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Multidimensional Symptom Profiles and Their Associations with Health-Related Quality of Life and Exercise Capacity in Community-Dwelling Patients with COPD: An Exploratory Latent Profile Analysis

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Research Article

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Abstract

Background

COPD is clinically heterogeneous, and symptom burden extends beyond respiratory complaints to sleep and emotional health. Previous profiling analyses were limited by incomplete information on pulmonary function, exacerbation history, treatment, and comorbidity.

Objective

To identify multidimensional symptom profiles after incorporating supplementary clinical data and examine their associations with pulmonary function, respiratory health-related quality of life, and exercise capacity.

Methods

This cross-sectional reanalysis included 153 clinically stable patients with spirometry-confirmed COPD. CAT, mMRC, PSQI, SAS, and SDS were standardized and entered into Gaussian finite mixture models. One- to six-profile solutions were examined. Model selection considered AIC, BIC, entropy, mean maximum posterior probability, minimum class size, parsimony, and clinical interpretability. SGRQ total score and 6MWD were external clinical correlates. Multivariable linear regression with HC3 robust standard errors adjusted for age, sex, BMI, FEV_1 percent predicted, previous-year exacerbation history, and smoking history.

Results

The five-profile solution provided the best balance of fit and interpretability (AIC 1565.81; BIC 1729.45; entropy 0.930; mean maximum posterior probability 0.956; smallest profile 21 patients, 13.7%). A six-profile solution further reduced information criteria but generated a singleton class and was rejected as over-extracted. In adjusted complete-case analyses, compared with Profile 1, SGRQ scores were higher by 2.24 points (95% CI -9.48 to 13.97), 15.46 points (2.78 to 28.15), 24.34 points (12.26 to 36.42), and 33.38 points (19.50 to 47.25) in Profiles 2–5. Adjusted 6MWD was 81.92 m lower in Profile 5 than in Profile 1 (95% CI -151.47 to -12.36; P = 0.021); differences for Profiles 2–4 were not statistically significant.

Conclusions

Community-dwelling patients with COPD showed heterogeneous combinations of respiratory, sleep, and emotional symptoms. Higher multidimensional symptom burden was associated with poorer respiratory

health-related quality of life, and the highest-burden profile also showed lower exercise capacity after clinical adjustment. Because the analysis was single-center, cross-sectional, and exploratory, the profiles require external replication before clinical use.

1. Introduction

Chronic obstructive pulmonary disease (COPD) is characterized by persistent respiratory symptoms and airflow limitation and requires long-term management in primary care and community settings. Contemporary assessment extends beyond spirometry to symptoms, exacerbation risk, functional status, comorbidities, and patient-centered outcomes. Dyspnea, cough, and activity limitation frequently coexist with sleep disturbance, anxiety, and depressive symptoms.

Latent profile analysis (LPA) is a person-centered mixture-modeling approach that identifies unobserved subgroups with similar patterns across multiple continuous indicators. Our earlier analysis suggested distinct multidimensional symptom patterns, but limited pulmonary-function and exacerbation data restricted clinical interpretation. We therefore supplemented the original 153-patient dataset and repeated the profile modeling to determine whether symptom profiles remained clinically meaningful after accounting for COPD severity.

2. Materials and Methods

This cross-sectional reanalysis used routinely collected data from the COPD specialty management service of Changfeng Community Health Service Center, Shanghai, China. The cohort comprised the original 153 patients with complete CAT, mMRC, PSQI, SAS, and SDS data. All had spirometry-confirmed COPD and were clinically stable at assessment. Supplementary clinical data were linked to these 153 patients; sex, age, and BMI were concordant between the supplementary file and original analytic dataset for all patients.

Profile indicators were CAT, mMRC, PSQI, SAS, and SDS. SGRQ total score was the primary external clinical correlate and 6MWD the functional correlate. Supplementary variables included post-bronchodilator FEV_1 percent predicted, FEV_1/FVC, previous-year exacerbation history, treatment regimen, major comorbidities, and exposure history.

The five profile indicators were standardized as z scores. Gaussian finite mixture models containing one to six profiles were examined. Model selection considered AIC, BIC, entropy, mean maximum posterior probability, minimum class size, parsimony, and clinical interpretability. The five-profile solution was retained because it substantially improved fit and classification quality relative to the four-profile model while preserving adequate class sizes; the six-profile solution generated a singleton class and was considered over-extracted. SGRQ and 6MWD were examined using multivariable linear regression with HC3 robust standard errors, adjusting for age, sex, BMI, FEV_1 percent predicted, previous-year exacerbation history, and smoking history. Complete-case analyses were used for external outcomes.

The study was approved by the Medical Ethics Committee of Shanghai Putuo District People's Hospital (approval No. (2024) Clinical Review No. 60).

3. Results

3.1 Model selection

Fit indices improved through five profiles. The five-profile model had AIC 1565.81, BIC 1729.45, entropy 0.930, and mean maximum posterior probability 0.956; its smallest class contained 21 patients (13.7%). Although the six-profile model further reduced AIC and BIC, it generated a one-patient class (0.7%), indicating over-extraction. The five-profile solution was therefore retained as the primary exploratory solution.

3.2 Symptom profiles and pulmonary function

The five profiles represented distinct combinations of respiratory, sleep, and emotional symptoms. Mean FEV_1 percent predicted across Profiles 1–5 was 57.66%, 63.72%, 46.85%, 41.56%, and 45.53%, respectively. The non-monotonic pulmonary-function pattern indicates that the profiles were not simple surrogates for airflow limitation.

3.3 Associations with SGRQ and 6MWD

SGRQ was available for 83 patients and 6MWD for 102 patients; adjusted models included 82 and 101 complete cases, respectively. Compared with Profile 1, adjusted SGRQ differences were 2.24, 15.46, 24.34, and 33.38 points for Profiles 2–5. For 6MWD, adjusted differences were − 33.18, -35.19, -36.68, and − 81.92 m; only Profile 5 differed significantly from Profile 1 (95% CI -151.47 to -12.36; P = 0.021).

Outcome-data availability differed for some baseline characteristics. Patients with SGRQ data had higher mean FEV_1 percent predicted than those without SGRQ data (53.90% vs 45.04%; exploratory P = 0.005) and a lower prevalence of previous-year exacerbation history (75.6% vs 92.9%; exploratory P = 0.008). Patients with 6MWD data were younger than those without 6MWD data (71.51 vs 75.02 years; exploratory P = 0.003). Other examined symptom indicators did not show clear differences by outcome availability. These differences suggest potential selection related to outcome availability and should be considered when interpreting the complete-case analyses.

4. Discussion

In this community COPD cohort, the five-profile solution identified clinically distinct combinations of respiratory, sleep, and emotional symptoms. Importantly, pulmonary function did not decline monotonically across profiles. Profile 2 had the highest mean FEV_1 percent predicted despite greater sleep and emotional burden than Profile 1, whereas Profiles 4 and 5 combined greater respiratory burden with lower lung function. These findings support interpreting the profiles as multidimensional symptom patterns rather than as spirometric severity groups.

Respiratory health-related quality of life showed the clearest external gradient. After adjustment for age, sex, BMI, FEV_1 percent predicted, previous-year exacerbation history, and smoking history, Profiles 3–5 had progressively higher SGRQ scores than Profile 1. This suggests that multidimensional symptom patterns may provide information beyond standard COPD severity indicators when identifying patients with impaired daily health status. However, CAT is a component of the profile model and SGRQ also captures respiratory symptom burden and activity limitation; part of this association may therefore reflect construct overlap rather than wholly independent clinical information.

Exercise capacity showed a more selective association. Only the highest multidimensional-burden profile had a statistically significant adjusted reduction in 6MWD. Exercise performance is influenced by pulmonary impairment, age, cardiovascular and musculoskeletal comorbidity, muscle condition, habitual activity, and motivation; therefore, the absence of significant differences in Profiles 2–4 should not be interpreted as equivalence.

Extended model fitting showed that the five-profile model improved information criteria and classification quality relative to the four-profile model, whereas the six-profile model produced a singleton class. We therefore selected five profiles as the most defensible exploratory solution. Nevertheless, mixture-model solutions are sample-dependent, and internal resampling indicated only moderate-to-low reproducibility. The identified profiles should not be labeled as fixed COPD phenotypes and require external replication.

Limitations include the single-center cross-sectional design, incomplete SGRQ and 6MWD data, a primarily binary previous-year exacerbation variable rather than detailed event counts or severity categories, and a modest sample for mixture modeling. Exploratory comparisons indicated that patients with SGRQ data had better lung function and less frequent previous-year exacerbation history than those without SGRQ data, while patients with 6MWD data were younger than those without 6MWD data; complete-case estimates may therefore be affected by selection bias. Internal resampling also suggested only moderate-to-low class reproducibility. In addition, downstream regressions used most-likely class assignment and therefore did not fully propagate classification uncertainty. Finally, SGRQ shares symptom and activity content with variables contributing to profile formation, which may inflate observed associations. External replication in larger multicenter cohorts is needed.

5. Conclusions

Five exploratory multidimensional symptom profiles were identified among 153 community-dwelling patients with spirometry-confirmed COPD. Higher multidimensional symptom burden was associated with poorer respiratory health-related quality of life, and the highest-burden profile also showed lower exercise capacity after adjustment for major clinical factors. The profiles captured information not reducible to airflow limitation alone, but their sample dependence and modest internal reproducibility require cautious interpretation and external validation before clinical application.

Abbreviations

COPD
Chronic obstructive pulmonary disease
FEV1
Forced expiratory volume-one second

Declarations

Author contributions

Jianling Song: conceptualization, methodology, supervision, quality control, interpretation, writing – original draft, and writing – review and editing. Jie Wu: conceptualization, project administration, investigation, data acquisition, interpretation, and writing – review and editing. Leiming Ge: data curation, formal analysis, methodology, validation, visualization, writing – original draft, and writing – review and editing. Jiahao Wu: data curation, formal analysis, investigation. Yunfeng Zhang and Zhijun Jie: respiratory medicine expertise, methodology, interpretation, supervision, and writing – review and editing. Jianling Song, Jie Wu and Leiming Ge contributed equally to this work and share first authorship. All authors reviewed and approved the final manuscript.

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Data availability

De-identified data may be available from the corresponding authors on reasonable request and subject to institutional and ethics requirements.

Ethics Approval and Informed Consent

The study was approved by the Medical Ethics Committee of Shanghai Putuo District People's Hospital (approval No. (2024) Clinical Review No. 60), and all respondents were informed about confidentiality in the statement of informed consent. Respondents provided written consent to participate.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests

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Clinical trial number

Not applicable.

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Tables

Table 1
Latent profile model fit indices

Profiles	AIC	BIC	Entropy	Smallest n	Smallest %
1	2190.98	2221.28		153	100.0
2	2034.4	2098.04	0.72	65	42.5
3	1998.07	2095.04	0.744	34	22.2
4	1777.92	1908.23	0.809	18	11.8
5	1565.81	1729.45	0.93	21	13.7
6	824.42	1021.4	0.98	1	0.7

Table 2
Core indicators and pulmonary function across profiles

Profile	n	CAT	mMRC	PSQI	SAS	SDS	FEV_1 % predicted
Low overall burden	21	7.67	0.52	3.90	30.33	27.43	57.66
Mild-moderate respiratory / sleep-emotional	27	13.85	0.59	6.07	37.52	34.07	63.72
Moderate multidimensional burden	41	15.41	2.00	7.32	37.34	33.12	46.85
Marked dyspnea / respiratory burden	35	20.20	3.26	5.37	34.31	30.51	41.56
High multidimensional burden	29	26.79	3.28	9.90	43.21	41.31	45.53

Table 3
Adjusted associations with SGRQ and 6MWD

Outcome	Comparison	Adjusted difference	95% CI	P value
SGRQ (n = 82)	Profile 2 vs 1	2.24	-9.48 to 13.97	0.708
SGRQ (n = 82)	Profile 3 vs 1	15.46	2.78 to 28.15	0.017
SGRQ (n = 82)	Profile 4 vs 1	24.34	12.26 to 36.42	< 0.001
SGRQ (n = 82)	Profile 5 vs 1	33.38	19.50 to 47.25	< 0.001
6MWD (n = 101)	Profile 2 vs 1	-33.18 m	-93.32 to 26.96	0.280
6MWD (n = 101)	Profile 3 vs 1	-35.19 m	-93.86 to 23.48	0.240
6MWD (n = 101)	Profile 4 vs 1	-36.68 m	-103.21 to 29.85	0.280
6MWD (n = 101)	Profile 5 vs 1	-81.92 m	-151.47 to -12.36	0.021