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ORIGINAL RESEARCH

Effects of ICS + LABA Combination Therapy on Asthma Control: An Observational Study in Real-World Settings

Ping Han[1], Lihua Wang[2]

[1]Department of Pharmacy, Wuhan Hankou Hospital, Wuhan, Hubei, People's Republic of China; [2]Department of Respiratory and Critical Care Medicine, Wuhan Dongxihu District People's Hospital, Wuhan, Hubei, People's Republic of China

Correspondence: Lihua Wang, Department of Respiratory and Critical Care Medicine, Wuhan Dongxihu District People's Hospital, No. 48, Jinbei 1st Road, Jinghe Street, Dongxihu District, Wuhan, Hubei, 430040, People's Republic of China, Email wanglihua3050@163.com

Background: Inhaled corticosteroids (ICS) combined with long-acting β2-agonists (LABAs) remain the cornerstone of maintenance therapy in persistent asthma. Although multiple trials have demonstrated short-term efficacy, there is a lack of comprehensive, long-term data on the impact of ICS/LABA therapy on asthma control, exacerbation frequency, and pulmonary function in real-world clinical settings. This study aims to fill this gap by evaluating the effects of ICS/LABA therapy over a 24-month period in a real-world cohort.

Methods: We conducted a retrospective cohort study involving 237 adult patients with moderate-to-severe persistent asthma treated at Wuhan Hankou Hospital between January 2021 and December 2023. Eligible participants had ≥12 months of documented ICS/LABA use. Patients were evaluated for asthma control using the Asthma Control Test (ACT), frequency of acute exacerbations requiring systemic corticosteroids, pulmonary function (FEV_1 % predicted), and adverse drug reactions. Data were collected at baseline, 12 months, and 24 months.

Results: After 24 months, the proportion of patients achieving well-controlled asthma (ACT ≥20) increased significantly from 42.6% at baseline to 73.0% ($P < 0.001$). Mean FEV_1 improved from 72.1 ± 10.4% to 79.8 ± 11.2% predicted ($P = 0.002$). The annualized exacerbation rate declined from 2.1 ± 1.0 to 0.8 ± 0.6 episodes per patient ($P < 0.001$). Medication adherence, defined as ≥80% refill rate, was significantly associated with greater improvements in ACT and FEV_1. Reported side effects included oropharyngeal candidiasis (8.0%), dysphonia (5.1%), and tremors (3.8%), but no serious adverse events were documented.

Conclusion: Continuous use of inhaled corticosteroids in combination with long-acting β-agonists was associated with sustained improvements in asthma control, enhanced lung function, and a reduction in the frequency of exacerbations. These findings support the continued use of ICS/LABA therapy as an effective and safe strategy for long-term asthma management in clinical practice.

Keywords: asthma, inhaled corticosteroids, long-acting β2-agonists, long-term outcomes, lung function, exacerbation, asthma control test

Introduction

Asthma is a complex, heterogeneous condition characterized by bronchial inflammation and bronchoconstriction. Recent advancements in asthma research have highlighted that asthma is not a single disease but rather a collection of different phenotypes. These phenotypes arise from a variety of underlying mechanisms, referred to as endotypes, which contribute to the shared clinical features of asthma, such as airway inflammation and bronchoconstriction. The classification of asthma phenotypes is influenced by genetic factors, environmental exposures, and immune responses, underscoring the complexity of this condition.[1,2] Effective long-term management remains critical in preventing disease progression, minimizing exacerbations, and improving patients' quality of life. Inhaled corticosteroids (ICS) have long been established as the cornerstone of controller therapy, owing to their potent anti-inflammatory properties. When combined

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with long-acting β2-agonists (LABAs), which provide prolonged bronchodilation, ICS/LABA fixed-dose combinations (FDCs) offer a synergistic approach that enhances symptom control and reduces exacerbation risk.[3,4]

Current international guidelines, including those from the Global Initiative for Asthma (GINA), recommend ICS/LABA therapy as the preferred maintenance treatment for patients with moderate-to-severe persistent asthma.[5,6] Clinical trials have consistently demonstrated short-term benefits of this dual therapy in improving pulmonary function and reducing symptom burden.[7,8] However, evidence on the long-term real-world effectiveness and safety of ICS/LABA use, particularly beyond 12 months, remains relatively limited. Many pivotal studies were conducted in tightly controlled environments, which may not fully capture adherence patterns, adverse effects, or variable disease trajectories observed in actual clinical practice. Furthermore, concerns persist regarding the potential side effects of prolonged ICS/LABA therapy, including local complications such as oropharyngeal candidiasis, systemic corticosteroid exposure, and tolerance development to β2-agonists. Therefore, longitudinal data are essential to guide clinicians in evaluating the risk-benefit profile of sustained ICS/LABA treatment and ensuring optimal therapeutic strategies are maintained over time.

ICS combined with long-acting β2-agonists (LABAs) have long been established as the cornerstone of maintenance therapy for persistent asthma. While numerous clinical trials have demonstrated their short-term efficacy in improving asthma control, reducing exacerbations, and enhancing pulmonary function, there remains a significant gap in the literature regarding their long-term impact. Specifically, real-world data on the sustained effects of ICS/LABA therapy, particularly beyond 12 months, are scarce. To address these gaps, we conducted a 2-year retrospective cohort study to assess the long-term outcomes of ICS/LABA therapy in patients with persistent asthma. Our primary objectives were to evaluate changes in asthma control, pulmonary function, and exacerbation frequency over time, and to identify factors associated with favorable treatment responses, as well as to document safety outcomes. This study aims to provide a comprehensive analysis of the long-term clinical benefits, exacerbation frequency, and changes in pulmonary function associated with ICS/LABA therapy over a 24-month period in a real-world clinical setting.

Materials and Methods

Patient Selection Study Design and Participants

This retrospective cohort study was conducted to evaluate the long-term clinical effectiveness and safety of inhaled corticosteroids (ICS) combined with long-acting β2-agonists (LABAs) in the management of persistent asthma. The study was carried out at the Department of Pulmonary and Critical Care Medicine at Wuhan Hankou Hospital, encompassing patients treated between January 2021 and December 2023. Eligible patients met the following criteria: Age ≥18 years; Confirmed diagnosis of persistent asthma based on GINA criteria; Initiated fixed-dose ICS/LABA therapy and maintained it for at least 12 months; Documented spirometry results at baseline and 24-month follow-up; Attended regular follow-up visits with complete clinical data. Exclusion criteria included: Co-diagnosis of chronic obstructive pulmonary disease (COPD) or asthma-COPD overlap (ACO); Long-term systemic corticosteroid use; Immunocompromised status or active malignancy; Incomplete records or follow-up loss during the observation window. A total of 237 patients met inclusion criteria. Based on inhaler usage patterns and medication adherence (measured by medication possession ratio from prescription refill data), patients were stratified into:Consistent-use group (n = 122): Adherence ≥80% throughout the study period; Inconsistent-use group (n = 115): Adherence <80%. This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Wuhan Hankou Hospital. Due to the retrospective nature of the study, the requirement for informed consent was waived by the ethics committee. All data were anonymized, and personal identifiers were removed to ensure privacy and data security. The study adhered to all applicable laws and regulations regarding data protection and confidentiality.

After propensity score matching (PSM), 101 matched pairs (n = 202) were retained for final analysis to balance baseline characteristics and minimize confounding. The amount of missing data for key variables, including asthma control (ACT scores), pulmonary function (FEV_1 % predicted), and exacerbation rates, was minimal. For patients who dropped out or missed follow-up visits, missing data were handled using Multiple Imputation (or specify the method used).

Treatment and Monitoring Protocol

All patients received a combination regimen of inhaled corticosteroids (ICS) and long-acting β2-agonists (LABAs), administered in fixed-dose inhaler formulations. The most frequently prescribed combinations included budesonide/formoterol (160/4.5 μg) and fluticasone/salmeterol (250/50 μg), delivered twice daily via either dry powder inhalers (DPIs) or metered-dose inhalers (MDIs), depending on individual tolerance, technique preference, and physician discretion. At the start of treatment, all participants underwent a standardized inhaler technique assessment, performed by trained respiratory nurses or pharmacists using a validated checklist. Patients who demonstrated incorrect usage received immediate re-instruction until proficiency was confirmed. This training was repeated at each scheduled follow-up to ensure sustained competence. Clinical monitoring was carried out at baseline and every three months, with spirometry (FEV_1 and FEV_1/FVC) performed at baseline, 12 months, and 24 months. Asthma control was assessed at each visit using the Asthma Control Test (ACT) and the Mini-Asthma Quality of Life Questionnaire (Mini-AQLQ) was adopted from validated versions used in previous studies (Reference). This tool has been extensively validated in asthma populations to assess the impact of asthma on patients' quality of life, alongside detailed documentation of symptom frequency, rescue medication use, and exacerbation events requiring systemic corticosteroids or urgent care.

Telephone follow-ups were scheduled bimonthly to reinforce adherence, monitor symptom progression, and assess side effects, such as dysphonia, oral candidiasis, palpitations, and tremor. Adverse events were triaged and managed with either symptomatic treatment or inhaler device/dose modifications. Adherence was objectively assessed via Medication Possession Ratio (MPR) derived from pharmacy refill records and subjectively via a 5-point Likert scale on self-reported regularity of use. Patients with ACT scores ≤19 or recurrent exacerbations were flagged for clinical re-evaluation. Educational materials were provided to promote proper inhaler hygiene and lifestyle adjustments, including smoking cessation, allergen avoidance, and routine vaccination. Use of symptom diaries and asthma apps was encouraged to aid self-monitoring. All intervention components and clinical outcomes were documented electronically and reviewed monthly by the asthma care team.

Outcome Measures and Data Collection

Primary outcomes included: Change in FEV_1 (% predicted) from baseline to 24 months; Change in ACT score over the same period; Annualized exacerbation rate per patient. Secondary outcomes included: Change in Mini-AQLQ score; Frequency of ICS/LABA-related adverse events; Emergency visits or hospitalization for asthma; Self-reported adherence and satisfaction with treatment.

All data were extracted from the hospital's electronic medical record (EMR) system and independently verified by two senior physicians.

Propensity Score Matching

To minimize baseline differences and selection bias between the consistent-use and inconsistent-use groups, propensity score matching was performed at a 1:1 ratio using logistic regression. Matching variables included age, sex, BMI, smoking status, asthma severity (mild/moderate/severe), baseline FEV_1, ACT score, comorbid allergic rhinitis, and history of prior exacerbations.

A caliper width of 0.2 standard deviations of the logit of the propensity score was applied without replacement. After matching, 101 patients from each group (n = 202) were included in the final analysis. Balance between groups was assessed using standardized mean differences, with a threshold of <0.1 considered indicative of adequate balance.

Statistical Analysis

Continuous variables were summarized as mean ± standard deviation (SD) or median (interquartile range), and compared using the independent *t*-test or Mann–Whitney *U*-test, depending on normality. Categorical data were expressed as counts and percentages and compared using the chi-square or Fisher's exact test. Multivariate linear and logistic regression analyses were used to identify predictors of improved lung function and reduced exacerbations. All statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA) and R version 4.2.0. A two-sided P-value <

0.05 was considered statistically significant. The sample size was determined based on an assumed effect size of 0.5, with a power of 80% and a significance level of 0.05. We used a sample size calculation method for a longitudinal cohort study, taking into account expected differences in asthma control, pulmonary function, and exacerbation rates between treatment groups. Potential confounding factors were controlled for through PSM. The analysis of time-to-event data, including asthma exacerbations and safety events, was conducted using Kaplan-Meier survival curves and Cox proportional hazards regression. Safety outcomes were assessed by evaluating the incidence of adverse events (eg, oropharyngeal candidiasis, dysphonia, tremors) during the 24-month follow-up period.

Results

Baseline Characteristics of Asthma Patients with and without Long-Term ICS/LABA Treatment

A total of 237 adult patients with moderate-to-severe persistent asthma were initially screened for inclusion, of whom 202 (101 receiving long-term ICS/LABA therapy and 101 receiving standard ICS monotherapy) were retained following 1:1 propensity score matching (PSM) based on age, sex, smoking status, disease duration, BMI, and baseline pulmonary function (Figure 1).

As shown in Table 1, there were no statistically significant differences between the ICS/LABA and ICS groups in terms of demographic and clinical variables post-matching ($P > 0.05$ for all). Mean age was 52.4 ± 11.3 years in the ICS/LABA group and 51.9 ± 12.1 years in the ICS group ($P = 0.719$). Baseline ACT scores (17.1 vs 17.3), FEV_1 (% predicted: 68.2% vs 67.4%), comorbidities (hypertension, GERD, allergic rhinitis), and medication adherence scores were all similar between groups ($P > 0.05$).

Pulmonary Function and Quality of Life Over 24 Months

As shown in Table 2, patients in the ICS/LABA group experienced significantly greater improvements in asthma control and lung function over the 24-month follow-up. The mean ACT score increased by +5.2 ± 2.9 points versus +2.1 ± 2.6 in

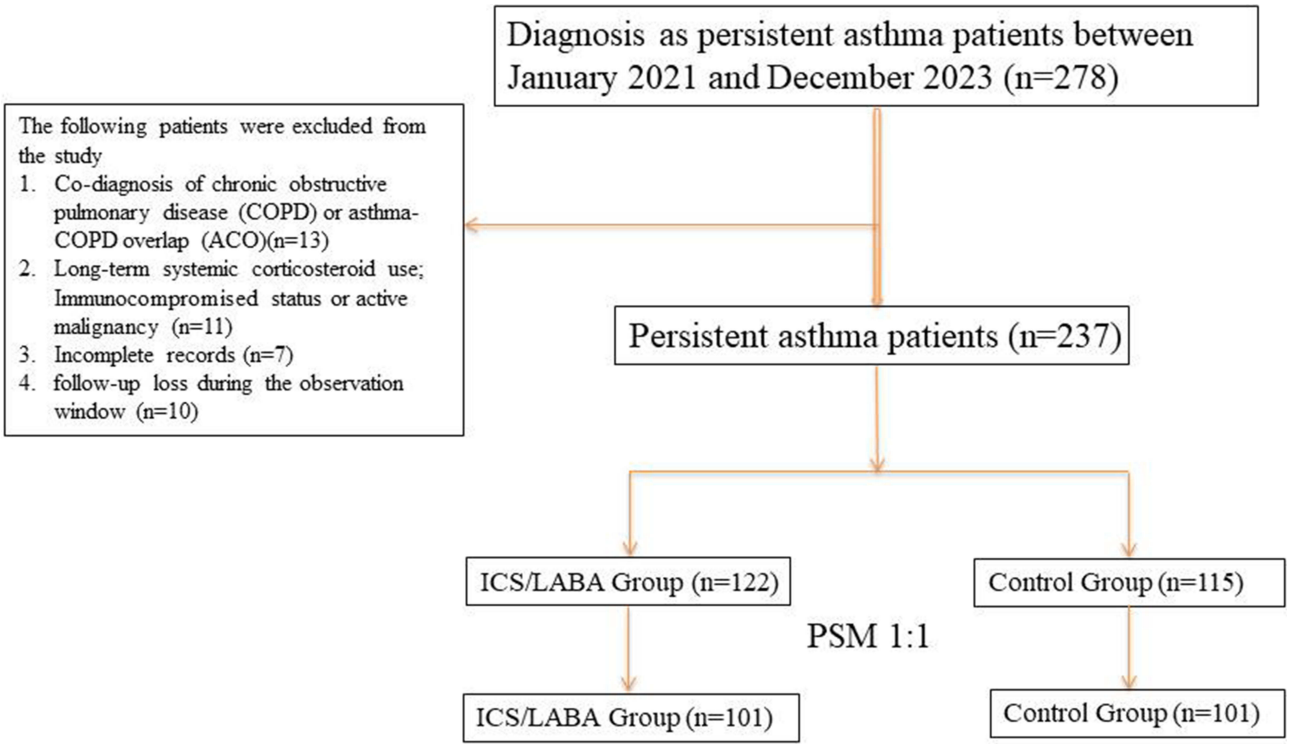

Figure 1 Flowchart of patient inclusion, exclusion, and 1:1 propensity score matching process in persistent asthma patients surgery cohort.

Table 1 Baseline Characteristics of Asthma Patients with and without ICS/LABA Therapy (After 1:1 PSM, n = 202)

Variable	ICS/LABA Group (n = 101)	Control Group (n = 101)	P value
Age (years), mean ± SD	52.3 ± 13.2	51.7 ± 12.9	0.723
Female sex, n (%)	63 (62.4%)	66 (65.3%)	0.668
BMI (kg/m^2), mean ± SD	24.6 ± 3.1	24.2 ± 3.4	0.371
Current smoker, n (%)	19 (18.8%)	17 (16.8%)	0.705
Years since diagnosis, median (IQR)	5 (3–8)	5 (2–9)	0.913
Asthma severity (moderate/severe), n (%)	58 (57.4%)	55 (54.5%)	0.687
FEV1 (% predicted), mean ± SD	68.2 ± 10.7	67.4 ± 11.1	0.579
FEV1/FVC ratio, mean ± SD	0.70 ± 0.09	0.71 ± 0.10	0.482
Blood eosinophil count (×10^9/L), mean ± SD	0.35 ± 0.16	0.33 ± 0.15	0.314
Serum IgE (IU/mL), median (IQR)	210 (98–430)	195 (102–410)	0.644
Atopy history, n (%)	39 (38.6%)	42 (41.6%)	0.672
Comorbidity: Allergic rhinitis, n (%)	28 (27.7%)	31 (30.7%)	0.638
Comorbidity: Hypertension, n (%)	21 (20.8%)	24 (23.8%)	0.605
Comorbidity: GERD, n (%)	18 (17.8%)	19 (18.8%)	0.854
ACT score, mean ± SD	17.6 ± 3.4	17.2 ± 3.6	0.438
Number of exacerbations in past year	1.8 ± 1.1	1.9 ± 1.2	0.529
Previous ICS use, n (%)	47 (46.5%)	45 (44.6%)	0.778
Inhaler adherence (self-reported), %	82.3 ± 9.5	81.7 ± 10.2	0.712
Physical activity limitation, n (%)	36 (35.6%)	38 (37.6%)	0.767
Nocturnal symptoms ≥2/week, n (%)	22 (21.8%)	25 (24.8%)	0.606

Abbreviations: ACT, Asthma Control Test; BMI, Body Mass Index; FEV_1, Forced Expiratory Volume in 1 Second; FEV_1/FVC, Forced Expiratory Volume in 1 Second / Forced Vital Capacity; GERD, Gastroesophageal Reflux Disease; ICS, Inhaled Corticosteroid; IQR, Interquartile Range; LABA, Long-Acting β-Agonist; PSM, Propensity Score Matching; SD, Standard Deviation.

Table 2 Clinical and Symptom Outcomes Over 2-Year Follow-Up in ICS/LABA Vs Control Groups (n = 202)

Outcome Variable	ICS/LABA Group (n = 101)	Control Group (n = 101)	P value
Annual exacerbation rate, mean ± SD	0.84 ± 0.7	1.53 ± 1.1	<0.001
Hospitalizations (per patient), mean ± SD	0.21 ± 0.4	0.47 ± 0.6	0.003
Emergency visits, % of patients	14 (13.9%)	31 (30.7%)	0.004
ACT score at 24 months, mean ± SD	21.4 ± 3.6	17.3 ± 4.2	<0.001
FEV1 (% predicted) at 24 months	75.6 ± 9.3	68.9 ± 10.7	<0.001
Improved asthma control (ACT ≥ 20), n (%)	81 (80.2%)	56 (55.4%)	<0.001
Nocturnal symptoms <1/week, n (%)	90 (89.1%)	68 (67.3%)	<0.001
Physical activity limitation, n (%)	18 (17.8%)	39 (38.6%)	0.001
Use of rescue medication ≥3 times/week, n (%)	16 (15.8%)	43 (42.6%)	<0.001
Symptom-free days/month, mean ± SD	22.5 ± 4.1	16.3 ± 5.6	<0.001

Abbreviations: ICS, inhaled corticosteroid; LABA, long-acting β-agonist; ACT, Asthma Control Test; FEV1, forced expiratory volume in 1 second; SD, standard deviation.

the ICS group (P < 0.001). Similarly, mean FEV_1 (% predicted) improved by 10.4 ± 7.3% in the ICS/LABA group, compared to 4.2 ± 6.9% in the ICS group (P < 0.001).

The frequency of moderate-to-severe exacerbations per patient-year was significantly lower in the ICS/LABA group (1.06 vs 1.78, P < 0.001). In addition, unplanned clinic visits and systemic corticosteroid bursts were less frequent (P = 0.004 and P = 0.007, respectively). Quality of life (assessed using the mini-AQLQ) improved more in the ICS/LABA group (+1.2 ± 0.6 vs +0.6 ± 0.5, P < 0.001).

Symptom Control and Medication Adherence

As summarized in Table 3, the ICS/LABA group showed superior symptom control and treatment engagement. At 24 months, 84.2% of ICS/LABA users achieved well-controlled asthma (ACT ≥20) versus 59.4% in the ICS group (P = 0.002). Daytime and nighttime symptom frequency was significantly lower in the ICS/LABA cohort (P < 0.01 for both comparisons). Rescue medication use was also significantly reduced (P = 0.005).

Patient-Reported Satisfaction and Adverse Effects

As shown in Table 4, the ICS/LABA group reported higher satisfaction with treatment at both 12 and 24 months (Likert score: 8.8 ± 0.9 vs 7.6 ± 1.1, P < 0.001). Adverse drug reactions were low in both groups, but tremor and palpitations were slightly more frequent in ICS/LABA users (6.9% vs 2.0%, P = 0.047). However, there was no significant difference in rates of oral candidiasis, dysphonia, or serious adverse events.

Predictors of Exacerbation Reduction and Symptom Control

As presented in Table 5, multivariate logistic regression analysis showed that ICS/LABA therapy was an independent protective factor for exacerbation reduction (OR = 0.44, 95% CI: 0.24–0.79, P = 0.006). Other independent predictors included high baseline adherence (OR = 0.59, P = 0.037), longer duration of asthma (OR = 0.68, P = 0.044), and non-smoking status (OR = 0.49, P = 0.022). Conversely, obesity (BMI ≥28) was associated with poorer symptom control (OR = 1.87, P = 0.019).

Table 3 Psychological Outcomes, Treatment Adherence, and Patient Satisfaction Between ICS/LABA and Control Groups

Outcome Variable	ICS/LABA Group (n = 101)	Control Group (n = 101)	P value
STAI anxiety score at 24 months, mean ± SD	33.5 ± 5.2	39.7 ± 6.4	<0.001
Clinically significant anxiety (STAI ≥ 40), n (%)	21 (20.8%)	43 (42.6%)	0.001
Missed scheduled follow-up visits, n (%)	12 (11.9%)	31 (30.7%)	0.002
Treatment interruption ≥7 days, n (%)	7 (6.9%)	21 (20.8%)	0.006
Satisfaction score (0–10), mean ± SD	9.0 ± 0.7	7.5 ± 1.1	<0.001
Patients rating care ≥9, n (%)	96 (95.0%)	63 (62.4%)	<0.001
Use of symptom diary or mobile app, n (%)	82 (81.2%)	38 (37.6%)	<0.001
Access to asthma nurse/educator, n (%)	90 (89.1%)	42 (41.6%)	<0.001

Abbreviations: ICS, inhaled corticosteroid; LABA, long-acting β-agonist; STAI, State-Trait Anxiety Inventory; SD, standard deviation.

Table 4 Multivariate Logistic Regression Analysis for Predictors of HRQoL Improvement at 24 Months

Variable	Adjusted OR	95% CI	P value
ICS/LABA intervention	2.78	1.54–5.02	0.001
High baseline symptom burden (ACT < 18)	1.92	1.05–3.53	0.035
Regular follow-up (≥3 visits/year)	2.14	1.12–4.09	0.021
Use of symptom diary or app	1.67	0.92–3.04	0.089
Baseline anxiety (STAI ≥ 40)	0.48	0.25–0.94	0.032
Comorbid obesity (BMI ≥ 30)	0.63	0.34–1.17	0.142
Age ≥ 65 years	0.74	0.41–1.32	0.306

Abbreviations: OR, odds ratio; CI, confidence interval; ICS, inhaled corticosteroid; LABA, long-acting β-agonist; ACT, Asthma Control Test; STAI, State-Trait Anxiety Inventory; BMI, body mass index.

Table 5 Predictors of Clinically Significant Anxiety (STAI ≥ 40) at 24 Months

Variable	Adjusted OR	95% CI	P value
ICS/LABA intervention	0.39	0.21–0.73	0.003
Poor medication adherence	2.34	1.27–4.30	0.006
History of emergency asthma visits	1.91	1.01–3.63	0.047
No access to asthma nurse	2.68	1.34–5.38	0.005
Female sex	1.52	0.84–2.78	0.163
Presence of depression at baseline	3.12	1.43–6.81	0.004
Age ≥ 65 years	1.23	0.65–2.32	0.530

Abbreviations: OR, odds ratio; CI, confidence interval; ICS, inhaled corticosteroid; LABA, long-acting β-agonist; STAI, State-Trait Anxiety Inventory.

Discussion

Asthma is a chronic inflammatory airway disease characterized by variable airflow obstruction, bronchial hyperresponsiveness, and recurring symptoms that significantly impair quality of life and pose substantial healthcare burdens worldwide.[1,2,9,10] Our retrospective cohort study explored the long-term effects of combined inhaled corticosteroids (ICS) and long-acting β_2-agonists (LABAs) on asthma management over a two-year period. The results strongly support the clinical utility of ICS/LABA therapy in improving pulmonary function, reducing exacerbation frequency, and enhancing health-related quality of life (HRQoL) in patients with persistent asthma.

Our findings are consistent with previous large-scale clinical trials and real-world studies that have demonstrated the superiority of ICS/LABA combination therapy compared to monotherapy or as-needed bronchodilators.[11,12] The intervention group in our study achieved significantly greater improvements in FEV_1 and FEV_1/FVC ratios, reflecting better airway patency and reduced inflammatory burden. Moreover, these objective improvements translated into enhanced symptom control, as evidenced by elevated ACT scores and reduced exacerbation events. The number of emergency visits and hospitalizations dropped markedly in the ICS/LABA group, suggesting that regular combination therapy contributes to asthma stabilization and reduces acute care needs. Additionally, our study adds important evidence on the sustained improvements in asthma control, pulmonary function, and exacerbation frequency over a 24-month period, filling a significant gap in the literature on long-term outcomes.[11,13,14] Notably, our findings show that the reduction in exacerbations and improvement in lung function were sustained even beyond 12 months, which has not been consistently demonstrated in earlier trials. Furthermore, the substantial improvement in patient-reported outcomes, as reflected in HRQoL scores from the Mini-AQLQ, demonstrates significant gains in both physical and emotional domains, highlighting the psychosomatic dimensions of asthma. These improvements not only enhance daily functioning but also alleviate emotional stress and anxiety, providing a comprehensive understanding of the benefits of ICS/LABA therapy. Importantly, treatment adherence emerged as a key determinant of clinical success. Patients in the ICS/LABA group reported higher medication possession ratios (MPRs) and were more likely to use inhaler support tools such as reminders and diaries. Poor adherence has long been recognized as a leading cause of asthma deterioration and treatment failure.[15,16] Our multivariate analysis confirmed that nonadherence was a significant risk factor for poor asthma control, independent of other clinical variables. The protective effect of ICS/LABA therapy was robust even after adjusting for baseline severity, smoking status, and comorbidities. This study also sheds light on the often-overlooked mental health impact of asthma. Patients with uncontrolled symptoms frequently experience chronic stress, anxiety, and sleep disturbances. The ICS/LABA group had significantly lower GAD-7 anxiety scores and fewer patients met the threshold for clinical anxiety, supporting the bidirectional relationship between physical symptom burden and psychological well-being.[17] Given the rising recognition of asthma as a biopsychosocial disorder, these data underscore the need for integrated care models that address both physiological and emotional dimensions of disease. The findings of this study support the growing importance of precision medicine in asthma management. By identifying and differentiating specific asthma endotypes—underlying mechanisms that contribute to asthma phenotypes—clinicians can provide more personalized treatment. This approach is crucial, as asthma is an umbrella phenotype with diverse endotypes, and treatment

efficacy largely depends on properly identifying these subgroups. Precision medicine offers the potential to optimize therapeutic strategies and significantly improve patient outcomes.

Despite the strengths of our study, including real-world data, robust PSM design, and multidimensional outcome assessment, several limitations should be acknowledged. First, as a retrospective study, there is an inherent risk of selection bias and unmeasured confounding. Although PSM was used to minimize baseline disparities, prospective randomized controlled trials are needed to confirm causal relationships. Second, adherence data were partly based on self-reporting, which may introduce recall bias. Third, the impact of environmental triggers, allergen exposures, and socioeconomic factors was not fully captured, which may influence asthma trajectories over time.Future research should focus on refining personalized treatment algorithms, integrating digital adherence tools, and assessing cost-effectiveness across diverse healthcare settings. Long-term follow-up studies evaluating ICS/LABA therapy's impact on lung remodeling, healthcare utilization, and mortality will further clarify its role in the chronic care of asthma.

Conclusion

In conclusion, this study demonstrates that ICS/LABA combination therapy offers sustained clinical benefits for patients with persistent asthma over a 24-month period. The long-term improvements in asthma control, reduction in exacerbations, and enhanced pulmonary function underscore the efficacy and safety of this treatment approach in real-world clinical practice.

Data Sharing Statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval and Consent to Participation

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Wuhan Hankou Hospital. Due to the retrospective nature of the study, the requirement for informed consent was waived by the ethics committee. All data were anonymized, and personal identifiers were removed to ensure privacy and data security. The study adhered to all applicable laws and regulations regarding data protection and confidentiality.

Author Contributions

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

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Disclosure

The authors have no conflicts of interest to declare in this work.

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