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# Telephone risk-based eligibility assessment for low-dose CT lung cancer screening

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## ABSTRACT

Eligibility for lung cancer screening (LCS) requires assessment of lung cancer risk, based on smoking history alongside demographic and medical factors. Reliance on individual face-to-face eligibility assessment risks inefficiency and costliness. The SUMMIT Study introduced a telephone-based lung cancer risk assessment to guide invitation to face-to-face LCS eligibility assessment, which significantly increased the proportion of face-to-face attendees eligible for LCS. However, levels of agreement between phone screener and in-person responses were lower in younger individuals and minority ethnic groups. Telephone-based risk assessment is an efficient way to optimise selection for LCS appointments but requires further iteration to ensure an equitable approach.

## INTRODUCTION

Lung cancer screening (LCS) using low-dose CT (LDCT) reduces lung cancer mortality in high-risk populations.[1 2] Eligibility is determined by lung cancer risk calculations, comprising smoking history, demographic and medical factors. No comprehensive population-based system exists from which LCS eligibility can be determined, therefore necessitating individual risk assessment of all potentially eligible individuals. Up to 88% of adults approached based on age alone were ultimately ineligible for LCS.[2 3] More targeted strategies including primary-care recorded smoking status or telephone screening of exclusion criteria (eg, current cancer treatment) still find 25%–50% of individuals ineligible at in-person assessment,[4 5] resulting in unnecessary appointments and potential distress.[6]

To reduce this inefficiency, the SUMMIT study introduced a telephone-based eligibility assessment ('phone screener') between the invitation and appointment to estimate individual lung cancer risk, in a similar approach to the Yorkshire Lung Screening Trial.[7] This manuscript reports the feasibility and accuracy of the phone screener in the first 12 months of recruitment.

## METHODS

The SUMMIT study is a prospective observational cohort study aiming to assess the implementation of LDCT for LCS in a high-risk population and to validate a multicancer early detection blood test. Study eligibility was assessed via a three-step process: primary care invitation, phone screener and face-to-face 'Lung Health Check' (LHC) (table 1). Potentially eligible individuals were invited by post from across north central and east London, with those meeting either US Preventive Services Task Force (USPSTF) 2014 criteria[8] or prostate, lung, colorectal, ovarian $(PLCO)_{m2012}$ 6-year lung cancer risk[9] ≥1.3% invited to undergo LCS as part of the study.

The initial phone screener (V.1) verified age and smoking status only; however, due to a high proportion of LHC attendees being ineligible for LCS, questions were expanded (V.2, conducted by National Health Service (NHS) band four staff), enabling estimation of USPSTF and $PLCO_{m2012}$ criteria (table 1). Eligible individuals were offered an LHC appointment at which NHS band five staff (blinded to phone screener responses) asked questions and measured height and weight to accurately assess USPSTF and $PLCO_{m2012}$ criteria (taken as the 'gold standard').

### Analysis

The accuracy of phone screener-based estimation of eligibility was quantified by the proportion of responders subsequently eligible for LCS at LHC appointment. Levels of agreement for individual participant responses during phone screener and LHC (for specific questions and overall eligibility status) were compared with Cohen's Kappa (K) and interpreted as per Landis and Koch,[10] for all LHC attendees and within age and ethnicity groups.

## RESULTS

### Effectiveness of telephone-based eligibility estimation on efficient utilisation of LHC appointments

Between March 2019 and April 2020, 30 759 individuals responded to the LHC invitation. The first 3.6% (n=1111) completed phone screener V.1, the remaining 96.4% (n=29 648) completed V.2 (figure 1). Significantly fewer individuals were eligible for an LHC using V.2 compared with V.1, (56.1% vs 86.9%, p<0.001). This resulted in an increased proportion of LHC attendees being LCS eligible (60.3% V.1 vs 82.6% V.2, p<0.001).

### Agreement between telephone screening and LHC assessments

For the 14 714 individuals who completed phone screener V.2 and attended an LHC, the level of agreement between eligibility assessments

**Table 1** Three step eligibility assessment for the SUMMIT Study and comparison of data collected at phone screener versus Lung Health Check to calculate lung cancer risk

| Primary care invitation | Phone-screener risk assessment | Face-to-face 'lung health check' eligibility assessment |
|---|---|---|
| Age 55–77 years<br>Current smoker within past 20 years<br><br>**Exclusion criteria:**<br>Dementia register<br>Housebound<br>Palliative care register or metastatic cancer<br>Refused research | Version 1: Verification of age and smoking status (smoker within last 20 years and more than 100 cigarettes in lifetime)<br><br>Version 2: Estimate of **USPSTF 2014 criteria** (30 pack-years of smoking and if a former smoker, have quit in the past 15 years) and/or **$PLCO_{m2012}$** 6-year lung cancer risk ≥1.3% | Calculation of: USPSTF 2014 criteria (30 pack-years of smoking and if a former smoker, have quit in the past 15 years)<br><br>and/or<br>**$PLCO_{m2012}$** 6 year lung cancer risk ≥1.3% |

| Phone screener (V2) estimate lung cancer risk | LHC assessment of lung cancer risk |
|---|---|
| **Categorical variables** | **Categorical variables** |
| Smoked >100 cigarettes in lifetime | Smoked >100 cigarettes in lifetime |
| Age (from GP extraction) | Age (from GP extraction) |
| Smoking status (current vs former) | Smoking status (current vs former) |
| Ethnicity (PLCO groups) | Ethnicity (PLCO groups) |
| Highest level of education | Highest level of education |
| History of COPD | History of COPD |
| Personal history of cancer | Personal history of cancer |
| Family history of lung cancer | Family history of lung cancer |
| **Continuous variables** | **Continuous variables** |
| Smoking duration | Smoking duration |
| Smoking consumption (amount) | Smoking consumption (amount) |
| | Periods of smoking abstinence |
| Self-reported height and weight (BMI estimate) | Measurement of height and weight (BMI calculated) |

BMI, body mass index; COPD, chronic obstructive pulmonary disease; GP, general practitioner; LHC, lung health check; PLCO, prostate lung colorectal ovarian; USPSTF, united states preventive services task force.

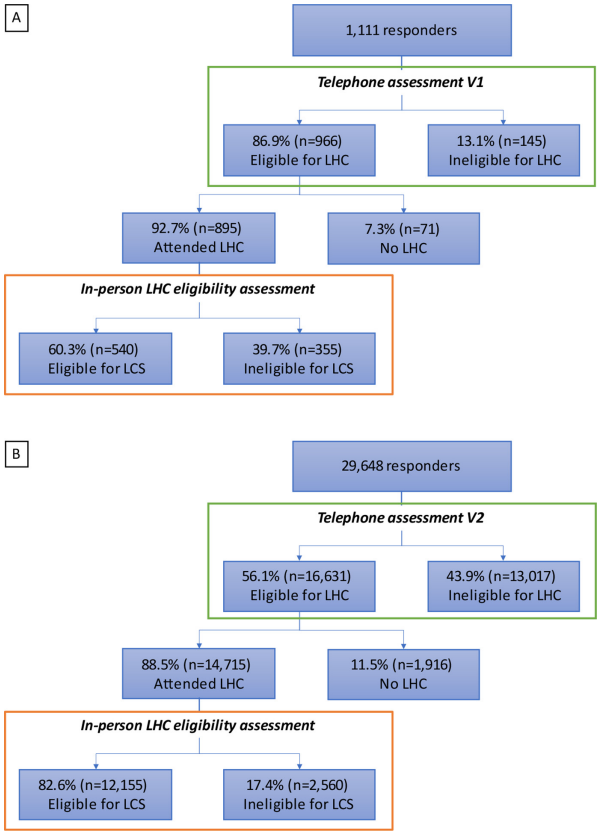


**Figure 1** Comparison between version 1 (A) and version 2 (B) of the phone screener in refining the population eligible for LHC. LCS, lung cancer screening; LHC, lung health check.

conducted by phone screener versus LHC was fair (K=0.441) for USPSTF criteria and moderate (K=0.346) for $PLCO_{m2012}$ criteria (table 2). Level of agreement between phone screener and LHC responses was substantial or 'almost perfect' for all categorical variables except educational status (K=0.347) (table 2). Statistically significant differences in mean pack-year history and body mass index were observed (table 2), but their magnitudes were unlikely to be clinically significant. The level of agreement for eligibility assessments was lowest in individuals from an Asian ethnic group and those aged 55–59 years and highest in the white ethnic group and those aged over 75 years (table 2).

## DISCUSSION

We present the first reported data demonstrating the impact of a telephone-based lung cancer risk assessment tool on optimising selection for LCS appointments. Introduction of the multifactor phone screener significantly increased the proportion of ineligible individuals identified, resulting in fewer face-to-face LHC appointments. Phone screener and LHC responses showed high levels of agreement for most eligibility questions. However, lower levels of agreement were seen for educational status in all individuals, and for overall eligibility criteria in younger and minority ethnic groups. Lower levels of agreement for USPSTF criteria (vs $PLCO_{m2012}$) are likely explained by the greater influence of smoking consumption on this score. Ambiguous responses regarding smoking consumption during the phone screener were interpreted to maximise lung cancer risk estimates, allowing opportunity for face-to-face eligibility assessment for individuals with borderline eligibility criteria, which may account for some of this variation. With approximately 4–6 weeks between phone screener and LHC, responses may legitimately change between these timepoints. We are unable to assess the impact of potential data entry errors, but a minority of individuals were excluded due to implausible values, highlighting the need for real-time data validation. Finally, periods of smoking abstinence were included in pack-year calculations at the LHC (reported by 62.7%) but not during the phone screener.

Blinding LHC staff to telephone screener responses allowed LHC responses to be evaluated independently. However, comparisons could only be drawn for those who both responded to the LHC invitation and were eligible during the phone screener, who may differ to non-responders and those who were found to be ineligible at phone screener. From this non-randomised study, it is not possible to ascertain if those considered ineligible by telephone screening were truly ineligible for LCS, and therefore the impact on the sensitivity of risk assessment, but this should be a small proportion.

Further research should investigate validated multilingual

**Table 2** Agreement between the phone screener questions and LHC assessments of (A) individual questions/eligibility criteria for all responders and (B) eligibility criteria across age/ethnicity subgroups

| (A) All responders (n=14 714) | Agreement between phone screener V2 and LHC | | |
|---|---|---|---|
| **Categorical** | **Level of agreement between phone screener and LHC (%, Kappa*)** | | |
| ≥100 cigarettes in lifetime | 99.9% (K=NA) | | |
| Current vs former smoker | 94.4% (K=0.891, p<0.001) | | |
| Ethnic group † | 95.8% (K=0.849, p<0.001) | | |
| Highest level of education achieved | 53.4% (K=0.347, p<0.001) | | |
| Personal history of COPD | 87.5% (K=0.692, p<0.001) | | |
| Personal cancer history | 95.8% (K=0.816, p<0.001) | | |
| Family history lung cancer | 91.1% (K=0.693, p<0.001) | | |
| USPSTF criteria | 76.6% (K=0.441, p<0.001) | | |
| $PLCO_{m2012}$ eligibility | 82.2% (K=0.346, p<0.001) | | |
| **Continuous** | **Mean difference (95% CI) between phone screener and LHC responses** | | |
| BMI‡ | –1.16 $kg/m^2$ (–1.21 to –1.11) | | |
| Pack-year history§ | 2.87 pack-years (2.58 to 3.16) | | |
| (B) **Agreement between phone screener V2 and LHC eligibility criteria across different age/ethnicity groups** | | | |
| | **n** | **USPSTF criteria** | **$PLCO_{m2012}$ eligibility** |
| **Age (from GP data extraction)** | | | |
| 55–59 years | 3643 | 71.0% | 72.1% |
| 60–64 years | 3727 | 76.3% | 79.8% |
| 65–69 years | 3541 | 79.6% | 86.3% |
| 70–74 years | 2718 | 79.5% | 90.8% |
| 75 years + | 1041 | 81.2% | 91.2% |
| Missing | 44 | | |
| **Ethnicity** | | | |
| Asian | 1343 | 69.2% | 69.9% |
| Black | 796 | 68.8% | 75.9% |
| Mixed | 356 | 73.3% | 77.5% |
| Other | 629 | 70.7% | 76.6% |
| White | 11 590 | 78.5% | 84.6% |

*Level of agreement according to K values defined[10] as 'slight' (0–0.2), 'fair' (0.21–0.4), 'moderate' (0.41–0.6), 'substantial' (0.61–0.8) or 'almost perfect' (0.81–1).
†Summarised as three-category variable (Asian, black or white). n=2,013 (13.7%) declined to answer during the phone screener. Responses were mandated at the LHC.
‡n=114 excluded due to implausible values (weight <30 kg or >200 kg; height <135 cm or 200 cm).
§n=103 excluded due to implausible values (>80 cigarettes per day or >280 grams of tobacco per week; smoking start age >smoking cessation age; smoking start or cessation age >current age; period of smoking abstinence >total smoking duration).
.BMI, body mass index; COPD, chronic obstructive pulmonary disease; LHC, lung health check; PLCO, prostate lung colorectal ovary; USPSTF, united states preventive services task force.

translations, cultural variations with acceptability and inclusion of diverse educational categories to ensure equitability and accuracy. Additionally, efficiency gains resulting from the phone screener are likely to impact cost-effectiveness, which requires further evaluation alongside wider patient satisfaction and any potential added benefits of LHC attendance for ineligible individuals including cardiovascular risk assessment, spirometry and smoking cessation.

Existing studies demonstrate targeted invitations followed by in-person LCS eligibility assessment lead to inefficient resource utilisation. The data presented here support telephone-based risk assessment as an efficient way to optimise selection for LCS appointments.

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