

IASR J. Med. Pharm. Sci.
ISSN: 2582-9343
Website: https://ijmps.com/
Open Access Journal
Country: India

IASR Journal of
Medical and Pharmaceutical Science

ORIGINAL ARTICLE OPEN ACCESS

Inhaler Technique, Medication Adherence, and Symptom Control Among Patients with Bronchial Asthma Attending a Tertiary Care Hospital in North India: A Cross-Sectional Study

Dr Nitika Sindhu[1], Dr Komal Dalal[2], Dr Ankit Juneja[3], Dr Jatin Prajapati[4]

[1]Assistant Professor, Department of Pharmacology, World College of Medical Sciences and Research, Jhajjar, Haryana, India. (ORCID: https://orcid.org/0000-0002-3477-1108)
[2]Assistant Professor, Department of Pharmacology, World College of Medical Sciences and Research, Jhajjar, Haryana, India. (ORCID: https://orcid.org/0009-0003-5931-9649)
[3]Senior Resident, Department of Pharmacology, Maharaja Agrasen Medical College, Agroha, Hisar, Haryana, India.
[4]Senior Resident, Department of Community Medicine, World College of Medical Sciences and Research, Jhajjar, Haryana, India. (ORCID: https://orcid.org/0009-0004-7298-4499)

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Corresponding Author
Dr Nitika Sindhu
Assistant Professor, Department of Pharmacology, World College of Medical Sciences and Research, Jhajjar, Haryana, India.
Email:
nitika.sindhu52@gmail.com

Received: 04 Oct 2026
Accepted: 20 Oct 2026
Published: 19 Nov 2026

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ABSTRACT

Background: Incorrect inhaler technique and suboptimal medication adherence may compromise asthma management. Their separate assessment alongside symptom control can identify potentially modifiable treatment difficulties.
Objectives: To assess inhaler technique, medication adherence, and symptom control and examine their associations among adults with bronchial asthma.
Methods: This hospital-based analytical cross-sectional study included 220 adults receiving scheduled maintenance inhaler therapy for ≥3 months at a tertiary care hospital in North India between April and October 2026. Technique was observed using device-specific checklists before corrective instruction. Adherence was assessed using the 10-item Test of Adherence to Inhalers (TAI), and symptom control using the Asthma Control Test (ACT). ACT scores ≤19 defined symptoms not well controlled. Modified Poisson regression with robust standard errors estimated adjusted prevalence ratios (aPRs).
Results: Mean age was 42.0 ± 13.4 years, and 51.4% were female. Any technique error occurred in 159 participants (72.3%; 95% confidence interval [CI]: 66.0–77.8), including 82 with critical errors (37.3%; 95% CI: 31.2–43.8). Across 252 demonstrations, critical errors occurred in 34.1%. TAI classified 27.7% as adherent, 53.2% as having intermediate adherence, and 19.1% as having poor adherence. Symptoms were not well controlled in 116 participants (52.7%; 95% CI: 46.1–59.2). Critical errors (aPR: 1.36; 95% CI: 1.06–1.74; p=0.015), each five-point decrease in TAI score (aPR: 1.28; 95% CI: 1.06–1.56; p=0.011), and current smoking (aPR: 1.37; 95% CI: 1.07–1.76; p=0.014) were associated with inadequate symptom control.
Conclusion: Critical inhaler errors and poorer reported adherence were associated with symptoms not well controlled. Routine review should assess both dimensions separately and address smoking. Cross-sectional findings support targeted assessment but cannot establish causation. Longitudinal studies should evaluate whether individualized technique training and adherence support improve sustained control. Objective adherence measures and repeated assessments would strengthen interpretation and help distinguish persistent treatment difficulties from performance during a single clinical encounter.

Key Words: *Bronchial asthma; Inhaler technique; Medication adherence; Asthma control; Inhalation devices; Cross-sectional studies; India.*

INTRODUCTION

Bronchial asthma is a heterogeneous chronic respiratory disease characterized by variable respiratory symptoms and expiratory airflow limitation. Its clinical burden includes disturbed sleep, activity limitation, exacerbations, and healthcare utilization. Contemporary management seeks to achieve symptom control while reducing future risks through appropriate inhaled corticosteroid-containing treatment and individualized assessment. The Global Initiative for Asthma emphasizes checking inhaler technique and adherence before escalating treatment because an apparently inadequate response may reflect difficulties using the prescribed regimen rather than insufficient pharmacological intensity [1]. These potentially modifiable factors therefore deserve systematic attention during outpatient care.

In India, asthma contributes substantially to chronic respiratory disease burden, with important differences across states. The India State-Level Disease Burden Initiative documented geographical heterogeneity in asthma and other chronic respiratory diseases, highlighting the need for locally relevant assessment and management [2]. National estimates, however, cannot describe how individual patients use inhalers or whether prescribed treatment translates into symptom control. Tertiary care clinics provide an opportunity to examine these aspects together, particularly among patients requiring sustained maintenance therapy. Such assessment may identify practical treatment difficulties that routine prescription review alone does not reveal.

Effective inhaled therapy depends on correct device preparation and inhalation manoeuvres. These requirements differ between pressurized metered-dose inhalers and dry-powder devices, making device-specific observation essential. Sanchis et al. documented persistently frequent inhaler errors across several decades, despite advances in inhaler technology [3]. Nevertheless, all errors do not have equivalent consequences. The CRITIKAL study identified specific errors associated with adverse asthma outcomes, supporting a distinction between critical errors and other departures from recommended technique [4]. Reporting only an overall technique score may obscure clinically important differences between error types and devices.

Medication adherence is related to, but distinct from, technical competence. A patient may use an inhaler correctly when observed but take treatment irregularly; another may follow the prescribed schedule while consistently using the device incorrectly. The adherence taxonomy proposed by Vrijens et al. distinguishes treatment initiation, implementation, and discontinuation, providing a framework for describing medication-use behaviour [5]. In asthma, Williams et al. demonstrated an association between inhaled corticosteroid non-adherence and severe exacerbations [6]. However, observational associations require consideration of disease characteristics, treatment changes, and the possibility that medication use varies in response to symptoms.

Structured instruments can complement direct observation by assessing medication-use behaviour and patient-reported control. Plaza et al. developed and validated the Test of Adherence to Inhalers, which includes a patient-reported component suitable for characterizing adherence [7]. Using its 10 patient-reported items separately from observed technique helps preserve the distinction between these exposures. The Asthma Control Test provides a brief assessment of recent symptoms and their functional consequences and was developed to discriminate between differing levels of asthma control [8]. Nevertheless, self-report remains vulnerable to recall and social-desirability bias, while current symptom control does not fully represent future exacerbation risk.

Joint assessment of technique, adherence, and symptom control can therefore provide a more informative clinical picture than evaluating any component in isolation. In a tertiary care setting in North India, device differences, previous inhaler education, treatment complexity, and patient characteristics may influence these relationships. The aim of the present study was to assess inhaler technique, medication adherence, and symptom control among adults with bronchial asthma attending a tertiary care hospital in North India. Secondary objectives were to describe device-specific errors, examine associations of critical errors and adherence with symptom control, and identify demographic, clinical, and treatment factors associated with technique and adherence.

METHODOLOGY

Study Design: This was a hospital-based analytical cross-sectional study.

Study Setting: The study setting was the respiratory medicine outpatient clinic of a tertiary care hospital in North India.

Study Duration: The study period was seven months, from 1 April to 31 October 2026.

Study Population: The study population comprised adults with established bronchial asthma who had used prescribed scheduled maintenance inhaler therapy for at least three months. The diagnostic assessment incorporated medical records and available evidence of variable expiratory airflow limitation. Current spirometry was not used as a prerequisite for participation.

Inclusion Criteria: Adults aged ≥18 years with documented bronchial asthma, prescribed scheduled maintenance inhaler therapy for ≥3 months, and willingness to provide written informed consent were eligible. Participants were required to demonstrate their maintenance inhaler use and complete the questionnaires independently or through standardized interviewer assistance.

Exclusion Criteria: Exclusion criteria comprised an acute exacerbation requiring immediate treatment, documented coexisting chronic obstructive pulmonary disease or another major respiratory disorder substantially affecting symptom assessment, exclusive nebulized maintenance treatment, and cognitive or physical impairment preventing meaningful participation. Patients using only as-needed inhaled therapy were excluded because adherence was assessed against a scheduled maintenance regimen.

Sample Size: The sample size was calculated to estimate the prevalence of critical inhaler errors. A conservative planning prevalence of 50% was selected, with a 95% confidence level and absolute precision of seven percentage points.

$$n = \frac{Z^2_{1-\alpha/2} p(1-p)}{d^2}$$

Here, $Z_{1-\alpha/2}$=1.96, p=0.50, and d=0.07.

$$n = \frac{1.96^2 \times 0.50 \times 0.50}{0.07^2} = 196$$

After allowing for 10% non-response or incomplete assessment:

$$n_{\text{adjusted}} = \frac{196}{0.90} = 217.78$$

After round off, we therefore enrolled 220 participants in our study.

Sampling Technique: Consecutive sampling was selected. Eligible patients attending the designated clinic were considered sequentially until the recruitment target was reached. Unique study codes prevented duplicate enrolment, and the screening record included eligibility, participation, and reasons for non-participation.

Data Collection Tools and Procedure: A structured case-record form covered age, sex, education, residence, smoking, body mass index, asthma duration, relevant comorbidities, and treatment history. Prescription review and participant interviews established the maintenance regimen, prescribed dosing schedule, inhaled corticosteroid dose category, reliever treatment, number of inhaler device types, and duration of device use.

Previous inhaler education was defined as a reported demonstration by a healthcare professional before the index visit. Previous technique review, use of a spacer, and recent changes in medication or device were recorded separately. Exacerbation history during the preceding 12 months included episodes requiring systemic corticosteroids, emergency attendance, or hospitalization; events arising from the same episode were counted once.

The assessment sequence comprised symptom-control and adherence questionnaires, followed by an unprompted demonstration of each maintenance device. Technique observers remained unaware of questionnaire scores. Corrective instruction and clinical review followed completion of the baseline assessment.

Assessment of Inhaler Technique: Technique was assessed by direct observation using a separate checklist for each device model, based on published device-specific assessment methods and manufacturer instructions [1,4]. Device preparation, dose loading, pre-inhalation expiration, mouthpiece seal, inhalation manoeuvre, actuation–inhalation coordination where applicable, and breath-holding were assessed according to the device requirements.

Participants demonstrated one complete dose using their usual device or an equivalent placebo device. For pressurized metered-dose inhalers used with a spacer, the checklist evaluated the complete inhaler–spacer system. The first unprompted demonstration determined baseline technique; prompting or coaching was reserved until assessment was complete.

A technique error was an incorrectly performed applicable checklist step. A critical error was a prespecified device-specific error expected to substantially compromise medication delivery, using published definitions where available [4]. Critical-error lists were fixed before assessment rather than derived from associations with the study outcomes.

The participant-level classifications were:

- **Error-free technique:** All applicable steps were performed correctly on every assessed maintenance device.
- **Non-critical errors only:** At least one error occurred, without a critical error on any assessed device.
- **At least one critical error:** A critical error occurred on one or more assessed maintenance devices.

Participants using multiple devices contributed once to participant-level estimates and separately to the relevant device-level descriptions. Device-specific error percentages used the number of demonstrations assessed for that device as the denominator. Raw checklist totals were not directly compared across devices with different numbers of steps.

Assessment of Medication Adherence: Medication adherence was assessed using the 10-item patient-reported Test of Adherence to Inhalers (TAI) [7]. Each item was scored from one to five, producing a total score of 10–50, with higher scores indicating better reported adherence.

Adherence categories were defined as:

- **Adherent:** Score 50.
- **Intermediate adherence:** Score 46–49.
- **Poor adherence:** Score ≤45.

The total score was retained for continuous analyses. Only the 10 patient-reported items contributed to the adherence measure, thereby keeping observed technique separate from adherence classification. Administration followed the original instructions using an appropriate validated language version and applicable permissions. Interviewer assistance preserved the original wording and response options. Incomplete questionnaires were not prorated.

Assessment of Asthma Symptom Control: Symptom control was assessed using the Asthma Control Test (ACT), comprising five items referring to the preceding four weeks [8]. Total scores ranged from 5–25, with higher scores indicating better control.

The descriptive categories were:

- **Well controlled:** Score 20–25.
- **Not well controlled:** Score 16–19.
- **Very poorly controlled:** Score 5–15.

For the primary association analysis, participants were classified as having well-controlled symptoms (ACT ≥20) or symptoms not well controlled (ACT ≤19). Symptom control was distinguished from asthma severity and future exacerbation risk. Questionnaire administration followed the validated instructions and applicable language and permission requirements.

Study Variables: The principal descriptive outcomes were the prevalence of technique errors, critical errors, TAI adherence categories, and ACT symptom-control categories. The primary analytical outcome was ACT ≤19, with critical-error status and adherence score treated as separate exposures. Potential explanatory variables included age, sex, education, smoking, body mass index, asthma duration, previous inhaler education, maintenance treatment intensity, and number of device types. Treatment intensity was represented by the prescribed inhaled corticosteroid dose category, using product-specific guideline dose ranges [1]; it was not equated with asthma severity.

Statistical Analysis: Continuous variables were summarized as mean ±standard deviation or median (interquartile range), and categorical variables as frequencies and percentages. Prevalence estimates were reported with Wilson 95% confidence intervals. Comparisons used appropriate t-tests, Mann–Whitney U tests, or chi-square/Fisher's exact tests. Spearman's correlation assessed relationships between TAI and ACT scores. Modified Poisson regression with robust standard errors estimated prevalence ratios for ACT ≤19, including critical-error status and TAI score per five-point decrease, adjusted for age, sex, smoking, and inhaled corticosteroid dose category. Model complexity, convergence, and collinearity were assessed. Missing assessments were reported with explicit denominators. All tests were two-sided, with $p<0.05$ considered statistically significant.

Ethical Considerations: Institutional Ethics Committee approval was obtained before study initiation, and written informed consent was obtained from all participants. Participation was voluntary, with the right to withdraw without affecting clinical care. Confidentiality was maintained using coded records and restricted data access. Clinically significant findings were communicated to the treating clinician. The study adhered to the Declaration of Helsinki and applicable national and institutional ethical requirements.

RESULTS

The analysis included 220 adults with bronchial asthma receiving scheduled maintenance inhaler therapy. The mean age

was 42.0 ±13.4 years, and 51.4% were female. Previous inhaler education was reported by 55.0%, while 30.5% reported at least one exacerbation requiring systemic corticosteroids, emergency attendance, or hospitalization during the preceding year (Table 1).

Table 1. Demographic and clinical characteristics of participants (N=220)

Characteristic	Value
Age, years, mean ± SD	42.0 ± 13.4
Male sex, n (%)	107 (48.6)
Female sex, n (%)	113 (51.4)
Rural residence, n (%)	96 (43.6)
Urban residence, n (%)	124 (56.4)
Current smoking, n (%)	31 (14.1)
Body mass index, kg/m², mean ± SD	25.0 ± 3.6
Asthma duration, years, median (IQR)	6.9 (4.2–11.8)
Allergic rhinitis, n (%)	89 (40.5)
Previous inhaler education, n (%)	121 (55.0)
≥1 exacerbation during the preceding 12 months, n (%)	67 (30.5)

SD: standard deviation; IQR: interquartile range. Events arising from the same exacerbation episode were counted once.

Maintenance Treatment and Inhaler Devices

Medium-dose inhaled corticosteroid treatment was the most frequent dose category. Most participants used one maintenance device, while 32 used two. Consequently, 252 device demonstrations were assessed (Table 2).

Table 2. Maintenance treatment intensity and inhaler-device characteristics

Characteristic	Number	Percentage
Prescribed ICS dose category (N=220)		
Low dose	56	25.5
Medium dose	111	50.5
High dose	53	24.1
Maintenance devices assessed per participant (N=220)		
One	188	85.5
Two	32	14.5
Device demonstrations assessed (N=252)		
Pressurized metered-dose inhaler without spacer	85	33.7
Pressurized metered-dose inhaler with spacer	45	17.9
Capsule-based dry-powder inhaler	76	30.2
Multidose dry-powder inhaler	46	18.3

ICS: inhaled corticosteroid. Dose categories represented prescribed treatment intensity rather than asthma severity. Device percentages used 252 demonstrations as the denominator. Percentages may differ slightly from 100% because of rounding.

Inhaler Technique

At least one technique error was observed in 159 participants (72.3%; 95% CI: 66.0–77.8%), including 82 with a critical error (37.3%; 95% CI: 31.2–43.8%). Error-free performance on every assessed maintenance device was observed in 61 participants. Device-level findings are presented in Table 3.

Table 3. Participant-level and device-level inhaler technique findings

Panel A. Participant-level classification (N=220)	n	%
Error-free technique on all assessed maintenance devices	61	27.7
Non-critical errors only	77	35.0
≥1 critical error on any assessed maintenance device	82	37.3
Total	**220**	**100.0**

Panel B. Device-level assessment	Demonstrations assessed, n	Any error, n (%)	≥1 critical error, n (%)	Error-free, n (%)

Metered-dose inhaler without spacer	85	65 (76.5)	40 (47.1)	20 (23.5)
Metered-dose inhaler with spacer	45	27 (60.0)	5 (11.1)	18 (40.0)
Capsule-based dry-powder inhaler	76	48 (63.2)	23 (30.3)	28 (36.8)
Multidose dry-powder inhaler	46	32 (69.6)	18 (39.1)	14 (30.4)
Total demonstrations	**252**	**172 (68.3)**	**86 (34.1)**	**80 (31.7)**

Participant-level categories were mutually exclusive. Critical errors were included within "any error." Device-level percentages used the corresponding device denominator. Participants using two devices contributed two demonstrations; device-level observations were therefore not independent.

The 86 demonstrations containing critical errors occurred among 82 participants. Metered-dose inhalers used with spacers had the lowest descriptive critical-error proportion. These device-level findings did not establish an independent effect of device type.

Medication Adherence and Symptom Control

Intermediate adherence was the most frequent TAI category. ACT-defined symptoms were well controlled in 104 participants, while 116 had scores ≤19 (Table 4).

Table 4. Medication adherence and asthma symptom-control distribution (N=220)

Measure	Value	95% CI for prevalence
TAI assessment		
Total score, median (IQR)	48 (46–50)	—
Adherent: score 50, n (%)	61 (27.7)	22.2–34.0
Intermediate adherence: score 46–49, n (%)	117 (53.2)	46.6–59.7
Poor adherence: score ≤45, n (%)	42 (19.1)	14.4–24.8
ACT assessment		
Total score, median (IQR)	19 (17–22)	—
Well controlled: score 20–25, n (%)	104 (47.3)	40.8–53.9
Not well controlled: score 16–19, n (%)	82 (37.3)	31.2–43.8
Very poorly controlled: score 5–15, n (%)	34 (15.5)	11.3–20.8
Combined analytical outcome: ACT ≤19, n (%)	**116 (52.7)**	**46.1–59.2**

TAI: Test of Adherence to Inhalers; ACT: Asthma Control Test; IQR: interquartile range; CI: confidence interval. Higher TAI scores indicated better reported adherence; higher ACT scores indicated better symptom control. Confidence intervals were calculated using the Wilson method. The combined ACT outcome included both categories scoring ≤19. Percentages may differ slightly from 100% because of rounding.

Mean TAI and ACT scores were 47.4 ±2.6 and 19.1 ±3.6, respectively. TAI scores showed a weak positive correlation with ACT scores (Spearman's ρ=0.179; p=0.008).

Characteristics According to Symptom-Control Status

Critical errors and current smoking were more frequent among participants with ACT scores ≤19. TAI score distributions differed significantly between the groups despite identical medians. The overall three-category adherence comparison did not reach statistical significance (Table 5).

Table 5. Clinical, technique, and adherence characteristics according to symptom control

Characteristic	Well-controlled symptoms: ACT ≥20 (n=104)	Symptoms not well controlled: ACT ≤19 (n=116)	p-value
Age, years, mean ± SD	41.8 ± 13.7	42.2 ± 13.3	0.835
Male sex, n (%)	54 (51.9)	53 (45.7)	0.356
Current smoking, n (%)	8 (7.7)	23 (19.8)	0.010
Body mass index, kg/m², mean ± SD	24.5 ± 3.2	25.4 ± 3.9	0.066
Asthma duration, years, median (IQR)	7.4 (4.4–12.4)	6.7 (3.4–11.7)	0.450
Previous inhaler education, n (%)	51 (49.0)	70 (60.3)	0.092
≥1 exacerbation during the preceding year, n (%)	33 (31.7)	34 (29.3)	0.697
≥1 critical inhaler error, n (%)	29 (27.9)	53 (45.7)	0.006
TAI total score, median (IQR)	48 (47–50)	48 (46–49)	0.037

TAI adherence category, n (%)			**0.199**
Adherent	34 (32.7)	27 (23.3)	
Intermediate adherence	54 (51.9)	63 (54.3)	
Poor adherence	16 (15.4)	26 (22.4)	

Percentages were calculated within symptom-control groups. Mean values were compared using Welch's t-test, medians using the Mann–Whitney U test, and categorical variables using Pearson's chi-square test. The adherence-category p-value represented the overall three-category comparison.

Mean ACT scores were 22.2 ±1.4 in the well-controlled group and 16.4 ±2.5 in the group with symptoms not well controlled. Corresponding mean TAI scores were 47.8 ±2.2 and 47.0 ±2.9.

Adjusted Associations With Symptoms Not Well Controlled

Critical inhaler errors and poorer reported adherence remained associated with ACT scores ≤19 after adjustment. Current smoking also retained an association with this outcome (Table 6).

Table 6. Crude and adjusted prevalence ratios for ACT-defined symptoms not well controlled (N=220)

Variable	Crude PR (95% CI)	Adjusted PR (95% CI)	Adjusted p-value
≥1 critical error versus no critical error	1.42 (1.11–1.80)	1.36 (1.06–1.74)	0.015
TAI score, per five-point decrease	1.30 (1.08–1.57)	1.28 (1.06–1.56)	0.011
Age, per 10-year increase	1.01 (0.92–1.11)	0.99 (0.91–1.08)	0.863
Male versus female sex	0.89 (0.69–1.14)	0.88 (0.69–1.13)	0.323
Current smoking versus no current smoking	1.51 (1.17–1.94)	1.37 (1.07–1.76)	0.014
Medium-dose versus low-dose ICS	1.30 (1.00–1.67)	1.31 (0.95–1.80)	0.096
High-dose versus low-dose ICS	0.87 (0.63–1.19)	1.09 (0.74–1.61)	0.651

PR: prevalence ratio; CI: confidence interval; ICS: inhaled corticosteroid. Modified Poisson regression with robust standard errors included all listed terms simultaneously. A five-point decrease in TAI score indicated poorer reported adherence. Prescribed ICS dose represented treatment intensity.

All 220 participants contributed to the adjusted analysis, including 116 with ACT scores ≤19. The model converged, and variance inflation factors ranged from approximately 1.01 to 1.51. Participants with critical errors had a 36% higher adjusted prevalence of symptoms not well controlled, while each five-point decrease in TAI score was associated with a 28% higher adjusted prevalence.

DISCUSSION

In this study of 220 adults receiving maintenance inhaler therapy, technique errors were frequent, and more than half had symptoms not well controlled. Critical errors and poorer reported adherence remained associated with inadequate symptom control after adjustment for demographic factors, smoking, and prescribed corticosteroid dose. These findings support evaluating technical competence and medication-taking behaviour separately because either may compromise treatment effectiveness, although the cross-sectional associations do not establish causation.

The prevalence of any technique error was 72.3%, while 37.3% demonstrated at least one critical error. This distinction is clinically important because minor checklist deviations and errors substantially compromising delivery should not be treated as equivalent. Sanchis et al. documented persistently frequent inhaler errors across several decades [3]. The CRITIKAL study further identified device-specific errors associated with asthma outcomes [4]. Together, these findings support direct observation rather than relying on patients 'reported confidence or duration of inhaler use.

Metered-dose inhalers used with spacers had the lowest descriptive critical-error proportion. However, this observation cannot establish device superiority because patient selection, prior instruction, and device requirements differed. Additionally, participants using multiple devices contributed correlated demonstrations. The participant-level analysis appropriately considered whether any maintenance device contained a critical error, but this definition may increase opportunities for detecting errors among multiple-device users. Device selection should therefore remain individualized, supported by demonstration and reassessment.

Intermediate adherence predominated, and only 27.7% achieved the maximum TAI score. The continuous adherence score was associated with symptom control, whereas the three-category comparison was not statistically significant. These

findings are compatible: categorization reduces information, while regression evaluates a specified score relationship with adjustment. Plaza et al. validated TAI as an inhaler-adherence instrument [7], but self-report does not confirm actual dosing. The adjusted prevalence ratio of 1.28 per five-point decrease should consequently be interpreted as an association with reported behaviour rather than objectively measured medication exposure.

Critical errors were associated with a 36% higher adjusted prevalence of symptoms not well controlled. This finding complements evidence linking inhalation errors with adverse outcomes [4]. Williams et al. also associated corticosteroid non-adherence with exacerbations [6], although exacerbation risk and recent symptom control are distinct outcomes. Current smoking retained an association, reinforcing the need to consider influences beyond inhaler use. Consistent with GINA recommendations, review should address technique, adherence, and relevant exposures before treatment escalation [1].

Strengths included device-specific observation before coaching, separate measurement of adherence and technique, explicit denominators, and adjusted prevalence-ratio estimation. Limitations included single-centre consecutive sampling, self-report bias, one observed demonstration, and residual confounding. Treatment intensity did not fully capture underlying severity, and reverse causation remained possible because symptoms may influence adherence and prescribing. The small proportion reporting poor adherence and limited score variation also affected interpretation. Previous education did not establish its quality or recency. Future multicentre longitudinal studies should incorporate repeated technique assessment, objective adherence monitoring, and exacerbation outcomes, while evaluating whether individualized training and coordinated follow-up improve sustained control beyond changes in prescribed treatment alone in routine outpatient practice.

CONCLUSION

Inhaler technique errors were common among adults receiving maintenance therapy for bronchial asthma, and more than half had symptoms not well controlled. Critical errors and poorer reported medication adherence were independently associated with inadequate symptom control after adjustment for selected clinical and demographic factors. These findings support assessing technical competence and medication-taking behaviour as separate components of routine asthma review. Device-specific demonstration, corrective instruction, and individualized exploration of adherence barriers may identify opportunities to improve treatment delivery before pharmacological escalation. Current smoking also warrants attention within comprehensive management. However, the cross-sectional design, self-reported adherence, and single observed demonstration limit causal interpretation. Differences between devices should remain descriptive rather than guide assumptions of superiority. Larger longitudinal studies incorporating objective adherence monitoring, repeated technique assessment, and exacerbation outcomes are needed to determine whether sustained, individualized support improves control beyond changes in prescribed treatment alone across diverse patient populations and routine outpatient care settings.

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