Lung cancer deaths (England 2001–2017)—comorbidities: a national population-based analysis

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ABSTRACT

Background The presence of comorbidities in people with lung cancer is common. Despite this, large-scale contemporary reports describing patterns and trends in comorbidities are limited.

Design and methods Population-based patterns and trends analysis using Office for National Statistics Mortality Data. Our cohort included all adults who died from lung cancer (ICD-10 codes C33–C34) in England between 2001 and 2017. We describe decedents with 0, 1 or ≥2 comorbidities and explore changes over time for the six most common comorbidities identified: chronic respiratory disease; diabetes; cardiovascular disease; dementia; cerebrovascular disease and chronic kidney disease. To determine future trends, the mean annual percentage change between 2001 and 2017 was calculated and projected forwards, while accounting for anticipated increases in lung cancer mortality.

Results There were 472,259 deaths from lung cancer (56.9% men; mean age 72.9 years, SD: 10.7). Overall, 19.0% of lung cancer decedents had 1 comorbidity at time of death and 8.8% had ≥2. The proportion of patients with comorbidities increased over time—between 2001 and 2017 decedents with 1 comorbidity increased 54.7%, while those with ≥2 increased 294.7%. The most common comorbidities were chronic respiratory disease and cardiovascular disease, contributing to 18.5% (95% CI: 18.0 to 18.9) and 11.4% (11.0 to 11.7) of deaths in 2017. Dementia and chronic kidney disease had the greatest increase in prevalence, increasing 311% and 289% respectively.

Conclusion To deliver high-quality outcomes for the growing proportion of lung cancer patients with comorbidities, oncology teams need to work across traditional boundaries of care. Novel areas for development include integration with dementia and chronic kidney disease services.

BACKGROUND

As our population ages, mortality from lung cancer—the most common cause of cancer-related deaths worldwide—is increasing. Between 2020 and 2040, lung cancer deaths are predicted to increase 37.3% in the UK and 63.8% globally.1 The demographics of lung cancer patients are also changing over time with the average patient becoming older and more likely to be living with one or more long-term health conditions at time of diagnosis.2 3

The negative impact of ageing and multimorbidity (defined as the presence of two or more long-term health conditions)4 on outcomes for lung cancer patients has been widely reported.5 Studies have found older patients are less likely to receive recommended anticancer therapies at diagnosis6 and throughout their illness,7 while the presence of...
comorbidities is associated with greater use of acute hospital services, lower health-related quality-of-life and increased mortality. Present-day healthcare systems, where individual diseases determine models of service delivery, often results in care that is fragmented, unsafe and inefficient for those with comorbidities. For patients and their families, attending the hospital multiple times for different conditions can be burdensome, resulting in polypharmacy and the receipt of contradictory medical advice. For healthcare professionals, caring for multimorbid patients can be overwhelming, including for oncologists who lack sufficient time to provide high-quality holistic care that incorporates broader health maintenance activities alongside anticancer treatment and monitoring.

With the increasing prevalence of multimorbidity, oncology services need to urgently adapt to meet the changing needs of their patient population as well as address current inequities in care. Understanding patterns and trends in comorbidities is important for healthcare planning and policy. Despite this, large-scale contemporary reports describing comorbidities in people with lung cancer are lacking. We therefore conducted the following study, the aim of which was to determine the patterns as well as actual and projected trends in comorbidities for lung cancer decedents in England.

METHODS
Our study is reported according to the RECORD statement.

Approval for the study and access to the data was received from the UK’s Office for National Statistics (ONS). As per ONS procedures, a Data Access Agreement was signed with requisites for data management and protection. In addition, all researchers accessing the data (LAH, WG and EC) were individually assessed and approved by ONS. As all data were fully anonymised, no additional approvals were required to complete the analysis according to the Information Commissioner’s Office guidelines, ONS procedures and those of King’s College London Research Ethics Committee.

Study design and datasets
We conducted a population-based patterns and trends analysis using ONS Mortality Data for England. The ONS is the UK’s largest independent producer of official statistics and is the recognised national statistical institute of the UK. Its Mortality Database holds information on all UK deaths including the ‘underlying cause of death’ and up to 15 ‘contributing’ causes of death. Coding is carried out according to internationally agreed rules and using the WHO’s Tenth Revision of the International Classification of Diseases and Related Health Problems (ICD-10). The ONS Mortality Database also contains basic demographic information such as the decedent’s age at death, gender and marital status.

National government statistics reporting the relative deprivation between neighbourhoods in England were used to derive information on decedents’ socioeconomic status.

The English Indices of Multiple Deprivation (IMD) version 2010 was linked to ONS Mortality data 2001 to 2010 and the IMD version 2015 was linked to data for 2011 to 2017.

Participants and variables
Our cohort included all adults (≥18 years at time of death) who died from lung cancer (underlying cause of death listed as ICD-10 codes C33 or C34) in England between 2001 and 2017. Descriptive variables were categorised as follows: age at death (<55; 55–64; 65–74; 75–84; 85+ years); gender (male; female); marital status (divorced/separated; married; single; widowed; unknown); socioeconomic status (IMD quintiles, 1, most deprived; 5, least deprived).

Analysis/statistical methods
For each lung cancer decedent, we examined all contributing causes of death listed on their death certificate. We excluded the following contributing causes from our analysis: accidents; minor ailments; acute and/or self-limiting conditions such as infections; conditions related to cancer, for example, bone metastases; as these were not considered comorbidities—a comorbidity being defined as a co-occurring chronic condition or disease expected to impair a patient’s long-term survival. All remaining contributing causes of death were conditions recognised as comorbidities—these were counted, and decedents categorised into those with zero, one or two plus comorbidities. Based on the findings of recent studies, we next considered six commonly recorded comorbidities and explored how their prevalence changed over time. These were: chronic respiratory disease (ICD-10 codes J4, J6, J7, J82 and J84); diabetes (E10-E14); cardiovascular disease including hypertension (I1, I20, I25, I7 and I8); dementia (F00, F01, F02, F03, G30-G32 and R54); cerebrovascular disease (I6) and chronic kidney disease (N11, N18 and N19). For future projections, we calculated the mean annual percentage change in comorbidities between 2001 and 2017 and projected this forward to 2040 while accounting for anticipated increases in lung cancer mortality.

All data were analysed using Microsoft Excel for Office 365 and Stata/IC 13 (STATA, College Station, TX).

RESULTS
In England, between 2001 and 2017, there were 472,259 deaths from lung cancer (ICD-10 codes C33 and C34). Mean age at death was 72.9 years (SD: 10.7); 56.9% of deaths were in men. Table 1 presents the demographic characteristics of the study population.
### Table 1  Cohort characteristics (n=472 259)

| Total       | Total sample | 2001–2005 | 2006–2010 | 2011–2015 | 2016–2017 |
|-------------|--------------|-----------|-----------|-----------|-----------|
| N (%)       | N (%)        | N (%)     | N (%)     | N (%)     | N (%)     |
| 472 259     | 100          | 133 981   | 100       | 139 595   | 100       | 142 590   | 100       | 56 093     | 100       |

**Age in years at time of death, mean (min;max)**

| Category | Total sample | 2001–2005 | 2006–2010 | 2011–2015 | 2016–2017 |
|----------|--------------|-----------|-----------|-----------|-----------|
| <55      | 25 243       | 8227      | 7 520     | 6 926     | 2 570     |
| 55–64    | 75 498       | 22 677    | 23 775    | 21 697    | 7 759     |
| 65–74    | 146 059      | 41 897    | 41 512    | 44 554    | 18 096    |
| 75–84    | 161 510      | 47 977    | 48 221    | 46 803    | 18 509    |
| 85+      | 63 949       | 13 613    | 18 567    | 22 610    | 9 159     |

**Gender**

| Category | Total sample | 2001–2005 | 2006–2010 | 2011–2015 | 2016–2017 |
|----------|--------------|-----------|-----------|-----------|-----------|
| Female   | 203 641      | 53 766    | 60 119    | 64 061    | 25 695    |
| Male     | 268 618      | 80 215    | 79 476    | 78 529    | 30 398    |

**Number of comorbidities**

| Category | Total sample | 2001–2005 | 2006–2010 | 2011–2015 | 2016–2017 |
|----------|--------------|-----------|-----------|-----------|-----------|
| 0        | 340 764      | 1,07 229  | 1,03 653  | 94 904    | 34 978    |
| 1        | 89 894       | 20 577    | 25 576    | 30 947    | 12 794    |
| 2+       | 41 601       | 6 175     | 10 366    | 16 739    | 8 321     |

**Marital status**

| Category            | Total sample | 2001–2005 | 2006–2010 | 2011–2015 | 2016–2017 |
|---------------------|--------------|-----------|-----------|-----------|-----------|
| Divorced/separated  | 59 262       | 13 109    | 16 809    | 20 598    | 8746      |
| Married             | 239 150      | 70 544    | 71 209    | 70 327    | 270 70    |
| Single              | 33 150       | 8 896     | 9 357     | 10 473    | 4424      |
| Widowed             | 137 802      | 40 585    | 41 362    | 40 384    | 15 471    |
| Unknown             | 289 5        | 847       | 858       | 808       | 382       |

**Socioeconomic status (IMD quintile)**

| Category               | Total sample | 2001–2005 | 2006–2010 | 2011–2015 | 2016–2017 |
|------------------------|--------------|-----------|-----------|-----------|-----------|
| 1 (most deprived)      | 125 190      | 36 968    | 37 061    | 36 931    | 14 230    |
| 2                      | 103 205      | 29 706    | 30 591    | 30 760    | 12 148    |
| 3                      | 92 998       | 26 088    | 27 638    | 28 120    | 11 152    |
| 4                      | 82 061       | 22 740    | 24 511    | 25 013    | 9 797     |
| 5 (least deprived)     | 68 805       | 18 479    | 19 794    | 21 766    | 8 766     |

IMD, Index of Multiple Deprivation.
Among all lung cancer decedents, 39.5\% (n=186,696) had at least one other illness/condition listed on their death certificate as contributing to the cause of death. This reduced to 27.8\% (n=131,495), once conditions and illnesses not considered to be comorbidities (accidents; minor ailments; acute and/or self-limiting illnesses; those related to cancer) were excluded. 19.0\% (n=89,894) of all lung cancer decedents had one comorbidity at time of death and 8.8\% (n=41,601) had two or more (table 1).

The proportion of decedents with comorbidities increased with age. For those <55 years, 2.7\% (95\% CI: 2.5 to 2.9) had two or more comorbidities at time of death compared with 13.1\% (95\% CI: 12.9 to 13.4) of those aged ≥85 years. The proportion of lung cancer decedents with comorbidities was also higher in more deprived areas of England (table 2).

The number of lung cancer decedents with comorbidities increased over time (figure 1). Between 2001 and 2017, the proportion of decedents with one comorbidity increased 54.7\% (from 14.8\% in 2001 to 22.9\% in 2017), while those with two or more comorbidities increased 294.7\% (from 3.8\% to 15.0\%). If current trends continue, by 2032, more than a quarter of all lung cancer patients will be living with multiple comorbidities at the end of life.

The most common comorbidities identified were chronic respiratory disease and cardiovascular disease including hypertension. In 2017, chronic respiratory disease contributed to 18.5\% (95\% CI: 18.0 to 18.9) of deaths from lung cancer and cardiovascular disease including hypertension to 11.4\% (11.0 to 11.7). Diabetes contributed to 4.9\% (95\% CI: 4.7 to 5.2), cerebrovascular disease to 2.6\% (95\% CI: 2.4 to 2.8), chronic kidney disease 2.3\% (95\% CI: 2.1 to 2.5) and dementia 4.2\% (95\% CI: 4.0 to 4.5). The prevalence of all six comorbidities increased significantly during the study period but was greatest for dementia (311\%) and chronic kidney disease (289\%) (figure 2). Based on our future projections, by 2045, 10\% of all lung cancer patients will be living with dementia at the end of life, 11\% with diabetes and 6\% with chronic kidney disease.

**DISCUSSION**

Using population-level data over a 17-year period (2001–2017) this study determined actual and predicted patterns and trends in comorbidities for lung cancer decedents in England, UK. Our findings provide valuable information for healthcare professionals, managers and policymakers when planning and delivering future cancer services.

We found the proportion of lung cancer decedents with two or more comorbidities increased 294.7\% between 2001 and 2017. Comorbid conditions are known to affect older patients disproportionately and our study suggests that if current trends continue, by 2032 more than 25\% of lung cancer patients will be living with multiple comorbidities at the end of life. While this increase is not unexpected given the broader context of population growth and ageing, our findings highlight the scale of these changes and emphasise the urgency with which oncology services need to adapt. Understanding the association between age, comorbidity type and severity is important as this has the potential to impact cancer patients’ treatment and prognosis.25–26 Furthermore, the prevalence of some comorbidities, such as HIV/AIDS and obesity,
decrease with age. By understanding current and future patterns and trends, policymakers can plan future services that are able to meet the needs and preferences of their patients and reduce inequities in care.

Currently in England, most oncology services remain single-disease focused in their approach to care—a model that fails most multimorbid cancer patients. Greater integration between specialities has the potential to improve outcomes for cancer patients and their caregivers, while also reducing strain on National Health Service resources. Research exploring the impact of integrated care models for individuals with non-cancer conditions have shown mostly positive outcomes, however, these studies have focused primarily on older and/or frail populations, and few have been extended beyond the demonstration phase. Evidence for the effectiveness of integrated care models beyond the experimental phase is much more limited, and when present, the impact has often taken years to be realised. Hebert and colleagues evaluated the impact of a coordination-type integrated care model on health, satisfaction, empowerment and the service utilisation of people aged ≥75 years at risk of functional decline in Quebec, Canada. Key components of the intervention included a case manager, single entry point, single assessment instrument coupled with a case-mix management system and coordination between decision makers and managers at regional and local levels. The quasi experimental study found greater satisfaction and patient empowerment in the intervention group along with a lower number of emergency department visits and hospitalisations. However, there was no significant difference in functional decline and unmet need between groups until year 4 of the study when the intervention group showed fewer cases of functional decline (p<0.001) and less unmet need (p<0.001).

Clarity regarding the components that challenge and support integrated models of care in oncology is still needed. A systematic review of interventions to improve coordination between primary care and oncology found insufficient evidence for the effectiveness of nurse navigators, treatment care plans and the creation of multidisciplinary teams. However, these results should be interpreted with caution as the impact from integrated care initiatives may only be seen years later—beyond the follow-up period of most research studies. While simple measures, such as coordinating clinic times, can minimise the need for repeated investigations and reduce burden on hospital transport services, in-depth evaluation of complex integrated service delivery models is still needed to determine their effectiveness.

There is more conclusive evidence for the benefits of integrating oncology with palliative care. In their landmark study, Temel and colleagues showed that patients newly diagnosed with non-small cell lung cancer who received palliative care soon after diagnosis had better outcomes, including greater improvements in quality of life and mood, compared with controls. The intervention arm of the randomised controlled trial involved patients receiving standard palliative care under ‘clinical practice guidelines for palliative care’

Figure 2  Actual (2001–2017) and projected (2018–2040) number and type of comorbidities for lung cancer decedents in England.
which include the management of comorbid conditions. This attention to patient’s comorbidities is likely to be one of the active ingredients that led to patients being more stable and having better outcomes.36

Understanding patterns and trends over time for different comorbidities provides healthcare professionals, managers and policymakers with opportunities to also consider novel approaches to service development. Our study found that the most common comorbidities for patients with lung cancer were chronic respiratory disease and cardiovascular disease including hypertension. However, the greatest increase in comorbidity prevalence was found for dementia and chronic kidney disease. When developing future cancer services, policymakers should consider models of care that involve collaboration and/or integration with healthcare professionals from dementia and renal support services. Not only do these comorbidities show the greatest increase in prevalence, they are also disciplines that oncologists are less likely to be familiar with and up-to-date with the latest investigative and management options.

Strengths and limitations
Strengths of our study include the use of ONS mortality data, allowing us to assess comorbidity patterns and trends at a population-level over time. The ONS Mortality Database uses information obtained from a patient’s death certificate, which unfortunately also presents limitations, mostly relating to a degree of inaccurate recordings.37 More recent evidence suggests that the overall accuracy of death certificate information has improved38 and cause of death information is reported to be more sensitive and specific for cancer than other diseases.39 However despite this, it is likely that our cohort included some patients whose cause of death and/or comorbidity data were inaccurately recorded. Furthermore, the increasing prevalence of comorbidities identified by our study may represent greater reporting over time rather than any actual increase in disease prevalence. Our data did not include information about the severity of any comorbidities listed or the amount and type of healthcare services accessed by patients prior to death. We were therefore unable to evaluate the impact of these factors. Finally, our future projections are simple and limited by assumptions that included a linear change over time.

CONCLUSIONS
The number of lung cancer decedents with multiple comorbidities is increasing over time. To deliver high-quality outcomes and positive experiences for this growing population, oncology services need to work across traditional boundaries of care. The most common comorbidities found in patients with lung cancer were chronic respiratory disease and cardiovascular disease including hypertension, however the greatest increase in prevalence was found for dementia and chronic kidney disease. Novel areas for development of integrated service delivery models, therefore, include collaboration with dementia and chronic kidney disease specialists.

Contributors Conception and design: LAH, EC and WG. Checking and cleaning of data: LAH and EC supervised by WG. Data analysis and interpretation: all authors. Manuscript writing: LAH with critical revisions from all authors. Final approval of manuscript: all authors.

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