Impact of low-dose CT screening on smoking cessation among high-risk participants in the UK Lung Cancer Screening Trial

Kate Brain,1 Ben Carter,1,2 Kate J Lifford,1 Olivia Burke,1 Anand Devaraj,3 David R Baldwin,4 Stephen Duffy,5 John K Field6

ABSTRACT

Background Smoking cessation was examined among a subset of current smokers who were high-risk participants in the UK Lung Cancer Screening (UKLS) pilot trial of low-dose CT screening.

Methods High-risk individuals aged 50–75 years who completed baseline questionnaires were randomised to CT screening (intervention) or usual care (no screening control). Smoking habit was determined at baseline using self-report. Smokers were asked whether they had quit smoking since joining UKLS at short-term follow-up (2 weeks after baseline scan results or control assignment) and longer-term follow-up (up to 2 years after recruitment). Intention to treat (ITT) regression analyses were undertaken, adjusting for baseline lung cancer distress, trial site and sociodemographic variables.

Results Of a total of 4055 individuals randomised to CT screening or control, 1546 were baseline smokers (787 control; 759 intervention). Smoking cessation rates were 5% (control n=367/786) versus 10% (intervention n=75/758) at 2 weeks and 10% (control n=79/775) versus 15% (intervention n=115/749) at up to 2 years follow-up. ITT analyses indicated that the odds of quitting among screened participants were significantly higher in the short term (adjusted OR 2.29, 95% CI 1.62 to 3.22, p=0.007) and those receiving a negative screening result may provide an additional cue to action in motivated high-risk smokers.

INTRODUCTION

Smoking is the leading cause of preventable morbidity and premature mortality worldwide.1 In the UK, an estimated 86% of lung cancer cases are attributable to smoking.2 The prevalence of cigarette smoking in the UK remained stable between 2006 and 2014 at approximately 10 million adults (−20%),3 and although these rates are much lower than those of the 1970s, this declining trend has begun to plateau.4 The association between cigarette smoking and socioeconomic group is well established, with higher smoking rates among people living in more deprived areas.5

Trials have been undertaken to ascertain the effectiveness of low-dose CT screening for the earlier detection of lung cancer in high-risk groups including smokers.6–9 The impact of CT lung screening on smoking cessation and abstinence has been examined in response to concerns that integrating CT screening with evidence-based smoking cessation interventions could prompt quitting.10–12 Evidence from controlled trials, however, suggests that participating in lung screening significantly increases smoking cessation rates overall compared with the general population, and that receiving a positive CT screening result may provide an additional cue to action in prompting cessation. The Danish Lung Cancer Screening Trial (DLCST) reported smoking cessation rates of almost 12% in both trial arms at 1 year follow-up, compared with the Danish population rate of 4%.13 Quit rate was significantly higher in smokers who had a positive CT result that required repeat scans.14 In the Dutch-Belgian NELSON trial, the overall quit rate at 2 years follow-up was 16.6% compared with a background population rate of 3–7%. Although a lower prolonged abstinence rate was observed in the screened arm (14.5%) versus...
control (19.1%), this effect disappeared following intention to
treat analysis, suggesting an overall positive effect of trial partic-
ipation.12 A non-significant trend towards increased smoking
cessation was seen in those with multiple indeterminate screening
results.13 The US National Lung Screening Trial (NLST)14 found
that, compared with normal lung screening results, receiving any
screen-detected abnormality significantly reduced the proba-
bility of continued smoking.

In addition to the moderating effect of lung screening results,
sociodemographic predictors of increased likelihood of smoking
cessation have been observed in previous lung cancer screening
studies. These have included older age,11 14 15 higher socioeco-
nomic group,14 higher education,12 being married14 and lower
nicotine dependency.11 14 In addition, participants with higher
levels of concern about lung cancer and greater perceived
benefits of stopping smoking,10 and those who intend to stop
smoking,11 12 are more likely to quit in the context of lung cancer
screening.

The UK Lung Cancer Screening (UKLS) pilot trial is the first
to assess the feasibility, cost-effectiveness and psychosocial
impact of lung cancer screening using a single low-dose CT
screen versus no screening in a UK high-risk population.9 16
The current study builds on previous UKLS reports by exam-
ining the behavioural effects of trial participation and modi-
fying variables on smoking cessation at short-term and long-
term follow-up. It was expected that screened participants, and
in particular those receiving positive CT results, would be more
likely to report quitting compared with control arm partici-
pants.

METHODS
Participants and procedures
A random sample of 247,354 individuals aged 50–75 years
residing in six recruitment areas in the UK (Liverpool, Knowsley
and Sefton; Cambridgeshire, Peterborough and Bedfordshire)
were sent trial information packs that included a self-report
questionnaire regarding lung cancer risk factors. From the ques-
tionnaire responders, 8,729 patients were identified as at high
risk of lung cancer (≥5% over 5 years) using the Liverpool Lung
Project (LLPv2) risk prediction model which includes age, sex,
family history of lung cancer, smoking duration, personal history
of other cancers and non-malignant respiratory diseases, and
exposure to asbestos.9 Characteristics of trial non-participants
are reported elsewhere.17 18

Following completion of a second questionnaire to identify
trial eligibility, those meeting the criteria were invited to attend
their local recruitment centre in Liverpool or Cambridge (trial
sites). High-risk individuals who gave informed written consent
were randomised on a 1:1 ratio to the intervention (screening)
or control arms. Randomisation used unique random personal
ID codes and computer-generated sequencing for allocation
concealment.9 Participants who self-reported smoking in the
first questionnaire were eligible for inclusion in the current
analyses. Participants in both trial arms were offered standard
smoking cessation advice leaflets and given a list of local NHS
Stop Smoking services pre-randomisation.

Participants completed a touchscreen questionnaire that
included baseline psychosocial measures (T0). A second psycho-
social questionnaire (T1) was sent approximately 2 weeks after
receiving either a letter of assignment to the control group or a
baseline CT scan result letter (intervention arm). T2 psycho-
social questionnaires were sent in a single mailshot during January
2014.

Measures
Smoking status was calculated at T0 based on self-report data
within the first UKLS questionnaire. Participants were catego-
rised into current smokers, ex-smokers and never smokers.

Smoking cessation was assessed using self-report at T1 and T2.
Participants were asked whether they had quit smoking since
joining UKLS, with response options ‘yes’, ‘no’, ‘no but I intend
to quit smoking within the next 6 months’, ‘not applicable’ (ie,
not a smoker at baseline). Participants who responded ‘no’ or
‘no, but intend to quit’ were categorised as non-quitters. Those
who responded ‘not applicable’ or who returned the question-
naire but missed out the smoking cessation question were cate-
gorised as non-completers.

Lung cancer distress was measured using six items adapted
from Lerman et al19 and Watson et al20 to assess the frequency of
lung cancer-related thoughts and their impact on mood and daily
functioning. Total score range was 6–24, with a score above 12.5
corresponding to a clinically significant threshold score on the
General Health Questionnaire-28.21

Sociodemographic variables (age and gender) were obtained
from medical records. Socioeconomic group was measured
using Index of Multiple Deprivation (IMD) ranks calculated
from postcodes and categorised into standard deprivation quin-
tiles (quintile 1 = most deprived, quintile 5 = least deprived).
Marital group and experience of lung cancer (self and/or close
others) were included in the T0 questionnaire.

Screening results
Baseline CT scan results in the intervention arm included nega-
tive (normal) results, those requiring a repeat scan in 3 or 12
months, those requiring referral to the multidisciplinary team
due to a major lung abnormality and significant incidental find-
ings (such as aortic aneurysms and pneumonia but with no find-
ings suspicious for lung cancer).

Statistical analysis
Analyses were conducted using Stata V.14. Following descriptive
analyses to examine baseline equivalence of trial arms, the base-
line characteristics of smokers who did and did not complete
follow-up questionnaires were compared using chi-squared
and independent t-tests. Participants who did not answer the
smoking cessation question at T1 or T2 were imputed as smokers
and included in the primary analysis of intervention effect using
the intention to treat (ITT) population, in accordance with
the Russell Standard for reporting smoking cessation trials.22
Complete case analyses were also conducted using univar-
iable logistic regression models fitted to the smoking cessation
outcome data at Tn and T2 independently with an inverse proba-

weighting.23 Additionally, as a secondary analysis to adjust
for confounders, multivariable logistic regression models were
fitted to evaluate the impact of trial allocation on smoking cessa-
tion at T1 and T2 adjusting for T0 (baseline) lung cancer distress,
sociodemographic factors (gender, age group, marital group,
deprivation quintile, experience of lung cancer) and trial site.16
Odds ratios (ORs) and adjusted ORs (aORs) with 95% CIs and p
values are presented. Due to multiple testing, p<0.01 was used
to denote statistical significance.

To investigate the effect of the baseline scan result on smoking
cessation, we summarised intervention arm participants into
those who had a scan leading to additional clinical investiga-
tion (including repeat scan, major abnormality and incidental
findings) and those receiving a negative result (ie, not requiring
further investigation). Participants randomised to the control
group were used as the reference category in order to reflect current practice. The impact of additional clinical investigation on smoking cessation at T1 and T2 was analysed using univariable and multivariable logistic regression in the ITT and complete case populations. Lung cancer distress, sociodemographic factors and trial site were included in multivariable analysis.

Further subgroup analyses were carried out within the intervention arm only, involving additional univariable regression analyses to examine T1 and T2 smoking cessation in those receiving additional clinical investigation compared with a negative result as the reference category. We carried out this analysis to reflect a potential national policy where participants receive routine lung screening.

RESULTS

Trial participation

In total, 4061 individuals (5% of 75,958 responders to the risk questionnaire; 47% of all high-risk positive responders) attended the recruitment clinic and consented to participate.21 As shown in figure 1, 4055 trial participants were randomised (n=2028 CT intervention, n=2027 control). In the subset of smokers who were included in the study, 759 (49%) were in the intervention arm and 787 (51%) were in the control arm. Characteristics of the smokers split by trial arm are provided in table 1, and indicate equivalence of groups in baseline sociodemographic and psychological characteristics.

Among smokers who were sent questionnaires, the completion rate at T1 (2 weeks follow-up) was n=527/758 (70%) for the intervention arm and n=479/786 (61%) for the control arm, giving a total T1 sample of n=1006. The completion rate at T2 (up to 2 years follow-up) was n=488/749 (65%) for the screening arm and n=377/775 (49%) for the control arm (total T2 n=865) (see figure 1).

Factors associated with non-completion

Baseline smokers in the control arm and those with experience of lung cancer were significantly less likely than those in the intervention arm to complete T1 questionnaires (see online Supplementary table 1). Trial site, age, gender, marital group, deprivation and T0 lung cancer distress were not statistically significantly associated with T1 completion.

T1 questionnaire completion was significantly lower among baseline smokers in the control arm and those recruited at the Liverpool site, in the most deprived quintile and with experience of lung cancer. Age, marital group, gender and baseline distress were not statistically significantly associated with T1 completion (see online Supplementary table 2).

Effect of trial allocation on T1 and T2 smoking cessation

Primary ITT and complete case analyses are summarised in table 2. After imputing missing data as smokers in the primary ITT analysis, within the screening arm 75/758 (10%) quit smoking at T1 and there were 527 eligible responders. In the control arm, 36/786 (5%) participants quit smoking at T1, and there were 479 eligible responders. T1 smoking cessation was statistically significantly higher in screened individuals compared with controls (OR 2.29, 95%CI 1.52 to 3.45, p<0.001), and remained statistically significant after adjusting for T0 distress and all other covariates (aOR 2.38, 95%CI 1.56 to 3.64, p=0.001). Complete case analysis confirmed that T1 smoking cessation was statistically significantly higher in the intervention group (aOR 2.09, 95%CI 1.36 to 3.23, p<0.001). Effects of covariates on T1 smoking cessation are included in online Supplementary table 3 (ITT analysis).

At T2, 115/749 (15%) participants quit smoking and 488 returned the questionnaire in the screening arm. There were 79/775 (10%) individuals who quit in the control arm and 377 eligible responses at T2 (see table 2). The effect of trial arm on quitting smoking at T2 was statistically significant in the crude ITT analysis (OR 1.60, 95%CI 1.18 to 2.17, p=0.003) and after adjusting for covariates (aOR 1.60, 95%CI 1.17 to 2.18, p=0.003). In complete case analysis, the difference in cessation rate between the intervention and control groups at T2 was not statistically significant (aOR 1.16, 95%CI 0.65 to 1.33, p=0.36), therefore these findings should be interpreted with caution. The influence of covariates on longer term smoking outcomes in ITT analysis are included in online Supplementary table 4.

Impact of additional clinical investigation on smoking cessation

As shown in table 3, T1 smoking cessation was reported by 16% (48/299) of participants who had additional clinical investigation following the baseline scan result and 11% (26/227) who received a negative result. These were both compared with 8% (36/479) who reported T1 smoking cessation in the control group. Using the imputed population, the impact of needing additional clinical investigation on T1 smoking cessation was statistically significant in univariable (OR 2.72, 95%CI 1.73 to 4.26, p<0.001) and multivariable (aOR 2.85, 95%CI 1.79 to 4.53, p<0.001) analysis. The effect of receiving a negative result on T1 smoking cessation was not significant at the 1% significance level in the univariable (OR 1.73, 95%CI 1.02 to 2.91, p=0.04) and multivariable (aOR 1.78, 95%CI 1.04 to 3.05, p=0.03) analysis. Similar findings were observed in complete case analysis for both T1 comparisons.

At T2, 30% (83/275) of participants who received additional clinical investigation following the baseline scan result and 15% (32/212) who had negative results reported cessation. These were compared with 21% (79/377) in the control group who reported quitting at T2. There was a statistically significant effect of additional clinical investigation on T2 smoking cessation in univariable (OR 2.24, 95%CI 1.60 to 3.14, p<0.001) and multivariable (aOR 2.29, 95%CI 1.62 to 3.22, p<0.001) ITT analysis. The effect of a negative result on T2 smoking cessation was not significant in univariable (OR 0.92, 95%CI 0.60 to 1.42, p=0.71) and multivariable (aOR 0.90, 95%CI 0.58 to 1.40, p=0.64) analysis; however, caution is needed when interpreting these findings. Similar results were observed in complete case analysis (see table 3).

Subgroup analyses in the intervention group only

At T1, there was no statistically significant effect of needing additional clinical investigation on smoking cessation compared with receiving a negative result (aOR 1.60, 95%CI 0.96 to 2.67, p=0.07). At T2, there was a clear effect on smoking cessation of additional clinical investigation compared with a negative result (aOR 2.57, 95%CI 1.64 to 4.03, p<0.001). Similar results were found in complete case analysis (results not shown).

DISCUSSION

Tobacco control is the major primary prevention option for lung cancer. The present study is the first to report the behavioural impact of CT screening in a UK high-risk population, and confirms the findings of previous trials that lung cancer screening does not falsely reassure smokers or reduce their motivation to...
stop smoking. Using the imputed population, the short-term quit rate of 10% among screened participants was higher than the background cessation rate in the general UK population (4%).\textsuperscript{25,26} With the longer term quit rate of 15% similar to that reported in the Dutch-Belgian NELSON trial\textsuperscript{12} and higher than the DLCST trial.\textsuperscript{11} Participating in the UKLS appeared to prompt smoking cessation overall, with a differential and positive effect of lung screening at short-term and longer-term follow-up.

While a degree of caution is needed due to imputation of missing responders as smokers,\textsuperscript{22} the present findings indicate that smoking cessation was higher in the intervention arm and that engaging in CT lung cancer screening increased the likelihood of stopping smoking in the longer term. Despite concerns about a negative lung screen offering a ‘license to smoke’,\textsuperscript{10} there was no evidence that UKLS screening participants who received an all-clear CT result were less likely to quit. Analysis indicated

Figure 1  Trial CONSORT (Consolidated Standards of Reporting Trials) diagram.
that a positive CT scan result prompted smoking cessation in the longer term compared with participants who were not screened and participants who received a negative scan, suggesting that a positive lung screening result may provide an additional stimulus for quitting over and above that of screening participation. This mirrors the findings of other controlled trials including the DLCST\textsuperscript{11} and US NLST,\textsuperscript{14} where smokers with identified abnormalities were more likely to stop smoking than those with normal results.

The current evidence suggests that an integrated package of CT lung screening and smoking cessation support has the potential to expedite quitting in smokers who are motivated and receptive. The voluntary nature of the trial meant that smokers who took part were self-selected and may already have been receptive. The voluntary nature of the trial meant that smokers who took part were self-selected and may already have been contemplating quitting.\textsuperscript{27} It is difficult, therefore, to directly attribute smoking cessation to UKLS participation, although Ostroff et al\textsuperscript{10} reported that smokers who quit after CT lung screening ascribed their decision to screening participation. In the current trial we observed a marginal trend towards higher baseline distress in those who reported quitting at short-term follow-up, the inclusions of mood and smoking-related cognitions on behavioural outcomes.

The limitations of sample size and study design are acknowledged. The UKLS trial was not specifically designed to test the effects of lung screening combined with smoking cessation support, hence the types of stop-smoking interventions accepted by participants were not recorded, nor were comparative data available on cessation rates in the Liverpool and Papworth regions during the life of the trial. It was not possible to ascertain the moderating role of nicotine dependence or biochemically validate self-reported smoking behaviour, therefore the current findings should be interpreted cautiously due to the sole use of self-reported cessation. Nevertheless, the present study adds to growing evidence that integrating CT lung screening with evidence-based smoking cessation interventions could prompt quitting in motivated high-risk smokers. While our sample was not sufficiently large to examine continued smoking abstinence in those who reported quitting at short-term follow-up, the NELSON trial indicated that combining low-dose CT screening with smoking cessation advice led to sustained abstinence.\textsuperscript{12} Most smokers enrolling in CT lung screening studies are motivated

### Table 1  Sample characteristics

<table>
<thead>
<tr>
<th></th>
<th>Not recorded (missing)</th>
<th>CT Scan (n=759) n (%) or mean (SD)</th>
<th>Control (n=787) n (%) or mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liverpool</td>
<td>425 (56%)</td>
<td>431 (55%)</td>
<td></td>
</tr>
<tr>
<td>Cambridge</td>
<td>334 (44%)</td>
<td>356 (45%)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>532 (70%)</td>
<td>551 (70%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>227 (30%)</td>
<td>236 (30%)</td>
<td></td>
</tr>
<tr>
<td>Marital group</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Married/cohabiting</td>
<td>3</td>
<td>502 (66%)</td>
<td>519 (66%)</td>
</tr>
<tr>
<td>Not married/cohabiting</td>
<td></td>
<td>256 (34%)</td>
<td>266 (34%)</td>
</tr>
<tr>
<td>IMD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quintile 1 (most deprived)</td>
<td>265 (35%)</td>
<td>265 (34%)</td>
<td></td>
</tr>
<tr>
<td>Quintile 2</td>
<td>93 (12%)</td>
<td>97 (12%)</td>
<td></td>
</tr>
<tr>
<td>Quintile 3</td>
<td>128 (17%)</td>
<td>125 (16%)</td>
<td></td>
</tr>
<tr>
<td>Quintile 4</td>
<td>108 (14%)</td>
<td>136 (17%)</td>
<td></td>
</tr>
<tr>
<td>Quintile 5 (least deprived)</td>
<td>165 (22%)</td>
<td>164 (21%)</td>
<td></td>
</tr>
<tr>
<td>Lung cancer experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>442 (58%)</td>
<td>433 (55%)</td>
</tr>
<tr>
<td>Yes</td>
<td>315 (42%)</td>
<td>352 (45%)</td>
<td></td>
</tr>
<tr>
<td>Cancer distress (T1)\textsuperscript{*}</td>
<td>2.23 (0.30)</td>
<td>2.24 (0.30)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.86 (3.08)</td>
<td>9.72 (2.99)</td>
<td></td>
</tr>
</tbody>
</table>

Percentages were calculated based on available data.

*Logn scores in normal text, original scores in italics (analyses performed using logn scores).

IMD, Index of Multiple Deprivation.

### Table 2  Effect of trial allocation on smoking cessation at T\textsubscript{1} (2 weeks) and T\textsubscript{2} (2 years) follow-up

<table>
<thead>
<tr>
<th>Time point</th>
<th>Analysis population</th>
<th>Quit smoking/total</th>
<th>Univariable OR (95% CI)</th>
<th>Multivariable OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CT scan (n=759)</td>
<td>Control (n=787)</td>
<td></td>
</tr>
<tr>
<td>T\textsubscript{1} (2 weeks)</td>
<td>Primary ITT* complete case</td>
<td>75/758 (10%)\textsuperscript{†}</td>
<td>36/786 (5%)\textsuperscript{†}</td>
<td>2.29 (1.52 to 3.45)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75/527 (14%)</td>
<td>36/479 (8%)</td>
<td>2.04 (1.34 to 3.10)</td>
</tr>
<tr>
<td>T\textsubscript{2} (2 years)</td>
<td>Primary ITT* complete case</td>
<td>115/749 (15%)\textsuperscript{†}</td>
<td>79/775 (10%)\textsuperscript{†}</td>
<td>1.60 (1.18 to 2.17)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>115/488 (24%)</td>
<td>79/377 (21%)</td>
<td>1.16 (0.84 to 1.61)</td>
</tr>
</tbody>
</table>

*Primary intention to treat (ITT) analysis using the imputed population. Where no data were available on smoking status at follow-up, the participant was assumed to be smoking.

†Participants were excluded due to administrative error: T\textsubscript{1} CT scan (n=1); T\textsubscript{1} control (n=1); T\textsubscript{2} CT scan (n=10); T\textsubscript{2} control (n=12).

‡Adjusted for T0 cancer distress, recruitment site, gender, age, marital group, deprivation and experience of lung cancer.
Table 3: Impact of baseline scan result on smoking cessation at T1 (2 weeks) and T2 (2 years) follow-up

<table>
<thead>
<tr>
<th>Baseline scan result</th>
<th>Quit smoking</th>
<th>Total</th>
<th>Univariable OR (95% CI)</th>
<th>Multivariable OR† (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ITT analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>Control group</td>
<td>36</td>
<td>786</td>
<td>Reference</td>
</tr>
<tr>
<td>Negative result‡</td>
<td>26</td>
<td>340</td>
<td>1.73 (1.02 to 2.91)</td>
<td>1.78 (1.04 to 3.05)</td>
</tr>
<tr>
<td>Additional investigation‡</td>
<td>48</td>
<td>416</td>
<td>2.72 (1.73 to 4.26)</td>
<td>2.85 (1.79 to 4.53)</td>
</tr>
<tr>
<td>T2</td>
<td>Control group</td>
<td>79</td>
<td>775</td>
<td>Reference</td>
</tr>
<tr>
<td>Negative result‡</td>
<td>32</td>
<td>338</td>
<td>0.92 (0.60 to 1.42)</td>
<td>0.90 (0.58 to 1.40)</td>
</tr>
<tr>
<td>Additional investigation‡</td>
<td>83</td>
<td>409</td>
<td>2.24 (1.60 to 3.14)</td>
<td>2.29 (1.62 to 3.22)</td>
</tr>
<tr>
<td><strong>Complete case analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>Control group</td>
<td>36</td>
<td>479</td>
<td>Reference</td>
</tr>
<tr>
<td>Negative result‡</td>
<td>26</td>
<td>227</td>
<td>1.59 (0.94 to 2.71)</td>
<td>1.61 (0.93 to 2.77)</td>
</tr>
<tr>
<td>Additional investigation‡</td>
<td>48</td>
<td>299</td>
<td>2.35 (1.49 to 3.72)</td>
<td>2.46 (1.53 to 3.96)</td>
</tr>
<tr>
<td>T2</td>
<td>Control group</td>
<td>79</td>
<td>377</td>
<td>Reference</td>
</tr>
<tr>
<td>Negative result‡</td>
<td>32</td>
<td>212</td>
<td>0.67 (0.43 to 1.05)</td>
<td>0.65 (0.41 to 1.04)</td>
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<tr>
<td>Additional investigation‡</td>
<td>83</td>
<td>275</td>
<td>1.63 (1.14 to 2.33)</td>
<td>1.66 (1.15 to 2.39)</td>
</tr>
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</table>

*Primary intention to treat (ITT) analysis using the imputed population.
†Adjusted for T0 cancer distress, recruitment site, gender, age, marital group, deprivation and experience of lung cancer.
‡One participant removed due to protocol deviation.

Lung cancer

Table 3: Impact of baseline scan result on smoking cessation at T1 (2 weeks) and T2 (2 years) follow-up

<table>
<thead>
<tr>
<th>Baseline scan result</th>
<th>Quit smoking</th>
<th>Total</th>
<th>Univariable OR (95% CI)</th>
<th>Multivariable OR† (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ITT analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>Control group</td>
<td>36</td>
<td>786</td>
<td>Reference</td>
</tr>
<tr>
<td>Negative result‡</td>
<td>26</td>
<td>340</td>
<td>1.73 (1.02 to 2.91)</td>
<td>1.78 (1.04 to 3.05)</td>
</tr>
<tr>
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<td>416</td>
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<td>2.85 (1.79 to 4.53)</td>
</tr>
<tr>
<td>T2</td>
<td>Control group</td>
<td>79</td>
<td>775</td>
<td>Reference</td>
</tr>
<tr>
<td>Negative result‡</td>
<td>32</td>
<td>338</td>
<td>0.92 (0.60 to 1.42)</td>
<td>0.90 (0.58 to 1.40)</td>
</tr>
<tr>
<td>Additional investigation‡</td>
<td>83</td>
<td>409</td>
<td>2.24 (1.60 to 3.14)</td>
<td>2.29 (1.62 to 3.22)</td>
</tr>
<tr>
<td><strong>Complete case analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>Control group</td>
<td>36</td>
<td>479</td>
<td>Reference</td>
</tr>
<tr>
<td>Negative result‡</td>
<td>26</td>
<td>227</td>
<td>1.59 (0.94 to 2.71)</td>
<td>1.61 (0.93 to 2.77)</td>
</tr>
<tr>
<td>Additional investigation‡</td>
<td>48</td>
<td>299</td>
<td>2.35 (1.49 to 3.72)</td>
<td>2.46 (1.53 to 3.96)</td>
</tr>
<tr>
<td>T2</td>
<td>Control group</td>
<td>79</td>
<td>377</td>
<td>Reference</td>
</tr>
<tr>
<td>Negative result‡</td>
<td>32</td>
<td>212</td>
<td>0.67 (0.43 to 1.05)</td>
<td>0.65 (0.41 to 1.04)</td>
</tr>
<tr>
<td>Additional investigation‡</td>
<td>83</td>
<td>275</td>
<td>1.63 (1.14 to 2.33)</td>
<td>1.66 (1.15 to 2.39)</td>
</tr>
</tbody>
</table>

*Primary intention to treat (ITT) analysis using the imputed population.
†Adjusted for T0 cancer distress, recruitment site, gender, age, marital group, deprivation and experience of lung cancer.
‡One participant removed due to protocol deviation.

To quit, therefore it will be critical to evaluate actual quit rates prompted by screening, and whether they are maintained over time in the context of a lung screening health service. We found that longer term study retention was less likely in smokers who were from socioeconomically deprived areas and who had experience of lung cancer. Evidence from other studies suggests that these high-risk groups may be deterred from lung screening due to fearful and fatalistic beliefs about lung cancer outcomes, stigma and scepticism about the benefits of screening.31–33 The consistent association between smoking, deprivation and lower smoking cessation at multiple points in the screening process,25,27,29 the programme for high-risk groups offers opportunities for addressing these high-risk groups may be deterred from lung screening due to fearful and fatalistic beliefs about lung cancer outcomes, stigma and scepticism about the benefits of screening.31–33 The consistent association between smoking, deprivation and lower screening uptake is a problem for public health that must be addressed in future lung screening.

Implementation of a UK national lung cancer screening programme for high-risk groups offers opportunities for smoking cessation at multiple points in the screening process, from the initial screening invitation to CT scanning and disclosure of results.10 Smoking cessation counselling combined with pharmacotherapy is effective,34–36 and could be successfully implemented in the lung screening setting.37 However, further behavioural research is needed to identify ways of engaging harder to reach smokers, and to robustly test the optimal type and timing of strategies for delivering stop-smoking support to high-risk participants. Successful integration of evidence-based strategies for smoking cessation with stratified lung cancer screening could be a prudent use of limited healthcare resources, translating into major health benefits for all smoking-related diseases.

Acknowledgements We wish to thank Bev Green for her invaluable contribution to trial administration, Fiona McDonald and Ghasem Yadegarfar for assisting with trial data collection, and the trial participants who gave their time in completing questionnaires. We acknowledge the wider UKLS management team: Tim Eisen, David Hansell, John Holemans, Terry Kavanagh, Keith Kerr, Martin Ledson, Arjun Nair, Richard Page, Mahesh Parmar, Robert Rintoul, Nicholas Screaton, Nicholas Wald, David Weller, David Wyness, and Paula Williamson. We would also like to thank Tim Coleman and Victoria Cornellis for their time in reviewing the statistical aspects of the manuscript.

Contributors KB: trial conception and design, data analysis, data interpretation, manuscript preparation; BC: trial statistician, statistical analysis, data interpretation, manuscript review; KUL: data collection, data analysis, data interpretation, manuscript review; GB: data analysis and interpretation, manuscript review; AD: radiological review, data interpretation and manuscript review; DRB - trial design, UK Lung Cancer Screening (UKLS) care pathway, data interpretation, manuscript review; SD: trial design, data interpretation, manuscript review; JRF: trial conception and design, data interpretation, manuscript review.

Funding National Institute for Health Research (NIHR) Health Technology Assessment programme. The views and opinions expressed therein are those of the authors and do not necessarily reflect those of NIHR HTA, NHS or the Department of Health. We acknowledge the support of the NIHR Biomedical Research Centre at South London and Maudsley NHS Foundation Trust and King’s College London (BC).

Competing interests None declared.

Ethics approval Ethical approval for the study was given by Liverpool Central Research Ethics Committee in December 2010 (reference number 10/H1005/74). All UKLS participants provided informed consent before taking part. The trial was registered with the International Standard Randomised Controlled Trial Register (ISRCTN) under the reference 78513845.

Provenance and peer review Not commissioned; externally peer reviewed.

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