ORIGINAL ARTICLE

Inequalities in outcomes for non-small cell lung cancer: the influence of clinical characteristics and features of the local lung cancer service

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ABSTRACT

Background The treatment given to patients with lung cancer and survival vary between and within countries. The National Lung Cancer Audit (NLCA) linked to Hospital Episode Statistics was used to quantify the extent to which these outcomes are influenced by patient features and/or hospital facilities and performance indicators.

Methods All patients with a histological diagnosis of non-small cell lung cancer (NSCLC) were included. Logistic regression was used to quantify the independent influence of features of both patients and hospitals on the likelihood of having surgery and Cox regression was used for survival analyses.

Results There were 34 513 patients with NSCLC in our dataset. After adjusting for age, sex, performance status, stage and Charlson Index of comorbidity, patients with NSCLC first seen in thoracic surgical centres (27% of the cohort) were 51% more likely to have surgery than those seen in non-surgical centres (adjusted OR 1.51, 95% CI 1.16 to 1.97). Resection rates varied from 13% to 17% between non-surgical and thoracic surgical centres. Surgery was the most powerful determinant of overall survival (adjusted HR 0.41, 95% CI 0.39 to 0.44).

Conclusion A minority of patients with NSCLC first seen in a thoracic surgical centre are more likely to have surgery and to benefit from the survival advantage this confers. This finding suggests that there is an opportunity to improve the outcome for patients with lung cancer in England by optimising access to thoracic surgeons in non-surgical centres.

Key messages

What is the key question?

- Is the variation in surgical resection rates across England primarily due to patient features or to the features of the NHS trust where a patient is first seen?

What is the bottom line?

- Having adjusted for all patient features (including co-morbidity), patients with NSCLC who are first seen in a thoracic surgical centre are 50% more likely to have surgery than those first seen in a non-surgical centre.

Why read on?

- Findings suggest that changes to the patient pathway could increase the number of people who are offered potentially curative surgery.

INTRODUCTION

Lung cancer is the commonest cause of cancer-related death worldwide. Non-small cell lung cancer (NSCLC) accounts for more than 80% of all lung cancers[1 2] and, for these people, surgical resection represents the best chance of cure.[3] The National Institute for Health and Clinical Excellence (NICE) recommended surgical resection for all patients with stage I and II disease who had no medical contraindications and adequate lung function.[4] At present only a small minority of people with NSCLC will have disease which is suitable for surgical resection.[5] There is evidence that surgical resection rates for lung cancer and survival from the disease vary between and within countries.[2 6–8] This variation is anecdotally attributed to geographical differences in patient features—for example, individuals from one area being older, presenting with late stage disease or having significant comorbidities which preclude an anaesthetic. Our intention was to adjust for all patient features and investigate whether the variation in outcomes at a hospital level were still evident.

In this study we have used the National Lung Cancer Audit (NLCA) dataset linked to Hospital Episode Statistics to quantify the influence of patient and NHS trust level features on access to surgery and survival for people with NSCLC in England. The NHS trust is the hospital where an individual is first seen, and 'trust level features' is the term used in this paper to describe markers of performance and the facilities available there. There are 157 NHS trusts in England and only 31 have thoracic surgery available on-site. There are 28 cancer networks in England. These networks cover a geographical area and bring together all those responsible for the commissioning and delivery of cancer care. Within each one there is a 'hub and spoke' system whereby specialist cancer centres, with thoracic surgeons available on-site, act as the 'hub' and provide specialist cancer services such as surgery and radiotherapy for the hospitals that compose the 'spokes'. Some thoracic centres are purely thoracic, others are cardiothoracic, but we have used the term 'thoracic surgical centre' as a means of describing the service they provide regardless of the subspecialty of the surgeons.

METHODS

Data for all English patients first seen between January 2004 and 31 December 2008 were downloaded from the NLCA for us by the NHS Information Centre for Health and Social Care. For this study we restricted our analyses to patients with a proven histological diagnosis of NSCLC. Our initial dataset included information on histological subtype, sex, age at diagnosis, socioeconomic status (census derived Lower Super Output Area Townsend Score), performance status (as classified by the Eastern Cooperative Oncology Group), stage at presentation (as classified by the American Joint Committee on Cancer and Union Internationale Contre le Cancer version 6), details of the NHS trust where a patient was first seen and whether surgical resection had occurred.

Although the NLCA records information on comorbid illness, these data are incomplete and are limited to only six disease groups. The audit records only whether or not the presence of this comorbid illness influenced the treatment decision. We therefore obtained permission to link the NLCA to Hospital Episode Statistics to provide information on inpatient episodes and diagnoses. The Hospital Episode Statistics dataset contains up to 20 diagnoses for each hospital episode coded using ICD-10, and our linked dataset covered the 11 financial years between 1997 and 2008. We used these data to calculate a Charlson Index,[9] which is a composite score of comorbidity which has been validated in cohorts of men and women with both malignant and non-malignant diseases. We excluded the ICD-10 codes for lung cancer in our calculations. To minimise bias resulting from reverse causation, we ignored the last 3 months of Hospital Episode Statistics data prior to the date of lung cancer diagnosis. This time period was arbitrarily chosen by the authors to avoid the bias that would arise if a patient appeared to develop a new comorbid disease shortly before the diagnosis of lung cancer was made and the two conditions were linked. We then divided the cohort into four groups on the basis of their Charlson score. We also used data from the Hospital Episode Statistics dataset to provide information on ethnicity.

In order to describe variation in the facilities available at NHS trusts, we created three binary variables: (1) whether or not a trust is a thoracic surgical centre; (2) whether or not it is a radiotherapy centre; and (3) whether or not the centre was actively entering patients into clinical trials for lung cancer. We defined a centre as being actively involved with lung cancer clinical trials if they were in the top 30% of trusts in terms of the proportion of their patients that were entered into clinical trials. To calculate these figures we used information supplied by the National Cancer Research Network on the number of trial participants for each NHS trust and our previous estimates of the total number of patients with lung cancer seen at each NHS trust.[10] A fourth binary variable thought to quantify the performance of the lung cancer multidisciplinary team was also created based on the results of the peer review process 2004–7. We took the overall score for each NHS trust and defined as 'excellent' any NHS trust which was in the top quartile. However, this was subsequently dropped from multivariate regression analyses due to the lack of evidence to support the assumption that it was influential.

We performed logistic regression analyses to estimate the ORs for receiving surgery, adjusting our analyses for all patient and NHS trust level features and clustering on NHS trusts. In order to look more specifically at variation in access to surgery in patients in whom we would expect to have a high chance of undergoing surgery, we repeated our analyses in a subgroup of patients with stage I or II disease.

For our survival analyses we used the date of diagnosis recorded in the NLCA as our start date where available and, in the absence of this, we interpolated a surrogate date of diagnosis using the date of first clinic appointment and the median interval between these dates for the cohort overall (10 days). The end date was either the date of death or the date of last data collection (30 September 2009). Because some patients with lung cancer are diagnosed at postmortem examination, we excluded people from the survival analysis when the date of death was the same as or earlier than the date of diagnosis. Cox regression analyses were used to calculate HRs and a multivariate model was constructed to mutually adjust for all patient and NHS trust features. The final Cox regression model included clustering by NHS trusts. We then repeated our survival analysis for the subgroup of patients with stage I and II disease as outlined above. We checked the proportional hazards assumption for our model by inspecting Nelson–Aaleen plots.

Finally, to determine whether people first seen at a thoracic surgical centre were different from those seen at a non-surgical centre, the demographic features of the two patient groups were compared and, for the subgroup of patients who had undergone surgery, we estimated survival according to where the patient was first seen.

RESULTS

Our NLCA dataset contained a total of 87 252 patients who were first seen at an English NHS trust between January 2004 and 31 December 2008. Histological diagnosis was based on a pretreatment histology examination as this would be the information available to multidisciplinary teams. Data in the early years of the NLCA were poorly completed and so 33 964 (42%) of this dataset had no pretreatment histology recorded. Small cell lung cancer accounted for 7845 patients (10%), 2772 (3%) had mesothelioma and 1872 (2%) had other diagnoses. There were 34 513 patients (43%) with a histological diagnosis of NSCLC; 33% of patients had squamous cell carcinoma, 27% had adenocarcinoma, 33% had NSCLC not otherwise specified and the remaining 7% had large cell tumours, bronchoalveolar cell carcinoma and carcinoma-in-situ. The median age at diagnosis was 71 years (IQR 63–77) and 60% were male. A total of 4485 patients (13%) underwent a surgical procedure. The median Charlson Index at diagnosis was 1 (IQR 0–2), with a minimum score of 0 and a maximum score of 17. There are 31 cardiothoracic surgical centres in England, 49 radiotherapy centres and 44 NHS trusts which were defined as trial active, which was equivalent to putting 5% of more of their patients with lung cancer into clinical trials. Among the thoracic surgical centres, 19 were also radiotherapy centres and 15 were trial-active. Twelve NHS trusts possessed all three features. Of the 34 513 patients, 9168 (27%) were first seen in thoracic surgical centres.

Access to surgery

Table 1 shows the results of univariate and multivariate logistic regression analyses for the associations between having surgery and patient and NHS trust features. As the Charlson Index increased, indicating a higher level of comorbid illness, the likelihood of having surgery decreased. The OR for having surgery, mutually adjusted for all patient and NHS trust features, for patients with a Charlson Index of ≥4 compared with patients with a Charlson index of 0 was 0.67 (95% CI 0.56 to 0.80). Patients in the fourth age quintile (76–80 years) were almost half as likely to undergo surgery as those in the youngest quintile (adjusted OR 0.56, 95% CI 0.49 to 0.56). Patients with

Table 1 Result of logistic regression analyses evaluating the influence of patient and NHS trust level features on the likelihood of receiving surgery clustered by NHS trust (n=34 513)

	No of patients	No who received surgery	(%)*	Unadjusted OR (95% CI)	Adjusted OR† (95% CI)	p Value
Sex						
Male	20 945	2637	13			
Female	13 568	1848	14	1.09 (1.02 to 1.17)	1.06 (0.99 to 1.15)	0.086
Age quintile						
1 (30–62 years)	8221	1290	16			<0.001‡
2 (63–69 years)	7635	1232	16	1.03 (0.95 to 1.13)	0.95 (0.85 to 1.05)	
3 (70–75 years)	7693	1050	14	0.85 (0.78 to 0.93)	0.79 (0.71 to 0.89)	
4 (76–80 years)	6115	652	11	0.64 (0.58 to 0.71)	0.56 (0.49 to 0.65)	
5 (81–100 years)	4849	261	5	0.31 (0.27 to 0.35)	0.26 (0.22 to 0.32)	
Stage						
IA	1178	722	61			0.001‡
IB	2138	1029	48	0.59 (0.51 to 0.68)	0.63 (0.52 to 0.76)	
IIA	202	121	60	0.94 (0.70 to 1.28)	0.96 (0.72 to 1.28)	
IIB	1448	515	35	0.35 (0.30 to 0.41)	0.35 (0.28 to 0.43)	
IIIA	2777	380	14	0.10 (0.09 to 0.12)	0.09 (0.07 to 0.11)	
IIIB	5427	297	5	0.04 (0.03 to 0.04)	0.03 (0.03 to 0.04)	
IV	10 968	271	2	0.02 (0.01 to 0.02)	0.02 (0.01 to 0.02)	
Occult	50	15	30	0.27 (0.15 to 0.50)	0.26 (0.13 to 0.52)	
Missing	10 325	1135	11	0.08 (0.07 to 0.09)	0.09 (0.07 to 0.12)	
Performance status						
0	5847	1651	28			<0.001‡
1	9282	1372	15	0.44 (0.41 to 0.48)	0.52 (0.46 to 0.59)	
2	5317	264	5	0.13 (0.12 to 0.15)	0.19 (0.15 to 0.24)	
3	3251	67	2	0.05 (0.04 to 0.08)	0.10 (0.08 to 0.14)	
4	760	13	2	0.04 (0.03 to 0.88)	0.11 (0.06 to 0.18)	
Missing	10 056	1118	11	0.32 (0.29 to 0.35)	0.40 (0.32 to 0.49)	
Ethnic group						
White	26 511	3443	13			0.39§
Black	234	27	12	0.87 (0.58 to 1.31)	0.84 (0.47 to 1.49)	
Asian	1905	262	14	1.07 (0.93 to 1.22)	1.13 (0.96 to 1.33)	
Mixed race	103	10	10	0.72 (0.37 to 1.38)	0.77 (0.33 to 1.78)	
Other	161	29	18	1.47 (0.98 to 2.20)	1.41 (0.88 to 2.27)	
Missing	5599	714	13	0.98 (0.90 to 1.07)	1.04 (0.92 to 1.17)	
Townsend quintile						
1 (most affluent)	5184	701	14			0.132‡
2	6393	856	13	0.99 (0.89 to 1.10)	0.99 (0.88 to 1.11)	
3	6660	872	13	0.96 (0.87 to 1.07)	1.04 (0.92 to 1.19)	
4	7148	942	13	0.97 (0.87 to 1.08)	0.98 (0.84 to 1.13)	
5 (least affluent)	9051	1110	12	0.89 (0.81 to 0.99)	0.86 (0.71 to 1.04)	
Missing	77	4	5	0.35 (0.13 to 0.96)	0.43 (0.15 to 1.23)	
Charlson Index						
0	15 573	2341	15			<0.001‡
1	6951	985	14	0.93 (0.86 to 1.01)	0.95 (0.86 to 1.04)	
2 or 3	5828	752	13	0.83 (0.77 to 0.91)	0.89 (0.80 to 0.99)	
4+	6161	407	7	0.40 (0.36 to 0.45)	0.67 (0.56 to 0.80)	
Surgery centre						
No	25 248	2947	12			
Yes	9265	1538	17	1.51 (1.41 to 1.61)	1.51 (1.16 to 1.97)	<0.001
Radiotherapy centre						
No	21 646	2614	12			
Yes	12 867	1871	15	1.24 (1.16 to 1.32)	1.02 (0.83 to 1.27)	0.854
Trial entry						
'Poor'	23 136	2817	12			
'Good'	11 377	1668	15	1.24 (1.16 to 0.32)	1.15 (0.88 to 1.50)	0.34

*Percentage of each variable who received surgery.
†OR for surgery adjusted for all other variables in the table.
‡p for trend.
§Result of a log likelihood ratio test.

more advanced disease stage and poorer performance status were also less likely to have surgery. There was no evidence that ethnic group or socioeconomic status influenced the likelihood of having surgery.

If a patient was first seen in a thoracic surgical centre they were 51% more likely to have surgery, even after adjusting for all of the patient level features (adjusted OR 1.51, 95% CI 1.16 to 1.97). There was some evidence that this difference between

surgical and non-surgical centres varied year on year (test for interaction, p=0.003), but there was no obvious trend over time as the ORs for 2004, 2005, 2006, 2007 and 2008 were 1.58 (95% CI 0.82 to 3.05), 2.50 (95% CI 1.57 to 3.88), 1.80 (95% CI 1.18 to 2.72), 1.11 (95% CI 0.76 to 1.64) and 1.47 (95% CI 1.09 to 1.99), respectively. In our multivariate analyses, whether the NHS trust was a radiotherapy centre or an active trial centre did not influence the likelihood of having surgery. The overall score at peer review had no influence on the likelihood of receiving surgery. Of those individuals first seen in an 'excellent' NHS trust, 943 (12%) had surgery compared with those first seen in a 'standard' NHS trust (adjusted OR 0.97 (95% CI 0.88 to 1.06)). We identified 4966 patients who had stage I or II disease, 2387 of whom (48%) had surgery. In these patients the likelihood of having surgery was 53% higher in patients first seen at NHS trusts that were thoracic surgical centres than in those seen in non-surgical centres (adjusted OR 1.53, 95% CI 1.09 to 2.13).

Survival analysis

A small number of patients (n=148) had a date of death on or before the date of diagnosis and so were excluded from the survival analyses. In our survival analyses women had a better prognosis than men but, as age, stage and performance status increased, the prognosis worsened (table 2). Patients with a Charlson Index score of ≥4 had an adjusted HR of 1.59 (95% CI 1.52 to 1.66) compared with those with a Charlson Index score of 0. There was no evidence that social deprivation was linked to worse survival. Whether the NHS trust where a patient was first seen was a thoracic surgical centre or not had no significant effect on overall mortality. The results of peer review had no effect on overall mortality (adjusted HR 1.01, 95% CI 0.98 to 1.04). There was no evidence that our proportional hazards assumption was incorrect.

Patients who had surgery had an almost 60% lower overall mortality (adjusted HR 0.41, 95% CI 0.39 to 0.44) compared with those who did not have surgery, even after adjusting for all patient features. In the subgroup of people with stage I or II disease where 48% had surgery, the fully adjusted HR was very similar at 0.41 (95% CI 0.37 to 0.46). The median survival for patients with stage I or II disease who had surgery was 774 days (IQR 305–2150) compared with a median survival of only 174 days (IQR 63–394) for those who did not have surgery.

The demographic features of patients first seen at thoracic surgical and non-surgical centres were similar (table 3), although the proportion of patients from the least affluent quintile of society was higher for the thoracic surgical centres than the non-surgical centres (p<0.001). Of the 4485 (13%) patients who had surgery, 34% were first seen in a thoracic surgical centre. Survival after surgery did not appear to be related to where the patient was first seen (adjusted HR 1.01, 95% CI 0.87 to 1.19).

DISCUSSION

Our results demonstrate that the likelihood of having surgery for patients with a histological diagnosis of NSCLC is independently influenced by patient level features including age, stage, performance status and comorbidity, and also by whether or not the patient is first seen at a thoracic surgical centre. Even after allowing for patient level features, those first seen at a surgical centre were 51% more likely to have an operation. This difference persisted among the subgroup of patients with early stage disease where surgery would be the preferred treatment modality and one might expect little variation in practice.

Our results also show that female sex, younger age, good performance status at diagnosis and early stage disease were all associated with better survival. By linking in information from Hospital Episode Statistics, we were also able to quantify comorbid illness relating to hospital admissions by calculating a Charlson Index and found that, as this score increased, survival became poorer. Whether or not an individual had surgery as part of their treatment plan was also an important determinant of survival, with those who did have surgery having a 60% reduction in their likelihood of death. This difference was identical in our subgroup of patients with early stage disease. In order to determine whether the higher surgical resection rates for patients first seen at thoracic surgical centres reflected these centres operating on patients with more advanced disease and/or a worse prognosis, we compared the patient features between people seen first at a thoracic surgical centre and those seen elsewhere. We found no difference in either survival or patient level features, with the exception that the thoracic surgical centres had a higher proportion of patients from more deprived backgrounds. This suggests that, if the clinical pathway was altered to ensure that the 73% of patients first seen at a non-surgical centre had the same chance of having surgery as those first seen at a thoracic surgical centre, this would increase the overall resection rate in this patient group from 13% to 17% with no detrimental impact on survival after surgery.

Although the NLCA is not mandatory, there is evidence within their annual reports that case ascertainment has increased steadily and is now in excess of 90%.[11–13] We have previously studied the validity of this dataset and have found no evidence of bias dependent on the levels of reporting by individual NHS trusts,[10] which provides reassurance that the dataset reflects the full spectrum of lung cancer in England. Although a large proportion of our cohort had missing data for histology, we were still able to analyse a subgroup of more than 30 000 patients with histologically-proven NSCLC. Alongside case ascertainment, data completeness has improved year on year.[11 12] Our marker of comorbid illness was derived from codes relating only to hospital admissions and so will not have captured details of conditions managed independently by general practitioners. This means that, despite being a strong predictor of both survival and having surgery, our calculated Charlson Indices may be too low and this raises the possibility of residual confounding by comorbidity. However, when we adjusted our model for surgical resection and site first seen, the OR for Charlson Index did not change at all, suggesting that comorbidity is not a confounder for this association. The distribution of Charlson Indices in this cohort is very similar to those in both general practitioner datasets[14] and cohorts of patients with NSCLC.[15 16] One potential weakness is that there is no information on whether some patients who were offered surgery declined this intervention. Our research does not represent a randomised controlled trial looking at the impact of surgery in patients with NSCLC, and there has never been such a trial. The National Lung Cancer Screening Trial (USA) was recently stopped because the primary outcome of a significant reduction in mortality from lung cancer was reached (>20%). This study compared chest x-ray with CT scanning and patients found to have lung cancer at a sufficiently early stage were treated surgically. This is the first time that screening has been shown to reduce mortality.[17] What we are able to report are observational data from a large unselected cohort which illustrate the survival advantage of surgery in spite of adjusting for many patient features. It is possible that our results are still subject to some residual confounding or selection bias and this may mean that the marked benefit of surgery we have observed may be an overestimate of the true benefit.

Table 2 Results of Cox regression analyses using all patient features, all NHS trust level features, surgical intervention or not and clustering by NHS trust (n=34 365)

	No of patients	No who died	(%)*	Unadjusted HR (95% CI)	Adjusted HR† (95% CI)	p Value
Sex						
Male	20 848	17 144	82			
Female	13 517	10 616	79	0.90 (0.88 to 0.92)	0.90 (0.88 to 0.92)	<0.001
Age quintile						
1 (30—62 years)	8183	6372	78			<0.001‡
2 (63—69 years)	7616	5897	77	1.02 (0.98 to 1.06)	1.04 (1.00 to 1.07)	
3 (70—75 years)	7660	6210	81	1.15 (1.11 to 1.19)	1.10 (1.06 to 1.14)	
4 (76—80 years)	6084	5068	83	1.28 (1.24 to 1.33)	1.17 (1.13 to 1.22)	
5 (81—100 years)	4822	4213	87	1.57 (1.51 to 1.64)	1.32 (1.26 to 1.39)	
Stage						
IA	1177	448	38			<0.001‡
IB	2137	1062	50	1.43 (1.28 to 1.60)	1.27 (1.11 to 1.46)	
IIA	202	79	39	1.03 (0.81 to 1.31)	1.00 (0.79 to 1.28)	
IIB	1446	905	63	2.08 (1.85 to 2.32)	1.71 (1.48 to 1.99)	
IIIA	2772	2083	75	2.82 (2.55 to 3.13)	1.98 (1.73 to 2.27)	
IIIB	5410	4564	84	4.09 (3.71 to 4.50)	2.67 (2.33 to 3.05)	
IV	10 913	10 106	93	6.37 (5.80 to 7.01)	3.85 (3.35 to 4.42)	
Occult	50	26	52	1.56 (1.05 to 2.31)	1.24 (0.83 to 1.86)	
Missing	10 258	8487	83	3.93 (3.57 to 4.32)	2.53 (2.19 to 2.91)	
Performance status						
0	5839	3804	65			<0.001‡
1	9267	7226	78	1.49 (1.43 to 1.55)	1.28 (1.22 to 1.33)	
2	5300	4737	89	2.50 (2.40 to 2.61)	1.87 (1.76 to 1.99)	
3	3230	3103	96	4.51 (4.30 to 4.74)	3.12 (2.91 to 3.35)	
4	737	722	98	7.62 (7.03 to 8.25)	5.21 (4.39 to 6.17)	
Missing	9992	8168	82	1.82 (1.75 to 1.89)	1.54 (1.45 to 1.62)	
Ethnic group						
White	26 408	21 488	81			0.0004§
Black	231	177	77	0.84 (0.72 to 0.97)	0.81 (0.70 to 0.93)	
Asian	1897	1433	76	0.98 (0.93 to 1.03)	0.95 (0.89 to 1.02)	
Mixed race	103	84	82	0.86 (0.77 to 1.18)	0.96 (0.79 to 1.18)	
Other	160	115	72	0.83 (0.69 to 1.00)	0.86 (0.73 to 1.02)	
Missing	5566	4463	80	1.03 (1.00 to 1.06)	1.05 (1.01 to 1.09)	
Townsend quintile						
1 (most affluent)	5172	4161	80			0.661‡
2	6363	5128	81	1.01 (0.97 to 1.05)	1.00 (0.96 to 1.05)	
3	6627	5345	81	1.03 (0.99 to 1.06)	1.00 (0.96 to 1.05)	
4	7115	5671	80	1.01 (0.97 to 1.05)	0.99 (0.94 to 1.03)	
5 (least affluent)	9011	7390	82	1.04 (1.00 to 1.08)	0.99 (0.94 to 1.05)	
Missing	77	65	84	1.12 (0.87 to 1.42)	0.87 (0.67 to 1.14)	
Charlson index						
0	15 536	12 105	78			<0.001‡
1	6931	5431	78	1.10 (1.06 to 1.13)	1.06 (1.02 to 1.09)	
2 or 3	5795	4592	79	1.16 (1.12 to 1.20)	1.07 (1.03 to 1.11)	
4+	6103	5632	92	2.00 (1.93 to 2.06)	1.59 (1.52 to 1.66)	
Surgery						
No	29 887	25 940	87			
Yes	4478	1820	41	0.24 (0.23 to 0.25)	0.41 (0.39 to 0.44)	<0.001
Surgery centre						
No	25 131	20 517	82			
Yes	9234	7243	79	0.91 (0.89 to 0.94)	0.95 (0.89 to 1.01)	0.09
Radiotherapy centre						
No	21 536	17 550	81			
Yes	12 829	10 210	80	0.97 (0.95 to 0.99)	1.02 (0.96 to 1.09)	0.539
Trial centre						
Poor	23 043	18 642	81			
Good	11 322	9118	81	0.98 (0.95 to 1.00)	1.01 (0.96 to 1.06)	0.734

*Percentage of patients in each variable who have died.
†Adjusted HR is adjusted for all other variables in the table.
‡p for trend.
§Result of a likelihood ratio test.

Table 3 Demographic features of patients with non-small cell lung cancer (NSCLC) based on where they were first seen (total number with NSCLC=34 513)

	Thoracic surgical centre N (%)	Non-surgical centre N (%)
Total	9265 (27)	25 248 (73)
Sex		
Male	5648 (61)	15 297 (61)
Female	3617 (39)	9951 (39)
Median (IQR) age (years)	70 (63–77)	71 (63–77)
Performance status		
0	1804 (19)	4043 (16)
1	2487 (27)	6795 (27)
2	1388 (15)	3929 (16)
3	824 (9)	2427 (10)
4	169 (2)	591 (2)
Missing	2593 (28)	7463 (30)
Stage		
IA	372 (4)	806 (3)
IB	582 (6)	1556 (6)
IIA	62 (0.7)	140 (0.5)
IIB	381 (4)	1067 (4)
IIIA	746 (8)	2031 (8)
IIIB	1388 (15)	4039 (16)
IV	3003 (32)	7965 (32)
Occult	16	34
Missing	2715 (29)	7610 (30)
Charlson Index		
0	4221 (46)	11 352 (45)
1	1784 (19)	5167 (20)
2 or 3	1564 (17)	4262 (17)
4+	1696 (18)	4465 (18)
Townsend quintile		
1 (most affluent)	1116 (12)	4068 (16)
2	1602 (17)	4791 (19)
3	1470 (16)	5190 (21)
4	1724 (19)	5424 (21)
5 (least affluent)	3339 (36)	5712 (23)
Surgery		
No	7727 (83)	22 301 (88)
Yes	1538 (17)	2947 (12)

The main strengths of this study are the large size and the quality of the NLCA dataset[10] and the addition of an independent comorbidity score in the form of the Charlson Index. The Charlson Index was originally developed and used prospectively in a cohort of people with breast cancer,[9] and it has subsequently been validated in patient cohorts encompassing both malignant[18 19] and non-malignant disease processes.[20] Previous research has shown that the Charlson comorbidity Index is associated with lung cancer incidence[21] and also survival.[22]

Our study found that patients with NSCLC who are first seen in a thoracic surgical centre have an advantage over those with similar disease seen at non-surgical centres with regard to access to surgery. We also found that having surgery had a large beneficial impact on survival, and this highlights the importance of access to this intervention. Previous research in this area in Scotland has shown that, as distance from a cancer centre increases, survival decreases,[23] suggesting that accessibility of services is a key factor in lung cancer outcome. Other research has shown that being first seen in a radiotherapy centre is associated with an increased likelihood of receiving 'active treatment',[24] and that being first seen in a specialist cancer centre is associated with a small improvement in overall survival.[25 26] There have been several large-scale reviews and policy documents in the UK designed to address inequality in cancer outcome including the Calman-Hine report,[27] the NHS Cancer Plan[28] and the Cancer Reform Strategy.[29] Creating specialist cancer centres has been pivotal to this programme of change and, while centralising services will create greater experience and expertise in one centre, it may potentially disadvantage individuals in remote settings and increase geographical inequalities. The results of our study suggest that more reforms are needed to ensure that all people with lung cancer have equal access to surgical intervention where this is appropriate.

CONCLUSIONS

The Department of Health has published guidance that that as many as 20% of patients with NSCLC may be suitable for surgical resection.[30] Our findings suggest that, if all patients with NSCLC had the same access to this intervention as those first seen at a thoracic surgical centre, the resection rates in England would increase from 13% to 17% with no detrimental impact on survival after surgery. However, what our study does not show is what aspects of 'being a surgical centre' are crucial to increasing resection rates. It is possible that this may simply be the presence of a surgeon on-site, but other aspects of the lung cancer service within these specialist centres may also be important such as the composition of the multidisciplinary team, improved access to specialist radiological and cardiovascular investigations and the geographical location of these thoracic surgical centres. Given the poor prognosis of lung cancer in the UK, understanding the care pathways in more detail and, in particular, the barriers to surgical intervention that currently exist for people seen in non-surgical centres is a pressing priority. The peer review data available at the time of this research did not influence clinical outcome measures in lung cancer, and further research is required to determine what performance measures should be collected in order to accurately describe variation in practice. As the NLCA matures, the addition of more specific information on the composition of local cancer centres and networks is essential to enable these questions to be answered.

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