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Participation in community-based lung cancer screening:

the Yorkshire Lung Screening Trial

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Abstract

Question: Screening with low dose computed tomography (LDCT) reduces lung-cancer mortality; however, the most effective strategy for optimising participation is unknown. Here we present data from the Yorkshire Lung Screening Trial, including response to invitation, screening eligibility and uptake of community-based LDCT screening.

Methods: Individuals aged 55 to 80, identified from primary care records as having ever smoked, were randomised prior to consent to invitation to telephone lung cancer risk assessment or usual care. The invitation strategy included General Practitioner endorsement, pre-invitation and two reminder invitations. After telephone triage, those at higher risk were invited to a Lung Health Check (LHC) with immediate access to a mobile CT scanner.

Results: Of 44,943 individuals invited, 50.8% (n=22,815) responded and underwent telephone-based risk assessment (16.7% and 7.3% following first and second reminders respectively). A lower response rate was associated with current smoking status ($_{adj}$OR 0.44, 95%CI 0.42-0.46) and socio-economic deprivation ($_{adj}$OR 0.58, 95% CI 0.54-0.62 most vs. least deprived quintile). Of those responding, 34.4% (n=7,853) were potentially eligible for screening and offered a LHC, of whom 86.8% (n=6,819) attended. Lower uptake was associated with current smoking status ($_{adj}$OR 0.73, 95%CI 0.62-0.87) and socio-economic deprivation ($_{adj}$OR 0.78, 95% CI 0.62-0.98). In total 6,650 individuals had a baseline LDCT scan, representing 99.7% of eligible LHC attendees.

Conclusion: Telephone risk assessment followed by a community-based LHC is an effective strategy for lung cancer screening implementation. However, lower participation associated with current smoking status and socio-economic deprivation underlines the importance of research to ensure equitable access to screening.

Introduction

Lung cancer outcomes are poor as symptomatic disease is commonly associated with advanced, incurable cancer. Screening with low dose computed tomography (LDCT) dramatically improves outcomes by finding early stage disease thereby reducing lung cancer specific mortality (1, 2). LDCT screening was approved by the US Preventive Services Task Force (USPSTF) in 2013, and yet only 5% of eligible adults underwent screening in 2018 (3). As in other developed nations, lung cancer incidence and mortality in the UK are highest in more deprived areas (4) reflecting the link between smoking and low socio-economic position (5).

People who smoke and those from more deprived communities historically have lower levels of cancer screening participation (6, 7). Several 'barriers' to participation have been identified, including practical issues such as travel or psychological factors which negatively impact a person's motivation to attend (8, 9). A number of approaches to overcome these 'barriers' have been explored. Examples include Manchester's Lung Health Checks (LHC), which took screening directly into highly deprived areas using mobile CT scanners (10, 11) and the Lung Screen Uptake Trial (LSUT) which tested a low burden, stepped invitation strategy to a hospital-based LHC and demonstrated uptake of 52.6% and reduced social gradient (12).

The UK does not yet have a comprehensive lung cancer screening programme, although a number of pilots have recently commenced (13). The Yorkshire Lung Screening Trial (YLST) is a large randomised controlled trial of LDCT screening taking place across Leeds, United Kingdom which includes a number of novel design features (14). First, through permission granted by the UK Health Research Authority, we analysed demographic and clinical data for non-responders to a written LHC invitation. Second, YLST is one of the first targeted screening programmes worldwide to exclusively use telephone triage to determine screening eligibility. Finally, as in the Manchester LHCs, screening takes place on mobile units located in convenient community locations across Leeds. Here we report

the response to telephone triage invitation, screen-eligibility, and LHC uptake in those at higher risk of lung cancer, including an analysis of factors associated with non-response and non-uptake.

Materials and Methods

Study design: The design of YLST has been published previously (14). Primary objectives include participation rates, performance of risk-based eligibility criteria and clinical outcomes of invitation to targeted community-based LDCT screening for lung cancer versus usual care (no invitation). YLST utilises a Zelen design, with residents of Leeds recorded as having ever smoked randomised (1:1) prior to consent to either invitation to a telephone risk assessment and for those at higher risk community-based LHC and LDCT screening, or to no invitation (current usual care in the UK). The unit of randomisation is the household to avoid cohabitees being allocated to different study arms.

Study population: Individuals aged 55 to 80 years, registered with a participating General Practice (GP) in Leeds, whose primary care record indicated they had ever smoked were identified as potential study participants. Exclusion criteria included: lung cancer within 5 years, prior metastatic cancer, terminal illness, severe frailty/dementia, nursing home resident or CT thorax within 12 months. GP data was extracted monthly during the recruitment period (November 2018 and February 2021). Index of Multiple Deprivation (IMD) was recorded; this is a measure of relative deprivation in small areas of England (based on postcode of residence) ranked from 1 (most deprived) to 32,844 (least deprived).

Study invitation: A GP endorsed pre-invitation and invitation letter, alongside a low burden information leaflet (adapted from the LSUT) (15), was sent to the intervention arm. For the first 2 months of the study, people who had not responded within 2 weeks were sent a reminder letter; from January 2019 onwards 2 reminder letters were sent to non-responders. Invitational material was designed to replicate a clinical service and therefore research was not mentioned (until individuals attended the LHC).

Telephone triage: Individuals who contacted the telephone triage service had their screening eligibility checked according to United States Preventive Services Task Force (USPSTF) 2013 criteria (age 55-80, ≥30 pack-years, smoked within 15 years) or lung cancer risk using $PLCO_{M2012}$ (6-year risk

≥1.51%) and LLP (v2) (5-year risk ≥5%) models (16-18). If at least one of the three criteria were met, a LHC appointment was offered. The $PLCO_{M2021}$ model includes height and weight which participants reported during the phone call, and ethnicity criteria (White/Black/Asian/Hispanic/Other/Prefer not to say). Those eligible for screening were offered a LHC appointment.

Lung Health Check: The LHC took place in mobile units in 11 community locations (supermarket/retail centre or council car parks) across Leeds. LHCs were run by a Research Nurse or Senior Clinical Trial Assistant and included measurement of height and weight and re-checking of screening eligibility. The consultation involved a detailed discussion about the benefits and harms of screening. Those who wished to proceed provided fully informed written consent for study participation. Participants completed a LHC questionnaire, clinical parameters were measured (spirometry, oxygen saturation and exhaled carbon monoxide) and immediate opt-out smoking cessation support was offered (19). A baseline LDCT scan was performed immediately or at a future date, according to participant preference.

Covid-19 pandemic: The study opened in November 2018 but paused due to the Covid-19 pandemic (March to June 2020). Following appropriate adaptations (pre-visit telephone calls for Covid symptoms, temperature check, appropriate personal protective equipment, information on the trial website, cessation of spirometry) recruitment recommenced July 2020 and completed February 2021.

Analysis: A YLST primary objective is to measure participation in community-based screening. A primary outcome measure is response to telephone triage invitation, defined as the proportion posted an invitation who contacted the telephone triage line. A secondary outcome measure is LHC uptake, defined as the proportion offered a LHC appointment who attended. Simple descriptive analyses are used for response and uptake and characteristics of attendees. GP codes were used to derive most recent smoking status and ethnicity, which were adapted from UK Government definitions (Office for National Statistics - ONS) (20) and primary care research (21). Factors

associated with telephone response and LHC uptake were investigated using univariate and multivariable logistic regression (Stata v17.0). The multivariable model was derived by including variables with a P value <0.20 by univariate analysis and using backwards stepwise selection with a threshold P value of 0.01 for elimination. Odds Ratios (ORs) are presented with 95% confidence intervals (95% CI). Statistical tests are two-sided.

Ethical and regulatory framework: The study design was approved by the Health Research Authority following review by Research Advisory Group (reference 18/NW/0012) and the Confidentiality Advisory Group (CAG) (reference 18/CAG/0038). The study was granted a Section 251 exemption in order to process identifiable information from non-consenting participants.

Results

Almost all General Practices in Leeds participated in the study (n=84/86, 97.7%). A total of 44,943 individuals randomised to the intervention arm are included in this analysis (Figures 1 and 2). Most were from single-participant households (69.3%, n=31,157), 30.3% (n=13,620) were from two-participant households and 0.4% (n=166) had three or more participants. Baseline characteristics are summarised in Table 1. Overall, mean age was 66 years, approximately half were male (52.3%) and 30% were in the most deprived IMD quintile. Based on GP codes, 50.1% were categorised as 'white' and 40.8% 'mixed' ethnicity; 69.1% were categorised as previous smokers and 29.9% as current smokers.

Response to invitation: Just over half (n=22,815) of invitees contacted the telephone triage service (50.8%, 95%CI 50.3% to 51.2%, Table 1). Response rate was marginally higher in one participant households (51.2%, n=15,962/31,157) compared to households with two or more (49.7%, n=6,853/13,786). Response rate was 50% prior to the Covid pandemic (November 2018 to February 2020) and 52.5% when the study reopened with Covid-adaptations (July 2020 to February 2021). Analysis of the impact of reminder invitations, undertaken from January 2019 when invitees (n=39,117) received up to two reminder letters, showed that 28% (n=10,971) responded after the initial invitation, 16.7% (n=6,520) after a first and 7.3% (n=2,845) after a second reminder.

Based on primary care recorded smoking status, response was 33.7% (n=4,528/13,435) in people who currently smoke and 58.1% (n=18,046/31,036) in people who used to smoke. Equivalent values were 40.6% (n=5,539/13,641) in the most socio-economically deprived quintile and 59.7% (n=4,067/6,811) in the least deprived, and 38.7% (n=4,565/11,809) and 61.2% (n=3,937/6,430) in those aged <60 and ≥75 respectively. Unadjusted and adjusted analyses are shown in Table 2. Response increased with age; those aged ≥75 years were twice as likely to respond compared to those aged <60 ($_{adj}$OR 1.99, 95% CI 1.87-2.12). After adjustment, the odds of responding were 19% lower in men ($_{adj}$OR 0.81, 95% CI 0.78-0.84), 42% lower in the most deprived quintile compared to

the least ($_{adj}$OR 0.58, 95% CI 0.54-0.62) and 56% lower in people categorised as currently smoking ($_{adj}$OR 0.44, 95% CI 0.42-0.46). Asian/Asian British and mixed ethnicity were associated with lower response compared to White ($_{adj}$OR 0.79, 95% CI 0.68-0.90 and $_{adj}$OR 0.93, 95% CI 0.89-0.97, respectively).

Telephone triage outcome: Of 22,815 individuals who contacted the telephone triage line, 34.9% (n=7,958) fulfilled the screening eligibility criteria (Table 3); 15.1% (n=3,437) were ineligible because they self-reported never smoking (despite the having a smoking-related code in their GP record). Baseline data from responders with a self-reported history of ever-smoking is summarised in Table 3. Self-reported ethnicity was predominantly white (95.3%); this differed from primary care records where 52.4% were recorded as white and 40.5% mixed.

The median phone call duration was 4.1 minutes (IQR 2.6-9.8) overall, 0.8 minutes (IQR 0.5-1.3) in people who reported never smoking, 3.6 minutes (IQR 2.8-4.8) in people who had ever smoked but were ineligible and 7.5 minutes (IQR 5.7-10.1) in eligible people (see Table 4). The total duration of phone calls with responders who were ineligible for screening (n=11,420) was 685 hours. Ineligible people who continued to smoke were offered immediate on-line referral to the local Stop Smoking Service.

The characteristics of responders stratified by screening eligibility is detailed in Table 3. Eligibility increased with age, a self-report of currently smoking (33.7% of eligible compared to 6.5% of ineligible individuals) and greater tobacco smoke exposure. Significant differences in eligibility by gender and IMD were noted, variables not currently included in risk models. The proportion of people who currently smoke eligible for screening was 78.3% (n=2,683/3,427) compared to 33.1% in those who used to smoke (n=5,275/15,951). Of note, 33% of those eligible were in the most socio-economically deprived quintile compared to 19.6% of those ineligible.

Lung Health Check: Of 7,853 individuals offered a LHC appointment, 9.8% (n=784) declined and 3.5% (n=250/7,069) did not attend. LHC uptake in those offered an appointment was therefore 86.8% (n=6,819/7,853). Of 6,819 LHC attendees, 152 were found to be ineligible following either re-calculation of risk score (n=132) or another exclusion criteria identified during the face to face consultation (n=20). A further 17 declined a CT scan following supported information decision making. This resulted in 6,650 people undergoing a baseline LDCT scan representing 84.7% of those eligible following telephone triage (n=6,650/7,853) and 99.7% of those eligible following their LHC appointment (n=6,650/6,667). The median time between telephone triage and LHC was 20 days (IQR 15-29).

Characteristics were compared between those attending (n=6,819) the LHC appointment and those who either declined or did not attend (n=1,034) (Table 5). Adjusted analysis demonstrated that non-attendance increased with age ($_{adj}$OR 0.38, 95% CI 0.29-0.48 for those aged ≥75yrs compared to <60yrs), deprivation ($_{adj}$OR 0.78, 95% CI 0.62-0.98, most deprived IMD quintile compared to least deprived) and self-reported current smoking ($_{adi}$OR 0.73, 95% CI 0.62-0.87) (Table 6). Attendance in responders who were eligible and invited to a LHC was higher in men ($_{adj}$OR 1.33, 95% CI 1.16-1.52).

Discussion

In this study we assessed the participation of residents in Leeds, aged 55-80 who had a GP record of having ever smoked, in a community-based targeted lung cancer screening programme. From a total of 44,943 invitees, 50.8% responded. Of those responding 34.4% were potentially eligible for screening, 29.9% attended a LHC, and 29.1% (n=6,650) underwent LDCT screening. We demonstrated a marked difference in response according to primary care derived smoking status, with odds of responding reduced by 56% in people who currently smoke ($_{adj}$OR=0.44, 95%CI 0.42-0.47). This inequality in participation persisted in those at higher risk and invited to a community-based LHC, with 27% lower screening attendance in those self-reporting current smoking ($_{adj}$OR=0.73, 95%CI 0.62-0.87). A similar pattern was seen for high socio-economic deprivation, with response 42% lower in the most deprived IMD quintile compared to the least deprived ($_{adj}$OR=0.58, 95%CI 0.54-0.62) and LHC attendance 22% lower ($_{adj}$OR=0.78, 95%CI 0.62-0.98). While older age groups were more likely to respond, they were less likely to attend if offered a LHC.

Our data provide novel insights into those individuals who choose not to respond to a written invitation to a LHC assessment. While consistent with evidence from other cancer screening programmes (12, 22-24), the magnitude of the difference in response is notable for age, deprivation and current smoking status, and the size of the YLST population allows for good precision around estimates. Current smoking status and lower socio-economic position are associated with higher incidence of lung cancer (25), so our data suggests that the people most at risk seem the least likely to engage with the LHC/screening programme. Future work will investigate how these factors are related to the clinical outcome of lung cancer diagnosis and inequalities relating to stage at diagnosis. The finding of lower response rates in Asian/Asian British and mixed ethnicity groups is also noteworthy and underlines the importance of future research to ensure access to screening is equitable irrespective of ethnicity. Ethnic categorisation was closely matched between the two sources (GP coded and self-reported) for Black and Asian groups (1.2% and 1.7% of respondents

respectively). The proportions categorised as White were markedly different between the two sources (52.4% for GP data versus 94.4% for self-reported data), which reflected the mixed ethnicity category in GP data (40.5%) which was not an option for self-reported data (where the categorisation matched that used in the PLCO risk model).

The overall proportion of people responding to the invitation process (50.8%) was similar to that seen in LSUT (52.6%) (12) and significantly higher than participation reported in the US (3). This may reflect the similar invitation strategy used in the two studies (pre-warning letter, GP-endorsement of invitation, use of a low burden leaflet and a reminder letter for non-responders). YLST was the first study to use a second reminder letter, and this appeared to augment the overall response rate by 7%. Interestingly participation rates were not adversely affected by the Covid-19 pandemic, which may reflect the fact that LHC were provided in community locations rather than hospital sites.

Assessing lung cancer risk and screen eligibility by a telephone triage line proved highly effective. Only 2.2% of mobile unit attendees (n=152/6,819) were found to be ineligible following reassessment during the face-to-face LHC (often due to differences between estimated and measured height and weight). The telephone calls were generally of short duration (median 4.1 minutes). For those self-reporting that they had never smoked, or for those who had ever smoked but were ineligible for screening, calls were shorter still (median duration 0.8 and 3.6 minutes respectively). There were 11,420 ever smokers who after telephone assessment were ineligible for screening, equating to a time of 685 hours over the course of the study. Services that offer face-to-face risk assessments for all participants generally offer 20-minute appointments, which would result in 3,807 hours for these respondents, a more than 5-fold increase. Although there was no formal process evaluation, the telephone conversations were well received.

One possible downside of telephone triage and subsequent attendance for a face-to-face LHC with LDCT screening is the potential for people to disengage between the phone call and appointment on the mobile unit. Those people opting not to take up the offer of a face-to-face LHC were more likely

to be from deprived populations and currently smoking. Despite a higher rate of response to the telephone triage invitation, women and older people were less likely to attend or take up the offer of a LHC appointment or screening and further research is needed to investigate underlying reasons.

Strengths and limitations: Strengths of the study include the high participation rate amongst General Practices within Leeds (84 of 86 took part in the study) and the high level of completeness of data analysis. Of 89,917 individuals for whom data was extracted from primary care systems, only 123 (0.14%) were excluded from analysis due to either registered dissent or a national NHS data opt-out. The ability to analyse characteristics of those not responding to screening invitation gives valuable insight into this population.

A possible limitation of YLST is that as a research study it may not accurately predict participation rates in a national lung cancer screening programme provided as a routine NHS service. People from lower socio-economic groups are less likely to participate in research studies and this might have contributed to the differential response reported. To mitigate this (and with approval from the Research Ethics Committee), no contact was made with the control (usual care) population. A full explanation of the research-nature of the study was only provided at the time of attendance at the LHC when participants were invited to provide informed written consent for participation in a research study. There was a conscious decision not to advertise the service or undertake community engagement, given that only those people randomised to the intervention group could access this service. It maybe that this limited overall participation.

Summary: YLST has shown an encouraging response to invitation to a LHC with lung cancer screening, considerably in excess of the most recently reported participation rates in the US. This may relate to the use of invitation strategies that have been shown to work in other screening programmes. In addition, the use of a second reminder letter appears to augment response rate by 7% and may be a useful addition to future programmes. The use of a telephone triage service to identify those fulfilling eligibility criteria for screening was accurate and efficient and may represent

the optimal model of triage for lung cancer screening. Despite the overall encouraging response to invitation, very significant disparities remain, with people who currently smoke, and those from more deprived populations much less likely to respond. Thus people at higher risk of lung cancer appear less inclined to participate in screening. There is therefore an urgent need to address barriers to participation in these populations in order to maximise the lives saved by lung cancer screening and ensure equitable access to services in those most at risk of lung cancer.

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Table 1: Demographic and baseline clinical characteristics of the intervention arm of the YLST stratified by non-response or response (contacted telephone triage line) following invitation.

	Intervention group		Non-responders		Responders		P value
Number, n (%)	44,943		22,128	(49.2)	22,815	(50.8)	
Age, mean (SD)	66.1	(7.2)	64.8	(7.1)	67.3	(7.1)	
Age, n(%)							<0.001
<60	11,809	(26.3)	7,244	(32.7)	4,565	(20.0)	
60-64	9,936	(22.1)	5,329	(24.1)	4,607	(20.2)	
65-69	8,619	(19.2)	3,745	(16.9)	4,874	(21.4)	
70-74	8,149	(18.1)	3,317	(15.0)	4,832	(21.2)	
75+	6,430	(14.3)	2,493	(11.3)	3,937	(17.3)	
Gender, n (%)							<0.001
Female	21,446	(47.7)	9,969	(45.1)	11,477	(50.3)	
Male	23,496	(52.3)	12,158	(54.9)	11,338	(49.7)	
Indeterminate	1	(<0.1)	1	(<0.1)	0		
Median IMD rank (IQR)	15,050	(4,014-23,016)	11,508	(3,091-21,681)	17,272	(6,658-23,723)	<0.001
IMD Quintile, n (%)							<0.001
1	13,641	(30.4)	8,102	(36.6)	5,539	(24.3)	
2	7,184	(16.0)	3,709	(16.8)	3,475	(15.2)	
3	7,621	(17.0)	3,537	(16.0)	4,084	(17.9)	
4	9,638	(21.4)	4,012	(18.1)	5,626	(24.7)	
5	6,811	(15.2)	2,744	(12.4)	4,067	(17.8)	
Missing	48	(0.1)	24	(0.1)	24	(0.1)	
Ethnicity(derived)*, n(%)							<0.001
White	22,500	(50.1)	10,524	(47.6)	11,958	(52.4)	
Black or Black British	690	(1.5)	415	(1.9)	275	(1.2)	
Asian or Asian British	932	(2.1)	544	(2.5)	388	(1.7)	
Mixed	18,339	(40.8)	9,102	(41.1)	9,237	(40.5)	
Other	486	(1.1)	291	(1.3)	195	(0.9)	
Unclear	357	(0.8)			190	(0.8)	
Not stated	1,639	(3.7)	1,067	(4.8)	572	(2.5)	
COPD code, n (%)	4,364	(9.7)	2,219	(10.0)	2,145	(9.4)	0.16
Smoking status (derived)*, n(%)							<0.001
Currently smoking	13,435	(29.9)	8,907	(40.3)	4,528	(19.9)	
Previously smoked	31,036	(69.1)	12,990	(58.7)	18,046	(79.1)	
Never smoked	13	(<0.1)	5	(<0.1)	8	(<0.1)	
Non-informative code	459	(1.0)	226	(1.0)	233	(1.02)	

Table 2: Investigation of factors associated with response to the telephone triage line following invitation: univariate and multivariable analyses.

	Univariate		Multivariable	
	OR (95% CI)	**P-value**	**Adjusted OR (95% CI) n=44,943**	**P-value**
Age				
<60	1.00		1.00	
60-64	1.37 (1.30, 1.45)	<0.001	1.31 (1.24-1.39)	<0.001
65-69	2.06 (1.95, 2.18)	<0.001	1.86 (1.76-1.97)	<0.001
70-74	2.31 (2.18, 2.45)	<0.001	1.92 (1.81-2.04)	<0.001
75+	2.50 (2.35, 2.67)	<0.001	1.99 (1.87-2.12)	<0.001
Gender				
Female	1.00		1.00	
Male	0.81 (0.78, 0.84)	<0.001	0.81 (0.78, 0.84)	<0.001
IMD Quintile				
1	0.46 (0.43, 0.49)	<0.001	0.58 (0.54-0.62)	<0.001
2	0.63 (0.59, 0.68)	<0.001	0.71 (0.66-0.76)	<0.001
3	0.78 (0.73, 0.83)	<0.001	0.84 (0.78-0.89)	<0.001
4	0.95 (0.89, 1.01)	0.09	0.98 (0.92-1.05)	0.54
5	1.00		1.00	
Ethnicity (derived)				
White	1.00		1.00	
Black or Black British	0.58 (0.50, 0.68)	<0.001	0.93 (0.79, 1.09)	0.36
Asian or Asian British	0.63 (0.55, 0.72)	<0.001	0.79 (0.68, 0.90)	0.001
Mixed	0.89 (0.86, 0.93)	<0.001	0.93 (0.89, 0.97)	<0.001
Other	0.59 (0.49, 0.70)	<0.001	0.73 (0.61, 0.89)	0.001
Unclear	1.00 (0.81, 1.23)	0.98	1.06 (0.85, 1.32)	0.62
Not stated	0.47 (0.43, 0.52)	<0.001	0.52 (0.47, 0.58)	<0.001
Smoking status (derived)				
Previously smoked	1.00		1.00	
Currently smoking	0.37 (0.35, 0.38)	<0.001	0.44 (0.42, 0.46)	<0.001
Never smoked	1.15 (0.38, 3.52)	0.80	1.13 (0.36, 3.53)	0.83
Non-informative smoking code	0.74 (0.62, 0.89)	0.002	0.78 (0.65, 0.94)	0.01
COPD	0.93 (0.87, 0.99)	0.025		

Table 3: Baseline characteristics of responders who had ever smoked by eligibility for lung cancer screening based on telephone risk assessment.

	Responders who had ever smoked		Eligible (High risk)		Ineligible (Low risk)		P-value
Number (%)	19,378		7,958	(41.1)	11,420	(58.9)	
Age, n(%)							<0.001
<60	3,858	(19.9)	1,129	(14.2)	2,729	(23.9)	
60-64	3,882	(20.0)	1,333	(16.8)	2,549	(22.3)	
65-69	4,131	(21.3)	1,727	(21.7)	2,404	(21.1)	
70-74	4,150	(21.4)	1,922	(24.2)	2,228	(19.5)	
75+	3,357	(17.3)	1,847	(23.2)	1,510	(13.2)	
Gender, n(%)							<0.001
Female	9,567	(49.37)	3,653	(45.9)	5,914	(51.8)	
Male	9,811	(50.63)	4,305	(54.1)	5,506	(48.2)	
IMD rank, median (IQR)	17,272	(6,658-23,723)	12,679	(3,531-21,819)	18,918	(8,077-25,059)	<0.001
IMD quintile, n (%)							<0.001
1	4,857	(25.1)	2,622	(33.0)	2,235	(19.6)	
2	3,035	(15.7)	1,396	(17.5)	1,639	(14.4)	
3	3,479	(18.0)	1,400	(17.6)	2,079	(18.2)	
4	4,637	(24.0)	1,577	(19.8)	3,060	(26.8)	
5	3,352	(17.3)	955	(12.0)	2,397	(21.0)	
Missing	18	(0.09)	8	(0.1)	10	(0.1)	
Ethnicity (self-report)*, n (%)							<0.001
White	18,461	(95.3)	7,682	(96.5)	10,779	(94.4)	
Black	238	(1.2)	61	(0.8)	177	(1.6)	
Asian	338	(1.7)	98	(1.2)	240	(2.1)	
Hispanic	25	(0.1)	2	(<0.1)	23	(0.2)	
Other	217	(1.1)	76	(1.0)	141	(1.2)	
Prefer not to say	99	(0.5)	39	(0.5)	60	(0.5)	
COPD code, n (%)	2,122	(9.3)	1,826	(23.0)	296	(2.6)	<0.001
Smoking status (self-report)*, n(%)							
Current smoking	3,427	(17.69)	2,683	(33.7)	744	(6.5)	<0.001
Previously smoked	15,951	(82.31)	5,275	(66.3)	10,676	(93.5)	
Pack-years, median(IQR)	17.25	(6-32)	35	(25.5-45)	8.5	(3-16.5)	<0.001
Missing	3,437	(15.1)	0		0		
Quit time, median(IQR)	20	(6-37)	12	(6-21)	33	(20-42)	<0.001
Missing, n(%)	0		0		0		
Education, n(%)							<0.001
No qualifications (left school <=15)	9,515	(49.1)	4,896	(61.5)	4,619	(40.5)	
O-levels or equivalent	3,944	(20.4)	1,396	(17.5)	2,548	(22.3)	
A-levels or equivalent	845	(4.4)	234	(2.9)	611	(5.4)	
Some college (not a degree)	2,600	(13.4)	836	(10.5)	1,764	(15.5)	

	Responders who had ever smoked		Eligible (High risk)		Ineligible (Low risk)		P-value
Graduate	1,595	(8.2)	408	(5.1)	1,187	(10.4)	
Post-graduate	755	(3.9)	142	(1.8)	613	(5.4)	
Prefer not to say	124	(0.6)	46	(0.6)	78	(0.7)	
Missing	0		0		0		
Family history of LC, n(%)							<0.001
Yes	2,908	(15.0)	1,598	(20.1)	1,310	(11.5)	
No	16,471	(85.0)	6,360	(79.9)	10,110	(88.5)	
Missing	0		0		0		
First degree relative with LC, n(%)							0.96
Yes	2,802	(96.4)	1,540	(96.4)	1,262	(96.4)	
No	106	(3.7)	58	(3.6)	48	(3.7)	
Missing	0		0		0		
1st degree relatives							<0.001
1	2,525	(86.8)	1,357	(84.9)	1,168	(89.2)	
2	239	(8.2)	158	(9.9)	81	(6.2)	
≥3	38	(1.3)	25	(1.6)	13	(1.0)	
Missing	106	(3.7)	58	(3.6)	48	(3.7)	
Age 1st degree relative with LC, n(%)							<0.001
<60 years	801	(27.5)	483	(30.2)	318	(24.3)	
≥60 years	2,001	(68.8)	1,057	(66.1)	944	(72.1)	
Missing	106	(3.7)	58	(3.6)	48	(3.7)	

LC, lung cancer. * Self-reported ethnicity and current smoking status collected during telephone triage.

Table 4: Duration of telephone triage calls and appointment booking according to self-reported smoking history and risk-assessed eligibility for screening.

Type of call	Median (IQR) call duration in minutes[$]	Number of calls during baseline round	Median (IQR) calls per day	Total call time during baseline round in minutes[$]	Median (IQR) time for calls per day in minutes[$]
Ever smoked eligible **	7.5 (5.7-10.1)	7,954	11.5 (5-22)	64,912	91.7 (38.8-182.6)
Ever smoked ineligible*	3.6 (2.8-4.8)	11,424	14 (6-31)	46,135	64.3 (24.4-120.2)
Never smoked*	0.8 (0.5-1.3)	3,437	5 (2-9)	3,898	5.62 (2.4-11.3)
Total	4.1 (2.6-9.8)	22,815	29 (10-61)	114,945	139.3 (51.6-303.4)

* For people who had never smoked, or who had ever smoked but were ineligible for lung screening, the time taken to complete the triage form was taken to be the call duration. ** For people who had ever smoked and were eligible for screening, the call time was estimated to be double the time taken to complete the electronic lung cancer risk triage form to allow time for appointment booking on the Patient Administration System. $ Time expressed in minutes with decimal points.

Table 5: Demographic and clinical information for people invited for a Lung Health Check by attendance

	Total invited	Attended	Declined/DNA	P-value
Number (%)	7,853	6,819 (86.8)	1,034 (13.2)	
Age, n(%)				<0.001
<60	1,121 (14.3)	1,005 (14.7)	116 (11.2)	
60-64	1,318 (17.8)	1,165 (17.1)	153 (14.8)	
65-69	1,702 (21.7)	1,489 (21.8)	213 (20.6)	
70-74	1,899 (24.2)	1,654 (24.3)	245 (23.7)	
75+	1,813 (23.1)	1,506 (22.1)	307 (29.7)	
Gender, n(%)				<0.001
Female	3,606 (45.9)	3,057 (44.8)	549 (53.1)	
Male	4,247 (54.1)	3,762 (55.2)	485 (46.9)	
IMD rank, median(IQR)	12,679 (3,531-21,843)	12,732 (3,605-21,860)	10,212 (3,086-20,733)	0.003
IMD quintile, n(%)				<0.001
1	2,587 (32.9)	2,194 (32.2)	393 (38.0)	
2	1,379 (17.6)	1,229 (18.0)	150 (14.51)	
3	1,385 (17.6)	1,187 (17.4)	198 (19.2)	
4	1,555 (19.8)	1,377 (20.2)	178 (17.2)	
5	939 (12.0)	825 (12.1)	114 (11.0)	
Missing	8 (0.1)	6 (0.1)	1 (0.1)	
Ethnicity, n(%) *				0.26
White	7,583 (96.6)	6,592 (96.7)	991 (95.8)	
Black	60 (0.8)	52 (0.8)	8 (0.8)	
Hispanic	1 (<0.1)	1 (<0.1)	0	
Asian	94 (1.2)	82 (1.2)	12 (1.2)	
Other	76 (1.0)	63 (0.9)	13 (1.3)	
Prefer not to say	39 (0.5)	29 (0.4)	10 (1.0)	
COPD code, n(%)	1,791 (22.8)	1,508 (22.1)	283 (27.4)	<0.001
Smoking status*, n(%)				<0.001
Currently smoking	2,652 (33.8)	2,226 (32.6)	608 (58.8)	
Previously smoked	5,201 (66.2)	4,593 (67.4)	426 (41.2)	
Pack-years, median (IQR)	35 (25.5-45)	35 (26.7-45)	34 (25-45)	0.49
Quit time (previously smoked)	12 (6-21)	12 (6-21)	11 (5-20)	0.16

DNA, Did not attend. IMD, Index of Multiple Deprivation. IQR, Interquartile range. COPD, Chronic Obstructive Pulmonary Disease. * Self-reported ethnicity and smoking status.

Table 6: Univariate and multivariable analysis of factors predicting the likelihood of Lung Health Check/screening uptake amongst those invited.

	Univariate		Multivariable	
	Odds Ratio (95% CI)	**P-value**	**Adjusted Odds Ratio (95% CI), n=7,845**	**P-value**
Age				
<60	1.00		1.00	
60-64	0.88 (0.68-1.13)	0.32	0.82 (0.63-1.06)	0.12
65-69	0.81 (0.63-1.03)	0.08	0.70 (0.54-0.89)	0.003
70-74	0.78 (0.62-0.99)	0.04	0.59 (0.46-0.75)	<0.001
75+	0.57 (0.45-0.71)	<0.001	0.38 (0.29-0.48)	<0.001
Gender				
Female	1.00		1.00	
Male	1.39 (1.22-1.59)	<0.001	1.33 (1.16-1.52)	<0.001
IMD quintile				
1	0.77 (0.62-0.96)	0.02	0.78 (0.62-0.98)	0.04
2	1.13 (0.87-1.47)	0.35	1.12 (0.86-1.46)	0.38
3	0.83 (0.65-1.06)	0.14	0.84 (0.66-1.08)	0.17
4	1.06 (0.83-1.37)	0.60	1.09 (0.84-1.40)	0.52
5	1.00		1.00	
Smoking status				
Previously smoked	1.00		1.00	
Current smoking	0.69 (0.61-0.79)	<0.001	0.73 (0.62-0.87)	<0.001
Quit Time	1.01 (1.00-1.01)	<0.001	1.01 (1.01-1.02)	0.001
Pack Years	1.00 (0.99-1.00)	0.49		
COPD	1.33 (1.14-1.54)	<0.001		
Ethnicity				
White	1			
Black	0.98 (0.46-2.06)	0.95		
Hispanic[1]	-	-		
Asian	1.03 (0.56-1.89)	0.93		
Other	0.73 (0.40-1.30)	0.18		
Prefer not to say	0.44 (0.21-0.90)	0.02		

IMD, Index of Multiple Deprivation. COPD, Chronic Obstructive Pulmonary Disease. [1] only two individuals in this group, odds ratio not calculable. Multivariable analysis shows final model after backwards stepwise logistic regression using a p-value threshold of 0.01 for elimination.

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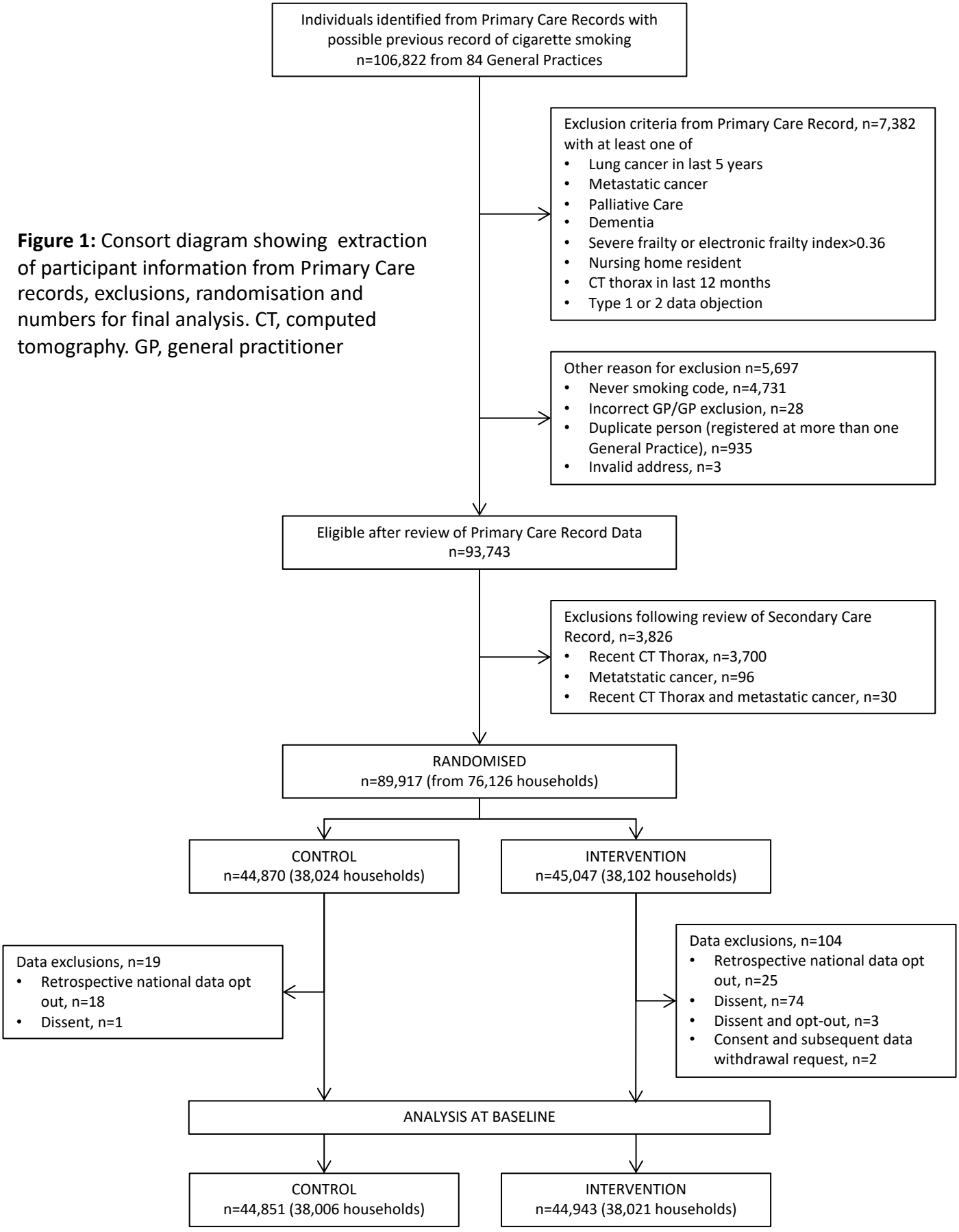

Figure 1: Consort diagram showing extraction of participant information from Primary Care records, exclusions, randomisation and numbers for final analysis. CT, computed tomography. GP, general practitioner

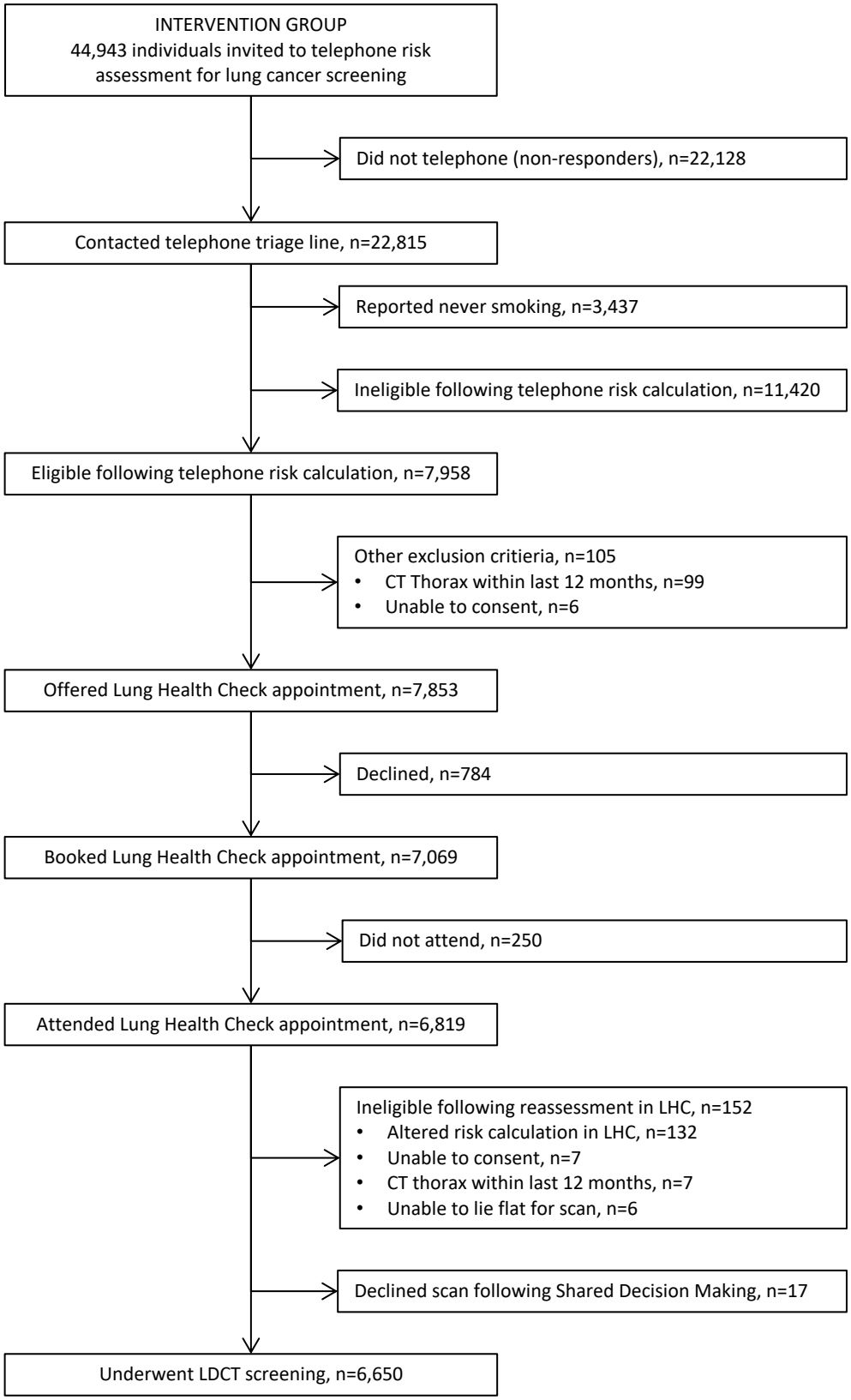

Figure 2: Consort diagram showing outcomes for 44,943 individuals analysed in intervention group. CT, computed tomography. LDCT, low dose computed tomography.