

Original Article

Association Between Rehabilitation Access Barriers, Treatment Adherence, and Functional Status Among Patients With COPD in Lahore, Pakistan: An Analytical Cross-Sectional Study

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ABSTRACT

Background: Pulmonary rehabilitation is an established component of chronic obstructive pulmonary disease (COPD) care, but logistical, financial, and symptom-related barriers may limit participation. **Objective:** To examine associations among rehabilitation access barriers, treatment adherence, and functional status in adults with COPD. **Methods:** An analytical cross-sectional study was conducted over six months at Ashraf Medical Centre, Sargodha, Pakistan. Sixty-two adults with COPD were selected using purposive sampling. Access burden was recorded using a research-developed 10-item score (0–30). Rehabilitation initiation and attendance, London Chest Activity of Daily Living (LCADL) score, six-minute walk distance (6MWD), and COPD Assessment Test (CAT) score were assessed. Spearman correlations, group comparisons, and exploratory multivariable regression were undertaken. **Results:** Rehabilitation was prescribed to 41/62 (66.1%) participants, of whom 27/41 (65.9%) initiated it. Mean attendance among prescribed participants was $45.0 \pm 36.6\%$. Barrier scores were higher among non-initiators than initiators (18.50 ± 3.16 vs 12.63 ± 4.35 ; $p < 0.001$). Higher barrier scores correlated with lower attendance ($\rho = -0.733$; $p < 0.001$). After adjustment for age, FEV₁ percentage predicted, and dyspnea, each five-point increase in barrier score was associated with lower odds of initiation (adjusted odds ratio 0.18; 95% CI 0.05–0.64; $p = 0.008$). Unadjusted relationships between barriers and functional outcomes were attenuated in adjusted linear models. **Conclusion:** Greater reported access burden was associated with poorer rehabilitation uptake and attendance. Associations with functional status were largely explained by measured clinical severity indicators and require cautious interpretation. **Keywords:** Chronic obstructive pulmonary disease; pulmonary rehabilitation; access barriers; treatment adherence; functional capacity; health services accessibility.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is associated with persistent respiratory symptoms, reduced exercise tolerance, and restrictions in everyday activities. Pulmonary rehabilitation is recommended as an integral element of COPD management because structured exercise, education, and behavior-change support can improve exercise performance, dyspnea, and health-related quality of life (1). A recent component network meta-analysis further supports the value of appropriately designed rehabilitation programmes, while a separate systematic review found improvements among patients with severe and very severe COPD (2,3). These benefits depend partly on whether eligible patients can access and engage with rehabilitation services.

Despite strong clinical recommendations, pulmonary rehabilitation remains substantially underused. Barriers occur at several stages, including referral, first attendance, programme completion, and subsequent home activity. Rochester identified interactions among patient circumstances, geography, social conditions, clinical symptoms, and the organisation of services (4). Watson and colleagues found persistent shortcomings in interventions intended to improve referral, uptake, and adherence, while real-world assessments confirm incomplete enrolment and completion among people with COPD (5,6). Consequently, the number of patients receiving a recommendation for rehabilitation should not be confused with the number actually beginning or attending prescribed sessions.

Access is not distributed equally. A systematic review of equity in rehabilitation delivery has highlighted the relevance of social determinants of health (7). Geographic analyses have shown how service location can constrain access, and

qualitative work in a rural Indian setting described limited service availability and practical difficulties in reaching appropriate care (8,9). Such findings are particularly relevant to settings in which repeated travel, direct expenditure, and informal support arrangements affect the feasibility of attending supervised rehabilitation.

Patient perspectives add further complexity. Qualitative research has described physical symptoms, low motivation, financial constraints, and organisational factors as obstacles to pulmonary rehabilitation (10). A mixed-methods synthesis also identifies both barriers and facilitators that influence participation (11). Primary-care referral studies have shown that decisions and communication by healthcare professionals contribute to uptake, while reviews of care disparities have documented inequalities across the COPD treatment pathway (12,13).

Adherence itself is a multidimensional outcome. Patients may receive a prescription but never initiate rehabilitation, may start yet attend few sessions, or may undertake prescribed activity at home without participating regularly in supervised sessions. Studies of home-based nonadherence and observed rehabilitation participation indicate that clinical and social characteristics may accompany these different engagement patterns (14,15). Furthermore, individuals with more severe dyspnea may experience both greater perceived barriers and worse functional performance, complicating interpretation of unadjusted associations.

Evidence linking self-reported rehabilitation barriers, actual session attendance, and multiple complementary measures of functional status remains limited in the local clinical context. The present study examined the association of rehabilitation access burden with initiation and attendance and evaluated the relationships of barriers and adherence with dyspnea-related activities of daily living, walking capacity, and COPD-related health status among adults receiving care at Ashraf Medical Centre, Sargodha, Pakistan.

MATERIALS AND METHODS

An analytical cross-sectional observational study was undertaken over a six-month period at Ashraf Medical Centre, Sargodha, Pakistan. The study included 62 adult patients with COPD identified through purposive sampling. Each participant contributed a single observational record to the analytical dataset. Relevant clinical characteristics and rehabilitation-related variables were evaluated at the study assessment; the six-month period represented study conduct rather than repeated participant-level measurement. Written informed consent was obtained from participants, and ethical approval was provided by Ashraf Medical Centre, Sargodha, Pakistan.

The dataset included age, gender, educational attainment, employment status, urban or rural residence, duration of COPD, body mass index, forced expiratory volume in one second (FEV_1) expressed as percentage of predicted, number of exacerbations during the previous 12 months, modified Medical Research Council (mMRC) dyspnea grade, and oxygen use. Rehabilitation access variables included whether rehabilitation had been prescribed and initiated, distance to the rehabilitation service in kilometres, one-way travel time in minutes, reported travel expense in Pakistani rupees, and a composite barrier burden score. The research-developed barrier score summed ten items rated from zero to three and ranged from 0 to 30, with larger values representing greater perceived barriers. This locally developed score was treated as an exploratory measure rather than a previously validated instrument.

For patients prescribed supervised rehabilitation, the number of sessions prescribed and attended was recorded. Attendance was calculated as 100 multiplied by attended sessions divided by prescribed sessions. Participants prescribed rehabilitation who attended no sessions were assigned 0% attendance; session denominators and attendance percentages were not assigned to participants without a rehabilitation prescription. Recorded reasons for missed sessions were coded as none, cost, transport, symptoms, time, or other. Prescription of home exercise and number of days of home exercise during the preceding week were recorded separately, with home-exercise frequency applicable only to those who had received a home-exercise prescription.

COPD-related health status was represented by the COPD Assessment Test (CAT), scored from 0 to 40, with higher scores indicating greater disease impact; the instrument was developed and validated by Jones and colleagues (16). Functional limitation attributable to breathlessness during activities of daily living was measured using the 15-item London Chest Activity of Daily Living (LCADL) scale, with total scores from 0 to 75 and higher scores indicating greater limitation (17). Functional exercise performance was expressed as the distance walked in six minutes, in metres (6MWD), an established field-walking outcome in chronic respiratory disease (18). The mMRC score was used to describe breathlessness severity and to account for important clinical differences in multivariable analysis.

All 62 participant records were evaluated for duplicate observations, coding-range inconsistencies, applicability of conditional fields, and agreement of recorded attendance percentages with calculated values. Descriptive analyses included frequencies with percentages for categorical variables and mean $\pm$ standard deviation or median with interquartile range for quantitative measurements. Rehabilitation initiation was assessed among participants with a rehabilitation prescription. The Mann–Whitney U test was used for exploratory comparisons of continuous and ordinal variables between initiators and non-initiators. Spearman's rank correlation coefficient described bivariate relationships among barrier burden, attendance, and functional outcomes. Seven primary correlation tests spanning barrier burden and functional status or attendance, and attendance and functional status, were also evaluated using the Benjamini–Hochberg false-discovery-rate procedure. Multivariable logistic regression examined the association between a five-point increase in barrier burden and rehabilitation initiation, adjusting for age, FEV₁ percentage predicted, and mMRC dyspnea grade. Separate ordinary least-squares models with heteroskedasticity-robust (HC3) standard errors evaluated associations of barrier burden with LCADL, 6MWD, and CAT after adjustment for the same variables. Attendance percentage was also modelled among participants prescribed rehabilitation. Associations are reported with 95% confidence intervals and two-sided p-values. IBM SPSS Statistics version 26.0 was the designated study analysis software; participant-level derived analyses and estimates were independently checked using reproducible statistical calculations. Reporting was assessed against the STROBE recommendations for observational research (19).

RESULTS

The analytical dataset included 62 adults with COPD and contained no exact duplicate records. Mean age was 64.48 $\pm$ 9.39 years; 44 (71.0%) participants were male, 17 (27.4%) were female, and one (1.6%) was recorded in the other gender category. Forty-two (67.7%) lived in urban areas. Mean COPD duration was 8.20 $\pm$ 3.64 years, mean FEV₁ percentage predicted was 47.74 $\pm$ 13.80%, and mean mMRC dyspnea grade was 1.74 $\pm$ 1.07. Mean LCADL, 6MWD, and CAT values were 22.65 $\pm$ 8.09, 385.00 $\pm$ 92.46 m, and 15.76 $\pm$ 7.36, respectively (Table 1).

Rehabilitation had been prescribed to 41 participants (66.1%), while 21 (33.9%) had no rehabilitation prescription. Among those prescribed rehabilitation, 27 (65.9%) had started and 14 (34.1%) had not started. Mean attendance in the prescribed group was 45.05 $\pm$ 36.59%; among participants who initiated rehabilitation, mean attendance was 68.41 $\pm$ 20.01%. All 21 records lacking session counts and attendance percentages corresponded to participants without a rehabilitation prescription. Home exercise was prescribed to 37 (59.7%) participants, who reported a mean of 3.84 $\pm$ 1.38 exercise days in the previous week (Table 2 and Figure 1).

Among participants prescribed rehabilitation, those who had not started had higher barrier scores than those who had started (18.50 $\pm$ 3.16 versus 12.63 $\pm$ 4.35; $p < 0.001$). Non-initiators reported greater service distance (19.72 $\pm$ 7.98 versus 11.84 $\pm$ 6.65 km; $p = 0.004$), travel time (57.79 $\pm$ 14.69 versus 38.78 $\pm$ 14.54 minutes; $p < 0.001$), and travel expense (PKR 971.43 $\pm$ 346.81 versus 655.56 $\pm$ 328.85; $p = 0.012$). Non-initiators also had higher CAT scores (19.64 $\pm$ 6.70 versus 13.11 $\pm$ 7.14; $p = 0.005$). Differences in LCADL and 6MWD between the two groups were not statistically significant (Table 3).

Table 1. Demographic, clinical, and functional characteristics (n=62)

Characteristic	Value
Age, years	64.48 $\pm$ 9.39
Male	44 (71.0%)
Female	17 (27.4%)
Other gender	1 (1.6%)
Urban residence	42 (67.7%)
Rural residence	20 (32.3%)
COPD duration, years	8.20 $\pm$ 3.64
Body mass index, kg/m ²	24.29 $\pm$ 3.90
FEV ₁ , % predicted	47.74 $\pm$ 13.80
Exacerbations in preceding year	0.90 $\pm$ 1.05
mMRC dyspnea grade	1.74 $\pm$ 1.07
Oxygen use	18 (29.0%)
Access barrier total, 0–30	14.10 $\pm$ 4.76
Distance to rehabilitation service, km	13.76 $\pm$ 8.05
Travel time, minutes	44.48 $\pm$ 17.92
Travel expense, PKR	758.87 $\pm$ 368.71
LCADL total	22.65 $\pm$ 8.09
Six-minute walk distance, m	385.00 $\pm$ 92.46
CAT total	15.76 $\pm$ 7.36

Barrier burden was inversely associated with attendance among prescribed participants (Spearman $\rho = -0.733$, $p < 0.001$). The barrier score correlated positively with CAT score ($\rho = 0.405$, $p = 0.001$) and LCADL ($\rho = 0.272$, $p = 0.033$), and negatively

with 6MWD ($\rho=-0.376$, $p=0.003$). Among prescribed participants, greater attendance correlated with lower CAT score ($\rho=-0.403$, $p=0.009$), whereas attendance correlations with LCADL ($\rho=-0.187$, $p=0.242$) and 6MWD ($\rho=0.133$, $p=0.408$) were not statistically significant. Associations between distance and attendance ($\rho=-0.546$, $p<0.001$) and travel cost and attendance ($\rho=-0.512$, $p<0.001$) were also observed (Table 4).

In multivariable logistic regression, each five-point increment in barrier burden was associated with substantially lower odds of rehabilitation initiation (adjusted odds ratio 0.18; 95% CI 0.05–0.64; $p=0.008$), conditional on age, FEV₁ percentage predicted, and mMRC dyspnea. Among participants prescribed rehabilitation, adjusted linear regression estimated a 4.94-percentage-point lower attendance rate per one-point higher barrier score (95% CI –7.69 to –2.18; $p<0.001$). By contrast, adjusted barrier coefficients were not statistically distinguishable from zero for LCADL, 6MWD, or CAT (Table 5). In these models, higher mMRC dyspnea grade remained independently associated with greater LCADL limitation, shorter walking distance, and higher CAT score.

Table 2. Rehabilitation prescription, initiation and attendance

Measure	Value
Rehabilitation prescribed	41/62 (66.1%)
Rehabilitation not prescribed	21/62 (33.9%)
Initiated among those prescribed	27/41 (65.9%)
Did not initiate among those prescribed	14/41 (34.1%)
Attendance, prescribed group, %	45.05 ± 36.59
Attendance, initiators only, %	68.41 ± 20.01
Home exercise prescribed	37/62 (59.7%)
Home-exercise days among those prescribed, days/7	3.84 ± 1.38
Missed-session reason: cost	11/41 (26.8%)
Missed-session reason: transport	10/41 (24.4%)
Missed-session reason: symptoms	9/41 (22.0%)
Missed-session reason: time	5/41 (12.2%)
Missed-session reason: other	4/41 (9.8%)
Missed-session reason: none	2/41 (4.9%)

Table 3. Comparison according to rehabilitation initiation among prescribed participants (n=41)

Variable	Initiated (n=27)	Not initiated (n=14)	p-value
Age, years	64.37 ± 8.67	64.57 ± 8.85	0.934
FEV ₁ , % predicted	49.24 ± 13.89	43.64 ± 12.71	0.187
mMRC dyspnea grade	1.41 ± 1.08	2.29 ± 0.99	0.027
Barrier score, 0–30	12.63 ± 4.35	18.50 ± 3.16	<0.001
Distance, km	11.84 ± 6.65	19.72 ± 7.98	0.004
Travel time, minutes	38.78 ± 14.54	57.79 ± 14.69	<0.001
Travel cost, PKR	655.56 ± 328.85	971.43 ± 346.81	0.012
LCADL total	21.15 ± 8.11	24.79 ± 8.40	0.168
6MWD, m	389.44 ± 95.66	379.29 ± 81.05	0.660
CAT total	13.11 ± 7.14	19.64 ± 6.70	0.005

Table 4. Spearman correlation analyses

Exposure	Outcome	n	Spearman ρ	p-value	FDR q-value
Barriers	Attendance percentage	41	–0.733	<0.001	<0.001
Barriers	LCADL total	62	0.272	0.033	0.046
Barriers	Six-minute walk distance	62	–0.376	0.003	0.006
Barriers	CAT total	62	0.405	0.001	0.004
Attendance percentage	LCADL total	41	–0.187	0.242	0.282
Attendance percentage	Six-minute walk distance	41	0.133	0.408	0.408
Attendance percentage	CAT total	41	–0.403	0.009	0.016

Table 5. Exploratory adjusted regression analyses

Outcome	Barrier effect estimate (95% CI)	p-value	Model R ²
Rehabilitation initiation, aOR per 5 barrier points	0.18 (0.05 to 0.64)	0.008	—
Attendance %, β per 1 barrier point	–4.94 (–7.69 to –2.18)	<0.001	0.494
LCADL total, β per 1 barrier point	–0.15 (–0.53 to 0.23)	0.443	0.418
Six-minute walk distance, metres, β per 1 point	–0.53 (–4.73 to 3.67)	0.806	0.548
CAT total, β per 1 barrier point	–0.09 (–0.37 to 0.18)	0.496	0.688

Table notes: Continuous data are mean ± standard deviation unless otherwise indicated. Table 3 p-values are from two-sided Mann–Whitney U tests. Table 4 false-discovery-rate q-values were derived by Benjamini–Hochberg adjustment of the seven tabulated correlation tests. Table 5 estimates were adjusted for age, FEV₁ percentage predicted, and mMRC dyspnea grade; linear models used HC3 heteroskedasticity-robust confidence intervals. Logistic regression results are odds ratios rather than regression coefficients. The barriers measure is research-developed and has not been independently validated in the analyzed.

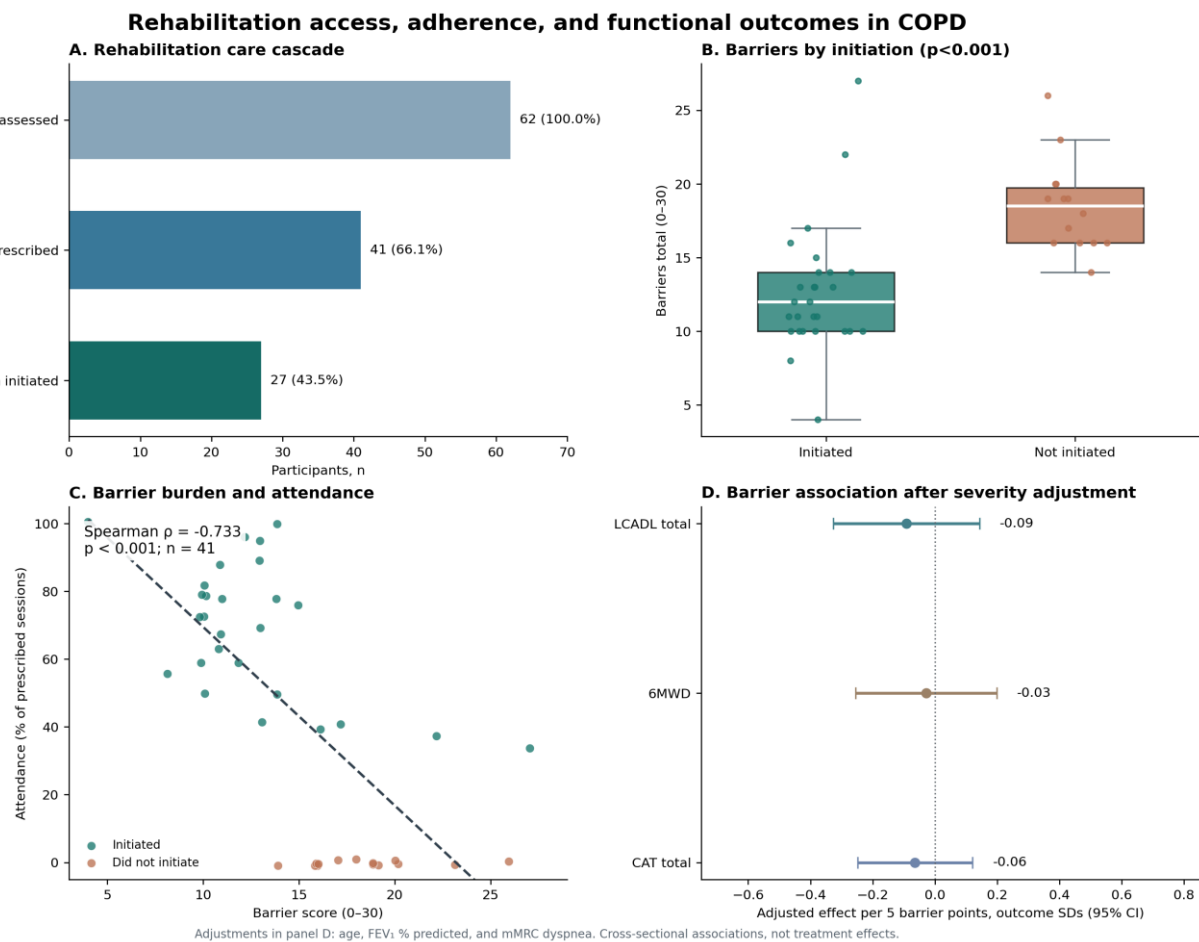


Figure 1 illustrates the attrition from prescription to initiation, higher observed barrier scores among non-initiators, and the strong inverse association between barrier burden and attendance.

The figure illustrates rehabilitation access, treatment adherence, and functional outcomes among 62 patients with chronic obstructive pulmonary disease (COPD). Of the 62 participants assessed, 41 (66.1%) were prescribed pulmonary rehabilitation, while only 27 (43.5%) initiated treatment, indicating a substantial gap between rehabilitation prescription and uptake (Panel A). Patients who did not initiate rehabilitation demonstrated significantly higher access-barrier scores than those who initiated treatment ($p < 0.001$), with median scores of approximately 19 and 12, respectively (Panel B). Among participants prescribed rehabilitation ($n = 41$), higher barrier scores were strongly associated with lower treatment adherence, measured as the percentage of prescribed sessions attended (Spearman's $\rho = -0.733$, $p < 0.001$), suggesting that greater perceived barriers were associated with reduced rehabilitation participation (Panel C). However, after adjustment for age, FEV₁ percentage predicted, and modified Medical Research Council (mMRC) dyspnea grade, barrier scores showed no statistically significant associations with functional outcomes, including London Chest Activity of Daily Living (LCADL) score ($\beta = -0.09$), six-minute walking distance (6MWD; $\beta = -0.03$), and COPD Assessment Test (CAT) score ($\beta = -0.06$), as all 95% confidence intervals crossed zero (Panel D). Overall, these findings indicate that rehabilitation access barriers are strongly associated with treatment initiation and adherence, whereas their independent associations with functional status were not statistically significant after adjustment for disease severity and demographic factors.

DISCUSSION

The present study found that perceived rehabilitation access burden was closely associated with both the decision to begin a prescribed programme and the proportion of prescribed sessions attended. Approximately one-third of patients with a rehabilitation prescription did not start, and overall attendance among prescribed patients was below half of scheduled sessions. Although greater barriers also tracked with poorer CAT scores, greater dyspnea-related activity limitation, and shorter walking distances in unadjusted analysis, these functional associations were not independently evident after adjustment for age, airflow limitation, and dyspnea severity. Thus, the strongest supported finding concerns access and engagement rather than a direct independent relationship between access barriers and physical function.

This pattern is broadly consistent with evidence that the rehabilitation care pathway has several distinct points of attrition. Watson and colleagues observed that interventions addressing referral and uptake have produced mixed results, while Hug and colleagues quantified imperfect uptake and completion in routine COPD care (5,6). Recent mixed-methods reviews similarly identify transport, practical logistics, perceived need, symptom-related apprehension, social support, and programme-level factors influencing uptake and completion (11,20). The present data suggest that barriers are relevant even after a clinician has prescribed rehabilitation, because the analysis of initiation and attendance was restricted to the 41 participants for whom rehabilitation was actually prescribed.

The associations of greater distance, travel time, and travel expense with non-initiation are plausible in the context of repeated service attendance. Geographic inequities in access to pulmonary rehabilitation have been demonstrated in health-system analyses, and qualitative work in South Asia has documented the practical burden of travelling to limited specialist services (8,9). Equity-focused evidence suggests that disadvantages can accumulate across socioeconomic and geographical dimensions (7). The present study cannot establish whether transport expense itself was the decisive reason for an individual patient's nonattendance, but the convergence of geographical and financial measures supports examining service accessibility alongside clinical referral decisions.

Higher perceived burden was associated with lower attendance even when age, FEV₁ percentage predicted, and dyspnea were included in the model. Prior work on rehabilitation nonadherence and long-term participation indicates that attendance is shaped by factors that extend beyond airflow obstruction alone (14,21). However, access-barrier scores could partly reflect symptoms, fatigue, the financial burden of illness, or other factors not completely represented by these covariates. Furthermore, a locally developed total score may combine heterogeneous barriers whose individual contributions cannot be separated using the available aggregate variable. Although the adjusted initiation odds ratio was substantial, the relatively small prescribed subgroup and wide confidence interval warrant restrained interpretation.

In unadjusted analyses, the barrier score correlated with the CAT, LCADL, and 6MWD outcomes. These measures assess related but non-identical domains: CAT captures the overall impact of COPD, LCADL measures breathlessness-related limitation during daily activities, and 6MWD reflects field exercise performance (16–18). The loss of independently detectable barrier associations after adjustment, alongside strong associations between mMRC dyspnea and these outcomes, suggests that symptom severity is an important shared correlate. These cross-sectional models neither show that access barriers are irrelevant to long-term functional outcomes nor establish that rehabilitation attendance improves function. Treatment effects require appropriately timed longitudinal assessments or controlled intervention studies.

Strategies for reducing structural barriers deserve consideration, although this study did not test their effectiveness. Observational comparisons of home-based and outpatient rehabilitation suggest that delivery setting affects implementation and possibly exercise responses (22). Recent reviews of tele-rehabilitation and mobile-app-supported self-directed programmes have examined alternatives to repeatedly travelling to a rehabilitation centre, with findings supporting their potential role while underscoring programme heterogeneity and variable implementation requirements (23,24). Their suitability for resource-constrained services must be evaluated against patient technology access, supervision needs, safety, and local clinical capacity rather than assumed from evidence generated in different healthcare systems.

Strengths of this analysis include participant-level verification of rehabilitation prescription and attendance denominators, explicit separation of non-prescription from non-initiation, complementary measures of access and function, and severity-adjusted analyses. Limitations include purposive recruitment at one centre, a modest overall sample and smaller initiation subgroup, absence of repeated assessments, lack of item-level data to assess the reliability or construct validity of the research-developed barrier score, and possible residual confounding by social and clinical variables. The single-record design also precludes establishing whether barriers preceded functional limitation, whether symptoms influenced attendance, or whether rehabilitation participation subsequently changed clinical outcomes. These considerations limit causal inference and external generalisability.

CONCLUSION

Among adults with COPD at Ashraf Medical Centre, greater perceived rehabilitation access burden was associated with lower initiation and attendance among patients prescribed rehabilitation. Travel distance, time, and expense were also associated with non-initiation. Associations between barriers and clinical or functional outcomes were evident before adjustment but not after accounting for measured severity-related characteristics. The findings support the

importance of assessing practical access constraints alongside the clinical need for pulmonary rehabilitation, while prospective follow-up and validation of the barrier measure are needed to evaluate subsequent functional consequences.

DECLARATIONS

Authors' Contributions:	Concept: SNR; Design: SNR, RNA; Data Collection: RNA, FA; Analysis: SNR, RNA; Drafting: SNR, RNA
Ethical Approval:	The institution responsible for ethical review was Ashraf Medical Centre, Sargodha, Pakistan
Informed Consent:	Written informed consent was obtained from all participants before enrolment.
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Data Availability:	De-identified data may be available from the corresponding author on request, subject to participant consent and institutional confidentiality requirements.
Acknowledgments:	None.
AI Declaration:	Generative AI tools were used solely for language and grammatical refinement. The authors verified the final manuscript and remain fully responsible for its accuracy, integrity, and scientific content.

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