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Unravelling the risk factors associated with under- and over-diagnosis of COPD

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Introduction

Chronic obstructive pulmonary disease (COPD) is a major cause of mortality and morbidity.[1] The Global Initiative for Chronic Obstructive Lung Disease (GOLD)[2] defines COPD as "a common, preventable and treatable disease that is characterised by persistent respiratory symptoms and airflow limitation that is due to abnormalities usually caused by significant exposure to noxious particles or gases".

The Clinical Commissioning Group (CCG) commissioned a county-wide spirometry service with the aim to support GP practices to identify, diagnose and initiate the management of new patients (without pre-existing respiratory disease) with COPD. The service was operated by a Respiratory Nurse Specialist (RNS) credited by the Association of Respiratory Technology and Physiology (ARTP) in spirometry who examined 375 patients in five practices across the county over 9 months.

A pivotal point very early in the project was the high numbers of patients being referred into the service with an existing respiratory diagnosis (asthma or COPD). Although this was originally outside the project remit, it highlighted historic 'missed, under- or over-diagnoses' of COPD (and asthma), which reflected the national picture described by Diab *et al* in 2018,[3] and thereafter underpinned the additional direction the project took to accept all referrals into the service (with or without existing respiratory disease).

The service embraced the opportunity to set about identifying the multifactorial reasons for under- and over-diagnosis of COPD with the determination to find ways to improve the accuracy of COPD diagnosis in the locality. The process would include, where available, vigilant examination of each individual patient's historic medical notes and previous spirometry then, during the face-to-face consultation, establish a comprehensive respiratory history alongside current signs and symptoms together with accurate quality-assured diagnostic spirometry (in all cases reversibility testing was performed) to either confirm, amend the existing diagnosis or establish a new diagnosis of COPD or asthma or other respiratory disease.

Data collection

Those with an existing diagnosis (COPD, asthma)

Scrutinisation of historic spirometry, medical notes and history were cross-referenced with new spirometry, current signs and symptoms, and medical, respiratory and occupational history and exposure to noxious substances. Thereafter, an accurate diagnosis was created or factors identified that may have influenced missed or over-diagnosis of COPD. Allowance was given for any disease progression in those with a pre-existing respiratory diagnosis.

Those with no existing diagnosis (new diagnosis of asthma or COPD)

Although this cohort comprised new patients with no pre-existing diagnosis, a number had performed spirometry previously. Scrutinisation of historic spirometry, medical notes and history were then cross-referenced with new spirometry, current signs and symptoms, and medical, respiratory and occupational history and exposure to noxious substances. Thereafter, an accurate diagnosis was formulated and factors identified that may have influenced a missed diagnosis of COPD.

A summary of the data collected is shown in Table 1.

Table 1: Summary of data

Total patient appointments booked = 429	429	**Referral source:** **Nurse 57.3%** **GP 42.6%**
DNA exacerbating or contraindications	20 + 34 Total 54	
Total seen by service and full history and spirometry performed (n=375)	Cohort 1: 272 patients without an existing diagnosis (COPD, asthma, ACOS, other) Cohort 2: 103 patients with existing diagnosis (COPD, asthma, ACOS, other)	Outcome of all spirometry: Normal: 70 (18.7%) Obstructive: 283 (75.5%) Restrictive: 16 (4.3%) Combined: 6 (1.6%)
Patients without existing diagnosis (n=151 new COPD diagnosis, 4 ACOS)	Patients with 'existing' diagnosis: COPD x33, asthma x69, ACOS x1 Final outcome after review by service: COPD x 29, asthma x60, ACOS x10 Diagnosis removed x2, restrictive diagnosis x2 ACOS diagnosis increased from 1 to 10 (likely due to disease progression)	At the end of the project a total of 180 patients with confirmed COPD and 14 ACOS ACOS is an advancement of obstructive lung disease in most cases developing life-limiting outcomes.

ACOS, asthma–COPD overlap syndrome.

Treatment outcomes

Examination of the treatment options is a valuable indication that COPD diagnosed in new patients is still late in the disease trajectory – that is, symptoms and exacerbations have already manifested. It is essential to intercept these patients earlier in the disease in order to instigate treatment and reduce exposure to any noxious substances and make a formal COPD diagnosis.

Understandably, in those with existing respiratory disease, the progression of symptoms and exacerbations is more apparent.

Treatment outcomes for patients without and with an existing respiratory diagnosis of COPD are shown in Table 2.

Historic and current diagnosis

Of interest, following the examination of historic notes and spirometry, a number of those with an existing diagnosis (COPD, asthma and asthma–COPD overlap syndrome (ACOS)) were in fact found to be misinterpreted and incorrect. Therefore, a 'changed or removed' diagnosis of COPD or asthma was made based on the original spirometry. This was further substantiated by the current history-taking and new spirometry, taking into account disease progression. In addition, among those without an existing respiratory diagnosis but who had historic spirometry, there were a number of patients with a missed diagnosis of COPD.

Across both cohorts the severity of COPD was distributed similarly. Remarkably, a number of new COPD patients were already in the 'severe' (15/151) and 'very severe' (5/151) categories,[2] further demonstrating the presence of a late/delayed COPD diagnosis with evidence of irreversible lung decline.

Unsurprisingly, a number of patients with an existing COPD or asthma diagnosis were newly diagnosed with ACOS during the project, which is an acceptable reflection of disease progression. However, there were a number of patients with a diagnosis of 'without existing disease' in whom ACOS was newly diagnosed during the project. This advanced state of disease reflected the impact of a delayed or incorrect diagnosis on patient outcomes (Table 3).

Critical analysis of existing/historic spirometry (NB: not current) and medical notes

The examination of historic spirometry in both those with or without existing respiratory disease revealed the following:

- Relatively low numbers (63%) of those with an existing diagnosis (asthma or COPD) had historic spirometry to examine and only 36% (asthma 44% and COPD 56%) of these were 'accurate/reproducible and had an absence of anomalies' and suitable for interpretation. This reflects the National Asthma and COPD Audit Programme (NACAP) 2018 findings where only 59.5% of COPD patients had spirometry recorded.
- Of interest, 15% of those without an existing diagnosis had historic spirometry available (where a respiratory diagnosis must have been suspected previously). Following the removal of those that were 'inaccurate/not reproducible and had anomalies', 58% were suitable for interpretation.
- In both cohorts those actually suitable for interpretation were

Table 2: Treatment outcomes for patients without and with an existing respiratory diagnosis of COPD

	Category	GOLD description	Comment
Treatment outcomes without existing respiratory diagnosis of COPD			
GOLD (2020) ABCD treatment guide 'New' COPD (n=151) (NB: ACOS patients excluded)	GOLD A: 17 patients (11.2%)	Low symptoms Low exacerbations SABA prescribed	Low numbers as expected. These patients do not present early enough in the disease trajectory due to low level of symptoms/exacerbations.
	GOLD B: 62 patients (41%)	High symptoms Low exacerbations LAMA LABA/LAMA	High numbers as expected as they present when symptoms impact on lifestyle or ADL. Previously no or missed diagnosed
	GOLD C: 48 patients (31.7%)	Low symptoms High exacerbations LAMA	High numbers signify the delay in diagnosis, whereby exacerbations have progressed. Previously no or missed diagnosed
	GOLD D: 24 patients (15.9%)	High symptoms High exacerbations LAMA, LABA ICS trial	High numbers signify the delay in diagnosis, whereby exacerbations and symptoms have progressed. Previously no or missed diagnosed
Treatment outcomes in patients with existing respiratory diagnosis of COPD			
GOLD (2020) ABCD treatment to those with existing diagnosis of COPD still in place (n=29) (NB: ACOS patients excluded)	GOLD A: 2 patients	Low symptoms Low exacerbations SABA prescribed	As expected, low numbers as patients have existing disease and progression to next step of treatment
	GOLD B: 4 patients	High symptoms Low exacerbations LAMA LABA/LAMA	Symptoms have progressed with disease progression to next step
	GOLD C: 11 patients	Low symptoms High exacerbations LAMA	Exacerbations have progressed with disease progression to next step
	GOLD D: 12 patients	High symptoms High exacerbations LAMA, LABA ICS trial	Exacerbations and symptoms have progressed with disease progression to this step

ACOS, asthma–COPD overlap syndrome; ADL, activities of daily living; ICS, inhaled corticosteroids; LABA, long-acting bronchodilators; LAMA, long-acting muscarinic antagonists; SABA, short-acting bronchodilators.

checked for accuracy of the original interpretation (these were cross-referenced with the most appropriate guideline available at that time – that is, NICE 2004 or GOLD 2009).[4,5]

- Furthermore, in those with existing disease, 69% were accurate whilst, in those with no existing disease, 66% were accurate interpretations, providing further support that under- and over-diagnosis of COPD is dependent not only on the accuracy of spirometry performed but also the accuracy of interpretation.
- Remarkably, 40 patients with an existing obstructive diagnosis (asthma/COPD/ACOS) had no evidence of historic spirometry, which is aligned with the NACAP (2018) findings. This highlights the absence of accurate diagnostic processes in place. Possible explanations in this locality may be that COPD6 monitor or forced expiratory volume in 1 second (FEV_1) assessment alone were used in some cases, or spirometry was performed and not retrievable or visible at the time of the project.
- In a number of cases, FEV_1 was used by mistake instead of FEV_1/FVC ratio to define obstruction, which would influence over- and under-diagnosis of COPD.
- Demonstration of a comprehensive clinical history was not

Table 3: Historic and current diagnosis

'Existing' diagnosis of respiratory disease (n=103)

Existing diagnosis (n=103)	New diagnosis during project	Analysis of old spirometry (n=63)	Severity of FEV_1 in those diagnosed with COPD during the project[2]	
1 ACOS	1 ACOS	1 original spirometry	1 Very severe	NB: COPD6 is a handheld screening device
69 Asthma	5 ACOS 2 Alternative (HF and Restrictive) 4 COPD 58 Asthma	41 original spirometry 0 COPD6 4 FEV_1 alone 24 no spirometry	FEV_1 severity: 0 Mild 1 moderate 2 severe 1 very severe	
33 COPD	2 normal (diagnosis removed) 4 ACOS 2 Asthma 25 COPD	22 original spirometry 3 COPD6 device 1 FEV_1 alone 7 no formal spirometry	FEV_1 severity: 3 Mild 14 moderate 5 severe 3 very severe	FEV_1 determines severity of disease

'Without existing respiratory' diagnosis (n=272)

New diagnosis during project	Existing spirometry available (n=41)	Severity of FEV_1 in those diagnosed with COPD during the project[2]
No new diagnosis found 12		NA
ACOS 4	4 spirometry	1 Severe
Alternative (HF/ restrictive) 6	2 spirometry	NA
	2 spirometry	NA
99 Asthma		
151 COPD	16 spirometry 15 spirometry 2 FEV_1 alone 73 COPD6 device	FEV_1 severity: 9 mild 122 moderate 15 severe 5 very severe

ACOS, asthma–COPD overlap syndrome; FEV1, forced expiratory volume in 1 second.

always evident – that is, signs and symptoms, and medical, respiratory and occupational history and exposure to noxious substances.

- Encouragingly, there was documentary evidence in many cases of ruling out other disease/diagnosis.
- All historic spirometry was performed and documented by nurses. However, nurses making a respiratory diagnosis were represented in small numbers. This is a development opportunity for those nurses performing spirometry to enhance their knowledge and skills to be able to interpret the results, providing a more succinct holistic service for the patient.

Full details are shown in Table 4

Risk factors

Having identified under-diagnosed/over-diagnosed/missed diagnosis of COPD, the next stage was to collate all of the risk factors identified and stratify into under- and over-diagnosis and thereafter to look at solutions that could be instigated in the future (see details in Table 5).

Summary of project

Following examination of each individual patient's previous medical notes and historic spirometry (where available) and during face-to-face consultation, the author documented a comprehensive respiratory history, current signs and symptoms in collaboration with accurate spirometry and reversibility testing, with interpretation of the results. This supported either confirmation,

Table 4: Critical analysis of existing/historic spirometry (NB: not current) and medical notes

	Those 'without' existing diagnosis (asthma, COPD, ACOS, other), n=272	Those 'with' existing diagnosis (asthma, COPD, ACOS, other), n=103
1 Examination of historic spirometry	*Spirometry available: 41 (15%)* Evidence of post-bronchodilation, 32/41 (78%) Repeatable FEV_1 and FVC 3 within 3%, 30/41(73%) Anomalies (abrupt end, cough, poor flow, slow start, etc), 12/41 (29%) Predicted values recorded, 38 (92%) Trace available, 38 (92%) Total repeatable, accurate/acceptable/reversible full spirometry to interpret, 24/41 (58%) Spirometry unavailable in 231 cases includes: COPD6 device, 7 patients FEV_1 alone for diagnosis, 2 (unknown equipment for FEV_1 alone)	*Spirometry available: 63 (61%)* Evidence of post bronchodilation, 31/63 (49%) Repeatable FEV_1 and FVC - 3 within 3%, 23/63 (36%) Anomalies (abrupt end, cough, poor flow, slow start, etc), 16/63 (25%) Predicted values recorded, 59/63 (93%) Trace available, 58/63 (92%) Total repeatable, accurate/acceptable/reversible full spirometry to interpret, 23/63 (36%) Spirometry unavailable in 40 cases includes: COPD6 device, 3 patients FEV_1 alone for diagnosis, 5 (unknown equipment for FEV_1 alone)
Only those with historic repeatable/ reproducible spirometry were used for interpretation	Interpretation of 24: FEV_1 /FVC ratio below 70% in 18 patients (NB: both asthma and COPD) Interpretation accurate in 16/24 (66.6%) COPD 6 patients (37.5%) and asthma 10 patients (62.5%) 3 acceptable recordings available had clear documentary evidence to demonstrate that FEV_1 /FVC ratio was used to identify obstruction and also the FEV_1 staging of the disease severity (GOLD, 2020)[2]	Interpretation of 23: FEV_1 /FVC ratio below 70% in 18 patients (NB: both asthma and COPD) Interpretation accurate in 16/23 (69%) COPD 9 patients (56%) and asthma 7 patients (44%) 6 acceptable recordings available had clear documentary evidence to demonstrate that FEV_1 /FVC ratio was used to identify obstruction and also the FEV_1 staging of the disease severity (GOLD, 2020)[2]
2 Examination of medical record	*Of 41 without pre-existing spirometry* Clinical history available, 36 Clinical history contained comprehensive childhood, smoking, occupational information, 28 Evidence of current symptoms at the time cough, SOB, exacerbations, 34 SpO2 recorded, 37 Evidence of ruling out other disease (asthma, ILD, bronchiectasis, etc), 8 Other tests (chest x-ray, IGE, α1-antitrypsin, sputum), 11	*Of 63 with pre-existing spirometry* Clinical history available, 48 Clinical history contained comprehensive childhood, smoking, occupational information, 39 Evidence of current symptoms at the time cough, SOB, exacerbations, 46 SpO_2 recorded, 54 Evidence of ruling out other disease (asthma, ILD, bronchiectasis etc), 12 Other tests (chest x-ray, IGE, α_1-antitrypsin, sputum), 9
3 Diagnosis	*Of 41 with spirometry* Both clinical history and spirometry used to rule in/out a diagnosis, 30 Spirometry alone used to rule in/out a diagnosis, 4 History alone used to rule in/out a diagnosis, 7 Which guideline was used to define obstruction (ie, GOLD, 2020) FEV_1 /FVC <70% x, 7 patients Which guideline was used to stage severity of FEV_1 GOLD, 2009[5] or NICE, 2010[6] or NICE, 2004[4] (see table below notated x0) *NB: This is relevant because of the disparity between historic guidelines in the FEV_1 staging* Who made or ruled out a diagnosis: Nurse: 3 GP: 37 Hospital team made diagnosis: 1	*Of 63 with spirometry* Both clinical history and spirometry used to make diagnosis, 39 Spirometry alone used to make diagnosis, 3 History alone used to make diagnosis, 21 Which guideline was used to define obstruction (ie, GOLD, 2020) FEV_1 /FVC <70% x, 6 patients Which guideline was used to stage severity of FEV_1 GOLD, 2009[5] or NICE, 2010[6] or NICE 2004[4] (see table below notated x0) *NB: This is relevant because of the disparity between historic guidelines in the FEV_1 staging* Who made diagnosis: Nurse: 6 GP: 57 Hospital team made diagnosis: 0

amendment to the existing diagnosis or establishment of a new diagnosis. This facilitated appropriate management of the respiratory disease or further investigation of a non-respiratory cause.

The author identified that under- and over-diagnosis of COPD had the following key predisposing causative/risk factors.

(1) Insufficiently accurate spirometry testing

- Absence of any spirometry
- Absence of trained accredited clinicians performing and interpreting spirometry
- Spirometry performed but not accurate, reproducible or anomalies present
- Spirometry performed but not interpreted correctly

(2) Not adhering to guidelines when performing and interpreting spirometry and making a diagnosis

- The presence of all the three key fundamental elements (history of symptoms, noxious gas exposure and airflow obstruction) to diagnose COPD effectively were absent in a number of cases (as recommended by GOLD),2 revealing that either history taking or spirometry had been historically used in isolation to make a diagnosis.
- Using a fixed ratio of FEV_1/FVC rather than lower limit of normal (LLN) increases the prevalence of under- and over-diagnosis of COPD
- Absence of documentary evidence demonstrating the use of which standardised national spirometric criteria to interpret spirometry – that is, obstructive spirometry is defined as FEV_1/FVC ratio either <0.7 or 5% below the LLN (GOLD, 2020),[2] affecting the rates of under- and over-diagnosis
- Guidelines can be confusing and, in particular, there was some disparity between NICE (2004)[4] and GOLD (2009)[5] before 2010 for the staging of COPD severity (see Appendix 1 online at www.pcrs-uk.org)
- When history was recorded in some of the cases, evidence of 'comprehensive history taking' was not always in place. In particular, the recording of specific signs and symptoms were absent (eg, productive cough, wheeze, dyspnoea and exacerbations) or being asymptomatic was not recorded.
- In some cases, the diagnosis was inhibited by ad hoc/inaccurate COPD screening programmes leading to over- and under-diagnosis of COPD.
- Importantly, nurses performing spirometry in general practice very often have limited access/funding/time to attend formal accredited or practical education.
- Many nurses undertaking the ARTP spirometry training during the time of the project had not attended or undertaken previous asthma or COPD training, and this made it difficult for them to understand and put into context spirometry in relation to the disease and its management. In addition, they did not always have the insight to rule in or out other disease (eg, asthma, bronchiectasis, heart failure).

Reflection and recommendations

We know from clinical evidence and guidelines that accurate quality-assured spirometry and comprehensive history taking is vital to underpin the correct and timely diagnosis of COPD. It is important to mention at this stage that there is a wealth of good practice and expertise throughout the county. The outcomes found reflected the national picture in that, due to multifactorial reasons, we have neglected at times to diagnose COPD effectively.

Historically, there were common barriers to performing and interpreting spirometry including inappropriate equipment (COPD6, FEV_1 alone), unskilled operators and interpreters (nurses and GPs), a deficit in access to robust training and using history taking or spirometry in isolation. Failure to avoid tunnel vision in diagnosing respiratory symptoms and considering other causes beyond COPD appears common.

However, in more recent years there has been more availability and recognition of the importance of spirometry training for nurses. At the present time, NHS England has driven the recommendation that formal spirometry accreditation is to be accomplished by those clinicians performing and interpreting spirometry by 2021. Diagnosis of breathlessness and respiratory symptoms is moving towards a hub-based model using trained practitioners who are skilled in respiratory diagnostics.

Nevertheless, there are still further barriers in general practice that prevent the accurate performance and interpretation of spirometry and diagnosis of COPD. In particular, the enormity and diversity of the individual practice nurse's role reduces the number of nurses in a surgery who can be freed up from other responsibilities, trained and undertake this role. This is further impacted by the fluidity of practice nursing at the current time. Commonly, as experienced and accredited practice nurses retire or leave the service, there is often a skills gap in the surgery. There is very little succession planning to replace the high volume of extremely skilled practice nurses who are reaching retirement age. It is especially difficult to 'grow your own' in smaller surgeries.

If there is no succession planning, this leads to recruitment becoming a frantic search for experienced/trained practice nurses, of which the numbers are essentially diminishing. More recently, though, practice nursing has developed a career pathway and is becoming increasingly more attractive to newly qualified nurses. In addition, obtaining funding within a practice for training courses and also the willingness and commitment from the individual practice nurse in terms of time and undertaking academic study has an impact on the number of skilled operators available.

Recommendations

The recommendations originally targeted the performance of

Table 5: Problems/risk factors identified which led to under-diagnosis or over-diagnosis of COPD

	Under-diagnosis	Over-diagnosis	Problem identified	Solution
Screening programmes	Countywide screening programmes existed 5–7 years ago using COPD6 monitors or in some cases FEV_1 alone	Countywide screening programmes existed 5–7 years ago using COPD6 monitors or in some cases FEV_1 alone		
	(1) Poor quality technique	(1) Poor quality technique	(1) Poor quality technique. Not all staff were trained in operating COPD6 monitors, leading to inaccurate readings and interpretation/diagnosis	(1) Provision of training in appropriate screening equipment
	(2) Not targeting appropriate demographic groups	(2) Not targeting appropriate demographic groups	(2) Appropriate or at-risk patients missed/excluded	(2) Create screening programmes that target a demographic group in those with known risk factors (ex/current smoking with/without cannabis), occupational exposure, chest exacerbations / infections, poor social economic and younger age group Smokers, etc
	(3) Absence of referral on to full post-bronchodilator spirometry COPD diagnosis based on COPD 6 or FEV_1 only	(3) Absence of referral on to full post-bronchodilator spirometry COPD diagnosis based on COPD 6 or FEV_1 only	(3) Full spirometry not performed resulting in missed or over-diagnosis of COPD	(3) Create a referral on process for full post-bronchodilation' spirometry
	(4) Screening programmes not available	(4) Screening programmes not available	(4) Absence of'case finding. This process can be: -costly for practices to instigate -practitioners require training	(4) 'Targeted screening programmes' *COPD6 has its place in screening programmes but not as a diagnostic tool*
Patient history taking	(1) Clinical and symptom history not comprehensively recorded at point of diagnosis Specifically missing elements of smoking history, noxious exposure risk factors, occupational exposure, exacerbations, symptoms (productive cough etc.)	(1) Clinical and symptom history not comprehensively recorded at point of diagnosis Specifically missing elements of smoking history, noxious exposure risk factors, occupational exposure, exacerbations, symptoms (productive cough etc.)	(1) Absence of documented clinical history leads to missed or incorrect respiratory diagnosis	(1) Educational intervention underpinned by current evidence-based guidelines Specifically ensuring that diagnosis must comprise of all 3 key elements (history, exposure and spirometry)

Table 5: Problems/risk factors identified which led to under-diagnosis or over-diagnosis of COPD (continued)

	Under-diagnosis	Over-diagnosis	Problem identified	Solution
	(2) In cases where no symptoms were recorded there was also no record if the patient was actually asymptomatic		(2) Missing those in the younger age group who are asymptomatic but have early stages of COPD	(2) Encourage documentation if the patient is asymptomatic (particularly in the younger patients with obstructive post-bronchodilation spirometry)
	(3) Limited evidence of ruling in or out, alternative diagnosis or co-existing disease; asthma, bronchiectasis, ILD and heart failure (Iin particular, respiratory symptoms such as breathlessness in those with existing heart failure may lead to underdiag-noses of COPD)	(3) Limited evidence of ruling in or out, alternative diagnosis or co-existing disease; asthma, bronchiectasis, ILD and heart failure. (respiratory symptoms such as breathlessness may lead to over-diagnosis of COPD. If other diseases are not ruled out, ie, heart failure or ILD, asthma)	(3) A number of clinicians assessing patients not always having the knowledge and skills to rule in or out other disease.	
	(4) History taking used as stand-alone diagnosis measure- in the absence of spirometry may lead to overlooking the younger less symptomatic patients	(4) History taking used as stand-alone diagnosis measure. Over-diagnosis more commonly found in those without spirometry but with increased symptoms and smokers	(4) Risk of over- or under-diagnosis	
			Discrepancies across the county whereby nurses are able to access/undertake recommended COPD, asthma educational qualifications; (expensive/time consuming courses for individual and practice) Absence of a usable/ accessible competency framework for respiratory nursing There had been a reliance in primary care on sponsored formal and informal courses/ training and conference places from pharmaceutical companies and during the past decade this has declined	Facilitate nurses to undertake respiratory modules and training. Underpin this process with practical support in the workplace. As a locality, actively seek out training needs in practices and provide support for individual nurses

Table 5: Problems/risk factors identified which led to under-diagnosis or over-diagnosis of COPD (continued)

	Under-diagnosis	Over-diagnosis	Problem identified	Solution
			Educational information disseminated to practices and practice managers does not always reach the individual nursing staff Rural practices have limitations with geographical attendance toon courses and training.	
Diagnostic (post bronchodilation) spirometry	(1) Spirometry not performed at all for a variety of reasons	(1) Spirometry not performed at all and reliance on history taking	(1) Airflow obstruction not identified when spirometry unavailable (a) Trained spirometry practitioners not available readily in all practice (b) In settings where resources were low, spirometry equipment was not available.	Educational intervention Access to accredited ARTP spirometry course (robust training to ensure accurate, repeatable post-bronchodilation spirometry without anomalies (cough, abrupt stop, etc) Support through mentoring in the clinical setting for those under-taking or have completed the ARTP module or equivalent training.
	(2) Performed but not acceptable/accurate - not repeatable, not the number of blows, anomalies (cough, short, abrupt end, etc.); see also interpretation.	(2) Performed but not acceptable/accurate - not repeatable, not the number of blows, anomalies (cough, short, abrupt end, etc.); see also interpretation	(2) Substandard inaccurate spirometry technique (untrained clinicians performing spirometry) can lead to misinterpretation of results and incorrect diagnosis	
	(3) Reversibility or post-bronchodilator spirometry not performed	(3) Reversibility or post-bronchodilator spirometry not performed	(3) Absence of reversibility/post-bronchodilation testing over-estimates the prevalence of COPD (and potentially misses an asthma diagnosis). This requires a longer appointment which is not always available due to the cost or awareness of the significance of reversibility to the practice	(3) Highlight to the practices and clinicians the significance of post-bronchodilation spirometry
	(4) Demographic inaccuracies influencing predicted values and outcome. Project findings included; inaccurate age, ethnicity, height for baseline	(4) Demographic inaccuracies influencing predicted values and outcome. Project findings included; inaccurate age, ethnicity, height for baseline	(4) Inaccurate predicted values may lead to under- and over-diagnosis	(4) Specify the importance and rationale for recording height, sex, race and age accurately

Table 5: Problems/risk factors identified which led to under-diagnosis or over-diagnosis of COPD (continued)

	Under-diagnosis	Over-diagnosis	Problem identified	Solution
	(5) Spirometers not verified daily or serviced annually, potentially leading to under-diagnosis	(5) Spirometers not verified daily or serviced annually, potentially leading to over-diagnosis	(5) In some cases spirometers had no record of spirometer either having a full service history with annual calibration or weekly/daily verification checks being performed.	(5) Support in the clinical setting to create policy and protocol to manage equipment, perform and interpret spirometry using current evidence-based guidelines
	(6) Widespread practice using a fixed ratio cut off 70% FEV_1 /FVC rather than a patient-specific LLN may have led to under-diagnosis in the younger individuals (<40 years)	(6) Widespread practice using a fixed ratio cut off 70% FEV_1/FVC rather than patient-specific LLN may have led to over-diagnosis in the elderly	(6) Not using the patient -specific LLN may lead to under- or over-diagnosis of COPD	(6) Mentor clinicians to ensure the machine values are set to display the LLN
	(7) Spirometry used as stand-alone diagnosis In the absence of comprehensive history taking	(7) Spirometry used as stand-alone diagnosis In the absence of comprehensive history taking	(7) Incomplete assessment leads to 'over- and under-diagnosis' of COPD A common theme found among practices and practice nurses is the costly and time-consuming ARTP course for both the nurse and the practice. Within this locality, funded ARTP courses were available. However, a number of clinicians who attended struggled with achieving accreditation as they did not have the asthma or COPD knowledge to underpin understanding of this course and spirometry.	Provision of a structured respiratory education programme with a systematic training plan; in particular, prioritising asthma and COPD training which will ultimately underpin the ARTP spirometry accreditation. Mentoring and supporting in clinical practice will increase the clinician's confidence and learning.
Interpretation	(1) Numerical values used for interpretation either not recorded or recorded inaccurately	(1) Numerical values used for interpretation either not recorded or recorded inaccurately	(1) Not using correct values/criteria to interpret spirometry ie, confusing either FEV_1 or FEV_1 /FVC ratio leading to misdiagnosis	*Educational intervention:* Teaching a methodical approach for reading and interpreting spirometry; (a) Assure accuracy -Do the demographics match the patient? -Are there 3 reproduceaible blows? -Are there anomalies?
	(2) Failure to identify from the recording any errors (ie, abrupt end, cough) or absence of 3 reproducible blows prior to interpreting the spirometry	(2) Failure to identify from the recording any errors (i.e, abrupt end, cough) or absence of 3 reproducible blows prior to interpreting the spirometry.	(2) Not recognising errors/anomalies that presented at time of spirometry leading to incorrect/inaccurate diagnosis	

Table 5: Problems/risk factors identified which led to under-diagnosis or over-diagnosis of COPD (continued)

	Under-diagnosis	Over-diagnosis	Problem identified	Solution
	Errors found by author and not identified at interpretation: (a) too short a blow led to underestimation of FVC and false raising/ normalising the FEV_1/FVC ratio, missing an obstructive diagnosis or misdiagnosis of restrictive disease (b) Inadequate number of blows, in particular relaxed FVC, whereby air trapping not identified	Errors found by author: (a) Extra breath FVC over-estimated and FEV_1 /FVC under-estimated (obstructive picture) (b) Submaximal effort at FEV_1, falsely reduced the FEV_1 used for interpretation giving a ratio that was obstructive when actually it was normal In one case, using a change in FEV_1 /FVC (rather than change in FEV_1) to indicate a positive reversibility for asthma as both FEV_1 and FVC rose post-bronchodilation then FEV_1 /FVC ratio did not change and COPD diagnosed and missed asthma diagnosis		(b) Identify post-bronchodilation obstruction, restriction or normality and severity of obstruction: Adherence to guidelines and specify which criteria are used for interpretation, i.e. FEV_1 /FVC ratio for obstruction (using LLN) and FEV_1 for the severity of disease. (c) Use spirometry collaboratively with comprehensive history taking and noxious gas exposure or not, to form a diagnosis-ruling in or out other disease ARTP accreditation/ training for nurses and GP's in the performance and interpretation of spirometry Support in clinical practice by mentoring
	(3) Not recognising demographic inaccuracies input into spirometer (height, age, wrong gender) leading to potential under/over-estimated predicted values, in particular those close to normal/ abnormal line	(3) Not recognising demographic inaccuracies input into spirometer (height, age, wrong gender) leading to potential under/over-estimated predicted values, in particular those close to normal/abnormal line	(3) Leading to incorrect/inaccurate diagnosis	

Diagnosis requires a three-pronged approach: (1) documented history of symptoms (ie, productive cough, shortness of breath, (2) documented history of noxious exposure (smoking, fuel and occupational exposure) and (3) demonstration of airflow limitation through accurate spirometry (GOLD, 2020).[2]

FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; LLN, lower limit of normal.

spirometry and, more fully, the diagnosis of COPD in the locality. COVID-19 has impacted the recommendations; it has made us reconsider how we offer respiratory diagnostic services, but the diagnosis of COPD and other respiratory conditions still needs to be delivered in a timely accurate way by clinicians who are trained to do this and are competent and feel confident to do so.

- There are inconstancies across the locality in the level of exposure/awareness/access to all training that practice nurses have. Therefore, mentors and practice nurse facilitators should be used to reach out to practices and individual nurses to 'sign post' formal academic training, in particular highlighting opportunities of funded places with providers such as the CCG, pharmaceutical sponsorship, etc.
- It is important to raise awareness to practice teams and future candidates that a systematic approach to education is required whereby training and understanding of COPD and asthma are prerequisite to underpinning and improving the understanding and a successful outcome.
- Mentorship by ARTP-accredited respiratory nurses/mentors should be provided in the clinical workplace to support those undertaking the accredited ARTP qualification, provided through a commissioned service. As diagnostic hubs are developed, mentorship will also be a function of the hub.
- Mentorship is also provided following accreditation through

practical support in the workplace to improve confidence, knowledge and skills to perform spirometry. This includes mainly registered nurses, but there is also a growing number of non-registered nurses who are undertaking spirometry accreditation. This may be by rotation through a PCN-based diagnostic hub.

- If a practice continues to offer spirometry, then mentorship would also encompass support in the creation of an individual practice 'spirometry policy and standards' which are underpinned by national guidelines for performance and interpretation of spirometry. This includes the importance of choosing and specifying which guideline is followed for identifying obstruction (FEV_1/FVC ratio) and the staging of the severity of COPD (FEV_1).
- Mentorship also supports 'post accreditation' of those developing interpretation of spirometry skills and comprehensive history taking in order to have a robust COPD diagnostic process and rule out other disease.
- Engaging practice nurses to work collaboratively with practice nurse support groups and integrated respiratory teams to further enhance/consolidate their knowledge, skills and confidence.
- Implementing a localised standardised competency framework for respiratory skills adapted from the PCRS respiratory framework.
- Succession planning, prompting/supporting practices to identify staff who are approaching retirement and helping to create a strategy to build/retain a skilled workforce. Introduce new ways of thinking rather than trying to overburden and upskill one new member of staff and consider having a part time nurse with a special interest/ expertise in respiratory. Encourage every practice to have a named respiratory lead GP and nurse.
- Set out targeted COPD screening to appropriate demographic age and risk groups.
- Educational intervention for GPs who may be less likely to attend formal and informal training due to the diversity of their role and expectation that their expertise is established.

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Further reading

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Appendix 1

Table 1. Degree of severity of airflow obstruction according to NICE and GOLD Guidelines.

		Severity of airflow obstruction		
Post-Bronchodilator FEV_1/FVC	FEV_1% Predicted	NICE 2004	GOLD 2009	NICE 2010
			Post-Bronchodilator	Post-Bronchodilator
<0.7	≥ 80%		Stage1-Mild	Stage 1-Mild*
<0.7	50-79%	Mild	Stage 2 Moderate	Moderate
<0.7	30-49%	Moderate	Stage 3 -Severe	Severe
<0.7	< 30%	Severe	Stage 4-Very Severe	Very Severe **

.* COPD should not be diagnosed in the absence of symptoms in patients with mild airways obstruction

** or FEV_1<50% in the presence of respiratory failure