The Cost of Lung Cancer Screening and Uptake Maximisation: Findings from the Yorkshire Lung Screening Trial

Yingying Zhang, [1] Sebastian Hind, [1] Catriona Marshal, [2] Neil Hancock, [2] Rhian Gabe, [3] Philip Crosbie,[4] Matthew Callister [2,5]

Introduction

In the UK (and internationally), lung cancer (LC) screening has become an increasingly implemented approach to reduce the rate of late-stage disease at diagnosis and subsequent LC mortality. However, despite widespread cost-effectiveness research in this field, little consideration has been given to the actual cost implications of extending screening capacity to achieve national screening programmes (Grover, 2022).

LC screening with low-dose computed tomography (LDCT) has been shown to reduce LC mortality in randomised controlled trials, and many high and middle-income nations are now at various stages of implementing national screening programmes (Hinde 2018). In September 2022, the UK National Screening Committee recommended implementing LDCT screening; a full roll-out is expected by the end of the decade (UK National Screening Committee, n.d.).

In this paper, we report the results of an extensive cost analysis of the screening approach taken in the Yorkshire Lung Screening Trial (YLST), an ongoing randomised control trial of invitation to community-based LDCT screening versus usual care in a targeted population at risk of LC (Crosbie 2020). This is the most extensive LC screening programme in the UK to undertake a health economic analysis (6,650 recruits at baseline round) and the first to do so over two rounds of screening. The Manchester Lung Health Check Pilot involved 1,384 individuals undergoing a baseline round of LDCT screening, while the UK Lung Screening Pilot included 1,994 individuals undergoing baseline screening (Hinde 2018). The paper considers the costs from the initial identification of at-risk individuals through to the diagnosis of cancer and false positives, with subsequent treatment costs outside the scope of this research.

YLST utilised mobile screening units that travelled to various community locations across Leeds every month. Mobile screening was utilised in YLST to enhance accessibility for participants, addressing capacity issues within fixed-site hospital radiology departments. A similar model based on community-based screening has been adopted by the NHS England Lung Cancer Screening Programme, which is currently being rolled out.

Lung Health Check and LDCT Screening

YLST conducts LDCT screening in mobile units at convenient community locations, as travel was identified as the most significant barrier to screening uptake in the UKLS (Ali, 2015). The mobile van comprises a mobile CT scanner and support accommodation. While the van and equipment were rented, Leeds Teaching Hospital (LTH) provided staffing.

Potentially eligible individuals were identified through GP records based on age and smoking status and eligibility was determined during a telephone-based risk assessment with the screening team. Eligible individuals were those who were aged between 55 and 80 years old and classified as at high

risk of developing LC using any of three risk criteria (LLP_{v2} ≥5% risk of LC over the next 5 years, $PLCO_{M2012}$ ≥1.51% risk of LC over the next 6 years, $USPSTF_{2013}$ 30 pack year history of smoking, and quit time <15 years in people who had stopped smoking). Screening was offered if any of the tools returned a high-risk score. The full protocol has been previously published (Crosbie 2020).

The source of cost data

The number of individuals (1) in the randomisation cohort, (2) in the intervention group, (3) receiving invitation reminders, (4) who had a telephone triage call and (5) being invited for LC screening were provided by the YLST team. The unit cost of pre-invitation notices, GP-endorsed invitation letters, invitation reminders, screening appointment letters and the average duration of a telephone triage call were provided by the YLST finance team. The Unit Cost of Health and Social Care Manual (Jones et al., 2024) was used to extract information on staff salaries, including qualifications, overheads, and oncosts. Diagnostics items and consumption rates for both true and false positives were extracted from trial and clinical records by the YLST team, with unit costs updated based on the NHS Cost Collection for 2022/23 (NHS, 2023).

Results

Table 0.1 provides details of the costing elements considered, from the identification of potentially eligible individuals through to the final diagnostic decision, as well as the approach taken to derive values for each element. The total cost of each trial component is reported in the table, with the full cost of the YLST trial estimated at £5,009,145. As expected, the highest cost element is the delivery of screening itself, representing £3,259,949 of the total cost.

There are several ways this cost can be presented depending on the denominator of interest, a few of which are summarised here:

- £111 per individual invited to health check based on initial eligibility checks (106,822 were identified in the trial, with 44,943 randomised to the intervention arm).
- £17,763 per LC identified through screening (282 LCs were diagnosed in the first two rounds of YLST screening).
- £22,564 per early-stage lung cancer identified through screening (222 out of the 282 LCs diagnosed were at Stage I or II).

Discussion and Conclusion

In this paper, we have summarised the estimated costs associated with identifying eligible patients, offering health checks, including mobile CT scanning for those who are eligible, and requiring a diagnostic workup for all negative, false-positive, and true-positive scans for the YLST trial.

As this trial has taken place in the backdrop of the national rollout of LC screening in the UK, we have commented on the expected impact of the national rollout on the marginal cost of the different elements of LC screening in Table 0.1 In most cases, these would imply a reduced marginal cost as the scale increases; however, a national rollout will require significant investment in infrastructure, implying fixed costs beyond the marginal cost values estimated here. The funding for a nationwide roll-out is currently activity-driven, with providers being funded separately for each participant that completes a LC risk assessment, and each LDCT scan undertaken.

It is also important to note that many of the costing elements are sensitive to the approach taken in the trial. For example, three risk scores were used in YLST, which required both extra time to estimate the scores as well as resulted in a rate and distribution of LCs implying costs of diagnosis that will vary to different eligibility criteria.[1]

The costs reported here will provide valuable insight for local and national commissioners seeking to set up LC screening services and screening services more generally.

Funding information

The study was funded by Yorkshire Cancer Research (award reference L403).

Author affiliation

1. Centre for Health Economics, University of York, York, United Kingdom
2. Leeds Institute of Health Sciences, University of Leeds, Leeds, United Kingdom
3. Centre for Evaluation and Methods, Wolfson Institute of Population Health, Queen Mary University of London, London, United Kingdom
4. Division of Immunology, Immunity to Infection and Respiratory Medicine, Faculty of Biology, Medicine and Health, The University of Manchester, Manchester, United Kingdom
5. Department of Respiratory Medicine, Leeds Teaching Hospitals NHS Trust, Leeds, United Kingdom

[1] In the ongoing national rollout, two risk criteria (LLP_{v2} and $PLCO_{M201}$) instead of three are used and a lower threshold ($LLP_{v2} \geq 2.5\%$ instead of 5%) results in more people become eligible for screening.

Table 0.1 YLST costing elements, approach, sources, and resultant cost estimates

Element	Costing approach	Source or reference	Unit cost per person/event (2022/23 prices)	Frequency per screening round		Total YLST cost	Future rollout implications
				Prevalent	Incident		
Identification and engagement – total cost £302,807							
Identifying eligible individuals for randomisation	50-80 year-old ever smokers identified from GP data (n=106,822). Cost estimate based on previous patient index service costing (£36,000 one of costing) spread over an estimated 13 million ever smokers in England (Health Survey for England 2015) to get the unit cost per person	GOV.UK Digital Marketplace 2022	£0.003 per person	One-off cost	N/A	£320	Routine repeated access to existing data for incremental screening eligibility will likely remain at a minimal cost.
Pre-invitation notice	44,943 individuals were randomized to the intervention group and sent information about the LHC service	YLST finance team	£0.671	44,943	N/A	£30,157	Unit cost may reduce as scale increases.
GP endorsed the invitation letter for participation	Intervention group invited to telephone risk assessment for lung cancer screening	YLST finance team	£0.803	44,943	N/A	£36,089	Unit cost may reduce as scale increases.
Invitation reminder	Non-responders receive up to two reminders.	YLST finance team	£0.854 per reminder, or £1.108 per person	1st: 73.2% (32,898) 2nd: 56.5% (25,393)	N/A	£49,781	Unit cost may reduce as scale increases.
Telephone triage call	Triage assessing screening eligibility and calculating LC risks. Nurse-led primary care based, median call duration of 3.6 mins for ineligible ever-smokers and 7.5 mins for eligible ever-smokers	YLST finance team and Unit Cost Manual (Jones, 2024)	£7.75	22,815	N/A	£176,816	It will likely remain similar; however, improved accuracy in routine smoking status data would save time wasted on ineligible individuals.
Screening appointment letter	Consenting eligible individuals sent letters with details of the appointment	YLST finance team	£0.712	7,069	6,476	£9,644	Unit cost may reduce as scale increases.
Lung Health Check (LHC) and screening (conducted on a mobile CT scanner and support vehicle) – total cost £3,259,949							
LHC and screening – including surveillance scans	Staffing is based on one band six nurses and either three band 4 SCTAs or two band 4 SCTAs and one band three admin officer. Salary per hour includes the costs of qualifications, salary on costs, and overheads. Risk score conducted at baseline LHC only.	YLST finance team and researcher calculations of clinical waste[1], YLST management team and Unit Cost Manual (Jones, 2024) Estates Returns Information Collection (2023)	Per day: generator (£144.75), mobile CT (£2,595), support vehicle (£1,199), clinical waste (£2.45), staffing (£1,329). Prevalent - £302.90 per person Incident - £239.56 per person	6,650 scans (over 384 days)	5,184 scans (over 232 days)	£3,256,146	A third round occurred after this study, which had a higher cost of £4,115 for mobile van rent per day. It has been estimated that for the National rollout, 45 screens will be conducted per day at baseline and 60 at subsequent rounds, for a comparative cost of £146.31 and £109.73, including surveillance scans.
Taxi	The total taxi cost for T0 and T2 is £3,803.4 and was spread over the 11,834 individuals attending T0 and T2 screens to get the average taxi cost per person.	YLST finance team	£0.32			£3,803.4	It is likely to remain similar if offered consistently with YLST.
Diagnosis – total cost £1,446,388							

CT scan reporting	Sent to existing Leeds Teaching Hospital radiologists to be interpreted	YLST finance team	£40 per scan	6650 plus 1392 surveillance	5184 plus 910 Surveillance	£565,440	The full rollout may reduce the marginal cost of scan reporting.
Screening review meeting	It discusses all the indeterminate, positive, and incidental scan reports or some adverse scan reports. It consists of one Band 4 Clinical Trial Assistant, one Band 5 nurse, a Consultant Respiratory Physician, a Research Fellow/Junior Doctor, and a Consultant Radiologist. One discussion takes, on average, 2 mins 48 secs.	YLST finance team, YLST data, Unit Cost Manual (Jones, 2024)	£20.01 per discussion	4575	1806	£127,675.52	It is expected to remain unchanged for national rollout.
Double-read negative scans	According to the YLST protocol (Crosbie, 2020), 5% of all negative scans were randomly selected to be second-read by a different radiologist for quality assurance. According to the YLST finance team, 336 (5.05%) total T0 scans were double-read in T0. We use the same proportion to derive the number of double-read scans in T2.	YLST finance team, Crosbie 2020	£40 per scan	336	262	£23,920	There is no plan to do second reads of negative scans in the national programme.
False positive cases, diagnosis, and surgery	Positive cases from the screening were referred to the LTH lung cancer screening service, and almost all had further investigations, after which some cases were not diagnosed with lung cancer and were classified as false-positive cases. In a few cases, patients underwent surgery.	YLST finance team. NHS Cost Collection schedule 2022/2023 (NHS, 2023)	Average unit cost per false positive case: £1,791 (including £571 for surgery)	81	35	£207,806	It is informed by national guidance and good practice, so it is unlikely to change in the short term but may reduce with scale.
Lung cancer diagnostics	This covers the referral of suspected cancers from the screening review team to the MDT to the final diagnosis. The YLST trial team provided diagnostic workup resources, and unit costs were applied based on the most appropriate Cost Collection value. Diagnostic costs were stratified by type and stage of cancer to reflect the different activities required.	YLST data, NHS Cost Collection schedule 2022/2023 (NHS, 2023)	Average unit cost by stage: I £1,736, II £2,074, III £2,425, IV £1,665, limited £2,347, extensive £829	Stage I: 105, II: 23, III: 25, IV: 10, limited: 8, extensive: 4.	Stage I: 84, II: 10, III: 4, IV: 1, limited: 5, extensive: 3.	£521,547	It is informed by national guidance and good practice, so it is unlikely to change in the short term but may reduce with scale.

(Notes: 1. Cost of disposing of clinical waste was estimated using an estimated weight of 8kg per week and an average cost of incineration (clinical waste) per kilogram for Leeds Teaching Hospital NHS Trust (Estates Returns Information Collection (2023)).

References

Cancer Research UK; 2014. Incisive Health. Saving lives, averting costs: An analysis of the financial implications of achieving earlier diagnosis of colorectal, lung and ovarian cancer.

Crosbie, Philip A. J, et al. "Participation in community-based lung cancer screening: the Yorkshire Lung Screening Trial." *European Respiratory Journal* 60.5 (2022).

Crosbie, P. A. J., et al. "The Yorkshire Lung Screening Trial (YLST): Protocol for a randomised controlled trial to evaluate invitation to community-based low dose computed tomography screening for lung cancer versus usual care in a targeted population at risk. *BMJ Open*. 2020; 10: e037075."

NHS England and the NHS Improvement. "*National cost collection 2022/23*." NHS England and NHS Improvement (2023). [Available from: https://www.england.nhs.uk/costing-in-the-nhs/national-cost-collection/

GOV.UK Digital Marketplace. *Health Information Consulting Ltd, Patient-Provider Index 2022* [Available from: https://www.digitalmarketplace.service.gov.uk/g-cloud/services/844828413177937.]

Grover, H., et al. "Systematic review of the cost-effectiveness of screening for lung cancer with low-dose computed tomography." *Lung Cancer* 170 (2022): 20–33.

Hinde, S., et al. "The cost-effectiveness of the Manchester 'lung health checks,' a community-based lung cancer low-dose CT screening pilot." *Lung Cancer* 126 (2018): 119–124.

Jones, K., Weatherly, H., Birch, S., Castelli, A., Chalkley, M., Dargan, A., Forder, J., Gao, M., Hinde, S., Markham, S., Premji, S., Findlay, D. & Teo, H. (2024). *Unit Costs of Health and Social Care 2023 Manual.* Technical report. Personal Social Services Research Unit (University of Kent) & Centre for Health Economics (University of York), Kent, UK 10.22024/UniKent/01.02.105685.

NatCen Social Research UCL. *Health Survey for England 2015*. Trend tables commentary. NHS Digital; 2016.

Estates Returns Information Collection, Summary page, and ERIC 2022/23 dataset - NHS England Digital. (2023 Dec. 14). NHS England Digital. https://digital.nhs.uk/data-and-information/publications/statistical/estates-returns-information-collection/england-2022-23#summary

UK National Screening Committee. (2022). *Final report on the cost-effectiveness of low-dose computed tomography (LDCT) screening for lung cancer in high-risk individuals. UK Government.* https://view-health-screening-recommendations.service.gov.uk/document/586/download

UK National Screening Committee. (n.d.). *Lung cancer screening recommendations*. Retrieved December 11, 2024, from https://view-health-screening-recommendations.service.gov.uk/lung-cancer/

Upperton, S.E C., et al. "The radiology quality assurance process in the Yorkshire Lung Screening Trial, and findings from the baseline round of low dose CT screening for lung cancer." *The British journal of radiology* 96.1151 (2023): 20230126.