Implementing lung cancer screening: baseline results from a community-based 'Lung Health Check' pilot in deprived areas of Manchester

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ABSTRACT

We report baseline results of a community-based, targeted, low-dose CT (LDCT) lung cancer screening pilot in deprived areas of Manchester. Ever smokers, aged 55–74 years, were invited to 'lung health checks' (LHCs) next to local shopping centres, with immediate access to LDCT for those at high risk (6-year risk ≥1.51%, $PLCO_{M2012}$ calculator). 75% of attendees (n=1893/2541) were ranked in the lowest deprivation quintile; 56% were high risk and of 1384 individuals screened, 3% (95% CI 2.3% to 4.1%) had lung cancer (80% early stage) of whom 65% had surgical resection. Taking lung cancer screening into communities, with an LHC approach, is effective and engages populations in deprived areas.

INTRODUCTION

The symptomatic presentation of lung cancer is typically associated with advanced disease and poor survival. Screening asymptomatic at-risk subjects with low-dose CT (LDCT) reduces lung cancer specific mortality by 20%.[1] However, current smoking and low socioeconomic status (SES) are associated with reduced participation in lung cancer screening trials.[2–4] Reducing barriers to participation in those at greatest risk is a critical challenge to screening implementation.[5] To address this and the high burden of lung cancer in our local community, we designed and piloted a community-based, lung cancer screening service. The screening programme was developed around the concept of a one-stop 'lung health check' (LHC), which incorporated a holistic lung health programme and was located next to local shopping centres. The service was designed to minimise barriers to participation by reducing travel and increasing convenience/service accessibility. We selected screening participants according to individualised risk, using the $PLCO_{M2012}$ model, at a 6-year lung cancer risk threshold of ≥1.51%.[6] A similar approach was used in the UK Lung Cancer Screening Trial (UKLS), which selected participants based on 5-year risk ≥5% (Liverpool Lung Project model), this was cost-effective and resulted in a high prevalence of lung cancer.[7]

METHODS

Ever smokers, aged 55–74 years, registered at participating general practitioner practices (n=14), were invited to a community-based LHC, where respiratory symptoms, spirometry and 6-year lung cancer risk ($PLCO_{M2012}$) were assessed alongside smoking cessation advice[8]; anyone with a risk ≥1.51% was offered annual screening, over two screening rounds, including an immediate LDCT scan (online supplementary document for more detailed methodology). CT scans were reported by the National Health Service (NHS) Consultant Radiologists with an interest in thoracic radiology. Pulmonary nodules were managed in accordance with the British Thoracic Society guidelines adapted for an annual screening programme.[9] Scan reports were categorised as negative, indeterminate or positive. Indeterminate results required a 3-month surveillance scan and positives immediate assessment in the rapid access lung cancer clinic. A false positive was any screened individual referred to the cancer clinic who was not diagnosed with lung cancer.

RESULTS

Demand was extremely high, and all LHC appointments were booked within a few days; 99.5% consented to the research database (n=2541). Baseline characteristics are detailed in table 1. Overall, 56.2% (n=1429) of attendees qualified for screening, and 1384 had an LDCT scan (35 excluded because CT thorax <12 months, 7 declined and 3 unable—claustrophobia); 82.6% of baseline scans were classified as negative (n=1143), 12.7% indeterminate (n=176) and 4.7% positive (n=65) (figure 1). Negative scans had no nodules (73.8%; n=844), nodules <6 mm (24.9%; n=284) or larger stable/benign nodules (1.3%; n=15). Three-month scans were performed for either nodule (87.8%; n=166) or non-nodule surveillance

Table 1 Characteristics of individuals who attended the LHC, stratified by lung cancer risk

Variable	All	Lung cancer risk		P value
		High (PLCO ≥1.51%)	Low (PLCO <1.51%)	
Number of attendees (%)	2541	1429 (56.2)	1112 (43.8)	–
Mean age (years±SD)	64.1 (5.5)	64.7 (5.4)	63.4 (5.5)	*
Sex M/F (F%)	1245/1296 (51.0)	706/723 (50.6)	539/573 (51.5)	0.64
Median IMD rank (IQR)	2873	2866 (3994)	3109 (8345)	*
BMI (%)				
< 18.5	42 (1.7)	33 (2.3)	9 (0.8)	*
18.5 – 24.9	531 (20.9)	353 (24.7)	178 (16.0)	*
25 – 29.9	982 (38.7)	541 (37.9)	441 (39.7)	*
30 – 39.9	875 (34.4)	460 (32.2)	415 (37.3)	
≥ 40	111 (4.4)	42 (2.9)	69 (6.2)	
Education (%)				
Less than 'O' level	1567 (61.7)	998 (69.8)	569 (51.2)	*
'O' level	511 (20.1)	255 (17.9)	256 (23.0)	*
'A' level	106 (4.2)	49 (3.4)	57 (5.1)	
University/college	213 (8.4)	84 (5.9)	129 (11.6)	
University degree	91 (3.6)	31 (2.2)	60 (5.4)	
Postgrad/professional	53 (2.1)	12 (0.8)	41 (3.7)	
Smoking status (%)				
Current	891 (35.1)	754 (52.8)	137 (12.3)	*
Former	1650 (64.9)	675 (47.2)	975 (87.7)	
Smoking exposure (mean±SD)				
Duration (years)	34.6 (14.7)	43.8 (8.2)	22.8 (12.6)	
Cigs/days	20.4 (13.0)	24.0 (12.9)	15.8 (11.5)	
Pack-years	36.7 (27.8)	51.6 (26.8)	17.7 (14.2)	
Spirometry (mean ±SD)				
FEV_1	2.3 (0.8)	2.1 (0.7)	2.6 (0.8)	
% predicted FEV_1	90.1 (25.0)	84.0 (24.3)	98.0 (23.6)	
FVC	3.3 (1.0)	3.1 (1.0)	3.4 (1.0)	
% predicted FVC	102.6 (24.9)	99.4 (24.5)	106.6 (24.7)	
FEV_1/FVC ratio	70.8 (10.6)	67.8 (11.0)	74.7 (8.7)	
Airflow obstruction				
Yes (%)	944 (37.2)	716 (50.1)	228 (20.5)	
COPD/emphysema				
Yes (%)	566 (22.3)	471 (33.0)	95 (8.5)	
FH lung cancer				
Yes (%)	553 (21.8)	392 (27.4)	161 (14.5)	
MRC dyspnoea score (%)				
1	1791 (70.5)	920 (64.4)	871 (78.3)	
2	494 (19.4)	310 (21.7)	184 (16.6)	
3	163 (6.4)	123 (8.6)	40 (3.6)	
4	91 (3.6)	74 (5.2)	17 (1.5)	
5	2 (0.1)	2 (0.1)	0 (0)	
Performance status (%)				
0	1552 (61.1)	768 (53.7)	784 (70.5)	
1	763 (30.0)	481 (33.7)	282 (25.4)	
2	187 (7.4)	152 (10.6)	35 (3.1)	
3	38 (1.5)	28 (2.0)	10 (1.0)	
4	1 (0.0)	0 (0)	1 (0.0)	

*P value <0.0001.
BMI, body mass index; FH, family history; IMD, index of multiple deprivation; LHC, lung health check; MRC, Medical Research Council.

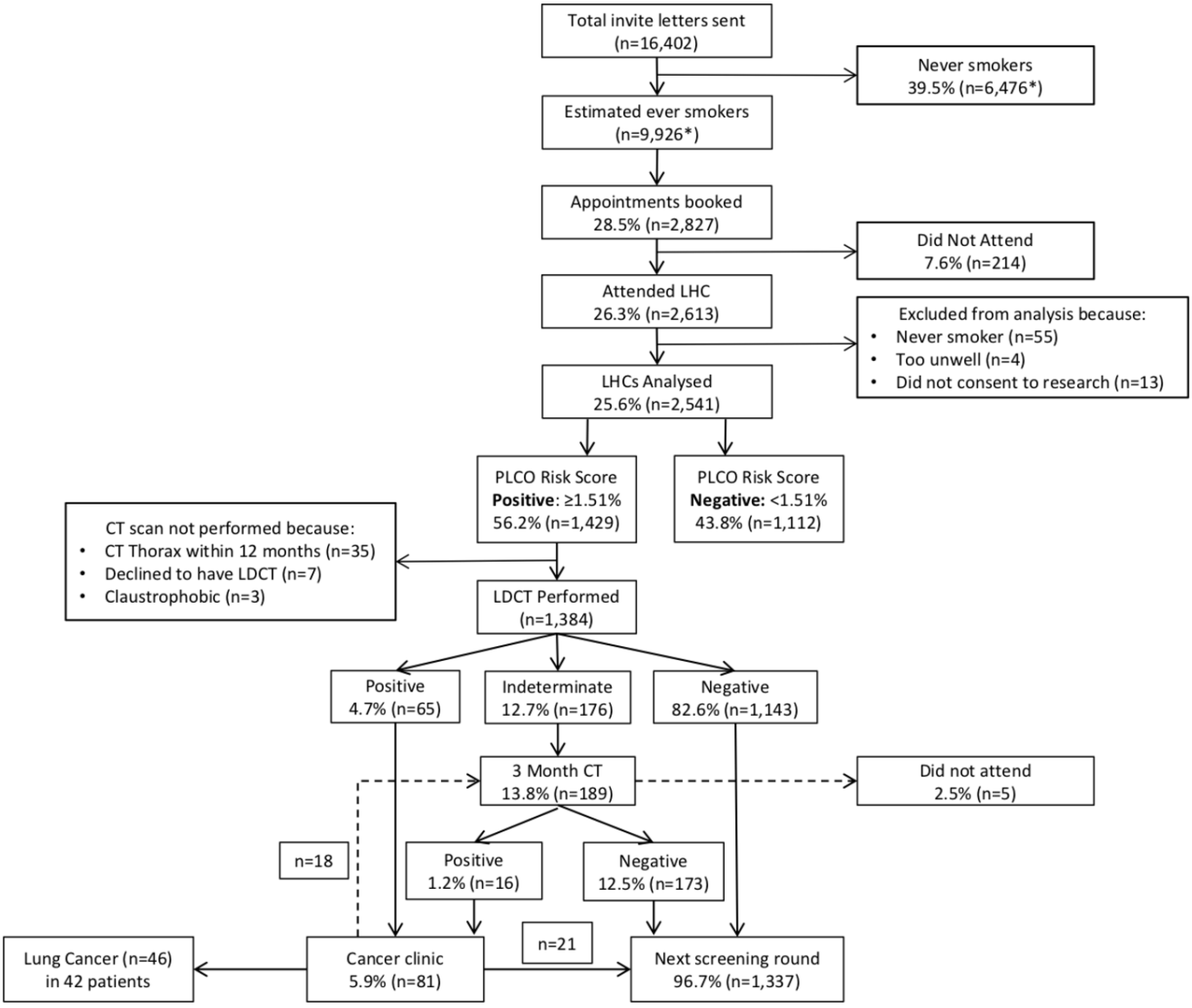

Figure 1 Diagram showing flow of participants through the screening service. *Based on general practitioner-recorded smoking status for 15 072 invitees. LDCT, low-dose CT scan; LHC, lung health check.

(12.2%; n=23). The dominant nodule at baseline was solid (54.2%; n=90), part solid (12%; n=20) or a pure ground-glass opacity (pGGO) (33.7%; n=56).

Of 81 (5.9%) individuals assessed in the cancer clinic, 42 were confirmed to have lung cancer. The false positive rate was 48.1% (n=39/81) as a proportion of cancer clinic referrals, or 2.8% of everyone screened. Patients who ultimately did not have cancer had the following investigations: positron-emission tomography (PET)–CT (n=17), bronchoscopy (n=9), endobronchial ultrasound (n=3), staging CT (n=6) and percutaneous biopsy (n=4). No surgical interventions were required for benign disease; one patient had a pneumothorax post-CT-guided biopsy.

The prevalence of lung cancer was 3% (95% CI 2.3% to 4.1%; n=42/1384); 46 lung cancers were detected as three patients had >1 cancer (table 1). Cancers were 63% stage I (n=29/46), 17.4% stage II (n=8/46), 8.7% stage III (n=4/46) and 10.9% stage IV (n=5/46). While we recognise the inherent biases associated with historical controls, this represented a significant stage shift (P<0.0001) compared with lung cancers (n=399) diagnosed across the same geographical area the year before the pilot started (31% stage I+II and 48% stage IV). The characteristics of screen detected cancers are detailed in table 2; pathological types included adenocarcinoma (n=24), squamous cell (n=13), small cell (n=2), adenosquamous (n=2) and carcinoid (n=1). Four cases had a clinical diagnosis without pathological confirmation. The surgical resection rate was 65.2% (n=30/46). There was one death within 90 days of surgery. A curative intent treatment was offered for 89.1% (n=41/46) of cancers.

DISCUSSION

In this paper, we report baseline results from the UK's first community-based, LDCT lung cancer screening service, using mobile CT scanners. Our approach was to target high-risk individuals in deprived areas of Manchester, with an invitation to convenient community-based LHC with immediate access to CT. We selected the screened population according to individual risk scores ($PLCO_{M2012}$). The prevalence of lung cancer was 3%, and most screen detected lung cancers were early stage (80.4%). The surgical resection rate was 65%, fourfold higher than the

Table 2 Clinical details of screen detected lung cancers

ID	Sex	Age	PS	MRC	TNM	Final stage	Pathological type	Histology subtype (resected adenocarcinomas)	Treatment
1	M	57	1	1	cT1a N0 M0	IA	Adenocarcinoma	–	Radiotherapy[R]
2	F	61	2	3	pT1a N0	IA	Adenocarcinoma	Undetermined	Surgery
3	F	69	0	1	pT1a N0	IA	Squamous	–	Surgery
4	F	65	0	1	pT1a N0	IA	Adenocarcinoma	Acinar	Surgery
5	F	74	1	1	pT1a N0	IA	Adenocarcinoma	Acinar	Surgery
6	F	70	0	1	pT1b N0	IA	Adenocarcinoma	Lepidic 40%, papillary 35%, acinar 20%, solid 5%	Surgery
7[A]	F	60	3	4	pT1a Nx	IA	Adenocarcinoma	Acinar	Surgery
8[A]					pT1a Nx	IA	Adenocarcinoma	Papillary	
9[A]					pT1a Nx	IA	Adenocarcinoma	Acinar	
10	F	74	2	4	cT1b N0 M0	IA	Clinical	–	Surgery—declined
11	M	69	0	1	pT1a N0	IA	Adenocarcinoma	Papillary	Surgery
12	M	66	0	1	pT1a N0	IA	Squamous	–	Surgery
13	F	65	1	1	pT1a N0	IA	Adenocarcinoma	Lepidic 90%, acinar 10%*	Surgery
14[B]	F	74	1	1	pT1a N0	IA	Adenosquamous	Acinar	Surgery
15[B]					pT1a N0	IA	Squamous	–	
16	F	72	2	1	pT1b N0	IA	Typical carcinoid	–	Surgery
17	M	73	0	1	pT1a N0	IA	Adenocarcinoma	Acinar	Surgery
18	M	64	1	1	cT1a N0 M0	IA	Clinical	–	SABR
19	F	65	1	2	pT1a N0	IA	Adenocarcinoma	Acinar 80%, lepidic 20%	Surgery
20	F	73	0	1	cT1a N0 M0	IA	Clinical	–	Surgery—declined
21	F	72	0	2	pT1a N0	IA	Squamous	–	Surgery
22[C]	F	73	1	1	pT1aN0	IA	Adenocarcinoma	Acinar 70%, lepidic 30%	Surgery
23[C]					pT2aN0	IB	Squamous	–	
24	M	70	0	1	pT2a N0	IB	Adenocarcinoma	Mixed acinar (>10%), lepidic, papillary	Surgery
25	F	71	0	1	pT2a N0	IB	Squamous	–	Surgery
26	M	67	1	3	pT2a N0	IB	Adenocarcinoma	Lepidic 55%, papillary 40%, acinar 5%	Surgery
27	F	64	1	4	pT2a N0	IB	Adenocarcinoma	Solid 90%, acinar 10%	Surgery
28	F	67	1	3	pT2a N0	IB	Adenocarcinoma	Acinar 95%, lepidic 5%	Surgery
29	F	62	3	4	cT2 N0 M0	IB	Squamous	–	SABR
30	F	60	0	1	cT1a N1 M0	IIA	Small	–	Chemoradiotherapy[C]
31	M	68	1	2	pT1a N1	IIA	Adenosquamous	Solid	Surgery/chemotherapy[A]
32	M	63	0	1	cT1 N1 M0	IIA	Squamous	–	Radiotherapy[R]
33	M	72	1	2	pT2b N0	IIA	Adenocarcinoma	Acinar	Surgery
34	M	69	3	5	cT1a N1 M0	IIA	Small	–	Chemotherapy
35	F	70	1	2	pT3 N0	IIB	Adenocarcinoma	Acinar 50%, lepidic 40%, papillary 10%	Surgery
36	M	73	0	1	cT3 N0 M0	IIB	Squamous	–	Radiotherapy[R]
37	M	57	3	5	cT3 N0 M0	IIB	Clinical	–	Radiotherapy[R]
38	F	61	0	1	pT2a N2	IIIA	Squamous	–	Surgery/chemotherapy[A]
39	M	65	0	2	pT2a N2	IIIA	Adenocarcinoma	Acinar 60%, lepidic 30%, solid 5%, papillary 5%	Surgery/chemotherapy[A]
40	M	74	0	1	cT4 N2 M0	IIIA	Squamous	–	Chemoradiotherapy[S]
41	M	73	0	1	pT4 N2	IIIB	Squamous	–	Surgery/chemotherapy[A]
42	F	65	2	3	cT4 N0 M1a	IV	Adenocarcinoma	–	Chemotherapy
43	F	66	1	1	cT4 N2 M1b	IV	Adenocarcinoma	–	Radiotherapy[P]
44	M	63	0	1	cT4 N2 M1b	IV	Squamous	–	Chemotherapy—declined
45	F	71	0	1	cT2 N2 M1b	IV	Adenocarcinoma	–	Chemoradiotherapy[S]
46	M	71	2	4	cT4 N1 M1b	IV	Adenocarcinoma	–	Chemotherapy

[R]Radical treatment, [C]concurrent treatment, [S]sequential treatment, [P]palliative treatment, [A]adjuvant chemotherapy. [A,B,C], cancers in the same patient.
TNM staging using V.7.
*Case with a rapid development of a solid component over 3 months.
MRC, Medical Research Council; PS, performance status; SABR, stereotactic ablative radiotherapy; TNM, tumour, node and metastasis.

UK average. Median deprivation rank was within the lowest decile for England (2873), markedly lower than UKLS (17 374)[7] and in contrast to screening trials where participation favours more affluent and better educated individuals,[2] suggesting our approach engaged individuals of lower SES from deprived areas, a key demographic of the 'hard-to-reach'.

To minimise overdiagnosis, only persistent pGGOs ≥5 mm were surveyed and subsolid lesions with a solid component ≥8 mm investigated; intervention was generally reserved for lesions with avidity on PET scan above the mediastinal blood pool or a volume doubling time <400 days. All surgically resected adenocarcinomas had ≥10% non-lepidic and invasive histology, suggesting this approach was appropriate. No surgery was performed for benign disease. One death occurred within 90 days of surgery (in a patient with two confirmed lung cancers). This mortality is below the national average, but underlines the importance of appropriate patient selection and minimising unnecessary invasive procedures.

In conclusion, our results have demonstrated that an appropriately designed service, using an LHC approach, can engage participants at high risk of lung cancer from deprived areas. This resulted in high rates of early stage lung cancer detection with minimisation of harms. It was not a clinical trial but an evidence-based pragmatic evaluation of an NHS commissioned and implemented pilot within a regional lung cancer service. Further evaluation of the Manchester LHC model will be undertaken in a roll-out of the service across the whole of North Manchester and at a number of additional sites as recently announced by NHS England.[10]

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