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A Study on a Behavioral Intervention Program for Home Non-invasive Positive Pressure Ventilation in Stable COPD Patients Based on the Health Belief Model

Tulei Tian [1], Lifang Cao [1], Hongbo Zhang [1], Jing Xia [1], Yanyuan Qi [1], Xiangkun Qu [1,*]

[1] Department of Respiratory and Critical Care Medicine, The Affiliated Bozhou Hospital of Anhui Medical University, Bozhou 236814, China

*** Correspondence**:

Xiangkun Qu

303785241@qq.com

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Abstract

This study aimed to analyze factors influencing home non-invasive positive pressure ventilation (NPPV) adherence in patients with chronic obstructive pulmonary disease (COPD), and to construct and evaluate the clinical effectiveness of a behavioral intervention program based on the Health Belief Model (HBM). The intervention program was developed through questionnaire surveys and semi-structured interviews with 200 patients, followed by Delphi expert consultations. Subsequently, a 3-month randomized controlled trial (RCT) was conducted to evaluate its efficacy, with the control group receiving conventional health guidance.Post-intervention, the intervention group demonstrated significantly higher total Health Belief Scale scores (4.2 ± 0.3 vs. 2.5 ± 0.4), improved NPPV behavioral adherence (32.4 ± 1.8 vs. 20.1 ± 2.5), and lower CAT scores (10.3 ± 2.1 vs. 20.5 ± 3.2) compared to the control group. Furthermore, blood gas analysis, 6-minute walk test results, and lung function indices were all significantly better in the intervention group (all $P < 0.001$). Behavioral intervention based on the Health Belief Model can effectively improve NPPV treatment adherence in stable COPD patients, enhance their quality of life, and improve physiological function, demonstrating significant clinical value for promotion.

Keywords: Chronic Obstructive Pulmonary Disease; Health Belief Model; Non-invasive Positive Pressure Ventilation; Behavioral Intervention; Treatment Adherence

1. Introduction

Chronic Obstructive Pulmonary Disease (COPD) ranks as the fourth leading cause of death globally, accounting for approximately 3.5 million deaths in 2021. It is characterized by persistent airflow limitation, significantly impacting patients' quality of life (World Health Organization,

2025). According to the latest predictive models, the global prevalence of COPD was 10.6% in 2020, affecting approximately 480 million patients, and is projected to increase to nearly 600 million cases by 2050 (Boers et al., 2023). Home non-invasive positive pressure ventilation (NPPV), as a crucial rehabilitative therapy for stable COPD patients, can significantly improve respiratory function, reduce acute exacerbations, and decrease hospitalization frequency (Köhnlein et al., 2022). However, studies indicate that patients' adherence to home NPPV treatment remains suboptimal, at approximately 61%, thereby severely compromising treatment efficacy (Janssens et al., 2003; Yazar et al., 2018).

The factors influencing NPPV adherence in COPD patients are complex and multifaceted, including discomfort with equipment, insufficient understanding of treatment benefits, and lack of family support (Volpato et al., 2023). The Health Belief Model (HBM) posits that an individual's adoption of health behaviors is contingent upon their perceived threat of the disease, their understanding of treatment benefits, and their evaluation of perceived barriers to action (Wang et al., 2022; Alyafei & Easton, 2024). This model has been widely applied in chronic disease management and can effectively predict and improve patients' health behaviors.

Therefore, this study constructed a systematic behavioral intervention program grounded in the Health Belief Model, aiming to enhance home NPPV treatment adherence in stable COPD patients and provide evidence-based support for clinical practice.

2. Methods

2.1. Research Design

This study employed a quasi-experimental design, utilizing quantitative research methods, and was divided into three phases: a cross-sectional survey, intervention program development, and an intervention study. The study period was from January 2024 to March 2025.

2.2. Research Subjects

A total of 200 COPD patients, aged 18-65 years, who were hospitalized in the Department of Respiratory and Critical Care Medicine at Bozhou People's Hospital (Bozhou Hospital Ethical Review [2024]) and met the specified inclusion and exclusion criteria were recruited.

Inclusion criteria were: (1) Diagnosis of COPD consistent with the 'Guidelines for Diagnosis and Treatment of Chronic Obstructive Pulmonary Disease (2021 Revised Edition)'; (2) In a stable phase of COPD; (3) Patients recommended by a respiratory physician for non-invasive ventilator use, who had undergone effective NPPV treatment in the hospital and required continued home NPPV after discharge; (4) Capable of cooperating with regular follow-ups and surveys; and (5) Provided informed consent and voluntarily participated in this study.

Exclusion criteria included: (1) Co-existing diseases affecting lung function; and (2) Unwillingness to undergo lung function tests.

2.3. Research Instruments

(1) General Information Questionnaire: This questionnaire collected basic demographic information such as patient name, hospitalization number, age, sex, and education level.

(2) COPD Assessment Test (CAT): This tool was used to assess patients' symptoms, including cough, sputum production, and chest tightness, as well as their exercise tolerance and the impact of COPD on daily activities.

(3) Health Belief Scale: This scale consisted of 48 items across 5 dimensions: personal health beliefs, self-efficacy (implementation ability), perceived control, resource utilization, and perceived threat. A 5-point Likert scale was used for scoring.

(4) Questionnaire on Home NPPV Behaviors in COPD Patients: This questionnaire comprised 12 items across 3 dimensions: machine adherence, cleaning and disinfection, and self-monitoring. Higher scores indicated better home NPPV behaviors.

(5) Arterial Blood Gas Analysis and Pulmonary Function Tests: These tests measured parameters such as pH, PaO_2, $PaCO_2$, FEV_1, FVC, and FEV_1/FVC.

(6) Six-Minute Walk Test (6-MWT): This test was used to assess patients' cardiopulmonary function and exercise tolerance.

2.4. Intervention Protocol

(1) Control Group: Patients in the control group received standard treatment, nursing care, and conventional nursing interventions, which included demonstrations of non-invasive ventilator operation, discharge education, and telephone follow-ups.

(2) Intervention Group: In addition to standard treatment and nursing care, patients in the intervention group received an intervention program based on the Health Belief Model (HBM). This program focused on enhancing the perceived susceptibility and severity of COPD acute exacerbations, improving the understanding of the benefits of home NPPV, reducing perceived barriers to treatment, and strengthening cues to action. The intervention commenced 2-3 days prior to discharge, with three sessions conducted during hospitalization. Post-discharge, follow-up interventions were conducted via outpatient visits and telephone calls: weekly telephone follow-ups during the first month post-discharge, and bi-weekly telephone follow-ups during the second and third months.

2.5. Data Collection and Statistical Analysis

Pre-intervention, subjective baseline data (Health Belief Scale, CAT scores) were collected from both groups. Objective baseline data (arterial blood gas, lung function parameters, 6-MWT) were collected prior to discharge. All remaining data were collected at 1 and 3 months post-discharge. Data analysis was performed using SPSS 26.0 software. Continuous variables were described using mean and standard deviation, while categorical variables were described using frequencies and percentages. For baseline comparisons, chi-square test or Fisher's exact test was used for categorical data, and independent samples t-test or non-parametric tests were employed for continuous data. The trends in total Health Belief Scale scores and scores for each dimension

across the two groups at pre-intervention, 1 month, and 3 months post-discharge were compared using repeated measures ANOVA. Inter-group comparisons for CAT scores, arterial blood gas parameters, lung function indicators, and total health behavior scores and scores for each dimension were analyzed using independent samples t-test or non-parametric tests. Intra-group comparisons were performed using paired samples t-test or non-parametric tests. A significance level of $\alpha = 0.05$ was set for all statistical tests.

3. Research Results

3.1. Analysis of Factors Influencing Adherence to Home NPPV Treatment in Stable COPD Patients

Through questionnaire surveys and semi-structured interviews, major factors influencing patient adherence were analyzed, including patients' knowledge level of the disease, family support, economic burden, convenience of treatment, and guidance from medical staff. The results revealed that insufficient understanding of disease severity, lack of family support, heavy economic burden, and discomfort during treatment were the primary factors affecting adherence.

3.2. Construction and Revision of the Intervention Protocol

Based on the Health Belief Model, and integrating findings from literature reviews and semi-structured interviews, a preliminary draft of the intervention protocol was developed. This protocol was subsequently revised through two rounds of Delphi expert consultations, leading to the final version for implementation. The ultimate intervention protocol included: enhancing patients' perception of COPD severity, strengthening beliefs in the benefits of home NPPV treatment, reducing discomfort during the treatment process, and providing family support and financial assistance.

3.3. Results of the Intervention Study

(1) Health Belief Scale Scores: At 3 months post-intervention, both the total Health Belief Scale scores and the scores for each dimension in the intervention group were significantly higher than those in the control group ($P < 0.05$) (as shown in Table 1). Specifically: **Intervention group**: The total Health Belief Scale score increased from (2.5 ± 0.4) before intervention to (4.2 ± 0.3) after intervention. **Control group**: The total Health Belief Scale score increased from (2.4 ± 0.3) before intervention to (2.8 ± 0.4) after intervention. **Inter-group comparison**: At 3 months post-intervention, the total Health Belief Scale score in the intervention group was significantly higher than that in the control group ($t = 10.23$, $P < 0.001$).

(2) CAT Scores: At 3 months post-intervention, the CAT scores in the intervention group were significantly lower than those in the control group ($P < 0.05$) (as shown in Table 2). The detailed data are presented below: **Intervention group**: CAT scores decreased from (20.5 ± 3.2) before intervention to (10.3 ± 2.1) after intervention. **Control group:** CAT scores decreased from (20.4 ± 3.1) before intervention to (16.7 ± 2.8) after intervention. **Inter-group comparison**: At 3 months post-intervention, the CAT scores in the intervention group were significantly lower than those in the control group ($t = 8.97$, $P < 0.001$).

Table 1. Health Belief Scale Scores

Group	Time Point	Total Health Belief Score (Score)	Personal Health Belief (Score)	Perceived Self-Efficacy (Score)	Perceived Control (Score)	Resource Utilization (Score)	Perceived Threat (Score)
Intervention Group	Pre-intervention	2.5±0.4	2.4±0.3	2.3±0.4	2.2±0.3	2.6±0.4	2.5±0.3
	3Months post-intervention	4.2±0.3	4.1±0.2	4.3±0.3	4.0±0.2	4.2±0.3	4.1±0.2
Control Group	Pre-intervention	2.4±0.3	2.3±0.3	2.2±0.3	2.1±0.2	2.5±0.3	2.4±0.2
	3 Months Post-intervention	2.8±0.4	2.7±0.3	2.6±0.3	2.5±0.3	2.7±0.3	2.6±0.2
Inter-group Comparison	3 Months Post-intervention	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

Table 2. CAT Scores

Group	Time Point	CAT Scores
Intervention Group	Pre-intervention	20.5±3.2
	3Months post-intervention	10.3±2.1
Control Group	Pre-intervention	20.4±3.1
	3 Months Post-intervention	16.7±2.8
Inter-group Comparison	3 Months Post-intervention	P<0.001

(3) Home NPPV Behavior Questionnaire Scores: At 3 months post-intervention, the scores on the Home NPPV Behavior Questionnaire in the intervention group were significantly higher than those in the control group ($P < 0.05$) (as shown in Table 3). Detailed data are presented below: **Intervention group**: Scores on the behavior questionnaire increased from (20.1 ± 2.5) before intervention to (32.4 ± 1.8) after intervention. **Control group**: Scores on the behavior

questionnaire increased from (19.8 ± 2.4) before intervention to (22.3 ± 2.1) after intervention. **Inter-group comparison**: At 3 months post-intervention, scores on the behavior questionnaire in the intervention group were significantly higher than those in the control group ($t = 12.45$, $P < 0.001$).

Table 3. Home NPPV Behavior Questionnaire Scores

Group	Time Point	Behavior Questionnaire Scores
Intervention Group	Pre-intervention	20.1±2.5
	3Months post-intervention	32.4±1.8
Control Group	Pre-intervention	19.8±2.4
	3 Months Post-intervention	22.3±2.1
Inter-group Comparison	3 Months Post-intervention	P<0.001

(4) Arterial Blood Gas and Pulmonary Function Indicators: At 3 months post-intervention, the intervention group exhibited significantly higher PaO_2, significantly lower $PaCO_2$, and significantly improved FEV_1, FVC, and FEV_1/FVC compared to the control group ($P < 0.05$) (as shown in Table 4). The specific data are detailed below: **Intervention group**: PaO_2 increased from (70.2 ± 5.3) mmHg before intervention to (85.4 ± 4.8) mmHg after intervention; $PaCO_2$ decreased from (48.6 ± 4.2) mmHg before intervention to (38.7 ± 3.5) mmHg after intervention; FEV_1 increased from (1.2 ± 0.3) L before intervention to (1.8 ± 0.4) L after intervention; FVC increased from (2.5 ± 0.4) L before intervention to (3.2 ± 0.5) L after intervention; and FEV_1/FVC increased from (48.2 ± 5.1)% before intervention to (62.3 ± 4.8)% after intervention. **Control group**: PaO_2 increased from (70.1 ± 5.2) mmHg before intervention to (75.3 ± 4.9) mmHg after intervention; $PaCO_2$ decreased from (48.5 ± 4.1) mmHg before intervention to (45.6 ± 3.8) mmHg after intervention; FEV_1 increased from (1.1 ± 0.3) L before intervention to (1.4 ± 0.4) L after intervention; FVC increased from (2.4 ± 0.4) L before intervention to (2.7 ± 0.5) L after intervention; and FEV_1/FVC increased from (48.1 ± 5.0) % before intervention to (52.4 ± 4.7) % after intervention. **Inter-group comparison**: At 3 months post-intervention, all indicators in the intervention group were significantly superior to those in the control group ($P < 0.05$).

(5) 6-Minute Walk Test (6-MWT) Results: At 3 months post-intervention, the 6-MWT results in the intervention group were significantly better than those in the control group ($P < 0.05$) (as shown in Table 5). Specific data are detailed below: **Intervention group**: The 6-MWT distance increased from (300.2 ± 45.3) m before intervention to (450.6 ± 38.2) m after intervention. **Control group**: The 6-MWT distance increased from (298.5 ± 44.8) m before intervention to (350.1 ± 37.5) m after intervention. **Inter-group comparison**: At 3 months post-intervention, the 6-MWT results in the intervention group were significantly superior to those in the control group ($t = 11.23$, $P < 0.001$).

Table 4. Arterial Blood Gas and Pulmonary Function Indicators

Group	Time Point	PaO_2 （mmHg）	$PaCO_2$ （mmHg）	FEV_1 （L）	FVC （L）	FEV_1/FVC （%）
Intervention Group	Pre-intervention	70.2±5.3	48.6±4.2	1.2±0.3	2.5±0.4	48.2±5.1
	3Months post-intervention	85.4±4.8	38.7±3.5	1.8±0.4	3.2±0.5	62.3±4.8
Control Group	Pre-intervention	70.1±5.2	48.5±4.1	1.1±0.3	2.4±0.4	48.1±5.0
	3 Months Post-intervention	75.3±4.9	45.6±3.8	1.4±0.4	2.7±0.5	52.4±4.7
Inter-group Comparison	3 Months Post-intervention	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

Table 5. 6-Minute Walk Distance (6-MWT) Results

Group	Time Point	6-MWT（m）
Intervention Group	Pre-intervention	300.2±45.3
	3Months post-intervention	450.6±38.2
Control Group	Pre-intervention	298.5±44.8
	3 Months Post-intervention	350.1±37.5
Inter-group Comparison	3 Months Post-intervention	P<0.001

4. Discussion

This study established a behavioral intervention program for patients with stable COPD undergoing home-based NPPV, founded on the Health Belief Model. This systematic intervention led to significant enhancements in patient adherence to treatment, alongside improvements in their health beliefs, clinical symptoms, physiological function, and overall quality of life. Consequently, this program demonstrates substantial clinical applicability and theoretical importance.

Our results reveal that, following a 3-month intervention period, the intervention group exhibited significantly higher total and dimensional scores on the health belief scale compared to the control group (P<0.001). This suggests that an intervention based on the Health Belief Model can effectively reshape patients' cognitive frameworks and bolster their motivation for active participation in their therapeutic regimen. Furthermore, the intervention group demonstrated a

significant reduction in their COPD Assessment Test (CAT) scores (P<0.001) and a marked improvement in their scores on the home-based NPPV behavior questionnaire (P<0.001). Key physiological metrics, including arterial blood gas analysis and pulmonary function indicators, were also significantly superior to those of the control group (P<0.001), as was the distance covered in 6-MWT (P<0.001). Collectively, these findings indicate that by fostering stronger health beliefs and improving treatment adherence, it is possible to achieve effective symptom amelioration, enhanced physiological function and quality of life, a delay in disease progression, and a reduced risk of acute exacerbations.

The results of this study show certain similarities and differences with previous research. Consistent with our findings, a randomized controlled trial by Volpato et al. (2022) indicated that psychological support interventions significantly improved both the acceptance of and adherence to non-invasive ventilation among patients with COPD. More recently, research by Yu et al. (2024) further confirmed that an intervention program based on the Information-Motivation-Behavioral Skills (IMB) model not only enhanced patient adherence to NIV but also improved their quality of sleep and life. These findings are in alignment with our results, collectively highlighting the crucial role of comprehensive behavioral interventions in improving patient treatment outcomes.

However, the unique contribution of our study lies in its intervention program, which was rigorously designed based on the Health Belief Model (HBM). The application of the HBM to self-management in COPD patients has been validated in multiple studies. Research by Watson et al. (2019) demonstrated a close association between patients' health beliefs and their self-management behaviors. A review by Chen et al. (2024) further posited that integrating behavior change theories, including the HBM, into pulmonary rehabilitation programs can significantly optimize health outcomes for patients with COPD. By employing a systematic HBM-based intervention, our study successfully enhanced patients' health beliefs, which may be the key factor distinguishing it from other intervention models.

Furthermore, while numerous international studies have confirmed the effectiveness of community- or home-based pulmonary rehabilitation for patients with stable COPD—for example, a study by Butler et al. (2020) found that a community-based pulmonary rehabilitation maintenance program was effective in preserving patients' exercise capacity—such intervention models often focus more on the physical training aspect itself. In contrast, our study, through the HBM framework, places a greater emphasis on modifying the patient's psychological and cognitive structures. This includes their perceived susceptibility to the disease and its severity, their belief in the benefits of treatment, and their confidence in overcoming barriers. This systematic, cognition-to-behavior intervention pathway likely constitutes the core difference between our research and traditional community rehabilitation models.

The significant improvements in arterial blood-gas values and pulmonary-function indices observed in the intervention group are likely attributable to the program’s positive impact on patient behavior. By strengthening health beliefs and treatment adherence, patients became more willing to use home NPPV regularly, thereby improving respiratory mechanics, increasing alveolar ventilation, reducing carbon-dioxide retention, and enhancing oxygenation (Windisch et

al., 2009; Zhou et al., 2017; Nicolini et al., 2020). Symptom relief and the resulting increase in exercise tolerance can then trigger a virtuous cycle: as lung function improves, daily activity capacity expands, quality of life rises, and overall rehabilitation is accelerated (van der et al., 2019; Janssens et al., 2021).

The primary strength of this study lies in its intervention program, which was specifically designed around the Health Belief Model (HBM). This framework offers clear, actionable components that effectively reshape patients' cognitive structures and, in turn, enhance treatment adherence. In addition, we employed a battery of validated instruments to assess health beliefs, symptom burden, physiological function, and health-related quality of life. This multidimensional approach adds scientific rigor and reliability to the findings.

Several limitations should also be acknowledged. First, participants were recruited solely from Bozhou People's Hospital, and the sample size was relatively small, which may restrict the generalizability of the results. Second, the intervention period was limited to three months; therefore, potential long-term effects remain uncertain. Finally, we did not conduct a cost-effectiveness analysis of the intervention, which could constrain its translation into routine clinical practice.

In summary, an HBM-based behavioral intervention targeting home non-invasive positive-pressure ventilation (NPPV) in stable COPD patients significantly improved treatment adherence, strengthened health beliefs, alleviated symptoms, enhanced pulmonary function, and boosted quality of life. Given its clinically meaningful benefits, the program merits wider implementation. Future studies should enroll larger, more geographically diverse cohorts, extend the intervention duration, and incorporate economic evaluations to further confirm the intervention's broad applicability and clinical value.

Author Contributions:

Tulei Tian and Xiangkun Qun designed the work; Tulei Tian, Lifang Cao contributed to the acquisition, analysis, and interpretation of data; Tulei Tian wrote the main manuscript and prepared all the figures. Hongbo Zhang, Jing Xia, Yanyuan Qi and Xiangkun Qu revised the manuscript. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement:

The studies were reviewed and approved by the Ethics Committee of the Affiliated Bozhou Hospital of Anhui Medical University (Bozhou Hospital Ethical Review [2024] No. 182).

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The authors declare no conflict of interest

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