COPD Diagnostic Questionnaire (CDQ) for selecting at-risk patients for spirometry: a cross-sectional study in Australian general practice

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BACKGROUND: Using the COPD Diagnostic Questionnaire (CDQ) as a selection tool for spirometry could potentially improve the efficiency and accuracy of chronic obstructive pulmonary disease (COPD) diagnosis in at-risk patients.

AIM: To identify an optimal single cut point for the CDQ that divides primary care patients into low or high likelihood of COPD, with the latter group undergoing spirometry.

METHODS: Former or current smokers aged 40–85 years with no prior COPD diagnosis were invited to a case-finding appointment with the practice nurse at various general practices in Sydney, Australia. The CDQ was collected and pre- and post-bronchodilator spirometry was performed. Cases with complete CDQ data and spirometry meeting quality standards were analysed (1,054 out of 1,631 patients). CDQ cut points were selected from a receiver operating characteristic (ROC) curve.

RESULTS: The area under the ROC curve was 0.713. A cut point of 19.5 had the optimal combination of sensitivity (63%) and specificity (70%) with two-thirds below this cut point. A cut point of 14.5 corresponded to a sensitivity of 91%, specificity of 35% and negative predictive value of 96%, and 31% of patients below this cut point.

CONCLUSIONS: The CDQ can be used to select patients at risk of COPD for spirometry using one cut point. We consider two possible cut points. The 19.5 cut point excludes a higher proportion of patients from undergoing spirometry with the trade-off of more false negatives. The 14.5 cut point has a high sensitivity and negative predictive value, includes more potential COPD cases but has a higher rate of false positives.

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is characterised by airflow obstruction and is an important cause of mortality and disability worldwide.1,2 COPD should be suspected in patients 40 years or older with symptoms such as dyspnoea, chronic cough with or without sputum production and exposure to risk factors such as tobacco smoke, smoke from home cooking or occupational dusts and chemicals.3 The gold standard for COPD diagnosis is post-bronchodilator spirometry performed in those patients suspected of having COPD.3

General practitioners have an important role in diagnosing COPD as most patients with chronic or persistent respiratory symptoms present in primary care.4 It is important to diagnose COPD in those patients with risk factors to help relieve symptoms, improve health status, prevent exacerbations and disease progression, and reduce early mortality.5 It is also important to avoid misdiagnosis of COPD to limit inappropriate use of COPD medications leading to unnecessary health-care expenditure and potential adverse effects.7 There are barriers to spirometry use in general practice, which include lack of expertise in performing spirometry, poor access to a well-maintained spirometer and the time-consuming nature of pre- and post-bronchodilator spirometry.6,7 This can lead to under-diagnosis and misdiagnosis of COPD, particularly if general practitioners rely on a symptom-based assessment for the diagnosis.5,6

The COPD Diagnostic Questionnaire (CDQ) is an 8-item tool designed by the COPD Questionnaire Study Group from a cross-sectional study of primary care patients ≥40 years old from the United Kingdom and the United States with a history of smoking but no prior respiratory diagnosis (Table 1).8,9 It was developed to improve the efficiency and accuracy of COPD diagnosis in primary care by removing the need for spirometry in low-risk patients.2 Although not initially designed to be a diagnostic tool, it has been externally validated in various international studies,10–13 as well as a previous study by our group in an Australian general practice cohort.14 These studies showed that the CDQ does not perform well as a COPD diagnostic tool. However, it could be used as a filtering tool to select patients at high risk of COPD to undergo spirometry.9,15

The CDQ in its original format has a three-tier scoring system with two cut points (16.5 and 19.5) that divide subjects into three groups of COPD likelihood; low (≤16.5), medium (16.5–19.5) and high (≥19.5).9 Price et al.9 proposed that the high likelihood group should, and the low likelihood group should not, require spirometry in most regions. Furthermore, Price et al.9 suggested that the intermediate zone could undergo spirometry but where there were limited resources to do spirometry, these patients...
could be followed up clinically and spirometry deferred to a later date to minimise the number of unnecessary spirometries.

The International Primary Care Respiratory Group recommended a diagnostic process where all patients over 35 years old should be evaluated for their risk of having COPD by completing the CDQ, with any score above the 16.5 cut point going on to have diagnostic spirometry. This recognises from a clinical point of view that a single cut point is needed to decide whether to proceed to spirometry. However, there is a lack of evidence to show the 16.5 cut point is optimal for this filtering process. The sensitivities at the 16.5 cut point from four CDQ external validation studies were 89–94%. The aim of this study was to find an optimal single cut point that divides primary care patients into a low or high likelihood of COPD, with the high likelihood patient scoring above the cut point progressing to spirometry. We aim to set an optimal CDQ cut point that maximises sensitivity while excluding subjects at low risk of COPD, therefore reducing the number of spirometries performed.

### MATERIALS AND METHODS

#### Subject recruitment for this study

Methods were outlined in detail in our previous CDQ validation study on the same patient cohort. In brief, patients in this study were from a case-finding recruitment group for a cluster-randomised controlled trial of early intervention in COPD by practice nurse (PN)–general practitioner teams. Patients were 40–85-year-old former or current smokers with no previous diagnosis of COPD from general practices in Sydney. They completed the CDQ with the PN followed by the PN performing pre- and post-bronchodilator spirometry based on the American Thoracic Society and the European Respiratory Society (ATS/ERS) 2005 lung function guidelines. The PNs used the practice’s own spirometer, which had been calibrated by the research team. Spirometry tracings were independently reviewed by a respiratory physiologist (AJC). Cases where spirometry met quality standards based on ATS/ERS 2005 criteria and complete CDQ data were present were included for the analysis. A study diagnosis of COPD based on Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines was assigned to subjects who had a post-bronchodilator forced expiratory volume in 1 s (FEV1) forced vital capacity ratio of < 0.7. The criteria for COPD severity grading was based on the GOLD staging criteria: Stage I—FEV1 ≥ 80% (mild), Stage II—50% ≤ FEV1 < 80% (moderate), Stage III—30% ≤ FEV1 < 50% (severe) and Stage IV—FEV1 < 30% (very severe).

CDQ score and statistical analysis

The analysis methods were based on a protocol outlined by Price et al., with the CDQ having a range of scores 0–38. The sensitivity, specificity, positive predictive value and negative predictive value were calculated at 1-point intervals between the minimum and maximum scores using the non-parametric method when determining the receiver operating characteristic (ROC) area under the curve (ROCAUC). These intervals were used to determine cut points. The raw CDQ score was used as the screening test variable and the COPD diagnosis from spirometry as the dichotomised classification variable for calculation of the ROCAUC. Analyses were performed using SPSS (IBM, Armonk, NY, USA) and Microsoft Excel (Microsoft, Redmond, WA, USA) software.

#### RESULTS

Characteristics of participants

As reported in our earlier publication, there were 1,631 patients who attended for case-finding recruitment. Of these, 1,054 (65%) had complete CDQ recorded and spirometry meeting quality criteria for analysis. There were 178 patients (10.9% of 1,631) who were excluded due to incomplete CDQs and 472 (28.9%) had spirometry not meeting quality criteria. There were 63 patients (3.9%) who had both incomplete CDQ and spirometry not meeting quality criteria. Table 2 shows the population characteristics of the group. After post-bronchodilator spirometry, 13.1% of the total population were diagnosed with COPD. The group scoring > 19.5 had a third of all patients and about two-thirds of all COPD patients but 20% of patients with COPD scored < 16.5.

#### CDQ performance to identify COPD at different cut points

Figure 1 shows the ROC curve and the position of the original two cut points. The ROCAUC was 0.713 ± 0.023 with the higher cut point of 16.5.

#### Table 1. COPD Diagnostic Questionnaire (CDQ)

| Question                                                                 | Response categories | CDQ score |
|--------------------------------------------------------------------------|--------------------|-----------|
| What is your age in years?                                               | 40–49 years old    | 0         |
|                                                                          | 50–59              | 4         |
|                                                                          | 60–69              | 8         |
|                                                                          | 70+                | 10        |
| What is the total number of years you have smoked?                       | 0–14 pack-years    | 0         |
|                                                                          | 15–24              | 2         |
|                                                                          | 25–49              | 3         |
|                                                                          | 50+                | 7         |
| How many cigarettes do you currently smoke each day?                     | BMI < 25.4         | 5         |
| (If you are an ex-smoker, how many did you smoke each day?)              | 25.4–29.7          | 1         |
|                                                                          | < 29.7             | 0         |
| Body mass index (BMI) = weight (kg)/height (m)^2                         | Yes                | 3         |
| Does the weather affect your cough?                                      | No/No cough        | 0         |
|                                                                          | Yes                | 3         |
| Do you ever cough up phlegm (sputum) from your chest when you don’t have a cold? | No                  | 0         |
| Do you usually cough up phlegm (sputum) from your chest first thing in the morning? | Never              | 0         |
| How frequently do you wheeze?                                           | Occasionally or more often | 4 |
|                                                                          | Never              | 0         |
| Do you have or have you had any allergies?                               | Yes                | 0         |
|                                                                          | No                 | 3         |
A sensitivity of at least 90% and 87% of patients scoring below the cut point. GOLD severity grading versus CDQ score

Table 4 shows the distribution of patients with COPD by GOLD staging in the entire group and those groups separated by the 14.5 and 19.5 cut points. No one had GOLD stage IV COPD. The majority of patients had GOLD stage II (66 (47.8%)). About 37% of COPD-positive patients fell below the 19.5 cut point that includes the majority of patients had GOLD stage II (66 (47.8%)). About 37% of COPD-positive patients fell below the 19.5 cut point that includes the majority of patients had GOLD stage II (66 (47.8%)).

**DISCUSSION**

Main findings

Although recommended in guidelines, performing spirometry on all current and former smokers has proved difficult to implement in primary care.11,12 In this paper we examined the role of the CDQ as a filtering tool, where a single cut point was chosen to identify patients at higher risk of having COPD and needing to progress to diagnostic spirometry. The authors felt this was a simpler
spirometry referral model than the original two cut point model proposed by Price et al.,9 removing the uncertainty of having an intermediate likelihood group that may or may not undergo spirometry.

The literature suggests that a cut point with the best balance between sensitivity and specificity based on the ROC curve is considered best at discriminating between diseased and non-diseased cases.19,20 In this study, using these methods would result in 19.5 being the optimal cut point. However, this has a sensitivity of only 63% and 37% of COPD diagnoses would be missed. To some clinicians, this would be considered an unacceptably high rate of missed COPD diagnoses. This is compared with 9.4% of potential COPD diagnoses excluded by the 14.5 cut point for example. If the 16.5 and 19.5 cut points originally proposed for the CDQ were applied to the study population, sensitivity and negative predictive values would be less than the 14.5 cut point.

Influences on choosing an optimal cut point are the need to maximise the detection of COPD while making a substantial reduction in the burden of performing spirometry. A highly sensitive cut point would suit this objective better than one with a high specificity.21 It is difficult to find evidence supporting an ideal threshold sensitivity level; however, selection of an optimal cut point can be varied to increase sensitivity or specificity depending on what the test is used for.20 The authors proposed a potential cut point of 14.5 because of its high sensitivity similar to the 16.5 cut point in other studies (90.6%) and high negative predictive value (96%).10–13 At the same time, 31% of patients in the low likelihood group do not need to undergo spirometry. The authors felt that a single cut point <14.5 would lead to a minimal gain in sensitivity while resulting in a substantial increase in spirometries performed. For example, choosing a 12.5 cut point would lead to a ~3% increase in sensitivity but would require 10% more spirometries than a 14.5 cut point (21 vs 31% patients below cut point).

On the basis of the GOLD COPD severity criteria, the majority of COPD patients were in GOLD stage II (66 (47.8%)) with most patients below the 16.5 and 19.5 cut points being in GOLD stage I (Table 4).9 By using a 14.5 cut point for spirometry selection, no GOLD stage III COPD patients would miss out on spirometry, whereas 2 out of 10 patients (20%) with GOLD stage III score below the 19.5 cut point would miss. Clinicians concerned about potentially missing patients with severe COPD would perhaps prefer a more sensitive cut point.

Weaknesses and limitations of this study
One strength of this study is that there was a large sample of primary care patients from a different population (Australia) to the original CDQ study (USA and UK) made up of former and current smokers, unlike the first CDQ validation study in the Netherlands where all patients were current smokers.6,10 This study was undertaken across several sites using each practice’s nurses and pre-existing spirometry machines. This represents real world use of spirometry in Australian general practice rather than laboratory-based methods, despite 35% of patients being excluded from the statistical analysis due to incomplete CDQ or spirometry not meeting quality criteria.

Asymptomatic patients will generally score lower on the CDQ than symptomatic patients (Table 1). As our sample included patients without respiratory symptoms, this may underestimate the ability of the CDQ to detect cases of COPD as defined by the GOLD guidelines.8 This limitation also applies to other CDQ studies that looked at detecting spirometrically defined COPD in patients with risk factors for COPD but not necessarily with symptoms.9–14
by setting a single cut point for the CDQ. We suggest consideration of two possible cut points. A single cut point of 19.5 based on ROC curve criteria can be considered to be an ideal cut point as it has the best balance of sensitivity and specificity. However, this has a substantial false-negative rate compared with a lower cut point of 14.5, and the 19.5 cut point potentially excludes a small number of patients with severe COPD. The 14.5 cut point increases sensitivity and negative predictive value while reducing false-negative CDQs. However, this cut point excludes a smaller proportion of patients from undergoing spirometry. The single cut point concept can be applied to different populations using our study’s protocol. The pros and cons of this approach and the proposed cut points warrant debate in the primary care respiratory community.

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CONTRIBUTIONS
The original trial on which this study was based was conceived by NZ, Dr Jeremy Bunker and Professor Guy Marks and all authors contributed to this study’s design, either through the original trial or the current study. OCPvS advised on the design of the CDQ. AC designed the spirometry toolkit for diagnosis of COPD and performed quality assessment of the spirometry. AJSt was the primary author and performed the bulk of the statistical analysis, aided by IH. All authors contributed to and approved the final version of the manuscript.

COMPETING INTERESTS
The authors declare no conflict of interest. OCPvS is an Assistant Editor of npjPCRM, but was not involved in the editorial review of, nor the decision to publish, this article.

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