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Health Enterprise East

COUNTING THE COST OF RESPIRATORY DISEASE

A MEDTECH NAVIGATOR REPORT

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Medtech Navigator

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Report Summary

This report contains information relevant to the economic burden of respiratory diseases. The individual care pathways recommended by NICE are summarised in the report. We analyse the cost of respiratory diseases broken down by pathway such as primary care, secondary care, diagnosis and treatment, to present the economic impact on the NHS. The potential opportunities for innovation are given from a health economic perspective. Finally, we provide the five main procurement routes to sell innovative technologies to the NHS.

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1. Background

The NHS Long Term Plan, published in January 2019, has identified the area of respiratory diseases as one of the top clinical priorities[1]. The NHS Long Term Plan describes how the NHS will contribute and increase its efforts in improving diagnosis and treatment, and support for patients with respiratory diseases.

Approximately 12.7 million people in the UK, equivalent to one in five people, are living with respiratory diseases: Respiratory diseases affect the airways and lungs and it was estimated that around 550,000 people are newly diagnosed every year with such conditions[2]. The most common respiratory diseases are chronic obstructive pulmonary disease (COPD), asthma, lung cancer and pneumonia.

In EU countries, it has been identified that respiratory disease is the third biggest cause of death, after cardiovascular disease and cancer. In 2015, the UK had the highest age-standardised death rates from respiratory diseases in the EU (shown in Figure 1)[3]: Respiratory diseases are the cause of death of approximately 115,000 people in the UK each year, accounting to 20% of all deaths, which corresponds to one person dying from respiratory diseases every five minutes[2].

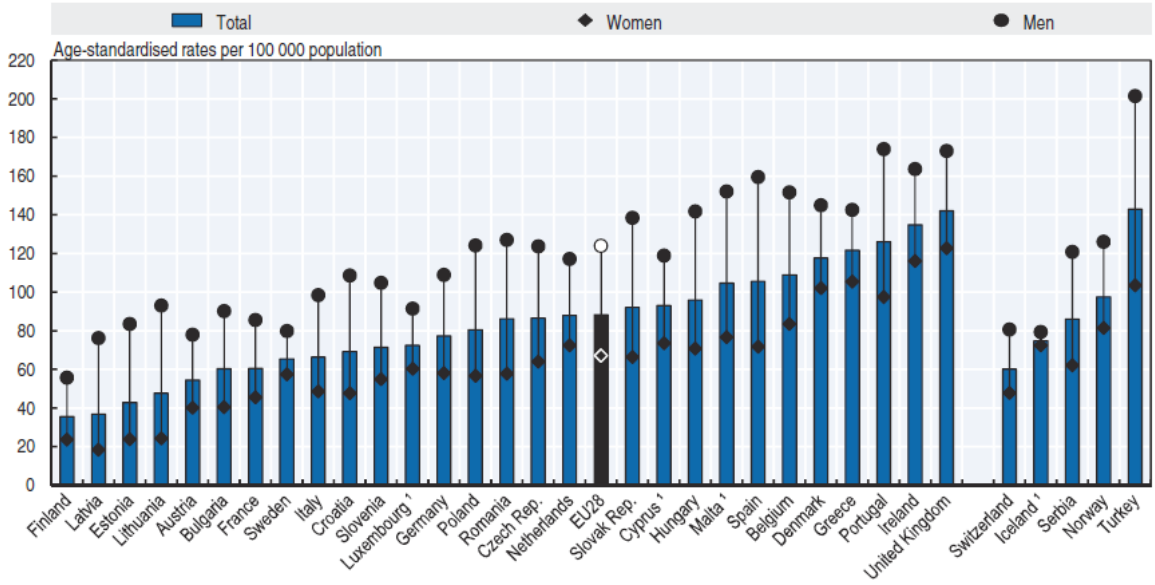

Figure 1 Respiratory disease mortality in EU countries, 2015. Source: OECD[3].

There have been few significant improvements in survival outcomes in respiratory disease, as although the number of people killed by cardiovascular disease in the UK fell by 26,000 (15%) 2008 to 2012, the number of deaths from respiratory disease has remained stable during the same period[2].

In 2017, age-standardised avoidable mortality rate from respiratory diseases was approximately 25% in England[4]. The National Institute for Health and Care Excellence

(NICE) proposed the prevention of respiratory diseases by stopping smoking, increasing vaccination and improving air pollution[5].

COPD

The World Health Organisation (WHO) estimated that chronic obstructive pulmonary disease (COPD), including emphysema and chronic bronchitis, affects more than 200 million people in the world, 65 million of whom have moderate to severe conditions[6]. Over 1.1 million people in England are living with COPD and its prevalence rate in the population was 1.93% in 2018[7].

COPD is the second main cause of death caused by respiratory diseases in the UK, following lung cancer, accounting for around 26% of all respiratory disease mortality[2]. In 2017, approximately 27,000 people were killed by COPD in England[8]. The number of patients dying from COPD has also been growing, with 5% higher mortality in 2012 than in 2008[2].

The main symptoms of COPD include increasing breathlessness, a persistent chesty cough, chest infections and persistent wheezing.

Asthma

According to Asthma UK, there are around 5.4 million people in the UK who receive treatment for asthma[9]. Approximately 160,000 people were newly diagnosed with asthma in 2012, leading asthma to be the most prevalent of all respiratory diseases[2].

Asthma is particularly prevalent in children, as around 20% of all patients with asthma (1.1 million) are under the age of 15 year olds[9]. WHO reported that 14% of children globally are suffering from asthma and this rate is rising[6].

The main symptoms of asthma are wheezing, breathlessness, tight chest and coughing. A life-threatening symptom of asthma is an asthma attack, which can also worsen the condition. In 2017, asthma attacks killed 1,484 people in the UK even though many of these could have been avoided[10].

Asthma is a chronic disease and there is currently no cure; however, appropriate treatments can effectively offer control over the condition. One of the most common therapies for asthma is to inhale medication in order to relieve or stop symptoms.

Lung cancer

Lung cancer kills around 35,500 people every year[2] in the UK and it is one of the most common cause of deaths amongst all cancer types and respiratory diseases. In 2017, it was noted that the mortality rates of lung cancer, and percentage of all deaths in both men and women in England, were 6.2% and 5.1%, respectively[11]. In 2016, around 47,300

people were diagnosed with lung cancer in the UK while more than 40% of those diagnosed with lung cancer are aged over 75[12].

According to Cancer Research UK, 79% of lung cancer cases in the UK are preventable[13]. 72% of lung cancer cases in the UK are caused by smoking and so lung cancer could largely be prevented through tobacco control.

There are two main forms of primary lung cancer that begins in the lungs: non-small-cell lung cancer (NSCLC) and small-cell lung cancer (SCLC). NSCLC is the most common type of lung cancer, accounting for about 87% of lung cancer incidences and it consists of three types: adenocarcinoma, squamous cell cancer and large cell carcinoma. Although not so common as NSCLC, SCLC, usually spreads faster than NSCLC[14].

Pneumonia

Pneumonia is an inflammation of the tissue in the lungs, usually caused by a bacteria, viruses and occasionally fungal infection. The inflammation causes the tiny air sacs in the lungs to fill with fluid.

Pneumonia is the third biggest cause of death from respiratory disease and it killed around 25,000 people in England, in 2017[15] and approximately 220,000 people are diagnosed every year in the UK[2]. Although pneumonia affects people of any ages, around 87% of people who die from pneumonia are over 75 typically because elderly people are less able to recover from pneumonia than young people[2]. However, it is also the leading cause of death in children under 15, accounting for 3.5% of all deaths in this age group.

Respiratory diseases are the leading cause excess winter mortality with pneumonia being the most common cause of winter death. The excess winter mortality index in England reported that 47.7% more pneumonia deaths occurred in the winter months of 2018 to 2019 compared to other seasons[16].

2. Care Pathway

COPD

The Chronic Obstructive Pulmonary Disease (COPD) Pathway is one of eight NHS RightCare Pathways in the NHS RightCare Intelligence Programme. The COPD pathway four National Challenges:[17]

- Early detection and Accurate diagnosis,
- Optimal long-term condition management,
- Hospital readmission,
- Unexpected mortality.

A large number of people with COPD do not realise they have it until their first hospital admission for exacerbation. NICE provides interactive pathway guidelines which help with improving early diagnosis and managing exacerbations (NG115)[18] and pathway in COPD (Figure 2)[19].

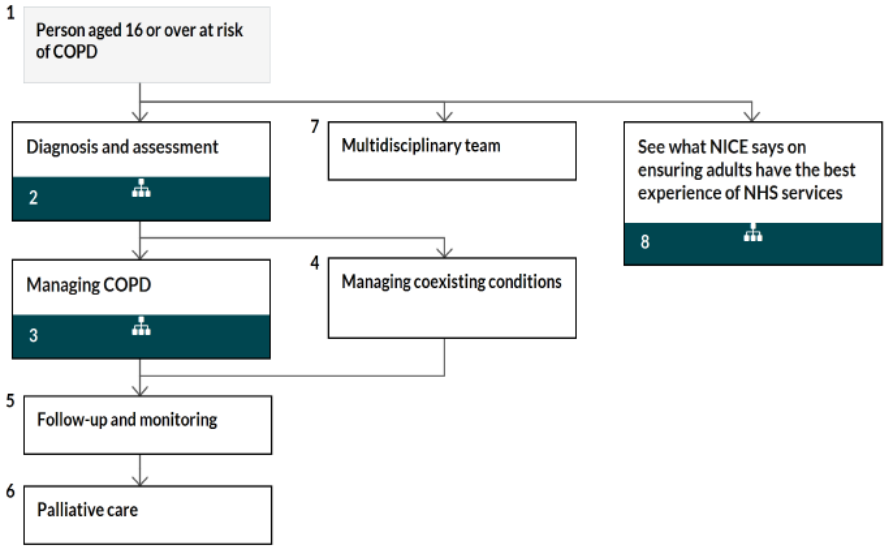

Figure 2 Overview pathway for COPD. Source: NICE Pathway[19].

COPD in people over 35 who have a risk factor, generally smoking or a history of smoking, is diagnosed on the basis of symptoms. The main symptom of COPD is breathlessness and the dyspnoea scale published by Medical Research Council (MRC) has been used to grade the effect of breathlessness[20].

Spirometry is performed to confirm the diagnosis of COPD. It is recommended that Global Lung Function Initiative 2012 reference values[21] are used but it is recognised that these values are not appropriate for all ethnic groups. In addition to spirometry, all patients should have a chest radiograph, a full blood count and have their BMI calculated.

For people with emphysema/signs of chronic airways disease on chest X-ray or CT scan, primary care respiratory review and spirometry should be considered.

Referral may be appropriate for people at all stages of the COPD, not only at the most severe stage, in order to gain specialist advice.

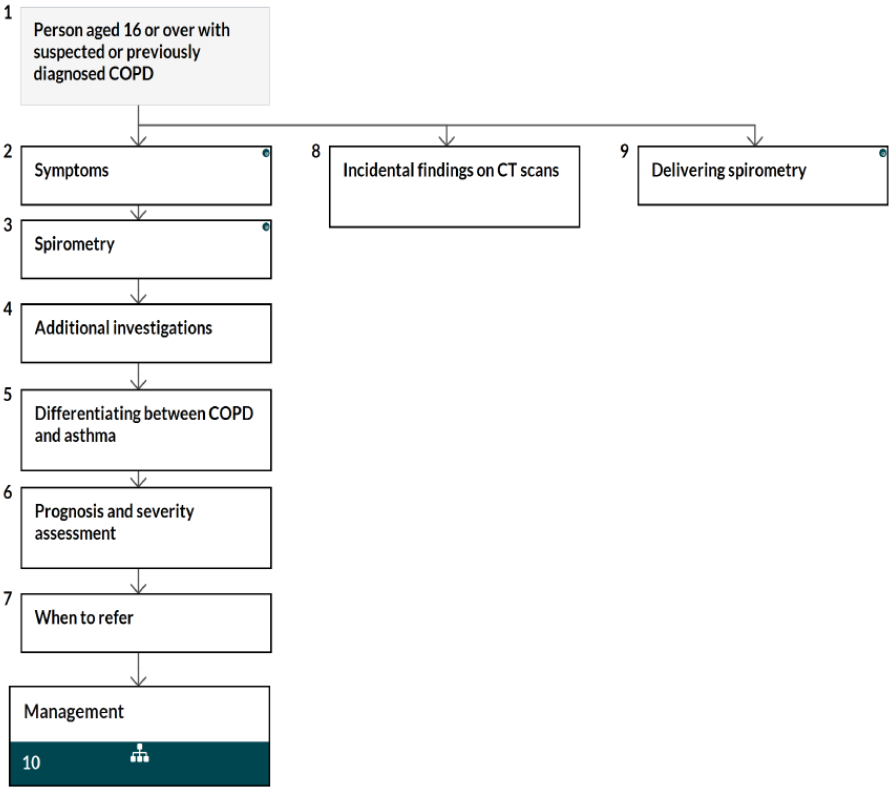

Figure 3 Pathway for diagnosing and assessing COPD. Source: NICE Pathway[19].

After being diagnosed with COPD, treatment to stop smoking, vaccination and pulmonary rehabilitation[22] will be offered, and self-management plan will be co-developed as fundamental care.

If these interventions are not sufficient to provide relief, inhaled therapy is provided as the initial empirical treatment to relieve breathlessness and exercise limitation. Inhalers, spacers and nebulisers are used as delivery systems to treat stable COPD. Oral therapy, oxygen therapy and lung surgery/lung reduction procedures are also used for COPD treatment.

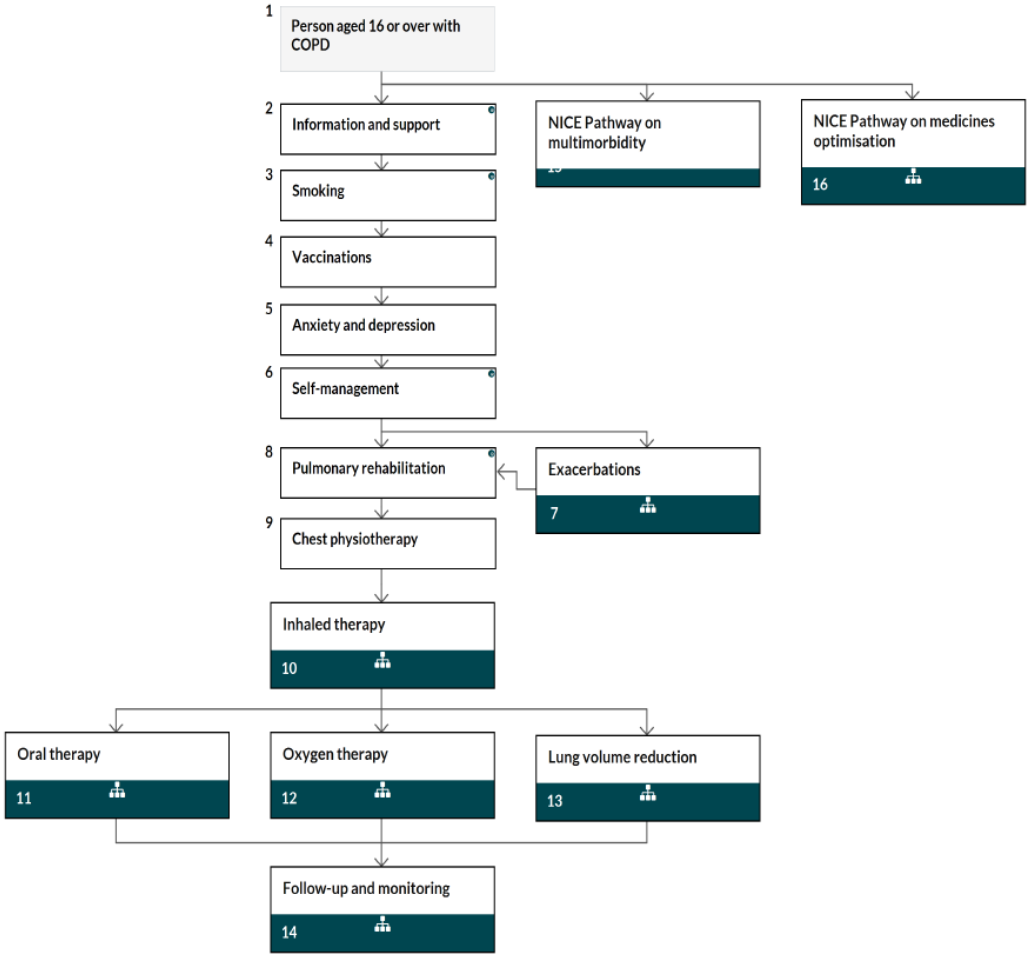

Figure 4 Pathway for managing COPD. Source: NICE Pathway[19].

Asthma

Asthma is often misdiagnosed as untreated COPD. NICE guidelines (NG80)[23] and the pathway[24], illustrated in Figure 5, aim to improve the accuracy of diagnosis, help people to control their asthma and reduce the risk of asthma attacks.

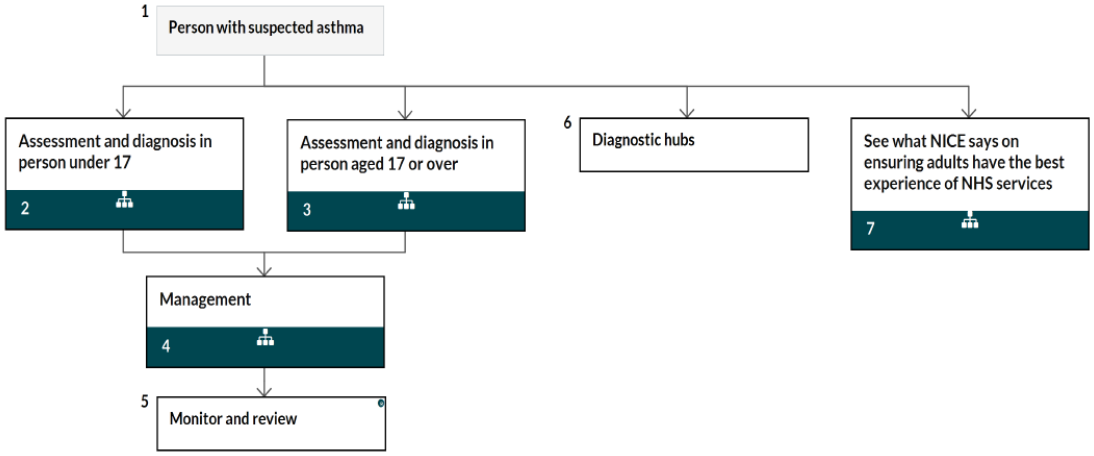

*Figure 5 Overview pathway for asthma. Source: NICE Pathway**Error! Bookmark not defined.**.*

For adults, young people and children aged 5 and over, an objective test is performed with checking symptoms to diagnose asthma.

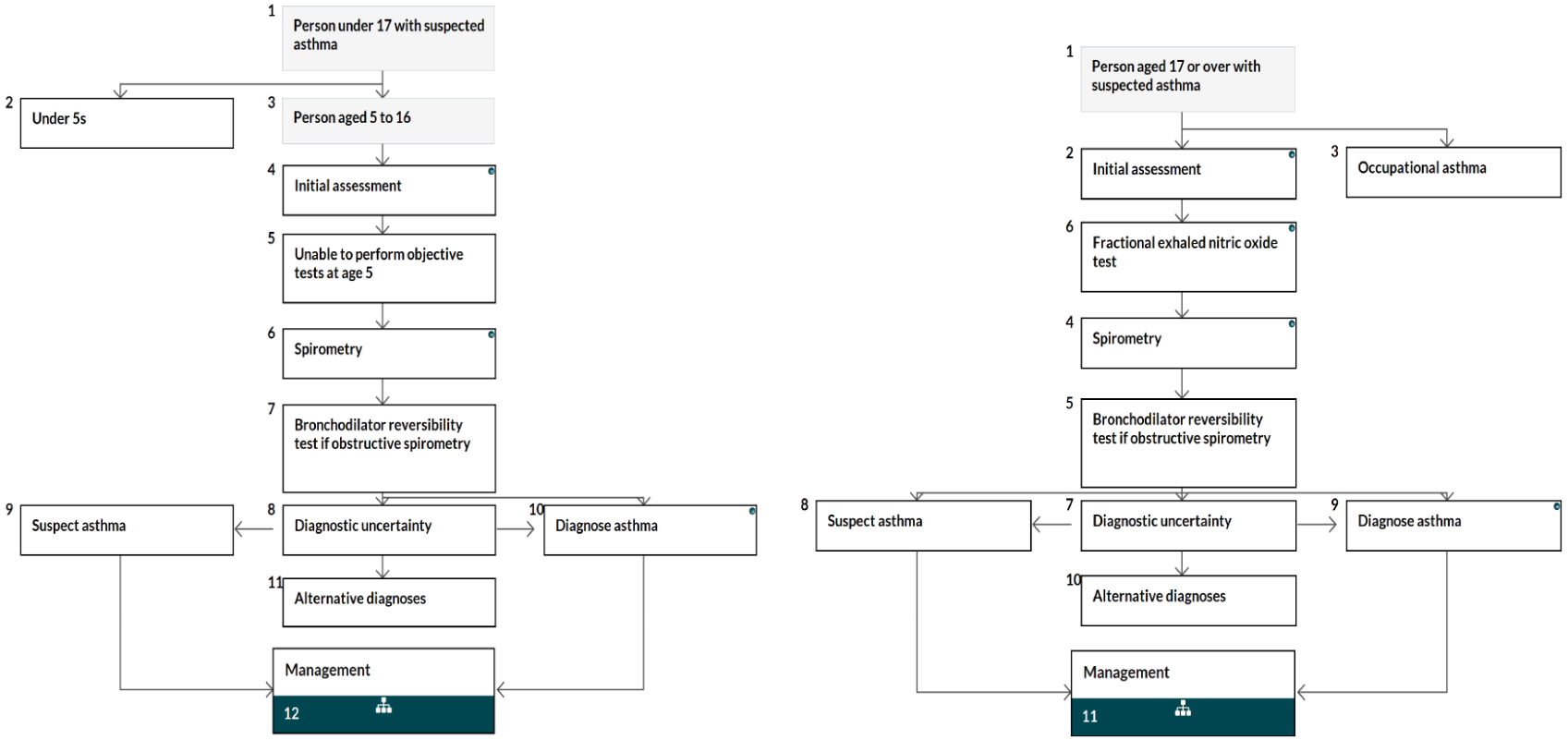

*Figure 6 Pathways for assessing and diagnosing asthma in those under, and over, 17 years of age. Source: NICE Pathway****Error! Bookmark not defined.****.*

The following tests are primarily used as objective tests:

- Fractional exhaled nitric oxide (FeNO) test for airway inflammation measures.
- Spirometry, Bronchodilator reversibility and Peak expiratory flow variability for lung function measures.
- Direct bronchial challenge test with histamine or methacholine for airway hyperreactivity measure.

A summary of objective test threshold levels is provided in the NICE guideline (NG80)[23].

The main treatment for children under 5 with suspected asthma is based on observation and clinical judgement. If they have symptoms when they reach 5 years, performing objective tests is recommended.

People with newly diagnosed asthma or with uncontrolled asthma are treated in most cases by inhaled medicines using asthma medicines described below:

- Short-acting beta-2 agonist (SABA) as reliever therapy
- Inhaled corticosteroid (ICS) as the first-line maintenance therapy
- Leukotriene receptor antagonist (LTRA)
- Long-acting beta-2 agonist (LABA)

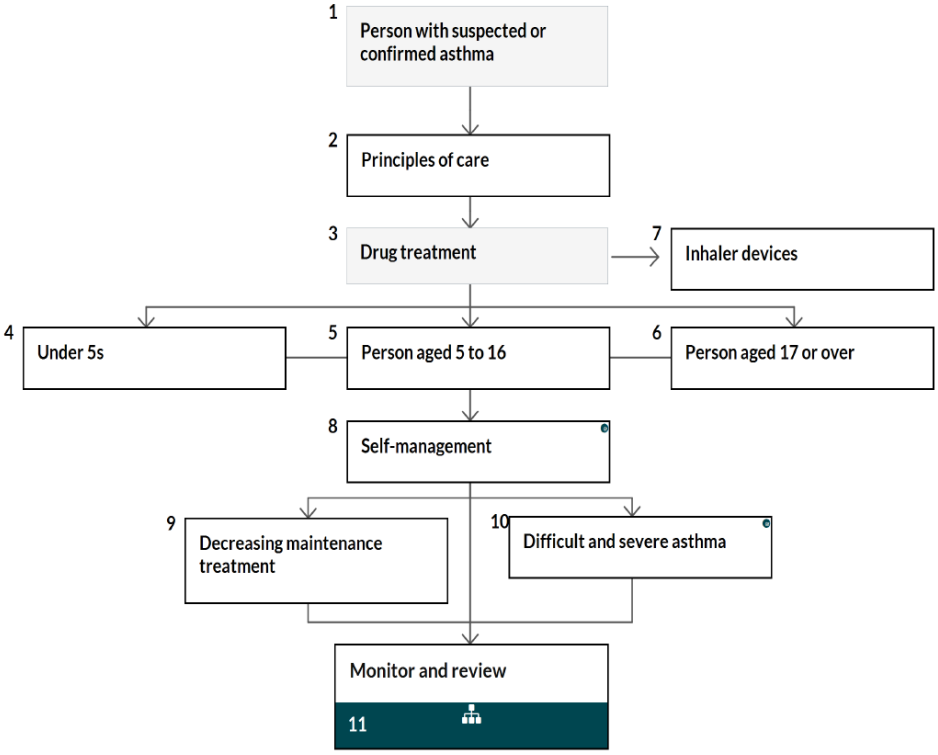

*Figure 7 Pathway for managing asthma. Source: NICE Pathway**Error! Bookmark not defined.**.*

Lung cancer

Early diagnosis of lung cancer is important to avoid its exacerbation. NICE guideline (NG12)[25] has recommended that people should be referred using a suspected cancer pathway referral (for an appointment within 2 weeks) for lung cancer if they have chest X-ray findings that suggest lung cancer or they are aged 40 and over with unexplained haemoptysis (spiting blood).

In addition, NICE has produced the guideline for diagnosis and management of lung cancer (NG112)[26] to improve outcomes for patients. The pathway of diagnosis and treatment of lung cancer has been also visualised by NICE (Figure 8)[27].

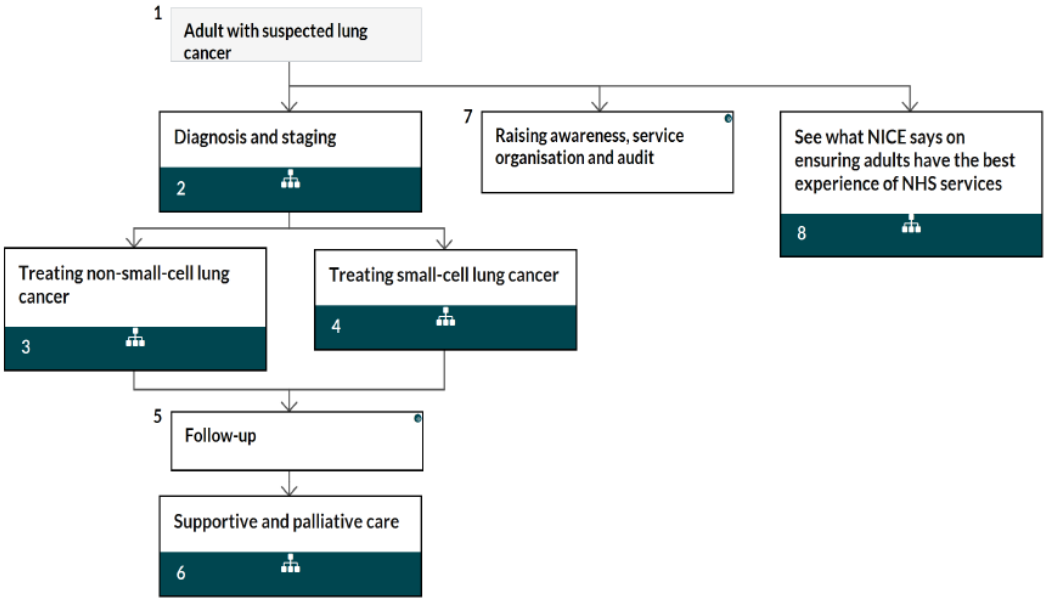

Figure 8 Overview pathway for lung cancer. Source: NICE Pathway[27].

A contrast-enhanced chest CT scan is offered to people with known or suspected lung cancer to further the diagnosis and stage the disease. Contrast-enhanced CT of the chest, liver adrenals and lower neck should be performed before any biopsy procedure.

For people with peripheral chest lesions on CT, positron-emission tomography CT (PET-CT) is the preferred first test after CT. Image-guided biopsy is also offered when treatment can be planned on the basis of this test. If determination of nodal stage affects treatment, biopsy of any enlarged intrathoracic nodes, or other lesions in preference to the primary lesion, is performed.

For people with central chest lesions on CT, flexible bronchoscopy is offered. PET-CT is offered, followed by EBUS-TBNA (endobronchial ultrasound-guided transbronchial needle aspiration) and/or EUS-FNA (endoscopic ultrasound-guided fine-needle aspiration), to people who have enlarged intrathoracic lymph nodes.

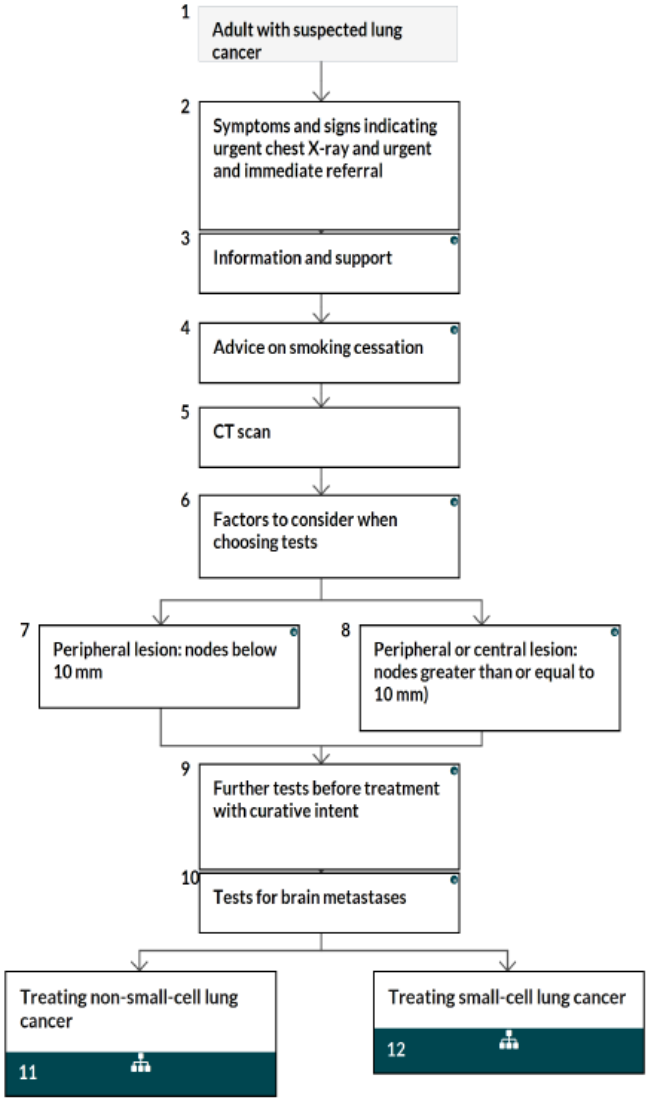

Figure 9 Pathway for diagnosis and staging of lung cancer. Source: NICE Pathway[27].

Patients with lung cancer who could potentially benefit from curative treatment should be offered positron-emission tomography CT (PET-CT) prior to treatment.

Treatment for lung cancer varies with each form: non-small-cell lung cancer (NSCLC) and small-cell lung cancer (SCLC).

The primary treatment with curative intent for NSCLC is surgery and radiotherapy, while a combination treatment can also be prescribed, such as chemoradiotherapy and multimodality treatment. For people with advanced NSCLC, systematic anti-cancer therapy (SACT) using several types of cancer drugs are offered. Pathways for the use of SACT for advanced squamous NSCLC and for advanced non-squamous NSCLC have been produced by NICE[26].

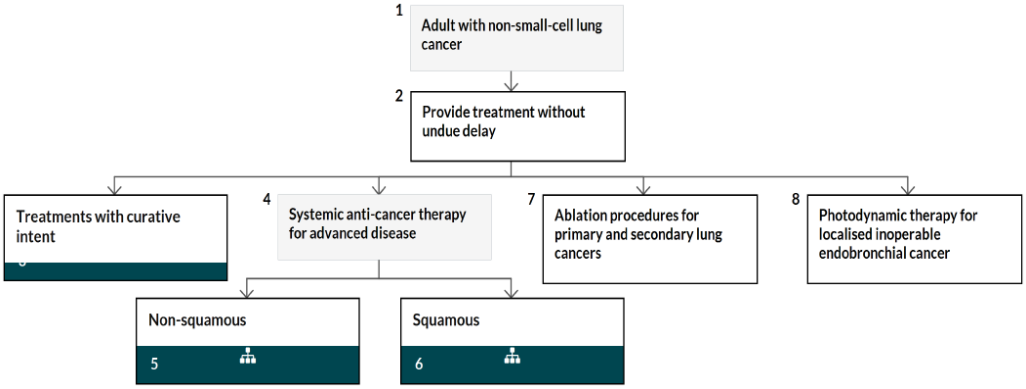

Figure 10 Pathway for treating non-small-cell lung cancer. Source: NICE Pathway[27].

For early-stage SCLC, surgery is considered as first-line treatment. Cisplatin-based and platinum-based combination chemotherapy are offered to people with limited-stage and extensive-stage disease SCLC, respectively.

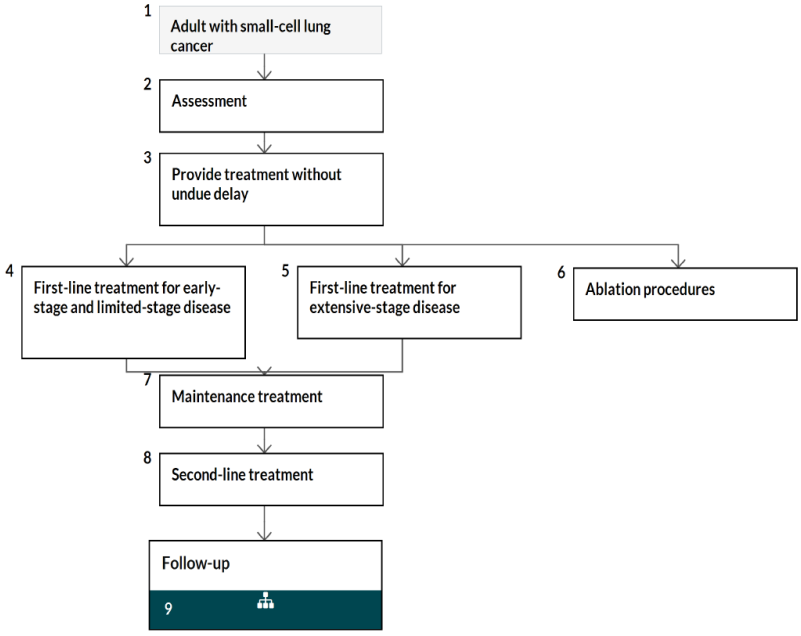

Figure 11 Pathway for treating small-cell lung cancer. Source: NICE Pathway[27].

Pneumonia

NICE has classified pneumonia as either community-acquired or hospital-acquired, based on different microbial causes and patient factors in the clinical guidance (CG191)[28]. Furthermore, NICE has produced guidelines for each pneumonia to provide different management strategies (NG138, NG139)[29,30] and visualised their care pathway (Figure 12)[31].

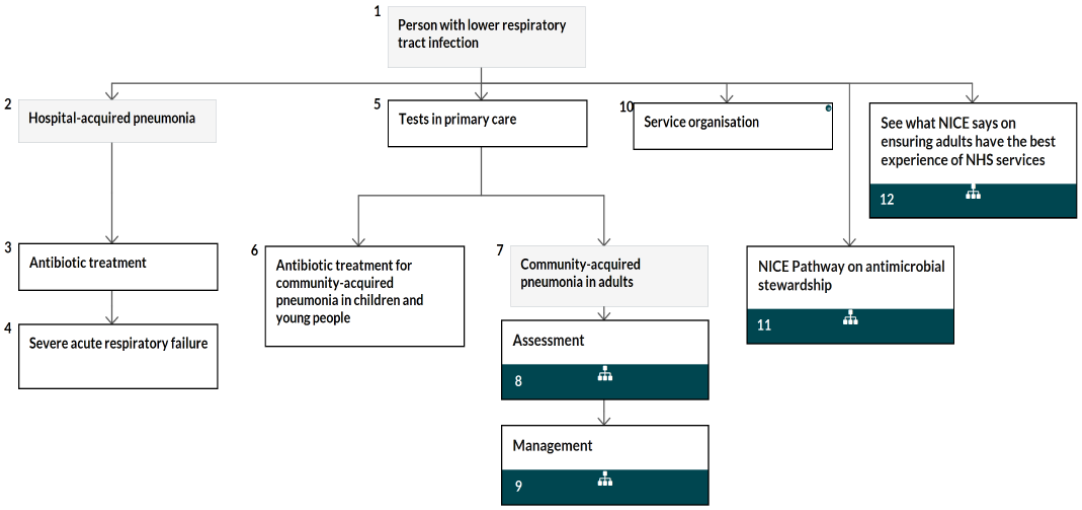

Figure 12 Overview pathway for pneumonia. Source: NICE Pathway[31].

Community-acquired pneumonia is acquired outside hospitals, including in a nursing home. A C-reactive protein (CRP) test may be applied for people presenting with symptoms of lower respiratory tract infection in primary care, if a diagnosis of pneumonia has not been made after clinical assessment. The results of the CRP test are used to guide antibiotic prescription. When clinical diagnosis is made in primary care, the severity assessment is performed by using CURB65 score[32] to decide whether patients need hospital assessment.

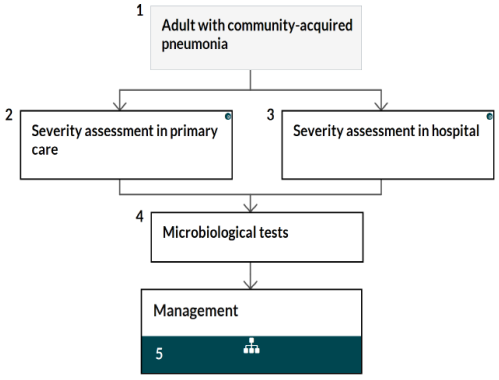

Figure 13 Pathway for assessment of community-acquired pneumonia in adults. Source: NICE Pathway[31].

When managed in hospital, the diagnosis is usually confirmed by chest X-ray and the severity assessment is performed by using CURB65 score to guide the management of community-acquired pneumonia.

In addition, microbiological tests are offered only for patients with moderate- or high-severity community-acquired pneumonia.

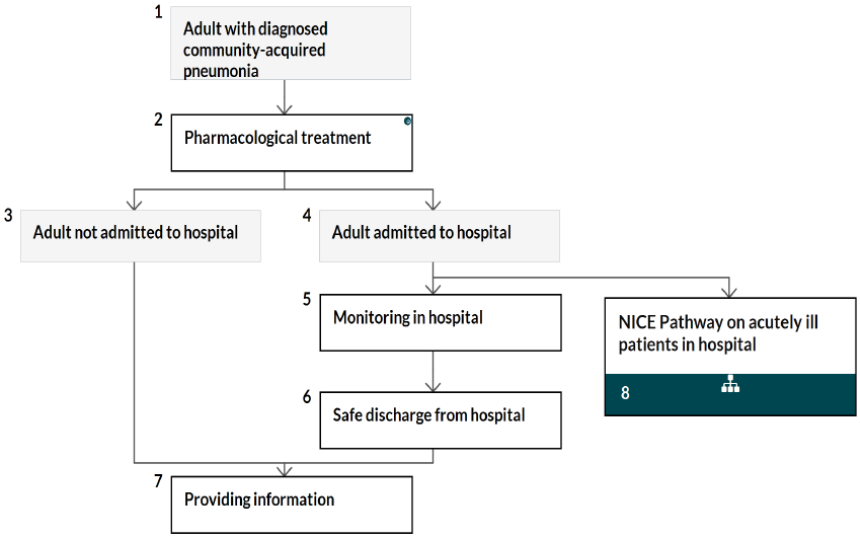

Figure 14 Pathway for management of community-acquired pneumonia in adults. Source: NICE Pathway[31].

Hospital-acquired pneumonia develops 48 hours or more after hospital admission and that was not incubating at hospital admission, and it is usually confirmed by chest X-ray.

Antibiotics are prescribed as first-line treatment for both pneumonias, although the types of the prescribed antibiotics differ. Furthermore, prescription of antibiotics depends on patients' severity and ages. Antibiotics for community-acquired pneumonia and for hospital-acquired pneumonia are summarised in NICE guideline [NG138] and [NG139], respectively[29,30].

3. Cost Burden

Overall cost burden to the NHS

The British Lung Foundation estimated that the annual costs of all respiratory diseases to the UK was £11.1 billion, equivalent to 0.6% of UK GDP in 2014[33]. £9.9 billion among them was the direct cost to the NHS: GP appointments, time in hospital, treatments and medication. £1.2 billion was also lost as the indirect cost because of working days loss. Including the intangible costs provides an estimated total cost of £165 billion.

The breakdown of costs by each respiratory condition is as follow:

Table 1 Costs by respiratory condition. Source: British Lung Foundation[33].

Condition	Direct costs (£m)	Indirect costs (£m)	Total costs (£m; excluding intangible costs)	Proportion
Lower respiratory infections	£797	£866	£1,663	15%
Upper respiratory infections	£37	£40	£76	1%
Trachea, bronchus and lung cancers	£163	£20	£183	2%
Chronic obstructive pulmonary disease	£1,847	£61	£1,909	17%
Asthma	£2,941	£98	£3,039	27%
Other respiratory problems	£4,110	£137	£4,246	38%
All respiratory problems	**£9,895**	**£1,222**	**£11,116**	**100%**

Net Ingredient Cost (NIC) for medicines prescribed in primary care to treat respiratory diseases was £1.1 billion in 2017[34]. The average NIC per item prescribed for respiratory diseases remains relatively high; £15.2 in 2017, compared to the reduction of NIC for cardiovascular system (Table 2).

Table 2 NIC per item and number of items prescribed. Source: University of Kent[34].

Condition	Respiratory system		Cardiovascular system	
	NIC per item	Items dispensed	NIC per item	Items dispensed
2007	£16.50	53.6 m	£7.20	250.9 m
2017	£15.20	72.1 m	£3.70	300.6 m

Generic prescribing is estimated to relate to this difference. The patent of one of the cardiovascular medicines expired in 2012 and it might reflect the decreasing of NIC per

item. On the other hand, it is suggested that generic prescribing is not appropriate for inhaled medicines for respiratory diseases because it may lead to inappropriate medications.

The cost burden broken down by each disease:

COPD

As shown in Figure 15, the total annual costs of caring for people with COPD in England has been projected to reach approximately £2.3 billion by 2030, with increasing of the COPD population[35]. These costs included the maintenance costs for the ongoing care and the additional costs for moderate or severe exacerbations of COPD.

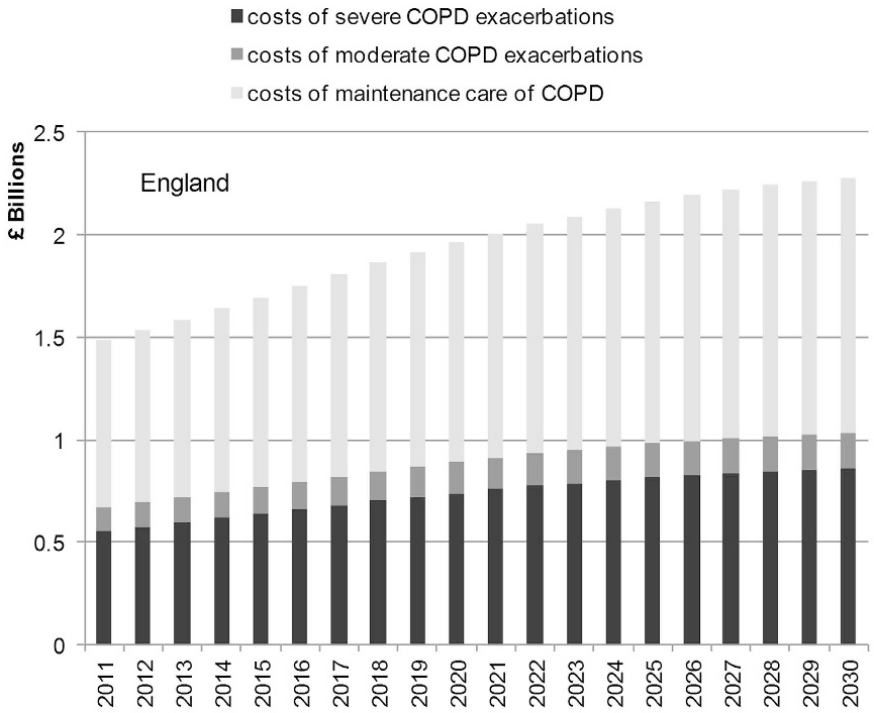

Figure 15 Projected total annual direct healthcare costs of COPD in England from 2011 to 2030. Source: Scientific Reports[35].

Data from a 2004 paper, adjusted to 2018/19 prices, estimates the direct costs of COPD per patient to be approximately £1,459 per year (Table 3)[36]. This study revealed that the unscheduled emergency care costs, such as hospital admission costs and A&E costs, were the major cause of cost burden resulting from COPD. The inadequate diagnosis and management of COPD in primary care is suggested to result in the unscheduled care.

Table 3 The estimated average annual COPD costs per patients. All costs have been inflated from 2003/2004 values to reflect 2018/2019 prices using the HCHS pay and prices index. Source: Respiratory Medicine[36].

Item	Cost per patient	
Hospital admission	£791.39	
Accident and Emergency	£32.13	
GP visits	£22.55	
Specialist visits	£34.44	
Unscheduled emergency care	**£880.51**	(60%)
GP visits	£165.31	
Specialists visits	£73.75	
Scheduled care	**£239.05**	(16%)
Regular prescription medication	£200.37	
Antibiotics for respiratory infections	£25.72	
Influenza vaccines	£6.27	
Home oxygen therapy	£39.69	
Treatment for COPD	**£272.06**	(19%)
Chest X-rays	£51.12	
Hypodermic needle/syringe tests of blood oxygen	£15.88	
Diagnosis	**£67.00**	(5%)
Total	**£1,458.62**	

A later cohort study[37] identified that £2,108 was spent on the annual COPD management cost in the UK primary care per patient even excluding medication costs. A breakdown of total average costs is shown in Figure 16 which highlights that GP interactions contributed most to these costs.

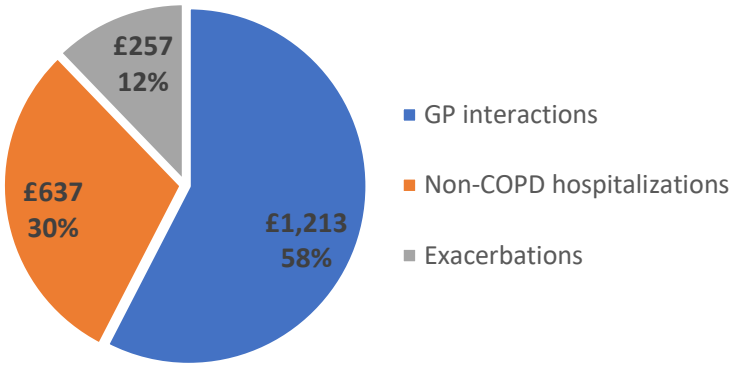

Figure 16 The annual average cost of COPD management per patient. Source: International Journal of COPD[37].

This study has also revealed that the annual costs for COPD management in the UK primary care escalated with the frequency of exacerbations; the total annual costs were £1,523,

£2,405 and £3,396 for patients with no, one, and two or more exacerbations, respectively (Figure 17).

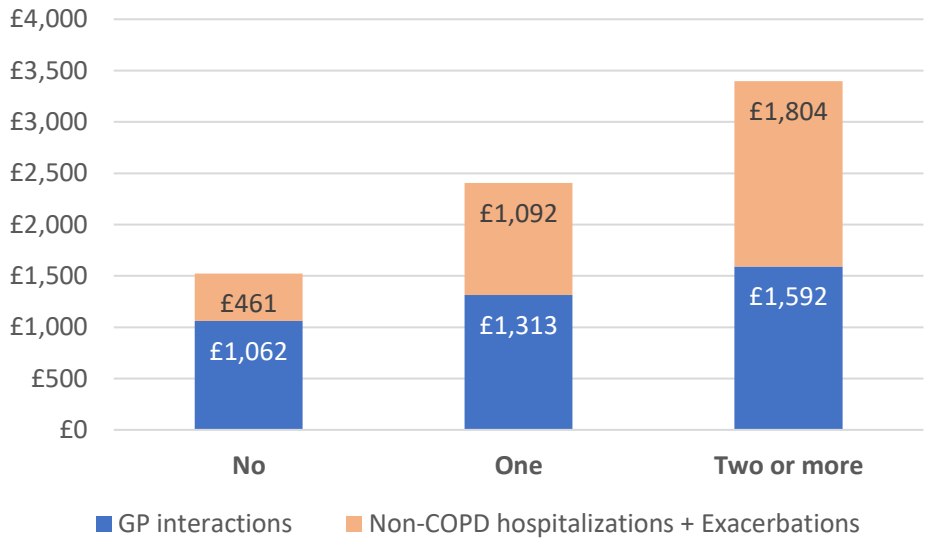

Figure 17 The average annual COPD management costs per patients split by the frequency of exacerbations. Source: International Journal of COPD[37].

Asthma

From the results of an Asthma UK study, at least £1.2 billion is estimated to be spent on asthma care in the UK public sector every year[38]. Table 4 outlines a breakdown of these costs. The costs incurred in primary care are the largest, accounting for 75% of total cost, and over £764 million is spent on prescription costs.

Table 4 Estimated costs for asthma in the UK. All costs have been inflated from 2011/2012 values to reflect 2018/2019 prices using the HCHS pay and prices index. Source: BMC Medicine[38].

	Cost (£m)	
Prescription costs	£764	
GP consultations	£124	
Practice nurse consultations	£59	
Calls to out-of-hours	£2	
Primary care	**£949**	(75%)
Ambulance Trips	£38	
Accident and Emergency	£15	
Hospital admission	£98	
ICU	£6	
Secondary care	**£157**	(12%)
Disability living allowance	**£169**	(13%)
Total	**£1,275**	

Lung cancer

A cohort study of the cost of cancer care in England has clarified that the lung cancer care costs in terminal phase contributed significantly the largest share to lung cancer costs, accounting for 66% of the total cost (Table 5)[39]. It is suggested to be due to poor survival and a large proportion of patients dying in the year of their diagnosis. Lung cancer is estimated to cost £380.93 million to the healthcare system in England.

According to research by Oxford University group in 2012, it was reported that the annual cost of lung cancer treatment was £9,071 per patient[40]. In contrast, the average spend on all cancer patients was £2,776, indicating that lung cancer costs the UK healthcare system a greater amount than any other cancer.

Table 5 Five-year lung cancer prevalence costs by phase of care. All costs have been inflated from 2010/2011 values to reflect 2018/2019 prices using the HCHS pay and prices index. Source: British Journal of Cancer[39].

	Cost (£m)			
	18-64	≥65	All ages	% (A)
Initial phase	£42.21	£74.86	£117.06	(24%)
Continuum phase	£17.85	£29.11	£46.96	(10%)
Terminal phase	£95.09	£227.23	£322.32	(66%)
Total health-care costs (A)	£155.15	£331.20	£486.34	
Comparison group costs (B)	£14.15	£91.26	£105.42	
Net health-care costs (A–B)	**£140.99**	**£239.94**	**£380.93**	

The late stage cancer treatment per individual is significantly more expensive than earlier stage treatment[41]. For non-small cell lung cancer (NSCLC), the stage 1 treatment cost is £7,952, whereas stage 4 treatment cost is £13,078. The cost of chemotherapy is the main burden on treatment for lung cancer at stage 4. In addition to the high expenses, nearly 50% of lung cancer patients are diagnosed at stage 4, whereas around 25% are diagnosed at earlier stages: stage 1 or 2[42]. A detailed breakdown of costs by stage is provided in Table 6.

Table 6 Treatment costs by stage per individual excluding the costs of recurrence. Source: Cancer Research UK[41].

	Diagnostics	Surgery	Radio-therapy	Chemo-therapy	Other	Total
Stage 1	£2,939	£2,561	£731	£0	£1,720	**£7,952**
Stage 2	£2,939	£2,561	£731	£290	£1,827	**£8,349**
Stage 3	£3,124	£1,283	£1,199	£290	£2,837	**£8,733**
Stage 4	£2,906	£181	£1,377	£5,669	£2,944	**£13,078**

Pneumonia

From a cost burden analysis of community-acquired pneumonia[43], it is estimated that approximately £1.2 billion is spent on community-acquired pneumonia every year and 96% of the expenditure is in secondary care.

Table 7 Annual direct costs to the NHS for managing community-acquired pneumonia. All costs have been inflated from 1992/1993 values to reflect 2018/2019 prices using the HCHS pay and prices index. Source: European Respiratory Journal[43].

Item	Annual direct costs to the NHS (£m)	
GP consultations	£15.8	
Community nurse visits	£3.6	
GP prescribed drugs	£4.2	
GP-initiated diagnostic tests	£23.5	
Community dispensing fees	£0.3	
Primary Care	**£46.4**	(4%)
Outpatients visit	£17.3	
Hospital stay	£1,072.1	
NHS transport	£19.8	
Drugs prescribed in hospital	£36.0	
Diagnostic tests for in-patients	£35.5	
Laboratory assays	£0.8	
Hospital dispensing fees	£3.6	
Secondary Care	**£1,185.2**	(96%)
Total cost	**£1,231.6**	

4. Opportunities for innovation from Health Economic perspective

Preventing and/or Reducing the Asthma attacks rates

A study of asthma care cost in the UK has identified that the average cost per patient who had an asthma attack was more than 3.5 times higher than those who did not[44], meaning that approximately £500 could be saved per patient by preventing asthma attacks.

As shown in Table 8, the secondary care costs for patients with asthma attacks far outweigh those who experience no attacks; the secondary care cost for patients with attacks was £377.94 compared with £22.43 for patients with no attacks.

This result underlined the benefit for cost reduction by innovation to prevent and/or reduce asthma attacks.

Table 8 Average costs per patient with attack and with no attacks. All costs have been inflated from 1999/2000 values to reflect 2018/2019 prices using the HCHS pay and prices index. Source: Thorax[44].

	Average cost per patient	
Item	**with attacks**	**with no attacks**
GP consultation	£73.25	£25.65
Nurse consultation	£3.43	£1.71
Nurse review	£16.01	£11.91
Routine medication	£236.29	£138.44
Primary Care	**£328.98**	**£177.71**
Emergency medication	£2.11	£0.17
Hospital stay	£313.83	£13.06
A&E visit	£18.05	£0.52
Outpatients	£43.94	£8.68
Secondary Care	**£377.94**	**£22.43**
Overall cost	**£706.92**	**£200.14**
Total saving costs by preventing attacks	-	**£506.79**

Improving efficiency of Chest CT scan by using AI technology

Artificial Intelligence (AI) technology is expected to improve time efficiency and accuracy in radiology. To predict its impact on the cost saving to the NHS, we conducted scenario analyses. It is estimated that the following outcomes might be achieved:

1) Improved efficiency through time saved reading more scans per hour,
2) Improved accuracy, reduction in error and improved speed of detection.

1. Improved efficiency through time saved reading more scans per hour

We anticipate that AI technology will support radiologists to identify the incidence of pulmonary nodules, saving their working time due to the reduction of incidental findings times.

For this analysis we have assumed:

- Working time of radiologists (Band 8C) is 1,599 hours per year[45].
- 612,000 Chest and/or abdomen CT scan are undertaken per year[46].
- Unit costs of radiologists (Band 8C) is £95 per working hour[45].

This analysis revealed that around £4.8 million could be saved by introducing AI technology to reduce the radiologists time.

Table 9 The scenario analysis of reducing radiologists time by AI technology.

	Standard diagnosis	Diagnosis using AI technology
Radiologist Time (mins)		
Clinical review	7	7
Incidental findings	6	2
Reporting	2	1
Total Time	15	10
# of cases per hour	4	6
# of cases per year	6,396	9,594
# of radiologist needed per year	96	64
# of radiologist saved per year	-	32
Total saving costs	**-**	**£ 4,841,992**

2. *Improved accuracy, reduction in error and improved speed of detection*

AI technology is anticipated to improve detection and classification of actionable nodules and it might help to reduce the follow-up CT scan.

For this analysis we have assumed:

- 47,300 patients are diagnosed with lung cancer per year[12].
- The lung cancer detection rate is 2.1%[47].
- 47.7% of screenings require the follow-up CT scan at 3months and/or 12 months[47].
- The cost of CT scan is ~£97 per procedure[48].
- AI technology can reduce the referral rate by 5% or 20%.

This analysis estimated that about £5.2 million could be saved by reducing follow-up by 5%, if Ai technology could improve the accuracy of detection.

Table 10 The scenario analysis of reducing follow-up by AI technology.

	Standard diagnosis	**Diagnosis using AI tech**	
Reduced referral rate	-	5%	20%
The rate of follow-up CT	47.7%	45.3%	38.2%
Numbers for follow-up CT	1,071,007	1,017,457	856,806
Total cost for follow-up CT	£ 103,887,693	£ 98,693,308	£ 83,110,154
Total saving costs	**-**	**£ 5,194,385**	**£ 20,777,539**

5. Procurement landscape

The NHS spends approximately £27 billion every year on goods and services. To save its cost, NHS Supply Chain has tried to develop the consistent procurement landscape. There are five main procurement routes for companies to sell products and services to the NHS[49]:

i) Selling direct to NHS organisations (e.g. NHS trusts / CCGs)
ii) Selling through via NHS Supply Chain
iii) Selling through collaborative Procurement Hubs
iv) National framework collaborations and contracts in England
v) Government tenders and contracts

Details of each route are described below.

i) Selling direct to NHS organisations (e.g. NHS trusts / CCGs)

NHS organisations can decide and purchase products/services directly from the manufacturers or distributors within purchasing rules and arrangement. Companies which have specific products/services easily matched to NHS organisations can sell directly to them.

This direct approach to individual NHS organisations via procurement department or clinicians requires the development of a business case. Business cases are typically prepared by the general / divisional manager of the clinical area involved from the NHS Trust, although the business cases may also include content and input from clinicians, finance and the company itself. These business cases tend to be generic and focus on the unmet need.

ii) Selling through via NHS Supply Chain

NHS Supply Chain manages the sourcing, delivery and supply of healthcare products, services and food for NHS trusts and healthcare organisations across England and Wales.

NHS Supply Chain consolidate orders from over 800 suppliers, saving trusts time and money and removing duplication of overlapping contracts.

In 2017, the Department of Health produced the Future Operating Model for NHS procurement[50]. This included plans to double the amount of goods and consumables which are procured via NHS Supply Chain.

The Future Operating Model for NHS Procurement also outlines the formation of category towers, grouped into procurement categories: Medical products, Capital expenditure and Mom-medical spending.

Table 11 Procurement category towers. Source: NHS England[49].

Medical category towers		
Tower number	**Category**	**Awarded to**
1	Ward based consumables	DHL Supply Chain Ltd
2	Sterile based intervention equipment and associated consumables	NHS Collaborative Procurement Partnership (CPP)
3	Infection control and wound care	DHL Supply Chain Ltd
4	Orthopaedics, trauma and spine, opthalmology	NHS Collaborative Procurement Partnership (CPP)
5	Rehabilitation, disabled services, women's health and associated consumables	NHS Collaborative Procurement Partnership (CPP)
6	Cardiovascular, radiology, audiology and pain management	Health Solutions Team Ltd
Capital towers		
Tower number	**Category**	**Awarded to**
7	Large diagnostic, capital devices including mobile and consumables	DHL Supply Chain Ltd
8	Diagnostic equipment and consumables	Akeso and Company Ltd
Non-medical towers		
Tower number	**Category**	**Awarded to**
9	Office Solutions	Crown Commercial Service (CCS)
10	Food	Foodbuy
11	NHS Hotel Services	NHS North of England Commercial Procurement Collaborative

iii) Selling through collaborative Procurement Hubs

NHS Trusts and CCGs may also choose to procure products via the Collaborative Procurement Partnership[51], made up of four regional procurement hubs:

- NHS Commercial Solutions (CS),
- NHS North of England Commercial Procurement Collaborative (NOE CPC),

- East of England NHS Collaborative Procurement Hub (EOE)
- NHS London Procurement Partnership (LPP).

iv) National framework collaborations and contracts in England

The Crown Commercial Service (CCS) is the biggest public procurement organisation in the UK. They provide procurement savings for the government and the UK public sector, including health, local government, devolved administrations, education and not for profit organisations.

Selected companies who are comprised with collaborative purchasing contracts contractually agree to provide specific products or services at a given price to any NHS trust that uses them: This is led by the CCS, which provides the guidance on how to become a supplier through the CCS[52].

v) Government tenders and contracts

As a public body, NHS England adheres to both EU and national procurement rules[53] for procurement of supplies and services over specific monetary thresholds. These rules ensure transparency, equity of access and help to assess value for money and the suitability of potential providers. These procurement opportunities are put out to tender.

Contracts Finder[54] enables searches for NHS contracts opportunities worth over £10,000.

The NHS England eTendering Service[55] provides a free, simple, secure and efficient access to tendering activities and contract negotiations over the Internet.

An additional route, indirect route to the NHS, is to sell products and services to an existing supplier to the NHS.

6. Publicly available data

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