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ORIGINAL RESEARCH

Validation and Clinical Analysis of the Quantitative COPD Exacerbation Recognition Tool (Q-CERT): Diagnostic Performance and Association with Lung Function Impairment

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Objective: There is a need for a patient-centered tool that can quantitatively identify acute exacerbations of COPD. This study aims to develop and validate a digital tool that enables such care by providing a quantifiable severity score.

Methods: A total of 161 AECOPD patients and 130 stable COPD patients from Henan Provincial People's Hospital were enrolled. Demographics, clinical symptoms, pulmonary function parameters and admission laboratory data for patients were collected. The COPD Exacerbation Recognition Tool (CERT) was quantified using a 4-point Likert scale (0–3) to derive the Quantitative-CERT (Q-CERT) score. Effectiveness of the CERT and Q-CERT in identifying AECOPD was assessed.

Results: The CERT demonstrated strong diagnostic performance for recognizing AECOPD, with a sensitivity of 85.7%, specificity of 80.8%, and accuracy of 83.5%. The quantitative Q-CERT score further optimized diagnostic accuracy. At a cutoff of 5 points, the Q-CERT provided optimal sensitivity (89.4%) and specificity (83.8%) combination, with an AUC of 0.956 (95% CI: 0.937–0.976, $P< 0.001$). Q-CERT scores were significantly higher in patients with AECOPD than in those with stable COPD (8 vs. 0 points, $P< 0.001$). Furthermore, elevated Q-CERT scores correlated negatively with pulmonary function parameters, including FEV1%pred, FEV1/FVC, MEF75%pred, MEF50%pred, and MMEF%pred ($r = -0.406$ to -0.358, all $P < 0.001$), with the strongest associations observed in small airway metrics. Conversely, higher Q-CERT scores showed positive correlations with the neutrophil-to-lymphocyte ratio (NLR) ($r = 0.181$, $P<0.05$) and platelet-to-lymphocyte ratio (PLR) ($r = 0.245$, $P<0.05$).

Conclusion: Q-CERT enhanced the original CERT's ability to identify AECOPD. And total score was correlated with pulmonary function impairment and systemic inflammation, making it an efficient and reliable tool for clinical practice.

Keywords: chronic obstructive pulmonary disease, COPD, acute exacerbation, COPD exacerbation recognition tool, CERT, patient-centered monitoring

Introduction

Chronic Obstructive Pulmonary Disease (COPD) represents a significant public health issue worldwide, leading to disability and mortality.[1] Recurrent acute exacerbations (AEs) are closely linked to accelerated lung function decline, reduced work capacity, and increased socioeconomic burden,[2] also serve as critical factor contributing to premature death among patients.[3,4] Despite the substantial impact, numerous studies have shown that acute exacerbations of COPD (AECOPD) are often underdiagnosed or delayed in recognition,[5] with many patients misinterpreting symptoms like dyspnea and cough as normal aging signs. This tendency may lead to a watchful waiting approach or a preference for

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self-medication,[6,7] leading to delayed medical consultation, increasing exacerbation frequency, hospitalization, and disability. Fear of hospitalization and concerns about medications further delay care, complicating disease management.[8]

These challenges are largely due to a lack of disease awareness, particularly in primary care and among elderly individuals, hindering the timely recognition of clinical deterioration and the determination of when to seek medical intervention.[9] Additionally, poor patient recognition of exacerbations limits clinicians to accurately assess exacerbation risks. Therefore, the implementation of tools to assist patients in proactively identifying AECOPD is crucial for both patients and healthcare providers.

Currently, various monitoring tools have been developed for identifying and managing AECOPD. For instance, the Exacerbation of Chronic obstructive pulmonary disease Tool (EXACT)[10,11] and EXACT-PRO[12] are self-reported tools designed for patients to document daily symptoms and exacerbation events. However, these tools are often too complex for daily use due to their length and the number of items involved. Clinical prediction models, such as the DETECT, utilize medical history, physical signs, and symptoms to assess disease exacerbations and severity.[13] Another prediction model developed in Korea evaluates the exacerbation risk based on a combination of internal factors (eg., demographics, lung function, medication use, and exacerbation history) and external factors (including air pollution, meteorological conditions, and influenza virus infections).[14] Although these models help clinical decision-making, their reliance on diverse data dimensions make them difficult to implement. Other tools, such as the St. George's Respiratory Questionnaire (SGRQ) and the ESCO (Exacerbation of COPD and Symptoms) score, are effective in both clinical trials and practice but also feature complex scoring algorithms, limiting their practicality. Despite these challenges, such tools are valuable for early AECOPD identification and intervention. To improve patient outcomes, especially in primary care, there is a need for simpler, more user-friendly self-assessment tools that allow patients to quickly and accurately recognize exacerbations.

The COPD Exacerbation Recognition Tool (CERT) comprises five items across four dimensions: cough, sputum production, dyspnea, and activity limitation.[15] Unlike previous tools focused on patients' current symptoms, CERT is distinctive in emphasizing patients' symptom changes relative to their usual state, improving patients' sensitivity to exacerbations and facilitating timely reporting. Moderate worsening in two or more items shows strong discriminative power for identifying AECOPD. However, CERT relies predominantly on qualitative descriptors, limiting objective assessment and hindering correlation analyses with other clinical variables. This study aims to validate CERT's generalizability in identifying AECOPD and proposes a revised version—Quantitative-CERT (Q-CERT)—which replaces qualitative items with a scoring system. It also reports Q-CERT's initial validation and explores correlations between Q-CERT scores and clinical indicators such as lung function and inflammatory.

Methods

Participants

This study included 161 clinically confirmed patients with acute exacerbations of COPD (AECOPD) who were treated at Henan Provincial People's Hospital from November 2023 to December 2024, as well as 130 stable COPD patients seeking medical care for other conditions during the same period. AECOPD is clinically defined as an event characterized by increased dyspnea and/or cough and sputum that worsens in < 14 days which may be accompanied by tachypnea and/or tachycardia, and requires changes in medication regimens or hospitalization according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2023 criteria.[16] CERT-reported AECOPD is characterized by moderate worsening of two or more CERT items.

Inclusion and Exclusion Criteria

Inclusion criteria were male or female patients aged≥40 years with spirometrically confirmed COPD per GOLD 2023 (ie. the post-bronchodilator forced expiratory volume in 1 second and forced vital capacity ratio (FEV1/FVC) less than 0.70). Exclusion criteria: (1) Current bronchial asthma, pulmonary fibrosis, cystic fibrosis, bronchiectasis, pneumothorax, lung cancer, or other lower respiratory tract abnormalities; (2) Systemic inflammatory diseases, psychiatric or cognitive impairment, or factors affecting study participation; (3) Contraindications for spirometry (eg. prior lung volume reduction surgery or lung transplantation).

Data Collection

For the study, data were collected from the hospital information system (HIS), including demographic and clinical characteristics such as age, sex, body mass index (BMI), smoking index, and COPD duration. On admission, all patients completed the CERT questionnaire. Additionally, post-bronchodilator pulmonary function parameters were recorded, including FEV1, FVC, FEV1/FVC, peak expiratory flow (PEF), maximum mid-expiratory flow (MMEF), maximal expiratory flow at 75% of FVC (MEF75), maximal expiratory flow at 50% of FVC (MEF50), and maximal expiratory flow at 25% of FVC (MEF25). Laboratory data of AECOPD patients on the admission day were also collected, including white blood cell, neutrophils, monocytes, lymphocytes, eosinophils, neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and C-reactive protein (CRP).

Quantitative-CERT (Q-CERT) Revision and Data Processing

The CERT consists of five items that assess changes in the patient's current symptoms compared to their usual status: worsening cough, volume of sputum increased, shortness of breath, laborious breathing, and limitation of motion. Building upon the original CERT tool, an ordinal scale scoring method[17] was employed to quantify the severity of each item (ie., "as usual", "mild", "moderate", and "severe"), which was formatted as a 4-point semantic Likert scale (0, 1, 2, 3 point) for more precise measurement (Figure S1).

Statistical Analyses

Statistical analyses were conducted using SPSS 21.0. Outcome measures were summarized as means with SDs or median with quartiles for continuous variables or numbers with percentages n (%) for categorical variables. The differences in variables between the groups were analyzed using independent samples *t*-test, Wilcoxon *U*-test and Chi-square test. The receiver operating characteristic (ROC) curve was used to analyze the diagnostic efficacy, and the Spearman correlation was used to analyze the correlation between indicators. Statistical significance was defined as $P<0.05$.

Results

Patient Characteristics

Table 1 presents the demographic and clinical characteristics of patients with AECOPD (n=161) and stable COPD (n=130). The AECOPD group had a slightly higher mean age (70.0 vs. 68.2 years, $P=0.088$) and longer disease duration (5 vs. 3 years, $P=0.179$), though not statistically significant. Both groups were predominantly male (88.8% vs. 84.6%,

Table 1 Comparison of Demographic and Clinical Characteristics Between AECOPD and Stable COPD Patients

	AECOPD (n=161)	Stable COPD (n=130)	$Z/\chi^2/t$	*P* value
Age, year	70.0±8.7	68.2±8.9	−1.709	0.088
Sex			1.120	0.300
Male	143(88.8)	110(84.6)		
Female	18(11.2)	20(15.4)		
BMI, kg/m^2	23.7±4.1	24.4±4.4	1.283	0.200
Duration COPD, yrs	5(1, 10)	3(1, 8)	−1.344	0.179
Smoking index			6.988	0.072
0	31(19.3)	37(28.5)		
≤ 200	23(14.3)	10(7.7)		
200–400	26(16.1)	14(10.8)		
>400	81(50.3)	69(53.1)		
FEV1%pred	50.4(39.0, 67.3)	56(40.8, 74.2)	−1.410	0.158

Notes: Data are presented as mean ± SD, n (%), or M (Q1, Q3).
Abbreviations: COPD, Chronic obstructive pulmonary disease; AE, Acute exacerbation; BMI, Body mass index; FEV1, Forced expiratory volume in 1 second; %pred, %predicted.

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P=0.300) with similar BMI (23.7 vs. 24.4 kg/m^2, *P*=0.200) and heavy smoking history (>400) (50.3% vs. 53.1%, *P* =0.072). Lung function (FEV1% predicted) was slightly lower in the AECOPD group (50.4% vs. 56.0%, *P*=0.158), but without statistical significance.

Performance for Recognizing COPD Exacerbations of the CERT

A comparative analysis of the five CERT items between AECOPD and stable COPD groups showed significant differences in symptom severity (all *P*<0.001), with effect sizes (r_{rb}) ranging from 0.538 (Limitation of motion) to 0.729 (Shortness of breath), shown in Table 2. Specifically, AECOPD patients reported substantially greater deterioration in respiratory symptoms relative to their stable counterparts, with 70.2% experiencing moderate-to-severe worsening cough (vs 14.6% in stable group) and 56.5% with moderate-to-severe increased sputum (vs 13.0%). Notably, severe dyspnea was reported by 52.2% of AECOPD patients (vs 3.1%), and 36.0% had labored breathing (vs 0%), 21.1% showed substantial activity limitation (vs 0%).

Table 3 evaluated the predictive performance of the CERT against clinician-diagnosed AECOPD. Among 291 patients analyzed, CERT demonstrated robust characteristics, with sensitivity 85.7% (138/161) and specificity 80.8% (105/130) for recognizing exacerbations. The tool showed positive and negative predictive values of 84.7% and 82.0% respectively, with an overall predictive accuracy of 83.5%. Notably, the likelihood ratio analysis (+LR=4.46; -LR=0.18) and Youden's index (0.670) confirmed CERT's substantial discriminative power for AECOPD recognition.

Table 2 Comparison of CERT Items Between AECOPD and Stable COPD Patients

	AECOPD (n=161)	Stable COPD (n=130)	*Z* value	r_{rb}	*P* value
Worsening cough, n (%)			−10.739	0.630	<0.001
As usual	17(10.6)	90(69.2)			
Mild	31(19.3)	21(16.2)			
Moderate	70(43.5)	17(13.1)			
Severe	43(26.7)	2(1.5)			
Volume of sputum increased, n (%)			−9.817	0.576	<0.001
As usual	24(14.9)	94(72.3)			
Mild	46(28.6)	19(14.6)			
Moderate	59(36.6)	15(11.5)			
Severe	32(19.9)	2(1.5)			
Shortness of breath, n (%)			−12.437	0.729	<0.001
As usual	13(8.1)	97(74.6)			
Mild	18(11.2)	21(16.2)			
Moderate	46(28.6)	8(6.2)			
Severe	84(52.2)	4(3.1)			
Laborious breathing, n (%)			−10.839	0.635	<0.001
As usual	40(24.8)	114(87.7)			
Mild	30(18.6)	9(6.9)			
Moderate	33(20.5)	7(5.4)			
Severe	58(36.0)	0(0.0)			
Limitation of motion, n (%)			−9.184	0.538	<0.001
As usual	58(36.0)	118(90.8)			
Mild	47(29.2)	3(2.3)			
Moderate	22(13.7)	9(6.9)			
Severe	34(21.1)	0(0.0)			

Notes: Data are presented as n (%).
Abbreviations: COPD, Chronic obstructive pulmonary disease; AE, Acute exacerbation; r_{rb}, Rank-biserial correlation coefficient.

Table 3 Comparison of COPD Patient Classification Based on Clinician-Diagnosed (Acute Exacerbation [AECOPD] vs. Stable COPD) versus the CERT

	Clinician-Diagnosed AECOPD	Clinician-Diagnosed Stabled COPD	Total
CERT-reported AECOPD	138	25	163
CERT-reported stabled COPD	23	105	128
Total	161	130	291

Notes: Data are presented as numbers.
Abbreviations: COPD, Chronic obstructive pulmonary disease; CERT, COPD exacerbation recognition tool.

Performance for Recognizing COPD Exacerbations of the Q-CERT

Quantitative analysis using the ordinal Q-CERT scale revealed significantly higher scores in the AECOPD group compared to stable COPD controls (median [IQR]: 8 [6, 11] vs. 0 [0, 4] points; $P < 0.001$). Table S1 summarizes the sensitivity, specificity, and positive and negative predictive values for recognizing COPD exacerbations of the Q-CERT. ROC curve analysis demonstrated that Q-CERT exhibited excellent discriminative performance for recognizing exacerbations (AUC = 0.956, 95% CI: 0.937–0.976; $P < 0.001$). An optimal cutoff score of 5 maximized predictive efficacy, achieving a sensitivity of 89.4%, specificity of 83.8%, Youden's index of 0.732, positive predictive value of 87.3%, and negative predictive value of 86.5% (Figure 1; Table S1).

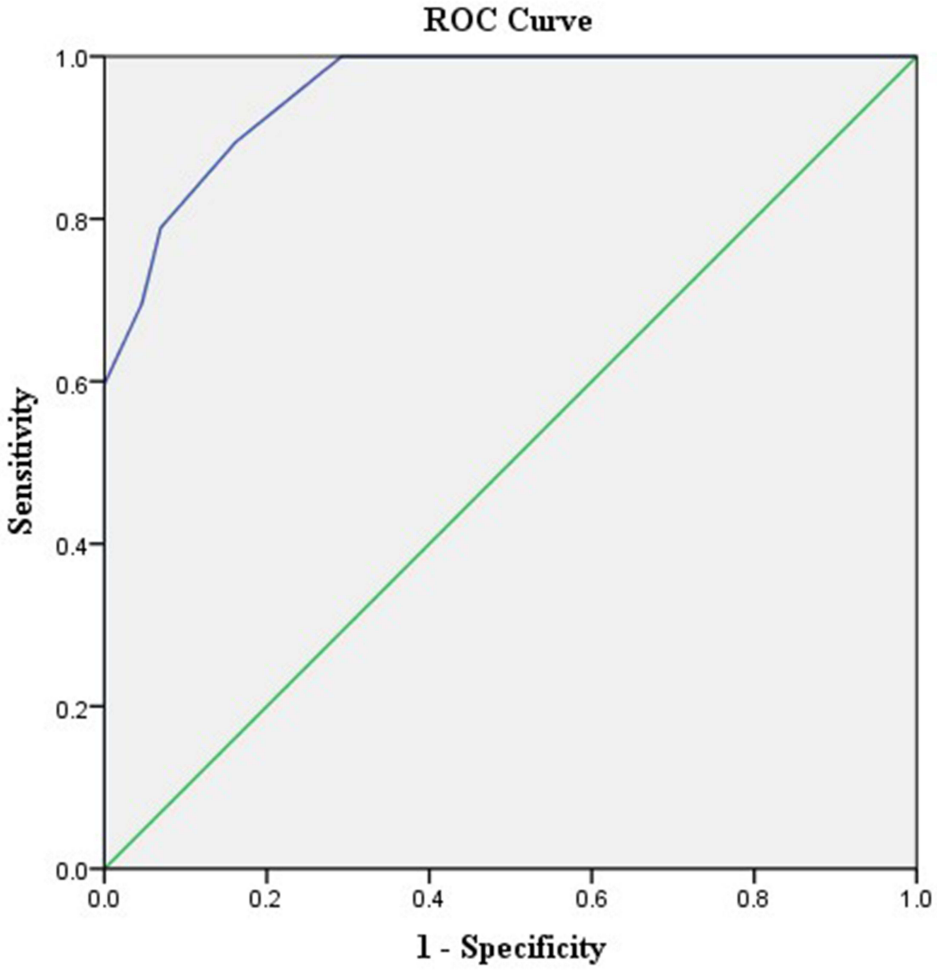

Figure 1 Receiver operating characteristic (ROC) curves of Q-CERT total score for recognizing COPD exacerbation. The solid blue line indicates the ROC curve of Q-CERT total score (AUC = 0.956). The solid green line represents the reference line.
Abbreviations: COPD, Chronic obstructive pulmonary disease; Q-CERT, Quantitative- COPD exacerbation recognition tool.

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Q-CERT Scores Correlate with Impaired Lung Function During AECOPD

Q-CERT total scores exhibited significant inverse correlations with all measured pulmonary function parameters in AECOPD patients (all $P<0.01$; Table 4). Stronger associations were observed with small airway metrics, particularly MEF75%pred (r=−0.406), MEF50%pred (r=−0.370) and MMEF%pred (r=−0.374), all $P<0.001$. Moderate correlations were found for FEV1/FVC (r=−0.356) and FEV1%pred (r= −0.388) (both $P < 0.001$), while weaker yet significant relationships existed for FVC%pred (r= −0.207, $P=0.008$) and MEF25%pred (r= −0.260, $P = 0.001$). These consistent negative correlations indicate that higher symptom burden quantified by Q-CERT was associated with worsening airflow limitation, especially in small airways.

Association Between Q-CERT Scores and Inflammatory During AECOPD

Inflammatory biomarker analysis revealed limited associations with Q-CERT scores in AECOPD patients (shown in Table 5). While most hematologic parameters showed no significant correlations, two systemic inflammatory indices demonstrated significant but weak correlations: NLR (r=0.181, $P=0.022$) and PLR (r =0.245, $P=0.002$), while lymphocyte counts showed a marginal inverse association (r=−0.158, $P=0.045$). Other inflammatory markers, including white

Table 4 Correlation Between Q-CERT Total Scores and Pulmonary Function Parameters in AECOPD Patients

Variables	Q-CERT Total Scores	
	r	*P* value
FEV1/FVC	−0.356	<0.001
FEV1%pred	−0.388	<0.001
FVC%pred	−0.207	0.008
PEF%pred	−0.358	<0.001
MMEF%pred	−0.374	<0.001
MEF75%pred	−0.406	<0.001
MEF50%pred	−0.370	<0.001
MEF25%pred	−0.260	0.001

Abbreviations: FEV1, Forced expiratory volume in one second; FVC, Forced vital capacity; PEF, Peak expiratory flow; MMEF, Maximum mid-expiratory flow; MEF75, Maximal expiratory flow at 75% of FVC; MEF50, Maximal expiratory flow at 50% of FVC; MEF25, Maximal expiratory flow at 25% of FVC; %pred, %predicted.

Table 5 Correlation Between Q-CERT Total Scores and Inflammatory Biomarkers in AECOPD Patients

Variables	Q-CERT Total Scores	
	r	*P* value
White blood cell count	0.007	0.927
Neutrophil count	0.056	0.480
Lymphocyte count	−0.158	0.045
Monocyte count	0.106	0.181
Eosinophil count	−0.036	0.650
NLR	0.181	0.022
PLR	0.245	0.002
CRP	0.076	0.349

Abbreviations: NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; CRP, C-reactive protein.

blood cell (r=0.007), neutrophils (r=0.056), eosinophils (r=−0.036) and CRP levels (r=0.076), showed no meaningful correlations with Q-CERT total scores (all $P > 0.05$).

Discussion

COPD remains one of the leading causes of mortality worldwide, with a core challenge in clinical management being the recognition of acute exacerbations. These exacerbations accelerate disease progression, increase healthcare costs and adversely affect patient prognosis.[6] The GOLD 2023 guidelines introduced important updates to the classification of disease assessment, replacing the previous ABCD grouping to the ABE grouping system.[16] Notably, patients with two or more moderate exacerbations or one hospitalization due to exacerbation in the past year are classified as "high-risk". This adjustment emphasizes the critical role of exacerbation risk assessment in guiding treatment strategies and reinforces the importance of exacerbation management within overall disease control. However, AECOPD is substantially underreported, with an estimated unreported rate ranging from 40% to 78% globally.[18,19] Various factors contribute to the underreporting of COPD exacerbations by patients, with a lack of awareness and understanding of the disease and severity of symptom deterioration being key reasons for this phenomenon. A survey conducted by Kessler et al revealed that only 1.6% of patients could accurately understand the medical definition of "acute exacerbation", and approximately one-third were unaware of their exacerbation events.[20] Therefore, improving patient awareness and developing more sensitive, simple, and practical tools to assist them in recognizing exacerbations are crucial for better disease management.

This study optimized and validated the CERT and its quantitative version, Q-CERT, to evaluate their predictive value for AECOPD in clinical practice. The results demonstrated that the CERT exhibits high efficacy, with sensitivity, specificity, and accuracy of 85.7%, 80.8%, and 83.5%, respectively. These performance metrics indicate robust diagnostic capability and are consistent with findings from previous studies,[15,21] confirming that CERT, as a symptom-based tool, effectively aids patients in recognizing AECOPD. Moreover, the quantitative version (Q-CERT) further enhanced the identification capacity for AECOPD, with an area under the curve (AUC) of 0.956, exhibiting superior sensitivity and specificity. This enhancement may be attributed to the fact that some patients with severe baseline symptoms exhibit reduced sensitivity to symptom changes during exacerbations, which the Q-CERT total score appears to capture this subgroup of patients. Differ from the original CERT, which uses a single threshold (moderate worsening of two or more items) to report AECOPD—potentially overlooking potential cases with mild multidimensional worsening—the Q-CERT incorporates a quantitative scoring system. This system replaces categorical judgments with a continuous score based on objective assessment of all core indicators. And the optimal total score threshold was determined using ROC curve analysis. At a cutoff value of 5, Q-CERT demonstrated excellent discriminative performance with a sensitivity of 89.4% and specificity of 83.8%. This indicates that Q-CERT is more adept at capturing symptom variations associated with AECOPD,[16] especially in scenarios where individual patient responses may differ. These findings offer an effective tool readily applicable to clinical practice for standardizing AECOD identification, as well as a clear and actionable threshold for healthcare providers.

Secondly, the inverse correlation between Q-CERT scores and pulmonary function parameters further supports its clinical relevance. Specifically, Q-CERT scores showed negative correlations with FEV1%pred, FEV1/FVC, and PEF% pred. This aligns with the conclusions drawn by Le Rouzic et al, who identified FEV1%pred <50% as an independent risk factor for predicting future frequent AEs.[22] Bae, J et al also reported that each 10% decrease in FEV1% predicted was associated with a 23.4% increase in the risk of moderate-to-severe AEs.[23] These findings suggest that higher Q-CERT scores may reflect more severe airway obstruction. This aligns with the pathophysiological mechanisms of AECOPD, where AEs are often accompanied by intensified airway inflammation and mucus production, leading to acute deterioration in lung function. Additionally, Q-CERT scores were significantly negatively correlated with parameters reflecting small airway function, including MMEF%pred, MEF75%pred, and MEF50%pred. As small airways are typically the initial site of pathology in COPD, their dysfunction often precedes a significant decline in FEV1.[24,25] Results from the multinational study (BOLD) have shown that small airway dysfunction is significantly associated with an increased risk of respiratory symptoms.[26] These findings suggest that Q-CERT, by quantifying symptom burden, indirectly reflects the degree of pulmonary function impairment and disease severity, further underscoring its potential value in the clinical evaluation of AECOPD.

Furthermore, inflammation is one of the key mechanisms in the pathogenesis of COPD. Compared to stable COPD patients, those experiencing AEs exhibit significantly higher levels of airway and systemic inflammation. NLR and PLR are low-cost, easily accessible markers that reflect systemic inflammation and have been shown in multiple studies to be closely associated with the occurrence of AECOPD. For instance, Yao et al analyzed clinical data from 303 AECOPD patients and found that the combination of NLR and PLR with CRP significantly increased the sensitivity for predicting AECOPD mortality.[27] NLR is also closely correlated with the clinical condition of COPD patients. Research has shown that in COPD patients, NLR is positively correlated with the severity of emphysema and the modified Medical Research Council (mMRC) dyspnea score, and NLR levels are significantly elevated during exacerbations.[28]

Notably, emerging evidence has highlighted the critical role of infectious factors, particularly viral infections, in exacerbating systemic inflammation and influencing clinical outcomes in COPD. A retrospective study demonstrated that, among patients with COVID-19, the presence of COPD was associated with a significantly increased risk of mortality and prolonged recovery time,[29] suggesting that infection-related inflammatory responses may further amplify systemic inflammatory burden and worsen clinical outcomes. Similarly, Hassan et al reported that, in COPD patients, lower respiratory tract infection was significantly associated with increased mortality risk,[30] which is closely linked to enhanced inflammatory responses. These findings indicate that systemic inflammation in COPD patients is not solely driven by the underlying disease but may be further exacerbated by external factors such as infections, leading to an amplified inflammatory state. This mechanism is consistent with our findings, in which the Q-CERT score was positively correlated with NLR and PLR. Therefore, an elevated Q-CERT score may reflect a heightened inflammatory status, and this association may be more pronounced in the context of infection or acute exacerbation. In primary healthcare settings, the combined use of the Q-CERT score with routine inflammatory markers such as NLR and PLR may provide a more comprehensive and practical approach for the early identification of AECOPD and the assessment of inflammatory burden. This integrated strategy reduces reliance on single biomarkers and improves risk stratification accuracy in complex clinical scenarios, such as coexisting infections, thereby facilitating optimized clinical decision-making and improved patient outcomes.

The limitations of this study should be acknowledged. First, this was a single-center exploratory study, given the heterogeneity in patients' clinical conditions and disease courses in real-world practice, our findings may not encompass all specific scenarios. External validation in more diverse, multicenter and larger patient cohorts is warranted to further confirm the generalizability and robustness of Q-CERT. Second, while this study preliminarily demonstrated the value of Q-CERT in identifying AECOPD, future research incorporating prospective follow-up data could assess its predictive ability for acute exacerbation recurrence risk or readmission rates. Such efforts would substantially enhance the clinical utility of the tool and strengthen its role in the dynamic management of COPD. Lastly, the association between Q-CERT, NLR, and PLR suggests that this tool may capture specific inflammatory response states. Subsequent studies could build on this by exploring the combination of Q-CERT with more diverse biomarkers (eg., cytokines, microbiomes) to develop a more precise "clinical-biological" integrated assessment framework.

Conclusion

In summary, both CERT and Q-CERT demonstrate high sensitivity and specificity for identifying AECOPD. As a simple and easy-to-use tool, Q-CERT not only effectively assists patients (especially in primary care settings) to recognize AECOPD, but also enhances the self-management capabilities of individuals with COPD, thereby improving overall treatment outcomes. These findings support the integration of Q-CERT into routine clinical practice.

Data Sharing Statement

Researchers interested in collaboration and further information are invited to contact the corresponding author XJZ (zhangxiaoju@zzu.edu.cn).

Ethics Statement

This study was conducted in compliance with the Declaration of Helsinki. This study was approved by the Ethics Review Committee of Henan Provincial People's Hospital (No. 2022042). Participates gave informed consent to participate in the study before taking part.

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

Professor Paul Jones is part time contractor for GlaxoSmithKline, outside the submitted work. the authors report no conflicts of interest in this work.

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