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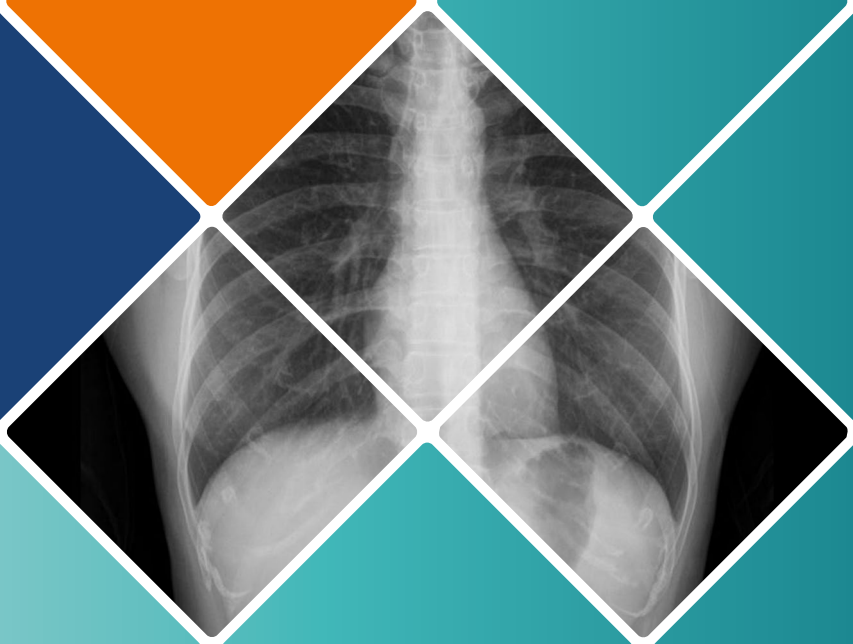

Missed detection of lung cancer on chest X-rays of patients being seen in primary care

Independent report by the
Healthcare Safety Investigation Branch NI-000836

October 2021

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About HSIB

We conduct independent investigations of patient safety concerns in NHS-funded care across England. Most harm in healthcare results from problems within the systems and processes that determine how care is delivered. Our investigations identify the contributory factors that have led to harm or the potential for harm to patients. The safety recommendations we make aim to improve healthcare systems and processes, to reduce risk and improve safety.

We work closely with patients, families and healthcare staff affected by patient safety incidents, and we never attribute blame or liability.

Considerations in light of coronavirus (COVID-19)

We have adapted some of our national investigations, reports and processes to reflect the impact that COVID-19 has had on our organisation as well as the healthcare system across England. For this report, the way we engaged with staff was revised.

A note of acknowledgement

We would like to thank Tracey whose experience is central to this investigation. Tracey was open with the investigation about what had happened and her reflections on what might have made a difference. Information shared by Tracey helped to inform the investigation and provided invaluable insight into the impact of such incidents. Tracey hopes her story might promote change.

In accordance with her wishes, Tracey is referred to by name throughout this report.

We also thank the healthcare staff and subject matter advisors who gave their time to provide us with information and expertise which contributed towards this report, and the stakeholder organisations and professional bodies who supported the investigation.

About Tracey

There is a little plaque on the windowsill in Tracey's house that says 'I can do anything, but not everything'. It is not true. Tracey does everything. She is the full-time carer for two family members, she is actively involved with a lung cancer support group, she has lots (and lots and lots) of friends and groups that she meets regularly and goes on holidays with most years. And then there are the three dogs, monster cat, two guinea pigs and a tortoise. And the plan for a camper van for adventures ahead. So, Tracey is a busy – very busy – person. She is also courageous, kind, optimistic and you will usually find her laughing. Her view on life? "You've got to be positive."

About this report

This report is intended for healthcare organisations, policymakers and the public to help improve patient safety in relation to the delayed diagnosis of lung cancer.

Our investigations

Our investigators and analysts have diverse experience of healthcare and other safety-critical industries and are trained in human factors and safety science. We consult widely in England and internationally to ensure that our work is informed by appropriate clinical and other relevant expertise.

We undertake patient safety investigations through two programmes:

National investigations

Concerns about patient safety in any area of NHS-funded healthcare in England can be referred to us by any person, group or organisation. We review these concerns against our investigation criteria to decide whether to conduct a national investigation. National investigation reports are published on our website and include safety recommendations for specific organisations. These organisations are requested to respond to our safety recommendations within 90 days, and we publish their responses on our **website**.

Maternity investigations

We investigate incidents in NHS maternity services that meet criteria set out within one of the following national maternity healthcare programmes:

- Royal College of Obstetricians and Gynaecologists' 'Each Baby Counts' report
- MBRRACE-UK 'Saving Lives, Improving Mothers' Care' report.

Incidents are referred to us by the NHS trust where the incident took place, and, where an incident meets the criteria, our investigation replaces the trust's own local investigation. Our investigation report is shared with the family and trust, and the trust is responsible for carrying out any safety recommendations made in the report.

In addition, we identify and examine recurring themes that arise from trust-level investigations in order to make safety recommendations to local and national organisations for system-level improvements in maternity services.

For full information on our national and maternity investigations please **visit our website**.

Addendum to report (March 2022)

The research safety recommendation (R/2021/152) was originally issued to NHS England and NHS Improvement. Following publication of the report, and on their advice, the recommendation was re-issued to the National Institute for Health Research. The report has been amended to reflect this change.

Executive Summary

Background

This investigation explores the issues contributing to delayed diagnosis of lung cancer. Specifically, it explores delays resulting from missed detection of possible lung cancer on chest X-rays of patients being seen in primary care.

As an example, which is referred to as 'the reference event', the investigation considered the experience of Tracey, who saw her GP on multiple occasions with respiratory symptoms over the course of a year. Tracey had three chest X-rays during this time which did not identify a possible lung cancer.

The investigation's findings, safety recommendations and safety observation aim to facilitate the timely diagnosis of lung cancer and so improve care for patients across the NHS. Some of the findings and conclusions may also be applicable to other cancers and conditions

The reference event

Tracey contacted her general practice with symptoms of cough and shortness of breath which she had had for several months. She was initially prescribed antibiotics by a nurse practitioner for a presumed chest infection.

As Tracey's symptoms did not improve, she saw a GP who referred her for a chest X-ray. This X-ray, and a subsequent one, did not identify a possible lung cancer. Tracey was at low risk of lung cancer as she was 49 years old and had never smoked. Over the next 7 months, Tracey was seen at the GP practice on multiple occasions with an ongoing cough and shortness of breath without a cause being identified.

Nine months after Tracey's first visit to the practice with respiratory symptoms, she saw a GP because she was experiencing central chest pain in addition to her worsening breathlessness. The GP referred Tracey to the emergency department and ordered an urgent CT scan. Tracey had a chest X-ray in the emergency department; the report on this X-ray did not identify a possible lung cancer. The

CT scan performed a few days later identified likely lung cancer which appeared to have spread throughout Tracey's lungs.

The respiratory consultant who saw Tracey to discuss her diagnosis was open about the fact that findings on the previous X-rays suggested that cancer may have been present but that this was not identified. The consultant referred the matter as a patient safety incident requiring investigation.

Tracey was referred to the oncology team (specialist cancer team) and, after further tests, began drug treatment for her cancer.

The national investigation

Delayed diagnosis of lung cancer is a nationally recognised patient safety risk. HSIB contacted the hospital where the reference event occurred. The Trust welcomed HSIB's involvement and collaborated with information gathering. After initial information had been gathered and evaluated against a set of patient safety risk criteria, HSIB's Chief Investigator authorised a national safety investigation.

Findings

- Lung cancer in people who have never smoked is increasing.
- Media messaging highlighting the close link between lung cancer and smoking, and the often non-specific symptoms of lung cancer, have created a significant diagnostic challenge for GPs.
- A chest X-ray is the recommended first test to assess whether a patient may have lung cancer. Chest X-rays are difficult to interpret and about one in five cancers are missed. A chest X-ray report that does not identify cancer has the potential to falsely reassure GPs.
- Evidence indicates that it may be beneficial to amend the safety netting advice for healthcare professionals in the National Institute for Health and Care Excellence guidance. In this context, safety netting advice refers to advice given to healthcare professionals on the precautionary measures they should take to mitigate the risk of missed diagnosis. The amended advice should make clearer what should be offered to patients who have ongoing, unexplained symptoms after a negative chest X-ray.
- CT scanning is a more accurate test to diagnose lung cancer and is used more widely in other developed countries which have better cancer survival rates. There is national recognition that major investment is needed in CT scanning equipment and workforce to perform and report scans.

- Using low-dose CT (a scan that exposes a patient to a smaller amount of radiation compared to conventional CT) to screen people at high risk of lung cancer, such as current or past smokers, has been shown to be beneficial. There is no significant evidence, and differing opinion, as to whether low-dose CT should replace chest X-ray as the first-line diagnostic test to assess for lung cancer in patients seeing their GP with non-specific symptoms. Research is needed to determine the clinical and cost-effectiveness of this.

- An increasing number of artificial intelligence products are being marketed to aid the detection of lung disease including cancer. There is variable testing and evaluation of these products.

- Expertise is an important factor in mitigating the risk of missed cancer on chest X-rays. There are educational platforms that can help the healthcare staff who review and interpret X-rays to develop their skills and assess their own performance. These may be helpful to assure quality and contribute to ongoing professional development.

HSIB makes the following safety recommendations

Safety recommendation R/2021/152:
HSIB recommends that the National Institute for Health Research assess the priority, feasibility and impact of future research to address whether low-dose computed tomography (CT) is clinically and cost-effective for the diagnosis of lung cancer in symptomatic patients seen in primary care and consider the most appropriate way of building up the evidence base on this topic.

Safety recommendation R/2021/153:
HSIB recommends that the National Institute for Health and Care Excellence reviews its current safety netting advice to healthcare professionals with respect to the investigation of possible lung cancer. The wording of the advice should be amended as required to make it clearer what should be offered to patients with ongoing, unexplained symptoms who have had a negative chest X-ray.

Safety recommendation R/2021/154:
HSIB recommends that NHSX, in collaboration with relevant stakeholders such as The Royal College of Radiologists and The Society and College of Radiographers, develops guidance to support independent benchmarking and validation of artificial intelligence algorithms for the identification of lung diseases such as cancer.

HSIB makes the following safety observation

Safety observation O/2021/129:
It may be beneficial if existing educational platforms were used to support healthcare staff who report on chest X-rays with their ongoing professional development and demonstration of the clinical quality of their work.

Contents

1 Background and context **10**

2 The reference event **20**

3 Involvement of the Healthcare Safety Investigation Branch **25**

4 Analysis and findings – the reference event **31**

5 Analysis and findings from the wider investigation **48**

6 Summary of findings, safety recommendations and safety observations **74**

7 References **76**

8 Endnotes **89**

1 Background and context

1.1 Lung cancer

1.1.1 There are approximately 46,700 new diagnoses of lung cancer a year in the UK (Cancer Research UK, 2019). It is most often diagnosed in people over 70 years of age (Cancer Research UK, n.d.a). Research shows that 8 out of 10 cases of lung cancer are caused by smoking (Cancer Research UK, 2019). Approximately 56% of people are diagnosed following referral for a chest X-ray (Aslam et al, 2018a).

1.1.2 While smoking remains the largest risk factor for lung cancer in the UK, if considered as a separate entity, lung cancer in never-smokers is the eighth most common cause of cancer-related death in the UK (Bhopal et al, 2019). The term 'never-smoker' generally refers to patients who have smoked less than the equivalent of 100 cigarettes in their lifetime (Subramanian and Govindan, 2007). With rates of smoking declining, the relative proportion of lung cancer in never-smokers is increasing. In addition, the prevalence of lung cancer in never-smokers is rising (Couraud et al, 2012).

1.1.3 Lung cancer does not always cause symptoms in its early stages [1]. Many of the signs and symptoms can also be caused by other medical conditions. The most common symptoms of lung cancer are:

- a persistent cough
- shortness of breath
- coughing up phlegm (sputum) with blood in it
- having an ache or pain in the chest or shoulder
- feeling tired all the time (fatigue)
- losing weight (Cancer Research UK, n.d.b).

1.1.4 There are different types of lung cancer and they are divided into two main groups:

- non-small-cell lung cancer
- small-cell lung cancer.

1.1.5 The type depends on the cell that the cancer started in. Around 80% to 85% of lung cancers in the UK are non-small-cell lung cancer (Cancer Research UK, 2020). Adenocarcinoma, which starts in the mucus-making gland cells in the lining of a person's airways, is a common subtype of non-small-cell lung cancer (British Lung Foundation, n.d.). The patient in the reference event, Tracey, was diagnosed with adenocarcinoma.

1.1.6 Lung cancer is the third most common cancer diagnosed in England, but accounts for the most deaths (Cancer Research UK, n.d.c; The Association of the British Pharmaceutical Industry, 2017). According to figures for 2010 to 2014, estimated five-year survival rates are among the lowest in Europe (United Kingdom Lung Cancer Coalition, 2019; NHS England Lung Clinical Expert Group, 2017; Independent Cancer Taskforce, 2016).

1.1.7 The low survival rate reflects the fact that two-thirds of patients with lung cancer are diagnosed at an advanced stage when treatment to cure the disease (curative treatment) is no longer feasible (NHS England and NHS Improvement, 2019a; The Association of the British Pharmaceutical Industry, 2017; del Ciello et al, 2017; Independent Cancer Taskforce, 2016). This is particularly true of patients diagnosed via an emergency presentation (The Association of the British Pharmaceutical Industry, 2017). Tracey was diagnosed at an advanced stage of disease and after being referred to the emergency department by her GP (**see section 2**).

1.1.8 In 2016, only 25.7% of all lung cancer patients were diagnosed at an early stage (NHS England, 2018a). Early diagnosis of lung cancer is one of the main goals to improve survival rates (Bradley et al, 2019; del Ciello et al, 2017). The aim for the NHS in England is to achieve diagnosis of cancer at an early stage in three quarters of patients by 2028 (NHS England and NHS Improvement, 2019a).

1.1.9 Because of the low survival rates, there has been a national focus on lung cancer (Getting It Right First Time, 2019; NHS England, 2018a). Rapid diagnostic and assessment pathways have been developed to help patients get a diagnosis at an earlier stage when treatment could be more effective and potentially curative (United Kingdom Lung Cancer Coalition, 2019; Lung Clinical Expert Group, 2017). Specifically, 14-day and 28-day pathways have been designed, with GP access to rapid chest X-ray [2] and CT scan results [3] when lung cancer is suspected (NHS England, 2018a).

1.1.10 The National Cancer Audit found that 72.2% of cancer patients first reported symptoms at their GP surgery or during a GP home visit (Swann et al, 2018). For more than one in five patients, GP surgeries reported an avoidable delay somewhere along the journey to diagnosis. More than a quarter of

the avoidable delays (28%) were reported to be due to doctors (GPs or specialists) failing to make the diagnosis – for example, when 'symptoms were difficult to assess' (Swann et al, 2018).

1.1.11 The audit showed that in 45% of all cancer patients at least one primary care-led diagnostic investigation was carried out before referral to a specialist (Swann, et al, 2018). A chest X-ray is the recommended and most common first investigation to help assess the possibility of lung cancer (Bradley et al, 2019; National Institute for Health and Care Excellence., 2019).

1.1.12 The time between a patient's first visit to a GP with symptoms likely related to the subsequent cancer diagnosis, and specialist referral for suspected cancer, is longer for cancers with non-specific symptoms such as lung cancer (Swann et al, 2018).

1.1.13 Lyratzopoulos et al (2014) studied the frequency of, and reasons for, multiple GP pre-referral consultations in patients subsequently diagnosed with cancer. They found this varied by cancer site (where the cancer is in a person's body) and found this variation to be consistent with each cancer's 'symptom signature', with some cancers, such as lung cancer, being harder to diagnose than others. Accordingly, about 30% of patients with lung cancer will have had three or more consultations with their GP before they are referred for suspected cancer, resulting in a delay in diagnosis (Lyratzopoulos et al, 2012; Royal College of General Practitioners, 2011).

1.1.14 The dominant, most consistent respiratory symptom documented when Tracey attended her GP was a cough. This is a prevalent health problem, reported by 10% to 20% of adults (Morice et al, 2006).

1.1.15 Cough is 'one of the most common reasons' for attendances in primary care (Speich et al, 2018). A chronic cough can be defined as one lasting more than 8 weeks (Morice et al, 2006). It has been estimated that 'about one in ten' patients present to primary care with a chronic cough (Gruffydd-Jones, 2020). This symptom can be an indication of numerous respiratory conditions, the vast majority of which will be diseases other than lung cancer (Gruffydd-Jones, 2020; Speich et al, 2018; Morice et al, 2006). This means that a GP is likely to see patients with a chronic cough frequently, but lung cancer rarely.

1.1.16 In the UK, approximately 40% of patients with lung cancer are diagnosed following an emergency admission to hospital (Elliss-Brookes et al, 2012). This is 15% higher than the average for all cancers. Furthermore, the percentage of people with lung cancer diagnosed via GP referral is

lower than for most other cancers, with 21% of lung cancer patients being diagnosed through this route compared to 26% of all cancer patients (The Association of the British Pharmaceutical Industry, 2017).

1.1.17 Across all cancer types, the relative survival rate at 1 year is significantly lower (20% to 40%) for cases where the patient was diagnosed following an emergency admission to hospital than any other route (such as GP referral or screening programmes) (Elliss-Brookes et al, 2012).

1.1.18 The COVID-19 pandemic has created additional challenges to early diagnosis of lung cancer. The reluctance of patients to seek medical attention and an over-burdened health service has resulted in significant backlog of referrals for suspected cancer (Maringe, 2020). In England, urgent referrals for lung cancer have been the most impacted compared to all other types of cancers. It is estimated the COVID-19 pandemic could lead to an additional 1,372 deaths due to lung cancer (United Kingdom Lung Cancer Coalition, 2020).

1.2 Reporting chest X-rays

1.2.1 Chest X-ray is the recommended diagnostic test to assess for lung cancer in patients attending primary care with symptoms such as cough and breathlessness (National Institute of Health and Care Excellence, 2019).

1.2.2 Chest X-rays commonly cannot enable a definitive diagnosis of lung cancer to be made as they often cannot distinguish between cancers and other conditions such as pneumonia (Roy Castle Lung Cancer Foundation, 2019).

1.2.3 X-rays are usually reviewed by a radiologist (a doctor trained to interpret X-rays and other diagnostic images). The radiologist then writes a report of their findings and interpretation of the findings for the doctor who has referred the patient. This process is referred to as ‘reporting’. However, radiographers [4] with appropriate additional training can also report chest X-rays and increasingly do so.

1.2.4 Due to the quantity of X-rays and other diagnostic images that require reporting, many Trusts outsource some of this work to an external teleradiology [5] company or group (Care Quality Commission, 2018). The Trust where the reference event took place outsourced work to a large, external, national networked teleradiology group.

1.2.5 Radiologists often develop a special interest and expertise in interpreting images of a particular part of the body. Such specialists may spend most of their time reporting such images, potentially losing skills outside their area of expertise.

1.2.6 Chest X-rays are a common imaging investigation and one that nearly all radiologists would be expected to report. However, chest X-rays are acknowledged to be difficult to interpret due to the number of anatomic structures and vessels present in the chest which can make it difficult to identify any abnormalities (**see 1.4**).

1.2.7 Errors can be categorised as a 'miss' when a primary or critical finding is not observed, or as a 'misinterpretation' when errors in interpretation result in an incorrect diagnosis (Busby et al, 2018).

1.2.8 Significant rates of diagnostic error have been found in the interpretation of imaging. As early as 1959 a study reported a 32% retrospective error rate in the interpretation of abnormal chest X-rays (Garland, 1959) This level of error has persisted (Kim and Mansfield, 2014; Berlin, 2007).

1.3 Missed detection of lung cancer

1.3.1 Although chest X-ray is the recommended first-line diagnostic test, it is easier to detect lung cancer with a CT scan. Approximately 90% of missed lung cancers are from X-ray imaging. Only 5% of misses are from CT scans (del Ciello et al, 2017). A chest X-ray is a two-dimensional image representing a complex three-dimensional structure – a person's thorax with the heart, lungs, major pulmonary vessels and bony structures in the chest wall. CT scanning uses an X-ray beam which encircles the patient, producing a computer-generated cross-sectional image of the chest. There is also the option of using a special dye or contrast agent which can further help image interpretation. Unlike a CT scan image, on a chest X-ray image the structures inside the chest overlap, which can hide an early-stage lung cancer. On some occasions, the cancer is hidden to the extent that it cannot be detected. On other occasions, it is possible to detect the cancer, or signs of it, but they are missed. The reference event, and this report, focuses on these latter occasions.

1.3.2 In advanced economies with better outcomes for patients with lung cancer, investigations such as CT scans are used more extensively (Eurostat, Statistics Explained, 2019). The UK's CT scan capacity of 8 scanners per million people is significantly lower than the European average of 21.4 (United Kingdom Lung Cancer Coalition, 2019). Furthermore, the UK has an estimated 7 radiologists per 100,000 population which is 'one of the lowest in Europe' and compares to an average of 12 radiologists per 100,000 population for Western Europe (GE Healthcare Partners, 2018).

1.3.3 The interval between the actual identification of a lung cancer and its first retrospective appearance on a chest X-ray has been found to range from 0.2 to 48 months (Monnier-Cholley et al, 2001; Austin et al, 1992; Forrest and Friedman, 1981).

1.3.4 Bradley et al (2019) carried out a systematic review of the sensitivity of chest X-rays for detecting lung cancer in people presenting with symptoms. The evidence suggested that the sensitivity is 'only 77% to 80%'. This means that while the majority of lung cancers can be identified on chest X-rays, nearly a quarter are missed which may cause a 'delayed diagnosis for several thousand patients each year' and affect these patients' prognosis.

1.3.5 Bradley et al (2019) state:

'If chest X-ray were a novel technology, it is debatable whether the available evidence would be deemed sufficient to support its implementation as a diagnostic test for lung cancer.' As earlier diagnosis is closely associated with improved survival rates (del Ciello et al, 2017; Turkington et al, 2002; Quekel et al, 1999), Bradley et al (2019) conclude:

'GPs should take limited reassurance from a non-diagnostic chest X-ray and consider additional imaging or referral of those at high risk, or re-imaging in the face of continuing symptoms.'

1.3.6 With regard to more definitive imaging such as CT scans, the authors note that given resource restrictions and the potential to cause harm through over-diagnosis, 'further work is required to determine which patients can be reasonably followed up by safety netting [information about actions to take if their condition fails to improve], following an unremarkable chest X-ray and which patients require further investigation' (Bradley et al, 2019).

1.3.7 In 2008 The Royal College of Radiologists highlighted literature reporting missed cancer rates from 20% to 60% (The Royal College of Radiologists, 2008). The College stated: 'It is imperative to have a high standard of reporting accuracy by radiologists in order to detect lung cancer at the earliest stage possible'. It set a target that any lesion (abnormal change in tissue) present should be identified in 75% of chest X-rays performed within 1 year of the lung cancer diagnosis. The College suggested that data be collected to assess local practice and make recommendations to promote change if the target is not met (The Royal College of Radiologists, 2008).

1.4 Reasons for missed detection of lung cancer

1.4.1 Various factors contribute to missed diagnoses of lung cancer on chest X-rays. Evidence suggests that these include observer error, lesion characteristics and technical considerations (del Ciello et al, 2017).

Observer error

1.4.2 Observer error is 'likely the biggest cause of misdiagnosis of lung cancer' (del Ciello et al, 2017). Such errors can be classified into three categories (Kundel et al, 1978):

- scanning error
- recognition error
- decision-making error.

1.4.3 Scanning error essentially means that the lesion is not seen during the 20 to 30 seconds spent on average analysing a chest X-ray. This error has been found to account for about 30% of missed lung cancers (del Ciello et al, 2017). Currently, large parts of a chest X-ray are often not scanned by the human eye during review (Manning et al, 2004). Studying these errors, Manning et al (2004) found that more time spent visually scrutinising all areas would be required to increase detection of lung cancers.

1.4.4 The experience of the person reporting the X-ray also plays a role in scanning error. Expert reviewers develop an ordered, systematic scanning pattern, reducing the risk of missing any abnormalities (del Ciello et al, 2017).

1.4.5 Recognition error is where the person reviewing an X-ray scans the image adequately but does not detect possible cancer lesions. This accounts for about 25% of missed cancer lesions (del Ciello et al, 2017). Brogdon et al (1983) found the mindset – specifically the vigilance and attitude – of the X-ray reviewer in searching for lung lesions to be an important element of this error. Issues such as work conditions and human factors like fatigue, bias and level of suspicion of cancer have been found to affect this, but also the age of the patient, their clinical history and the presence of other abnormalities – vigilance or alertness to the possibility of a lung cancer is greater in patients deemed to be at high risk rather than those considered to be at low risk (del Ciello et al, 2017).

1.4.6 Decision-making error occurs when the reviewer identifies an anomaly but interprets it incorrectly as being 'normal'. This is the cause of 45% of errors (del Ciello et al, 2017). The experience of the X-ray reviewer is one of the most important elements influencing this kind of error (Kundel and Follette, 1972).

Lesion characteristics

1.4.7 Lesion characteristics are strongly related to the probability of identifying possible cancer. Del Ciello et al (2017) state that: 'Dimension, conspicuity [how conspicuous the lesion is], and location are the most important features to consider.'

1.4.8 Small lesions are more likely to be missed (del Ciello et al, 2017; Turkington et al, 2002). However, factors such as visibility of the lesion margins and density are also important in detection (Quekel et al, 1999).

1.4.9 Detection of lesions on chest X-rays is 'strongly influenced' by their location and whether there are overlying anatomic structures (such as the ribs, heart, diaphragm and lung vessels) creating 'anatomic noise' (del Ciello et al, 2017). Lesions in the upper lobes of the lung are more likely to be missed (Turkington et al, 2002; Quekel et al, 1999; Austin et al, 1992). That said, this may be partially explained by the higher frequency of lung cancer occurrence in the upper lobes (Byers et al, 1984).

Technical considerations

1.4.10 Image quality and patient positioning and movement are elements that influence the probability of missing lung cancers (Brogdon et al, 1983).

1.4.11 Chest X-rays are usually taken in the postero-anterior view (where the X-ray beam enters through the back of the chest and exits out the front) and lateral (side) view, with the patient standing up. There are differing opinions on the value of obtaining a lateral view in addition to a postero-anterior view (**see 4.2**).

1.5 Decision-making and cognitive biases

1.5.1 Human decision-making processes contribute to observer error resulting in misses and misinterpretations in radiology. Busby et al (2018), referring to theories about human decision making and judgement, explain that individuals process information and make estimates and choices through the intuitive thought processes – also known as 'heuristics'.

1.5.2 Intuitive thought processes, sometimes called type 1 thinking [6], 'allow for rapid – almost reflexive – decision making with limited information' (Busby et al, 2018). Thus, experienced radiologists may reach a diagnosis 'without much conscious deliberation using a variety of heuristic techniques'. Busby et al (2018) state that although common and usually effective, heuristics 'may fail due to inherent errors called biases'.

1.5.3 At least 30 biases that affect human decision-making have been recognised (Croskerry, 2002). In their article on bias in radiology, Busby et al (2018) describe 10 of the most common biases that affect radiologic decision making and detail strategies to avoid bias. The effect of biases on interpretation of images has been described in a previous HSIB report (**Healthcare Safety Investigation Branch, 2020**).

1.5.4 The most common cognitive bias in radiology is 'satisfaction of search' (Kim and Mansfield, 2014). This refers to an individual's decreased vigilance and/or awareness of additional abnormalities after the first abnormality has been found. In a study of radiologic diagnostic errors, 22% were related to satisfaction of search (Kim and Mansfield, 2014).

1.5.5 Examples of other biases important in radiologic errors discussed by Busby et al (2018) include:

- Inattentional blindness – this describes findings that are missed because they are hidden in plain sight. Findings can be missed because of their location or because of the unexpected nature of the findings. The significant influence of this bias on radiologists was demonstrated in a study in which a cartoon gorilla was inserted into the lung fields on a chest scan. It was missed by 83% of radiologists who were asked to search for pulmonary nodules (Drew et al, 2013).

- Premature closure – the tendency to accept an initial diagnosis as final during the preliminary stages of evaluation. This is the most common type of cognitive error in clinical medicine (Graber et al, 2005). Busby et al (2018) say this bias can result from convenience or because a diagnosis has been made and thinking has, in effect, stopped. This bias may be particularly prevalent if an individual is fatigued and can be compounded by satisfaction of search and satisfaction of report.

- Satisfaction of report – the tendency to perpetuate an impression written in a prior imaging report, whether a colleague's or one's own. In a study reviewing 656 past imaging examinations within a delayed diagnosis, satisfaction of report was found to be the fifth most common cause of diagnostic errors (Kim and Mansfield, 2014).

1.6 Strategies to reduce the risk of misdiagnosis

1.6.1 Strategies to reduce the risk of misdiagnosis from misses and misinterpretations are directed at both an individual and system-wide level.

1.6.2 At an individual level, Busby et al (2018) describe strategies to counteract or minimize the impact of cognitive biases on decision-making. For example, having a structured, methodical, systematic search pattern when reviewing images; always reviewing prior images and coming to one's own interpretation before reading existing reports; self-questioning about possible alternative diagnoses before finalising a diagnosis; and awareness of recent cases that might impact on interpretation of current images. In addition, the authors argue that understanding thought processes and vulnerability to cognitive biases can help a radiologist identify when they may be most susceptible to error.

1.6.3 The importance of reviewing prior images is highlighted by other authors (del Ciello et al, 2017). Doing this has been shown to provide diagnostic value in 89% of examinations (White et al, 1994) and is reflected in The Royal College of Radiologists' Standards for interpreting and reporting imaging investigations (The Royal College of Radiologists, 2018).

1.6.4 Quiet, undisturbed conditions, or at least an environment in which unnecessary interruptions are reduced as far as possible, along with equipment such as monitors for viewing images being of high quality with all available functionality, are well recognised as important in reducing radiology errors (Busby et al, 2018; del Ciello et al, 2017).

1.6.5 Computer-aided detection systems and artificial intelligence algorithms when used as a second reader of a chest X-ray have been shown to reduce the risk of missed lung cancers (United Kingdom Lung Cancer Coalition, 2019; Mayo and Leung, 2018; del Ciello et al, 2017; Li et al, 2008).

1.6.6 Another way to increase recognition of small lesions is the use of CT, which allows the production of several section images at different depths. CT can be performed using varying doses of radiation. CT scans using a lower dose will not have the same resolution as scans using a higher dose but still give a significantly improved view of internal organs and structures compared with chest X-rays (Vikgren et al, 2008; Sone et al, 1998; Kaneko et al, 1996).

1.6.7 It has been proposed that CT may become the investigation of choice for patients considered to be at high risk of lung cancer who have new respiratory symptoms (Turkington et al, 2002). NHS England and NHS Improvement has commissioned Lung Health Check centres to perform low-dose CT scanning in their Targeted Lung Health Check programme to achieve earlier diagnosis in smokers and ex-smokers at significant risk (NHS England and NHS Improvement, 2019b).

2 The reference event

This investigation used the following patient safety incident, referred to as 'the reference event', to examine the issue of delayed diagnosis of lung cancer in patients seen in primary care.

2.1 Tracey's story

2.1.1 Tracey is 50 years old. She has never smoked. Tracey began to experience "a wheeze" in 2018. She thought dust from building work being carried out at her home could be the cause.

2.1.2 At the start of 2019 Tracey began to feel short of breath and she thought she may be developing a chest infection. At this time, her husband had a stroke and required brain surgery. Tracey was advised that her husband may not survive. Tracey was making frequent visits to the hospital; she described her focus of attention as being on her husband rather than her own health.

2.1.3 Tracey's shortness of breath did not improve, and she had a dry cough that had persisted for more than 3 weeks. Concerned, she contacted her GP practice and saw a nurse practitioner on 4 April 2019. She was diagnosed with a chest infection and given antibiotics. Her symptoms did not go away. Tracey saw the nurse practitioner a further three times over the following month and was prescribed three further courses of antibiotics. Tracey recalls asking to see a GP as her cough persisted and she felt "we weren't getting anywhere".

2.1.4 Tracey saw a GP on 10 May 2019. The GP documented Tracey's 5-month history of a cough and that she had had four courses of antibiotics. The GP referred Tracey to the local hospital for a chest X-ray. This was carried out the same day and reported by consultant radiologist 1. No major findings were identified though there was some uncertainty around the lack of clarity of the right heart border. Because of this uncertainty and because the clinical information provided mentioned longstanding symptoms, radiologist 1 recommended that a right lateral X-ray be performed. Tracey recalled being told by the GP that "a different view" was needed. The lateral chest X-ray was obtained on 7 June 2019 and again no significant findings were identified when the X-ray was interpreted by consultant radiologist 2. Tracey remembered being told by her GP that "everything was clear".

2.1.5 Tracey said that despite this reassurance her symptoms seemed to be getting worse. She therefore made another appointment to see her GP but recalled being reassured that her symptoms may be stress related, given everything she had gone through with her husband. She was assessed for asthma but not found to have this condition.

2.1.6 Tracey described the remaining months of 2019 as being very difficult. Her shortness of breath seemed to be slowly getting worse, her cough was not going away, and yet at further GP appointments she did not feel there was a particular concern about her symptoms. She recalled a focus on the stress she was under as a result of her carer responsibilities. Tracey said she began to believe her symptoms must really be psychological and stress related: "I was so convinced it was stress and in my head."

2.1.7 By January 2020 Tracey's breathing was "so bad" that she again contacted her GP practice. On 14 January she saw a GP. Her respiratory symptoms were now accompanied by central chest pain which was worse on breathing in, and had been present for 48 hours. The GP requested an urgent chest CT scan and referred Tracey to the emergency department (ED) for further assessment.

2.1.8 At the ED, tests were carried out which excluded a possible heart problem in view of her chest pain. Tracey's 1-year history of a cough and shortness of breath on exertion was documented, along with the fact that she had never smoked. Her past normal chest X-ray was noted and that she was awaiting a chest CT scan booked by her GP. A third chest X-ray was performed, and no concerns were identified from a preliminary review by an ED doctor. Tracey's chest pain settled with painkillers (co-codamol) and physiological observations (such as heart rate, blood pressure and temperature) were within expected ranges. Tracey was therefore discharged home with pain relief medication for presumed muscular chest pain. The ED X-ray was formally reviewed and reported by consultant radiologist 3 on 19 January. Again, no significant findings were identified.

2.1.9 The CT scan requested by Tracey's GP was performed on 2 February 2020. The clinical history included on the CT scan request form was 'Cough and shortness of breath'. The report for the CT scan (completed 7 February 2020) noted comparison made with Tracey's X-ray in January 2020. The report findings included:

'There is … what looks like abnormal soft tissue encasement of the left lower lobe bronchus measuring in the region of 4 cm which is very suspicious for a primary lung tumour. There are multiple small nodules throughout both lungs which are very suggestive of metastases [secondary growths] measuring up to 10 mm in the right upper lobe.'

The report concluded that 'Appearances are very suggestive of left lower lobe collapse secondary to an obstructing endobronchial tumour with bilateral lung metastases and mediastinal nodal involvement' – that is, the images suggested cancer which had spread throughout the lungs. The

radiologist notified the lung cancer multidisciplinary team (MDT) of the result so that discussions regarding further tests and possible treatment options could be scheduled. The result was also sent to the GP who requested the scan.

2.1.10 Tracey saw that GP the same day to hear the result and that it was highly likely she had lung cancer. Tracey remembered that visit and being told the bad news. She said: "I didn't accept it at first." She described the result not making any sense: "I had had all these X-rays and been to A&E, I thought how could it go from clear to all over my lungs?" The GP documented that Tracey was 'shocked and tearful' and that she did not want to tell immediate family straight away as she did 'not want to shock them'. The GP made an urgent (no more than 2 week wait) referral to the respiratory clinic for suspected lung cancer.

2.1.11 Tracey recalled leaving the GP feeling "confused and worried". She said the GP was unable to answer any of her questions because they did not have the specialist knowledge required to do so. She said the GP was aware of this issue and "felt the same" as they had "no answers". Tracey described a confused and anxious 2 weeks waiting to see the respiratory consultant. She thought it would be better for both patients and GPs if a patient was given the CT scan result by someone who could answer inevitable questions about what the result meant and what would happen next.

2.1.12 On 13 February 2020, Tracey had an appointment in the respiratory clinic. Tracey said the lung specialist she saw was "amazing". She said this doctor told her that they could "see something on previous X-rays" and that they would be reporting the matter to the head of the radiology department for investigation. They explained to her about the duty of candour (the legal requirement for healthcare organisations to be open and honest with patients about errors in care).

2.1.13 In the following weeks, Tracey had further tests to aid diagnosis and inform treatment decisions. These included a biopsy which she arranged privately to speed up her diagnosis. On 21 February 2020, the lung cancer MDT confirmed that she had lung cancer (adenocarcinoma) which was found to be at an advanced stage having spread beyond her lungs. Tracey was referred to the oncology team (the specialist cancer team).

2.1.14 In March 2020 Tracey commenced palliative treatment – that is, treatment which aims to extend life expectancy and/or improve quality of life rather than provide a cure.

2.1.15 A CT scan performed in June 2020 showed that Tracey's cancer had responded to treatment. At the time of HSIB's investigation, Tracey's most recent CT scan on 16 March 2021 showed that her cancer was stable. However, when the investigation met with Tracey in June 2021, she explained that the cancer had spread to her pelvic bones and that she was due to start a course of radiotherapy treatment for this.

2.2 Impact

2.2.1 The investigation spoke with the Tracey. She was very willing to be involved in the national investigation to "help make things better for others".

2.2.2 In 2019, following her husband's hospitalisation, Tracey became his full-time carer. She is also the carer for her son. Tracey has a daughter at secondary school. Discussing the impact of her delayed diagnosis, Tracey said she thought it had "probably made a difference" to her treatment options. She wondered if surgery might have been possible if the diagnosis had been made sooner. She described knowing – having a "gut feeling" – that something was seriously wrong but did not know what it was. The delay had left her "going over conversations" and wishing she had "pushed more … asked more questions".

2.2.3 Reflecting on her journey to diagnosis, she considered that the follow-up imaging after her initial X-ray should have been a CT scan to confirm or exclude the possibility of something serious. In addition, her experience was that despite her symptoms the GPs she saw did not sufficiently consider the possibility of cancer because she did not fit the typical risk profile, as she was a relatively young woman who had never smoked. She summed up the situation: "I didn't fit the tick box, so I didn't get a CT scan."

2.2.4 Tracey contrasted the advertisements on television and elsewhere with the response from the GPs she saw. The advertisements encourage people to take a cough of more than 3 weeks seriously and seek GP advice; yet when she did this she felt "very much dismissed … symptoms put down to first asthma and then stress". Tracey summed it up as her respiratory symptoms "not being dealt with as a priority".

2.2.5 The Trust considered the impact of the delay in Tracey's diagnosis of lung cancer. Its conclusion was that it had resulted in permanent, severe harm. The Trust investigation report stated that if a CT scan had been performed in June 2019 it was 'likely that the diagnosis would have been made'. Although it is not possible to know the extent of Tracey's cancer in June 2019, the report said: 'Earlier diagnosis may well have led to differing treatment options as at diagnosis the patient would have been likely to have had an earlier stage of disease.'

2.2.6 The HSIB investigation sought an independent opinion from a consultant respiratory physician with nationally recognised expertise in lung cancer. Specifically, the consultant was asked whether the 9-month delay in Tracey's diagnosis, from 10 May 2019 (her first chest X-ray) to 2 February 2020 (when she had a CT scan), was likely to have resulted in a change in the stage of her lung cancer. Their opinion was informed by the history provided by the investigation and a review of Tracey's chest X-rays and CT scan, together with their knowledge and expertise regarding tumour growth and progression of lung cancer.

2.2.7 In the consultant's opinion, based on the size of the metastases present on the CT scan in February 2020, they would have been present in May 2019 (and visible on a CT scan but not a chest X-ray) although smaller in size. Thus, the cancer had already spread, and, in their view, it was unlikely that the delay had resulted in a shift in stage of cancer at diagnosis. They stated that the impact on treatment was therefore minimal, but that Tracey would have had more symptoms for a longer time because of the delay. They added that had Tracey been investigated for lung cancer nearer the onset of her symptoms (Tracey's cough and shortness of breath had been ongoing for 5 months at the time of her first chest X-ray) this may have been different.

3 Involvement of the Healthcare Safety Investigation Branch

This section outlines how HSIB was alerted to the issue of delayed diagnosis of lung cancer. It also describes the criteria HSIB used to decide whether to go ahead with the investigation, and the methods and evidence used in the investigation process.

3.1 Notification of reference event

3.1.1 Delayed diagnosis of cancer is a well-recognised national safety issue. HSIB prioritised this theme as a safety risk for investigation.

3.1.2 Missed detection of possible cancer on chest X-rays is a known contributory factor in the delayed diagnosis of lung cancer. The Trust where the reference event occurred had reported it as a serious incident on the national database for reporting serious incidents in healthcare (the Strategic Executive Information System [7]).

3.1.3 HSIB contacted the Trust and a scoping investigation was commenced. The purpose of scoping investigations is to explore the identified patient safety risk(s), and to consider the practicality and value of proceeding to a national investigation. The Trust welcomed HSIB involvement and fully collaborated with information gathering.

3.2 Decision to conduct a national investigation

3.2.1 Following initial information gathering, HSIB's Chief Investigator authorised a national investigation based on the following patient safety risk criteria:

Outcome impact – what was, or is, the impact of the safety issue on people and services across the healthcare system?

3.2.2 Delay in diagnosis of lung cancer can alter a patient's prognosis and shorten their life expectancy. In addition, delayed diagnosis adversely affects a patient's experience of care; evidence shows they have a strong preference for prompt diagnosis (Risberg et al, 1996).

3.2.3 Estimated 5-year survival rates (2010 to 2014) in the UK are among the lowest in Europe (United Kingdom Lung Cancer Coalition, 2019; NHS England Lung Clinical Expert Group, 2017; Independent Cancer Taskforce, 2016). This reflects the fact that two-thirds of patients with lung cancer are

diagnosed at an advanced stage of the disease when curative treatment is no longer feasible (NHS England and NHS Improvement, 2019a; The Association of the British Pharmaceutical Industry, 2017; del Ciello et al, 2017; Independent Cancer Taskforce, 2016).

3.2.4 As well as the human cost, such incidents undermine patient confidence and trust in healthcare services. They also incur a financial burden and damage a hospital's reputation. Among radiologists specialising in chest imaging, failure to diagnose lung cancer is the most common reason for a legal claim being instigated (Baker et al, 2013).

Systemic risk – how widespread and how common a safety issue is this across the healthcare system?

3.2.5 There are approximately 46,700 new diagnoses of lung cancer a year in the UK (Cancer Research UK, 2019). Most diagnoses are made following referral for chest X-ray (Aslam et al, 2018a). Evidence indicates that about one in five lung cancers are missed on chest X-ray with the potential to cause a 'delayed diagnosis for several thousand patients each year' (Bradley et al, 2019). Approximately 90% of missed lung cancer cases occur on chest X-ray compared to 5% on CT scans (del Ciello et al, 2017).

3.2.6 The safety risk has a wide geographic spread and is well recognised as a national issue. Reflecting this, The Royal College of Radiologists recommended that data be collected to assess local practice. The College set a target that lesions present should be identified in 75% of chest X-rays performed within 1 year of the lung cancer diagnosis (The Royal College of Radiologists, 2008).

3.2.7 The national cancer diagnosis audit found that 67.5% of patients with cancer first reported symptoms at their GP surgery or during a GP consultation (Swann et al, 2018). About 30% of patients with lung cancer will have had three or more consultations with their GP before being referred for suspected cancer, resulting in a delay in diagnosis (Lyratzopoulos et al, 2012; Royal College of General Practitioners, 2011). The non-specific symptoms suggestive but not diagnostic of lung cancer create a significant challenge for GPs.

3.2.8 There are contextual issues which influence the detection of lung cancers on chest X-rays. These include the challenges in distinguishing a lung cancer from other anatomical structures on X-rays, the viewing equipment and the working conditions within which X-rays are reviewed, and the availability and access to more definitive imaging such as CT scans. In advanced economies with better outcomes for patients with lung cancer, investigations such as CT scans are used more extensively (Eurostat, Statistics Explained, 2019).

Learning potential – what is the potential for an HSIB investigation to lead to positive changes and improvements to patient safety across the healthcare system?

3.2.9 Despite the safety risk of missed lung cancer on chest X-rays being long recognised and advances in diagnostic technology, this risk has remained. This suggests there are complexities associated with making improvements that need to be understood and acknowledged.

3.2.10 Safety investigations can provide insight into persistent safety risks and make recommendations that stimulate change. In addition, they provide an opportunity to share learning from stakeholders and/or healthcare providers that have made beneficial improvements to positively influence processes and practices across organisations.

3.3 Investigation scope

After initial evidence gathering, it was agreed that the terms of reference were to:

1 understand the context and contributory factors influencing a delay in lung cancer diagnosis in patients repeatedly attending primary care with non-specific symptoms

2 identify the system-wide factors that help or hinder the diagnosis of lung cancers on chest X-rays

3 consider the use of chest X-ray to assess for lung cancer in low-risk, symptomatic patients being seen in primary care

4 identify the implications of the findings for mitigating the risk of delayed diagnosis of lung cancer.

3.4 Evidence gathering and verification of findings

3.4.1 Multiple sources of evidence were gathered and analysed by the investigation, including:

- review of Tracey's clinical records and national guidance and standards regarding review of chest X-rays
- interview and telephone conversations with Tracey

- interviews with seven staff members either directly or indirectly involved in the reference event
- review of the Trust's internal serious incident investigation report
- review of research literature relevant to the safety risks, in particular literature regarding the interpretation of chest X-rays to understand the complexities of the task, and literature regarding the challenges for GPs in suspecting lung cancer in patients with non-specific symptoms
- interview with the clinical director for radiology in one trust who was using artificial intelligence to support clinical interpretation of chest X-rays.

3.4.2 Stakeholders and subject matter advisors across the healthcare system were contacted to provide authoritative comment on systemic issues impacting on the delayed diagnosis of lung cancer and missed cancers on chest X-rays. These included:

- The Royal College of Radiologists
- The Society and College of Radiographers
- British Society of Thoracic Imaging
- National Institute for Health and Care Excellence
- Royal College of General Practitioners
- NHSX
- NHS England and NHS Improvement Cancer Clinical Advisory Group
- Roy Castle Lung Cancer Foundation
- Lung Cancer and Mesothelioma Clinical Expert Group
- Public Health England – UK Screening Committee.

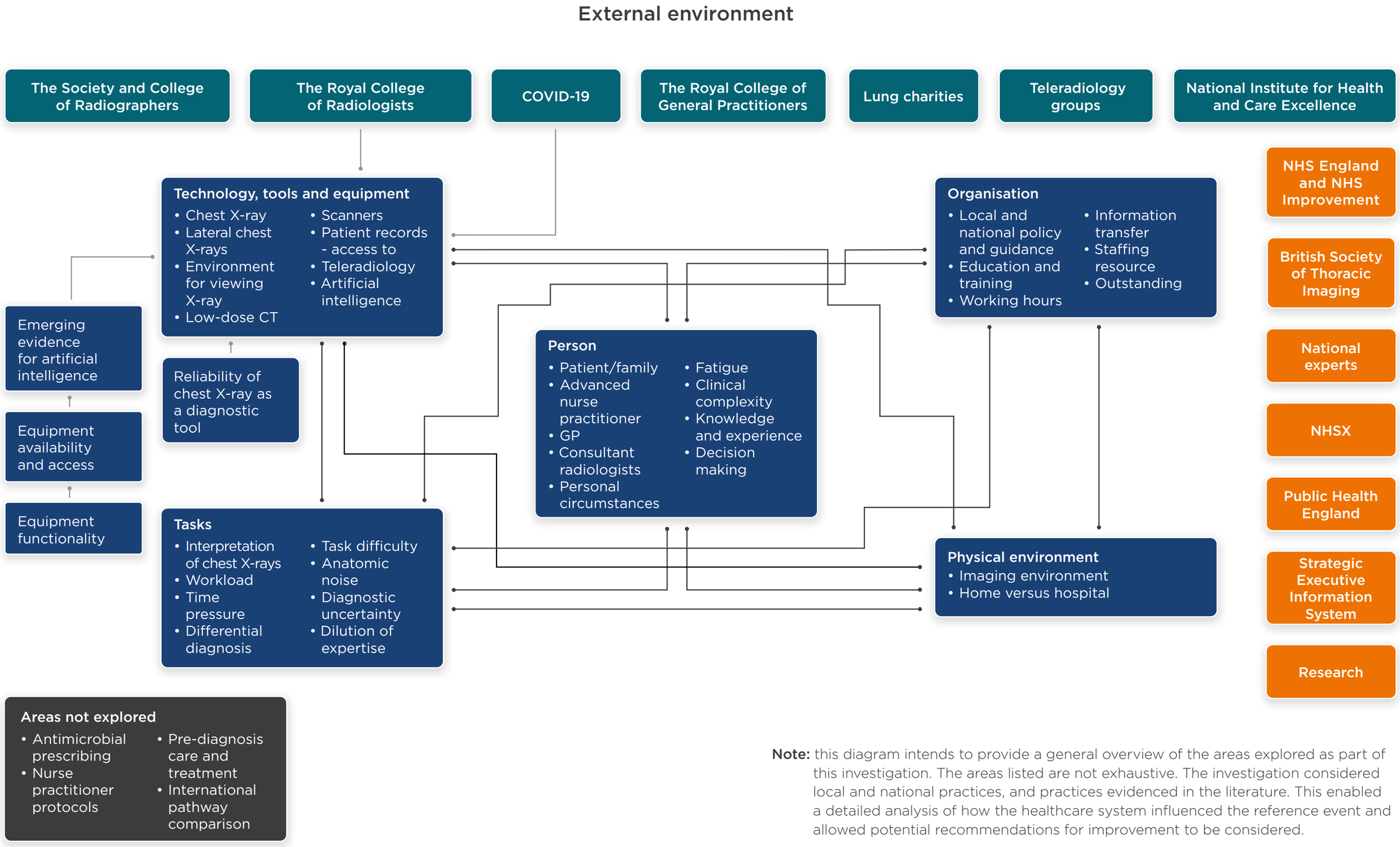
3.4.3 A semi-structured interview plan was developed to gather information on the safety risk, and a thematic analysis was performed.

3.4.4 The investigation findings were shared with the stakeholders and subject matter advisors. This enabled checking for factual accuracy and overall sense-checking. The stakeholders contributed to the development of the safety recommendations based on the evidence gathered.

3.5 Analysis of the evidence

3.5.1 The investigation used a model called Systems Engineering Initiative for Patient Safety (SEIPS) to analyse the evidence gathered in the investigation (Holden et al, 2013; Carayon et al, 2006). SEIPS provides a human factors framework for understanding the work system (that is, the external environment, organisation, internal environment, tools and technology, tasks, and persons), work processes (including physical, cognitive and social/behavioural aspects) and the relationship between these and the resulting outcomes in healthcare. Figure 1 shows the aspects of the work system which were explored as part of the investigation.

Figure 1 Work system factors explored in this investigation



Note: this diagram intends to provide a general overview of the areas explored as part of this investigation. The areas listed are not exhaustive. The investigation considered local and national practices, and practices evidenced in the literature. This enabled a detailed analysis of how the healthcare system influenced the reference event and allowed potential recommendations for improvement to be considered.

4 Analysis and findings – the reference event

This section describes the investigation's findings in relation to the reference event. It focuses on the systemic factors that contributed to Tracey's lung cancer being missed on her chest X-rays and that influenced staff members' decisions and actions.

4.1 Missed detection of possible lung cancer on Tracey's chest X-rays

4.1.1 The HSIB investigation found that observer error, lesion characteristics and technical issues (**see 1.4**) contributed to lung cancer not being identified on Tracey's X-rays. The Trust's serious incident report concluded: 'In retrospect, all of the chest x-rays showed an abnormality within the lung which required further investigation.' However, the report identified reasons why the abnormalities were not identified by the consultant radiologists who reviewed the X-rays at the time. These reasons reflect those recognised nationally and described in section 1.

4.1.2 The X-ray taken on 10 May 2019 was a postero-anterior (PA) view – that is, the X-ray beam enters through the back of the patient's chest and exits out the front. This is the typical X-ray view requested. The clinical information on the X-ray request said: 'Cough for 5 months. Initially productive but now dry. No haemoptysis [coughing up blood].'

4.1.3 Consultant radiologist 1 reviewed and reported the chest X-ray from an office on one of the Trust's hospital sites. The Clinical Service Lead for Radiology and the Assistant Medical Director for Clinical Governance described the environment as "quiet" and "undisturbed".

4.1.4 Consultant radiologist 1 reported their findings on 24 May 2019:

'... lungs appear clear apart from minor subsegmental atelectasis [change in density] at the left base. Heart is not enlarged. No significant abnormality seen in the pleura [thin layer of tissue that envelopes the lungs and lines the interior wall of the chest cavity]. No evidence of hyperinflation of the lungs or hilar lymphadenopathy [enlargement of lymph nodes].'

The radiologist included in their report that they had not been able to visualise the right heart border but thought this was 'due to a little obliquity of the radiograph [poor image quality].' In essence, the radiologist did not identify anything concerning.

4.1.5 The X-ray was reviewed by the Clinical Service Lead for Radiology as part of the Trust's investigation. With the benefit of hindsight, a mass in the left lower lung lobe was identified. However, the Trust investigation report stated that the mass was not obvious as it was 'located behind the heart shadow'. In a letter to Tracey, the Service Lead explained that cancers 'are seen as grey shadow, which appear very similar to the shadows caused by the heart'. Tracey's lung cancer was located '... right behind the heart shadow, making it quite difficult to identify'.

4.1.6 The HSIB investigation obtained an independent review of this X-ray through The Royal College of Radiologists. The reviewer stated that he was not surprised the lesion was not seen given its location behind the heart shadow. They thought "a large number" of radiologists would have missed it.

4.1.7 The evidence indicates that the radiologist missed the potential lung cancer due to its position and characteristics (**see 1.4.7 to 1.4.9**). This is a common and well-recognised cause of missed lung cancers (del Ciello et al, 2017). Specifically, normal anatomic structures (ribs, vertebra and so on) and organs such as the heart are known to obscure identification of cancers (del Ciello et al, 2017; Quekel et al, 1999).

4.1.8 Although this radiologist did not see the left-sided mass, they identified a change in appearance in the left lung base and, together with the history and inability to identify the right heart border wrote in their report that 'in view of the long history suggest a right lateral [taken from the patient's side] chest radiograph [X-ray] in the first instance in further assessment'.

4.1.9 Consultant radiologist 1 said that based on the clinical information on the X-ray request form, they assumed Tracey was a non-smoker; if the patient was a smoker this was usually stated on the form given the association with lung cancer. The consultant stated that while mindful of the possibility of cancer, based on the clinical information their suspicion of this was not high.

4.1.10 Consultant radiologist 1 explained that technically the chest X-ray was not optimal (it seemed the chest X-ray was taken when the patient was in a position that was slightly rotated). They said the subtle change in appearance at the left lung base and the difficulty in identifying the right heart border were not, of themselves, concerning and "may or may not" be indicative of an abnormality. Consultant radiologist 1 stated they "wanted more information ... to show what's going on" and so requested a lateral X-ray, in keeping with their long-established practice.

4.1.11 Consultant radiologist 1 said that if they had identified anything concerning, they would have requested a CT scan, but this seemed an unnecessary examination at that point in time when clarity was all that was required: "if nothing is going on you don't need a CT scan". Consultant radiologist 1 pointed out that a lateral chest X-ray was a "quick and easy" test to answer the question of whether there was a concern – and, therefore, a need for a CT scan. Looking at the lateral X-ray in hindsight they considered the abnormality to be clearly shown and requiring follow-up.

4.1.12 Consultant radiologist 1 agreed that lots of their colleagues might request a CT scan in this scenario because they had less experience in reporting chest X-rays. They said they had over 40 years' experience and were very familiar with chest X-rays. They pointed out that in their early career CT scans were not available so considerable expertise was developed over years of interpreting chest X-rays – both PA and lateral views. Consultant radiologist 1 said they would not disagree with the practice of doing CT in this scenario as CT provides more and clearer information, but stated it was not necessary as the lateral view provided the answer.

4.1.13 The Trust investigation concluded that a chest CT scan would have been preferable to a lateral chest X-ray and more informative. The Assistant Medical Director for Clinical Governance (and a consultant radiologist) said that it was "better to do too many CT scans than miss a lung cancer". The Trust report speculated that this was not requested as 'there were no significant concerns identified' and this was confirmed following HSIB's interview with consultant radiologist 1.

4.1.14 The independent reviewer for the HSIB investigation agreed that a CT scan would have been appropriate in this scenario. They considered the request for a lateral view to be "out of step" with current practice.

4.1.15 The lateral X-ray taken on 7 June 2019 was reviewed by consultant radiologist 2, who was from the external teleradiology group contracted by the Trust to provide imaging reporting. The clinical information on the X-ray request form was entered by a GP at Tracey's GP practice. This stated: 'Right heart border not separately identified on PA chest.' The history of respiratory symptoms was not mentioned.

4.1.16 The GP who completed the request form for the lateral X-ray told the investigation that it was not unusual for a further investigation to be recommended when the findings from the first were not clear. They said their usual practice was to refer to the first investigation in their request, and that they would have assumed the radiologist would have then looked at the first and compared it with the second, thus being aware of the clinical reason

for the request. However, they saw it as a learning point for themselves – and their colleagues – to ensure the reasons for a first X-ray request were repeated on any additional view requested.

4.1.17 Consultant radiologist 2 reported his findings on 11 June: 'No retrocardiac [behind the heart] abnormality. Lung bases are clear. Normal appearance of the heart. No bone abnormality in the spine. Conclusion: No diagnostic feature of note.' In essence, the radiologist did not identify anything concerning.

4.1.18 In their statement for the Trust investigation, consultant radiologist 2 said:

'In retrospect there is a vague density overlying the lower thoracic vertebral bodies [spinal region that is attached to the rib cage] but there are confluent soft tissue densities from the aorta [main artery of the body], vertebra [backbone], ribs, scapula [shoulder blade] and pulmonary vessels [blood vessels] which at the time was felt to account for the appearances. Having been reassured by the lack of anything significant, referral for a CT scan seemed inappropriate.'

In essence, these comments point to the difficulty of differentiating possible cancers from other normal anatomical features.

4.1.19 In addition to consultant radiologist 2's review and comment regarding the lateral X-ray they reported, the external provider of radiology services, as part of its governance processes, reviewed and provided a report for the Trust investigation. This report concluded that:

'There is subtle increase in density projected over the lower thoracic vertebral bodies which in retrospect probably corresponds to the subsequently identified malignancy. I think this is mainly a retrospective diagnosis as the appearances are extremely subtle on the right lateral chest x-ray. The key abnormality is on the previous chest x-ray which shows left lower lobe collapse, depression of the left hilum, midline shift to the left and some small pulmonary nodules … Learning point(s): When reporting a lateral chest x-ray, always review in conjunction with the recent PA projection.'

In essence, this report says the cancer was difficult to identify on the lateral X-ray but that it was easier to identify an abnormality on the previous X-ray in May 2019.

4.1.20 The Trust investigation found the lung abnormality 'subtle in appearance'. The Trust's report said there were differing opinions as to whether identification of the abnormality would be expected or not. The opinion of the Clinical Service

Lead for Radiology was that the abnormality should have been identified. However, the Trust report explained that lateral views 'may at times be more difficult to interpret than the commonly used frontal X-rays'. Furthermore, as this view is not usually requested, 'radiologists are less familiar with reading lateral chest x-rays'. The Trust investigation report stated that a chest CT scan would have been easier to report.

4.1.21 The independent reviewer for the HSIB investigation said that, in their view, there was "clearly an abnormality" on the lateral chest X-ray. They said they "would expect a radiologist to spot it". In their view the lesion was very visible.

4.1.22 The evidence reflects the differing opinions that can exist between radiologists regarding interpretation of the same diagnostic examination – in this case, a chest X-ray. This is well recognised within radiology (Strickland, 2015). One study of abdominal and pelvic CT examinations found discrepancy in interpretation of between 26% and 32% respectively (Abujudeh et al, 2010).

4.1.23 In addition to this known variability, the HSIB investigation was mindful of the significance and influence of hindsight bias. Hindsight bias is the tendency to retrospectively de-emphasise the difficulty in making the diagnosis after it has been confirmed. This means that identifying a possible cancer in retrospect, with knowledge of the diagnosis of lung cancer, is very different from identifying it in real time (Busby et al, 2018; Dekker, 2014).

4.1.24 The Trust investigation report and the reviewer from the external radiology group stated the importance of referring to previous X-rays to inform X-ray findings. This is recognised as good practice – analysis of prior imaging is described as one of the 'essential steps in producing an imaging report' in The Royal College of Radiologists' Standards for interpretation and reporting of imaging investigations (2018).

4.1.25 The teleradiology group's system automatically pulls a patient's last three radiologic examinations so these are available to support the interpretation of current images. The requirement to review previous images is included in the guidelines produced by the teleradiology group. In their review of missed lung cancers, del Cello et al (2017) include the value of reviewing previous X-rays for comparison as one strategy to minimise the risk of observer error.

4.1.26 Although review of previous X-rays is acknowledged as good practice and the expected professional standard, the HSIB investigation was told by staff within the Trust and national stakeholders that this did not always happen. The Trust's Assistant Medical Director for Clinical Governance said the practice of reviewing previous images was "highly variable" and that it "doesn't happen as much as it should". Similarly, although the Clinical Director for the teleradiology

group stated that review of previous imaging is the group's policy and "should be mandatory" as it is the change in appearance that often indicated a problem, he said that "in reality, some radiologists do and some don't".

4.1.27 The gap between work as prescribed in guidelines and policies and work as done in the real world is acknowledged in safety literature (Shorrock, 2016; Dekker, 2014). Contributing factors include workload, time pressure and fatigue – all factors particularly relevant in the healthcare setting. In relation to teleradiology, the Clinical Director said there were sometimes technical issues that meant previous images did not get transferred across. In such cases they said that in emergencies, where urgent patient care is paramount, the advice to radiologists was to state in their reports that prior images were not available for them to review. In normal circumstances, they said the absence of previous imaging, if considered necessary for accurate interpretation of the current study, should result in a request for that previous imaging or for the study to be returned unreported.

4.1.28 It is not possible to know for certain if consultant radiologist 2 reviewed the previous X-ray from 10 May. The electronic radiology system does not provide evidence which would clarify this. Consultant radiologist 2 believed the previous image and report would have been available for them to view, they said it was usually "no problem" to access these. Consultant radiologist 2 recalled thinking "the patient was rotated" on the PA X-ray, so their "assumption" was that they must have looked at the previous X-ray to have had this in their mind.

4.1.29 Consultant radiologist 2 said that follow-up X-rays are usually the same (PA) view and comparison is made to identify change – either the development or resolution of a condition. In this case, they were not comparing like with like as it was a different view. They thought it was possible they had not referred to the previous image because of this.

4.1.30 Consultant radiologist 2 was reporting X-rays from home and described the conditions as undisturbed.

4.1.31 Tracey's (PA) X-ray on 14 January 2020 was reviewed by consultant radiologist 3, an employee of the same external teleradiology group. The clinical information on the request form stated: 'admitted with central chest pain, SOB [short of breath] on exertion, dry cough for 1 year.' The findings, reported on 19 January 2020, were: 'Heart and mediastinal [region between the lungs] contours are normal. No collapse or any consolidation or focal lung lesion. No pleural effusion [condition affecting the lining (pleura) of the lung]. No displaced rib fractures, no pneumothorax [collapsed lung].' In essence, no abnormalities were identified.

4.1.32 Consultant radiologist 3 provided a statement for the Trust investigation. They apologised for missing the abnormality and stated: 'In hindsight and in comparison, with previous exam of 10/05/2019 there is a left retrocardiac density. However due to the composite shadow of the left breast and descending aorta this has been missed by me…' The radiologist has highlighted the difficulty of identifying the abnormality due to the shadow of other normal structures.

4.1.33 Consultant radiologist 3 told the HSIB investigation that looking at the X-ray with hindsight they could see they had "under called" the examination and missed the abnormalities. Thinking about their mindset and potential "bias" at the time and possible contributing factors in addition to its location, they said the clinical history on the request form did not raise "alarm bells" for cancer and neither did the previous X-ray reports. Thus, their suspicion of lung cancer was low.

4.1.34 The external provider also provided a report for the Trust investigation. This concluded:

'There are features of left lower lobe collapse with associated underlying mass. The collapsed left lower lobe can be seen as increased density medially behind the heart. There is loss of definition of the descending aorta, which has developed since the previous x-ray (10/05/2019). The trachea [windpipe] is deviated to the left. The left hilum and left main bronchus are displaced inferiorly. In addition there are some small nodules peripherally within the left lung in the mid and upper zones suspicious for metastases.'

The report identified learning points for the radiologist which were that they needed to be:

'… sensitive to the features of left lower lobe collapse and abnormalities projected behind the heart. The reason for trachea deviation and hilar displacement should also be sought. Comparison with previous imaging is [appropriate] when there is any doubt/uncertainty. Detection of small peripheral pulmonary nodules can be challenging when there are overlying ribs, but again comparison with previous imaging is helpful.'

In essence, the report identified features that warranted concern and highlighted the value of comparison with previous X-rays.

4.1.35 The Trust's review of the January X-ray described the abnormalities as 'more evident' and concluded they 'should have been identified'. The Trust's investigation report noted that the radiologist had not mentioned any comparison with previous chest X-rays which 'may have assisted in the identification of the abnormalities'.

4.1.36 The independent reviewer for the HSIB investigation considered that the January X-ray, like the initial PA X-ray in May 2019, was "difficult to interpret" due to the overlying structures and shadows. In common with the other reviewers, they highlighted the importance and value of referring to previous X-ray reports and reviewing previous images.

4.1.37 Consultant radiologist 3 told the investigation that "as a rule" they review previous X-ray reports. They said they like to see previous images too, particularly if their suspicion of cancer is high. Consultant radiologist 3 could not recall if both the previous PA and lateral X-rays were available for them to view or just the lateral one. It is not possible to clarify from the electronic radiology system what consultant radiologist 3 reviewed at the time of reporting the January X-ray.

4.1.38 Radiologist 3 reports images from their home. They told the investigation that they took care to ensure they were undisturbed and that working conditions were optimal. For example, taking regular breaks, never working long hours or into the evening, and having black-out blinds so that light and glare does not hamper image visibility.

4.1.39 The evidence further highlights the role of observer error and lesion characteristics in missing lung cancer. In addition, the importance of reviewing previous X-rays to reduce the risk of missing abnormalities is again demonstrated. Overall, the evidence indicates the complexity of interpreting chest X-rays and the skill and expertise required to identify subtle anatomic changes that might indicate abnormality.

4.1.40 The CT scan requested by the GP Tracey saw on 14 January 2020 and performed on 2 February identified the abnormalities present.

Summary

4.1.41 Overlying normal anatomical structures obscured Tracey's lung cancer. These are well-recognised reasons for lung cancers being missed on chest X-rays.

4.1.42 Lateral chest X-rays are not commonly performed and expertise in reporting them has diminished.

4.1.43 Comparison with previous imaging is helpful when interpreting X-ray findings.

4.1.44 Chest CT scans are more informative and therefore more useful when additional imaging is required to aid diagnostic assessment.

4.2 Request for a lateral chest X-ray

4.2.1 The Trust investigation report stated that it is 'unusual' to request a lateral chest X-ray. The Trust Quality and Safety Lead for imaging estimated that fewer than 10 lateral chest X-rays were performed in 2019. As a result of so few being performed, the report said that expertise in reporting them had 'been diluted'.

4.2.2 The Trust investigation report said that although there was not a protocol or guideline stating that lateral chest X-rays should not be performed, 'it was more a practice that had developed for CT scans to be requested instead'. This reflects the fact that an abnormality will be more visible on a CT scan. The Clinical Service Lead for Radiology said it was "safest" to request a CT scan if there was any suspicion of abnormal pathology.

4.2.3 The Trust report included the opinion of the Clinical Service Lead for Radiology. In their view, radiologists 'of the experience' of consultant radiologist 1 who reported the 10 May 2019 X-ray 'have a tendency' to use lateral chest X-rays. This is because in the past CT scans were not available so radiologists would request a different view – to supplement the PA view – to help inform a diagnosis.

4.2.4 National stakeholders such as The Royal College of Radiologists concurred that requests for lateral X-rays in scenarios like the reference event are now rare, with CT scans being requested when there was concern about possibly abnormal pathology. The Clinical Director of the teleradiology group was of the view that lateral X-rays "don't have a place in modern radiology".

4.2.5 The Trust investigation report stated that consultant radiologist 3 had in other instances requested CT scans; senior clinicians contributing to the HSIB investigation believed this consultant would have requested a CT scan if they had identified concerning findings.

4.2.6 Consultant radiologist 2, who reported the lateral chest X-ray, has many years of experience. Their comments to the HSIB investigation provided further evidence that lateral X-rays are uncommon, with a CT scan having become the test of choice when findings are unclear on a PA X-ray. Radiologist 2 estimated that they had not reported a lateral chest X-ray "for years".

4.2.7 Consultant radiologist 3 also has many years of experience and agreed that lateral chest X-rays were an examination requested in the past but not the present. They estimated that they had not reported a lateral chest X-ray "for years".

4.2.8 Consultant radiologist 2 told the investigation that they and other radiologists requested lateral views in the past as an adjunct to PA "when we didn't have CT and there was no alternative". They said that the experience of missing cancers in the past meant they and their colleagues now order a CT in times of uncertainty: "... we think there's no point in second guessing, the important issue is making a diagnosis." Consultant radiologist 2 explained that CT scans make "whatever is there visible so you can resolve the matter".

4.2.9 Summing up, consultant radiologist 2 said a CT scan should be "the gold standard" because "we've all made mistakes and not because it's [the abnormality] not there but because it's not apparent. We need to make things more apparent to more people, more often".

4.2.10 Consultant radiologist 2 said that if a follow-up X-ray is requested as an adjunct to answer a question mark or concern in a radiologist's mind, it was pertinent to have that follow-up X-ray sent to the same radiologist for reporting as they will know what the uncertainty was and what they wanted to resolve. Echoing this, consultant radiologist 3 said PA and a lateral view used to be requested together and reviewed alongside each other.

4.2.11 Based on the X-ray request information, consultant radiologist 2 knew they were looking to see the heart border. However, without having gone through the process of interpreting the original X-ray it was not possible to know what was in the first radiologist's head, and the nuance of the uncertainty leading to the request for an additional view was lost.

4.2.12 The Clinical Service Lead for Radiology agreed with this view. They said that in the past, when requesting a lateral view was common, the workflow of radiologists was very different, and it was possible to follow patients through their radiology investigation pathway in a way that is not possible now. The clinical service lead told the investigation that even if a radiologist requested to report a follow-up X-ray it may or may not happen as the complexities of the workload workflow meant this could not be guaranteed. However, they said that within the Trust's radiology department there had been agreement that if, in exceptional circumstances, a lateral view was requested it should only be reported by the requesting radiologist.

4.2.13 Learning from this incident, the Trust's radiology department changed its practice to make CT the default imaging requested when X-ray findings are unclear (**see 4.5**).

4.2.14 The use of lateral chest X-rays varies internationally. A review of the research literature concluded that they should not be used routinely as their diagnostic value was 'highly dependent' on the clinical reason for their use (Osman and Williams, 2014). The value of a lateral view in identifying missed cancers or other lesions is considered in a number of studies. There are differing opinions in the literature with some authors suggesting they are unnecessary (Forrest and Sagel, 1979). However, in one study, lateral views were found to be particularly helpful in identifying pulmonary (lung) lesions in some patients (Wu et al, 2008). Other research also supports the use of a lateral view X-ray as an aid to identification of lung cancers (Chotas and Ravin, 1994). Reviewing the evidence, del Cello et al (2017) concluded lateral chest X-rays to be 'a significant tool for lung cancer detection'. They noted that the utility of an additional X-ray needed to be weighed against the additional cost, radiation exposure and clinical need.

4.2.15 Considering the radiologist's request for a lateral X-ray in May 2019, the Medical Director of Professional Standards at The Royal College of Radiologists agreed with the Trust investigation that a request for a CT scan would have been more appropriate. That said, in relation to the value of lateral X-rays per se, he reiterated that in his opinion it was this X-ray that clearly showed an abnormality and made the lesion visible.

Summary

4.2.16 Evidence indicates that CT scans have replaced lateral X-rays as the examination of choice when there is concern about possible abnormality.

4.2.17 Changes in workload and work practice make it difficult to ensure the same radiologist reports additional X-rays requested for an individual patient.

4.2.18 Although not commonly requested, lateral chest X-rays may have value in identifying cancers and other abnormalities.

4.3 Review and reporting of Tracey's chest X-rays

4.3.1 Due to the quantity of imaging requiring reporting, the Trust routinely outsources images for reporting to an external, private, teleradiology group. Radiologists employed by the group review the images and reports are submitted back to the Trust.

4.3.2 Governance arrangements within the teleradiology group facilitate assessment of its performance. For example, the group's Clinical Audit Lead told the HSIB investigation that 2% of X-rays reported by radiologists are routinely audited and 5% of sectional imaging such as CT. In addition, errors

(misses and misinterpretations) made by radiologists are tracked so their error rate – and nature of their errors – is known, allowing for early intervention and support when required. The investigation was told that the error rate of the two radiologists involved was within expected limits. The Trust's Assistant Medical Director for Governance told the investigation that the governance structures within the teleradiology group were "way ahead" of most trusts.

4.3.3 In addition to assuring performance, the teleradiology group supplies reporting radiologists with the equipment for reviewing images so the functionality is of an assured standard. They also have policies detailing expected practice; for example, the maximum number of hours to be worked to avoid fatigue and ensuring the reporting environment is quiet and undisturbed.

4.3.4 Clinical staff (including national stakeholders) interviewed as part of the HSIB investigation agreed that chest X-rays are perhaps the most difficult to interpret due to the overlying structures and blood vessels in the chest. However, they are an extremely common diagnostic test (NHS England, 2018b) and one that nearly all radiologists are expected to interpret and report, even if they have developed expertise and mostly report non-chest X-rays or other types of imaging.

4.3.5 The Assistant Medical Director had asked the Trust investigation to consider the range of radiologists reporting chest X-rays, the proposal being that reporting should be restricted to those who routinely reported and/or had particular expertise in chest imaging.

4.3.6 The Clinical Service Lead for Radiology considered this suggestion. While accepting that it may be the ideal, they said that this was not practicable currently given the volume of chest X-rays to report and the need to report them in a timely way.

4.3.7 The Clinical Service Lead likened chest X-rays in radiology to "taking the pulse" in medicine – something so commonly done that requesting only those with specialist expertise and interest do it did "not make sense". They thought the department would "fall over" if this was instituted. That said, the Clinical Service Lead for Radiology and Assistant Medical Director pointed out that they have a large and growing cohort of advanced practice radiographers trained specifically to report chest X-rays and who are reporting large numbers of them. They said that although these radiographers do not have the medical training of radiologists, they had not identified a higher number of errors among these staff. The investigation found other evidence which confirmed that with appropriate education and training, reporting radiographers can interpret chest X-rays at a level comparable to consultant radiologists (Woznitza et al, 2018). The Clinical Service Lead for Radiology's

opinion was that a chest X-ray reported by them may be preferable to it being reported by a radiologist who specialised in a particular area and rarely reported chest X-rays. The benefit and performance of radiographers trained to report X-rays is covered in a previous HSIB report (**Healthcare Safety Investigation Branch, 2020**).

4.3.8 Consultant radiologist 1, who reported Tracey's X-ray of 10 May 2019, had specialist expertise and interest in musculo-skeletal imaging (imaging related to the bones and muscles of the body). However, they had many years of experience so were very familiar with reporting chest X-rays. Consultant radiologist 2, who reported Tracey's lateral X-ray of 7 June 2019 was a general radiologist, so did not have a particular area of specialist expertise. Consultant radiologist 3, who reported the chest X-ray of 14 January 2020, was a general radiologist with a particular interest in gynaecological and chest imaging.

Summary

4.3.9 The Trust routinely outsourced images for reporting to an external, private, teleradiology group.

4.3.10 Chest X-rays are complex to interpret yet most radiologists are expected to report on them. Limiting the number of reporters is not practicable due to the volume of chest X-ray reports.

4.4 Multiple visits to GP with respiratory symptoms

4.4.1 Like most patients diagnosed with lung cancer, Tracey first reported symptoms to her GP. In addition, as with about one third of patients, she had multiple consultations before her lung cancer diagnosis (**see 1.1.12 to 1.1.15**). Tracey had 15 consultations, by telephone or face to face, with either a nurse practitioner or GP in 2019. Six of the consultations were with a nurse practitioner and nine were with a GP.

4.4.2 The GP practice has electronic records and clinical staff have full access to these during consultations with patients, so can see previous attendances and the reasons for these. The investigation was told by one of the GPs at the practice that they would have a "quick look" at "what has been going on in recent months" and their expectation was that their colleagues would do this too. In addition, their experience was that patients say when they have had previous attendances for the same reason.

4.4.3 In 8 of Tracey's 15 consultations, respiratory symptoms were documented in the medical notes with a persistent cough and shortness of breath being the primary symptoms described. These are common symptoms of lung cancer. However, they are also common symptoms of many other medical conditions.

4.4.4 Four courses of antibiotics were prescribed for Tracey during April and May 2019 for presumed chest infections. These were prescribed by the nurse practitioner.

4.4.5 Of Tracey's 15 consultations in 2009, 7 were primarily for reasons other than respiratory symptoms. These included dizziness and vertigo; abdominal pain and urinary symptoms; and chest pain – specifically, over her sternum (breastbone).

4.4.6 In accordance with the National Institute for Health and Care Excellence guidance (2019) a chest X-ray was requested by the first GP who saw Tracey after four consultations with the nurse practitioner and four prescriptions of antibiotics. The HSIB investigation spoke with the one of the GPs at the practice. They pointed out that it is well recognised that X-rays fail to identify "about 20%" of cancers. Reviewing Tracey's GP medical records, it appeared that this provided reassurance that lung cancer was not a diagnosis to be pursued. The fact that Tracey had never smoked, was a relatively young woman (so did not have obvious risk factors) and had no distinctive symptoms (such as coughing up blood) likely contributed to this.

4.4.7 A chest CT scan was requested when Tracey saw a GP in January 2020. The GP documented that Tracey had a cough; shortness of breath and central chest pain for over a year, and that these symptoms had worsened in the last few weeks. It appeared this worsening of symptoms, together with previous X-rays which had not identified anything, led to the request for a chest CT scan and referral to the emergency department for the 'new type of chest pain'.

4.4.8 Tracey said her respiratory symptoms were perceived to be stress related and she agreed that she was under considerable stress in 2019 due to her husband's illness on top of her existing carer responsibilities. Stress was documented in 4 of the 15 consultations. The HSIB investigation was mindful that this focus was in the context of two chest X-rays having been performed and no concerning abnormalities found.

4.4.9 The HSIB investigation contacted the GP practice to inform and involve those who saw Tracey in the investigation. One of the GPs, who did not see Tracey in 2019 but who has been very involved in her clinical care, participated in the investigation. They said that following Tracey's diagnosis of lung cancer, there had been a discussion about her care to look for learning points. Tracey's journey to diagnosis had also been shared at a GP trainee tutorial to help with

trainee learning. A further discussion within the GP practice took place following contact from HSIB. The question of whether it would have been appropriate to have requested a CT scan was considered in these conversations.

4.4.10 The GP said that they and their colleagues saw "a huge number of patients with cough as a symptom" and that where this symptom persists they would refer all patients for a chest X-ray. They said that clinical colleagues present at the discussion knew chest X-rays can miss cancers.

4.4.11 The HSIB investigation tried to contact the nurse practitioner to involve her in the investigation. The investigation was advised that the nurse was covering maternity leave at the GP practice in 2019 and no longer worked there. The GP participating in the investigation made the nurse aware of HSIB's involvement and invitation to participate. The investigation was advised that the nurse was not currently working and would want to review the clinical records before being involved. The investigation did not receive any further communication.

4.4.12 The Assistant Director for Clinical Governance and the Clinical Service Lead for Radiology told the investigation that GP access to CT scans was "not a problem" in 2019. This was confirmed by the GP practice.

4.4.13 The GP pointed out that requesting a CT scan means "subjecting patients to large amounts of radiation – a risk we have to consider". In response to being asked whether there should be more routine requests for CT scans, they thought this best answered by respiratory specialists and radiologists. They reiterated that while lung cancer is one cause of a cough, "there are many, many more that are more likely". Perceptions of lung cancer and the radiation risk of CT are covered further in **section 5**.

4.4.14 The Assistant Director for Clinical Governance and the Clinical Lead for Radiology both pointed out the difficulty for GPs in forming a diagnosis from a non-specific symptom such a cough. The Assistant Director for Clinical Governance said that picking out the patient with lung cancer from all those attending with cough and shortness of breath was like "finding a needle in a haystack". The Clinical Lead for Radiology said that GPs may only see a new diagnosis of lung cancer a couple of times in their career, so it was "not at the forefront of their mind". Delay in lung cancer diagnosis because of patients seeing GPs with non-specific symptoms, such as a cough, is well recognised and reflected in literature (**see 1.1.14 to 1.1.15**).

4.4.15 The Medical Director of Professional Standards at The Royal College of Radiologists stated that it would not be appropriate for a GP to request a CT scan for everyone presenting with a persistent cough but no obvious risk factors

for lung cancer. However, given that Tracey's symptoms were not getting better and that a cause had not been found for them or diagnosis made, his view was that a referral to a respiratory physician would have been appropriate.

4.4.16 The Joint Honorary Secretary of the Royal College of General Practitioners told the HSIB investigation that "failure to respond" was an important indicator of the need to refer for further assessment and/or investigation. They said scenarios such as Tracey's were "very tricky" and that it was "not unusual" to see patients with a cough and shortness of a breath for a year. They stated that in the context of a normal chest X-ray and no "red flags" for lung cancer (symptoms such as coughing up blood) a GP would "need a reason" to refer; a patient not getting better would provide that reason.

4.4.17 Tracey's GP said that seeing patients with an ongoing cough was "incredibly common" and thought referring everyone to a respiratory consultant or for a CT scan would result in a "massive increase in work for secondary care, and unnecessary investigations".

4.4.18 Tracey had shared with this GP the problems with receiving her CT scan result from a GP who was unable to answer her questions (**see 2.1.11**). The GP said there were differing views among their colleagues about what the ideal was, however guidance is clear that it is the responsibility of the clinician who requested the radiological investigation to give the result (The Royal College of Radiologists, 2016). The GP said that in her opinion, "the solution is that the GP breaks the news but that the appointment with a specialist is then within maybe 48 hours rather than the current 2 weeks".

4.4.19 A previous HSIB investigation into unexpected significant radiological findings considered patients views on who informed them of the results. The evidence was that their priority was being told the result as soon as possible, ideally by a clinician, but not necessarily a GP (**Healthcare Safety Investigation Branch, 2019**).

Summary

4.4.20 Tracey was seen on multiple occasions in her GP practice with respiratory symptoms prior to her diagnosis of lung cancer.

4.4.21 In the absence of symptoms specifically indicative of lung cancer, failure to respond to treatment or symptoms not resolving may be an important indicator of the need to refer for further investigation or specialist respiratory assessment.

4.4.22 Receiving a cancer diagnosis from a GP means patients may wait several weeks until their specialist appointment before getting answers to their questions.

4.5 Actions resulting from the Trust's internal investigation

4.5.1 The Trust's internal investigation resulted in several safety actions to reduce the risk of recurrence. The key action was:

Safety action:
A CT scan of the chest should be requested in cases where there is uncertainty regarding pathology instead of a lateral chest X-ray. If in exceptional circumstances a radiologist requests a lateral chest X-ray, the same radiologist should provide the report for this X-ray.

5 Analysis and findings from the wider investigation

This section sets out the findings from the investigation's analysis of evidence in the context of the wider healthcare system.

The wider investigation gathered evidence and developed safety recommendations with the reference event scenario in mind.

The findings are presented within the following themes:

- use of chest X-ray to assess for lung cancer
- safety netting advice
- the role of artificial intelligence
- maintaining and assuring expertise in interpretation of chest X-rays.

The investigation recognises that there are challenges with the detection of other cancers on X-rays, and for GPs when patients with those cancers present with non-specific symptoms, but these challenges are outside the scope of this report. However, some of the findings may be of relevance in improving early diagnosis of these other cancers.

5.1 Use of chest X-ray to assess for lung cancer

5.1.1 The National Institute for Health and Care Excellence (NICE) recommends that an urgent (within 2 weeks) chest X-ray is offered 'to assess for lung cancer' in people aged over 40, who have never smoked, and have two or more of a defined set of symptoms. Cough and shortness of breath are included in the set of symptoms (National Institute for Health and Care Excellence, 2019).

5.1.2 Chest X-rays are readily available and a relatively quick test to perform. Most lung cancers can be identified on chest X-rays but at least 20% are known to be missed (**see 1.3.4 to 1.3.7**). X-rays are, therefore, unreliable as a test to exclude lung cancer and can provide false reassurance to GPs (Foley et al, 2021). The Joint Honorary Secretary of the Royal College of General Practitioners said that as a GP when you see a negative chest X-ray (that is, an X-ray reported as not showing an abnormality of concern) "you go phew". He told the investigation that the "diagnostic uncertainty" of chest X-rays needed to be better appreciated by GPs.

5.1.3 CT is a more sensitive test for the diagnosis of lung cancer and screening for the disease has been found to be beneficial in asymptomatic individuals (people without symptoms) at high risk. The Dutch–Belgian lung-cancer screening trial (NELSON) recruited individuals between 50 and 74 years of age who were current or former smokers. Screening with low-dose CT resulted in a 24% relative reduction in mortality (death rates) from lung cancer and diagnosis at an earlier stage when treatment could be more effective (De Koning et al, 2020).

5.1.4 The US-based National Lung Screening Trial (NLST) recruited individuals between 55 and 74 years old who were smokers or had ever smoked. The trial reported a 20% reduction in lung cancer mortality and a 6.7% reduction in all-cause mortality for low-dose CT compared with chest X-ray (Aberle et al, 2011). Furthermore, analysis found little cost difference between the two screening approaches (Gareen et al, 2018).

5.1.5 The UK Lung Cancer Screening pilot, which used a validated individual risk assessment to offer low-dose CT to patients between 50 and 75 years old identified to be at high risk (due to smoking and other risk factors) showed it was possible to detect lung cancer at an early stage and deliver potentially curative treatment in over 80% of cases. Health economic analysis suggested that the intervention would be cost effective (Field et al, 2016).

5.1.6 A lung cancer screening study, SUMMIT, is examining the feasibility of detecting lung cancer earlier through large-scale national screening. Initial findings from the study in which high-risk individuals had a CT scan were that 70% of lesions detected in people's lungs were identified when the cancer was at an early stage (Campbell, 2021). This contrasts with the current situation where three quarters of people are diagnosed at a late stage of cancer when there is no possibility of a cure and treatment options are limited (**see 1.1.6 to 1.1.8**).

5.1.7 NHS England and NHS Improvement is currently piloting screening for lung cancer through its lung health checks. The checks involve a low-dose CT scan to assess for lung cancer in individuals at high risk due to smoking and age. There are 14 pilots targeting individuals over 50 years with a history of smoking. The UK National Screening Committee is evaluating the clinical and cost effectiveness of this approach. If shown to be effective, national stakeholders believed it was likely that a screening programme for patients at high risk would be rolled out nationally.

5.1.8 Stakeholders interviewed were unanimous that screening individuals at high risk was needed to reduce lung cancer mortality rates. The Medical Director of the Roy Castle Lung Foundation summed up views heard by the investigation: "It's how we're going to make the big difference."

5.1.9 Tracey, and patients like her, would not meet the criteria for screening both due to age and not smoking. Thus, if individuals at low risk like Tracey develop symptoms that are suggestive of but not specific to lung cancer, they will be assessed using an inferior test. The circumstances of the reference event, and other evidence gathered by the investigation, suggest GPs are very reassured by a negative chest X-ray, irrespective of knowing a proportion of lung cancers will be missed by the test. The Foley et al study (2021) showed that interventions such as including a caveat on the X-ray report to alert GPs that a normal chest X-ray does not exclude cancer have very limited effect.

5.1.10 The investigation found differing, strong opinions among stakeholders on whether low-dose CT should replace chest X-ray as the first-line diagnostic test in patients like Tracey, who are at low risk of lung cancer and see their GP with non-specific symptoms.

5.1.11 In favour of more routine use of low-dose CT, the Standards Lead for the British Society of Thoracic Imaging (BSTI) stated that chest X-rays were "not the right test" to assess for lung cancer. They said that "the right thing is undoubtedly to do CT first".

5.1.12 The Standards Lead pointed out the disparity that currently exists between asymptomatic patients screened for lung cancer (using CT scan), and symptomatic patients seeing their GP (assessed with a chest X-ray). They told the investigation that if a chest X-ray was proposed for the lung cancer screening programmes "you'd be ridiculed and yet we still rely on an insensitive technique as the first-line test in symptomatic patients … It makes no sense".

5.1.13 This opinion was echoed by the National Specialty Advisor for Imaging for NHS England, who is also a radiologist specialising in chest imaging. They told the investigation: "… it's just common sense … we know that chest X-ray cannot answer the question of whether a patient has lung cancer … if you were a patient which test would you want?"

5.1.14 The Taskforce for Lung Health published a briefing paper in May 2021 on the diagnosis of lung disease from a patient perspective. The paper stated the limitations of chest X-rays for diagnosing lung cancer and recommended a straight to CT pathway for use in primary care. The problems with the current approach were highlighted:

'Sending a symptomatic patient for a chest X-ray only to have to follow up with a CT scan is unnecessary duplication, more costly, and creates a delay in making the diagnosis. For patients, having to be sent back for additional tests can cause anxiety, takes up their time, impacting on things such as work and

childcare, and in the worst situations … a falsely reassuring chest X-ray can leave them with undiagnosed lung disease.'
(Taskforce for Lung Health, 2021)

5.1.15 The patient-centred Taskforce briefing paper, like stakeholders, emphasised the disparity between the imaging offered to symptomatic patients seeing their GP and those who are asymptomatic and living in an area with a Targeted Lung Health Check programme. The paper stated that 'this is both unfair and unclear to patients, and creates inequality'. The paper concluded that with the move towards screening it was 'increasingly untenable to maintain a pathway for patients with symptoms of lung cancer which is slower and less effective than for those with no symptoms' (Taskforce for Lung Health, 2021).

5.1.16 A study published in 2021 (Foley et al, 2021) concluded that the approach of using chest X-ray as the first-line investigation for suspected lung cancer in primary care patients 'may be harmful'.

5.1.17 The study reviewed 1,488 chest X-rays referred from primary care for suspected lung cancer. The most common presenting symptom was a cough. The X-rays were coded as normal; alternative diagnosis; or suspicious for cancer. The chest X-rays reported as normal contained a caveat in the report which stated that a CT scan was recommended to exclude cancer. Key findings were:

- There was no difference in survival rates between the patients with different chest X-ray codes. This means a patient with a normal X-ray may, in fact, have advanced cancer (but it just not visible or not interpreted as abnormal).
- Only 10% of patients with an X-ray coded as normal underwent a subsequent CT (compared to 92% when the X-ray was coded as suspicious for cancer).
- There was a significant delay in lung cancer diagnosis in the 10% of patients with a normal X-ray that went on to have CT.

5.1.18 The study concluded that GPs may be falsely reassured by a negative X-ray meaning patients with potentially lower-stage, treatable lung cancers may be missed. The authors said the results also suggested that using chest X-ray to triage patients with suspected lung cancer prioritises resources to those with advanced disease. The authors concluded that 'consideration should be given to the use of CT as the first-line investigation for primary care patients with suspected lung cancer'.

5.1.19 Earlier research by Quekel et al also highlighted the potential harms of using chest X-ray to assess for lung cancer. They found that missed lung cancer on chest X-ray led to over a year delay in diagnosis during which time 43% of lesions progressed to a later stage. In addition, the number of patients receiving curative surgery was found to be lower when abnormalities were initially missed on X-ray (Quekel et al, 1999). The research indicates that replacing chest-X-ray with the more sensitive test of low-dose CT could result in earlier diagnosis, at an earlier stage of cancer, for these patients with improved survival.

5.1.20 In contrast, the investigation heard from stakeholders not in favour of using low-dose CT as the first line diagnostic test in symptomatic patients at low risk of lung cancer seen in primary care. Stakeholders who expressed this view included the chair of the national Lung Cancer Clinical Expert Group; the lead for one of the lung cancer screening pilots in England; and a GP who has spent several years researching early lung cancer diagnosis. In their view, the evidence was not there to support this change or prove that the benefits outweighed potential harms. They shared research that informed their opinion.

5.1.21 An observational study looking at the consequences of false negative chest X-rays in patients diagnosed with lung cancer did not find any adverse impact on stage (the size of a tumour and how far it had spread) or survival rates (Bradley et al, 2021a). The study included GP-requested chest X-rays of over 2,000 symptomatic patients diagnosed with lung cancer within the year. It compared time to diagnosis, stage at diagnosis and survival between those with a positive X-ray (abnormality detected or suspicion of cancer) and those with a negative X-ray (no abnormality detected or an abnormality not requiring follow-up). In 18% of patients the chest X-ray was reported as negative. Unsurprisingly, the time to diagnosis was significantly longer in these patients (median duration to diagnosis of 204 days compared to 43 days for those with a positive chest X-ray) but the outcome in terms of stage and survival was not affected.

5.1.22 Bradley et al (2021a) state that the association between the length of time it takes to reach a diagnosis and survival is 'known to be complex'. They note that studies have found positive, negative and no associations and say that this is likely related to the diversity of cancer symptoms. They explain that while undetected cancer will progress, rapidly progressive cancer which results in poorer outcomes may also be diagnosed more quickly because they have more pronounced symptoms. Hence there are confounding factors which may affect study findings.

5.1.23 Studies have also sought to estimate the likelihood of being diagnosed with lung cancer in symptomatic patients with a negative chest X-ray result. Bradley et al (2021b) estimated this for a range of symptoms (including

cough, breathlessness, weight loss and fatigue) and symptom combinations. The cancer incidence at 1 and 2 years for patients with a negative chest X-ray was 0.35% and 0.71% respectively. The study found that for most symptoms the likelihood of being diagnosed with lung cancer following a negative CXR 'remains very low'. Within 1 year of a negative chest X-ray, the risk was less than 1% for all individual symptoms except for haemoptysis (coughing up blood) which was 2.9%. The significance of this symptom has been identified by previous research (Hamilton, 2009) and is reflected in NICE guidance (National Institute for Health and Care Excellence, 2019). For the symptom of a cough, and with a negative chest X-ray, the risk of a lung cancer diagnosis at 1 year was 0.33% (1 in every 300 patients); the risk for the combination of cough and breathlessness was 0.42% (1 in every 238 patients).

5.1.24 Bradley et al (2021b) concluded that chest X-ray could be considered 'well suited to its role as a first-line investigation' in a setting such as primary care. They state that the study findings support NICE guidance which considers an abnormal chest X-ray result as the main criterion for a suspected cancer referral; the exception being haemoptysis, which warrants referral even in the absence of a chest X-ray.

5.1.25 Aslam et al carried out a study addressing the question of what proportion of patients undergoing chest X-ray for lung cancer symptoms, in accordance with NICE guidelines, are diagnosed with lung cancer over a 2-year follow-up period. From a review of 8,986 chest X-rays, the study identified 143 patients (1.6%) who had been diagnosed with lung cancer over the following 2 years. Rates of lung cancer diagnosis were highest within 3 months of the chest X-ray, equating to 1 case per 143 chest X-rays. As expected, the rates of diagnosis within 3 months were much higher in smokers (either current or past) than in those who had never smoked at 1.0% (1 in 100) and 0.1% (1 in 1,000) respectively. This equated to 1 cancer diagnosis per 101 and 728 chest X-rays respectively (Aslam et al, 2018b).

5.1.26 The investigation interviewed one of the authors of the study. The potential implications of using low-dose CT rather than chest X-ray as the first-line test for symptomatic patients seen in general practice were discussed. They explained that the study gave some indication of the resource implication and the additional number of lung cancer diagnoses if CT was used as the first-line test. If it is assumed that any patients diagnosed after 4 months had a negative chest X-ray, the percentage of diagnoses from CT would be 1.0% for smokers and 0.1% for never-smokers. The study concluded that investigation with CT rather than chest X-ray is likely to expedite diagnosis for these patients (Aslam et al, 2018b).

5.1.27 The investigation interviewed the Consultant Clinical Advisor at NICE who was responsible for clinical quality assurance of the guidance on referral for suspected cancer when it was published in 2015. They explained that NICE guidance is not "predicated on detecting every case of lung cancer at an early stage", NICE's role being "to produce cost effective guidance for the NHS". The Clinical Advisor pointed to the balance that must be struck between clinical effectiveness and cost effectiveness; early detection of cancer and not overwhelming the health service. That said, the Clinical Advisor stated that NICE was very aware of the apparent anomaly of asymptomatic individuals at high risk of lung cancer being offered a low-dose CT scan (within Lung Health Check Programme areas) while symptomatic patients at low risk seen in primary care are offered a chest X-ray.

5.1.28 The Clinical Advisor said that the current guidance was written in the context of "imperfect evidence". The NICE guideline states that 'No primary care evidence was identified' on the diagnostic accuracy of chest X-ray or CT in patients with suspected lung cancer in primary care or the cost effectiveness (National Collaborating Centre for Cancer, 2015). Data on the performance and benefits of low-dose CT in the diagnosis of lung cancer is from screening studies of asymptomatic individuals at high risk. Results and outcomes may be different in primary care patients where the prevalence of lung cancer is different and who, being symptomatic, likely have more advanced disease.

5.1.29 Discussing the reference event scenario of a low-risk (never smoked) patient with symptoms attending their GP, the Clinical Advisor said: "... there's an absence of good health economic evidence to say which people would be appropriate for a CT scan to diagnose lung cancer at an earlier stage." They stated that any changes to NICE guidance would require research to provide "robust health economic evidence" to determine the cost effectiveness of CT in that situation. The evidence would need to show whether using CT rather than chest X-ray made any difference to health outcomes, and what percentage of patients this might involve.

5.1.30 The investigation had sight of a research proposal by the Leeds Institute of Health Sciences aiming to provide the evidence needed to inform a potential change in NICE guidance. The aim of the study was to work out the clinical and cost-effectiveness of low-dose CT in the assessment of primary care patients with symptoms that could be caused by lung cancer.

5.1.31 The study planned to recruit patients who, in accordance with NICE guidance, had a chest X-ray ordered by their GP for symptoms of possible lung cancer. Permission would have been sought to have both a low-dose CT and a chest X-ray taken, so that the two tests could be compared. For each test, the study planned to work out how many cancers were found and how many

were missed. Information was to be collected on any extra findings and any tests that happened because of the result of the low-dose CT. Based on this, the study intended to work out the overall benefit to patients and calculate the total cost to the NHS.

5.1.32 The risks and benefits found by such research would help determine whether low-dose CT should (or should not) replace chest X-ray as the first-line test for this group of patients. If the advantages of low-dose CT proved greater than the additional costs and risks, the research had the potential to change the way possible lung cancer is investigated by GPs and contribute to earlier diagnosis of lung cancer. Equally, if low-dose CT was shown to cause more harm overall or be too expensive, the study would confirm that chest X-ray should not be replaced by low-dose CT.

5.1.33 The research proposal was submitted to the National Institute for Health Research. Funding was not agreed, with cost and study design being cited as reasons for the decision.

5.1.34 In addition to the concern about cost effectiveness, the investigation heard other objections to the use of CT as the first-line diagnostic test for patients seeing their GP. Broadly, these related to the risks of radiation involved with CT, inadequate resources, and the burden on the healthcare system of incidental findings – that is, findings unrelated to the reason for the test that would require further investigation and/or follow-up.

Risks of radiation involved with CT

5.1.35 There are naturally occurring or 'background' sources of radiation [8] that everyone is subjected to as part of daily life. Exposure to radiation carries risk such as the chance of developing cancer. X-rays and CT involve the use of radiation to create images. CT uses a greater amount of radiation than chest X-ray. A chest X-ray exposes a person to about the same as 10 days' worth of natural background radiation. A low-dose CT scan is comparable to receiving 6 months of natural background radiation (RadiologyInfo.org, n.d.).

5.1.36 The risk associated with radiation was raised most strongly by the non-radiologists interviewed by the investigation, such as the GP in the reference event and representative from the Royal College of General Practitioners. The Standards Lead for BSTI told the investigation that if low-dose CT was used, as in the screening pilots for lung cancer, the radiation risk was "negligible".

5.1.37 NHS England's National Specialty Advisor for Imaging said the concern about dose "belonged to the 60s and 70s". They noted that low-dose CT scans use a 10th of the dose of full-dose CT. In addition, both the Standards Lead and National Specialty Advisor for Imaging pointed out that, as in the

reference event, patients who attend their GP with symptoms often end up having multiple chest X-rays before eventually having a CT, so can end up being exposed to more radiation than if they had the low-dose CT used in the screening pilots as their first diagnostic test.

5.1.38 Research by Gonzalez et al (2008) estimated the reduction in death rates required to outweigh the radiation-induced cancer risk from lung screening for people under the age of 55 using low-dose CT. The study considered the risks to asymptomatic individuals from three annual screens with low-dose CT starting at age 30, 40 and 50. Risks for both never-smokers and current smokers were calculated. The risk of radiation-induced breast cancer was also estimated for women.

5.1.39 The results indicated that before the age of 50, the mortality reduction from lung cancer screening that is required to outweigh the radiation risk 'may be substantial, and in some cases unattainable' (de Gonzalez et al, 2008). For example, if screening of female never-smokers started at age 30, a 125% mortality reduction would be required to outweigh the risk of radiation-induced lung cancer. The mortality reduction required to outweigh risk dropped to 25% if screening started at age 50. The required mortality reduction to outweigh the radiation risk was shown to be considerably lower (10%) in smokers aged about 50. The estimated risk of radiation-induced breast cancer was 4 cases per 10,000 women screened from age 50 to 52.

5.1.40 The study authors point out that for a percentage of older smokers, screening will reveal abnormalities suggestive of possible cancer; these subjects will usually be referred for to receive additional follow-up CT scans. Additional scans will involve additional radiation so further increase the mortality reduction required to outweigh the risks (de Gonzalez et al, 2008).

5.1.41 Importantly, this study estimated radiation risks for screening in asymptomatic individuals – specifically, three annual low-dose CT scans. The scenario being considered by the investigation is one low-dose CT scan in a symptomatic patient. However, the estimated risk table in the study shows that for a woman in her 40s who is a never-smoker, the radiation-induced lung cancer mortality exceeds the mortality without screening: 3 per 10,000 (radiation induced lung cancer mortality) verses 1.8 per 10,000 (cumulative risk of lung cancer mortality without screening). Added to this is the radiation-induced breast cancer mortality. Again, this relates to screening asymptomatic individuals not a symptomatic patient in primary care, but nonetheless the evidence indicates the risk of radiation is an important consideration if low-dose CT were to become the first-line diagnostic test to assess for lung cancer.

Inadequate resource

5.1.42 Stakeholders interviewed by the investigation were unanimous in their view that there is inadequate resource to use CT as the first-line test to assess for lung cancer in patients attending their GP with non-specific symptoms like cough and breathlessness. This lack of resource relates to the number of CT scanners, radiographers to acquire the scans, and radiologists to report chest CT (NHS England, 2020). Summing up the views expressed, one consultant respiratory physician said, "we are miles behind other countries".

5.1.43 The UK is recognised to have fewer scanners and radiologists per head of population than most of Europe (**see 1.3.2**). In 2017 England ranked lowest of 23 developed countries for CT provision (NHS England, 2020). Consequently, there are far fewer CT scans carried out in England compared to other developed countries. Comparison of CT scans per 10,000 population with 25 other developed countries in 2017 showed that England's activity would need to rise by 77% to reach these other countries' average. This would mean an additional 4.4 million scans per annum (NHS England, 2020).

5.1.44 While stakeholders agreed that there was a resource deficit, there were differing opinions about the implications of this in assessing symptomatic patients attending their GP. On the one hand, the investigation heard that CT was a scarce and stretched resource which should be saved for those with a clear need for it. One stakeholder, a GP and clinical researcher, pointed out that one unintended harm that would likely result from increasing the use of CT – in particular, in patients at low risk of lung cancer – was the collateral delays to diagnosis of disease (not just lung cancer) in other patients requiring CT. On the other hand, the investigation heard comments such as those by the Standards Lead for the British Society of Thoracic Imaging who said "doing nothing" and "questioning the approach purely because of resource" was "not acceptable". Furthermore, the Standards Lead said the current use of CT prioritised the resource to those with advanced disease rather than identification of early lung cancer when more curative treatment options may be available.

5.1.45 The Standards Lead, and other stakeholders, pointed out the benefits of a proactive approach to health – an approach reflected in the NHS Long Term Plan (NHS England and NHS Improvement, 2019a) and Professor Sir Mike Richards' review on diagnostics (NHS England, 2020). The Standards Lead said the direction of travel needed to be community diagnostic hubs with CT scanners as an essential requirement.

5.1.46 In his 2020 review of diagnostics, Professor Sir Mike Richards noted the rise in diagnostic activity over the past 5 years and that this had become further stretched by the COVID-19 pandemic. The review recommended that CT scanning capacity should be 'expanded by 100%' over the next 5 years 'to meet increasing demand and to match other developed countries'. The review also recommended 'a major expansion in the imaging workforce – an additional 2,000 radiologists and 4,000 radiographers (including advanced practitioner radiographers, who undertake reporting)' (NHS England, 2020).

5.1.47 Community diagnostic hubs were proposed in the review report as the way to accommodate the necessary expansion in diagnostic services. It stated that three hubs per million population should be established in the first instance, broadly equivalent to the number of hospitals. Provision of diagnostics such as X-ray and CT, and consulting rooms to explain findings and assess patients were detailed as an expected part of hub provision. Patients such as Tracey, who saw her GP with 'non-specific symptoms, which could be due to cancer' were highlighted as one of the groups appropriate to be seen in a diagnostic hub (NHS England, 2020).

5.1.48 Given the national recommendations already made by Professor Sir Mike Richards in his diagnostics report, there seemed little value in this investigation repeating the need for an increase in CT scanning capacity and workforce to acquire and report scans. However, given the significance of these safety issues and the need for them to be addressed as a priority, the investigation sought an update on progress from NHS England and NHS Improvement.

5.1.49 In relation to the expansion in the imaging workforce, NHS England and NHS Improvement said that it was working closely with Health Education England to deliver the recommendation. The investigation was told of planned investment of £17m in 2021/22 to build more workforce capacity by upskilling the current workforce and purchasing additional training equipment and software. In addition, the investigation was advised that Health Education England had invested £46m in growing the diagnostic workforce with the possibility of further additional funding.

5.1.50 Regarding CT scanning capacity, the investigation was advised that this had been increased both by funding additional independent sector mobile CT scanning (136,000 additional tests in the financial year 2021/22) and by expanding NHS capacity through the roll-out of community diagnostic hubs. The investigation was told that 36 early adopter hubs had been approved (all of which will provide CT) and would be operational by autumn 2021. A second tranche of hubs was anticipated to be functional from early 2022. A bid for further investment was to be made to deliver Professor Sir Mike Richards' recommendations in full.

5.1.51 Several stakeholders raised concern about the additional time needed to perform and report a CT scan compared to a chest X-ray. Thoracic radiologists interviewed told the investigation that a low-dose CT scan without contrast (a special dye which can further help image interpretation) did not take much longer than a chest X-ray to perform, so time to carry out the scan was not an issue. The investigation was informed by the radiologists interviewed that interpreting a chest CT scan was easier than a chest X-ray but in view of the number of images to review, did take slightly longer to report. That said, stakeholders such as NHS England's national Specialty Advisor for Imaging and the Standards Lead for BSTI countered this concern, pointing out that this test was much more likely to assist with diagnosis, so could be time saving in the long run.

Incidental findings

5.1.52 There are many different incidental findings that can be identified on CT scans (including low-dose CT) such as lung disease, problems with coronary arteries, and cancers in areas such as the thyroid and adrenal glands. Although screening pilots have not showed a significant reduction in overall mortality because of these findings (Aberle et al, 2011) stakeholders such as the Standards Lead for BSTI pointed to the benefits in allowing early appropriate treatment.

5.1.53 The benefits from screening pilots for individuals at high risk of lung cancer may, or may not, be the same if low-dose CT is used for patients at low risk of lung cancer and who have non-specific symptoms. A GP and clinical researcher focused on the diagnosis of lung cancer told the investigation that there was not yet the evidence to prove that the benefits of incidental findings outweighed the risks and burden on healthcare resources in this group of patients. One important aspect of the risks is the psychological cost to patients in terms of anxiety and distress, as such findings can lead to further investigations and treatment of disease that was not necessarily going to cause harm (O'Sullivan et al, 2018).

5.1.54 A common incidental finding on CT scans is pulmonary nodules (small growths in the lung, usually not cancerous). Evidence gathered by the investigation suggested that there is significant concern about the burden of workload that would be created by follow-up of nodules if use of CT increased. Views heard were summed up by one of the consultant radiologists interviewed: "... lots will be benign or so slow growing you'll die with not because of them ... but once found you're obliged to take further with biopsy, surveillance ... it's a massive undertaking with a high burden."

5.1.55 In contrast, the Standards Lead for BSTI said that nodules were an important finding on a lung CT and that existing guidelines were clear about which nodules warranted follow-up and which did not. Similarly, they said that it was possible for nearly all the incidental findings to have a templated report and actions. However, the Standards Lead said concerns about incidental findings highlighted the need for chest CT scans to be reported by a radiologist with expertise in interpreting this imaging so they could make specific and appropriate recommendations and prevent unnecessary follow-up (**see 5.4**).

5.1.56 The importance of expertise was echoed by the Director of Radiology Research at Oxford University Hospitals NHS Trust. They estimated that low-dose CT would identify nodules in 30% of individuals over 60 years. A radiologist with expertise in chest CT would have confidence to interpret these as relevant or not, whereas a radiologist without expertise would be likely to recommend follow-up with full-dose CT.

Summary

5.1.57 A negative chest X-ray can falsely reassure GPs. That said, research indicates that lung cancer is very unlikely in symptomatic patients who do not have haemoptysis following a negative chest X-ray.

5.1.58 CT is a more sensitive test to diagnose lung cancer and is used more widely in other developed countries. There is national recognition that major investment is needed in CT scanners and workforce to acquire and report scans. A national review of diagnostics in 2020 made recommendations to address these areas and work is progressing against the targets set.

5.1.59 Using low-dose CT to screen individuals at high risk of lung cancer has been shown to be beneficial. There was unanimous support among stakeholders for a national screening programme to be set up for lung cancer in patients at high risk.

5.1.60 National stakeholders hold differing opinions as to whether low-dose CT should replace chest X-ray as the first-line diagnostic test to assess for lung cancer in patients at low risk seeing their GP with non-specific symptoms. Existing research is mixed about the benefits of this approach.

5.1.61 Evidence is needed to determine the clinical and cost-effectiveness of using low-dose CT rather than chest X-ray as the first-line diagnostic test for patients at low risk of lung cancer with non-specific symptoms seen in primary care. This would help inform whether a change in NICE guidance was warranted.

5.1.62 Incidental findings from increased use of CT may create a burden on healthcare resources. However, they have been shown to contribute to a reduction in death rates and health gains in screening pilots of individuals at high risk of lung cancer. It is unclear whether the benefits of incidental findings outweigh the disadvantages in symptomatic patients at low risk of lung cancer.

HSIB makes the following safety recommendation

Safety recommendation R/2021/152:
HSIB recommends that the National Institute for Health Research assess the priority, feasibility and impact of future research to address whether low-dose computed tomography (CT) is clinically and cost-effective for the diagnosis of lung cancer in symptomatic patients seen in primary care and consider the most appropriate way of building up the evidence base on this topic.

5.2 Safety netting advice for healthcare professionals

5.2.1 Individuals who smoke are at high risk of lung cancer. However, the number of people who smoke is decreasing and the numbers of lung cancers in those who have never smoked is rising (**see 1.1.2**). This means the perception of lung cancer as a 'smokers' disease' needs to change. The number of people dying each year from lung cancer unrelated to smoking is greater than the number who die of cervical cancer, lymphoma, leukaemia, ovarian and stomach cancer (Duffy, 2021; Bhopal et al, 2019). Lung cancer in never-smokers is 'under-recognised, rather than uncommon' (Bhopal et al, 2019).

5.2.2 The investigation had contact with two lung cancer charities for patients with specific types of lung cancer that are common in never-smokers. They told the investigation about an education campaign targeting GPs to raise awareness of lung cancer in never-smokers and the need to explore this diagnosis in patients who are apparently at low risk who have ongoing non-specific symptoms (ALK Positive UK, n.d.). The campaign features patients with experiences like those of Tracey in the reference event.

5.2.3 In addition to the historically strong (and correct) messaging linking lung cancer with smoking, the non-specific symptoms of the disease create a significant diagnostic challenge for primary care. Cough and shortness of breath, as experienced by Tracey in the reference event, are common presenting symptoms. Stakeholders told the investigation that GPs see large numbers of patients with these symptoms; cough is one of the most common reasons for seeking medical advice in primary care (**see 1.1.14 to 1.1.15**). Furthermore, although individuals who have a cough for more than 3 weeks are advised to see their GP (NHS, n.d.), evidence indicates that coughs frequently last much longer than this (Morice et al, 2020; Speich et al, 2018; British Thoracic Society Guidelines, 2006). This point was echoed by respiratory physicians interviewed during the investigation.

5.2.4 Haemoptysis (coughing up blood) is the symptom most indicative of lung cancer (**see 5.1.23**). However, a study identifying the first reported symptoms of lung cancer and whether these had changed over time (2000 to 2017), found that the proportion of patients reporting cough and breathlessness had increased and the proportion reporting haemoptysis had decreased. Cough was the most common first reported symptom. The study concluded that 'clinicians should be aware that, although haemoptysis remains an important symptom, its presentation is increasingly rare. Medical education needs to place at least as much emphasis on the more common symptom of cough and dyspnoea [shortness of breath] as it does haemoptysis' (Chowienczyk et al, 2020).

5.2.5 Other research has also identified that the commonest symptoms of lung cancer are cough and shortness of breath (Walter et al, 2015; Iyen-Omofoman et al, 2013; Hamilton et al, 2005). Similarly, the relative rarity of haemoptysis in patients attending primary care has been confirmed. For example, one study found this was only experienced by 2.1% of patients with lung cancer (Iyen-Omofoman et al, 2013). Another study, reviewing patients' symptoms in primary care pre diagnosis, found only 10 out of 132 patients (7.5%) reported haemoptysis, with cough being the most common symptom (Mitchell et al, 2013).

5.2.6 These findings reflect those found in a study that aimed to develop risk estimates for primary care symptoms and cancer. As with other research, cough and shortness of breath were the most common symptoms of lung cancer (and haemoptysis relatively rare) although the likelihood of cancer with these symptoms was low. The study concluded that 'to expedite diagnosis of lung cancer, the focus will have to be on the softer symptoms, such as dyspnoea and cough' (Hamilton, 2009).

5.2.7 Such findings have important implications for GPs. However, the frequency of symptoms of cough and breathlessness in general practice together with the infrequency of lung cancer makes the task of diagnosis challenging. Research shows that a full-time GP is likely to diagnose approximately one person with lung cancer each year (National Collaborating Centre for Cancer, 2015; Hamilton, 2009) whereas they are likely to see patients with cough and breathlessness every day (Gruffydd-Jones, 2020). Thus, GPs gain little personal experience of diagnosing lung cancer during their career.

5.2.8 Stakeholders interviewed were unanimous that in this context it was extremely difficult for GPs to distinguish between those patients whose symptoms were attributable to lung cancer and the majority whose were not. The joint Honorary Secretary for the Royal College of General Practitioners summed up the situation for GPs, describing it as trying to "fish out the

needle in the haystack". The task is even more difficult in the absence of risk factors such as smoking, and more difficult again when the chest X-ray report does not identify anything abnormal.

5.2.9 The diagnostic challenge of lung cancer points to the importance of the 'safety netting' advice for healthcare professionals. In this context, safety netting advice refers to the advice given to healthcare professionals on the precautionary measures they should take to mitigate the risk of missed diagnosis. NICE guidance on suspected cancer includes safety netting advice. However, the advice is at the end of the assessment and referral information for all cancers included in the guidance; it is at considerable distance from the section on assessment and referral for lung cancer. Furthermore, the advice is generic to all cancers apart from the statement 'Be aware of the possibility of false-negative results for chest X-rays' (National Institute of Health and Care Excellence, 2019). Research by Foley et al (2021) indicates that this warning has limited impact on GPs (**see 5.1.16 to 5.1.18**). The advice does not state when or what should be offered to patients in this scenario who have ongoing, unexplained symptoms.

5.2.10 Subject matter advisors such as the joint Honorary Secretary for the Royal College of General Practitioners, the Medical Director of the Roy Castle Lung Foundation, NHS England's Specialty Advisor for Imaging, and an academic GP researching early diagnosis of lung cancer highlighted the significance of unresolving symptoms and the absence of a diagnosis in deciding who should be offered CT. Respiratory and radiology stakeholders were unequivocal that a patient aged over 40 who had an unresolving, unexplained cough for 6 months despite treatment should be offered a low-dose CT scan. Several consultant respiratory physicians put the timescale at 3 months; they pointed out they were biased because of their experiences of seeing non-smoking patients with lung cancer who had repeatedly seen their GP. Commenting on Tracey's experience in the reference event, one said "we've all seen this".

5.2.11 Irrespective of identifying possible lung cancer, stakeholders said that low-dose CT was warranted in the context of unresolving, unexplained symptoms to establish a diagnosis and therefore start appropriate treatment. Stakeholders were agreed that an appropriate alternative to CT was a referral to a respiratory physician for assessment. That said, the majority were of the view that this would result in a CT scan anyway, so was just adding time delay. But the bottom line was that a patient with unresolving, unexplained symptoms needed to be "in the system being investigated".

5.2.12 Considering the need for strengthened safety netting advice, the investigation was mindful of the approach taken in Denmark to facilitate earlier diagnosis of cancer in patients being seen in primary care. Like the UK, Denmark had lower lung cancer survival rates than other comparable countries. Following the introduction of pathways which prompted proactive investigation of non-specific symptoms suggestive of lung cancer, 3-year survival for lung cancer increased from 11% to 20% (Vedsted and Olesen, 2015).

5.2.13 Vedsted and Olesen (2015) state that in developing the Danish approach for improving the diagnosis of lung cancer, it became 'obvious' that an urgent referral pathway (akin to the referral for an appointment within 2 weeks in England) for red flag symptoms was 'inadequate to ensure timely diagnosis of all cancer patients'. They highlight research demonstrating that a health-care system that 'focusses on cancer diagnosis based on alarm symptoms alone might also be a health-care system that favours 'the sick-quick' and lets down the majority with vague symptoms' (Vedsted and Olesen, 2015).

5.2.14 One element of the Danish approach was the development of diagnostic centres and direct access for GPs to diagnostic centres for rapid tests for patients with either vague or serious but non-specific symptoms. For patients with vague 'low-risk but not no risk' symptoms, 'no-yes-clinics' (NYC) were set-up. These allow the 30% to 40% of cancer patients like Tracey, who present with vague symptoms to their GP, to have the same fast route to diagnosis as those with red flag symptoms clearly suggestive of cancer (Vedsted and Olesen, 2015).

5.2.15 The Danish diagnostic centres have informed the Multidisciplinary Diagnostic Centres and rapid diagnostic pathways piloted in areas of England (Oxford University Hospitals NHS Foundation Trust, n.d.; Chapman et al, 2020) and the diagnostic hubs proposed in the 2020 review of diagnostic services (NHS England, 2020). Vedsted and Olesen (2015) state that the approach can be both effective and efficient. They highlight a study showing that giving GPs access to low-dose CT for suspected lung cancer did not increase the overall number of scans requested when those ordered by respiratory physicians was factored in.

5.2.16 Alongside the diagnostic challenge, stakeholders told the investigation about organisational and cultural factors that also contribute to a delay in lung cancer diagnosis for patients seen in primary care. These add further weight to the need to strengthen the safety netting advice for healthcare professionals. The most significant factor is the lack of CT resource (**see 5.1.42 to 5.1.43**). Commenting on this, the Medical Director for the Roy Castle Lung Foundation and respiratory physicians who were interviewed by the investigation pointed out that it was easy for a GP to refer a patient for a chest X-ray whereas availability of CT varies widely across England.

5.2.17 Another factor raised with the investigation was the gatekeeper role of GPs. This was perceived to inhibit or delay referral and/or diagnostic tests, particularly in the context of a scarce resource like CT. The Joint Honorary Secretary of the Royal College of General Practitioners said CT is viewed as a "specialist investigation" in primary care. Furthermore, the Secretary said that there were often "lots of questions asked" and, in some areas, requests were still "frowned upon". A related point was made by one of the respiratory physicians interviewed, who is also a researcher into early diagnosis of lung cancer: "CT is still treated as some sort of deluxe investigation, it isn't … it needs be utilised much more frequently."

5.2.18 The National Clinical Director for Cancer told the investigation that those in primary care "feel they should be restrained and shouldn't over-burden secondary care". As a result, behaviour was "calibrated to resisting referral". They noted that while this strategy worked well for some conditions it was "a bad setting for lung cancer". The Clinical Director said that the threshold at which primary care make a specialist referral to exclude lung cancer is much higher than is wanted and is recommended by NICE (where urgent referral is recommended if the risk of cancer based on presenting symptoms is thought to be 3% or more). They stated this tendency to act as "guardians" of resource needed to change – a change that would be facilitated by increasing CT resource and capacity for investigation through diagnostic hubs.

5.2.19 Comments by the National Clinical Director for Cancer were echoed by a respiratory consultant and researcher in lung cancer. They told the investigation that there are far fewer referrals to exclude lung cancer than other cancers. They pointed out that this was despite the fact that "lung cancer is one of the common cancers and the most common cause of death".

5.2.20 Another stakeholder, an academic GP, said the professional identity and culture of many GPs is bound up with managing risk and not referring onwards too frequently. They said this culture meant there could be delays in referral for specialist opinion and investigation for patients whose symptoms warranted this. In his view a patient who has presented three times with unresolving symptoms and no diagnosis needs further investigation and specialist assessment. Furthermore, the GP said patients should be active partners in the decision about referral and further investigation. In the reference event, Tracey described a "gut feeling" that something was seriously wrong, yet felt this possibility was discounted. Her experience is mirrored by others like her who do not smoke so are not perceived to be at risk of lung cancer (Rawlinson, 2021).

5.2.21 Comments about the unwanted side-effects of gatekeepers in primary care are reflected in research. For example, a study by Vedsted and Olesen (2011) comparing European countries' primary care and their 1 year cancer survival rates found that countries with a strong gatekeeper role also had the lowest cancer survival rates. The authors conclude that this could suggest 'where GPs were good gatekeepers [they] had become too reluctant to refer early to diagnostic investigations'. Further, the study found that access to diagnostic services in the initial phase was slow or rationed, resulting in patients not getting timely investigation.

5.2.22 The evidence indicates that it may be beneficial for the safety netting advice for healthcare professionals in the guidance on referral for suspected cancer (National Collaborating Centre for Cancer, 2015) to make clearer what should be offered to patients with unresolving, unexplained symptoms after a negative chest X-ray.

5.2.23 The investigation spoke about NICE's existing safety netting advice with one of its Programme Directors, along with the Consultant Clinical Advisor who was responsible for clinical quality assurance of the guidance when it was published. They said that including the possibility of false-negative chest X-ray results in the existing advice aimed to ensure GPs were not inappropriately reassured. In effect, the intent was to act as a prompt, or to highlight, that a management plan was needed if there were ongoing, unexplained symptoms. They agreed that there was the potential to amend the wording of the safety netting advice to clarify this intent.

Summary

5.2.24 Rates of smoking are declining and the relative proportion of lung cancers in those who have never smoked is rising.

5.2.25 Media messaging highlighting the link between lung cancer and smoking, together with the non-specific symptoms suggestive of lung cancer, has created a significant diagnostic challenge for GPs.

5.2.26 Evidence indicates that it may be beneficial to amend the safety netting advice for healthcare professionals in NICE guidance. The amended advice should make clearer what should be offered to patients with ongoing, unexplained symptoms after a negative chest X-ray.

5.2.27 In the context of scarce CT resource, organisational and cultural factors such as the gatekeeper role of GPs can contribute to a delay in lung cancer diagnosis for patients seen in primary care.

HSIB makes the following safety recommendation

Safety recommendation R/2021/153:
HSIB recommends that the National Institute for Health and Care Excellence reviews its current safety netting advice to healthcare professionals with respect to the investigation of possible lung cancer. The wording of the advice should be amended as required to make it clearer what should be offered to patients with ongoing, unexplained symptoms who have had a negative chest X-ray.

5.3 Artificial intelligence

5.3.1 Artificial intelligence (AI) means technology enabling the programming or training of a device or software to:

- perceive environments through the use of data
- interpret data using automated processing designed to be similar to human thought processes
- make recommendations, predictions or decisions with a view to achieving a specific objective (National Security and Investment Act, 2021).

5.3.2 AI has the potential to support radiologists and reporting radiographers in the interpretation of chest X-rays and so mitigate the risk of lung cancer being missed. Radiologists interviewed during the investigation were unanimously positive about the potential benefits of AI in reducing the number of lesions not seen, or not recognised as abnormal. As well as potentially helping accuracy, stakeholders highlighted the fallibility of humans that AI may help counter. Views heard were summed up by the Standards Lead for BSTI: "... why would you not want a tool to help you ... we all have lapses in concentration or can get distracted."

5.3.3 Stakeholders told the investigation that there was a burgeoning number of AI applications on the market. They expressed caution regarding the manufacturers' claims of product capabilities.

5.3.4 Although the number of AI applications available is growing rapidly (Mehrizi et al, 2021; NHS England, 2020), their routine use in daily clinical practice is limited (He et al, 2019). A systematic review of AI in diagnostic radiology found that the products available offered many different functionalities yet each focused on a narrow medical question or disease target so were 'far from being comprehensive' (Mehrizi et al, 2021). This narrowness was shown to limit applicability in clinical practice.

5.3.5 The review authors concluded that the technology was in an 'emerging' phase with functionalities and use cases 'yet to be developed, critically evaluated in practice, and complemented by the subsequent developments' (Mehrizi et al, 2021). This conclusion was echoed in the review of diagnostics commissioned by NHS England (2020).

5.3.6 A systematic review by Aggarwal et al (2021) evaluated the diagnostic accuracy of AI. The review focused on several specialties, one being respiratory imaging. Wide variation was found in study design, methodology, reference standards and metrics used to report performance which limited 'the generalisability and applicability of their findings' (Aggarwal et al, 2021). A high risk of bias was identified due to the issues found. Furthermore, the authors found that critical appraisal and independent evaluation of these technologies were in their 'infancy'.

5.3.7 Aggarwal et al (2021) stated that there was a need for well-designed studies that 'explicitly address questions concerning transparency, reproducibility, ethics and effectiveness'. While the authors found high diagnostic accuracy in medical imaging, they found that it was it was difficult to determine whether the algorithms were 'clinically acceptable or applicable' because of the study limitations.

5.3.8 Recommendations to address the review findings included the availability of large, open-source, anonymised datasets to enable greater reproducibility of models; collaboration with academic centres to utilise their expertise in trial design; and the creation of AI-specific standards for study design and reporting to help clarify clinical utility.

5.3.9 The investigation interviewed the Director of Radiology Research at Oxford University. The Director is a radiologist who has helped assess applications for AI projects seeking NHSX grant support and is the chief medical officer for the National Consortium of Intelligent Medical Imaging (one of five centres funded to support the development, validation and deployment of medical imaging AI to improve patient care).

5.3.10 Commenting on current knowledge regarding the value of AI in detecting lung cancer on chest X-rays, the Director said it can "probably" help humans. They pointed out that much of the research to date is based on retrospective data and what was needed was a prospective study to see if AI added to, or was better than, humans at detection of lung cancer on X-rays.

5.3.11 The Director of Radiology Research described other challenges to be resolved. For example, if an AI programme determines cancer is present but the radiologist's interpretation is that the patient has an infection, what should happen? They noted that humans manage uncertainty and

nuance; they can put together images and clinical data as well as liaise with colleagues to arrive at an opinion or judgement. In contrast, AI currently is only good at "binary decision-making" – that is, determining whether something is normal or abnormal. Furthermore, the Director explained that AI often cannot interpret unfamiliar image data. As an example, they shared an image of a cat shown to an algorithm in place of a chest X-ray which the AI programme determined with 99% confidence to be lung disease.

5.3.12 Accepting the current limitations and need for more evidence, the Director of Radiology Research said that AI was "getting better and better".

5.3.13 The investigation interviewed a consultant radiologist and medical director at an NHS trust which had deployed AI to support the interpretation of chest X-rays. The consultant is also the director of a radiology company and has a particular interest and expertise in AI. The investigation was keen to understand the experience of using AI in practice. Comments made by the consultant reflected evidence found in the literature and opinion expressed by the Director of Radiology Research regarding the limitations of AI: "… it can only look at a specific number of things." The consultant said introducing AI had been "useful **in the way we used it** [emphasis added]" which was to filter normal from abnormal, and as a decision support for radiologists.

5.3.14 The consultant echoed the importance of the validation process for marketed AI platforms and transparency of datasets used to test products.

5.3.15 Reflecting the growth and interest in AI, in 2019 NHSX set up an AI Lab to support the adoption of AI in the health system. In addition, in partnership with the National Institute for Health Research (NIHR) and Accelerated Access Collaborative [9] (AAC), funding was made available through an AI award scheme to facilitate innovation and accelerate testing of the most promising AI technologies. The importance of rapidly evaluating promising new technologies such as AI, and the scheme's role in this, was highlighted in the 2020 review of diagnostics (NHS England, 2020).

5.3.16 The Head of AI Imaging at NHSX told the investigation that there was a need to make the introduction of AI into healthcare organisations "more rigorous". They said there was a need for a more centralised approach which allowed for oversight of AI being used in clinical practice and for "stress-testing", "evaluation" and "validation" of products on the market and their stated capability – for example, having open access to the datasets on which models (such as lung cancer algorithms) were developed and tested. In essence, issues of governance and quality assurance.

5.3.17 The Head of AI Imaging spoke of the need for guidance to be developed to facilitate evaluation of AI products marketed for the detection of lung cancer. They said this would help define "what good looked like" and enable independent benchmarking. The guidance would make clear to AI companies the expectations regarding the testing and validation of lung disease algorithms, as well as support commissioners and/or healthcare providers to assess products.

Summary

5.3.18 There is an increasing number of AI products being marketed to aid the detection of lung disease including cancer.

5.3.19 Product specifications vary along with the testing and evaluation of those products.

5.3.20 There is a need for guidance to facilitate independent benchmarking and validation of AI products marketed to aid the detection of lung cancer.

HSIB makes the following safety recommendation

Safety recommendation R/2021/154:
HSIB recommends that NHSX, in collaboration with relevant stakeholders such as The Royal College of Radiologists and The Society and College of Radiographers, develops guidance to support independent benchmarking and validation of artificial intelligence algorithms for the identification of lung diseases such as cancer.

5.4 Maintaining and assuring expertise

5.4.1 Chest X-rays are the most frequently requested diagnostic imaging test by GPs in England (NHS England, 2019). Most qualified radiologists are expected to be able to report them. However, radiologists and respiratory physicians who provided subject matter advice for the investigation were unanimous that chest X-rays were perhaps one of the most difficult images to interpret. This is because of the overlying anatomic structures (such as the ribs, heart, diaphragm and lung vessels) in the chest which make findings unclear and make it difficult to differentiate normal from abnormal.

5.4.2 The subject matter advisors considered expertise to be an important factor in mitigating the risk of missed lesions. This view is evidenced by research (del Ciello et al, 2017) and it is recommended that radiologists and reporting radiographers report a minimum of 2,000 chest X-rays annually to help develop and maintain expertise (Accelerate, Coordinate, Evaluate (ACE) Programme, 2017). However, the investigation was told that nationally there was little in place

to support radiologists in self-assessing and assuring their expertise. This may be of particular relevance if a radiologist has specialised and spends the majority of their time reporting one mode of imaging and/or body region and only occasionally reports others. The Director of Radiology Research (a consultant radiologist) at Oxford University summed up the situation, saying: "... the quality of the reporter is not routinely assessed in the NHS."

5.4.3 The Director of Radiology Research pointed out the discrepancy between the requirement to demonstrate currency of knowledge and self-assessment about, for example, fire safety arrangements, and that required to demonstrate currency and assessment of clinical quality. A qualified radiologist working in the NHS has a statutory and mandatory duty to regularly undertake and complete self-assessment on fire safety yet there is no equivalent requirement to undergo standardised self-assessment of clinical expertise. The Director of Radiology Research contrasted this with other high-risk industries such as aviation where a pilot is required, at defined intervals, to undertake flight simulation to provide assurance of competence and enable them to identify and rectify any skills deficit.

5.4.4 The teleradiology group in the reference event internally audited a percentage of the chest X-rays (and other images) reported by their radiologists as part of their governance processes (**see 4.3.2**). The clinical audit lead said that auditors were selected according to set criteria which included expertise in the area audited. The auditors were asked to provide educational feedback, with references to relevant literature where appropriate. In addition, reporters were asked to provide written reflections on their learning if there were discrepancies between auditor findings and their own. The audit lead stated that the aim of this process was to improve the quality of reports through reflection and focus on continued professional development. They said that learning points from individual discrepancies were shared with other reporters within the teleradiology group through regular educational reviews and online seminars. The investigation was told this mechanism of assurance was above that in place in most trusts.

5.4.5 While this level of audit may not exist in most hospitals, the governance processes of many radiology departments will include discrepancy meetings to share learning and improve practice for radiologists and reporting radiographers. Discrepancy meetings are promoted by The Royal College of Radiologists, and it has published standards to provide guidance on how these should be run (The Royal College of Radiologists, 2020). The College advised that it also shares learning through its newsletters and annual meeting. For reporting radiographers, The Society and College of Radiographers said that their work is routinely assessed by both audit and peer review. A survey of London NHS trusts confirmed the latter but noted there was variation in the methods used (Woznitza et al, 2021).

5.4.6 The investigation found educational platforms in existence designed to both develop and enable self-assessment of skills in interpreting chest X-rays and other imaging. One example is the Report and Image Quality Control tool (RAIQC) developed at Oxford University Hospitals. This tool simulates real-world situations and provides models at varying levels of difficulty across a range of techniques, diseases and procedures. The tool facilitates learning for those in training and assessment of skills for already experienced reporters. It has been clinically validated and received governance approval within some hospitals in the NHS.

5.4.7 The investigation spoke with the Director of Radiology Research at Oxford University Hospitals about the tool. They pointed out the importance of quality control and ongoing assessment of competence. They said this was in place for radiologists involved in national screening programmes such as breast screening. Similarly, it is to be put in place for lung cancer screening as part of the Targeted Lung Health Check programme by NHS England. Outside of these specific areas, there is not a standardised system of quality control and feedback – for example, it is not in place for the detection of lung cancers on routine chest X-rays.

5.4.8 The Director of Radiology Research explained the purpose of RAIQC in the context of the reference event: "... people want and need to know when they miss a lung cancer on chest X-ray ... there needs to be continual training and development ... [RAIQC] acts like flight simulation for pilots." They described the feedback provided by the tool which reflected evidence in the research literature regarding the importance of a structured scanning technique (Busby et al, 2018). The Director of Radiology Research explained that RAIQC allowed radiologists and reporting radiographers to both self-assess and compare themselves to their (anonymous) peers (that is, those at the same level of training and experience). If they wished, individuals could compare themselves with those with more experience and training.

5.4.9 The investigation was told that the Oxford and London Deaneries have adopted RAIQC to support the learning needs of radiographers and radiologists in training. In addition, Prostate Cancer UK and Public Health England are using different modules for aspects of their work where they want to provide an assessment of quality and reporting accuracy. A previous HSIB report mentioned RAIQC as a means to develop and assess competency in identifying the correct placement of nasogastric tubes on chest X-ray (**Healthcare Safety Investigation Branch, 2020**).

5.4.10 Although there is no requirement to undertake self-assessment of expertise for tasks such as chest X-ray interpretation, the investigation acknowledges that there is a professional requirement for all registered clinicians to engage

with processes designed to demonstrate fitness to practise and ongoing professional development. From a patient perspective, these processes aim to provide confidence in the safety and quality of care. From a clinician perspective, educational platforms such as RAIQC provide an opportunity to gain insight into areas where they excel and areas where they could improve, providing feedback to facilitate this. In addition, on occasions where a clinician misses a diagnosis, self-assessment could provide reassurance to the clinician, patient and healthcare organisation of their proficiency or provide the means to rectify this if needed.

Summary

5.4.11 Chest X-rays are difficult to interpret due to overlying anatomic structures.

5.4.12 Expertise is an important factor in mitigating the risk of missed lesions. Once a clinician is qualified, there is no requirement or opportunity for self-assessment of tasks such as chest X-ray interpretation.

5.4.13 Educational platforms exist to develop clinicians' skills and enable them to self-assess their interpretation of chest X-rays and other imaging.

5.4.14 From a patient, professional and organisational perspective, a self-assessment tool for clinicians that provides feedback to facilitate improvement may be helpful to assure quality and contribute to ongoing professional development.

HSIB makes the following safety observation

Safety observation O/2021/129:
It may be beneficial if existing educational platforms were used to support healthcare staff who report on chest X-rays with their ongoing professional development and demonstration of the clinical quality of their work.

6 Summary of findings, safety recommendations and safety observations

6.1 Findings

- Lung cancer in people who have never smoked is increasing.
- Media messaging highlighting the close link between lung cancer and smoking, and the often non-specific symptoms of lung cancer, have created a significant diagnostic challenge for GPs.
- A chest X-ray is the recommended first test to assess whether a patient may have lung cancer. Chest X-rays are difficult to interpret and about one in five cancers are missed. A chest X-ray report that does not identify cancer has the potential to falsely reassure GPs.
- Evidence indicates that it may be beneficial to amend the safety netting advice for healthcare professionals in the National Institute for Health and Care Excellence guidance. In this context, safety netting advice refers to advice given to healthcare professionals on the precautionary measures they should take to mitigate the risk of missed diagnosis. The amended advice should make clearer what should be offered to patients who have ongoing, unexplained symptoms after a negative chest X-ray.
- CT scanning is a more accurate test to diagnose lung cancer and is used more widely in other developed countries which have better cancer survival rates. There is national recognition that major investment is needed in CT scanning equipment and workforce to perform and report scans.
- Using low-dose CT (a scan that exposes a patient to a smaller amount of radiation compared to conventional CT) to screen people at high risk of lung cancer, such as current or past smokers, has been shown to be beneficial. There is no significant evidence, and differing opinion, as to whether low-dose CT should replace chest X-ray as the first line diagnostic test to assess for lung cancer in patients seeing their GP with non-specific symptoms. Research is needed to determine the clinical and cost-effectiveness of this.
- An increasing number of artificial intelligence products are being marketed to aid the detection of lung disease including cancer. There is variable testing and evaluation of these products.

- Expertise is an important factor in mitigating the risk of missed cancer on chest X-rays. There are educational platforms that can help the healthcare staff who review and interpret X-rays to develop their skills and assess their own performance. These may be helpful to assure quality and contribute to ongoing professional development

HSIB makes the following safety recommendations

Safety recommendation R/2021/152:
HSIB recommends that the National Institute for Health Research assess the priority, feasibility and impact of future research to address whether low-dose computed tomography (CT) is clinically and cost-effective for the diagnosis of lung cancer in symptomatic patients seen in primary care and consider the most appropriate way of building up the evidence base on this topic.

Safety recommendation R/2021/153:
HSIB recommends that the National Institute for Health and Care Excellence reviews its current safety netting advice to healthcare professionals with respect to the investigation of possible lung cancer. The wording of the advice should be amended as required to make it clearer what should be offered to patients with ongoing, unexplained symptoms who have had a negative chest X-ray.

Safety recommendation R/2021/154:
HSIB recommends that NHSX, in collaboration with relevant stakeholders such as The Royal College of Radiologists and The Society and College of Radiographers, develops guidance to support independent benchmarking and validation of artificial intelligence algorithms for the identification of lung diseases such as cancer.

HSIB makes the following safety observation

Safety observation O/2021/129:
It may be beneficial if existing educational platforms were used to support healthcare staff who report on chest X-rays with their ongoing professional development and demonstration of the clinical quality of their work.

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8 Endnotes

[1] In this context, the 'stage' describes the extent of cancer in a person's body. The stages of cancer are numbered 0 to 4 depending on how much the cancer has grown and how far the cancer has spread, with 4 indicating that the cancer has spread to at least one other organ in the body.

[2] A chest X-ray is an image used to diagnose conditions affecting the chest, its contents, and nearby structures in the body. Chest X-rays are the most common images taken in medicine.

[3] A computed tomography (CT) scan uses X-rays and a computer to create detailed images of the inside of a patient's body.

[4] Radiographers are regulated healthcare professionals. This report refers to diagnostic radiographers who are trained and educated to perform clinical imaging examinations while providing care and support for patients, families and carers.

[5] Teleradiology is the transmission of radiological patient images, such as X-rays, CTs, and MRIs, from a healthcare organisation to external radiologists for review and reporting. The resulting reports are then transmitted back to the original healthcare facility.

[6] In contrast with type 1 thinking, type 2 thinking is slow, analytical and effortful. This type of thinking is employed when situations are difficult and/or unfamiliar. This type of thinking takes time and is more cognitively demanding but is more likely to help the radiologist determine the correct diagnosis (Busby et al, 2018).

[7] Reports of patient safety incidents, including clinical incidents, are submitted by trusts to a national database. Incidents which are considered serious incidents, which include those resulting in permanent harm or death, should also be recorded on the Strategic Executive Information System. This system facilitates the monitoring of investigations between NHS providers and commissioners. A full list of incidents defined as serious can be found in the Serious Incident Framework (NHS England, 2015).

[8] The type of radiation being referred to is ionising radiation. Ionising radiation is a type of energy released by atoms in the form of electromagnetic waves or particles. It has more energy than non-ionising radiation, enough to cause chemical changes by breaking chemical bonds. This effect can cause damage to living tissue with the potential to cause harm.

[9] The Accelerated Access Collaborative brings together industry, regulators, NHS and other stakeholders to accelerate the introduction of new diagnostics, treatments and innovations to enhance care.

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