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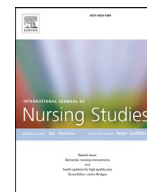
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Do working practices of cancer nurse specialists improve clinical outcomes? Retrospective cohort analysis from the English National Lung Cancer Audit[☆]

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ABSTRACT

Background: Cancer nurse specialists are advanced practitioners who offer continuity of care and expert support for people diagnosed with specific cancers. Health Education England's Cancer Workforce Plan prioritises expansion of cancer nurse specialist numbers by 2021 as part of the Cancer Taskforce Strategy for England.

Objective: To assess whether working practices of advanced practice specialist nurses are associated with clinical outcomes for people with lung cancer.

Methods: Adults with non-small cell lung cancer followed from 30 days post-diagnosis in English secondary care were obtained from the English National Lung Cancer Audit, 2007 to 2011. A national survey of lung cancer nurse specialists provided information on self-reported working practices. Mortality and unplanned admissions from 30 days to 12 months post diagnosis were respectively analysed using Cox and Poisson regression. Outcomes were assessed according to patients' receipt of initial assessments by a lung cancer nurse specialist and according to trust-level reported working practices. Regression models were adjusted for individual sociodemographic and clinical characteristics, error adjusted for intra-correlations within regional cancer networks, and presented separately according to patients' treatment pathways (surgery, chemotherapy, radiotherapy, or no anti-cancer therapy).

Results: Data for 108,115 people with lung cancer were analysed and associations with mortality and unplanned admissions were infrequent. Among people receiving only radiotherapy, however, the hazard for death was 17% lower among those who received an assessment by a lung cancer nurse specialist, compared with no assessment (hazard ratio = 0.83, 95% confidence interval 0.73–0.94; $p = 0.003$). The hazard was also lower among those receiving surgery (hazard ratio = 0.91, 0.84–0.99; $p = 0.028$). Among those receiving radiotherapy, nurse specialists' reported confidence within multidisciplinary team settings was associated with a lower risk of death (hazard ratio = 0.88, 0.78–1.00; $p = 0.049$) and a lower rate of unplanned cancer-related admissions (incidence rate ratio = 0.83, 0.73–0.95; $p = 0.007$). Lung cancer nurse specialist assessments before/at diagnosis, were associated with a 5% lower rate of unplanned admissions, compared to when assessments occurred after diagnosis.

Conclusion: The contribution of nurse specialist working practices was occasionally associated with better outcomes for people with lung cancer. These were not limited to a single treatment pathway, but do indicate discrete relationships within pathways. Our study provides initial measures of overall lung cancer nurse specialist working practices at trusts, however, more detailed studies with longitudinal measurement of lung cancer nurse specialist-patient interaction are needed to better ascertain impacts on long-term patient outcomes. The findings highlight opportunities for potential improvement in effectiveness of service and care management.

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What is already known about the topic?

- All patients should have access to a cancer specialist nurse, yet access is currently unequal.
- Nurse interactions can change likelihood of treatment received for lung cancer.
- Nurse Specialist workforce planning is a key factor in Health Education England's Cancer Taskforce Strategy.

What this paper adds

- Person-level nurse specialist interactions and trust-level workforce practices were associated with clinical outcomes for over 100,000 people with non-small cell lung cancer.
- Some specific associations with survival and unplanned hospital admissions were observed according to cancer treatment pathway.
- Initial evidence of cancer nurse specialist contributions to clinical outcomes can inform workforce planning, yet indicates further need to assess how nurse-patient interactions over time impact longer-term patient outcomes.

1. Introduction

Non-small cell lung cancer presents a significant burden for diagnosed individuals and health services, with only 38% of people surviving one year following diagnosis in the United Kingdom and low but varying five-year survival across Europe (RCP 2017, De Angelis et al., 2014). Presentation in the UK is often at late stage of disease or in frail individuals that are unlikely to undergo curative therapy. Unplanned hospital admissions present an additional burden on their lives that may be avoided through alternative care management initiatives (Leary and Baxter, 2014, Tsianakas et al., 2012).

Lung cancer nurse specialists are advanced practice nurses providing continuity of care across the cancer pathway, offering expertise within multidisciplinary settings and acting as individuals' key workers. Whilst there is wide variation in caseload size and a possible unmet need for those with advanced stage disease (Khakwani et al., 2016, Macmillan 2017), site-specific descriptive studies support the role of the lung cancer nurse specialist in advocating treatment and reducing emergency admissions for people with lung cancer (Leary and Baxter, 2014, Tod et al., 2015, Baxter and Leary, 2011). Equitable access to a lung cancer nurse specialist presents an opportunity to lessen lung cancer burdens on people and healthcare services.

Advanced practice nursing roles have developed in the UK over the last forty years, becoming common in cancer (Macmillan 2017) and established across Europe (Trueland, 2016). Frequently provided working practices are active symptom control, proactive management of care, psycho-social interventions and palliation (Baxter and Leary, 2011, Moore et al., 2006). In a large study of the English National Lung Cancer Audit, also known as the NLCA, we found variation across hospitals regarding the routine provision of such practices, yet we found no indication that availability was associated with the size of the lung cancer population served by the hospital nor with the anti-cancer facilities available (Stewart et al., 2018). Early integration of palliative care has been associated with improved survival in people with non-small cell lung cancer and represents a significant proportion of lung cancer nurse specialists' time in the United Kingdom (White, 2013, Handley et al., 2018).

In recognising National Institute of Health and Care Excellence guidelines (NICE 2011), Health Education England include cancer nurse specialists as a priority area for delivering the cancer strategy (NHSEngland 2017). Survival outcomes differ depending on treatment received; among people who are suitable for surgery, those who undergo resection can have a 70% reduction in risk of death compared with those who do not (Khakwani et al., 2013). Using the English National Lung Cancer Audit, we recently found that people were more likely to receive active treatment if they had an initial lung cancer nurse specialist assessment before or at the time of their lung cancer diagnosis (Stewart et al., 2018). Patients suitable for surgery were more likely to receive surgical resection if they were at trusts where the lung cancer nurse specialist team had manageable caseload sizes and were able to routinely provide key specialist nursing practices (Stewart et al., 2018). However, it is not clear whether lung cancer nurse specialist working practices are associated with longer-term clinical outcomes and how these may differ within a particular treatment pathway. We assessed whether lung cancer nurse specialist working practices were associated with mortality and unplanned hospital admissions in the English National Lung Cancer Audit to inform current workforce planning and future workforce policy.

2. Material and methods

2.1. Study design

An observational cohort study was performed retrospectively using routinely collected healthcare data made available for research. The data were from the National Lung Cancer Audit, also known as the NLCA, linked to official hospital admission data from the English Hospital Episode Statistics inpatient dataset, the National Cancer Action Team specialist nurse workforce census (NCAT 2012) and deaths from the Office for National Statistics. We also linked data from a bespoke survey completed by lung cancer nurse specialists on their self-reported working practices at hospital provider level (National Health Service trust).

2.2. Settings and participants

We included patients recorded in the Lung Cancer Audit Data, also known as LUCADA, with non-small cell lung cancer diagnosed between 2007 and 2011 who survived the initial 30 days following diagnosis. The Lung Cancer Audit Data pre-date the transition to including lung cancer in the current cancer registry system that is generic for all cancer types and draws clinical information from several embedded hospital systems. It was a bespoke audit system that included specific fields entered by hospital trusts for each patient. Audit fields individually reported each person's lung cancer nurse specialist assessment status (yes/no) and timing of assessment as before/at diagnosis versus after diagnosis. Where assessment data fields were missing, people were assigned to a separate category for analysis. To account for different care pathways following diagnosis, we assigned patients to one of four exclusive treatment pathways using a combination of Lung Cancer Audit Data and Hospital Episode Statistics data, applying procedural classifications previously described (Khakwani et al., 2016, Stewart et al., 2018): received surgery (resection with or without receipt of chemotherapy or radiotherapy), received chemotherapy (with or without receipt of radiotherapy), received radiotherapy alone, or did not receive active anti-cancer therapy. All treatments were categorised based on receipt for primary disease; detail to confirm palliative intent of radiotherapy was not available for these data. Clinical and sociodemographic characteristics of patients were also extracted from Lung Cancer Audit Data.

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2.3. Nurse-reported data on working practices (bespoke national survey)

Lung cancer nurse specialist working practices at each trust were declared in a national survey (Supplementary Document 1) with an average of 2.2 lung cancer nurse specialist responses per hospital trust (standard deviation ± 1.2) (Supplementary Table 1). We estimated a response rate of 65% of all lung cancer nurse specialist-whole time equivalents across England (76% where cancer nurse specialist was specified in the job title) with a range of 52.2% to 100.0% across strategic clinical networks (regional areas) using Macmillan workforce census data (Macmillan 2014) (Supplementary Table 2). Where a trust was not represented by a lung cancer nurse specialist response, through no participation or non-completion, it was assigned to an 'Unknown' category for analysis. As previously described (Stewart et al., 2018, Stewart et al., 2018), affirmative survey responses were aggregated by trust to represent the perspective of at least one lung cancer nurse specialist as an indication of key working practices available to their patient population. We assessed whether the lung cancer nurse specialist team reported confidence in challenging any member of the multidisciplinary team, and whether they could routinely provide key specialist working practices at diagnosis, follow-up (stable disease), or disease progression to at least 70% of their cases (Sections 16 and 18 of Supplementary Document 1). We assessed the routine provision of proactive management (regular contact with caseload to identify problems earlier) or formal holistic needs assessment (discussing what help people need and sign-posting support) which had shown to have disparity in provision between hospital trusts (Stewart et al., 2018) and had the potential to affect patient outcomes.

2.4. Statistical methods

Statistical analyses excluded people who died within 30 days of diagnosis as they were likely to be diagnosed at advanced stage and were unlikely to receive treatment or the benefits of ongoing lung cancer nurse specialist support due to their short survival. Among those who survived at least 30 days post-diagnosis, analyses of mortality and unplanned hospital admissions were performed from 30 days to 12 months post diagnosis. Because of the clear impact of treatment pathways on subsequent hospital admissions and survival, patients were analysed according to their treatment pathway (received surgery, received chemotherapy but no surgery, received radiotherapy alone, or did not receive active anti-cancer therapy, as described in Section 2.2 and (Khakwani et al., 2016, Stewart et al., 2018)).

For each of the 4 treatment pathways, Kaplan-Meier survival estimates were plotted according to whether patients had been assessed by a lung cancer nurse specialist and the timing of assessment, as reported in the Lung Cancer Audit Data. Cox regression was used to calculate hazard ratios for mortality associated with lung cancer nurse specialist assessment and working practices. Proportional-hazard assumptions were checked using Schoenfeld residuals. Incidence rate ratios for unplanned admissions according to lung cancer nurse specialist assessment and working practices were estimated using Poisson regression. We defined unplanned admissions as those that related to the patient's lung cancer by using Hospital Episode Statistics admission codes for neoplasms and/or respiratory related diseases in the primary diagnosis of the admission episode, coded using the International Classification of Diseases 10th Revision.

All analyses were performed initially as univariable models and then adjusted for a priori confounders: gender, age (<65, 65–75, >75 years), co-morbidity (0, 1, 2, 3+ using the Charlson Index), cancer stage (Union for International Cancer Control definition),

performance status (1–4 using the World Health Organisation/Eastern Cooperative Oncology Group score) and socioeconomic deprivation quintile (Townsend score). Regression estimates were generated using 30 regional cancer networks to derive robust standard errors for potential regional cluster correlations. Estimates are presented with 95% confidence intervals. All analyses were conducted using Stata Special Edition 15.0 (StataCorp 2015).

3. Results

We identified 108,115 individuals for analysis, grouped by the following treatment pathways: surgery (17,399), chemotherapy without surgery (36,789), radiotherapy alone (19,783) and no anti-cancer therapy (34,145). These people had survived at least 30 days following diagnosis and were matched across datasets.

3.1. Recorded specialist nurse assessments and clinical outcomes

The proportion of people not assessed by a lung cancer nurse specialist was low in all treatment pathways (surgery 3.3%; chemotherapy 2.0%; radiotherapy 3.3%; no therapy 7.9%). For people receiving surgery, Kaplan-Meier curves showed more than 75% of people surviving to one year, and no difference in survival between those who were and were not assessed by a lung cancer nurse specialist (Fig. 1). There was also little difference in median survival for people who received chemotherapy or no anti-cancer therapy. For people who received radiotherapy, median survival was 80 days (95% confidence interval 71–95) for people not assessed, compared with 155 days (95% confidence interval 149–160) for those receiving lung cancer nurse specialist assessment.

Regression models were adjusted for patient gender, age, co-morbidity, cancer stage, performance status and socioeconomic deprivation, for the associations of lung cancer nurse specialist assessment and working practices with mortality (Supplementary Table 3) and with unplanned hospital admissions (Supplementary Table 4). Supplementary tables show hazard ratios and incidence rate ratios with 95% confidence intervals and p-values for all adjusted analyses. Fig. 2 graphically summarises the adjusted hazard ratios for mortality and adjusted incidence rate ratios for unplanned admissions from these tables, showing the associations with lung cancer nurse specialist assessment for each of the four treatment pathways.

For most treatment groups, survival and unplanned hospital admissions were not associated with initial lung cancer nurse specialist assessment (Fig. 2). We did find an association between lung cancer nurse specialist assessment and mortality for people in the radiotherapy treatment pathway group, with a 17% reduction in the risk of death (\blacktriangle hazard ratio 0.83 95%CI 0.73–0.94) compared with people who were not assessed (Fig. 2, upper section). Among people who did not receive anti-cancer therapy, however, lung cancer nurse specialist assessment was associated with a higher rate of unplanned admissions (\blacksquare incidence rate ratio 1.12 95%CI 1.02–1.23).

Receiving a lung cancer nurse specialist assessment before/at diagnosis was associated with a lower risk of death for people who underwent surgery compared with those receiving assessment after diagnosis (\bullet hazard ratio 0.91 95%CI 0.84–0.99) (Fig. 2, lower section). When lung cancer nurse specialist assessment occurred before/at diagnosis, compared with after diagnosis, there was a lower rate of subsequent unplanned hospital admissions among patients in three of the four treatment pathways: surgery (\bullet incidence rate ratio 0.93; 95%CI 0.87–0.99), chemotherapy (\blacklozenge incidence rate ratio 0.94; 95%CI 0.91–0.98) no active anti-cancer therapy (\blacksquare incidence rate ratio 0.93; 95%CI 0.88–0.98).

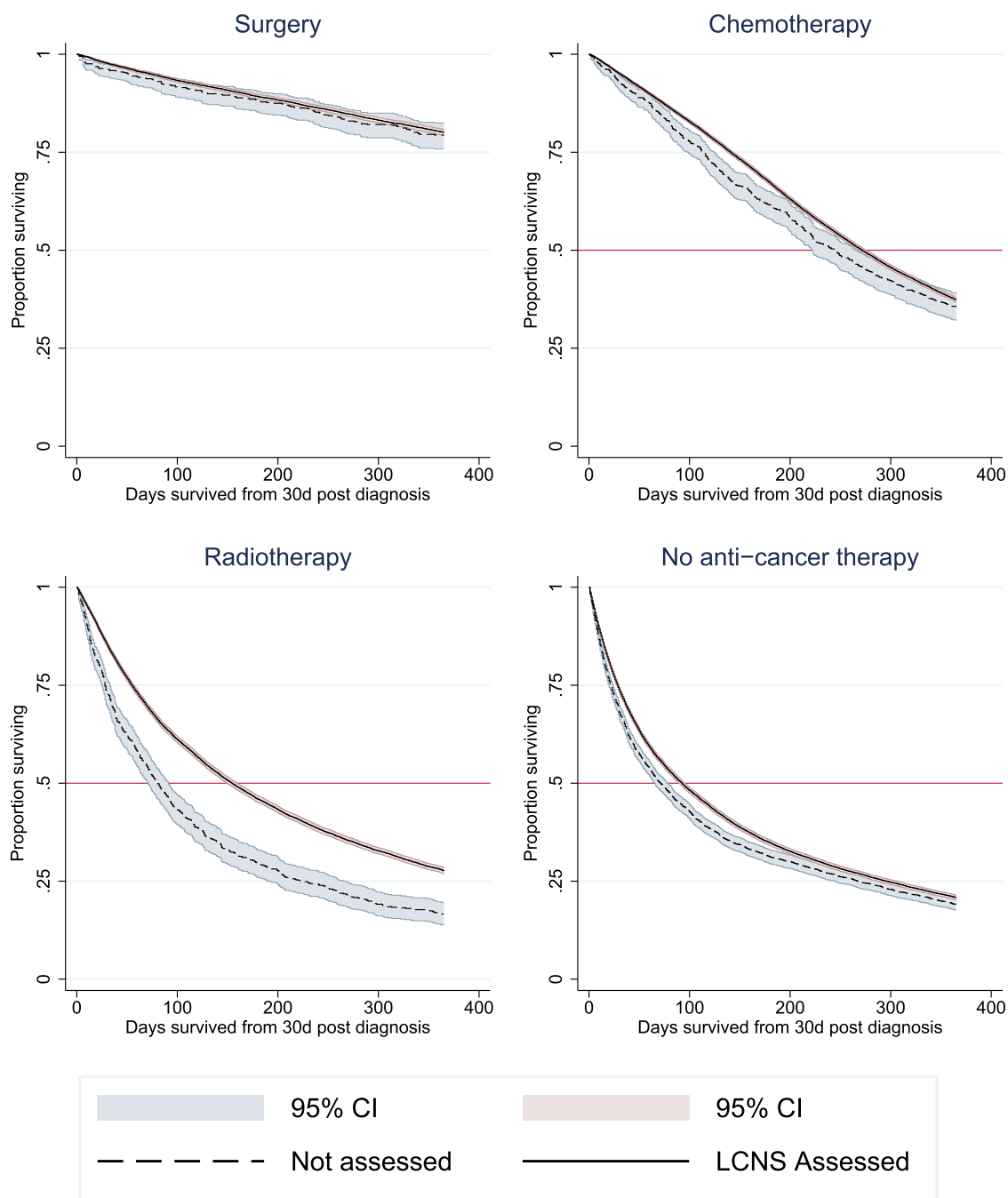


Fig. 1. Kaplan Meier survival estimates by treatment received. Fig. 1 legend. Unadjusted Kaplan Meier Curves of proportion surviving from 30 days post-diagnosis onwards. Survival is plotted according to whether people were assessed by a lung cancer nurse specialist (solid line) or not assessed (dashed line) with 95% confidence intervals (CI), for people within each treatment pathway. Horizontal reference line indicates median survival.

3.2. Reported specialist nurse working practices and clinical outcomes

Fig. 3 graphically summarises the adjusted hazard ratios for mortality and adjusted incidence rate ratios for unplanned admissions from Supplementary Tables 3 and 4, showing the associations with lung cancer nurse specialists' working practices for patients in each of the four treatment pathways. These working practices are based on the responses from the national lung cancer nurse specialist survey (as described in Section 2.3 and Supplementary Document 1).

For most treatment groups, routine provision of key lung cancer nurse specialist practices at a trust were not frequently

associated with survival or unplanned admission rates (Fig. 3). Among patients receiving chemotherapy, however, there was a lower risk of death for those in hospital trusts where lung cancer nurse specialist teams reported they could challenge any member within the multidisciplinary team (♦ hazard ratio 0.93 95%CI 0.88-0.99, Fig. 3 upper section). We also found associations for people in the radiotherapy treatment pathway, showing lower risk of death and fewer unplanned hospital admissions (▲ hazard ratio 0.88, 95%CI 0.78-1.00; ▲ incidence rate ratio, 0.83 95%CI 0.73-0.95, respectively) for those in trusts where lung cancer nurse specialist teams reported they could challenge any member within the multidisciplinary team (Fig. 3 upper section). Routine lung cancer

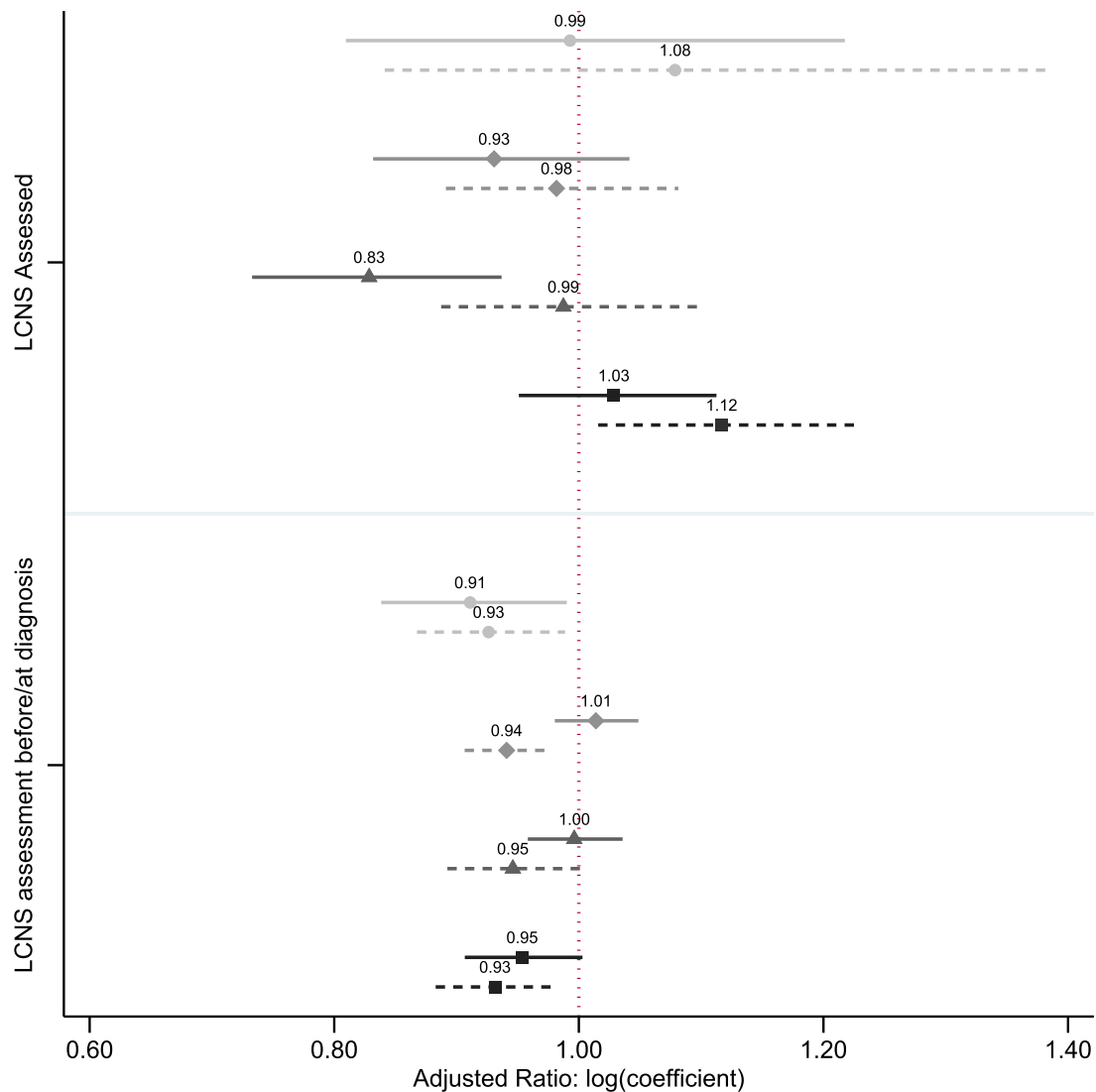


Fig. 2. Adjusted hazard ratios for death and adjusted incidence rate ratios for unplanned admissions according to lung cancer nurse specialist assessment as recorded in the National Lung Cancer Audit. Fig. 2 legend. Adjusted hazard ratios with 95% confidence intervals for death (solid lines) and adjusted incidence rate ratios with 95% confidence interval for unplanned cancer-related admissions (dotted lines). Comparisons are between patients receiving assessment by lung cancer nurse specialist (LCNS) relative to no assessment (upper section), and the timing of lung cancer nurse specialist assessment before/at time of diagnosis relative to after diagnosis (lower section). Ratios are separated according to patients' treatment pathways: ● surgery, ◆ chemotherapy, ▲ radiotherapy, ■ no anti-cancer therapy.

nurse specialist provision of holistic needs assessments at a trust was associated with a lower risk of death only for people in the radiotherapy treatment pathway (▲ hazard ratio 0.92 95%CI 0.82–1.00, Fig. 3, middle section), whilst routine provision of proactive management was associated with a higher risk of death for people in the surgery treatment pathway (● hazard ratio 1.10 95%CI 1.01–1.20, Fig. 3, lower section).

3.3. Consistency and discrepancy in missing data

For some patients, the initial lung cancer nurse specialist assessment field was missing, so it was not possible to establish whether or not they had a lung cancer nurse specialist assessment or the timing of assessment in relation to diagnosis (Stewart et al., 2018). Results for people who were missing lung cancer nurse specialist assessment information in the National Lung Cancer Audit were largely similar to people who received a lung cancer nurse specialist assessment; likewise results for people who were first seen at a trust where working practices were unknown were similar to where provision was routine (Supplementary Tables 3, 4).

4. Discussion

This study provides the first assessment in a nationally representative sample of people with non-small cell lung cancer, of how key lung cancer nurse specialist working practices may affect longer-term health outcomes. We used the English National Lung Cancer Audit to assess whether reported lung cancer nurse specialist assessments for patients and routine provision of key lung cancer nurse specialist working practices in hospital trusts were associated with survival and unplanned hospital admissions in the year following diagnosis. Whilst these health outcomes were not frequently associated with initial lung cancer nurse specialist assessments nor with trusts reporting routine provision of key lung cancer nurse specialist working practices, the modest number of findings offer insight into the potential impact of lung cancer nurse specialist working practices in terms of measurable benefit. Where we did observe lung cancer nurse specialist assessments and working practices to be associated with reduced survival or lower rates of unplanned admissions, these were not limited to a single treatment pathway. For people who received radiotherapy

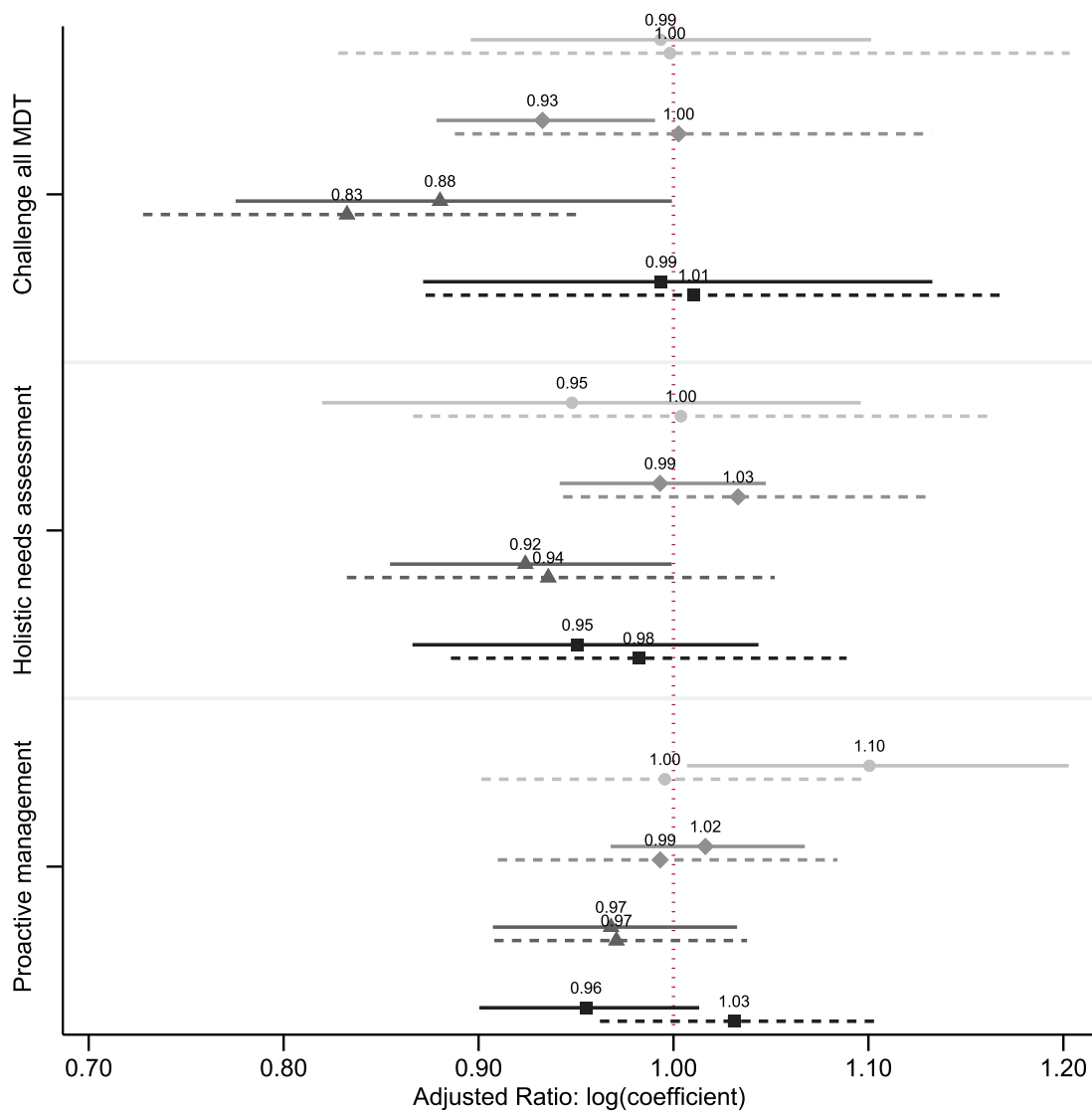


Fig. 3. Adjusted hazard ratios for death and adjusted incidence rate ratios for unplanned admissions according to routinely provided lung cancer nurse specialist practices ascertained in nationwide survey of specialist nurses. Fig. 3 legend. Adjusted hazard ratios with 95% confidence intervals for death (solid lines) and adjusted incidence rate ratios with 95% confidence interval for unplanned cancer-related admissions (dotted lines). Comparisons are between patients in trusts where: the majority of the lung cancer nurse specialist team was confident in challenging all multidisciplinary team (MDT) members relative to not confident (upper section); holistic needs assessment was routinely provided relative to not routine (middle section); proactive management was routinely provided compared to not routine (lower section). Ratios are separated according to patients' treatment pathways: ● surgery, ◆ chemotherapy, ▲ radiotherapy, ■ no anti-cancer therapy.

in particular, lung cancer nurse specialist assessment and effective multidisciplinary team practice were associated with increased survival and fewer unplanned admissions.

4.1. Strengths and limitations

Guidelines from the National Institute of Health and Care Excellence indicate that a lung cancer nurse specialist should be available at all stages of care to support people with lung cancer and their carers (NICE 2011). The National Lung Cancer Audit records information on a person's initial assessment with a lung cancer nurse specialist and proportions of people not assessed were low in all treatment groups. Non-avoidable reasons for the absence of an assessment may add bias, however we conducted our analyses observing National Institute of Health and Care Excellence guidelines that all people with lung cancer should be assessed by a lung cancer nurse specialist (NICE 2011). To our knowledge, there are no current data sources that provide

detailed information of lung cancer nurse specialist practices and patient interaction over time, alongside patient health outcomes for large representative patient populations. We used UK national healthcare databases, collected by the NHS as part of the care and support provided to service users, offering real world insights into the association of lung cancer nurse specialist practices and outcomes of people with cancer. We were able to adjust all measures of association for patients' sociodemographic and clinical characteristics, however, we acknowledge with the large number of analyses that chance findings can arise. Large scale routinely collected observational data are also limited by a lack of granular clinical decision detail and the presence of missing fields.

Previous analyses using National Lung Cancer Audit Data have shown that people with missing information for lung cancer nurse specialist assessment have almost the same demographic and clinical profile as patients who have been recorded as receiving lung cancer nurse specialist assessment, with only a small proportion recorded as not being assessed (Khakwani et al., 2016). Whilst we

cannot say definitively that patients with missing information have had an assessment, based on this analysis and the proportion with those recorded as having no lung cancer nurse specialist assessment, it is likely that patients with a missing field were missing at random and that the majority would have been assessed by a lung cancer nurse specialist. Improvements in treatment pathways over time may have affected the findings as the proportion of assessed individuals increased across the years of the study whilst missing proportions decreased, and those recorded as having no assessment increased by a small amount from 3% in 2007 to 6% in 2011 (Khakwani et al., 2016).

We acknowledge that audit information does not capture detailed information on lung cancer nurse specialist interaction following diagnosis such as the number of assessments, instances of nurse contact across the pathway, or types of support provided, so our measure of lung cancer nurse specialist assessment is relatively crude. We also used differences in lung cancer nurse specialist-reported working practices to provide insight into the key interventions that people may receive beyond initial recorded assessments. Routine provision of key working practices was measured at trust level and thus did not capture whether individuals specifically received holistic needs assessments or proactive management. As such, this study should be considered as an initial assessment requiring further research in this area to obtain longitudinal data collection on patient-specialist nurse interaction.

Survey linkage offers important aggregated information on lung cancer nurse specialist practices that may contribute to health outcomes for people with lung cancer, or may be indirectly associated owing to clinical ways of working and resource availability where key lung cancer nurse specialist working practices are routinely offered. Our analysis of lung cancer nurse specialist-reported working practices did not enable a direct evaluation of the relationship between the lung cancer nurse specialist and the person with lung cancer, unlike National Lung Cancer Audit Data, but provides a useful initial evaluation of workforce practice. The majority of the lung cancer nurse specialist workforce was represented in responses to the nationwide survey (Supplementary Document 1) although self-selection bias may have occurred; it is conceivable that the time required to respond and complete the survey may have been restricted for nurses in trusts where other workload pressures were greatest and these workload pressures may have also affected routine provision of key practices. Our previous study, however, showed that trusts not represented by a survey response were not different with regard to availability of anti-cancer facilities, lung cancer nurse specialist salary banding or lung cancer nurse specialist caseload size; although trusts without specialist anti-cancer treatment facilities and with lower salary-banded teams were slightly underrepresented (Stewart et al., 2018).

Patients included in the National Lung Cancer Audit are assigned to the hospital trust where they were first seen, which is in most cases where they are diagnosed and treated. Defining lung cancer nurse specialist working practice at a hospital trust where the individual is first seen is limited by the assumption that they follow the local pathway, which does not account for referred care. It does, however, ensure a focus on the key-worker role that the initial lung cancer nurse specialist assumes upon first contact (McPhillips et al., 2014). Although reported working practices aggregated at trust level may not always represent the experiences of the entire caseload, our analyses provide a unique large-scale perspective previously unaccounted for.

We assessed hospital admissions occurring between 30 days and 12 months after diagnosis, minimising impact from diagnostic-related admissions, and providing opportunity for lung cancer nurse specialist contact. Immortal time bias was minimised by excluding people who died within 30 days of diagnosis as lung cancer nurse specialist practices would be unlikely to influence

early clinical outcomes in late stage disease. Standard errors were adjusted for clustering of trusts within regional cancer networks, resulting in wider confidence intervals and more conservative estimates. We adjusted our analyses for a number of clinical and sociodemographic factors and assessed effects separately for different treatment pathways to minimise the impact of these factors on hospital admissions and survival. We acknowledge, however, that other clinical workforce practices and unmeasured clinical variables not assessed in our study also influence patients' health outcomes. Routine provision of key lung cancer nurse specialist working practices could also represent other good practices or organisation at trust level. We believe our study provides an important initial step in addressing specialist nurse contributions to clinical outcomes, yet further studies into patient reported outcome measures may offer insight into perceived team work and outcomes for people with lung cancer (Nartey et al., 2019).

4.2. Influence of working practices on clinical outcomes and care quality

Associations with lung cancer nurse specialist practices were most frequently observed for people who received radiotherapy, including lower risk of mortality over the year following diagnosis for patients who received a lung cancer nurse specialist assessment and those first seen at a trust where the lung cancer nurse specialist team routinely offered holistic needs assessments. For these patients, lower rates of unplanned admissions were associated with having a lung cancer nurse specialist assessment before or at their lung cancer diagnosis, and with being in a trust where lung cancer nurse specialist teams reported they could challenge any member within the multidisciplinary team. These findings could indicate lung cancer nurse specialist working practices particularly benefit people who are not fit for surgery or chemotherapy. They may alternatively reflect a discrepancy in people prioritised for assessment within the healthcare system, with those likely to benefit from lung cancer nurse specialist practices and radiotherapy receiving assessment, highlighting possible inequities that should be explored. Outcomes for the radiotherapy treatment group will be more variable in future datasets with advanced techniques, such as stereotactic ablative radiotherapy (SABR), resulting in inclusion of people with both good and poor performance status (Snee et al., 2016).

Individuals who undergo surgical resection for non-small cell lung cancer are largely diagnosed at an early stage with good performance status. Within the group receiving surgery, those who received an early lung cancer nurse specialist assessment had a lower risk of mortality and unplanned hospital admissions. We have previously found that lung cancer nurse specialist caseload pressures could contribute as a barrier to receipt of surgery (Stewart et al., 2018). Although we do not assume the direction of causation, it is possible that those with earlier assessments can be appropriately managed with greater chance for the necessary time to discuss treatment concerns, readiness and rehabilitation (Tod et al., 2015, Powell et al., 2015, Powell et al., 2014). This may alternatively reflect overall good practice by the lung cancer team. The finding that provision of proactive management was associated with a 10% greater risk of death for people who underwent surgery may reflect the lung cancer nurse specialist's ability to advocate prehabilitative options and undertake proactive efforts to support decisions and readiness for curative treatment, even in those who are borderline (Tod et al., 2015, Wynter-Blyth and Moorthy, 2017).

Cancer care in England is delivered using a team-based approach. The importance of assessing confidence and willingness of the lung cancer nurse specialist to constructively challenge other members of the multidisciplinary team has been demonstrated, in particular to enable advocating for the patient's own view

of their needs (Punshon et al., 2017, Crohns&ColitisUK 2017), yet the relationship between multidisciplinary team culture and longer-term patient outcomes has been less clear. The ability of the lung cancer nurse specialist to champion individual needs in inclusive and well-managed multidisciplinary team settings can lead to quantifiable benefit (Tod et al., 2015).

A recent National Lung Cancer Audit 'Spotlight Audit' demonstrated that among people with early stage non-small cell lung cancer who did not receive surgery, 31% opted out due to personal choice rather than suitability and half the sample did not choose a therapy with curative intent (RCP 2018). For people not receiving anti-cancer therapy in our study, our findings appear contradictory, which could reflect that this is a mixed clinical group in terms of fitness for treatment and personal choice against treatment. Patients receiving an initial lung cancer nurse specialist assessment had a higher rate of unplanned admissions compared with patients who had no lung cancer nurse specialist assessments. Among those who had an assessment, however, if this was an early assessment (before or at diagnosis, compared with after) they had fewer unplanned admissions. As we have acknowledged, this measure of lung cancer nurse specialist assessment does not capture the ongoing interaction between the patient and the lung cancer nurse specialist. It is possible, however, that increases in hospital admissions reflected better individual health awareness and communication with the lung cancer nurse specialist, who may have been a point of contact for integrated palliative care (White, 2013, Handley et al., 2018). In a US study, a nurse practitioner dedicated one slot in the daily schedule for urgent appointments, reducing unplanned hospitalizations for symptom-related care by 31% (Handley et al., 2018). Alternative services for people to access lung cancer nurse specialist care and expertise, such as specialist follow-up clinics or virtual community support (Moore et al., 2006, McPhillips et al., 2014, Basch et al., 2007, Greenhalgh et al., 2018), may reduce reactive practices and achieve better management without leading to an unplanned hospital admission (Leary and Baxter, 2014, Stewart et al., 2018, Handley et al., 2018).

We used accepted clinical outcomes of mortality and unplanned admission rates to assess how lung cancer nurse specialist working practices may lead to improvements for patients, however it is important to note that the role of the lung cancer nurse specialist is to focus on quality of care as a whole. This is conceptually difficult to measure and we used clinical outcomes as well as nurse-reported interventions as indicators of practice and patient outcomes. Good practice is therefore not distinguishable from specific interventions in this analysis. Studies into the National Cancer Patient Experience Survey may elucidate the impact of specialist nursing on quality of life for people with lung cancer (Abel et al., 2016).

4.3. Impact of findings on workforce planning

Phase 1 of Health Education England's Cancer Workforce Plan prioritises expansion of cancer nurse specialist numbers by 2021 (NHSEngland 2017), in line with the Cancer Taskforce Strategy for England and addressing perceived challenges to its success (Macmillan 2017). Operational workforce planning and staff retention is a focus for NHS Improvement, however, the most recent workforce census conducted in 2017 by Macmillan highlights large regional variations in vacancy rates and nurse specialist caseloads (Macmillan 2017). The most recent data from the National Lung Cancer Audit indicate that the commissioning guidance of one whole time equivalent lung cancer nurse specialist per 80 new diagnoses per year was still only being met by 32% of units in 2019 (compared with 19% in 2017) (Royal College of Physicians 2020). Although efforts have been made to measure working practice in this study, we emphasise that agreed upon, routinely-collected

metrics to model nurse-patient interaction are necessary to predict the impact of resourcing challenges.

Whilst our study did not show consistent associations between routine provision of key lung cancer nurse specialist working practices by trusts and long-term health outcomes, these findings provide some initial quantitative evidence of the contribution of the specialist cancer nurse workforce within specific treatment pathways, which could be utilised by commissioners. It also provides weight to the argument that stochastic, flexible frameworks to model the workforce may yield more intelligent solutions and more effective workforces (Harper, 2002), providing advanced nurse practitioners more focus on clinical responsibilities. National Institute for Health and Care Excellence guidelines note that lung cancer nurse specialist-led follow-up should be offered to people with lung cancer with a life expectancy of more than 3 months (NICE 2011). Trials in prostate cancer suggest digital technologies and virtual clinics could be effective at managing disease progression and individual concerns, whilst improving workforce efficiency (Viers et al., 2015).

CRedit authorship contribution statement

Iain Stewart: Formal analysis, Software, Data curation, Investigation, Writing - original draft. **Alison Leary:** Resources, Writing - review & editing. **Aamir Khakwani:** Software, Resources, Data curation. **Diana Borthwick:** Writing - review & editing. **Angela Tod:** Writing - review & editing. **Richard Hubbard:** Conceptualization, Writing - review & editing, Funding acquisition. **Paul Beckett:** Conceptualization, Writing - review & editing, Funding acquisition. **Laila J. Tata:** Conceptualization, Funding acquisition, Supervision, Project administration, Writing - review & editing.

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Conflict of Interest

IS, AT, AL & DB have no conflict of interest. PB is funded by the Healthcare Quality Improvement Partnership (HQIP) to act as a clinical lead for the National Lung Cancer Audit. LT has conducted the statistical analyses for the National Lung Cancer Audit annual reports from 2009 to 2013, which was funded by the NHS Information Centre. AK has conducted the analysis for National Lung Cancer Audit annual reports 2014 to current, including the pleural mesothelioma reports and Lung Cancer Clinical Outcomes Publications, funded by the Royal College of Physicians. LT and AK have not received any personal earnings from the NHS HSCIC for this work. RH has a grant provided by the British Lung Foundation chair of respiratory epidemiology.

Role of the funding source

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Author statement

The conception of the study was by LJT, RH, AL and PB. The lung cancer nurse specialist survey was designed by LJT and AL.

AK acquired and managed the data from the Health and Social Care Information Centre, all analysis was performed by IS. IS, LJ, AK, PB and RH were involved in the data interpretation. AL, AT and DB provided lung cancer nurse specialist expertise. The paper (including the initial draft) was written by IS. All authors contributed to and critically reviewed the manuscript, approving it prior to submission.

Data statement

The patient data that support the findings of this study are available from Public Health England Office for Data Release but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. National Cancer Action Team data are publicly available online and survey data are available from the authors upon reasonable request.

Ethics approval

The data were obtained from the Healthcare Quality Improvement Partnership. Ethical approval from the University of Nottingham medical school research ethics committee was obtained by the researchers to work on a linked Hospital Episode Statistics and National Lung Cancer Audit Data (RU943 177570-MV6J3). The National Lung Cancer Audit has Ethics and Confidentiality Committee (ECC) approval to use patient information from the National Health Services. Finally for this specific set of work, we also obtained approval from the Healthcare Quality Improvement Partnership who commissioned the audit, and the Health and Social Care Information Centre Caldicott guardian signed off the data sharing agreement [IG Reference: IC381DS]. The data were anonymised in the linked dataset by the Health and Social Care Information Centre personnel prior to being given to the researchers.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.ijnurstu.2020.103718](https://doi.org/10.1016/j.ijnurstu.2020.103718).

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