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Title: Lung Screen Uptake Trial (LSUT): Randomised controlled trial testing targeted invitation materials

Running title: Lung Screen Uptake Trial

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Contributions: Prof Jane Wardle, SMJ, SLQ, SWD, AM and DRB conceived the study design and wrote the funding application. Prof Jane Wardle, SMJ, SLQ, MR, RJB, AM, DRB, JW developed the protocol and measures. SLQ, MR and JD led the management and execution of the study. SLQ carried out the analyses with oversight from SWD. All authors contributed to the drafting of the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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ABSTRACT

Rationale: Low uptake of low-dose CT (LDCT) lung cancer screening, particularly by current smokers of a low socioeconomic position, compromises effectiveness and equity.

Objectives: To compare the effect of a 'targeted, low burden and stepped' invitation strategy versus control, on uptake of hospital-based 'Lung Health Check' appointments offering (LDCT) screening.

Methods: A two-arm, blinded, between-subjects, randomised controlled trial. 2012 participants were selected from 16 primary care practices using these criteria: i) aged 60-75, ii) recorded as a current smoker within the last seven years, iii) no pre-specified exclusion criteria contraindicating LDCT screening. Both groups received a stepped sequence of pre-invitation, invitation and reminder letters from their Primary Care Practitioner offering pre-scheduled appointments. The key manipulation was the accompanying leaflet. The intervention group's leaflet targeted psychological barriers and provided low burden information, mimicking the concept of the UK Ministry of Transport's annual vehicle test ('MOT for your lungs').

Measurements and Main Results: Uptake was 52.6%, with no difference between intervention (52.3%) and control (52.9%) groups in unadjusted (OR: 0.98, 0.82-1.16) or adjusted (aOR: 0.98, 0.82-1.17) analyses. Current smokers were less likely to attend (aOR: 0.70, 0.56-0.86) than former smokers. Socioeconomic deprivation was significantly associated with lower uptake for the control group only ($p<.01$).

Conclusions: The intervention did not improve uptake. Regardless of trial arm, uptake was considerably higher than previous clinical and real world studies, particularly given the

sample were predominantly lower socioeconomic position smokers. Strategies common to both groups, including a Lung Health Check approach, could represent a minimum standard.

KEY WORDS (MeSH): Lung Neoplasms, Early Detection of Cancer, Behavioural Sciences, Socioeconomic Factors

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Trial registration: This study was registered prospectively with the ISRCTN (International Standard Registered Clinical/soCial sTudy Number: ISRCTN21774741) on 23rd September 2015 and the NIH ClinicalTrials.gov database (NCT02558101) on 22nd September 2015).

INTRODUCTION

Lung cancer leads cancer mortality globally(1). While tobacco control strategies are the primary means to reduce incidence, early diagnosis markedly increases five-year survival from 6% to 82% (stage IV vs. 1A non-small cell)(2). Currently though, most (66%) diagnoses in the UK are made at an advanced stage(3). The US National Lung Screening Trial (NLST; n=53,454) demonstrated that screening asymptomatic high-risk adults using low-dose computed tomography (LDCT) reduced the risk of mortality from lung cancer by 20% compared with chest X-ray(4). Consequently, the US Preventive Services Task Force (USPSTF) recommended screening for high-risk adults. The UK's National Screening Committee are awaiting the Dutch-Belgian trial NELSON's findings (n=15,822), but early data suggest a mortality benefit(5).

Engaging those at high risk improves the risk-benefit ratio of screening. However, enrolment into lung screening trials has been low (<5%)(6) and skewed towards those at lower risk. Long-term smokers are overrepresented within lower socioeconomic position (SEP) communities, yet both current smoking status and low SEP are negatively associated with uptake(7,8) and positively associated with risk(9). Indeed, despite the USPSTF's recommendation, just 1.9% of eligible, high-risk individuals have been screened in the US(10). Attendance of pilot 'Lung Health Check' services in England has been relatively higher at 27% (Nottingham), 26% (Manchester), and 40% (Liverpool). Due to non-eligibility of some attenders, this translated to LDCT uptake by 13%, 14% and 9% respectively(11,12).

Psychological barriers to participation were identified by research(13) that we undertook to inform the present intervention. Together with existing studies, findings suggested smokers (compared with non-smokers) are more fatalistic about lung cancer, perceive treatment

efficacy as lower (13–17), feel stigmatised (13,18), hold higher affective risk perceptions, and fear diagnosis(13,19). Previous studies in colorectal cancer screening suggest tailoring leaflets to modify attitudinal barriers(20) may improve uptake(20–22). From a translational perspective, leaflets provide a low cost and scalable intervention.

In addition to targeting psychological barriers, behavioural science theory such as the Precaution Adoption Process Model(23), proposes that different types of information are needed depending on an individual's state of engagement, decision-making and behaviour. A first-time invitation might primarily focus on engaging individuals in considering the offer using a low burden approach, with subsequent communication promoting informed choice and reducing practical barriers. This stepped approach may be particularly important if the offer is anticipated to provoke fear, which can reduce receptivity (24,25), and for those with lower literacy, because information burden can reduce comprehension and promote distrust (23-26). However to-date, recruitment methods for trials have been cognitively and practically demanding.

Therefore, this trial primarily aimed to test the effect of targeted, stepped and low burden invitation materials on uptake of 'Lung Health Check' appointments offered in a real-world context. The secondary aims were to explore whether the intervention materials affected informed decision-making outcomes, to gauge likely uptake of a national programme and to examine the feasibility of invitation via primary care. Some results have been reported as an abstract(26).

METHODS

Design

A two-arm, blinded, between-subjects, randomised controlled trial design tested the effect of intervention invitation materials on uptake of a pre-scheduled Lung Health Check appointment, at which LDCT screening might be offered. A protocol has been published(27) with potential overlap. Eligible individuals were identified from primary care practices in London using electronic searches carried out between October 2015 and March 2017.

Eligibility criteria

The searches extracted individuals (n=147,015) aged 60-75 who had been recorded as a smoker since April 2010 (within 7 years of invitation). This was the date smoking status became a Quality and Outcomes Framework (QoF) indicator to ensure completeness and identify current and recent ex-smokers. The searches excluded individuals who had an active lung cancer diagnosis or metastatic cancer, were on the palliative care register, had undergone a recent CT thorax ($\leq$12 months), lacked capacity, had insufficient English or a comorbidity contraindicating screening or treatment. Lists were then screened by GPs. To avoid contamination, only one eligible individual per household was invited.

Randomisation

A web-based programme individually randomised participants (1:1) using permuted blocks to balance group allocation by practice. Identifiable details were concealed during assignment, which was carried out by a blinded researcher. Invited individuals were blind to the research nature at the invitation stage, to avoid undermining the primary outcome.

Intervention and control invitation materials

Our invitation methods and evidence are published(13,27) and appended (Supplementary File 1). Briefly, evidence-based methods were used for both invitation groups, including GP endorsement(21,28), pre-notification(29), reminders(30,31) and pre-scheduled appointments(32,33). The screening offer was framed within a 'Lung Health Check'. All participants received the same postal invitation letters from their primary care practice: pre-invitation letter, invitation letter with scheduled appointment, and reminder re-invitation letter with a second scheduled appointment (sent to non-responders ≥4 weeks after missed appointment). The letters were identical with two exceptions: 1) the intervention group's letters referred to 'ever smokers' whereas the control group's referred to 'current and former smokers', and 2) the intervention group's invitation letter included a bullet-pointed summary of the Lung Health Check, including LDCT scan offer, on the reverse side.

The key manipulation was the accompanying leaflet. The control group received an information booklet mimicking 'the facts' booklets of NHS cancer screening programmes. The intervention group received an 'M.O.T. for your lungs' leaflet, designed to target psychological barriers to attendance (fear, fatalism and stigma), to be low burden (sufficient for deciding to attend and consider the screening offer) and stepped (full information given at the appointment using the control group's booklet, or available before via a website, phone or post). An 'M.O.T.' is an annual roadworthy test for vehicles and was a lay concept perceived to be analogous to a medical check-up preferred by patient and public involvement groups.

Lung Health Check appointment

The appointments were run by research nurses and clinical trial practitioners at two London hospital outpatient clinics. The appointment included a medical and smoking history to determine risk-based eligibility for the LDCT scan according to one of three criteria: i) NLST ≥30 pack year smoking history and still smoking or quit ≤15 years; ii) Prostate, Lung, Colorectal and Ovarian (PLCO) score ≥1.51%, or iii) Liverpool Lung Project (LLP) score ≥2.5%. Full information about the risks and benefits of screening was provided to all using the control group's leaflet and supported by the nurse consultation. A spirometry test and carbon monoxide (CO) reading were also carried out. Participants self-reporting as current smokers or with a CO reading ≥10ppm were given accredited 'Very Brief Advice' on smoking (National Centre for Smoking Cessation and Training(34)) and randomised to an opt-out or opt-in referral intervention.

Ethics

Approval was granted by an NHS Research Ethics Committee (Reference:15/LO/1186).

Primary outcome measure

Attendance of the Lung Health Check appointment (% of those invited) to measure whether individuals could be engaged in considering a screening offer.

Secondary outcome measures

The pre-specified secondary endpoints in our statistical analysis plan (SAP) include comparison of uptake by demographic and smoking status sub-groups, uptake of LDCT screening for those eligible (and willingness among those ineligible), and informed decision-

making outcomes. Data on participants' engagement with the invitation materials were also collected. Further pre-specified endpoints are LDCT scan results, resource use, and psychological outcomes.

Demographic data

Pseudonymised data on age, sex, ethnicity and area-level socioeconomic deprivation (Index of Multiple Deprivation (IMD) score and rank), were collected from the primary care records of all those invited and again from attenders using self-report measures. Attenders also reported their education level and marital status. Hospital site of the screening offer was recorded.

Smoking data

Last recorded smoking status was extracted from primary care records (recoded as current/occasional, former and never). Self-reported smoking status and smoking history were collected from attenders. Smoking duration and pack-years were calculated by the research nurse in combination with participants' quit histories. For current smokers, the number of previous 'serious' quit attempts, tobacco dependence(35) and perceived chances of quitting(36) were measured.

Uptake data

Secondary outcomes included uptake of LDCT screening for those eligible, and willingness to be screened for those ineligible.

Decision-making outcomes

A self-complete paper questionnaire given at the appointment included adapted items from the Satisfaction with Decision (SWD) scale(37) and the low literacy version of the Decisional Conflict Scale (DCS)(38,39). A further nine items measured conceptual and numerical knowledge of lung cancer screening; including original and adapted items(40). Responses were dichotomised as correct vs. incorrect/not sure and summed.

Engagement with the invitation leaflets

Participants were asked whether they remembered, read and understood their respective leaflet, and whether they had been 'useful', 'difficult to understand', 'informative', 'too complicated', or had 'too little information'. Research nurses rated participants' background knowledge of screening subjectively as: 'none', 'very little', 'moderate', 'fairly good', and 'very comprehensive/near perfect'.

Statistical analyses

Sample size

Uptake for the control group was estimated to be 35% based on first-time uptake of the faecal occult blood test (FOBT) colorectal cancer screening programme in London within the two most deprived quintiles(41). With a target sample size of 2000 participants randomised evenly into two arms, the study was statistically powered (at 90%) to detect a 7% increase in uptake using two-sided tests at the 5% significance threshold. The 7% figure was based on studies testing targeted 'psycho-educational' invitations in colorectal screening(20,21) and considered a clinically meaningful benefit.

Primary analyses

Data were analysed using IBM SPSS (v.25). Analyses followed a prospectively registered SAP (DOI:10.17605/OSF.IO/HKEMM) and the trial protocol(27). The primary outcome was analysed using an intention-to-treat approach (n=2012). Attendance was compared by invitation group using logistic regression and a deviance chi-squared test for statistical significance.

Secondary analyses

Analyses tested for associations between demographic characteristics, smoking status, and attendance, using bivariate and then multivariable logistic regression models to calculate adjusted odds ratios (n=1970). Study-specific quintiles for IMD rank were calculated because the sample was skewed toward above average deprivation.

Logistic regression analyses then explored correlates of LDCT uptake among eligible participants. The decision-making outcomes were compared by invitation group, using chi-squared tests or T-tests. For data collected after attendance, 'prefer not to say', 'not stated' or 'don't know' responses were treated as missing.

RESULTS

Characteristics of the invited sample

The average age was 66.0 (SD:4.3), 53.7% were male, and the majority (79.7%) were from a White ethnic group (Table 1). Overall, there was higher representation of ethnic minority groups compared with the general population (14%) but lower than in London (40%), likely due to the younger age structure and differences in smoking prevalence(42). Nearly all

those invited (96.2%) were categorised within the most deprived (60.9%) or second most deprived (35.3%) IMD quintile. Three quarters (74.5%) were current smokers.

-Table 1-

Primary analyses

Uptake of the Lung Health Check

Sixteen GP practices participated with a combined population of 147,015 patients (Figure 1). 2012 individuals were randomised in equal numbers (n=1006) to the invitation groups. Over half 52.6% (1058) attended their appointment (Table 1).

Individuals predominantly attended the first appointment offered (40.3%), but 9.6% attended the second appointment offered with their reminder. There was no response from 42.1%. There was no statistically significant difference in uptake by hospital site (53.0% vs. 50.8%). Most (94.9%) attenders enrolled.

Near equal numbers from the intervention (52.3%) and control groups (52.9%: 526 vs. 532, respectively) attended. In unadjusted analyses, there was no association between invitation group and uptake (OR: 0.98; 0.82-1.16; Table 2).

-Figure 1–

Secondary analyses

Correlates of uptake of the Lung Health Check

Neither gender nor age were associated with uptake (Table 2). Ethnicity was associated with uptake across groups (p<.001). Compared with those of a White ethnic background, individuals of an Other ethnic background were more likely to attend (aOR: 2.34; 95% CI: 1.30-4.20) and those with no recorded ethnic group were less likely to attend (aOR: 0.09;

0.04-0.19). Higher deprivation was associated with lower uptake across study-specific IMD quintiles (p<.01). Individuals categorised within the three least deprived study-specific quintiles had higher odds of attendance compared with those in the most deprived quintile (aOR: 1.62; 1.21-2.15 and aOR: 1.68; 1.26-2.25). Current smokers were significantly less likely to attend than former smokers (aOR: 0.70; 0.56-0.86).

When analyses of uptake were stratified by invitation group, there were again no associations with gender, age or hospital site. For the control group, the same associations with Other (vs. White) ethnicity (aOR: 3.23; 1.28-8.14) and not stated ethnicity (aOR: 0.03; 0.00-0.19) were observed. Deprivation was significantly associated with increasingly lower odds of attendance across quintiles (p<.05). For example, the odds of uptake for the least deprived quintile were nearly twice as high as those for the most deprived (aOR: 1.93; 1.28-2.93). Ethnicity was also associated with uptake for the intervention group (p<.001), with lower odds of uptake for those with no stated ethnic group (aOR: 0.15; 0.06-0.35). Conversely, deprivation did not significantly differentiate uptake in the intervention invitation group.

Figure 2 presents the absolute percent uptake by study-specific IMD quintile and invitation group. The gradient appears relatively less steep in the intervention group, with uptake relatively higher for the two most deprived quintiles in the intervention group (47.9% and 53.5%) compared with the control group (42.8% and 49.7%), and relatively lower for the two least deprived quintiles (46.8% and 56.1% vs. 55.8% and 60.4%, respectively).

-Table 2 and Figure 2–

Smoking characteristics and eligibility for screening

On average, attenders reported beginning smoking aged 17.9 (SD: 5.8) and accumulated a 39.4 (SD: 25.0) pack-year history (Table 3). Most current smokers had tried to quit previously (78.7%) and had low confidence in their chances of quitting (58.7%). The majority (84.5%) were eligible for LDCT screening. Among those ineligible (n=160), willingness to be screened was high (81.9%).

-Table 3–

Uptake of the LDCT scan

Most (91.2%) of those eligible chose to have the scan (Table 4). Gender, age and marital status were not associated with LDCT uptake. For ethnicity, Asian ethnicity predicted lower odds of uptake compared with White ethnicity (aOR: 0.09; 0.02-0.31), but there were few Asian participants (n=13). There was no association with Black ethnicity, and too few non-cases within the other ethnic groups. Deprivation was not associated with LDCT uptake. In unadjusted analyses, current smokers were less likely to opt for the LDCT scan than former smokers, but the association was not statistically significant in adjusted analyses (aOR: 0.52; 0.27-1.01). Invitation group did not affect the likelihood of LDCT uptake.

-Table 4–

Engagement with the invitation leaflets

A higher number of control participants (81.3%) remembered receiving their respective leaflet compared with the intervention group (64.1%, p<.001). Intervention participants

understood more of their leaflet (p<.05) but there were no differences in background knowledge. Supplementary File 2 presents further analyses.

Decision-making outcomes

There was no difference in mean scores for conceptual and numerical knowledge by invitation group (Supplementary File 2). Across both groups, endorsement of the DCS was high (≥76.2%) indicating low conflict. Most participants reported awareness of the benefits of screening, knew which they valued, felt supported, and were clear about their choice (all ≥89.6%). The risks were less well understood. Fewer control participants reported that they knew what the risks were compared with intervention participants (76.2% vs. 83.2%, p<.05), but similar numbers knew which they valued (84.6% and 84.2%, respectively). Decisional satisfaction was high across groups; both self-reported and nurse-rated (all ≥97.3%).

DISCUSSION

Uptake of the Lung Health Check was 53% which is an important finding in itself, considerably higher than previously observed. The population was high-risk, with the majority eligible for LDCT screening. The intervention made no difference to uptake overall or by smoking status, with uptake biased in favour of former (compared with current) smokers. However, there was evidence that the targeted, stepped and low burden materials were relatively more effective at engaging the most deprived individuals.

A major strength of this study is its ecological validity. The design simulated a real-world service using practically feasible invitation methods via primary care, with the invited

sample unaware their attendance was under study. Collecting individual-level demographic and smoking data provided a comprehensive understanding of non-responders. A census-derived, area-based measure of deprivation allowed national comparison, but is less sensitive to individual variation. Moreover, the generalisability of these findings to affluent high-risk groups, a wider age range and ethnic minority groups may be limited. We had complete data on most variables but there were 26 (1.3%) missing deprivation scores. Sensitivity analysis using multiple imputation made no difference to the findings.

Fifty-three percent uptake is an encouraging figure compared with trials and pilot services to-date(11,12); especially given the invited sample was predominantly comprised of lower SEP current smokers. In UKLS, interest from the most deprived quintile did not reach 20%(9). Indeed, attenders were high-risk, with 84% eligible for LDCT screening. Furthermore, this was a first-time invitation with no wider publicity or community engagement(11,12). Uptake also compares favourably with first-time uptake of colorectal screening by Faecal Occult Blood Test (FOBT) in London (41%) and is on a par with national FOBT uptake (54%) when launched in 2006(41). However, uptake is lower than current national figures for breast (71%) and cervical (72%) cancer, but seemingly not because men were less likely to attend.

Finding a reduced socioeconomic gradient in uptake for the intervention group suggests that targeted and low burden invitation materials show promise for better engaging high-risk individuals living in the most socioeconomically deprived areas. Nevertheless, it was the control invitation strategy that achieved the highest uptake for the least deprived quintile. These results suggest that the intervention invitation approach may be the more equitable; holding potential for reducing inequalities and achieving a greater reduction in lung cancer

mortality by engaging those at highest risk. Future research should examine the feasibility and acceptability of stratifying invitation materials by area-level deprivation.

Related to this, intervention and control participants achieved similar decision-making outcomes, suggesting the 'low information burden' component did not compromise decision-making. In fact, it was control participants who less frequently felt informed about the risks of screening despite receiving this information in advance. Our 'low burden' component was informed by evidence that information burden can deter individuals with low literacy(43–45) and that a third of non-participants in colorectal screening have not read the information booklet(46). Moreover, information receptivity and comprehension may be adversely affected by a fearful emotional state(24,25), which a first-time lung screening invitation could provoke(13). Perhaps the appointment was a better environment to achieve comprehension, with the research nurse's support and time to mentally adjust to the offer. Alternatively, control participants may have paid less attention to the booklet at their appointment because the information was not novel. Nevertheless, these findings suggest that providing detailed information with screening invitations may neither be sufficient for supporting informed choice nor an equitable invitation approach. A low burden approach that builds up information in steps to full information provision during the appointment could be further tested for decision-making and inequalities in participation.

The intervention had no effect on smoking-related inequalities, with uptake skewed in favour of former smokers as in previous trials(7–9) and screening programmes for other cancer types(47–50). Research suggests that fatalism, fear and stigma are deep-rooted attitudes(13,17), which may be particularly resistant to change among current smokers. Alternatively, perhaps addiction-specific factors are more instrumental. As this was a

multifactorial intervention with no process evaluation, we cannot draw conclusions about individual components. It does however highlight there to be both independent and shared barriers to participation associated with lower SEP and current smoking status.

A simple primary care record search effectively identified a largely screening-eligible population, suggesting invitation through primary care is feasible for a population-based programme, as well as a strategy likely to improve uptake. Indeed, adopting the invitation methods common to both groups may optimise participation. This includes a Lung Health Check approach, GP endorsement(21,23), pre-invitations(29), postal reminders(30), and scheduled appointments(34,51). The reminder re-invitations offering a second scheduled appointment prompted uptake by a further 10%, suggesting that lowering practical demands helps non-responders overcome non-intentional barriers. While offering scheduled appointments appears to have been effective, 47% of invited individuals did not attend which has resource implications. We mitigated the impact by over-booking appointments and other strategies might include asking invitees to confirm attendance. Lessons could be learned from the UK's NHS Breast Cancer Screening Programme which sends timed appointments(30). Overall, the likely effectiveness of the methods shared by both trial arms suggests that translating intention into action may be easier to achieve than changing attitudes.

There remains a gap in knowledge of the most effective means of modifying psychological barriers to participation. More foundational and experimental research is needed to isolate and test different approaches. It is likely that a multi-pronged screening communication strategy would be needed as well as interventions at the wider healthcare system level, to ensure that the screening pathway optimises individuals' screening experience.

Uptake of LDCT screening is likely to increase if offered as an organised Lung Health Check programme and individuals are invited via primary care. It is possible to engage a high-risk, screening-eligible sample of lower SEP current smokers using feasible, population-based and low-cost methods. A targeted, stepped and low burden invitation approach shows promise for reducing the social gradient in uptake by engaging individuals living in areas of highest deprivation, without compromised decision-making. Further research is critical to understand how to further reduce inequalities; especially for current smokers.

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LEGENDS

Figure 1 CONSORT trial flow diagram

Figure 2 Uptake by study-specific[a] deprivation quintile (IMD) for each invitation group

Table 1 Sample characteristics of all those invited, overall and by invitation group

Table 2 Frequencies and logistic regression analyses examining the correlates of uptake

Table 3 Smoking characteristics of attenders consenting to LSUT and eligibility for LDCT

Table 4 Frequencies and logistic regression analyses examining the correlates of uptake of the LDCT scan among LDCT-eligible attenders

FOOTNOTES

Declaration of interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure_pdf and declare financial support from Cancer Research UK for the submitted work. SLQ, JD, MR, RJB, DRB, AB, NN, KS, SWD and JW declare no support from financial organisations that might have an interest in the submitted work in the previous three years. SMJ, JD and MR receive funding from a commercial US healthcare company (GRAIL Inc.) as part of funding for a large trial of low dose CT screening, called the 'SUMMIT Study'. SQ collaborates on the SUMMIT Study. SMJ has been paid by Astra Zeneca, BARD1 Bioscience and Achilles Therapeutics for being an Advisory Board Expert and travel to one US conference. SMJ receives grant funding from Owlstone for a separate research study. MR has received travel funding for a conference and educational meeting from Takeda and Astra Zenica. RJB has received grant funding from Vanilla Blush for a separate research study. AM has received travel funding, honorariums and consultancy payments from manufacturers of smoking cessation products (Pfizer Ltd, Novartis UK and GSK Consumer Healthcare Ltd) and hospitality from North51 who provide online and database services. AM also receives payment for providing training to smoking cessation specialists and receives royalties from books on smoking cessation. AM is an Associate of the New Nicotine Alliance (NNA) that works to foster greater understanding of safer nicotine products and technologies. All authors perceive that these disclosures pose no academic conflict for this study. All authors declare no other relationships or activities that could appear to have influenced the submitted work.

Role of the funding source

The funders had no role in the study design, data collection, data analysis and interpretation, the writing or the manuscript, or in the decision to submit the manuscript for publication. All authors and researchers are independent of the study funders. The corresponding author had full access to all data and had final responsibility for the decision to submit for publication.

Data sharing statement

Relevant individual de-identified participant data (including data dictionaries) will be made available upon reasonable request to SMJ. Data will be available to share after the publication of the study primary and secondary endpoints. The study protocol and SAP are openly available online and referenced in this manuscript.

Table 1 Sample characteristics of all those invited, overall and by invitation group

	All (n=2012)	Intervention (n=1006)	Control (n=1006)
Gender, % (n)			
Female	46.3 (931)	44.7 (450)	47.8 (481)
Male	53.7 (1081)	55.3 (556)	52.2 (525)
Age, mean (SD)	66.0 (4.3)	66.1 (4.3)	65.9 (4.3)
Ethnicity, % (n)			
Asian	2.1 (42)	2.3 (23)	1.9 (19)
Black	9.6 (193)	9.4 (95)	9.7 (98)
Mixed	1.7 (34)	1.4 (14)	2.0 (20)
White	79.7 (1604)	79.6 (801)	79.8 (803)
Other	2.9 (59)	3.1 (31)	2.8 (28)
Not stated	4.0 (80)	4.2 (42)	3.8 (38)
National IMD quintile, % (n)			
Quintile 1 (1-6496) most deprived	60.9 (1226)	60.5 (609)	61.3 (617)
Quintile 2 (6497-12993)	35.3 (711)	35.4 (356)	35.3 (355)
Quintile 3 (12994-19489)	2.3 (47)	2.5 (25)	2.2 (22)
Quintile 4 (19490-25986)	0.1 (2)	0.1 (1)	0.1 (1)
Quintile 5 (25987-32482) least deprived	-	-	-
Missing	1.3 (26)	1.5 (15)	1.1 (11)
Smoking status, % (n)			
Current smoker	74.5 (1499)	76.2 (767)	72.8 (732)
Former smoker	24.7 (497)	23.0 (231)	26.4 (266)
Never smoked tobacco	0.6 (13)	0.8 (8)	0.5 (5)
Refused/Not stated	0.1 (2)	-	0.2 (2)
Missing	0.0 (1)	-	0.1 (1)
Attendance, % (n) of all invited			
Overall	52.6 (1058)	52.3 (526)	52.9 (532)
Attended first appointment	40.3 (811)	39.7 (399)	41.0 (412)
Cancelled first appointment	5.0 (100)	4.6 (46)	5.4 (54)
Sent reminder (no response to first invitation)	54.7 (1101)	55.8 (561)	53.7 (540)
Attended second (reminder) appointment	9.6 (194)	9.4 (95)	9.8 (99)
Cancelled second (reminder) appointment	2.9 (59)	3.4 (34)	2.5 (25)
No response to reminder invitation	42.1 (848)	42.9 (432)	41.4 (416)

Figure 1 CONSORT trial flow diagram

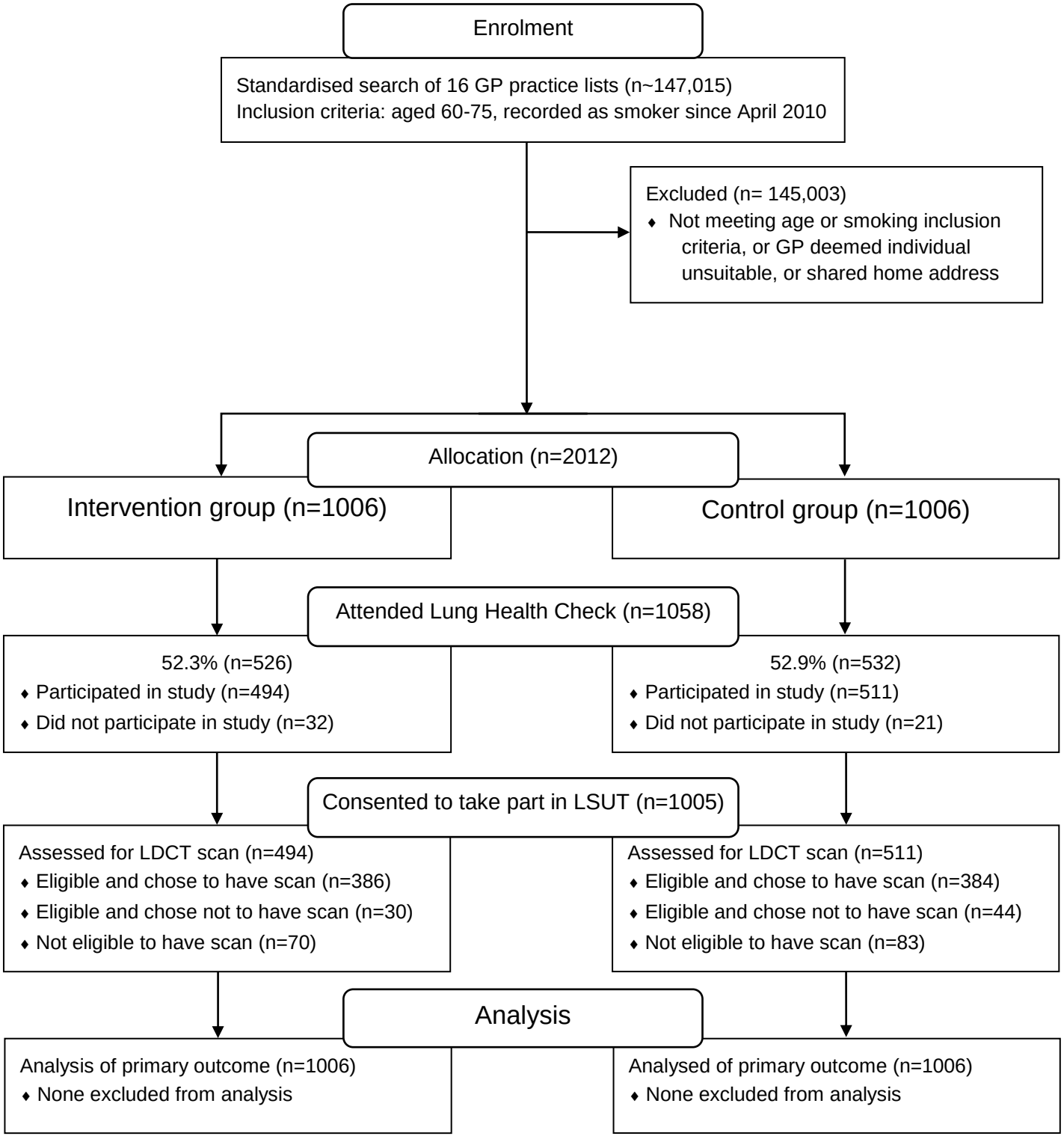
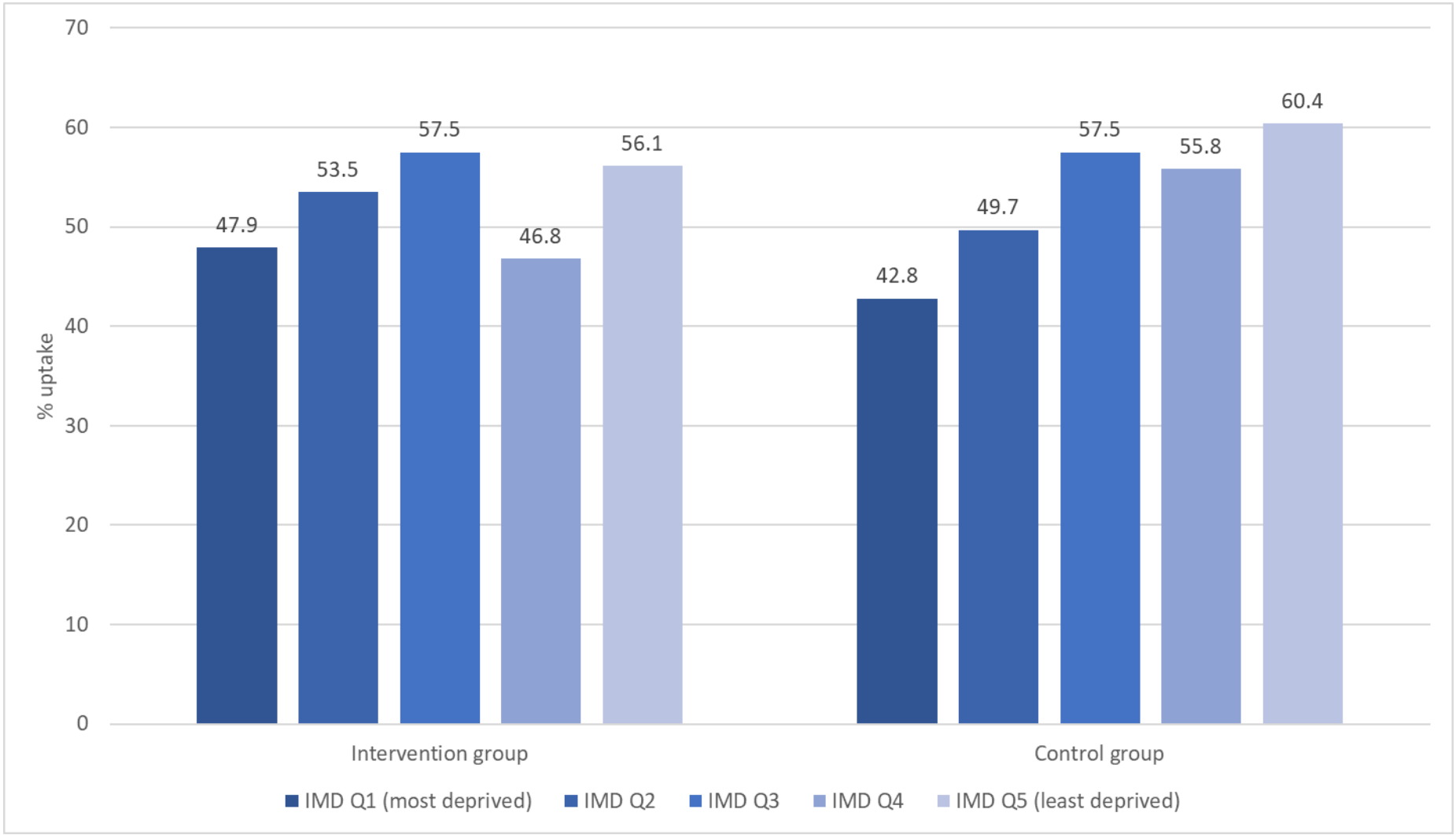


Table 2 Frequencies and logistic regression analyses examining the correlates of uptake

	All			Intervention		Control	
	Attended % (n) (n=2012)	**Unadjusted OR (95% CI) (n=2012)**	**Adjusted OR (95% CI) (n=1970)**	**Unadjusted OR (95% CI) (n=1006)**	**Adjusted OR (95% CI) (n=983)**	**Unadjusted OR (95% CI) (n=1006)**	**Adjusted OR (95% CI) (n=987)**
Gender		p=.557	p=.433	p=.828	p=.944	p=.290	p=.237
Female	52.0 (479)	1.00	1.00	1.00	1.00	1.00	1.00
Male	53.4 (574)	1.05 (0.88, 1.26)	1.08 (0.90, 1.29)	0.97 (0.76, 1.25)	0.99 (0.76, 1.29)	1.14 (0.89, 1.47)	1.17 (0.90, 1.52)
Age		p=.857	p=.879	p=.484	p=.365	p=.331	p=.188
		1.00 (0.98, 1.02)	1.00 (0.98, 1.02)	0.99 (0.96, 1.02)	0.99 (0.96, 1.02)	1.02 (0.99, 1.05)	1.02 (0.99, 1.05)
Ethnicity		p<.001	p<.001	p<.001	p<.001	p<.001	p<.001
White	54.1 (864)	1.00	1.00	1.00	1.00	1.00	1.00
Asian	52.6 (20)	0.85 (0.46, 1.57)	0.87 (0.45, 1.69)	1.13 (0.49, 2.60)	1.44 (0.56, 3.75)	0.61 (0.24, 1.53)	0.52 (0.20, 1.37)
Black	56.0 (107)	1.11 (0.82, 1.49)	1.11 (0.82, 1.51)	1.09 (0.71, 1.68)	1.06 (0.68, 1.65)	1.12 (0.73, 1.71)	1.17 (0.76, 1.81)
Mixed	36.4 (12)	**0.47 (0.23, 0.95)**	0.48 (0.24, 1.00)	0.35 (0.11, 1.12)	0.37 (0.11, 1.23)	0.56 (0.23, 1.38)	0.57 (0.23, 1.43)
Other	72.9 (43)	**2.29 (1.28, 4.10)**	**2.34 (1.30, 4.20)**	1.82 (0.85, 3.92)	1.92 (0.89, 4.15)	**3.07 (1.23, 7.66)**	**3.23 (1.28, 8.14)**
Not stated[a]	8.9 (7)	**0.08 (0.04, 0.18)**	**0.09 (0.04, 0.19)**	**0.15 (0.06, 0.35)**	**0.15 (0.06, 0.35)**	**0.02 (0.00, 0.17)**	**0.03 (0.00, 0.19)**
Study-specific deprivation quintile[b]		p<.01[c]	p<.01	p=.154[c]	p=.100	p<.01[c]	p<.05
Quintile 1 (most deprived)	45.2 (179)	1.00	1.00	1.00	1.00	1.00	1.00
Quintile 2	51.6 (205)	1.29 (0.97, 1.70)	1.28 (0.96, 1.71)	1.25 (0.84, 1.86)	1.28 (0.85, 1.92)	1.31 (0.89, 1.93)	1.31 (0.87, 1.96)
Quintile 3	57.5 (234)	**1.63 (1.23, 2.15)**	**1.62 (1.21, 2.15)**	1.49 (1.00, 2.21)	1.49 (0.99, 2.24)	**1.77 (1.20, 2.62)**	**1.74 (1.16, 2.61)**
Quintile 4	51.3 (195)	1.27 (0.96, 1.68)	1.23 (0.92, 1.64)	0.98 (0.66, 1.47)	0.96 (0.64, 1.45)	**1.63 (1.10, 2.42)**	**1.60 (1.06, 2.41)**
Quintile 5 (least deprived)	58.2 (227)	**1.65 (1.25, 2.19)**	**1.68 (1.26, 2.25)**	1.36 (0.91, 2.02)	1.44 (0.96, 2.17)	**2.01 (1.35, 2.99)**	**1.93 (1.28, 2.93)**
Smoking status		p<.001[d]	p<.01	p<.05[d]	p<.05	p<.01[d]	p<.05
Former smoker	60.2 (299)	1.00	1.00	1.00	1.00	1.00	1.00
Current smoker	50.3 (754)	**0.67 (0.55, 0.82)**	**0.70 (0.56, 0.86)**	**0.70 (0.52, 0.94)**	**0.72, 0.53, 0.97)**	**0.65 (0.49, 0.86)**	**0.68 (0.51, 0.92)**
Invitation group		p=.789	p=.843				
Control	53.0 (529)	1.00	1.00	-	-	-	-
Intervention	52.5 (524)	0.98 (0.82, 1.16)	0.98 (0.82, 1.18)	-	-	-	-

NOTE: [a]No record of ethnic group in primary care; [b]2010 IMD rank quintile with cut-offs based on distribution in LSUT sample; [c] Cases with no IMD rank/score were excluded (n=26 in full sample); [d]Never smokers (n=13 in full sample) and refused/missing smoking status (n=3 in full sample) were excluded

Figure 2 Uptake by study-specific[a] deprivation quintile (IMD) for each invitation group (n=2012)



NOTE: [a]2010 IMD rank quintile with cut-offs based on distribution in LSUT sample

Table 3 Smoking characteristics of attenders consenting to LSUT and eligibility for LDCT

	All (n=1000)[a]	Intervention (n=492)	Control (n=508)
Age started smoking, mean (SD, range)	17.9 (5.8, 6-55)	17.9 (5.5, 7-55)	17.9 (6.1, 6-55)
Age stopped smoking[b], mean (SD, range)	59.4 (10.7, 0-75)	59.8 (10.4, 21-75)	59.1 (11.0, 0-75)
Number of years smoked, mean (SD, range)	45.5 (9.5, 2-64)	45.6 (9.1, 2-64)	45.4 (9.9, 3-63)
Pack years, mean (SD, range)	39.4 (25.0, 1-171)	38.0 (22.2, 1-128)	40.7 (27.5, 1-171)
Usual daily cigarette consumption[c,d], % (n)			
1 to 10	55.7 (395)	55.3 (199)	56.2 (196)
11 to 20	33.3 (236)	34.7 (125)	31.8 (111)
21 to 30	5.9 (42)	5.3 (19)	6.6 (23)
≥31	2.3 (16)	2.2 (8)	2.3 (8)
Missing	2.8 (20)	2.5 (9)	3.2 (11)
Time to first cigarette[d], % (n)			
Within 5 minutes	16.5 (117)	16.9 (61)	16.0 (56)
6-30 minutes	33.4 (237)	33.9 (122)	33.0 (115)
31-60 minutes	16.8 (119)	17.2 (62)	16.3 (57)
>60 minutes	31.5 (223)	31.1 (112)	31.8 (111)
Missing	1.8 (13)	0.8 (3)	2.9 (10)
Nicotine dependence (HSI score)[d], % (n)			
Low dependence	38.9 (276)	38.6 (139)	39.3 (137)
Moderate dependence	42.9 (304)	43.1 (155)	42.7 (149)
High dependence	14.5 (103)	15.3 (55)	13.8 (48)
Missing	3.7 (26)	3.1 (11)	4.3 (15)
Perceived chance of quitting[d], % (n)			
Very low/Low/Not very high	58.7 (416)	56.9 (205)	60.5 (211)
Quite high/Very high/Extremely high	38.5 (273)	41.4 (149)	35.5 (124)
Missing	2.8 (20)	1.7 (6)	4.0 (14)
Previous quit attempts[d], % (n)			
None	20.3 (144)	21.7 (78)	18.9 (66)
1 to 5	59.7 (423)	57.5 (207)	61.9 (216)
>5	19.0 (135)	20.0 (72)	18.1 (63)
Missing	1.0 (7)	0.8 (3)	1.1 (4)
Eligibility for LDCT scan, % (n)	84.5 (845)	84.6 (416)	83.4 (429)
LDCT scan willingness (of ineligible), % (n)			
Yes, definitely	66.9 (107)	71.8 (56)	62.2 (51)
Yes, probably	15.0 (24)	10.3 (8)	19.5 (16)
Probably not	3.8 (6)	1.3 (1)	6.1 (5)
Definitely not	3.8 (6)	5.1 (4)	2.4 (2)
Missing	10.3 (17)	11.5 (9)	9.8 (8)

NOTE: [a]Never smokers (n=4) and missing smokers (n=1) were excluded; [b]Former smokers only (n=269) [c]For participants reporting grams of tobacco per week, these were converted to number of cigarettes per day; [d]Current smokers only (n=709)

Table 4 Frequencies and logistic regression analyses examining the correlates of uptake of the LDCT scan among LDCT-eligible attenders

	Attenders eligible for LDCT (n=845)		
	LDCT uptake % (n)	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**
Overall	91.2 (770)	-	-
Gender		p=.846	p=.979
Female	91.4 (342)	1.00	1.00
Male	91.1 (428)	0.95 (0.59,1.54)	1.01 (0.60, 1.68)
Age		p=.275	p=.267
	-	0.97 (0.92, 1.03)	0.97 (0.91, 1.03)
Marital status		p=.443	p=.394
Married/Cohabiting	92.2 (320)	1.00	1.00
Single/Separated/Divorced/Widowed	90.7 (449)	0.82 (0.50, 1.35)	0.79 (0.46, 1.36)
Ethnicity		p<.01	p<.01
White	91.3 (642)	1.00	1.00
Asian	53.8 (7)	**0.11 (0.04, 0.34)**	**0.09 (0.02, 0.31)**
Black	92.7 (76)	1.20 (0.50, 2.88)	1.28 (0.52, 3.14)
Mixed	100.0 (8)	-	-
Other	97.1 (34)	-	-
Not stated	100.0 (3)	-	-
Study-specific deprivation quintile[a]		p=.074	p=.072
Quintile 1 (most deprived)	88.2 (134)	1.00	1.00
Quintile 2	91.7 (154)	1.48 (0.71, 3.08)	1.82 (0.75, 3.49)
Quintile 3	95.6 (172)	**2.89 (1.22, 6.85)**	**2.82 (1.18, 6.78)**
Quintile 4	87.7 (136)	0.96 (0.48, 1.91)	0.94 (0.46, 1.91)
Quintile 5 (least deprived)	92.7 (165)	1.71 (0.81, 3.61)	1.74 (0.80, 3.77)
Smoking status		p<.05	p=.052
Former	94.6 (211)	1.00	1.00
Current (incl. occ)	90.0 (559)	**0.51 (0.27, 0.97)**	0.52 (0.27, 1.01)
Invitation group		p=.177	p=.075
Control	89.7 (384)	1.00	1.00
Intervention	92.8 (386)	1.47 (0.91, 2.40)	0.63 (0.37, 1.05)

NOTE: Missing data were excluded; [a]2010 IMD rank quintile with cut-offs based on distribution in LSUT sample