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ORIGINAL RESEARCH

Evaluating the Effectiveness of the COPD Assessment Test (CAT) in Screening for Chronic Obstructive Pulmonary Disease

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Background: Chronic obstructive pulmonary disease (COPD) is a major public health problem that remains largely under-diagnosed, mainly due to the under-use of spirometry to establish the diagnosis. The aim of this study is to evaluate the effectiveness of the Moroccan Arabic dialect version of the COPD Assessment Test (CAT) in screening for COPD.

Methods: This was a cross-sectional study carried out in primary care facilities in Morocco, involving participants aged 40 and over. The performance of CAT in detecting cases of COPD was measured with reference to the results of spirometry, considered to be the gold Standard.

Results: A total of 477 participants were included in the study. The prevalence of COPD was 6.7%. Internal consistency of the Moroccan Arabic dialect version of the CAT was high, with a Cronbach's alpha of 0.89. The total score of the CAT and of each item was significantly higher in subjects with COPD than in those without (P=0.000). Significantly negative correlations were found between CAT total score and FEV1 (r = −0.33, p=0.000), CAT and FVC (r = −0.22, p=0.000), CAT and FEV1/FVC ratio (r = −0.22, p=0.000). The receiver operating characteristic curve showed an area under the curve of 0.93. A CAT score of 10 was the optimal cut-off value for COPD screening, with a sensitivity, specificity, positive predictive value, and negative predictive value of 78.1%, 93.9%, 48.1% and 98.4%, respectively.

Conclusion: The results of the present study showed that the CAT could be used as a screening tool for COPD. The use of this tool by healthcare professionals in primary care settings will improve and promote early diagnosis of this chronic disease.

Keywords: chronic obstructive pulmonary disease, COPD assessment test, screening, primary care

Background

Chronic obstructive pulmonary disease (COPD) refers to a heterogeneous lung condition characterized by chronic respiratory symptoms (dyspnea, cough, and sputum), resulting from persistent airway and/or alveolar abnormalities, often leading to progressive airflow limitation.[1] COPD is a major public health problem responsible for significant economic and social disadvantage.[2,3] In 2016, 213 million cases of COPD were recorded worldwide,[4] and 3.23 million deaths were expected in 2019 due to COPD.[5] Internationally, the prevalence of COPD continues to rise.[6] Thus, according to World Health Organization (WHO) projections on mortality and disease burden, COPD will become the third leading cause of death by 2030.[7]

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The diagnosis of COPD relies on the performance of a lung function test called spirometry, considered the gold standard for confirming cases with an obstructive disorder.[8] However, the unavailability of spirometers in primary care units limits their use in daily clinical practice.[9] This leads to the under-diagnosis of COPD worldwide. Consequently, identifying cases of COPD at an early stage remains a challenge for healthcare systems worldwide.

Several efforts have been made to address the under-diagnosis of COPD. The Global Initiative for Chronic Obstructive Lung Disease (GOLD) regularly updates its guidelines on all aspects of COPD, including diagnosis and screening, to reflect the latest developments and innovations.[10] In addition, the World Health Organization (WHO) continues to place non-communicable diseases, including COPD, at the heart of its concerns, encompassing activities ranging from prevention and screening to management.[11] In addition, several case-finding tools have been developed to combat the problem of under-utilization of spirometry. These include portable devices such as peak flow meters and microspirometers. In addition, screening questionnaires are considered simple, easy-to-use, and inexpensive case-finding tools for identifying COPD patients.[12]

To address the problem of under-diagnosis and promote early diagnosis of COPD, we propose to evaluate the use of the COPD Assessment Test (CAT) in COPD case detection. The COPD Assessment Test (CAT) is a short questionnaire originally developed to assess the impact of COPD on the daily lives of sufferers.[13] It consists of eight questions covering the symptoms of the disease and their effects on patients' lives. The CAT questionnaire has been widely used, and its total score has been significantly correlated with validated questionnaires on the impact of COPD on the health status of affected patients.[14]

In Morocco, COPD is a public health problem, yet it remains largely underdiagnosed.[15] Therefore, the aim of this work is to evaluate the effectiveness of the Moroccan Arabic dialect version of the CAT questionnaire in screening for COPD in the population attending primary health care facilities. These facilities are considered to be patients' first point of contact with the healthcare system in Morocco. Although we have already estimated the prevalence of COPD in people aged 40 and over and identified the risk factors associated with its development in the first part of this research,[16] which explains certain similarities between the two studies, it should be noted that this study addresses another facet of our overall research, namely the effectiveness of the CAT tool in screening for cases of COPD in Morocco. With the exception of a single study conducted by Jones et al in which the authors used the CAT questionnaire to measure the impact of COPD on patients in the Middle East and North Africa, including Morocco,[17] to our knowledge, no study has yet been conducted in Morocco to investigate the usefulness of the CAT tool in screening for COPD cases based on spirometry results. In fact, a weakness of the study conducted by Jones et al is that it defines COPD cases on the basis of clinical and subjective data (presence of chronic bronchitis or emphysema and/or lifetime smoking exposure of around 10 packs per year), rather than on the basis of spirometry results. The Moroccan dialectal Arabic version of the CAT was obtained by following a rigorous process of translation, back-translation, and reconciliation. The questionnaire was initially translated from English into Moroccan dialectal Arabic by two translators. The two translated versions were compared and synthesized into a single consensus version, which was then back-translated by a third translator to check the faithfulness of the translation to the original. The back-translated version was then compared with the original version of the instrument. The research team then discussed each word of the questionnaire and made the necessary readjustments to ensure the cultural and linguistic appropriateness of the questionnaire.

Materials and Methods

Study Design and Participants

This was a cross-sectional study involving participants aged 40 and over. The study was conducted at primary health care facilities in the province of Settat, Morocco. Participants aged 40 and over were asked to complete a questionnaire (including CAT) and to perform a spirometry test before and after administration of a bronchodilator. Participants aged under 40, with one or more contraindications to spirometry, unable to perform a spirometry test, and those who refused to take part in the study were excluded from the study.

Data Collection

In parallel with the CAT questionnaire, we collected a range of data, including socio-demographic characteristics (such as age, gender, education level, marital status, and place of residence) and tobacco consumption. Smoking status was categorized as never-smokers, former smokers, and current smokers.[18] Participants' weight and height were measured. Body mass index (BMI) was categorized according to the WHO classification.[19] The Moroccan dialect Arabic version of the CAT questionnaire can be obtained on reasonable request from the corresponding author.

Pulmonary Function Test

Study participants underwent lung function testing before and after bronchodilator administration, using a spirometer (Spirolab MIR® Model, Rome, Italy). The test was performed in accordance with the recommendations of the American Thoracic Society (ATS) by a single and unique investigator trained for this purpose.[20] COPD was defined according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) diagnostic criteria as a ratio of mean expiratory volume in one second (FEV1) to forced vital capacity (FVC) of less than 0.7.[21]

Statistical Analysis

Statistical analyses were performed using IBM SPSS (Statistical Package for Social Sciences) version 21 software. Data were expressed as means ± standard deviation for quantitative variables and as percentages (%) for qualitative variables. Data normality was verified using the Shapiro–Wilk test. Depending on the distribution of the variables studied, the Mann-Whitney test was used for comparison between groups. Categorical variables were compared using the Chi-square test. Correlation between the CAT total score and pulmonary function parameters was measured by Spearman correlation coefficient. The internal consistency of the Moroccan Arabic dialect version of the CAT was assessed by calculating Cronbach's alpha. A Cronbach's alpha greater than 0.7 indicates good internal consistency of the instrument. The test's performance in terms of intrinsic values and field performance, namely specificity, sensitivity, negative predictive value, and positive predictive value, were calculated with reference to the results of spirometry, considered the gold standard in confirming cases of COPD. The receiver operating characteristic (ROC) curve was generated to detect the discriminative properties of different CAT score cut-off points in the identification of COPD cases. The area under the curve (AUC) was calculated to determine the diagnostic capacity of the CAT. Values of $p<0.05$ were considered as statistically significant.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and was approved by the ethics committee of the Moroccan Association for Research and Ethics (approval number IRB00012973). Informed consent was obtained from each participant at the beginning of the study.

Results

Characteristics of the Study Sample

A total of 477 participants meeting the study inclusion criteria were included in the final analysis. The mean age of the participants was 54.91 ± 11.9 years, and 38.6% were men. COPD was identified in 32 study participants, generating a prevalence of 6.7%. Only three of the study participants (0.6%) had previously undergone spirometry testing. The majority of patients identified as having COPD (93.75%) were not diagnosed. Table 1 shows the socio-demographic and clinical characteristics of the study sample.

Internal Consistency of the CAT

The internal consistency of the Moroccan Arabic dialect version of the CAT is high, with a Cronbach's alpha of 0.89, indicating good homogeneity between questionnaire items. (Table 2)

Table 1 Baseline Characteristics of Study Participants (N=477)

Characteristic	Mean ± SD *or* n (%)
Age	54.91±11.9
Gender	
Men	184 (38.6)
Female	293 (61.4)
Age group	
40–49 years	184 (38.6)
50–59 years	119 (24.9)
60–69 years	103 (21.6)
70 years and over	71 (14.9)
Residence	
Urban	258 (54.1)
Rural	219 (45.9)
Educational level	
Illiterate	227 (47.6)
Primary	121 (25.4)
College	62 (13)
Secondary	45 (9.4)
University	22 (4.6)
Marital status	
Single	43 (9)
Married	381 (79.9)
Divorced	22 (4.6)
Widowed	31 (6.5)
Mean BMI	28.28 ± 5.26
BMI classification	
Underweight	6 (1.3)
Normal weight	127 (26.6)
Overweight	175 (36.7)
Obese	169 (35.4)
Packs per year of smoking	4.97 ±15.13
Smoking status	
Never smokers	376 (78.8)
Former smokers	66 (13.8)
Current smokers	35 (7.3)

(*Continued*)

Table 1 (Continued).

Characteristic	Mean ± SD *or* n (%)
FEV1	2.65 ± 0.72
FVC	3.25 ± 0.91
FEV1/FVC	82.07 ± 8.17
COPD	
Yes	32 (6.7)
No	445 (93.3)
Already performed a spirometry test	
Yes	3 (0.6)
No	474 (99.4)
Previous diagnosis of COPD	
Yes	2 (6.25)
No	30 (93.75)

Notes: This table summarizes the baseline characteristics of the study sample. The mean age of participants was 54.91± 11.9 years, and 38.6% were male. Nearly half the participants were illiterate (47.6%) and 35.4% were obese. Regarding smoking status, 78.8% of participants were non-smokers, 13.8% were former smokers, and 7.3% were current smokers.
Abbreviations: SD, standard deviation; BMI, body mass index; FEV1, forced expiratory volume in one second; FVC, forced vital capacity.

Table 2 Internal Consistency of the Moroccan Arabic Dialect Version of CAT

	Total score Mean± SD	Cronbach's Alpha
CAT questionnaire	4.48 ± 5.82	0.89

Notes: This table presents the level of internal consistency of the Moroccan Arabic dialect version of the CAT. Our results show that Cronbach's alpha is 0.89, indicating good internal reliability. The level of internal consistency obtained demonstrates coherence between CAT questionnaire items and guarantees its reliability for assessing COPD in the population targeted by our study.

CAT Score in Patients with and without COPD

The mean total CAT score was 16.94 ±9.71 in participants with COPD, compared with 3.59 ± 4.21 in those without (p=0.000). A similar trend was observed for the overall scores of each questionnaire item, which were significantly higher in affected participants than in unaffected participants. Table 3 shows the distribution of the total score and of each CAT item in participants with and without COPD.

CAT Score and Pulmonary Function Parameters

The calculation of Spearman correlation coefficients revealed significantly negative correlations between FEV1, FVC, and FEV1/FVC ratio and the total CAT score. Consequently, an increase in CAT score leads to a significant decrease in pulmonary function parameters (Table 4 and Figure 1).

Table 3 CAT Results for Participants with and without COPD (N=477)

	COPD		*P-value*
	Yes (n=32) Mean ± SD	**No (n=445) Mean ± SD**	
CAT (Total)	16.94 ± 9.71	3.59 ± 4.21	0.000
Cough	2.59 ± 1.58	0.37 ± 0.75	0.000
Phlegm	2.53 ± 1.68	0.31 ± 0.75	0.000
Chest tightness	2.59 ± 1.68	0.33 ± 0.74	0.000
Shortness of breath	3 ± 1.36	0.94 ±1.06	0.000
Limitation of activities at home	1.75 ± 1.6	0.33 ± 0.78	0.000
Confidence to leave home	1.13 ± 1.6	0.08 ± 0.41	0.000
Sleep	1.44 ± 1.45	0.42 ± 0.8	0.000
Energy	2.16 ± 1.24	0.81± 0.86	0.000

Notes: This table shows CAT scores for participants with and without COPD. The results show that the total CAT score as well as the overall scores for all items were significantly higher in participants with COPD than in those without. These differences demonstrate the usefulness of the CAT in screening for COPD.

Abbreviations: CAT, COPD Assessment Test; COPD, chronic obstructive pulmonary disease; SD, standard deviation.

Table 4 Correlation Between Total CAT Score and Pulmonary Function Parameters

Variables	**r**	***P-value***
Total CAT and FEV1	−0.33	0.000
Total CAT and FVC	−0.22	0.000
Total CAT and FEV1/FVC	−0.22	0.000

Abbreviations: CAT, COPD Assessment Test; FEV1, forced expiratory volume in one second; FVC, forced vital capacity; r, Spearman correlation coefficient.

CAT Performance in COPD Screening

The receiver operating characteristic (ROC) curve showed an area under the curve (AUC) of 0.93 (95% CI; 0.89–0.97) (p=0.000) (Figure 2).

Test performance of CAT in terms of intrinsic values and field performance at each cut-off point is presented in Table 5. A CAT score of 10 was the optimal cut-off value for COPD screening, with a sensitivity, specificity, positive predictive value, and negative predictive value of 78.1%, 93.9%, 48.1%, and 98.4%, respectively (Table 5).

Discussion

The aim of this study was to evaluate the effectiveness of the Moroccan Arabic dialect version of the CAT questionnaire in screening for COPD. To our knowledge, this is the first evaluation of the diagnostic performance of the CAT in the Moroccan context.

Despite the progress made in terms of the national healthcare system, non-communicable diseases, including COPD, constitute one of the main challenges facing this system.[22] Indeed, the rapid economic and demographic transition that Morocco has undergone in recent decades has contributed to an increase in the burden of morbidity and mortality linked to this type of disease.[23–25] COPD is a major public health problem in Morocco.[15,26,27] Our study revealed a prevalence

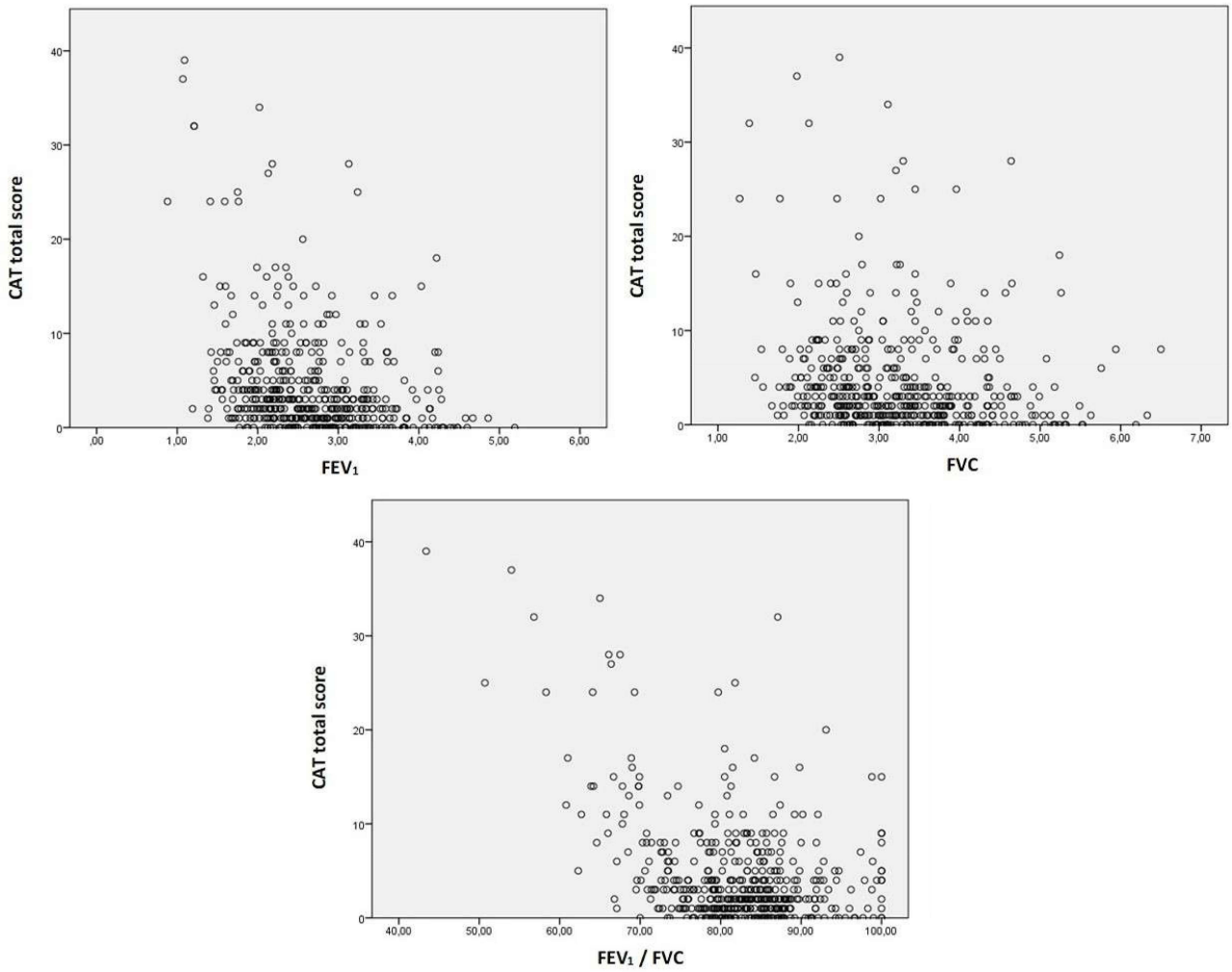

Figure 1 Correlation between total CAT score and pulmonary function parameters.

of 6.7%. This value is lower than that reported by a previous national study, which reported a prevalence of 12.6%.[15] This result could be explained by the relatively low proportion of men, smokers, and the elderly, considered to be high-risk groups for developing irreversible airway limitation.

Our results revealed that COPD remains largely underdiagnosed, with an estimated underdiagnosis rate of 93.75%. This finding is similar to the results of other studies, which have all shown extremely high rates of underdiagnosis, mainly due to the underutilization of spirometry.[28–30] These data illustrate the importance of seeking alternatives to spirometry to detect cases of COPD and promote early diagnosis of this chronic respiratory pathology, considered as a major public health problem worldwide.[31]

To address this problem of under-diagnosis, we investigated the ability of the COPD Assessment Test (CAT), originally designed to assess the impact of COPD on the daily lives of sufferers, to screen for cases of COPD. For the record, Jones et al have previously evaluated a classical Arabic version of the CAT to measure the impact of COPD on the daily lives of affected patients in the Middle East and North Africa, including Morocco.[17] However, classical Arabic is not commonly used in Morocco, and many people only speak the Moroccan dialect,[32,33] hence the need to translate and validate the original version of the CAT in our Moroccan context. The results of this translation work showed good internal consistency of the Moroccan Arabic dialect version of the CAT, with an estimated Cronbach's alpha of 0.89, testifying to good consistency between its items. The Cronbach's alpha obtained in our study is similar to that obtained by Jones et al.[13]

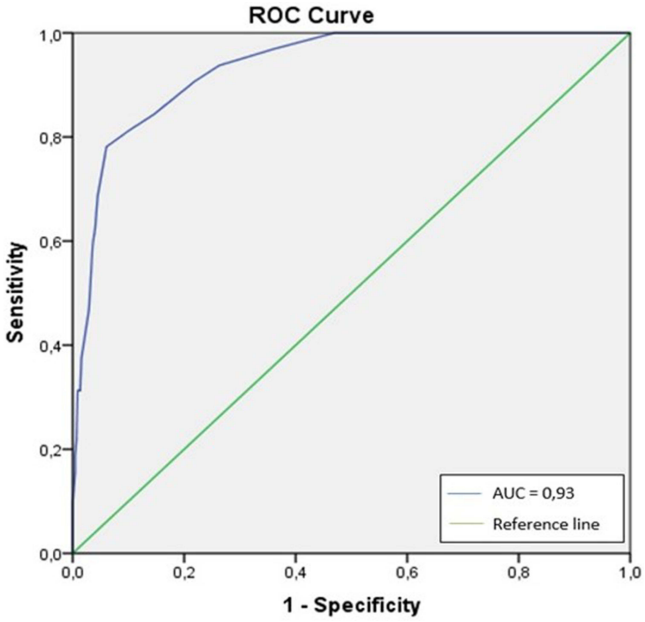

Figure 2 Receiver operating characteristic (ROC) curve for the COPD Assessment Test (CAT) in COPD case screening.

The distribution of mean CAT scores was significantly higher in participants with COPD than in those without. In addition, significantly negative correlations were found between the total CAT score and lung function parameters, namely FEV1, FVC, and FEV1/FVC ratio. Similar results have been documented in the scientific literature,[34] indicating that high CAT scores reflect a significant deterioration in lung function.

The receiver operating characteristic (ROC) curve showed an area under the curve (AUC) of 0.93. This result is very encouraging, as it suggests that the test has a high capacity to differentiate between classes. In other words, it is effective in discriminating between positive and negative test results with high precision. According to the ROC curve, a CAT

Table 5 Sensitivity, Specificity, Positive and Negative Predictive Values for the Different CAT Cut-off Points

Cut-off point	Sensitivity	Specificity	PPV	NPV
CAT 8	81.2%	89.9%	36.6%	98.5%
CAT 9	78.1%	93.5%	46.3%	98.3%
CAT 10	78.1%	93.9%	48.1%	98.4%
CAT 11	68.8%	95.5%	52.4%	97.7%
CAT 12	62.5%	96%	52.6%	97.3%

Notes: This table shows the values of CAT diagnostic performance parameters at different CAT score cut-off points. The results show that a score of 10 is the optimal cut-off point for COPD screening. The threshold was chosen by seeking a compromise between specificity and sensitivity, while taking into account the implications of COPD prevalence on predictive values (PPV and NPV). The balance between sensitivity and specificity was sought so that the test could identify a large possible number of COPD cases, while maintaining sufficient specificity to avoid false positives. Moreover, at a threshold of 10, the PPV and NPV were 48.1% and 98.4% respectively. These values are justified by the relatively low prevalence of COPD in our study (6.7%), which tends to increase the NPV and decrease the PPV, even though sensitivity and specificity are high.
Abbreviations: PPV, Positive predictive value; NPV, Negative predictive value.

score of 10 was found to be the optimum threshold value for detecting cases of COPD. This threshold value was also found in an earlier study conducted in Japan.[35] The intrinsic and field performance values of the Moroccan Arabic dialect version of the CAT were, respectively, 78.1%, 93.9%, 48.1%, and 98.4% for sensitivity, specificity, positive predictive value, and negative predictive value. The low positive predictive value (48.1%) could be explained by the low prevalence of COPD found in our series. However, these results are better than those obtained by Demirci et al in Turkey, who reported a sensitivity, specificity, positive predictive value, and negative predictive value, respectively, of 66.67%, 75.15%, 10.53% and 98.09%.[34] Taken together, our results indicate that the Moroccan Arabic dialect version of the CAT shows a very good performance in detecting cases of COPD and could be used as a promising alternative to spirometry. Indeed, health care units are rarely equipped with spirometers.[36]

It should be noted that lack of awareness may be a barrier to the adoption of the CAT questionnaire, even though it is an inexpensive, easy, and quick to administer case-finding tool. Indeed, a lack of COPD awareness exists among both patients and healthcare professionals. Consequently, raising awareness of COPD among healthcare professionals and the value of using CAT to promote early detection, as well as training in its use and interpretation of its results, are crucial to its successful implementation in Morocco's primary healthcare facilities, considered the first point of contact between the population and the healthcare system. In addition, effective health communication is essential to raise patients' awareness of COPD and the value of early detection.[37,38]

To our knowledge, this is the first study to assess the effectiveness of the CAT in COPD screening in Morocco. The strength of the present study lies in the fact that the performance of the Moroccan Arabic dialect version of the CAT in terms of intrinsic values and field performance was calculated based on the results of spirometry with a reversibility test. This examination is considered the gold standard for confirming cases of COPD. Nevertheless, we did not assess associations between CAT scores and other risk factors such as gender, age, and smoking status. Furthermore, the cultural and linguistic specificity of CAT adaptation could hamper the generalizability of our results. Therefore, similar studies in other settings, particularly where spirometry is underused, are needed in order to generalize the results of this study and reduce the underdiagnosis associated with COPD.

Conclusions

The results of this study highlight the usefulness of the Moroccan Arabic dialect version of the CAT as a high-performance tool for COPD screening. The use of this tool by healthcare professionals in their daily practice could help avoid the need for costly and less available spirometry tests, reduce the rate of under-diagnosis and promote early diagnosis of this chronic pathology, which represents a national public health problem. In addition, efforts to educate and raise awareness of its importance need to be deployed to ensure its implementation and adoption in care units. We plan to establish associations between CAT scores and the following factors: gender, age, and smoking status, using advanced statistical techniques which will enable us to propose an even stronger model for COPD case detection. Similar studies in other settings, particularly where spirometry is under-utilized, are needed to generalize the results of this study and reduce the under-diagnosis of COPD worldwide.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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