

Assessment of Inhaled Corticosteroid Adherence in Adults with Severe Asthma Receiving Biologic Therapy: A Retrospective Observational Study

Gökten Bulut¹, Derya Aydın²

¹Department of Allergy and Immunology, Atatürk City Hospital, Balıkesir, Türkiye; ²Department of Chest Diseases, Atatürk City Hospital, Balıkesir, Türkiye

Correspondence: Gökten Bulut, Department of Allergy and Immunology, Atatürk City Hospital, Balıkesir, Türkiye, Email goktenbulut58@gmail.com

Background: Inhaled corticosteroids (ICS) remain the cornerstone of long-term asthma management. However, adherence to inhaled therapy is frequently suboptimal, even among patients with severe asthma. Biologic therapies substantially improve clinical outcomes, which may unintentionally influence adherence to maintenance inhaler therapy.

Objective: To evaluate adherence to inhaled controller therapy in adults with severe asthma receiving biologic treatment and to identify clinical factors associated with inhaler non-adherence.

Methods: This single-center retrospective observational study included 173 adults with severe asthma receiving anti-IgE or anti-IL-5/IL-5Ra biologic therapy for at least 12 months. Adherence during the 12-month biologic treatment period was assessed using pharmacy dispensing records (PDR) and the 10-item Test of Adherence to Inhalers (TAI). Non-adherence was defined as medication possession ratio (MPR) <80% and/or TAI score ≤ 45 . Baseline Asthma Control Test (ACT) scores and FEV₁ (% predicted) values were recorded prior to biologic initiation. Multivariable logistic regression was performed to identify independent predictors of inhaler non-adherence.

Results: Overall, 49.1% of patients were classified as non-adherent when both methods were considered. Non-adherence rates were 38.2% according to PDR and 29.5% according to TAI (TAI ≤ 45). Agreement between methods was fair ($\kappa = 0.37$, $p < 0.001$). Higher baseline ACT scores measured prior to biologic initiation were independently associated with inhaler non-adherence (OR 1.26, 95% CI 1.15–1.38, $p < 0.001$). FEV₁ (% predicted) was not significantly associated with adherence status. Adherence to biologic therapy was substantially higher (90.8%) than adherence to inhaled therapy.

Conclusion: Inhaler non-adherence remains prevalent among patients with severe asthma receiving biologic therapy. Higher baseline ACT scores independently predict this risk. Routine multidimensional adherence assessment and structured patient education remain essential.

Keywords: severe asthma, inhaled corticosteroids, medication adherence, biologic therapy, asthma control test

Introduction

Long-term asthma control depends on the regular use of anti-inflammatory controller medications, with inhaled corticosteroids (ICS) playing a central role in suppressing airway inflammation and reducing exacerbation risk. Consistent use of inhaled therapy improves symptom control, preserves lung function, and enhances health-related quality of life.^{1–3} Nevertheless, real-world adherence remains suboptimal, and a substantial proportion of patients do not follow prescribed treatment regimens.⁴ Poor adherence is a well-recognized contributor to inadequate asthma control and increased healthcare utilization.⁵

Patients with severe asthma represent a relatively small subset of the asthma population but experience a disproportionate burden of morbidity, mortality, and healthcare costs.^{6,7} Failure to maintain regular ICS use remains an important and modifiable contributor to persistent symptoms and exacerbations.^{8,9}



The management of severe asthma has evolved substantially with the introduction of biologic therapies targeting key inflammatory pathways. Current international guidelines recommend biologic agents for selected patients whose disease remains uncontrolled despite optimized high-dose inhaled therapy.¹⁰ In Türkiye, approved biologic treatments include agents targeting immunoglobulin E and interleukin-5 or its receptor. Although biologic therapy improves symptom control and reduces exacerbations, its impact on adherence to background inhaled therapy remains unclear. Symptom improvement may reduce patients' perceived need for maintenance inhalers, potentially compromising long-term disease stability.

Guidelines recommend the combined use of the Test of Adherence to Inhalers (TAI) questionnaire and pharmacy dispensing records (PDR) to assess adherence, as no single method adequately captures medication-taking behavior.⁷ While several studies have examined inhaler adherence in severe asthma, data focusing specifically on patients receiving biologic therapy remain limited.

This study aimed to evaluate adherence to inhaled therapy using both patient-reported and pharmacy-based measures in adults with severe asthma receiving biologic treatment and to identify clinical predictors of inhaler non-adherence.

Methods

Study Design and Population

This retrospective observational study was conducted at the Allergy and Immunology Unit of Atatürk City Hospital, a tertiary-care center in Balıkesir, Türkiye.

Adult patients aged ≥ 18 years with severe asthma receiving anti-IgE (omalizumab) or anti-IL5/IL-5R α (mepolizumab, benralizumab) biologic therapy for at least 12 months were included. Biologic therapies were administered as subcutaneous injections at intervals of two to eight weeks according to approved dosing regimens.

Severe asthma was defined according to Global Initiative for Asthma (GINA) guidelines as asthma remaining uncontrolled despite optimized high-dose inhaled corticosteroid–long-acting β_2 -agonist (ICS–LABA) therapy and/or requiring maintenance oral corticosteroids (OCS).¹⁰

A standardized stepwise ICS dose-reduction protocol is considered only in patients who achieve sustained asthma control for at least 3 months, consistent with GINA step-down recommendations.

The study was approved by the local research ethics committee (Approval No: 2025/08/95). All procedures complied with the Declaration of Helsinki.

Assessment of Adherence

Adherence during the 12-month biologic treatment period was assessed using:

1. Pharmacy dispensing records
2. Test of Adherence to Inhalers

Medication possession ratio (MPR) was calculated as total days' supply dispensed divided by 365 days \times 100. MPR $\geq 80\%$ was considered adherent.¹¹

The validated 10-item TAI questionnaire (score range 10–50) was used.¹² A score ≤ 45 indicated poor adherence. Combined inhaler non-adherence was defined as MPR $< 80\%$ and/or TAI ≤ 45 .

Clinical Variables

Baseline Asthma Control Test (ACT)¹³ scores and forced expiratory volume in one second (FEV₁ % predicted) values were measured prior to biologic initiation. FEV₁ was calculated using Global Lung Function Initiative reference equations.¹⁴

Demographic variables included age and sex. Comorbidities and treatment regimens were recorded. Emergency department visits and hospitalizations refer to events occurring during the 12-month biologic treatment period.

Statistical Analysis

Continuous variables were expressed as mean \pm standard deviation or median (interquartile range). Categorical variables were expressed as number (%).

Comparisons were performed using the Mann–Whitney *U*-test, chi-square test, or Fisher's exact test, as appropriate. Agreement between adherence methods was evaluated using Cohen's kappa statistic.

Multivariable logistic regression analysis was performed to identify independent predictors of inhaler non-adherence. Statistical analyses were conducted using IBM SPSS Statistics version 25.0. A *p* value <0.05 was considered statistically significant.

Results

Patient Characteristics

A total of 173 patients with severe asthma receiving biologic therapy were included in the analysis. The median age was 53.4 years (IQR 50.49–56.32), and 76.9% of patients were female. Most patients (87.3%) had at least one comorbid condition. The most common comorbidities were allergic rhinoconjunctivitis (30.1%), nasal polyposis (16.8%), and gastroesophageal reflux disease (10.4%).

During the 12-month follow-up period while receiving biologic therapy, 12.1% of patients experienced at least one asthma-related emergency department visit or hospitalization (5.2% emergency department visits and 6.9% hospitalizations).

All patients were receiving combination inhaled corticosteroid–long-acting β_2 -agonist (ICS–LABA) therapy, and 56.6% were additionally using long-acting muscarinic antagonists (LAMA). Montelukast was prescribed in 67.0% of patients, and 9.8% were receiving maintenance OCS. Regarding biologic therapies, 46.2% of patients were treated with omalizumab, 37.0% with mepolizumab, and 16.8% with benralizumab. Adherence to biologic therapy was high (90.8%) based on injection administration records and pharmacy dispensing data.

Baseline lung function was moderately impaired, with a mean FEV₁ of $71.2 \pm 22.3\%$ predicted. The median baseline ACT score measured prior to biologic initiation was 11.8 (IQR 9.2–13.4).

Baseline demographic and clinical characteristics prior to biologic initiation are presented in [Table 1](#), whereas clinical outcomes and treatment characteristics during the 12-month biologic treatment period are summarized in [Table 2](#).

Inhaler Adherence Assessment

When adherence was evaluated using PDR, 38.2% of patients were classified as non-adherent (medication possession ratio [MPR] $<80\%$). Using the validated TAI cut-off of ≤ 45 , 29.5% of patients were identified as non-adherent.

When both methods were combined (MPR $<80\%$ and/or TAI ≤ 45), 49.1% of patients were classified as non-adherent, while 50.9% were classified as adherent.

Agreement between the two adherence assessment methods was fair ($\kappa = 0.37$, $p < 0.001$), indicating that pharmacy-based and patient-reported measures capture overlapping but distinct dimensions of adherence behavior ([Table 3](#)).

Comparison Between Adherent and Non-Adherent Patients

No statistically significant differences in inhaler adherence were observed according to sex, age, smoking status, presence of comorbidities, additional asthma treatments, or type of biologic therapy received.

When patients were classified according to combined adherence status, mean FEV₁ (% predicted) was numerically higher in non-adherent patients compared to adherent patients ($73.3 \pm 22.6\%$ vs. $69.3 \pm 22.0\%$, $p = 0.228$); however, this difference did not reach statistical significance. Similarly, no significant differences were observed between groups with respect to asthma-related emergency department visits ($p = 1.00$) or hospitalizations ($p = 1.00$) during the 12-month biologic treatment period. Baseline FEV₁ (% predicted) was also not significantly different between adherent and non-adherent patients ($p = 0.406$).

Table 1 Baseline Demographic and Clinical Characteristics Prior to Biologic Initiation (n = 173)

Characteristic	Value
Age, median (IQR), years	53.4 (50.49–56.32)
Female sex, n (%)	133 (76.9)
Smoking status, n (%)	
Never smoker	99 (57.2)
Former smoker	52 (30.1)
Current smoker	22 (12.7)
Any comorbidity, n (%)	151 (87.3)
Allergic rhinoconjunctivitis	52 (30.1)
Nasal polyposis	29 (16.8)
Gastroesophageal reflux disease	18 (10.4)
Bronchiectasis	15 (8.7)
Anxiety and depression	14 (8.1)
NERD	10 (5.8)
COPD	8 (4.6)
OSAHS	3 (1.7)
FEV ₁ (% predicted), mean ± SD	71.2 ± 22.3
ACT score, median (IQR)	11.8 (9.2–13.4)

Notes: Data are presented as median (interquartile range), mean ± standard deviation, or number (%).

Abbreviations: ACT, Asthma Control Test; COPD, chronic obstructive pulmonary disease; FEV₁, forced expiratory volume in one second; NERD, nonsteroidal anti-inflammatory drug–exacerbated respiratory disease; OSAHS, obstructive sleep apnea–hypopnea syndrome.

Table 2 Treatment Characteristics and Clinical Outcomes During the 12-Month Biologic Treatment Period (n = 173)

Variable	Value
Asthma-related emergency department visits, n (%)	9 (5.2)
Asthma-related hospitalizations, n (%)	12 (6.9)
Adherence to biologic therapy, n (%)	157 (90.8)
Inhaled therapies, n (%)	
ICS–LABA combination inhaler	173 (100.0)
LAMA	98 (56.6)
Montelukast	116 (67.0)
Maintenance oral corticosteroids	17 (9.8)
Biologic therapy type, n (%)	
Omalizumab	80 (46.2)
Mepolizumab	64 (37.0)
Benralizumab	29 (16.8)

Notes: Data are presented as number (%).

Abbreviations: ICS, inhaled corticosteroids; LABA, long-acting β_2 -agonists; LAMA, long-acting muscarinic antagonists.

In contrast, baseline ACT scores measured prior to biologic initiation were significantly higher in non-adherent patients compared to adherent patients (median 12.99 [IQR 12.24–13.74] vs. 9.64 [IQR 8.87–10.41], $p < 0.001$) (Figure 1).

Multivariable Analysis

Multivariable logistic regression analysis was performed to identify independent predictors of inhaler non-adherence, defined as combined non-adherence (MPR <80% and/or TAI ≤ 45). After adjustment for age, sex, FEV₁ (% predicted),

Table 3 Agreement Between Pharmacy Dispensing Records and the Test of Adherence to Inhalers (TAI)

	TAI Non-Adherent (≤ 45)	TAI Adherent (> 45)
PDR non-adherent ($< 80\%$)	49 (28.3%)	17 (9.8%)
PDR adherent ($\geq 80\%$)	23 (13.3%)	84 (48.6%)

Notes: Cohen's $\kappa = 0.37$, $p < 0.001$, Data are presented as number (%).

Abbreviations: PDR, pharmacy dispensing records; TAI, Test of Adherence to Inhalers.

comorbidity status, smoking status, biologic therapy type, emergency department visits, and hospitalizations, baseline ACT score remained independently associated with inhaler non-adherence (OR 1.26, 95% CI 1.15–1.38, $p < 0.001$) (Table 4).

No other variables demonstrated a statistically significant independent association with inhaler non-adherence.

Discussion

Adherence to long-term controller therapy remains a critical determinant of outcomes in chronic respiratory diseases.¹⁵ In asthma management, regular use of inhaled medications is essential to maintain disease stability and prevent exacerbations, whereas inconsistent use may lead to persistent symptoms, increased healthcare utilization, and inappropriate

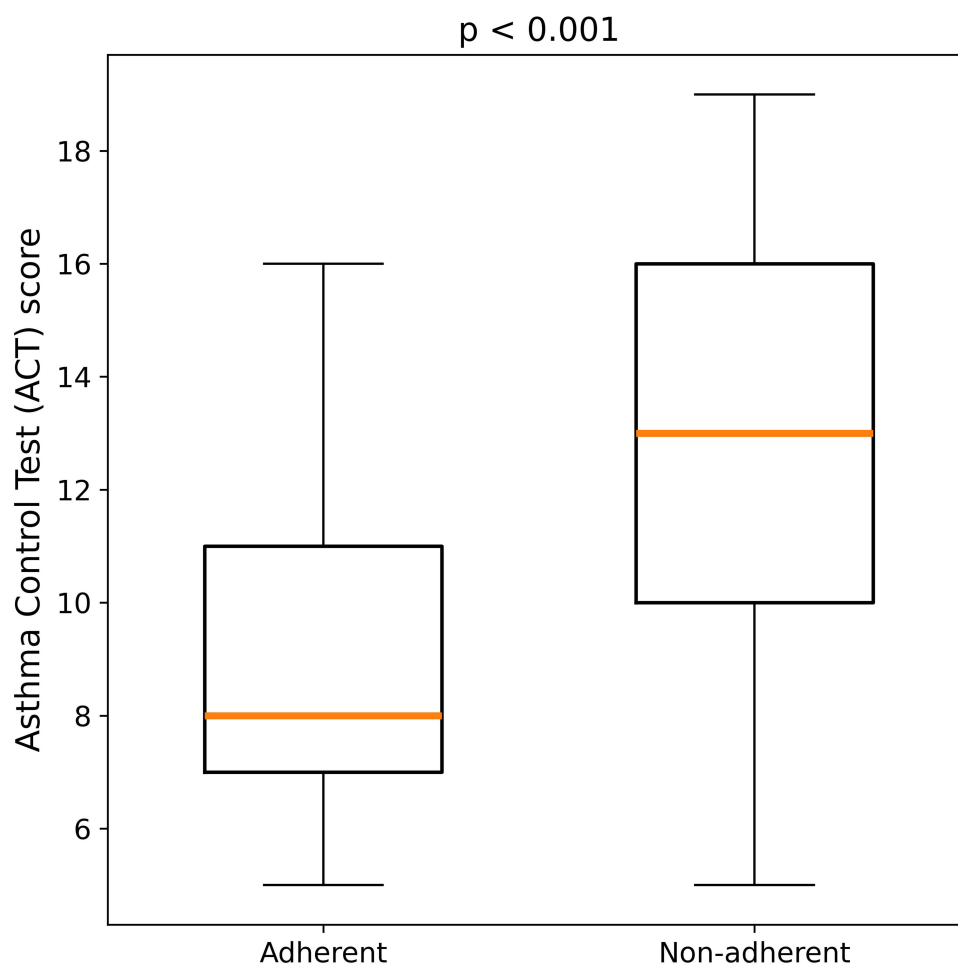


Figure 1 Baseline Asthma Control Test (ACT) scores prior to biologic initiation in adherent and non-adherent patients. The median and interquartile ranges are displayed, with whiskers indicating the range. ACT scores are higher in non-adherent patients compared to adherent patients, and the difference is statistically significant ($p < 0.001$).

Table 4 Multivariable Logistic Regression Analysis of Factors Associated with Inhaler Non-Adherence

Predictor	OR (95% CI)	p value
Age (per year)	0.97 (0.94–1.01)	0.128
Female sex	0.99 (0.38–2.54)	0.981
ACT score (per point)	1.26 (1.15–1.38)	<0.001
FEV ₁ (% predicted)	1.00 (0.99–1.02)	0.662
Any comorbidity	0.36 (0.10–1.30)	0.118
Former smoker	1.07 (0.45–2.56)	0.875
Current smoker	1.37 (0.40–4.61)	0.616
Mepolizumab vs omalizumab	0.98 (0.41–2.35)	0.960
Benralizumab vs omalizumab	1.63 (0.52–5.11)	0.405
Prior hospitalization	8.59 (0.55–134.78)	0.126
Prior ED visit	0.54 (0.02–11.80)	0.694

Notes: Odds ratios and 95% confidence intervals were derived from multivariable logistic regression analysis. All variables were entered simultaneously into the model. Continuous variables were analyzed per unit increase. Reference categories were male sex, never smoker, and omalizumab treatment.

Abbreviations: OR, odds ratio; CI, confidence interval; ACT, Asthma Control Test; FEV₁, forced expiratory volume in one second; ED, emergency department.

treatment escalation.^{1–3} Despite advances in pharmacological therapies, achieving sustained adherence continues to represent a major challenge, particularly among patients with severe asthma.

In the present study, approximately half of patients with severe asthma receiving biologic therapy were classified as non-adherent to inhaled treatment when both pharmacy dispensing records (PDR) and the validated TAI cut-off (≤ 45) were considered. This finding underscores the persistence of suboptimal adherence even in a population receiving advanced biologic therapy. The use of two complementary adherence assessment methods provided a more comprehensive evaluation, as reliance on a single tool may underestimate the true prevalence of non-adherence.

Consistent with prior studies,^{5,16} the proportion of non-adherent patients differed according to the assessment method, highlighting the multidimensional nature of adherence behavior. Agreement between TAI and PDR was fair ($\kappa = 0.37$), indicating that patient-reported and pharmacy-based measures capture overlapping but distinct aspects of medication use. Previous research has demonstrated that prescription filling does not necessarily translate into consistent medication use, and primary non-adherence remains common in asthma management.¹⁷ Taken together, these findings support the complementary use of subjective and objective adherence tools, as recommended by current guidelines.¹⁰

A principal finding of this study is that higher Asthma Control Test (ACT) scores measured prior to initiation of biologic therapy were independently associated with inhaler non-adherence. In multivariable logistic regression analysis, baseline ACT score remained significantly associated with non-adherence (OR 1.26, 95% CI 1.15–1.38, $p < 0.001$). Patients with better symptom control at the time of biologic initiation were more likely to demonstrate suboptimal adherence to inhaled therapy.

Because ACT was measured prior to biologic initiation and adherence was assessed during the subsequent 12-month treatment period, causal inference cannot be established. Therefore, this association should be interpreted as predictive rather than causative. One plausible explanation is that patients experiencing lower symptom burden may perceive less need for continuous controller therapy, leading to inconsistent inhaler use. Previous studies have similarly shown that perceived improvement in asthma control may reduce adherence to maintenance medications.^{18,19} Our findings extend this observation to a severe asthma population eligible for biologic therapy.

Importantly, ICS dose reduction in our center follows a structured, physician-supervised protocol consistent with GINA step-down principles and is implemented only after sustained clinical stability. Accordingly, the non-adherence observed in this study should not be interpreted as medically supervised treatment de-escalation. Although biologic therapies substantially improve asthma control and reduce exacerbation frequency, current international guidelines do not recommend routine discontinuation of ICS in biologic-treated patients. GINA advises that step-down of controller

therapy be considered only after sustained disease control and under close medical supervision, with ICS generally maintained as the foundation of anti-inflammatory management.¹⁰ Furthermore, while biologic agents have demonstrated oral corticosteroid-sparing effects in selected populations, robust evidence supporting safe and complete withdrawal of ICS remains limited.^{6,10} Therefore, reduced inhaler use among biologic-treated patients may reflect altered symptom perception rather than true resolution of underlying airway inflammation.

Notably, the association with adherence was observed for ACT but not for FEV₁ (% predicted). ACT reflects patient-reported symptom control, whereas FEV₁ represents objective airflow limitation. Previous literature indicates that correlations between ACT and FEV₁ are variable, while ACT often demonstrates stronger relationships with patient-centered outcomes such as quality of life.²⁰ These findings suggest that patients' perception of symptom control may exert a greater influence on adherence behavior than spirometric parameters.

Adherence to biologic therapy was substantially higher than adherence to inhaled medications. This observation is consistent with previous reports²¹ and may be explained by structured administration schedules, less frequent dosing, and higher perceived treatment efficacy. Notably, inhaler non-adherence was not associated with increased emergency department visits or hospitalizations during the 12-month follow-up period. This finding suggests that biologic therapy may mitigate short-term clinical deterioration, potentially attenuating the observable impact of suboptimal inhaler adherence. However, biologic therapy does not replace the anti-inflammatory foundation provided by inhaled corticosteroids. Therefore, poor adherence to inhaled therapy may still compromise long-term disease stability and confound interpretation of biologic treatment response.

Unlike some prior studies,^{22,23} we did not observe significant associations between inhaler adherence and demographic characteristics, smoking status, comorbidities, or type of biologic therapy received. Differences in population characteristics, healthcare systems, assessment tools, and sample size may account for these discrepancies.

This study has several strengths, including a well-characterized cohort of severe asthma patients receiving biologic therapy, the simultaneous use of complementary adherence assessment methods, and adjustment for potential confounders through multivariable analysis. However, certain limitations should be acknowledged. Both TAI and pharmacy dispensing records are indirect measures and do not constitute a gold standard for adherence assessment. PDR reflects medication dispensing rather than actual inhaler use, whereas TAI may be influenced by recall or reporting bias. Additionally, the retrospective single-center design may limit generalizability. Socioeconomic factors such as educational level, income status, and health literacy were not available in this dataset and therefore could not be included in the multivariable analysis. These variables are known to influence adherence behavior and may have acted as residual confounders.

Importantly, ACT scores analyzed in this study reflect asthma control prior to initiation of biologic therapy, reinforcing the temporal separation between predictor and outcome variables.

Conclusion

Inhaler non-adherence remains prevalent among patients with severe asthma receiving biologic therapy. Higher baseline ACT scores independently predict increased risk of inhaler non-adherence. Routine multidimensional adherence assessment and structured patient education are essential to optimize long-term asthma management.

Use of Artificial Intelligence

ChatGPT (OpenAI) was used to improve language clarity and structure. The authors reviewed and take full responsibility for the manuscript content.

Abbreviations

ACT, Asthma Control Test; CI, confidence interval; COPD, chronic obstructive pulmonary disease; ED, emergency department; FEV₁, forced expiratory volume in one second (% predicted); GINA, Global Initiative for Asthma; ICS, inhaled corticosteroids; IgE, immunoglobulin E; IL-5, interleukin-5; IL-5R α , interleukin-5 receptor alpha; LABA, long-acting β_2 -agonists; LAMA, long-acting muscarinic antagonists; MPR, medication possession ratio; NERD, nonsteroidal anti-inflammatory drug-exacerbated respiratory disease; OCS, oral corticosteroids; OR, odds ratio; OSAHS, obstructive

sleep apnea–hypopnea syndrome; PDR, pharmacy dispensing records; SABA, short-acting β_2 -agonists; TAI, Test of Adherence to Inhalers.

Data Sharing Statement

Data are available from the corresponding author upon reasonable request.

Ethics Approval

Approved by the local ethics committee of Atatürk City Hospital (Approval No: 2025/08/95).

Informed Consent

Written informed consent was obtained from all participants.

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.

Funding

No external funding was received.

Disclosure

The authors declare no conflicts of interest.

References

1. Thoonen BP, Schermer TR, Van Den Boom G, et al. Self-management of asthma in general practice, asthma control and quality of life: a randomized controlled trial. *Thorax*. 2003;58:30. doi:10.1136/thorax.58.1.30
2. Engelkes M, Janssens HM, De Jongste JC, et al. Medication adherence and the risk of severe asthma exacerbations: a systematic review. *Eur Respir J*. 2015;45:396. doi:10.1183/09031936.00075614
3. Van Boven JFM, Koponen M, Lalic S, et al. Trajectory analyses of adherence patterns in a real-life moderate to severe asthma population. *J Allergy Clin Immunol Pract*. 2020;8:1961. doi:10.1016/j.jaip.2019.12.002
4. Bozek A, Jarzab J. Adherence to asthma therapy in elderly patients. *J Asthma*. 2010;47:162–165. doi:10.3109/02770900903497204
5. De Llano LP, Sanmartín AP, González-Barcala FJ, et al. Assessing adherence to inhaled medication in asthma: impact of once-daily versus twice-daily dosing frequency. The ATAUD study. *J Asthma*. 2018;55:933–938. doi:10.1080/02770903.2018.1426769
6. Chung KF, Wenzel SE, Brozek JL, et al. International ERS/ATS guidelines on definition, evaluation and treatment of severe asthma. *Eur Respir J*. 2014;43:343–373. doi:10.1183/09031936.00202013
7. Zeiger RS, Schatz M, Dalal AA, et al. Utilization and costs of severe uncontrolled asthma in a managed-care setting. *J Allergy Clin Immunol Pract*. 2016;4:120–129.e3. doi:10.1016/j.jaip.2015.08.003
8. Gamble J, Stevenson M, McClean E, et al. The prevalence of nonadherence in difficult asthma. *Am J Respir Crit Care Med*. 2009;180:817–822. doi:10.1164/rccm.200902-0166OC
9. Murphy AC, Proeschal A, Brightling CE, et al. The relationship between clinical outcomes and medication adherence in difficult-to-control asthma. *Thorax*. 2012;67:751–753. doi:10.1136/thoraxjnl-2011-201096
10. Global Initiative for Asthma. Global strategy for asthma management and prevention. 2025. Available from: <https://ginasthma.org/2025-gina-strategy-report/>. Accessed June 12, 2025.
11. Karve S, Cleves MA, Helm M, et al. Good and poor adherence: optimal cut-point for adherence measures using administrative claims data. *Curr Med Res Opin*. 2009;25:2303–2310. doi:10.1185/03007990903126833
12. Plaza V, López-Viña A, Entrenas LM, et al. Validation of the Test of Adherence to Inhalers (TAI) for asthma and COPD patients. *J Aerosol Med Pulm Drug Deliv*. 2016;29:142–152. doi:10.1089/jamp.2015.1212
13. Uysal MA, Mungan D, Yorgancıoğlu A, et al. The validation of the Turkish version of asthma control test. *Qual Life Res*. 2013;22:1773–1779. doi:10.1007/s11136-012-0309-1
14. Quanjer PH, Stanojevic S, Cole TJ, et al. Multi-ethnic reference values for spirometry for the 3–95-year age range: the Global Lung Function 2012 equations. *Eur Respir J*. 2012;40:1324–1343. doi:10.1183/09031936.00080312
15. Bender BG, Bender SE. Patient-identified barriers to asthma treatment adherence. *Immunol Allergy Clin North Am*. 2005;25:107. doi:10.1016/j.iac.2004.09.005
16. Plaza V, Giner J, Curto E, et al. Assessing adherence by combining the test of adherence to inhalers with pharmacy refill records. *J Investig Allergol Clin Immunol*. 2021;31:58–64. doi:10.18176/jiaci.0461

17. Williams LK, Joseph CL, Peterson EL, et al. Patients with asthma who do not fill their inhaled corticosteroids: a study of primary nonadherence. *J Allergy Clin Immunol.* 2007;120:1153. doi:10.1016/j.jaci.2007.08.020
18. Normansell R, Kew KM, Stovold E. Interventions to improve adherence to inhaled steroids for asthma. *Cochrane Database Syst Rev.* 2017;4:CD012226. doi:10.1002/14651858.CD012226.pub2
19. Van Dijk BCP, Svedsater H, Heddimi A, et al. Relationship between the asthma control test and other outcomes: a targeted literature review. *BMC Pulm Med.* 2020;20:79. doi:10.1186/s12890-020-1090-5
20. Maddux JT, Inselman JW, Jeffery MM, et al. Adherence to asthma biologics: implications for patient selection, step therapy, and outcomes. *Chest.* 2021;159(3):924. doi:10.1016/j.chest.2020.10.050
21. Yonas MA, Marsland AL, Emeremni CA, et al. Depressive symptomatology, quality of life and disease control among individuals with severe asthma. *J Asthma.* 2013;50:884. doi:10.3109/02770903.2013.810750
22. Alqarni AA, Aldhahir AM, Siraj RA, et al. Asthma medication adherence, control, and psychological symptoms: a cross-sectional study. *BMC Pulm Med.* 2024;24:189. doi:10.1186/s12890-024-02995-x
23. López-Viña A, Giner J, Molina J, et al. Multidisciplinary consensus on nonadherence to inhaled therapy in Spanish asthma patients. *Clin Ther.* 2017;39:1730–1745. doi:10.1016/j.clinthera.2017.06.010

Journal of Asthma and Allergy

Publish your work in this journal

The Journal of Asthma and Allergy is an international, peer-reviewed open-access journal publishing original research, reports, editorials and commentaries on the following topics: Asthma; Pulmonary physiology; Asthma related clinical health; Clinical immunology and the immunological basis of disease; Pharmacological interventions and new therapies. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/journal-of-asthma-and-allergy-journal>

Dovepress
Taylor & Francis Group