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Guideline concordance for timely chest imaging after new presentations of dyspnoea or haemoptysis in primary care: a retrospective cohort study

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ABSTRACT

Background Guidelines recommend urgent chest X-ray for newly presenting dyspnoea or haemoptysis but there is little evidence about their implementation.

Methods We analysed linked primary care and hospital imaging data for patients aged 30+ years newly presenting with dyspnoea or haemoptysis in primary care during April 2012 to March 2017. We examined guideline-concordant management, defined as General Practitioner-ordered chest X-ray/CT carried out within 2 weeks of symptomatic presentation, and variation by sociodemographic characteristic and relevant medical history using logistic regression. Additionally, among patients diagnosed with cancer we described time to diagnosis, diagnostic route and stage at diagnosis by guideline-concordant status.

Results In total, 22 560/162 161 (13.9%) patients with dyspnoea and 4022/8120 (49.5%) patients with haemoptysis received guideline-concordant imaging within the recommended 2-week period. Patients with recent chest imaging pre-presentation were much less likely to receive imaging (adjusted OR 0.16, 95% CI 0.14–0.18 for dyspnoea, and adjusted OR 0.09, 95% CI 0.06–0.11 for haemoptysis). History of chronic obstructive pulmonary disease/asthma was also associated with lower odds of guideline concordance (dyspnoea: OR 0.234, 95% CI 0.225–0.242 and haemoptysis: 0.88, 0.79–0.97). Guideline-concordant imaging was lower among dyspnoea presenters with prior heart failure; current or ex-smokers; and those in more socioeconomically disadvantaged groups.
The likelihood of lung cancer diagnosis within 12 months was greater among the guideline-concordant imaging group (dyspnoea: 1.1% vs 0.6%; haemoptysis: 3.5% vs 2.7%).

Conclusion The likelihood of receiving urgent imaging concords with the risk of subsequent cancer diagnosis. Nevertheless, large proportions of dyspnoea and haemoptysis presenters do not receive prompt chest imaging despite being eligible, indicating opportunities for earlier lung cancer diagnosis.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Guidelines recommend prompt investigation of dyspnoea and haemoptysis in order to support early diagnosis of lung cancer but there is currently little evidence regarding how these guidelines are implemented.

WHAT THIS STUDY ADDS

⇒ Substantial proportions of patients newly presenting with dyspnoea or haemoptysis did not receive prompt imaging as recommended by clinical guidelines.
⇒ Guideline-concordant imaging was more likely in those later diagnosed with cancer, and less likely in patients who had recently had chest imaging and those with existing respiratory morbidities.
⇒ Among dyspnoea presenters, those with prior heart failure; current or ex-smokers; and those in more socioeconomically disadvantaged groups were also less likely to have guideline-concordant imaging.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Guideline-concordant imaging patterns are suggestive of appropriate clinical reasoning.
⇒ However, certain groups at higher risk of lung cancer were less likely to have urgent imaging.
⇒ Additionally, large proportions of individuals later diagnosed with cancer had not received urgent imaging indicating possible opportunities to improve earlier detection of lung cancer.

Linked

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INTRODUCTION

International and regional variation in cancer outcomes indicates the need for improvement in lung cancer diagnosis.[1–3] Lung cancer screening for high-risk individuals offers promise,[4–8] but most patients are diagnosed with cancer via symptomatic pathways, typically starting in primary care.[9] Nonetheless, achieving timely diagnosis of symptomatic lung cancer is challenging. The presenting symptoms of lung cancer are often non-specific, and other diagnoses such as chronic obstructive pulmonary disease (COPD), pneumonia and cardiac conditions may offer plausible alternative explanations.

In England and other countries, clinical guidelines have been developed to encourage the recognition and investigation of symptomatic individuals for suspected cancer in primary care.[10–13] The

guidelines recommend urgent referral (in England, via the 'two-week wait' fast-track referral pathway) or urgent primary care-led investigation for 'red-flag' symptoms with relatively high positive predictive value for cancer. For patients presenting with haemoptysis or persistent dyspnoea, urgent chest imaging is recommended.[14 15]

There is currently limited evidence about how primary care referral guidelines for suspected cancer operate in practice. A recent study found that three-fifths of patients with certain alarm symptoms (not including respiratory symptoms) were not referred in spite of guideline recommendations.[16] Understanding guideline implementation could inform the development of quality indicators to improve the diagnostic process.[17] With this goal in mind, we examined the proportion of patients with newly presenting dyspnoea or haemoptysis that received urgent chest imaging concordant with clinical recommendations and related variation by patient-level factors. Additionally, we examined patients diagnosed with cancer in the 12 months following symptomatic presentation by guideline-concordant status.

METHODS

Study design and population

We conducted an observational cohort study using anonymous electronic patient records collected between 1 April 2012 and 15 March 2017. Primary care data from the Clinical Practice Research Datalink (CPRD) GOLD were linked with cancer registration data collated by the National Cancer Registry Analysis Service (NCRAS) and secondary care data, including the English Hospital Episode Statistics Diagnostic Imaging Dataset (HES-DID).

For individuals presenting with haemoptysis or 'unexplained or persistent (longer than 3 weeks)' dyspnoea, the 2005 National Institute for Health and Care Excellence (NICE) guidelines recommend that an urgent chest X-ray is carried out within 2 weeks.[10] We defined two cohorts (each for dyspnoea and haemoptysis) using Read code lists to include individuals aged 30+ years if they had presented with either symptom at least 12 months following practice registration (see online supplemental appendix 1).[18 19] Patients were excluded if their outcome status could not be confirmed, namely if they presented on or after 16 March 2017 (ie, within 2 weeks from the last reliable date in the available DID data); had left their CPRD practice or had died within 2 weeks of presentation; or if their practice had left CPRD within 2 weeks from their presentation.

It was not possible to distinguish between patients who had experienced dyspnoea for 3 weeks or longer before consulting, and those consulting for new-onset dyspnoea as information on symptom duration was not available. Therefore, the first recorded occurrence in primary care was assumed to represent the first presentation of dyspnoea or haemoptysis, respectively.

Outcome of interest

A guideline-concordant imaging event was defined by applying the following three criteria to the linked DID data (see online supplemental appendix 2 for further details):

1. Imaging modality and body region: A chest X-ray or CT scan of the lung or chest using previously published National Interim Clinical Imaging Procedure (NICIP) and Systematised NOmenclature of MEDicine (SNOMED) code lists for such imaging investigations.[20]
2. Source of imaging referral: Imaging events ordered by a General Practitioner (GP) and/or from primary care.
3. Time from symptomatic presentation: Chest imaging that took place 0–14 days following symptomatic presentation was assumed to be relevant to the symptom.

Covariates of interest

Sex (male or female) and age group (10-year age bands from 30 to 39 years to 80+ years) were based on information in CPRD, and socioeconomic status (Index of Multiple Deprivation 2015 score quintiles based on patient postcode of residence) from linked national data. Ethnicity was categorised using information in the order of preference from HES inpatient, HES outpatient and HES-DID files and categorised as white, non-white or missing. Cancer diagnoses recorded in the 12 months following symptomatic presentation were based on national cancer registration data. Individuals were categorised as having been diagnosed with lung cancer; non-lung cancer excluding non-melanoma skin cancers (C44) and non-malignant tumours (D-code and in situ tumours); or no cancer. For patients with multiple tumours with the same diagnosis date, lung cancers and tumours with non-missing stage were prioritised over non-lung cancers and tumours with missing stage, respectively.

Each individual was categorised as a non-smoker, ex-smoker or current smoker based on primary care records prior to the date of symptomatic presentation by collating previously published Read code lists for smoking status and smoking cessation product codes and using the last observation carried forward approach to impute values closest to the index date where possible.[21–25]

Certain pre-existing conditions could serve as alternative explanations of dyspnoea presentation (COPD or asthma, and heart failure) and haemoptysis, thereby influencing the likelihood of receiving guideline-concordant imaging. Therefore, diagnoses of respiratory disease and heart failure recorded in primary care between 78 and 6 months prior to symptomatic presentation were used to categorise patients as having no morbidities; respiratory conditions only; heart failure only; respiratory conditions or heart failure; and both respiratory conditions and heart failure.[23 26]

Finally, we examined recent prior imaging as another possible explanation for guideline discordance, defined as receipt of primary care-ordered chest imaging up to 6 weeks prior to symptomatic presentation (specifically during a period from −42 days to −1 day from the index date).

Statistical analyses

The two patient-based symptom cohorts were examined independently of each other. Descriptive statistics followed by crude and adjusted logistic regression models were used to examine variation in guideline-concordant imaging by patient-level covariates (sex, age group, ethnicity, smoking status and pre-existing respiratory disease and heart failure). We considered two adjusted models: the first excluded cancer diagnosis status (as this is not known at the time of presentation when decision-making for using imaging takes place), while the second included cancer diagnosis as a covariate (as while this occurs after presentation, it may act as a marker of other unmeasured characteristics of individuals with lung cancer, eg, symptom severity and other features that may have been present at presentation and taken into account by the primary care physician).

Subsequently, among the subgroups of patients in each cohort who were diagnosed with lung cancer, descriptive statistics were used to compare stage at diagnosis (tumour, node, metastases (TNM) stages 1/2, 3/4 or missing), route to diagnosis (one of eight routes as established by NCRAS[27]) and time from symptomatic presentation to diagnosis (the diagnostic interval[28]) by imaging status, using χ^2 tests for significance.

Supplementary analyses

We undertook the following supplementary analyses, which are reported in the online supplemental appendix:

- Considering an imaging interval of 0–28 days from symptomatic presentation (instead of 14 days, as in the main analysis) (online supplemental appendix 3).
- Considering imaging ordered from any source within 14 days of symptomatic presentation (instead of just primary care-ordered imaging, as in the main analysis) (online supplemental appendix 4).

RESULTS

Study population

A total of 162 161 individuals with newly presenting dyspnoea and 8120 individuals with newly presenting haemoptysis were included (table 1). The majority of individuals in both symptom cohorts were 60 years or older, white and either ex-smokers or current smokers as opposed to non-smokers.

Guideline-concordant imaging

A total of 22 560/162 161 (13.9%) patients with dyspnoea and 4022/8120 (49.5%) patients with haemoptysis received guideline-concordant imaging, namely primary care-ordered chest imaging within 2 weeks of presentation (tables 2 and 3).

Among both cohorts, women, the youngest age groups (30–39 and 40–49 year-olds) and those with missing ethnicity were less likely to receive guideline-concordant imaging compared with men, 50–59 year-olds and white individuals, respectively. Individuals who had had chest imaging in the 6 weeks prior to symptomatic presentation were much less likely to receive guideline-concordant imaging (adjusted OR (aOR) 0.16, 95% CI 0.14–0.18 in dyspnoea cohort; aOR 0.09, 95% CI 0.06–0.11 in haemoptysis cohort). History of COPD/asthma was also associated with much lower odds of guideline concordance in dyspnoea presenters (aOR 0.23, 95% CI 0.23–0.24) with a much weaker though similar in direction association among haemoptysis presenters (0.88, 0.79–0.97).

In the dyspnoea cohort, individuals with lower socioeconomic status, current/ex-smokers and individuals with morbidities were less likely to receive imaging. Individuals with pre-existing COPD/asthma or heart failure were much less likely to receive imaging for dyspnoea, with the lowest odds of imaging seen among patients with both morbidity types (0.20, 0.17–0.24).

Adjustment for cancer made no material difference to the associations between sociodemographic variables and guideline-concordant imaging. Individuals who were diagnosed with lung cancer in the year post-presentation were more likely to have received urgent imaging for newly presenting dyspnoea or haemoptysis (2.07, 1.78–2.41 and 1.39, 1.06–1.83, respectively). A similar association was also observed among patients later diagnosed with other cancer types following a dyspnoea presentation (1.33, 1.20–1.48), but without such evidence for haemoptysis.

Lung cancer outcomes by imaging status

The proportion of patients subsequently diagnosed with lung cancer among those who received guideline-concordant imaging was twice as high compared with those not promptly imaged (1.1% vs 0.6%, p<0.001) for dyspnoea presenters, and a third higher for haemoptysis presenters (3.6% vs 2.7%, p=0.076) (table 4). However, the majority (854/1103, 70%) of dyspnoea presenters and (110/253, 43%) of haemoptysis presenters subsequently diagnosed with lung cancer did not receive guideline-concordant imaging.

Table 1 Composition of the dyspnoea cohort (n=162 161) and haemoptysis cohort (n=8120)

	Dyspnoea N (%)	Haemoptysis N (%)	P value*
Total	162 161 (100)	8120 (100)	
Sex			
Men	75 683 (47)	4728 (58)	<0.001
Women	86 478 (53)	3392 (42)	
Age group (years)			
30–39	9549 (6)	904 (11)	<0.001
40–49	16 602 (10)	1218 (15)	
50–59	24 772 (15)	1477 (18)	
60–69	38 835 (24)	1768 (22)	
70–79	40 491 (25)	1646 (20)	
80+	31 912 (20)	1107 (14)	
Ethnicity			
White	143 726 (89)	6857 (84)	<0.001
Non-white	7822 (5)	746 (9)	
Missing	10 613 (7)	517 (6)	
IMD quintile			
1 (least deprived)	32 621 (20)	1592 (20)	0.081
2	33 848 (21)	1614 (20)	
3	33 628 (21)	1704 (21)	
4	31 480 (19)	1619 (20)	
5 (most deprived)	30 514 (19)	1588 (20)	
Smoking status			
Non-smoker	34 576 (21)	1955 (24)	<0.001
Ex-smoker	69 667 (43)	3121 (38)	
Current smoker	57 559 (35)	3024 (37)	
Missing	359 (0.2)	20 (0.2)	
Morbidities†			
No COPD/asthma or HF	86 129 (53)	5596 (69)	<0.001
HF only	3417 (2)	144 (2)	
COPD/asthma only	70 008 (43)	2281 (28)	
COPD/asthma and HF	2607 (2)	99 (1)	
Imaging in the 6 weeks prior to presentation			
No prior imaging	153 538 (95)	7567 (93)	<0.001
Prior imaging	8623 (5)	553 (7)	
Cancer diagnosis in the year following symptomatic presentation			
No	158 575 (98)	7742 (95)	<0.001
Yes (lung cancer)	1103 (1)	253 (3)	
Yes (other cancer)	2483 (2)	125 (2)	

*From χ^2 test.
†Recorded in a period from 6 to 78 months prior to symptomatic presentation. Respiratory disease=COPD/asthma.
COPD, chronic obstructive pulmonary disease; HF, heart failure; IMD, Index of Multiple Deprivation.

Compared with those who did not receive guideline-concordant imaging, a slightly higher proportion of those who received imaging were diagnosed with advanced stage (TNM stages III–IV) among both dyspnoea and haemoptysis cohorts though this may have been a chance finding (table 5).

Table 2 Receipt of guideline-concordant imaging within 2 weeks from presentation among patients with newly presenting dyspnoea (n=162 161)

Dyspnoea	Total	Guideline-concordant imaging n (%)	Crude OR (95% CI)	Adjusted OR (95% CI)*	Adjusted OR (95% CI)†
Total	162 161	22 560 (14)	–	–	–
Sex			*<0.001*	*<0.001*	*<0.001*
Men	75 683	10 842 (14)	Ref	Ref	Ref
Women	86 478	11 718 (14)	**0.94 (0.91 to 0.96)**	**0.93 (0.90 to 0.95)**	**0.93 (0.90 to 0.96)**
Age group (years)			*<0.001*	*<0.001*	*<0.001*
30–39	9549	904 (9)	**0.65 (0.61 to 0.71)**	**0.55 (0.51 to 0.60)**	**0.55 (0.51 to 0.60)**
40–49	16 602	2216 (13)	0.96 (0.91 to 1.02)	**0.88 (0.83 to 0.93)**	**0.88 (0.83 to 0.93)**
50–59	24 772	3413 (14)	Ref	Ref	Ref
60–69	38 835	5462 (14)	1.02 (0.98 to 1.07)	**1.10 (1.04 to 1.15)**	**1.09 (1.04 to 1.14)**
70–79	40 491	6084 (15)	**1.11 (1.06 to 1.16)**	**1.14 (1.09 to 1.19)**	**1.13 (1.08 to 1.18)**
80+	31 912	4481 (14)	1.02 (0.97 to 1.07)	**0.93 (0.88 to 0.98)**	**0.92 (0.87 to 0.97)**
Ethnicity			*<0.001*	*<0.001*	*<0.001*
White	143 726	20 297 (14)	Ref	Ref	Ref
Non-white	7822	1139 (15)	1.04 (0.97 to 1.11)	0.96 (0.90 to 1.03)	0.97 (0.90 to 1.04)
Missing	10 613	1124 (11)	**0.72 (0.68 to 0.77)**	**0.68 (0.64 to 0.73)**	**0.68 (0.64 to 0.73)**
IMD quintile			*<0.001*	*0.001*	*0.001*
1 (least deprived)	32 621	5052 (15)	Ref	Ref	Ref
2	33 848	4754 (14)	**0.89 (0.85 to 0.93)**	**0.93 (0.89 to 0.97)**	**0.93 (0.89 to 0.97)**
3	33 628	4816 (14)	**0.91 (0.87 to 0.95)**	0.97 (0.93 to 1.01)	0.97 (0.93 to 1.01)
4	31 480	4173 (13)	**0.83 (0.80 to 0.87)**	**0.94 (0.90 to 0.98)**	**0.94 (0.90 to 0.98)**
5 (most deprived)	30 514	3752 (12)	**0.77 (0.73 to 0.80)**	**0.91 (0.87 to 0.96)**	**0.91 (0.87 to 0.95)**
Smoking status			*<0.001*	*<0.001*	*<0.001*
Non-smoker	34 576	5817 (17)	Ref	Ref	Ref
Ex-smoker	69 667	9483 (14)	**0.78 (0.75 to 0.81)**	**0.94 (0.91 to 0.98)**	**0.94 (0.90 to 0.98)**
Current smoker	57 559	7215 (13)	**0.71 (0.68 to 0.74)**	**0.88 (0.85 to 0.92)**	**0.88 (0.84 to 0.91)**
Missing	359	45 (13)	**0.71 (0.52 to 0.97)**	**0.63 (0.46 to 0.86)**	**0.62 (0.45 to 0.85)**
Morbidities‡			*<0.001*	*<0.001*	*<0.001*
No COPD/asthma or HF	86 129	17 678 (21)	Ref	Ref	Ref
HF only	3417	502 (15)	**0.67 (0.61 to 0.73)**	**0.61 (0.55 to 0.67)**	**0.61 (0.55 to 0.67)**
COPD/asthma only	70 008	4235 (6)	**0.25 (0.24 to 0.26)**	**0.23 (0.23 to 0.24)**	**0.23 (0.23 to 0.24)**
COPD/asthma and HF	2607	145 (6)	**0.23 (0.19 to 0.27)**	**0.20 (0.17 to 0.24)**	**0.20 (0.17 to 0.24)**
Imaging in the 6 weeks prior to presentation			*<0.001*	*<0.001*	*<0.001*
No prior imaging	153 538	22 271 (15)	Ref	Ref	Ref
Prior imaging	8623	289 (3)	**0.20 (0.18 to 0.23)**	**0.16 (0.14 to 0.18)**	**0.16 (0.14 to 0.18)**
Cancer diagnosis in the year following symptomatic presentation			*<0.001*		*<0.001*
No cancer	158 575	21 840 (14)	Ref	–	Ref
Lung cancer	1103	249 (23)	**1.83 (1.58 to 2.10)**	–	**2.07 (1.78 to 2.41)**
Other cancer	2483	471 (19)	**1.47 (1.32 to 1.62)**	–	**1.33 (1.20 to 1.48)**

Joint testing p values are presented in italics.
Cell values are provided in bold when accompanying 95% confidence interval values exclude parity (1.0).
*Adjusting for sex, age, ethnicity, IMD quintile, smoking status, morbidities and prior imaging.
†Adjusting for sex, age, ethnicity, IMD quintile, smoking status, morbidities, prior imaging and cancer diagnosis.
‡Recorded in the 78 months to 6 months prior to symptomatic presentation.
COPD, chronic obstructive pulmonary disease; HF, heart failure; IMD, Index of Multiple Deprivation

There was substantial variation in diagnostic route. Patients who received guideline-concordant imaging following dyspnoea or haemoptysis presentation were more likely to have been diagnosed via the two-week wait pathway for suspected cancer (43% vs 27% for dyspnoea; 59% vs 35% for haemoptysis), and less likely to be diagnosed via an emergency compared with those who did not receive guideline-concordant imaging, particularly for haemoptysis presenters (30% vs 38% for dyspnoea; 9% vs 30% for haemoptysis; p<0.001 for overall variation by concordant imaging status by diagnostic routes in both cohorts, table 5).

Table 3 Receipt of guideline-concordant imaging within 2 weeks from presentation among patients with haemoptysis (n=8120)

Haemoptysis	Total	Guideline-concordant imaging n (%)	Crude OR (95% CI)	Adjusted OR (95% CI)*	Adjusted OR (95% CI)†
Total	8120	4022 (50)	–	–	–
Sex			*0.007*	*0.001*	*0.001*
Men	4728	2402 (51)	Ref	Ref	Ref
Women	3392	1620 (48)	**0.89 (0.81 to 0.97)**	**0.85 (0.77 to 0.93)**	**0.85 (0.77 to 0.93)**
Age group (years)			*<0.001*	*<0.001*	*<0.001*
30–39	904	369 (41)	**0.69 (0.58 to 0.81)**	**0.65 (0.55 to 0.77)**	**0.66 (0.55 to 0.78)**
40–49	1218	566 (46)	0.86 (0.74 to 1.01)	**0.84 (0.72 to 0.98)**	**0.84 (0.72 to 0.98)**
50–59	1477	740 (50)	Ref	Ref	Ref
60–69	1768	979 (55)	**1.24 (1.08 to 1.42)**	**1.28 (1.11 to 1.48)**	**1.27 (1.10 to 1.47)**
70–79	1646	856 (52)	1.08 (0.94 to 1.24)	1.15 (0.99 to 1.34)	1.14 (0.98 to 1.32)
80+	1107	512 (46)	0.86 (0.73 to 1.00)	0.89 (0.75 to 1.05)	0.88 (0.74 to 1.04)
Ethnicity			*0.001*	*<0.001*	*<0.001*
White	6857	3438 (50)	Ref	Ref	Ref
Non-white	746	369 (49)	0.97 (0.84 to 1.13)	1.04 (0.88 to 1.22)	1.04 (0.89 to 1.22)
Missing	517	215 (42)	**0.71 (0.59 to 0.85)**	**0.69 (0.57 to 0.83)**	**0.69 (0.58 to 0.84)**
IMD quintile			*0.416*	*0.157*	*0.171*
1 (least deprived)	1592	789 (50)	Ref	Ref	Ref
2	1614	797 (49)	0.99 (0.86 to 1.14)	0.99 (0.86 to 1.14)	0.99 (0.86 to 1.14)
3	1704	855 (50)	1.02 (0.89 to 1.18)	1.02 (0.89 to 1.18)	1.02 (0.89 to 1.18)
4	1619	771 (48)	0.93 (0.81 to 1.06)	0.90 (0.78 to 1.04)	0.90 (0.78 to 1.04)
5 (most deprived)	1588	809 (51)	1.06 (0.92 to 1.21)	1.08 (0.94 to 1.26)	1.08 (0.93 to 1.25)
Smoking status			*0.760*	*0.426*	*0.432*
Non-smoker	1955	951 (49)	Ref	Ref	Ref
Ex-smoker	3121	1547 (50)	1.04 (0.93 to 1.16)	0.98 (0.86 to 1.10)	0.97 (0.86 to 1.10)
Current smoker	3024	1515 (50)	1.06 (0.95 to 1.19)	1.06 (0.94 to 1.19)	1.05 (0.93 to 1.19)
Missing	20	9 (45)	0.86 (0.36 to 2.09)	0.75 (0.30 to 1.84)	0.75 (0.31 to 1.85)
Morbidities‡			*0.182*	*0.065*	*0.063*
No COPD/asthma or HF	5596	2799 (50)	Ref	Ref	Ref
HF only	144	80 (56)	1.25 (0.90 to 1.74)	1.13 (0.80 to 1.60)	1.14 (0.81 to 1.62)
COPD/asthma only	2281	1094 (48)	0.92 (0.84 to 1.02)	**0.88 (0.79 to 0.97)**	**0.88 (0.79 to 0.97)**
COPD/asthma and HF	99	49 (49)	0.98 (0.66 to 1.46)	0.86 (0.57 to 1.30)	0.87 (0.58 to 1.31)
Imaging in the 6 weeks prior to presentation			*<0.001*	*<0.001*	*<0.001*
No prior imaging	7567	3971 (52)	Ref	Ref	Ref
Prior imaging	553	51 (9)	**0.09 (0.07 to 0.12)**	**0.09 (0.06 to 0.12)**	**0.09 (0.06 to 0.11)**
Cancer diagnosis in the year following symptomatic presentation			*0.077*		*0.057*
No cancer	7742	3816 (49)	Ref	–	Ref
Lung cancer	253	143 (57)	**1.34 (1.04 to 1.72)**	–	**1.39 (1.06 to 1.83)**
Other cancer	125	63 (50)	1.05 (0.73 to 1.49)	–	1.05 (0.72 to 1.52)

Joint testing p values are presented in italics.
Cell values are provided in bold when accompanying 95% confidence interval values exclude parity (1.0).
*Adjusting for sex, age, ethnicity, IMD quintile, smoking status, morbidities and prior imaging.
†Adjusting for sex, age, ethnicity, IMD quintile, smoking status, morbidities, prior imaging and cancer diagnosis.
‡Recorded in the 78 months to 6 months prior to symptomatic presentation.
COPD, chronic obstructive pulmonary disease; HF, heart failure; IMD, Index of Multiple Deprivation

Diagnostic interval among patients with lung cancer

Patients with dyspnoea who were subsequently diagnosed with lung cancer had a median (IQR) diagnostic interval of 83 (28–205) days, while among patients with haemoptysis this was 39 (21–71) days.

Patients who received imaging following dyspnoea presentation had a shorter diagnostic interval than those who did not (median: 34 vs 114 days, nearly a fourfold difference). In comparison, there was little difference in the distribution of time to cancer diagnosis by imaging status in the smaller

Table 4 Cancer diagnoses in the year following symptomatic presentation by imaging status

	Dyspnoea		Haemoptysis	
	No guideline-concordant imaging within 2 weeks from presentation	Guideline-concordant imaging within 2 weeks from presentation	No guideline-concordant imaging within 2 weeks from presentation	Guideline-concordant imaging within 2 weeks from presentation
Total (%)	139 601 (86)	22 560 (14)	4098 (50)	4022 (50)
No cancer (%)	136 735 (98)	21 840 (97)	3926 (96)	3816 (95)
Lung cancer (%)	854 (0.6)	249 (1.1)	110 (2.7)	143 (3.6)
Non-lung cancer (%)	2012 (1.4)	471 (2.1)	62 (1.5)	63 (1.6)
P value*	<0.001		0.076	

*X^2 test.

haemoptysis cohort (median: 39 days for both groups) (figure 1).

Supplementary analyses

Additional analyses considering a 4-week interval in which imaging took place (online supplemental appendix 3), or imaging ordered from secondary care and other sources in addition to imaging ordered by GPs (online supplemental appendix 4) identified a greater number of patients who received guideline-concordant imaging but patterns of variation by patient factors remained largely unchanged. One exception was in the haemoptysis cohort, where current smokers and patients subsequently diagnosed with lung cancer were more likely to have receive prompt imaging (whereas there was no such evidence in the main analysis).

DISCUSSION

Summary of findings

Less than one in seven patients with newly presenting dyspnoea and one in two patients with newly presenting haemoptysis received primary care-ordered chest imaging within 2 weeks of presentation in line with national guidelines. Women, younger patients, individuals who had received chest imaging before presentation and those with pre-existing COPD or asthma were less likely to receive guideline-concordant imaging, while individuals diagnosed with lung cancer in the year following presentation were more likely to have been promptly imaged. Of those who subsequently received a lung cancer diagnosis, most patients presenting with dyspnoea (854/1103, 70%) and many patients presenting with haemoptysis (110/253, 43%) had not received timely imaging.

In both cohorts, those who did not receive prompt imaging before lung cancer diagnosis were more likely to be diagnosed as emergencies. Among patients with lung cancer initially presenting with dyspnoea, prompt imaging was associated with shorter intervals to diagnosis.

Comparison with prior literature

A study examining urgent primary care referrals for six 'red-flag' cancer symptoms found that only 40% of eligible patients received an urgent referral within 14 days of presentation, with substantial variation by symptom[16]; in our study, the corresponding figures for prompt chest imaging being 14% and 50% for dyspnoea and haemoptysis, respectively. The proportion of symptomatic patients who were subsequently diagnosed with cancer without having received an urgent or fast-track referral ranged from 2.8% to 9.5% by symptom; in comparison, we found the respective proportions for lung cancer to be 0.6% of dyspnoea presenters and 2.7% of haemoptysis presenters. Our results are also aligned to a US study that identified 38% of patients with lung cancer had had a missed opportunity,[29] and a study using English electronic health records data that found 65% of patients with lung cancer who had a chest X-ray had received it 2 weeks or longer after presentation.[30]

Table 5 Lung cancer-related outcomes by imaging status

	Patients with dyspnoea diagnosed with lung cancer (N=1103)		Patients with haemoptysis diagnosed with lung cancer (N=253)	
	No guideline-concordant imaging	Guideline-concordant imaging	No guideline-concordant imaging	Guideline-concordant imaging
Total, N (%)	854 (77)	249 (23)	110 (43)	143 (57)
Stage at diagnosis	P=0.116*		P=0.673*	
Stages I–II (%)	161 (19)	38 (15)	24 (22)	29 (20)
Stages III–IV (%)	561 (66)	181 (73)	71 (65)	99 (69)
Stage missing (%)	132 (15)	30 (12)	15 (14)	15 (10)
Route to diagnosis	P<0.001*		P<0.001*	
TWW (%)	232 (27)	106 (43)	38 (35)	84 (59)
General Practitioner referral (%)	160 (19)	47 (19)	25 (23)	33 (23)
Emergency (%)	323 (38)	75 (30)	33 (30)	13 (9)
Hospital (%)	124 (15)	18 (7)	12 (11)	11 (8)
DCO/unknown (%)	15 (2)	3 (1)	2 (2)	2 (1)

*X^2 test p value.
DCO, death certificate only; TWW, two-week wait (fast-track referral pathway for suspected cancer)[27] .

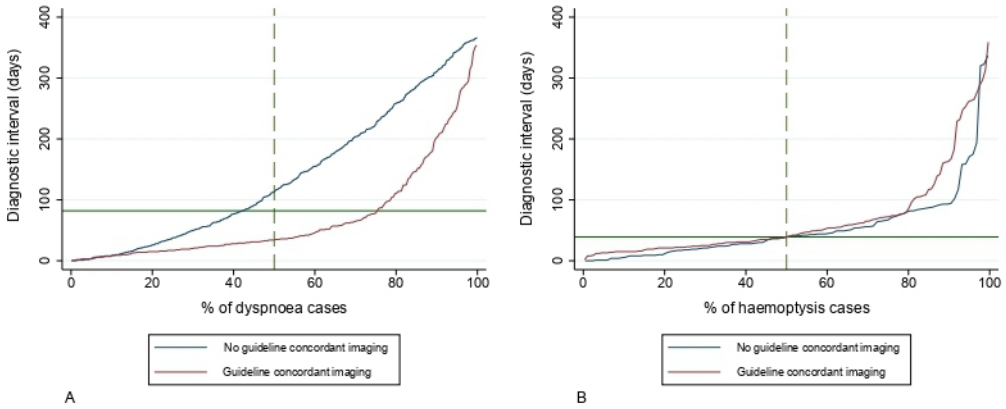

Figure 1 Time from symptomatic presentation to lung cancer diagnosis by imaging status in 1103 patients with dyspnoea (A) and 253 patients with haemoptysis (B). The horizontal green line represents the median diagnostic interval in all patients with lung cancer in the dyspnoea cohort (83 days) and the haemoptysis cohort (39 days), respectively.

Our findings indicate that patients with lung cancer who received guideline-concordant imaging had shorter diagnostic intervals but a higher proportion were diagnosed with advanced stage; this concords with previous research on patient populations with lung cancer that reported shorter diagnostic intervals among those with late-stage versus early-stage cancer.[31 32] This may also reflect confounding by indication and the waiting time paradox which has been previously described.[33]

Strengths and limitations

We analysed nationally representative linked primary care data. The HES-DID and NCRAS data sets represent gold standard sources of information on ascertaining imaging investigations[34] and cancer diagnoses,[35] respectively.

We acknowledge several limitations. First, factors beyond clinical decision-making in primary care such as imaging capacity and patients' ability to attend for the ordered investigations may have influenced whether or not guideline-concordant imaging occurred. Nevertheless, when we examined a longer period for the imaging to occur (online supplemental appendix 3) or included imaging ordered by other sources (online supplemental appendix 4), there remained substantial numbers of eligible individuals who did not receive prompt imaging. Furthermore, CT imaging may be subject to longer waiting times due to capacity constraints in comparison to X-rays. However, the vast majority (99%) of imaging events conducted in the chest region in both symptom cohorts (within 2 weeks from presentation or with no time constraint) were chest X-rays not CT imaging (data not shown).

The 2005 NICE guidelines indicate that patients with *persistent* dyspnoea should be ordered urgent chest imaging, defined as lasting 3 weeks or more.[10] Some of the individuals in our dyspnoea cohort may have presented with dyspnoea less than 3 weeks after onset, leading to the underestimation of the true proportion of clinically eligible individuals receiving guideline-concordant imaging. Free text primary care records data could have captured this kind of detail, but are not available for research purposes due to resource constraints in ensuring non-disclosivity of the data.[36]

We assumed that the chest imaging events identified following presentation were related and not incidental to the dyspnoea or haemoptysis, which could have led to the overestimation of guideline concordance. Similarly, we examined lung cancers that were diagnosed in the 12 months following symptomatic presentation: some of these cancers could also have been unrelated to the coded symptom. However, most imaging was conducted within the first 1–2 days from presentation, and the majority of lung cancers diagnosed in the 12 months after presentation were identified in the first 6 months (71% and 93% for dyspnoea and haemoptysis, respectively), supporting the validity of our assumptions (data not shown).

Implications

Individuals who presented with dyspnoea or haemoptysis and were later diagnosed with lung cancer were more likely to have received guideline-concordant imaging than symptomatic individuals who were not diagnosed with lung cancer. This suggests appropriate clinical decision-making took place for these individuals, though we must acknowledge there are additional patient, doctor and system-level factors contributing to urgent imaging taking place following presentation.

Some of the observed variation in guideline-concordant imaging may have a plausible explanation. Individuals with pre-existing respiratory disease and/or heart failure were less likely to receive urgent imaging, possibly because the symptoms were attributed to those conditions.[37] Women, younger patients and those who had had imaging prior to presentation were also less likely to receive guideline-concordant care, which may reflect appropriate assessment of the lower prior risk of lung cancer in these groups (compared with men, older patients and individuals who had not been ordered chest imaging recently, respectively).

Nevertheless, other patterns of variation are harder to explain: current or ex-smokers and patients residing in poorer neighbourhoods were less likely to receive prompt imaging for dyspnoea despite being at relatively higher risk of lung cancer compared with non-smokers or more affluent patients.[38] These associations require further elucidation, including through qualitative studies.

Substantial proportions of the individuals later diagnosed with cancer did not receive guideline-concordant imaging, potentially representing missed opportunities for earlier lung cancer diagnosis. Clinical case note review could enhance our understanding of the reasons for guideline discordance and missed opportunities.[39 40] Nevertheless, the findings demonstrate the potential for investigation or referral activity captured in electronic health record systems to be used as a diagnostic quality indicator. Additionally, examining provider-level variability in guideline-concordant care could be informative,[41] noting that

guideline concordance increased when we examined imaging ordered by all sources and not just primary care.

A critical consideration prior to improving guideline adherence is imaging access and capacity. Chest X-rays may miss 20% of symptomatic lung cancers[42] while CT capacity has been insufficient in England since before the emergence of COVID-19.[43] The recently launched community diagnostic centres (aiming to improve access to diagnostic tests outside of hospital settings) could form part of service redesigns aimed at improving lung cancer diagnosis pathways.[44]

CONCLUSION

In the context of cancer diagnosis, primary care-ordered urgent imaging patterns broadly accord with clinical risk. However, large proportions of dyspnoea or haemoptysis presenters do not receive prompt imaging, likely representing missed opportunities for more timely lung cancer diagnosis, especially in patients with haemoptysis. Developing quality metrics based on guideline concordance for prompt chest imaging could improve the quality and equity of urgent imaging in primary care.

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