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ARTICLE OPEN

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

Anthony J Stanley[1], Iqbal Hasan[2], Alan J Crockett[3,4], Onno CP van Schayck[5] and Nicholas A Zwar[1]

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.[3] 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.[5] 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 $\geqslant 40$ 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.[9] 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

[1]School of Public Health and Community Medicine, Faculty of Medicine, University of New South Wales, Kensington, New South Wales, Australia; [2]Centre for Health Equity Training Research and Evaluation (CHETRE), Ingham Institute, Liverpool BC, New South Wales, Australia; [3]School of Health, University of South Australia, Adelaide, South Australia, Australia; [4]Discipline of General Practice, School of Population Health, University of Adelaide, Adelaide, South Australia, Australia and [5]Department of General Practice, CAHPRI School for Public Health and Care, Maastricht University Medical Centre, Maastricht, The Netherlands.
Correspondence: AJ Stanley (ajstanley8@gmail.com)
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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
How many cigarettes do you currently smoke each day?	15–24	2
(If you are an ex-smoker, how many did you smoke each day?)	25–49	3
Packs per day = cigarettes per day/20 cigarettes per pack	50+	7
Pack-years = packs per day × years smoked		
What is your weight in kilograms?	BMI < 25.4	5
What is your height in metres?	25.4–29.7	1
Body mass index (BMI) = weight (kg)/(height (m))^2	< 29.7	0
Does the weather affect your cough?	Yes	3
	No/No cough	0
Do you ever cough up phlegm (sputum) from your chest when you don't have a cold?	Yes	3
	No	0
Do you usually cough up phlegm (sputum) from your chest first thing in the morning?	Yes	0
	No	3
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

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.[15] 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%.[10–13] The aim of this study was 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.[14] 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.[14,16] 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.[17,18] 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.[16] 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 (FEV_1)/forced vital capacity ratio of < 0.7.[3] The criteria for COPD severity grading was based on the GOLD staging criteria: Stage I—$FEV_1 \geqslant 80\%$ (mild), Stage II—$50\% \leqslant FEV_1 < 80\%$ (moderate), Stage III—$30\% \leqslant FEV_1 < 50\%$ (severe) and Stage IV—$FEV_1 < 30\%$ (very severe).[3]

CDQ score and statistical analysis

The analysis methods were based on a protocol outlined by Price *et al.*[9] with the CDQ having a range of scores 0–38. The sensitivity, specificity, positive predictive value and negative predicative 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 (ROC_{AUC}). 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 ROC_{AUC}. 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.[14] 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 ROC_{AUC} was 0.713 ± 0.023 with the higher cut point closer to the middle of the curve. Table 3 shows the sensitivity, specificity, predictive values and proportion of patients below various select cut points after ROC curve analysis. The sensitivity and specificity for the 16.5 cut point were 79.7 and 46.8%, respectively. The sensitivity and specificity for the 19.5 cut point were 63.0 and 70.1%, respectively. About two-thirds of patients scored below the 19.5 cut point and about 43% scored below the 16.5 cut point. The lowest cut point with at least 90% sensitivity was 14.5. This corresponded to a specificity of about 35%, positive predictive value of 17%, negative predicative value of 96% and a

Table 2. Population characteristics of the study group

	Study group
Patients (*n*)	1054
Age (years)	61.0 ± 11.3
Male number (%)	546 (51.8)
Body mass index (kg/m^2)	28.1 ± 5.3
Smoking history (pack-years)	24.1 ± 23.7
Proportion with COPD[a] (%)	13.1
Pulmonary function, % of predicted	
Post-bronchodilator (BD) FEV_1	94.5 ± 18.3
Post-BD FVC	95.9 ± 16.5
Average post-BD FEV_1/FVC %	77.5 ± 8.1
Pulmonary function (L)	
Post-BD FEV_1	2.8 ± 0.8
Post-BD FVC	3.6 ± 1.0
CDQ score	17.2 ± 5.5
Distribution in CDQ groups (% of 1,054)	
CDQ < 16.5	43.4
CDQ 16.5–19.5	22.4
CDQ > 19.5	34.3
COPD patients in CDQ groups (% of 138)	
CDQ < 16.5	20.3
CDQ 16.5–19.5	16.7
CDQ > 19.5	63.0

Data are presented as mean ± s.d. unless indicated otherwise.
Abbreviations: CDQ, COPD Diagnostic Questionnaire; COPD, chronic obstructive pulmonary disease; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity.
[a]Defined by post-BD FEV_1/FVC < 0.70 as per Global Initiative for Chronic Obstructive Lung Disease criteria.[3]

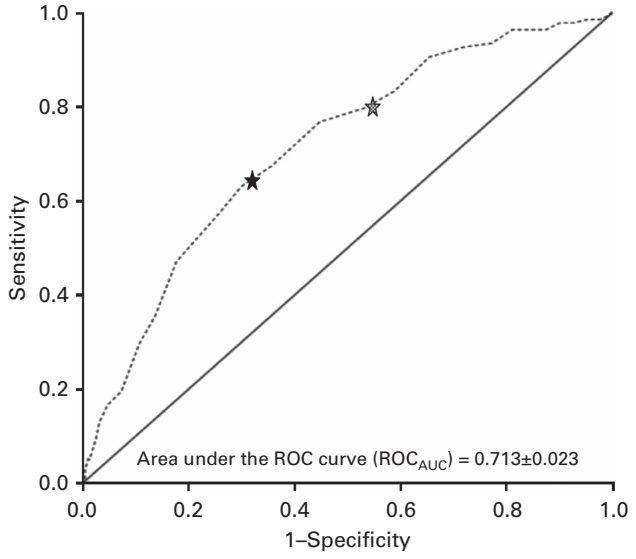

Figure 1. Receiver operating characteristic (ROC) curve comparing the COPD Diagnostic Questionnaire score to chronic obstructive pulmonary disease diagnosis. Cut point 16.5—grey star; 19.5—black star. An ROC_{AUC} of 0.5 is indicated by the solid diagonal line.

proportion below the cut point of 31%. A sensitivity of at least 95% corresponded to a cut point of 11.5, with sensitivity of 96.4%, specificity of about 19%, positive predictive value of 15%, negative predicative value of 97% and a proportion below the cut point of about 17%. The maximal positive predictive value of 29.4% corresponded to the 23.5 cut point, with sensitivity of about 30%, specificity of 90% and 87% of patients scoring below the cut point.

Table 3. Performance of CDQ at different cut points

Cut point	*Sensitivity*	*Specificity*	*Positive predictive value (%)*	*Negative predictive value (%)*	*Patients below the cut point (%)*
9.5	0.978	0.099	14.1	96.8	8.9
10.5	0.964	0.126	14.3	95.9	11.4
11.5	0.964	0.190	15.2	97.2	17.0
12.5	0.935	0.228	15.4	95.9	20.7
13.5	0.928	0.278	16.2	96.2	25.1
14.5	0.906	0.346	17.3	96.1	31.3
15.5	0.833	0.412	17.6	94.2	38.0
16.5	0.797	0.468	18.4	93.9	43.4
17.5	0.768	0.552	20.5	94.0	51.0
18.5	0.674	0.644	22.2	92.9	60.2
19.5	0.630	0.701	24.1	92.6	65.7
20.5	0.572	0.743	25.1	92.0	70.2
21.5	0.471	0.823	28.6	91.2	78.5
22.5	0.355	0.864	28.2	89.9	83.5
23.5	0.297	0.893	29.4	89.4	86.8
24.5	0.196	0.927	28.8	88.4	91.1

Abbreviation: CDQ, COPD Diagnostic Questionnaire.

Table 4. GOLD stage distribution of COPD-positive patients by original CDQ cut points and the 14.5 cut point

	All	*< 14.5*	*> 14.5*	*< 16.5*	*> 16.5*	*< 19.5*	*> 19.5*
GOLD I	62	10	52	19	43	30	32
GOLD II	66	3	63	8	58	19	47
GOLD III	10	0	10	1	9	2	8
Total patients	138	13	125	28	110	51	87

COPD GOLD staging classification.[3] Stage I—$FEV_1 \geqslant 80\%$; Stage II—$50\% \leqslant FEV_1 < 80\%$; Stage III—$30\% \leqslant FEV_1 < 50\%$; Stage IV—$FEV_1 < 30\%$.
Abbreviations: CDQ, COPD Diagnostic Questionnaire; COPD, chronic obstructive pulmonary disease; GOLD, Global Initiative for Chronic Obstructive Lung Disease.

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 2 out of 10 patients (20%) with GOLD stage III and 19 of 66 (28.8%) with GOLD stage II. There were 10% of GOLD stage III COPD patients who scored below the 16.5 cut point, with 68% of patients below this cut point being GOLD stage I. With a 14.5 cut point, 10 of 13 COPD-positive patients below the cut point were in GOLD stage I with the other 3 in GOLD stage II.

DISCUSSION

Main findings

Although recommended in guidelines, performing spirometry on all current and former smokers has proved difficult to implement in primary care.[3,9] 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 specifity.[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).[3] 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.

Strengths 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.[9,10] 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.[3] 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]

Interpretation of findings in relation to previously published work

There is variation in performance of CDQ across populations and therefore the value of a single cut point varies.[11] Several studies have examined the sensitivities and specificities of the CDQ at the 16.5 and 19.5 cut points. Sensitivities of 89–94% at the lower cut point and 66–85% at the higher cut point were found for four CDQ external validation studies.[10–13] Sensitivities at the 16.5 cut point in the validation studies by Frith *et al.* and Sichletidis *et al.*, for example, were 91%. This sensitivity is equivalent to the 14.5 cut point in this study.[12,13] However, the original CDQ study and this study had a sensitivity of ~80% at the 16.5 cut point.[9] These findings suggest that the optimal cut point will vary between populations. For a particular region, a cut point that has the optimal combination of sensitivity or specificity or whose sensitivity is $\geqslant 90\%$ could be chosen based on the study with a similar population.

Another approach to filtering patients for diagnostic spirometry is to use the Piko-6 flow meter (nSpire Health, Longmont, CO, USA).[12,13] Sichletidis *et al.*[12] proposed combining CDQ and post-bronchodilator Piko-6 flow meter to 'screen' patients for spirometry. Frith *et al.*[13] decided to use pre-bronchodilator Piko-6 on its own as a selection tool for spirometry rather than combining it with the CDQ. This appears to be a simpler approach than the Sichletidis *et al.* model, particularly with no bronchodilation needed for the Piko-6 meter.[12,13] Frith *et al.* selected an optimal cut point for the Piko-6 FEV_1/FEV_6 ratio based on the optimal combination of sensitivity and specificity, even though sensitivity for $FEV_1/FEV_6 < 0.75$ was 81% compared to 93% for $FEV_1/FEV_6 < 0.8$.[13] They postulated using the Piko-6 meter as a selection tool for spirometry with the < 0.75 cut point although the < 0.8 cut point would lead to a smaller number of potential COPD diagnoses being excluded.[13]

An editorial by Kotz and van Schayck[21] compared the performance of the CDQ to the Piko-6 flow meter from the Frith *et al.*[13] and Sichletidis *et al.*[12] studies. They wrote that the number of avoidable (negative) spirometries was much lower when using the Piko-6 but twice as many patients with COPD would be missed compared with the CDQ.[19] An advantage of the CDQ is that it can be used without medical assistance, unlike the Piko-6.[19] This means the Piko-6 could require longer training time than the CDQ and be more difficult for the patient to perform.

Implications for future research, policy and practice

Using the CDQ as a filter to select patients for diagnostic spirometry could potentially reduce the burden of spirometry in primary care with less clinical staff time needed. This could prove to be a cost-effective strategy for diagnosing COPD. Evaluating the implementation of the CDQ as a spirometry-filtering tool in primary care would be needed, particularly looking at the cost of time taken to administer the CDQ and the training time involved in educating PNs and general practitioners on its use.

Deciding on the optimal CDQ cut point for a particular region should be based on the results from one of the six CDQ studies.[9–14] Consensus guidelines regarding which cut point is optimal for which population would make the clinician's job easier. Furthermore, establishing a protocol on how to follow-up patients in the low likelihood group is also important, such as how often to repeat the CDQ, e.g., comparing six monthly with annual CDQs.

Conclusions

The results of this CDQ study suggest that the questionnaire can be used effectively as a selection tool for patients at high risk of COPD to undergo further spirometry by excluding subjects at low risk of COPD. This will limit the number of spirometries performed and exclude a small number of potential positive COPD diagnoses

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. AJS 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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