<td>EMR</td>
<td>Electronic Medical Record</td>
</tr>
<tr>
<td>PCP</td>
<td>Primary care provider</td>
</tr>
</tbody>
</table>
Preface

Other works that will not be presented as part of this thesis


Chapter I: Introduction

Lung cancer and lung cancer screening in the US
Lung cancer is the leading cause of cancer death and the second most common cancer in both men and women in the United States. Approximately 135,720 deaths due to lung cancer are expected in 2020(1). The prognosis of lung cancer depends on the stage at diagnosis. The 5-year survival rate progressively decreases from 61% to 35% to 6% for local, regional and distant stage of the disease(2). Early detection and treatment of lung cancer is crucial to improve the outcomes. However, there was no screening tool for lung cancer until 2011 when the results of the National Lung Screening Trial (NLST) was published(3). The NLST was a multicenter randomized clinical trial that demonstrated that three rounds of annual low-dose computed tomography (LDCT) screening reduced the risk of lung cancer death in the next 6.5 years from 1.66% to 1.33% (20% relative risk reduction) compared with an annual chest X-ray screening in high-risk individuals, defined as those who are aged 55 to 74 years, who have a history of a 30 pack-year of cigarette smoking, who currently smoke, or who quit smoking within the past 15 years(3). In 2013, the US Preventive Services Task Force issued a Grade B recommendation for LDCT lung cancer screening for individuals between 55 and 80 years who are at high risk for lung cancer based on their smoking history(4). In 2015, the Affordable Care Act mandated private insurance to cover LDCT for lung cancer screening for high risk individuals and the Center for Medicare and Medicaid Services (CMS) began its coverage(5).
The benefits and harms of lung cancer screening

Although LDCT screening reduces lung cancer mortality among high-risk individuals, there are potential harms from lung cancer screening. The identification rate of a positive finding, typically a small lung nodule, is on average 24.2% per a year(3). The vast majority of lung nodules are ultimately found to be false positive, but patients with positive findings will nonetheless require further work-up. Although most need annual follow-up LDCT to monitor lung nodules, some may require a lung biopsy to determine whether it is benign. There is a risk of complications from this invasive procedure, such as pneumothorax, bleeding and respiratory distress. Patients need to be fully informed of these possible harms that may arise from downstream evaluation after screening(6).

Shared decision-making for lung cancer screening

Shared decision-making (SDM) is a key component of patient-centered health care supported by the Institutes of Medicine and the Affordable Care Act(7, 8). SDM is an approach where patients and clinicians share the best available evidence on options (information exchange), where they review patient’s values and preference (deliberation), and work together to make a healthcare choice(decision-making)(9). SDM is advocated as the preferred model for decision-making in preference-sensitive decisions (10).

Due to a significant number of individuals who will require further work up for positive findings from LDCT screening and a very small number of individuals who will experience the significant benefit, mortality reduction, the decision of whether to proceed to lung cancer screening is preference sensitive. SDM for lung cancer screening between patients and providers is recommended by multiple professional
societies and mandated by CMS for the coverage of LDCT screening (4, 5, 11-13). To meet CMS mandates, SDM counseling for lung cancer screening needs to be provided by a physician or qualified non-physician practitioner including the use of one or more decision aids (DAs) and the following elements: determination of eligibility based on age and smoking history, absence of signs and symptoms of lung cancer, benefits and harms of screening, possible need for follow-up diagnostic testing, the risk of over-diagnosis, false positive rate, total radiation exposure, counseling on the importance of adherence to annual LDCT screening, impact of comorbidities and ability or willingness to undergo diagnosis and treatment, and importance of smoking cessation. CMS reimburses for SDM counseling itself and for lung cancer screening. Lung cancer screening is the only cancer screening that CMS has mandated SDM for (5). This CMS mandate and the provision of reimbursement for SDM for lung cancer screening are unprecedented.

**The current status of lung cancer screening and SDM**

Despite recommendations from multiple professional societies and insurance coverage, the uptake of LDCT lung cancer screening is low. Only 262,700 out of 6.8 million eligible patients (3.9%) received lung cancer screening in 2015 (14). The nationwide lung cancer screening rate remained low, 2.6% in 2016, based on the Lung Cancer Screening Registry (15). Screening rates varied by area, reported as 1.1% in the West, 1.7% in the South, 2.1% in the Midwest and 3.6% in the Northeast. Eighty-five percent of screening occurred in urban settings. The most recent screening rates of lung cancer screening are based on findings from the 2017 Behavioral Risk Factor Surveillance System (BRFSS) (16). Unfortunately, the data is limited to three states
since only Florida, Nevada and Georgia adopted the lung cancer screening module to report the screening rate. The self-reported screening rates among individuals eligible for lung cancer screening were 19.2% in Florida, 11.0% in Georgia and 6.9% in Nevada. Considering that 68% of women 40 years and older were up to date for breast cancer screening and 70% of individuals 50 years and older were up to date for colon cancer screening based on the 2018 BRFSS, the uptake of lung cancer screening remains concerningly low (17).

Even more concerning, the rate of patient-provider discussion, not necessarily SDM counseling, about lung cancer screening among potential eligible individuals decreased despite recommendations from multiple professional societies and the initiation of insurance coverage of lung cancer screening in 2014. It decreased from 25.4% in 2013 to 17.8% in 2017 among individuals with current smoking history and decreased from 14.6% to 9.9% among individuals with previous smoking history (4, 5, 11-13, 18). Since provider recommendation is a strong predictor of completion of cancer screening, interventions to promote patient-provider discussion about lung cancer screening is necessary to improve its uptake (19).

Measurement of the occurrence and the quality of SDM counseling is difficult without direct observation or recording of conversations. Among Medicare beneficiaries who underwent LDCT screening in 2016, only 9.0% had a separate SDM visit prior to LDCT based on Current Procedural Terminology code for SDM counseling (20). Brenner et al reviewed audio-recordings of visits that contained lung cancer screening discussions between patients and providers (21). Their analysis showed that providers spent only 0:59 min (range of 0:16 to 2:19 min) on SDM and they did not discuss the
harms of LDCT screening. There was no evidence of DA use during the discussions about lung cancer screening. This study showed the current patient-provider discussion was far from true SDM discussion. Providers reported the time was the barrier to SDM in a different study as it was reported in SDM in other healthcare choices (9, 22).

**Implementation strategy to promote SDM of lung cancer screening**

Previous studies of SDM of lung cancer screening have been focused on 1) development of DAs and its effects on patient knowledge, decisional conflict and acceptability, and 2) patients’ and providers’ perceptions of SDM for lung cancer screening (22-24). However, research about implementation strategy to promote SDM of lung cancer screening has been lacking.

Furthermore, previous research in implementation strategy in SDM in general has failed to identify an effective strategy to support implementation of SDM in real clinical settings (25, 26). As a result, SDM is poorly implemented especially in routine care despite support from health care policies. Innovative implementation strategies and interventions are needed to promote implementation of SDM for lung cancer screening.

**Text message intervention an implementation intervention tool**

Sending information about lung cancer screening to eligible patients prior to their visits with their providers may improve patient awareness and knowledge of lung cancer screening and activate patients in SDM of lung cancer screening. Using pre-visit time to initiate information exchange may save some of the limited visit time for patient-provider discussion and SDM rather than spending visit time for information exchange.

Text messaging systems have the potential to reach the lung cancer screening eligible population. Recent Pew data suggests that 91% of US adults own a cell
phone(27). Cell phone ownership is high across differing levels of income, educational status and race. In a systematic review of mobile phone-based interventions for smoking cessation, there was moderate-certainty evidence that automated text message-based smoking cessation interventions result in greater quit rates than minimal smoking cessation support (28). One study of text-based interventions which focused on people over 60 who smoke in rural communities showed the feasibility, acceptability and preliminary efficacy of text-based smoking cessation interventions, with eighty-one percent of participants reporting reading all the messages they received (29).

Text message interventions have been used in other cancer screenings as a reminder(30). A series of educational text messages about cervical cancer screening sent to a Korean population showed improvement in the knowledge of cervical cancer screening, and high satisfaction among participants (31). However, none of these previous text-message interventions in cancer screening aimed to promote patient-provider discussion and SDM.

The prevalence of cell phone ownership together with the promising findings from studies testing cell phone-based interventions suggest that use of a text messaging system could be an effective method to reach the lung cancer screening eligible population and promote patient-provider discussion about lung cancer screening by capitalizing on the time prior to their visits with their primary care providers (PCPs).

Co-production

The intervention to promote lung cancer screening discussion needs to be users-centered both for patients and providers and adoptable in health care systems. Such
intervention needs to be patient-centered for individuals eligible for lung cancer screening considering that lung cancer fear, stigma and self-blame from their own smoking behavior and socioeconomic factors negatively affect their healthcare engagement (32, 33). At a provider level, the intervention needs to fit in with the existing clinical workflow considering that patients and providers have multiple medical issues to discuss within the limited time during the visits(34).

Recently, co-production has regained interest among implementation scientists as a potential method to develop an effective, user-centered, efficient and equitable implementation strategy in health care. Co-production is the concept originated from political science and public management since 1942, while the concept of co-creation is a method commonly used in industries (35-37). Both co-creation and co-production involve end-users. However, the involvement of end-users is limited to the designing phase in co-creation while co-production involves end-users in both the designing and implementation phases of the service or the product. This involvement of end-users in the implementation phase distinguishes co-production from co-creation(35). Co-production is based on information exchange and shared decision making between the service users and providers to meet complex and unique service users' needs(38, 39). In health care research, clinicians and researchers as a service provider have knowledge of etiology, diagnosis, treatment options and prognosis as an expert. Patients and caregiver as a service user, know about the experience of illness as a person, social circumstances, and attitudes to risks, values and personal preference also as an expert(40). In co-production, we bring two experts together with the
assumption that both parties have a central role to play in the process as they each contribute different and essential knowledge (41).

Research in technology-assisted interventions in health care settings could benefit from co-production not only from co-creation. Technology-assisted implementation intervention developed in co-production methods may be more personalized and demand-driven and facilitate implementation and sustainability of the intervention in the real-world.

Chapter II: Objectives

The objective of this study was to develop educational text messages about lung cancer screening as an implementation intervention tool to promote patient and provider discussion about lung cancer screening. This text message series will be delivered to lung cancer screening-eligible patients prior to their visit with their primary care providers. Specifically, we sought to create text messages that would: 1) improve patients’ awareness of lung cancer screening, 2) increase patients’ knowledge about lung cancer screening using a pre-visit time frame, and 3) empower patients to talk with their providers about whether lung cancer screening is right for them. We will use co-production methods to create patient-centered intervention that aligns with the current clinical workflow.

In this thesis, we present the designing phase of the co-production of the text messaging intervention to promote SDM for lung cancer screening.
Aims

**Aim 1:** Co-production of educational text messages to promote SDM around lung cancer screening.

- **Aim 1a:** Content-generation with lung cancer screening eligible participants who had had lung cancer screening.
- **Aim 1b:** Content-sorting with lung cancer screening eligible participants who had never had lung cancer screening.

**Aim 2:** Evaluate participants’ reactions to receiving text messages about lung cancer screening and feasibility of the text messaging system.

Chapter III: Methods

We used a four-step process to co-produce text messages (Figure 1).

Setting

The study was conducted at a large northeast US academic health care system.

Step 1. Development of Drafts of Text Messages

Our research team was composed of pulmonologists, a primary care provider, and experts in lung cancer screening, implementation science, health informatics, patient and provider communication, health literacy and qualitative analysis. After reviewing the current clinical guidelines, CMS mandates and available DAs for lung cancer screening to identify the critical content to deliver via text messages to promote and prepare for SDM, our team drafted 14 text messages. The number of text messages was decided based on the amount of content and the number of text messages most likely needed to influence patient’s behavior since it is less likely that all the text messages would be read by patients based on the research team’s experience from the previous study(42). The series of text messages included an introductory message, fact-based messages to provide the key information regarding
lung cancer screening such as the major benefits and harms of lung cancer screening, supportive messages to emphasize the importance of SDM with their providers and of smoking cessation, and a final message to encourage patients to discuss lung cancer screening with their providers at their next visit (Figure 1).

**Step 2. Co-production of text messages with lung cancer screening experienced participants**

**Sample**

We identified and recruited a sample of patients who had completed a LDCT lung cancer screening at the UMass Memorial Medical Center. Inclusion criteria were 1) age 55 to 77 years, 2) current smoker or former smoker who quit within the past 15 years with a minimum smoking history of 30-pack-years (consistent with CMS eligibility criteria for lung cancer screening), 3) completion of a first LDCT for lung cancer screening within the past 12 months, and 4) possession of a text-enabled mobile phone. Exclusion criteria were 1) non-English speaker, 2) reside in a nursing home, 3) active cancer, 4) history of lung cancer, and 5) prisoner. We sought to obtain a sample which was diverse in terms of age, gender and smoking status.

**Conduct of study sessions: co-production**

Prior to the session, all participants provided written informed consent with their signature after a research staff member explained the study procedure, risks, benefits and participant rights. Each person took part in an in-person study session lasting approximately 75-90 minutes. All participants received a DA of lung cancer screening developed by the Agency for Healthcare Research and Quality (AHRQ) with the recruitment letter prior to this session(6). First, the study investigator (a pulmonologist, MIF) explained 1) the idea and goal of sending educational text messages about lung
cancer screening to patients, and 2) the goals and activities of the co-production session. She then reviewed a brief power point presentation which described the prevalence of lung cancer, the current status of lung cancer screening uptake in the US, the challenge of SDM, and the information necessary for SDM for lung cancer screening following the CMS mandates (Appendix 1).

Participants were then asked to complete three tasks: 1) review and edit sample text messages, 2) respond to written prompts and complete a statement (e.g., [I started to think about getting screened for lung cancer because [participant’s response]) and 3) write their own text messages about lung cancer screening. We provided three different DAs of lung cancer screening and a copy of the power point presentation for participants to reference during these activities if they wished (Appendixes 1) (6, 43).

Participants were also asked about 1) their reaction to the DA mailed with the recruitment letter, 2) their own discussions with their providers about lung cancer screening before and after LDCT, 3) their own smoking cessation efforts and experience, 4) the idea of delivering text messages about lung cancer screening to patients prior to their visits with providers, and 5) suggestions about this text message intervention. At the end of the session, participants provided limited demographic information. Interviews were audio-recorded and transcribed. Prior to Step 3, text messages were refined based on the input from participants from Step 2.
Step 3. Content-sorting with lung cancer screening eligible participants without previous lung cancer screening experience

Sample
To obtain feedback from the lung cancer screening eligible population who had not had a LDCT for lung cancer screening, we recruited a second sample of patients. We applied the same inclusion and exclusion criteria as in Step 2, with one change: we required patients NOT to have had a LDCT for lung cancer screening in the past nor a chest CT within the past 12 months. As in Step 2, we sought to recruit a sample which was diverse in terms of age, gender, and smoking status.

Conduct of study sessions: content-sorting
Prior to the session, all participants provided written informed consent with their signature after a research staff member explained the study procedure, risks, benefits and participant rights. Content-sorting sessions were conducted in-person and lasted approximately 45 to 75 minutes. At the start of the sessions, the goal of text messages and co-production were explained to participants. Then, participants were asked to review refined text messages, provide feedback on each message and given the option to edit messages. In Step 3, the same power point presentation used in Step 2 was given after participants completed reviewing the text messages (Appendix 1). The timing of the power point presentation was changed to obtain the reaction from these participants without previous experience of lung cancer screening, as if they were receiving text messages prior to their PCP visits. After the presentation, participants were asked to identify which of the text messages they recommend be delivered to lung cancer screening-eligible patients, and to explain why they would select or omit a message.
During these activities, participants were also asked about 1) their general reaction to the text messages, 2) their own smoking cessation efforts and experience, and 3) the idea of delivering text messages about lung cancer screening to patients prior to their visits with providers.

In addition, we showed patients two paper-based DAs for lung cancer screening for their review. One, from AHRQ, is a four-page paper-based DA that includes a pictogram to explain the benefits and harms of lung cancer screening and values clarification exercise questions(6). The other is a brief one-page DA without a pictogram or a clarification exercise developed by Han et al (43). We asked participants to select the DA that they recommended be sent with the text messages about lung cancer screening.

At the end of the session, participants were asked to complete a brief survey about demographics, health literacy and their intention to discuss lung cancer screening with their providers and to have a LDCT for lung cancer screening. Interviews were audio-recorded and transcribed. Text messages were revised further based on the feedback from participants from Step 3.

**Step 4. Feasibility testing of a lung cancer screening text message system**

All participants from Steps 2 and 3 were invited to participate in feasibility testing which involved receiving one text message per day for 14 days, and then responding to a telephone survey about their experience. The text messages were delivered at noon on Monday, Wednesday and Friday and at 4PM on Tuesday, Thursday, Saturday and Sunday. Participants were asked to keep all the text messages that they received in their cell phones. Within two days of the last message, a research staff member
administered a telephone survey to evaluate the feasibility of this text messaging system and participants’ reactions to receiving lung cancer screening text messages. The telephone interviews were audio-recorded and responses to open-ended questions were transcribed.

This study was approved by the Institutional Review Board at the University of Massachusetts Medical School.

**Measurements**

**Overview**

The primary outcome of this study was participant reactions to receiving educational lung cancer screening text messages in Step 4. Secondary outcomes were feasibility of the lung cancer screening text messaging system in Step 4 and participants’ engagement in co-production and content-sorting in Step 2 and 3.

**Baseline measures**

Participant characteristics including age, gender, race, ethnicity, detailed smoking history, insurance, education, marital status, and income were measured by a brief survey at the end of co-production and content-sorting sessions in Step 2 and Step 3, respectively. For Step 2, the result of the previous LDCT was also assessed since the result could influence participant’s perception of lung cancer screening.

**Outcome measures**

We explored participant reactions to receiving the lung cancer screening text messages via a telephone survey conducted within two days of the last text message. The study team adapted questions used in prior studies (44, 45) and created new questions specifically for this study. Both open-ended and close-ended questions were
included. Open-ended questions focused on: 1) general experience of receiving text messages, 2) what participants liked and disliked about the text messages, 3) any aspects of the messages that particularly “stood out”, 4) recommendations for changes to the messages and/or process, and 5) other thoughts about the text message intervention. Closed-ended questions asked about: 1) the number of text messages read; 2) recommendations for keeping or changing the number of text messages; 3) the content of text messages, 4) timing of delivering the text messages, 4) possible feelings of anxiety, fear or disturbance as a results of the text messages, 5) the link to a PDF, 6) overall rating of the text message series, and 7) whether the participant would recommend the text messages to others.

Feasibility of delivering text messages was measured by three questions in the survey: 1) the number of text messages that a participant received, 2) the content of the text message that a participant received on day 5, and 3) participant’s reported problems receiving text messages. We also reviewed the delivery log of the text messaging system which showed the time and the text messages sent to each participant.

Participant engagement in co-production and content-sorting during Step 2 and 3 was measured by the number of participants completing each activity (e.g., editing a text message, completing a sentence using a prompt, creating own messages, content-sorting) to evaluate engagement during these sessions.

Other measures

Health literacy assessed by the Single Item Literacy Screener and intention to obtain lung cancer screening were measured in participants without previous LCS
experience by the survey at the beginning of the session in Step 3, since health literacy affects understanding of the content of text messages and intent to obtain lung cancer screening may influence reactions to the lung cancer screening text messages (46).

To evaluate the effect of participation in this study on participants’ decision action, the patient-provider discussion of lung cancer screening, order for LDCT for lung cancer screening, and completion of LDCT were measured based on the EMR data collected 6 months after from the content-sorting session.

Data analysis
The PI (MIF) summarized feedback from participants collected during study sessions (Steps 2 and 3) and presented the summary to the research team. The research team (MIF, AP, KMM, TKH, RW, and RS) revised text messages based on the feedback from participants.

Quantitative analysis
We summarized continuous variables (age, pack-years, numbers of text messages actually received and desired to receive) using means and standard deviations. We computed frequencies and percentages of responses for categorical variables (gender, race, ethnicity, smoking status, years since quitting smoking, education, marital status, income, employment, insurance, type of cellphone, result of LDCT, decision intension, decision action, and response in the follow-up survey). All statistical analyses were performed with STATA version 15.

Qualitative analysis
Transcripts of co-production and content-sorting sessions from Step 2 and 3
We used content analysis for transcripts of co-production and content-sorting sessions. We first developed a codebook, using a deductive approach to include
elements necessary to consider in designing a text message intervention (e.g., style, tone, content and sender of text messages). We expanded the codebook inductively to include important concepts which emerged through a careful review of the transcripts (e.g., participant experience in lung cancer screening, smoking cessation). The PI (MIF) reviewed transcripts and developed the preliminary codebook, which was refined and revised by consensus (MIF, JS, RL, and KMM). When the codebook was finalized, all transcripts were read and coded by at least two investigators (MIF, SP, and RL).

The quotes from each code were further reviewed and subcategorized by at least two investigators (MIF, KJ, TS). We chose participant quotes that represented both the majority of sentiments in each question as well as any quotes that offered a valuable opinion for further development of this text message intervention.

Responses to open-ended survey questions in Step 4
Responses to open-ended questions including in the Step 4 survey were reviewed and categorized by at least two investigators (MIF, KJ, TS). We chose participant quotes that represented both the majority of sentiments to each question as well as any quotes that offered a contrasting opinion.

Chapter IV: Results

Study participation
Figure 2 shows the consolidated study flow diagram. Out of 253 potentially eligible patients identified through the Electronic Medical Records (EMR), 12 participants were enrolled and completed co-production sessions in Step 2. In Step 3, 577 potential eligible patients were identified in the EMR. Eleven participants completed
the content-sorting activity. We had planned to also recruit 12 participants for Step 3, however recruitment was stopped before recruiting the final participant due to the COVID-19 pandemic. Prior to Step 4, one participant from Step 2 withdrew with the result that a total of 22 participants received text messages and completed the follow-up survey.

**Participant characteristics**

Table 1 describes the demographics of participants in Step 2 and 3. Participants were diverse with respect to age, gender and smoking history. Per respective inclusion criteria, all participants in Step 2 had had LDCT for lung cancer screening, while no participant in Step 3 had previously been screened. Besides a lung cancer screening history, there was no significant difference between the two groups. The mean age of all participants from both groups was 63 years (S.D. 6.3). Participants were predominantly white (18/23 (78%)), 2 (9%) were black with 2 (9%) Hispanic. There were more women (13/23 (57%)) and more participants who previously smoked (14/23 (61%)). Half (7/14) of participants who formerly smoked had quit smoking within the past 5 years. The highest level of education was high school graduate for 9 out of 23 participants. Ten reported annual income of less than $30,000. The majority of participants (70%) reported having Medicare. All participants except for one participant had smart phones.

Of the 12 participants in Step 2 who had had LDCTs, all had Lung RADS 1 (normal) or 2 (benign) (Table 1). No participant had Lung RADS 3 (probably benign but requires short interval follow-up) or 4 (suspicious for malignancy).
Participant engagement

**Step 2: co-production session**

All participants completed the open-ended prompts in writing. Except for one participant who was concerned about her writing skill, all participants did at least some editing to the text messages. The average completion rates to write messages responding to written prompts was 91%, the average rate to edit sample text messages was only 55% (Tables 2 and 3). Figure 3 provides an example of how participants edited the message about follow-up of lung cancer screening by adding more information that was important to them. Participants did not like words they perceived as negative, such as “a heavy smoking history” or “harms” and removed those words. They made messages more personalized and engaging by changing the word “a person” to “you.” One participant added “as you know” in the front of the smoking cessation message to make this message “sounds more positive” and “not forced.” (Figure 4). Although most participants easily completed the messages by using prompts based on their experience, only 5 original messages were created by three participants (Table 4, Figure 5).

**Step 3: content-sorting session**

A total of ten participants completed the content-sorting activity to select messages that they recommended for use and rearranged the orders of messages (Figure 6). One participant did not think that sending lung cancer screening information through text messages was a good idea and did not complete the content-sorting activity. She still answered other questions, and shared her thoughts and suggestions about how to support patients and providers for SDM discussion of lung cancer screening during a time-limited clinical visit.
Table 5 describes the number of participants who recommended removing each message and quotes exemplifying their reasons for keeping or removing each message. Participants did not always verbalize a reason for keeping or removing specific messages.

Besides the introductory and closing messages, the only message that all participants recommended keeping was the message about eligibility for lung cancer screening. Participants also recommended sending this information earlier than the fifth day: “That’s gotta come really early to find out if they’re a candidate..., ‘cause if you wait too long, they might have gotten bored already.”

Five of ten participants suggested removing the sixth message that encourages patients to engage in SDM with their providers. One of the reasons was because they believed that their doctors, not patients, would decide their eligibility for lung cancer screening and this information to encourage SDM was unnecessary for patients.

Four participants removed the 7th message that explained that lung cancer screening had both benefits and harms and the 9th message about the false positive as one of the harms of lung cancer screening. Participants’ reasons for omitting these messages varied. Some thought that information on both the benefits and harms of lung cancer screening should be mentioned in text messages without detailed explanation to provoke the conversation with their PCPs. However, they suggested avoiding the word “harms”: “Don’t use the word ‘harms.’ That will scare people away.”

Others recommended removing the messages mentioning the harms of lung cancer screening since they did not perceive a false positive as a harm and it was
important to “accentuate the positive” and not to scare people by mentioning harms.

One participant stated “If the object [of lung cancer screening text message intervention] is to trigger me to discuss it with my doctor, [the benefits and harms of lung cancer screening] would be things I would think the doc would bring up.”

**Evolution of text messages through the process**

Based on the feedback from participants, text messages were refined after Step 2 and Step 3. For example, the name of sender was added to all the text messages to make the sender of text messages more obvious. The link to a DA was added, rather than referring to the paper DA (which had been mailed to participants) since a paper-based DA could be easily lost (Figure 7).

The evolution of the text messages from Step 1 to 4 is summarized in Table 6. The final versions were largely informed by participants’ suggestions, with one notable exception. While some participants recommended not to send the messages to explain about the harms of lung cancer screening, we decided to send the message about the harms in Step 4. This was because the previous study reported that the harms of lung cancer screening were often not mentioned by providers during the visit. The goal of the text messages about lung cancer screening is to promote SDM discussion between patients and providers about lung cancer screening.

**Selection of the DA to use with text messages of lung cancer screening**

Eight participants (72.7%) recommended to send a four-page DA developed by AHRQ with text messages since “colors would hold the attention”. Three participants (27.3%) recommended a single page DA since “it was more direct” and “quick and easy”.
Lung cancer screening decision intent and actions among participants in Step 3

At the end of content-sorting sessions, all participants in Step 3 were planning to discuss lung cancer screening with their providers at their next visit and would like to be screened for lung cancer. Eight out of eleven (73%) were planning to have lung cancer screening in the near future (Table 7).

Review of participant’s EHRs six months post session found that 6 participants (54%) had a visit with their primary care providers (PCPs). Only two participants’ EHRs contained documentation of discussion of lung cancer screening with their PCPs although four had an order placed for LDCT in the EHR. Subsequently, 3 out of 4 participants completed LDCT. One participant reported in the follow-up survey that he discussed lung cancer screening with his PCP and LDCT was not recommended. However, this discussion was not documented in the EMR (Figure 8).

Feasibility of delivery of text messages

A total of 15 text messages were delivered to 22 participants, the fourteen text messages plus an additional preliminary message confirming the enrollment of patients’ cell phone number in a text messaging system. All 22 participants completed the follow-up telephone surveys. Although no participant reported any problems in receiving the text messages, the median number of messages reported as received was 14 (range 5 to 15) (Table 8). When we asked the content of the fifth message that a participant received, five participants reported the content of the sixth message instead of the fifth. We found that the second message was not delivered to those five participants due to a problem with the programming of the text message system.
Participants’ reactions to receiving text messages about lung cancer screening

Tables 9 and 10 show the results of the survey. Out of 22 participants, 18 (86%) read all text messages. Only two participants reported difficulty in reading the text messages on their cell phones. The sender of the text messages was clear to participants. Although 16 participants related the number of the text messages as “just right”, participants also reported that text messages were “too frequent” and some of the contents were “repetitive”. They recommended sending fewer text messages (median 10, range 1 to 15).

All participants agreed that the text messages were easy to understand and the information in the text messages were important to them. As one participant commented: “They were informative, and they were not pushy.” Many participants (20/22 (91%)) found the link to the decision aid helpful.

Most participants (20/22 (91%)) did not think the lung cancer screening text messages disrupted their daily activities. However, three participants who had been screened and one participant who had not reported the text messages made them nervous: “[lung cancer screening text message] makes you uncomfortable in the sense that what they were saying is true.”

When participants were asked to select the message that stood out most, various messages were selected without any consensus. Although some participants in Step 3 recommended not sending the messages about the harms of lung cancer screening, some actually appreciated the message about the harms during the feasibility testing: “I liked the fact that you seem to care about me and informed me about false positives. You didn't pressure me too much to get my lungs checked.”
The smoking cessation messages caused a negative response from some participants: “I kind of laughed at the one that was lung cancer screening does not replace the need for quitting smoking... that was so obvious that it kind of made me laugh, it was like "really!?". On the other hand, it promoted other participants to call a smoking quit line.

Interestingly, some found that he closing message stood out and that it would empower them to discuss lung cancer screening with their providers: “I tried to avoid [a doctor]” and “It brought up questions to ask the doctor. A lead into a commitment to follow up with the doctor.”

All participants except for one agreed that the text messages were a good way to prepare patients to discuss lung cancer screening with their providers and they would recommend these educational text messages about lung cancer screening to other patients. Some explained the reasons that they liked these text messages: “I actually looked forward to them. Just so that I would get more information each time. Almost left me hanging at the end of each one, wondering what was next” and “And you know even if I didn't write it down, or I can't remember it, that side of my brain, ‘Oh I want to talk to the doctor about it’. Of course, they are there - they came right to me - it was like ‘Holy crap, this is perfect’.”

Participants also pointed out some of the challenges inherent in using text messages as an intervention: “If I wasn't expecting the texts... and you sent them every day like that... I'd probably block you.” One participant who used a flip phone not a smart phone stated “It's the fact that I can't go into the link. So that's one of the things you've got to take into consideration dealing with an older audience. A lot of people in
their mid 60’s are old or they have flip phones basically because it’s the only technology they want to deal with or it’s all that they can afford” and pointed out the potential digital divide between patients with and without a smart phone.

Finally, one participant’s comment highlighted the limitation of this text message intervention to promote patient-provider discussion: “I brought it up with [my doctor.] ‘Yeah, yeah it’s right for some people and not for others’ is kind of where he left it.” Even though text messages may successfully activate patients to talk with their providers, meaningful discussion about lung cancer screening requires that the provider engage in the discussion as well.

Chapter V: Discussion

We successfully co-produced patient-centered educational text messages about lung cancer screening with participants eligible for lung cancer screening, sent these messages, and assessed participants’ reactions.

Patient reactions to receiving educational text messages about lung cancer screening

Our findings suggest that lung cancer screening-eligible patients are open to receiving educational text messages. Participants perceived that educational text messages were informative, would empower patients to discuss lung cancer screening with their providers and would promote smoking cessation.

Participants’ reactions to receiving the text messages on their phones highlighted several strengths of text messages as a modality to deliver information: 1) patients can easily access the information at their convenience, 2) patients can keep the information in their cell phones and carry it with them, and 3) receiving the information via short,
spaced text messages prevented participants from feeling overwhelmed by receiving too much information all at once. Although some participants found getting information on lung cancer screening via cell phone disturbing, most participants reported that the text messages did not disrupt their daily activities or cause anxiety.

While participants’ reactions to the text messages were positive, implementation of this approach in clinical systems is likely to be challenging. Participants pointed out that patients may not trust text messages without the notification that these educational text messages about lung cancer screening would be sent to them from a trusted source. Ultimately, they may delete or block the messages without reading them.

Participants stressed the significant role of their providers in discussion and ultimate decision regarding lung cancer screening. This text message intervention might not promote discussion of lung cancer screening between patients and providers if providers are not ready to discuss lung cancer screening with their patients. Complementary interventions to support providers to engage in SDM discussions are also needed.

**Lessons learned about co-production**

We learned several things about co-production methods from this study. Although all participants were eligible for lung cancer screening, participants with versus without lung cancer screening experience contributed differently. Lung cancer screening experienced participants used their own experience to edit sample text messages or complete messages guided by prompts. In contrast, participants without lung cancer screening experience could not edit text messages, they were able to prioritize the text messages, considering the information conveyed through the lens of a naïve patient.
Input from participants with and without direct experience of lung cancer screening was valuable in co-producing this intervention.

The study activities of editing sample text messages and prioritizing the text message cards provided structure, and allowed us to successfully engage participants. These activities also triggered rich conversations, which were even more valuable in guiding further intervention development than actual messages edited or completed in response to prompts by participants. The format of individual sessions allowed participants to share their personal experience with the research team, which they may have been less likely to do in a focus group setting.

How to integrate and balance participants’ feedback with input from the research team considering the goals of the research is a known challenge in co-production methods. Our research team selected which participant’ feedback to integrate based on the vision that these lung cancer screening text messages will be delivered by lung cancer screening programs to patients prior to their PCP visits. Some participant’ feedback that was not selected for this project could be useful for other interventions such as a peer-to-peer text message intervention to support a lung cancer screening eligible population.

The role of each type of participant, the structured activities to engage participants, the format of each session (e.g., individual interviews vs. focus groups) and the guidance to balance input from participants and research teams are important to consider in co-production methods.
Advantages of education text messages as an intervention tool

Although several DAs for lung cancer screening are available, they are underutilized (21). Our educational text messages are not a DA and cannot deliver, all the topics to be discussed in SDM. However, our text messages delivered the key information including harms of lung cancer screening. This may be enough information exchange to initiate the first step of decision making process. Text messages may allow us to reach more lung cancer eligible population considering the higher usage of cell phones compared to patient portals and its ease to access messages without the extra step to log in. Our text messages can deliver information to patients prior to visits. The smaller amount of information in each message may increase the chance of patients reading the information. These advantages of text messages as an intervention tool were recognized by patient participants in this study.

Comparison with text message interventions for other cancer screening

Our goal in developing these text messages was not to unequivocally recommend lung cancer screening but rather to improve patients’ awareness of lung cancer screening and promote discussion and SDM with their providers. Therefore, we included the messages even about the harms of lung cancer screening. This differentiates our text message interventions from other cancer screenings, which focus mainly on benefits of cancer screening to increase screening rates(30).

Limitations of our study

There are some limitations in our study. The number of participants is relatively small although rich information was obtained from the individual participants. Although we included both participants with and without experience of lung cancer screening, none of our participants who had lung cancer screening experience had been
diagnosed with lung cancer or experienced any significant harms from lung cancer screening such as complications from a lung biopsy. Patients who had been diagnosed, or experienced harms might have provided different input compared to our participants who had normal or benign results from lung cancer screening. Participants who received the educational text messages and provided feedback were the same participants who were involved in co-production and content-soring; this involvement may have biased them to respond favorably to receiving the messages.

The COVID-19 pandemic affected this study, and likely limited participants’ opportunities to discuss lung cancer screening with their providers and to complete LDCT among participants without lung cancer screening experience in Step 3. Non-urgent medical care such as LDCT for lung cancer screening was not offered during the surge of the pandemic and patients avoided preventive care during the on-going COVID-19 pandemic(47, 48).

Future studies are needed to evaluate 1) naïve, lung cancer screening eligible patients’ perceptions of receiving these lung cancer screening text messages, 2) providers’ perceptions of this text message intervention for their patients, and 3) effectiveness of this text message intervention on improving patient knowledge and SDM discussions about lung cancer screening between patients and providers. Finally, it will be important to conduct a feasibility study by implementing this text message intervention in an existing clinical workflow. Studies such as these would provide insights as to whether this text message intervention about lung cancer screening would be a practical solution to promote patient-provider discussion of lung cancer screening in the real world.
In summary, we successfully developed and pre-tested educational text messages about lung cancer screening. Lung cancer screening eligible participants with and without previous lung cancer screening experience reacted positively to these messages and were generally supportive of using text messaging to improve patients’ awareness of lung cancer screening and promote lung cancer screening discussions between patients and providers.
Bibliography

8. The Patient Protectin and Affordable are Act, S. 933 (2010).
### Table 1. Participant characteristics

<table>
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<th>Total (N=23)</th>
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<th>Step 3 (N=11)</th>
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<td>How often do you need to have someone help you when you read instructions, pamphlets, or other written material from your doctor or pharmacy?</td>
<td>Never</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Rarely</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Sometime</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Often</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Always</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Type of cell phone, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smart phone</td>
<td>22 (96)</td>
<td>12 (100)</td>
<td>10 (91)</td>
</tr>
<tr>
<td>Flip phone</td>
<td>1 (4.3)</td>
<td>0 ()</td>
<td>1 (9)</td>
</tr>
<tr>
<td>Result of LDCT, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lung RADS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>NA</td>
<td>3 (25)</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>NA</td>
<td>9 (75)</td>
<td>NA</td>
</tr>
<tr>
<td>3</td>
<td>NA</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>4</td>
<td>NA</td>
<td>0</td>
<td>NA</td>
</tr>
</tbody>
</table>
Table 2. The number of participants with lung cancer screening experience who edited each sample text message in Step 2: N = 12

<table>
<thead>
<tr>
<th>Content of message</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Introduction</td>
<td>9 (75)</td>
</tr>
<tr>
<td>2 What is lung cancer screening?</td>
<td>3 (25)</td>
</tr>
<tr>
<td>3 How do you have lung cancer screening?</td>
<td>7 (58)</td>
</tr>
<tr>
<td>4 How often and how long do you do lung cancer screening?</td>
<td>6 (50)</td>
</tr>
<tr>
<td>5 Am I eligible?</td>
<td>7 (58)</td>
</tr>
<tr>
<td>6 Should I be screened?</td>
<td>5 (42)</td>
</tr>
<tr>
<td>7 Pros and cons of lung cancer screening</td>
<td>7 (58)</td>
</tr>
<tr>
<td>8 What are pros of lung cancer screening?</td>
<td>9 (75)</td>
</tr>
<tr>
<td>9 What are cons of lung cancer screening?</td>
<td>7 (58)</td>
</tr>
<tr>
<td>10 Talking with your healthcare provider</td>
<td>6 (50)</td>
</tr>
<tr>
<td>11 Your value and preference</td>
<td>6 (50)</td>
</tr>
<tr>
<td>12 Smoking cessation 1</td>
<td>6 (50)</td>
</tr>
<tr>
<td>13 Smoking cessation 2</td>
<td>9 (75)</td>
</tr>
<tr>
<td>14 Closing message</td>
<td>5 (42)</td>
</tr>
</tbody>
</table>

Table 3. The number of participants with lung cancer screening experience who responded to written prompts in Step 2: N = 12

<table>
<thead>
<tr>
<th>Prompt</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>You should think about getting screened for lung cancer if ....</td>
<td>11 (92)</td>
</tr>
<tr>
<td>I started to think about getting screened for lung cancer because ....</td>
<td>11 (92)</td>
</tr>
<tr>
<td>One 'con' or bad thing about lung cancer screening is ....</td>
<td>11 (92)</td>
</tr>
<tr>
<td>One 'pro' or good thing about lung cancer screening is ...</td>
<td>12 (100)</td>
</tr>
<tr>
<td>The most important thing you should know before you decide whether to have lung cancer is ...</td>
<td>12 (100)</td>
</tr>
<tr>
<td>The most important thing to ask your doctor about lung cancer screening is</td>
<td>12 (100)</td>
</tr>
<tr>
<td>Looking back, I wish I asked my doctor</td>
<td>12 (100)</td>
</tr>
<tr>
<td>Looking back, I'm glad my doctor told me</td>
<td>7 (58)</td>
</tr>
<tr>
<td>The most important thing to tell your doctor about yourself as you think about lung cancer screening is</td>
<td>10 (83)</td>
</tr>
<tr>
<td>The challenge that I had while talking about lung cancer screening with my doctor was</td>
<td>10 (83)</td>
</tr>
<tr>
<td>What made it easier to talk with my doctor was</td>
<td>11 (92)</td>
</tr>
<tr>
<td>Going through the lung cancer screening was</td>
<td>11 (92)</td>
</tr>
<tr>
<td>The most important thing you should know about actually being screened is</td>
<td>11 (92)</td>
</tr>
<tr>
<td>When I went through the screening, I was surprised that</td>
<td>11 (92)</td>
</tr>
<tr>
<td>After the screening was over, I found out</td>
<td>11 (92)</td>
</tr>
</tbody>
</table>
Table 4. Examples of creating messages responding to written prompts by participants with lung cancer screening experience in Step 2

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Participant’s response</th>
</tr>
</thead>
<tbody>
<tr>
<td>The most important thing to tell your doctor about yourself as you think about lung cancer screening is .....</td>
<td><em>that you be honest about your smoking.</em></td>
</tr>
<tr>
<td>The most important things to ask your doctor about lung cancer screening are.....</td>
<td>“does it hurt?” “what if you find something?”</td>
</tr>
<tr>
<td>What made it easier to talk with my doctor was ....</td>
<td><em>his knowledge of lung cancer and understanding my fears of the test.</em></td>
</tr>
<tr>
<td>I started to think about getting screened for lung cancer because ....</td>
<td><em>I have smoked for years and would like to improve my health and longevity.</em></td>
</tr>
</tbody>
</table>
Table 5. Results from content-sorting with lung cancer screening eligible participants without lung cancer screening experience in Step 3. N=11

<table>
<thead>
<tr>
<th>Reason to keep a message</th>
<th>Reason to remove a message</th>
<th>Number of participants who removed the message. N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hi, this is the Lung Cancer Screening Message Center from UMass. Your appointment with your primary care doctor is coming up soon. We would like to send text messages about lung cancer screening based on your smoking history. We would like you to learn about lung cancer screening before your next visit.</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>&quot;These two are good, 'cause you wanna introduce the idea, wanna make sure it's coming from the hospital. Make sure you know it's not scam&quot; &quot;The first one is always the most important.&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 What is lung cancer screening? Lung cancer screening is a test to look for signs of early stage lung cancer. The goal is to find the cancer at an early and more treatable stage.</td>
<td></td>
<td>3 (30)</td>
</tr>
<tr>
<td>&quot;'cause it's good that they know what it is. It's a test to see if you have early stages, and that's good. That's important that the people know that that's what they're looking – what you're looking for is potentially early stages, potentially curable stages, yeah, there, &quot;early and more treatable.&quot;&quot;</td>
<td>No quote</td>
<td></td>
</tr>
<tr>
<td>3 How do we do lung cancer screening? We use a computed tomography, called a “low-dose CT (CAT) scan.” A low-dose CT uses a computer and a series of X-ray with reduced amount of radiation. We take pictures of your lungs to look for anything significant. A low-dose CT can take about 10 min.</td>
<td></td>
<td>2 (20)</td>
</tr>
<tr>
<td>&quot;You wanna know what it is, and people wanna know, how do you do it? They wanna know how.&quot; &quot;Some people don’t wanna have a high dose of radiation.&quot; &quot;This one. This told me something I didn’t know.&quot;</td>
<td>&quot;Describing what it is and how it’s done are after the fact. The most important thing is bringing it up with your doctor, and then your doctor can give you as much information as you need.&quot;</td>
<td></td>
</tr>
<tr>
<td>4 How often do you need to have lung cancer screening? Lung cancer screening is not a one-time test. It requires at least a once-a-year follow-up to monitor any changes between low-dose CTs. Your doctor will set up further testing IF there is abnormality on low-dose CT.</td>
<td></td>
<td>4 (40)</td>
</tr>
</tbody>
</table>
No quote

"I don’t think how often you need to have it done should even be a discussion unless you’ve made the choice to have it done. Once you make the choice to have it done, then you discuss how often, but the how often is not important unless you get them to go on and have it first."

5 We would recommend lung cancer screening for people at high risk. It is for 55 to 77-year-old current or former smokers who quit within the last 15 years with certain amount of smoking history. Read the pamphlet about lung cancer screening that we sent for more information.

"Yeah, that’s gotta come really early that – to find out if they’re a candidate, just to pique their interest. Is this something that should be for me? That needs to be early, ’cause if you wait too long, they might have gotten bored already. So you have to keep them interested in the text messages. Have them question their own – I hate to say question their own mortality."

6 Am I eligible for lung cancer screening? It is important to talk with your health care provider about whether you are eligible for lung cancer screening based on your age, smoking history and other health conditions.

No quote

"I don’t think they need to make a decision whether they’re in a high-risk group, because people might scare them, and their doctor would know if they’re – if they bring it up. The doctor can say, “Well, you’re not in a high-risk group, so maybe you can wait another 10 years to even think about it, because” – yeah, ’cause that’s not information they need. They need to know that it’s available."

“You could combine some of [messages].”

7 Lung cancer screening has both pros and cons. It is important to learn about both pros and cons before you decide to have lung cancer screening.

“You definitely want them to know there are pros and cons. Whether you go into detail of them is not significant. What you want to do is get them to talk to their doctor about it. That’s key, and that’s where the stress should be, about getting them to bring it up to their doctor.”

“When I saw cons, that – now I gotta wait for the con, but you start off with a pro, and then you go to the con and, blink, blink. Don’t need that.”

“I would not worry about that. And the false-positives are – you run that risk, though, with everything.”

8 What are pros of lung cancer screening? One pro is that lung cancer screening may save your life from lung cancer if you are at high risk.

"You could combine some of [messages].”
“That’s important that they know that they’re gonna have it done, because it may save their life, and they may be able to find early and more treatable stages of cancer.”

“Well, for me, if the object is to trigger me to discuss it with my doctor, these would be things I would think the doc would bring up. And it seems to me that this is in the pamphlet.”

9 What are cons of lung cancer screening? One of the cons of lung cancer screening is the chance of a false alarm, which are spots in the lungs that are not cancerous. Further testing is required to confirm that the spots are not cancerous.

“I know that it’s important that you wanna make sure that people know there are cons, and that’s important to know there are cons, but don’t use the word “harms.” That will scare people away. But definitely the pros and cons have to be presented.”

“I don’t see it as a con. I mean, if they find a spot, it’s a pro. If they find out it’s non-cancerous, it’s a pro. So I don’t see it being a con. You see my point?”

“You wanna accentuate the positive. When people hear things about false-alarms, they think, “That’s what’s gonna happen to me,” when it’s probably – I would assume this is a low occurrence rate.”

“I would not worry about that. And the false-positives are – you run that risk, though, with everything.”

10 Should I be screened? It is important to discuss with your health care provider whether lung cancer screening is right for you considering your overall health condition and preference. Please refer the pamphlet if you would like to learn more.

“This one, keep. Only because you’re educating the patient.”

“Maybe this one, not necessary. I think the rest are necessary.”

11 What will happen after lung cancer screening? It is important to go over the results with your doctor. If you have any questions, please ask your doctor. It is about your health and it is important for you to understand the results and the follow-up plan.

“This is important, too. You wanna know if you have it or not.”

“Because it’s telling you to discuss things with your doctor. That’s very good. He’s there for you.”

“I mean, you can talk to him. He doesn’t read minds, but – so really need to talk to him.”

12 Lung cancer screening will not replace the need for quitting smoking. As you know, quitting smoking could reduce the chance of developing lung cancer.
“I think people should know that – this is kind of important, because, “Lung cancer screening will not replace the need to quit smoking,” and whether it’s – smoking affects you, whether you wanna admit it or not. It affects how you breathe. It affects a bunch of stuff that you do. You know what I mean? So, just because you get a screening doesn’t mean that you shouldn’t stop smoking. You should stop smoking.”

“This, to me, seems like everybody knows this by now. It’s everywhere. Everyone knows that smoking causes lung cancer, and it’s not – and getting the screening is not gonna keep you from preventing lung cancer.”

13 We hope that you feel ready to talk about lung cancer screening with your doctor at your next visit. Think about some questions that you would like to ask. Read the pamphlet for more information. We hope you found these messages helpful.

“Because now you’re talking about going to see the doctor. You gotta get comfortable to talk about something.”
Table 6. Summary of the evolution of educational text messages about lung cancer screening

<table>
<thead>
<tr>
<th>#</th>
<th>Original messages used in Step 2</th>
<th>Refined messages 1 used in Step 3</th>
<th>Refined messages 2 used in Step 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>Introduction</td>
<td>Introduction</td>
</tr>
<tr>
<td></td>
<td>Hi, this is the <em>I2P3-CT study center from UMass</em>. For the next 14 days, we will send you text messages about lung cancer screening. Our goal is to help you be able to talk with your health care provider about lung cancer screening at your next appointment.</td>
<td>Hi, this is the Lung Cancer Screening Message Center from UMass. Your appointment with your primary care doctor is coming up soon. We would like to send text messages about lung cancer screening based on your smoking history. We would like you to learn about lung cancer screening before your next visit.</td>
<td>Hi [FIRST NAME], this is the Lung Cancer Screening Message Center at UMass. Your appointment with your primary care doctor is coming up soon. Based on your smoking history, we would like to send you text messages about lung cancer screening for the next 14 days. We would like you to learn about lung cancer screening before your next visit.</td>
</tr>
<tr>
<td>2</td>
<td>What is lung cancer screening? Lungs cancer screening is one method to look for early stage lung cancer before a person has any symptoms. The goal is to find the cancer at an early and more treatable stage.</td>
<td>What is lung cancer screening? Lung cancer screening is a test to look for signs of early stage lung cancer. The goal is to find the cancer at an early and more treatable stage.</td>
<td>Am I eligible? (eligibility) We often recommend lung cancer screening for people at high risk. You may be at risk if you are 55 to 77-year-old current or former smokers who quit within the last 15 years with certain amount of smoking history. You can find more information in the written materials we sent you. Or you can go to this website <a href="http://bit.ly/2sYwovq">http://bit.ly/2sYwovq</a> UMass Lung Cancer Screening Message Center</td>
</tr>
<tr>
<td>3</td>
<td>How do you have lung cancer screening? We use <em>low-dose CAT scan (CT)</em> for lung cancer screening to take pictures of your lungs to look for a “spot” in the lungs that may or may not be cancerous.</td>
<td>How do you have lung cancer screening? We use a computed tomography, called a “low-dose CT (CAT) scan.” A low-dose CT uses a computer and a series of X-ray with reduced amount of radiation. We take pictures of your lungs to look for anything significant. A low-dose CT can take about 10 min.</td>
<td>What is lung cancer screening? Lung cancer screening is a test to look for signs of early stage lung cancer. The goal is to find the cancer at an early and more treatable stage. UMass Lung Cancer Screening Message Center</td>
</tr>
<tr>
<td>Page</td>
<td>Question/Text</td>
<td>Answer/Text</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><strong>Am I eligible?</strong></td>
<td>Lung cancer screening is only for people at high risk. It is for 55 to 77-year-old current or former smokers who quit within the last 15 years with a heavy smoking history.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><strong>Should I be screened?</strong></td>
<td>It is important to talk with your health care providers about whether or not you are eligible for lung cancer screening.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>Pros &amp; cons of lung cancer screening</strong></td>
<td>Lung cancer screening has both pros and cons. It is important to learn about both pros and cons before you decide to have lung cancer screening.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>How often and how long do you do lung cancer screening?</strong></td>
<td>Lung cancer screening is not a one-time test. It is series of low dose CT’s. It requires at least an annual follow-up.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>How often do you need to have lung cancer screening?</strong></td>
<td>How often and how long do you do lung cancer screening? Lung cancer screening is not a one-time test. It requires at least a once-a-year follow-up to monitor any changes between low-dose CTs. Your doctor will set up further testing if there is abnormality on low-dose CT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Pros &amp; cons of lung cancer screening</strong></td>
<td>Lung cancer screening has both pros and cons. It is important to learn about the pros and cons before you decide whether to have lung cancer screening.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>What are pros of lung cancer screening?</strong></td>
<td>One pro is that lung cancer screening may save your life from lung cancer if you are at high risk.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>What are cons of lung cancer screening?</strong></td>
<td>What are the cons of lung cancer screening? One con is that you could get a false alarm. Lung cancer screening may find spots in the lungs that are <strong>NOT</strong> due to cancer. If this happens, you could need more testing to find out if the spots are due to cancer or <strong>NOT</strong> due to cancer.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Check more in</strong> <a href="http://bit.ly/2sYwovq">http://bit.ly/2sYwovq</a></td>
<td>UMass Lung Cancer Screening Message Center</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><strong>What are pros of lung cancer screening?</strong></td>
<td><strong>What are pros of lung cancer screening?</strong></td>
<td><strong>Should I be screened?</strong></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>One pro is that lung cancer screening may save your life from dying from lung cancer if you are at high risk.</td>
<td>One pro is that lung cancer screening may save your life from lung cancer if you are at high risk.</td>
<td>Are you eligible for lung cancer screening? Talk with your doctor to find out whether you are eligible for lung cancer screening. It will depend on your age, smoking history and overall health. UMass Lung Cancer Screening Message Center</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9</th>
<th><strong>What are cons of lung cancer screening?</strong></th>
<th><strong>What are cons of lung cancer screening?</strong></th>
<th><strong>How do you have lung cancer screening?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One of the cons of lung cancer screening is the chance of a false alarm, which are spots in the lungs that are not cancerous. Further testing is required to confirm that the spots are not cancerous.</td>
<td>One of the cons of lung cancer screening is the chance of a false alarm, which are spots in the lungs that are not cancerous. Further testing is required to confirm that the spots are not cancerous.</td>
<td>How do we do lung cancer screening? We use a low-dose CT (CAT) scan. A low-dose CT uses a very small amount of radiation to take pictures of your lungs. Doctors check the pictures to look for anything abnormal. A low-dose CT can take about 10 minutes. UMass Lung Cancer Screening Message Center</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10</th>
<th><strong>Talking with your healthcare provider</strong></th>
<th><strong>Talking with your healthcare provider</strong></th>
<th><strong>How often and how long do you do lung cancer screening?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>It is important to discuss with your health care provider about both pros and cons of lung cancer screening.</td>
<td>Should I be screened? It is important to discuss with your health care provider whether lung cancer screening is right for you considering your overall health condition and preference. Please refer the pamphlet if you would like to learn more.</td>
<td>How often do you need to have lung cancer screening? Lung cancer screening is not a one-time test. You will need follow-up low-dose CT once a year to monitor any changes between scans. If your low-dose CT shows any problems, your doctor will set up further testing. UMass Lung Cancer Screening Message Center</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11</th>
<th><strong>Your value and preference</strong></th>
<th><strong>After lung cancer screening</strong></th>
<th><strong>Your value and preference</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>It is important to weigh the pros and cons of lung cancer screening and consider your preference.</td>
<td>What will happen after lung cancer screening? It is important to go over the results with your doctor. If you have any questions, please ask your doctor. It is about your health and it is important for you to understand the results and the follow-up plan.</td>
<td>Should you be screened? Talk with your doctor to decide whether lung cancer screening is right for you. It will depend on your overall health and what is most important to you. Refer to the pamphlet that we sent to you if you would like to learn more. <a href="http://bit.ly/2sYwovq">http://bit.ly/2sYwovq</a>. UMass Lung Cancer Screening Message Center</td>
</tr>
</tbody>
</table>
Smoking cessation 1
Quitting smoking could reduce the chance of developing lung cancer. Lung cancer screening will not replace the need for quitting smoking.

Smoking cessation 1
Lung cancer screening will not replace the need for quitting smoking. As you know, quitting smoking could reduce the chance of developing lung cancer.

After lung cancer screening
What should happen after you have lung cancer screening? It is important to go over your results with your doctor. If you have any questions, make sure to ask your doctor. It is important that you understand your test results and follow-up plan.

UMass Lung Cancer Screening Message Center

Closing message
We hope that you feel ready to talk about lung cancer screening with your doctor at your next visit. Think about some questions that you would like to ask. Read the pamphlet for more information. We hope you found these messages helpful.

Smoking cessation 1
Lung cancer screening does not replace the need for quitting smoking. As you know, quitting smoking could reduce your chance of getting lung cancer.

UMass Lung Cancer Screening Message Center

Closing message
Let’s think about what to ask your health care providers about lung cancer screening at your next visit.

Smoking cessation 2
If you decide that lung cancer screening is not for you, you can still work on quitting smoking to reduce chances of having lung cancer in the future.

Smoking cessation 2
Quitting smoking is not easy. To get help with quitting, talk with your doctor. Your doctor can help.

UMass Lung Cancer Screening Message Center

Closing messages
We hope that you feel ready to talk about lung cancer screening with your doctor at your next visit. Think about some questions that you would like to ask. You can go to the website: http://bit.ly/2sYwovq for more information. We hope you found these messages helpful!

UMass Lung Cancer Screening Message Center
Table 7. Decision intention about lung cancer screening among participants without lung cancer screening experience in Step 3. N=11

<table>
<thead>
<tr>
<th>Decision intention at the end of content-sorting session</th>
<th>Response</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much do you agree with following statement?</td>
<td>N (%)</td>
<td></td>
</tr>
<tr>
<td>Response option: strongly agree, agree, undecided/not sure, disagree, strongly disagree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“I want to be screened for lung cancer.”</td>
<td>Strongly agree or agree</td>
<td>11 (100)</td>
</tr>
<tr>
<td>“I plan to discuss lung cancer screening with my doctor at my next visit.”</td>
<td>Strongly agree or agree</td>
<td>11 (100)</td>
</tr>
<tr>
<td>“I plan to have lung cancer screening.”</td>
<td>Strongly agree or agree</td>
<td>8 (73)</td>
</tr>
</tbody>
</table>
Table 8. Feasibility of the text messaging system in Step 4

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 2</th>
<th>Step 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=11</td>
<td>N=11</td>
</tr>
<tr>
<td>1. How many text messages did you receive on your cell phone? (median, range)</td>
<td>14 (7-15)</td>
<td>14 (95-15)</td>
</tr>
<tr>
<td></td>
<td>N (%)</td>
<td>N (%)</td>
</tr>
<tr>
<td>2. Could you read the 5th text message [text message with a link to web] to me? Note: It starts with Lung cancer screening has both pros and cons.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes: 8 (73)</td>
<td>8 (73)</td>
</tr>
<tr>
<td></td>
<td>No: 3 (27)</td>
<td>2 (18)</td>
</tr>
<tr>
<td>3. Did you have any problems receiving the text messages?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes: 0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>No: 11 (100)</td>
<td>11 (100)</td>
</tr>
</tbody>
</table>
Table 9. Patients’ reactions to receiving educational text messages about lung cancer screening in Step 4

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 2</th>
<th>Step 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=11</td>
<td>N=11</td>
</tr>
<tr>
<td></td>
<td>N (%)</td>
<td>N (%)</td>
</tr>
<tr>
<td>1. How many of the text messages did you read?* (*Missing 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All/14</td>
<td>9 (90)</td>
<td>9 (82)</td>
</tr>
<tr>
<td>Most/9-13</td>
<td>1 (10)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Some/5-8</td>
<td>0 (0)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>A few/1-4</td>
<td>0 (0)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>2. How would you rate the number of messages that we sent you?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too few</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Too many</td>
<td>4 (36)</td>
<td>2 (18)</td>
</tr>
<tr>
<td>Just right</td>
<td>7 (64)</td>
<td>9 (82)</td>
</tr>
<tr>
<td>3. How many messages would you recommend that we send? (median, range)</td>
<td>10 (1-15)</td>
<td>10 (2-14)</td>
</tr>
<tr>
<td>4. It was clear the text messages came from UMass research team.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>9 (18)</td>
<td>9 (46)</td>
</tr>
<tr>
<td>Agree</td>
<td>7 (64)</td>
<td>4 (36)</td>
</tr>
<tr>
<td>Disagree</td>
<td>1 (9)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>1 (9)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>5. We sent our text messages around 4PM. How was that time for receiving the text messages? Did it seem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too early</td>
<td>1 (9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Too late</td>
<td>3 (27)</td>
<td>2 (18)</td>
</tr>
<tr>
<td>Just right</td>
<td>6 (55)</td>
<td>7 (64)</td>
</tr>
<tr>
<td>No preference/would not matter</td>
<td>1 (9)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>6. We sent our text messages around 12PM. How was that time for receiving the text messages? Did it seem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too early</td>
<td>1 (9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Too late</td>
<td>0 (0)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>Just right</td>
<td>8 (73)</td>
<td>8 (73)</td>
</tr>
<tr>
<td>No preference/would not matter</td>
<td>2 (18)</td>
<td>2 (18)</td>
</tr>
<tr>
<td>7. The lung cancer screening text messages got in the way of my daily activities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>0 (0)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>Agree</td>
<td>0 (0)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>Disagree</td>
<td>7 (64)</td>
<td>3 (27)</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>4 (36)</td>
<td>6 (55)</td>
</tr>
</tbody>
</table>
8. I had trouble reading the text messages on my cell phone.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>0 (0)</td>
<td>1 (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>0 (0)</td>
<td>1 (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>5 (45)</td>
<td>5 (46)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>6 (55)</td>
<td>4 (36)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. Did you think that it is helpful to have this link to a website for more information?

<table>
<thead>
<tr>
<th></th>
<th>Yes (100)</th>
<th>No (0)</th>
<th>Not sure (4.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>11</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Not sure</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

10. The text messages were easy to understand.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>4 (36)</td>
<td>1 (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>7 (64)</td>
<td>1 (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>0 (0)</td>
<td>3 (27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0 (0)</td>
<td>6 (55)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. The information in the text messages was important to me.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>4 (36)</td>
<td>5 (45)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>6 (55)</td>
<td>6 (55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>1 (9)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0 (0)</td>
<td>1 (9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. Receiving the text messages made me nervous.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>0 (0)</td>
<td>1 (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>3 (27)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>1 (9)</td>
<td>4 (36)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>7 (64)</td>
<td>6 (55)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13. Receiving the text messages was annoying.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>0 (0)</td>
<td>1 (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>3 (27)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>5 (46)</td>
<td>4 (36)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>3 (27)</td>
<td>6 (55)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>2 (18)</td>
<td>3 (27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>7 (64)</td>
<td>7 (64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>2 (18)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0 (0)</td>
<td>1 (9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
15. The text messages are a good way to prepare patients like me to talk about lung cancer screening with their doctor.

<table>
<thead>
<tr>
<th></th>
<th>My Group</th>
<th>Other Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>6 (55)</td>
<td>5 (45)</td>
</tr>
<tr>
<td>Agree</td>
<td>5 (45)</td>
<td>5 (45)</td>
</tr>
<tr>
<td>Disagree</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0 (0)</td>
<td>1 (10)</td>
</tr>
</tbody>
</table>

16. I would recommend these educational text messages about lung cancer screening to other patients.

<table>
<thead>
<tr>
<th></th>
<th>My Group</th>
<th>Other Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>7 (64)</td>
<td>7 (64)</td>
</tr>
<tr>
<td>Agree</td>
<td>4 (36)</td>
<td>3 (27)</td>
</tr>
<tr>
<td>Disagree</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0 (0)</td>
<td>1 (9)</td>
</tr>
</tbody>
</table>

17. Overall, how would you rate these text messages about lung cancer screening?

<table>
<thead>
<tr>
<th></th>
<th>My Group</th>
<th>Other Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>7 (64)</td>
<td>6 (55)</td>
</tr>
<tr>
<td>Very good</td>
<td>2 (18)</td>
<td>4 (36)</td>
</tr>
<tr>
<td>Good</td>
<td>2 (18)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>Fair</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Poor</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>
Table 10. Patients’ reactions to receiving educational text messages about lung cancer screening

<table>
<thead>
<tr>
<th>1. Could you tell me about your experience receiving our text messages about lung cancer screening?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content and Tone</strong></td>
</tr>
<tr>
<td>“They were generally positive in that there was a lot of information but it was spaced out so it was easy to digest.”</td>
</tr>
<tr>
<td>“The information was good. But I think, I don’t know I think there is a lot of fear in this. Umm. implanted in it not on purpose, you know what I mean?”</td>
</tr>
<tr>
<td>“I mean, that's kind of like oh boy... can it happen. I mean that was the only thing.”</td>
</tr>
<tr>
<td><strong>Frequency and number of text massages</strong></td>
</tr>
<tr>
<td>“Getting a message every single day...towards like the 3rd day, I just did not read them anymore. But I did go through them later on.”</td>
</tr>
<tr>
<td><strong>Empowerment</strong></td>
</tr>
<tr>
<td>About smoking cessation</td>
</tr>
<tr>
<td>“I just went back and read one of the things about lung cancer. You know I think that most smokers realize it, OK? But this is... the reminder that I should go get myself screened but at the same time I should - you really should quit smoking. It's really two things that I'm getting out of this.”</td>
</tr>
<tr>
<td>About talking with doctors</td>
</tr>
<tr>
<td>“I would never have brought it up with my doctor. I don’t want anything to be wrong when I go to the doctor. I just want to get in and out of there as fast as I possibly can. Like I said, I brought it up because I thought maybe I did.”</td>
</tr>
</tbody>
</table>

2. Did any of the text messages particularly stand out for you?

| Nothing particular |
| “I don’t think one in particular stood out, I think they all just blended with each other and went from one thing to another.” |
| “They are all very stood for me.” |
| **What is lung cancer screening?** |
| “I know it was in the beginning something hit me wrong. Oh, look for early signs of early lung cancer, the goal is to find cancer... I don’t know I think you use the word cancer too much.” |

| Am I eligible? |
| “It was the first message that you know people that were smokers... that are smokers or former smokers... that you know this is a wake-up call that you should have the lung cancer screening. I mean that kind of woke me up, I mean I have been smoking for a long time.” |

| Should I be screened? |
| “This kind of suggests to you, relatively gently, that you probably should. You should talk to your doctor about getting lung cancer screenings, so you have a better idea of your overall health.” |
Pro and cons of lung cancer screening.

What are the pros or cons of lung cancer screening?

“Yeah, I think that was helpful. Telling me like, you know, the test might not be 100% accurate. I didn't know that. I thought it was going to be like yes or no. But telling me that there are false positives were a possibility as well.”

Smoking cessation

“Just as far as you know quitting smoking and says you know that it is tough to quit smoking and I don’t know exactly where I saw that, but it was something like that... anyways. And that actually kind of prompted me to call the Massachusetts Quit Smoking or whatever it is.”

“The smoking ones didn't phase me so much as I had already quit. So to me if I could do it cold turkey so could the rest of the world.”

Closing message

“One suggesting that you talk to your physician to get additional information plus there was a link to go to the website.”

3. IF you could change one thing about this text message program, what would you change?

The number or the frequency of text messages

“Maybe decrease the frequency if the participant chooses to. There was quite a few of them and then after a while after...a few days I stopped looking at them. “

Opt-out option

“I mean with some variations liked we talked. Especially the first one where it's kind of explained opt in or opt out. You know, as long as you can let them opt out it will be great.”

Two-way text message system

“I would like it if you could answer it. You know what I mean?”

Link to smoking cessation resources

“What would probably be good is more links to... like quit smoking places and stuff like that because like I said, I actually went online and I started doing a search myself, you know? But if you could put in...like some links to... and kind of prompt people like me to start taking seriously about quitting smoking.”

4. What do you think about the idea of sending information about lung cancer screening via text messages?

Text messages are a good way.

“Even if I was you know, doing a job where I couldn’t access my phone and at the end of the day I... you know am sitting around at night, I would look at it and absorb it. I think more so than an email. There is so much junk email, but there isn't a lot of junk texts.”

“Well, I tell ya, as long as you’ve got the phone... I think it’s a good way to spread any kind of important medical health related Information, actually.”

“So it was good that it was there because it kept - not that you were focused on it, but...the stream of information every day, over the time, I think was more beneficial than getting it all in one chunk.”
The text messages are a bad way.

“Nope, I don't think it is proper. I don't think it's good. I think it keeps people in fear. Because this is not an option... the screening for the lung cancer.”

How to start sending text messages is a challenge.

“If I didn't already go through your program and I didn't already have a doctor suggest that I get screened, which I did, and I just started getting these texts out of the blue, I don't really know how I would react to it. I don't know... Did you ever think about quitting smoking or getting screened for lung cancer? Something like that to kind of grab your attention.”

“As long as the person talks with their doctor first, so it is not a surprise that they are getting something like that in a text message.”

What's about people who have only a flip phone not a smart phone?

“The only problem is where I got them on the flip phone I couldn't click on any of the links. Well I actually have internet on this but it's not like a touchscreen or anything and I can't scroll down the message line by line to actually click on the link. I can go on the internet and type in a browser - a link - but I can't click on one that has been sent to me.”
Figures

Figure 1. The process of co-production of educational text messages of lung cancer screening

**Step 1:** Development of drafts of text messages based on the guidelines and decision aids by the research team

**Step 2:** Co-production of text messages with participants with experience of lung cancer screening

Revision based on the feedback in Step 2 by the research team

**Step 3:** Content-sorting of text messages with participants without experience of lung cancer screening

Revision based on the feedback in Step 3 by the research team

**Step 4:** Feasibility test by sending text messages to participants from Step 2 and 3

Telephone survey to explore participants’ reactions

Revision based on the feedback in Step 4 by the research team

**Content of text messages**

1. Introduction
2. What is lung cancer screening?
3. How do you have lung cancer screening?
4. How often and how long do lung cancer screening?
5. Am I eligible?
6. Should I be screened?
7. Pros and cons of lung cancer screening
8. What are pros of lung cancer screening?
9. What are cons of lung cancer screening?
10. Talking with your health care provider
11. Your value and preference
12. Smoking cessation 1
13. Smoking cessation 2
14. Closing message
Figure 2. Study flow diagram

Step 2: Patients who HAD lung cancer screening

- Potential eligible in EMR N=253
  - Invitation letter not mailed N=38
  - Invitation letter mailed N=215
    - Not reached N=103
      - Mail undelivered (N=2)
      - No call attempted (N=47)
      - Phone disconnected (N=4)
      - No answer after call (N=50)
    - Reached N=112
      - Declined (N=84)
        - Incomplete screening (N=2)
        - Not eligible (N=9)
      - Enrolled N=17
        - Withdraw N = 5
          - Co-production N=12
            - Withdraw N=1
  - Received text messages N=11
  - Completed follow-up survey N=11

Step 3: Patients who have NOT had lung cancer screening

- Potential eligible in EMR N=292
  - Invitation letter not mailed N=285
    - Not reached N=169
      - Mail undelivered (N=1)
      - No call attempted (N=52)
      - Not eligible (N=8)
      - Phone disconnected (N=5)
      - No answer after call (N=103)
    - Reached N=116
      - Declined (N=71)
        - Not eligible (N=28)
      - Enrolled N=17
        - Withdraw N = 6
          - Content-sorting N=11
  - Received text messages N=11
  - Completed follow-up survey N=11
Lung cancer screening is not a one-time test. It is a series of low-dose CT’s. It requires at least an annual follow-up.

Edited message by Participants

Lung cancer screening is not a one-time test. It is a series of low-dose CT’s. It requires at least an annual follow-up. You will need as many follow-ups as your health care provider recommends.

Lung cancer screening is a series of low-dose CTs to see if there are any changes in between scans.

Lung cancer screening is not a one-time test. It is a series of low-dose CTs. You might have to have a screening in 3 months depending on the 1st results. It requires at least an annual follow-up.

Lung cancer screening is not a one-time test. It is a series of low-dose CTs. It is a testing that tracks or follows what is happening in a person's lungs according to their lifestyle. It requires at least an annual follow-up.
Figure 4. Examples of edited messages by participants with lung cancer screening experience in Step 2

- Make messages more supportive and personalized -

<table>
<thead>
<tr>
<th>Original Message</th>
<th>Edited Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung cancer screening is only for people at high risk. It is for 55 to 77-year-old current or former smokers who quit within the last 15 years with a heavy smoking history.</td>
<td>Lung cancer screening is only for people at high risk. It is for 55 to 77-year-old current or former smokers who quit within the last 15 years with a heavy smoking history.</td>
</tr>
<tr>
<td>Lung cancer screening is one method to look for early stage lung cancer before a person has any symptoms. The goal is to find the cancer at an early and more treatable stage.</td>
<td>Lung cancer screening is one method to look for early stage lung cancer before a person has any symptoms. The goal is to find the cancer at an early and more treatable stage.</td>
</tr>
<tr>
<td>Quitting smoking could reduce the chance of developing lung cancer. Lung cancer screening will not replace the need for quitting smoking.</td>
<td>As you know quitting smoking could reduce the chance of developing lung cancer. Lung cancer screening will not replace the need for quitting smoking.</td>
</tr>
<tr>
<td>It is important to talk with your healthcare providers about whether or not you are eligible for lung cancer screening.</td>
<td>If you are concerned about lung cancer, it is important to talk with your healthcare providers about whether or not you are eligible for lung cancer screening.</td>
</tr>
</tbody>
</table>
Figure 5. Written messages by participants with lung cancer screening experience in Step 2

- “I would advise everyone to question the procedure about getting lung cancer screening.”
- “This minor inconvenience could prevent the major inconvenience of lung cancer.”
- “Get screened to give you piece of mind.”
- “I would encourage, my sister, who quit smoking 7 years ago to get the screening.”
- “Don't think lung cancer happens to others. It could happen to you, but screening can detect and save your life.”
Figure 6. Example of the content-sorting activity with lung cancer screening eligible participants without lung cancer screening experience

BEFORE

1. Introduction
2. What is LCS? [REMOVE]
3. How do you have LCS?
4. How often and how long do you do LCS?
5. Am I eligible?
6. Should I be screened? [REMOVE]
7. Pros & cons of LCS [REMOVE]
8. What are pros of LCS?
9. What are cons of LCS?
10. Talking with your health care provider
11. After LCS
12. Smoking cessation
13. Closing message

AFTER

1. Introduction
3. How do you have LCS?
5. Am I eligible?
4. How often and how long do you do LCS?
8. What are pros of LCS?
9. What are cons of LCS?
10. Talking with your health care provider
4. How often and how long do you do LCS?
11. After LCS
12. Smoking cessation
13. Closing message
Figure 7. Example of the process of refining a text message

Original message

Lung cancer screening has both pros and cons. It is important to learn about both pros and cons before you decide to have lung cancer screening.

Refined Message

Lung cancer screening has both pros and cons. The balance of pros and cons may change based on your risk and your other health conditions. It is important to learn about both pros and cons before you decide to have lung cancer screening. Check more in https://nxt.to/KKb5VH9 -UMass Lung Screening Message Center-
Figure 8. Lung cancer screening decision action among patients without lung cancer screening experience in Step 3. N=11

Completed content-sorting session
N=11

Scheduled PCP appointment?

No
N=5

Completed PCP appointment?

No
N=0

No LDCT for LCS ordered
N=7

N=1

No LDCT for LCS completed
N=8

Yes
N=6

Yes
N=6

Documented LCS discussion with PCP?

No
N=4

LDCT for LCS ordered
N=4

N=2

LDCT for LCS completed
N=3

Result
Lung RADS1 (N=1)
Lung RADS2 (N=1)
Lung RADS3 (N=1)

Yes
N=2
Appendices

Appendix 1. Power point presentation about lung cancer screening facts

Welcome!

Our plan for today:
1. Lung cancer screening facts
2. Idea, text patients about lung cancer screening
3. Sample text messages
4. Help us create new text messages
5. Next steps

Facts about lung cancer

- Leading cause of cancer death by far
- No symptoms until it has spread
- Often found at later stage
- Early-stage lung cancer could be cured by surgery
- Screening looks for early-stage lung cancers

Lung cancer screening is new
Only 3.9% of people get screened

<table>
<thead>
<tr>
<th>Screening Rate (%)</th>
<th>Lung Cancer</th>
<th>Colon Cancer</th>
<th>Breast Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22</td>
<td>40.3</td>
<td>12.4</td>
</tr>
</tbody>
</table>

How do we screen for lung cancer?

- CAT scan
- Low dose of radiation to take X-rays of your lungs
- Takes a few minutes
- Not painful

Lung Cancer Screening Looks for Spots on the Lungs

Who should have lung cancer screening?

Recommendations based on age and amount of smoking

- Age 55 – 80 years
- Current smoker, or quit less than 15 years ago
- Smoked for at least 30 “pack years”
What are "pack years"?
The number of packs per day multiplied by the number of years smoked
For example:
• 1 pack a day for 30 years = 30 pack years
• 2 packs a day for 15 years = 30 pack years

When Should I get screened?
• Guidelines call for lung cancer screening every year until you’ve been smoke free for 15 years, or you’re over age 80.

Not everyone needs lung cancer screening
• Screening has both benefits and harms.
• Screening is only for people at high risk for lung cancer.
• Consider risks, benefits and harms before you decide.

What are the benefits of lung cancer screening?
• Decrease the chance of dying from lung cancer
• Decrease the chance of dying from any cause (not just lung cancer)

Possible harms of lung cancer screening
False alarms (false positives)
• Not all spots are cancer
• False alarms can cause stress or anxiety
• False alarms can result in procedures such as biopsy, that are not needed

What are false alarms?
If 1,000 people are screened every year for 5 years, about 3 will have a false alarm.
What are some additional potential harms of lung cancer screening?
• Radiation exposure
• Over-diagnosis
  May find slow-growing cancer that won’t cause problems

What is the bottom line on lung cancer screening?
• Pro: can save lives
• Cons:
  • “False positive” results lead to more testing
  • Radiation exposure
  • The right choice depends on what is most important to you.

Lung cancer screening is a choice
• Talk with your primary care provider.
• Consider the pros and cons, and what matters most to you.
• Think about your overall health.
• Make a decision that is right for you.

The best choice depends on your overall health and what is most important to you.

Lung cancer screening and smoking
• Screening will reduce the chance of dying from lung cancer.
• Screening will NOT reduce the chance of having lung cancer.
• To reduce the chance of having lung cancer, stop smoking.
• It is important to stop smoking whether or not you have lung cancer screening.

Our goals
By sending text messages, we hope to help patients...
• Learn more about screening
• Know what questions to ask
• Decide what is most important to them and tell their provider

We need your help!!

Let’s get started
Think about someone who may be a candidate for screening.
• What would you like to tell them?
• What would you want to make sure that they know?
• What questions should they ask their provider?