Lung cancer diagnoses have evolved over time. Before the coronavirus disease 2019 pandemic, the proportion of patients with stage 1 to 2 diseases had...
increased, up to 28% in 2019, with 43% presenting with stage 4 disease: a positive stage shift compared with that in 2014. Although the proportion of adenocarcinoma diagnoses is increasing, SCLC rates decreased from 11% to 8% (2014–2020).

Successful public health policies (Fig. 3) have ensured that the proportion of current U.K. smokers continues to fall, reducing significantly to 14.1% (6.9 million people) in 2019 (Fig. 1). The highest proportion of smokers is in the 25 to 34 years age group where 19% are current smokers. The Tobacco Control Plan (2017) aims to deliver a smoking prevalence of less than or equal to 5%. Unlike many other countries, the United Kingdom promotes electronic cigarettes for smoking cessation as a harm reduction strategy compared with conventional cigarettes in view of their greater smoking cessation effectiveness over nicotine replacement therapy, when accompanied by behavioral support. In 2019, a total of 5.7% of adults used an electronic cigarette, equating to nearly 3 million people.

**Screening**

Early detection is the most promising way to substantially reduce lung cancer mortality. Low-radiation dose computed tomography (LDCT) is the only currently proven method of early detection found to reduce mortality. In the United Kingdom, LDCT is not yet fully funded. National screening programs are first evaluated by the U.K. National Screening Committee (UKNSC), and then recommendations are made to government ministers before implementation in the four U.K. countries. Nevertheless, the latter process has been slow and hampered by the concern that, until the publication of NELSON, there was only the U.S. National
Lung Cancer Screening Trial to support mortality reduction. Furthermore, substantial issues with health economic modeling of LDCT have been identified. In parallel and drawing on evidence from the U.K. Lung Screening randomized trial, followed by several pilot programs revealing “real-world” feasibility, NHS England (NHSE) identified LDCT screening as an important way to achieve one of its long-term aims to increase the proportion of cancers detected at stages I to II to 75% by 2028. The National Cancer Programme Team, working with an Expert Advisory Group (including some members of the UKNSC) then began the process of stepwise implementation of computed tomography (CT) screening through the Targeted Lung Health Check program. The current re-evaluation of the health economics by the UKNSC may well result in a positive recommendation, and if so the Targeted Lung Health Check will be a model start for a full national program.

Diagnosis
In recent years, a key U.K. ambition has been faster diagnosis and standardization of lung cancer care. Driven by an evolving evidence base of improved outcomes from faster diagnosis and the demonstration of variability in practice, the vehicles for achieving this ambition have been the National Optimal Lung Cancer
Pathology and Molecular Diagnostics

The Royal College of Pathologists is responsible for a minimum data set for the reporting of lung cancer, both for resection specimens and smaller samples, containing mandatory core items and optional noncore items. The data set primarily references the WHO classification of lung tumors and the Union for International Cancer Control TNM staging classification and is updated regularly to reflect new additions. This provides a template for consistent national reporting and facilitates data collection for the NLCA. Core items are also part of the International Collaboration for Cancer Reporting data set to facilitate consistency internationally. Core items now include molecular results and programmed death-ligand 1 status when testing is undertaken. The College also provides recommendations for turnaround times in relation to biopsies and resections, with a recommendation to work toward those given in the NOLCP.

In relation to molecular testing, regional laboratories are being replaced in England by seven centrally funded Genomic Laboratory Hubs, with a central directory of molecular alterations requiring assessment. There are similar but separate centers for testing in Wales, Scotland, and NI. Testing is primarily through next-generation sequencing panels, supplemented by more specific targeting when next-generation sequencing fails or a more rapid result is required. Nevertheless, immunohistochemical screening for programmed death-ligand 1 and molecular abnormalities, such as ALK and ROS1, is still undertaken regionally. Although still in its first year and logistical issues remain, this service is providing a

### Table 1. Key Features of the U.K.’s National Optimal Lung Cancer Pathway and NICE Guidelines on the Diagnosis of Lung Cancer to Implement Faster Diagnosis and Standardization of Care

<table>
<thead>
<tr>
<th>Source and Topic</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOLCP: community CXR</td>
<td>CXRs reported within 24 h of image acquisition; preferably before patient leaves</td>
</tr>
<tr>
<td>NOLCP: CT imaging</td>
<td>CT within 72 h of CXR suggestive of lung cancer or GP referral for suspected lung cancer; preferably on the same day. CT results should be triaged on the same day</td>
</tr>
<tr>
<td>NOLCP: test bundles</td>
<td>To use groups of tests, requested simultaneously, that provide the required diagnostic, staging, and physiological information relevant to the stage and pattern of disease to ensure complete MDT discussion and treatment recommendations can be made</td>
</tr>
<tr>
<td>NICE: nodal staging with EBUS</td>
<td>Patients with suspected lung cancer with no evidence of distant metastases and any intrathoracic lymph node &gt;1 cm should undergo staging EBUS</td>
</tr>
<tr>
<td>NICE: brain imaging</td>
<td>Patients with stage II lung cancer should undergo contrast-enhanced CT brain followed by contrast-enhanced MRI brain when positive for brain metastases. Patients with stage III lung cancer should undergo contrast-enhanced MRI brain</td>
</tr>
<tr>
<td>NICE: physiological assessment</td>
<td>For patients with lung cancer and a possible treatment option of surgery, assess risk of mortality (e.g., Thoracscore), cardiac risk, postoperative predicted lung function (FEV1 and DLCO by means of segment counting), and functional ability (ISWT, CPET)</td>
</tr>
<tr>
<td>NICE: ISWT</td>
<td>Use a distance walked of &gt;400 m as a cutoff for good function</td>
</tr>
<tr>
<td>NICE: CPET</td>
<td>Use a VO2max of &gt;15 ml/kg/min as a cutoff for good function</td>
</tr>
</tbody>
</table>

CPET, cardiopulmonary exercise test; CT, computed tomography; CXR, chest radiograph; DLCO, diffusing capacity of the lungs for carbon monoxide; EBUS, endobronchial ultrasound; FEV1, forced expiratory volume in 1 second; GP, general practitioner (primary care physician); ISWT, incremental shuttle walk test; MDT, multidisciplinary team; MRI, magnetic resonance imaging; NICE, National Institute for Health and Care Excellence; NOLCP, National Optimal Lung Cancer Pathway; VO2max, maximum rate of oxygen consumption.
more uniform and complete molecular profile for patients.

**Surgery**

In common with other countries, dramatic changes in lung cancer surgery provision have occurred in the past 25 years. In 2017, lung cancer surgery was provided by 112 thoracic surgeons (1.5 per million) and 33 cardiothoracic surgeons in 39 units (0.59 per million), with a continued trend in expansion of numbers of thoracic and decline of cardiothoracic surgeons. The Society for Cardiothoracic Surgery in Great Britain and Ireland has published three “Blue Books,” most recently in 2018, giving an outline of U.K. thoracic and lung cancer surgery. Alongside surgical expansion, an increase in lung cancer resections was identified: 7228 cases reported between 2014 and 2015, more than double the median for 1980 to 2005. The Blue Books, the Lung Cancer Clinical Outcomes Project, and more recently the “Get It Right First Time” reports have published unit-specific data, permitting comparison in workload, type of surgery, resource utilization, and outcomes between units. The 2021 Lung Cancer Clinical Outcomes Project report, concerning operations performed in England in 2018, indicated medians of 243 lung cancer resections per unit and 52 per surgeon. In 2018, 62% of the patients with lung cancer with stages 1 to 2/performance status of 0 to 2 underwent surgery, equating to 18% of all patients with NSCLC, most (58%) resections being video-assisted thoracoscopic surgery, and only 2% by robot-assisted thoracoscopic surgery. Lung cancer surgery research is strong, led by the Thoracic Surgery Research Collaborative and the Cardiothoracic Interdisciplinary Research Network, supported through the Thoracic Forum.

**Radiotherapy**

There are 61 radiotherapy centers across the United Kingdom with an average of 2.7 whole time equivalent clinical oncologists specializing in lung cancer per center. NLCA data in 2015 to 2016 raised important concerns on important variation in lung cancer curative-intent treatment delivery. For stage I NSCLC, approximately one-quarter of patients received no curative treatment with a further approximate third being treated with conventional radiotherapy rather than stereotactic body radiotherapy (SBRT). Conventional radiotherapy is associated with inferior outcomes compared with SBRT for peripheral lesions, and limited access to SBRT across the United Kingdom was likely a contributing factor with only approximately 40% of centers offering lung SBRT in 2018. For stage III NSCLC, 60% of patients received only either active palliative treatment or best supportive care. Of the approximate 30% receiving radical-intent treatment, only 18% received multimodality treatment, with sequential chemoradiotherapy being offered approximately twice as often as concurrent. A broad regional variation was also noted with curative treatment rates varying from 8% to 80% across centers for stage III NSCLC management. From a curative radiotherapy perspective, these data highlighted an urgent need for clinician education and to ensure optimal technical capabilities across radiotherapy centers. Concurrent compared with sequential chemoradiotherapy rates have improved to 54% versus 46%, respectively, in 2019. All U.K. centers have intensity-modulated radiotherapy and volumetric-modulated arc therapy planning capability. All have respiratory motion management strategies and cone beam CT image guidance for treatment delivery. In addition, the NHSE SBRT national rollout program in collaboration with radiotherapy and trial quality assurance team has now led to all 51 radiotherapy centers in England (and 55 of 61 U.K. centers) being quality assured for lung SBRT by May 2021. The NHSE nonlung SBRT rollout program continues.

**Systemic Therapy**

In the United Kingdom, clinical oncologists make up most of the workforce and deliver both radiotherapy and systemic therapies. Medical oncologists deliver systemic therapies alone, whereas radiation oncologists, who deliver radiotherapy alone, are rare in the United Kingdom and are usually confined to specialist centers. Systemic anticancer therapy (SACT) requires two approvals before NHS utilization: first, regulatory approval (post-Brexit by the U.K. Medicines and Healthcare Products Regulatory Authority [MHRA] and pre-Brexit by the European Medicines Agency), and second, reimbursement (health technology appraisal [HTA]). NI is in a regulatory transition phase remaining aligned to European Union regulations. After regulatory/marketing authorization, the drug is available for reimbursement/purchase privately, but not in the NHS. Agencies responsible for NHS HTA/reimbursement are as follows: NICE (for England), the All Wales Medicines Strategy Group (for Wales), the Scottish Medicines Consortium (for Scotland), and the Northern Irish Department of Health, Social Services and Public Safety for NI. Schemes exist for prelicensure NHS use of innovative medicines, by means of the MHRA or manufacturer. Post-Brexit, the Project Orbis framework program allows drugs approved by the U.S. Food and Drug Administration to receive expedited MHRA review and rapid NHS access. Given that marketing authorization is prerequisite for HTA, along with a culture of strong evidence-based governance, U.K. SACT practice is bound by licensed indication with off-label prescribing generally impossible. Moreover, after NICE approval, the NHS usually imposes multiple criteria, mostly reflecting trial eligibility, for example, performance status of 0 to 1 only, restricting access further to reflect the agreed economic
Figure 4. NICE algorithm of systemic treatment options for (A) advanced squamous NSCLC; (B) advanced nonsquamous NSCLC: EGFR TKI, ALK, or ROS-1 positive; and (C) advanced nonsquamous NSCLC: no gene mutation or fusion protein. NICE, National Institute for Health and Care Excellence; PD-L1, programmed death-ligand 1; TKI, tyrosine kinase inhibitor.
model. Given the current complexity of SACT decision-making in advanced NSCLC, NICE has produced algorithms for advanced NSCLC (Fig. 4A–C), although these do not reflect approvals in all devolved nations and all reimbursed drug indications in non–NICE-approved pre-license/postlicense schemes.

Challenges and Unique Features

The United Kingdom has a unique not-for-profit National Healthcare System, but allowing rapid implementation of change, excellent data capture, and ability to map and reveal regional variation. Nevertheless, NHS funding is tied to governmental expenditure, with an urgent need to invest in infrastructure and workforce. A survey of 160 hospitals in England and Wales by the NLCA in 2019 highlighted some gaps in workforce provision according to NHSE recommendations (Table 2). Nevertheless, admixed with HTA is strong MDT working, a culture of evidence-based medicine, and peer review of all cases in MDT meetings.

### Table 2. Lung Cancer Workforce

<table>
<thead>
<tr>
<th>Staff Member</th>
<th>Median Number of Staff Per Unit</th>
<th>Range of Number of Staff Per Unit</th>
<th>NHS England Commissioning Guidance</th>
<th>% of Units Meeting Commissioning Guidance in 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonologists</td>
<td>4</td>
<td>0.14</td>
<td>10 sessions per week for direct clinical care per 200 new diagnoses per year</td>
<td>16</td>
</tr>
<tr>
<td>Clinical oncologists</td>
<td>1</td>
<td>0.27</td>
<td>At least 1/3 of job plan devoted to lung cancer</td>
<td>70</td>
</tr>
<tr>
<td>Medical oncologists</td>
<td>1</td>
<td>0.18</td>
<td>At least 1/3 of job plan devoted to lung cancer</td>
<td>60</td>
</tr>
<tr>
<td>Thoracic surgeons</td>
<td>3</td>
<td>0.7</td>
<td>At least 1/3 of clinical time dedicated to lung cancer</td>
<td>75</td>
</tr>
<tr>
<td>Thoracic radiologists</td>
<td>2</td>
<td>0.14</td>
<td>At least 1/3 of job plan devoted to lung cancer</td>
<td>83</td>
</tr>
<tr>
<td>Pathologists</td>
<td>3</td>
<td>0.21</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Lung cancer nurse specialists</td>
<td>N/A</td>
<td>N/A</td>
<td>One whole time equivalent per 80 new cases per year</td>
<td>32</td>
</tr>
</tbody>
</table>

Adapted from https://nlca.rcp.ac.uk/Content/misc/NLCA_organisational_audit_2019.pdf.
N/A, not available; NHS, National Health Service.
Central to this are lung cancer nurse specialists acting as key workers for newly diagnosed patients, supporting and guiding patients, with many trained as independent prescribers or in other specialist roles traditionally undertaken by physicians. The United Kingdom has a government-funded clinical research delivery infrastructure enabling the success of flagship studies, such as TracerX and VIOLET, and active professional interdisciplinary groups, such as the British Thoracic Oncology Group, patient-facing charities (e.g., the Roy Castle Lung Cancer Foundation), and several diseasespecific patient-advocacy groups, for example, EGFR-positive U.K. patient and physician advocacy are strong at all levels in the United Kingdom, enabling a joint voice to improve lung cancer outcomes.

CRediT Authorship Contribution Statement

**Neal Navani:** Conceptualization, Investigation, Resources, Writing—original draft, Writing—review and editing, Project administration.

**David R. Baldwin, John G. Edwards, Mathew Evison, Fiona McDonald, Andrew G. Nicholson:** Writing—original draft, Writing—review and editing.

**Jackie Fenemore, Elizabeth K. Sage:** Writing—review and editing.

**Sanjay Popat:** Conceptualization, Investigation, Resources, Writing—original draft, Writing—review and editing, Supervision.

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