Section: Miscellaneous

Original Research Article

INHALER TECHNIQUE AND ITS ASSOCIATION WITH DISEASE CONTROL IN ASTHMA AND COPD: A CROSS-SECTIONAL STUDY USING TEIT, CAAT AND PEAK EXPIRATORY FLOW RATE

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ABSTRACT

Background: Correct inhaler technique is essential for achieving adequate pulmonary drug deposition and optimal therapeutic benefit in patients with asthma and chronic obstructive pulmonary disease (COPD). In routine practice, however, technique-related errors remain common and may contribute to persistent symptoms and impaired pulmonary function. Evidence simultaneously evaluating inhaler technique against both patient-reported symptom burden and objective airflow parameters remains limited in the North Indian population. **Objective:** To assess inhaler technique among patients with asthma and COPD and determine its association with disease-control parameters, including the Chronic Airways Assessment Test (CAAT) score and Peak Expiratory Flow Rate (PEFR).

Materials and Methods: This cross-sectional study included 156 patients aged 18–65 years with asthma or COPD receiving inhaled therapy at a tertiary-care teaching hospital in Uttar Pradesh, India. Inhaler technique was assessed using the Typical Errors in Inhaler Technique (TEIT) checklist for pressurized metered-dose inhalers (MDI), MDI with spacer, and dry-powder inhalers (DPI). An error percentage >15% was classified as incorrect inhaler use. Disease status was assessed using CAAT and PEFR. Associations were evaluated using appropriate parametric or non-parametric tests, Spearman correlation, and multivariable linear regression.

Results: Of 156 participants, 113 (72.44%) demonstrated incorrect inhaler technique and only 43 (27.56%) were classified as correct users. Mean TEIT error percentage was 41.36 ± 26.78%. Correct users had markedly lower CAAT scores than incorrect users [median 9.0 (IQR 6.0–14.0) vs 24.0 (21.0–29.0); $p<0.001$] and substantially higher PEFR [483 (394–504) vs 253 (226–293) L/min; $p<0.001$]. TEIT error percentage correlated strongly and positively with CAAT score ($\rho=0.926$) and inversely with PEFR ($\rho=-0.921$). CAAT and PEFR were also strongly inversely correlated ($\rho=-0.936$). After adjustment for age and body mass index, TEIT error percentage remained independently associated with higher CAAT score ($\beta=0.296$; 95% CI 0.274–

0.319; p<0.001) and lower PEFR (β=−3.453 L/min per 1-percentage-point increase in errors; 95% CI −3.765 to −3.140; p<0.001). Device type was significantly associated with technique errors; mean TEIT error percentage was highest with standard MDI (46.39%), compared with MDI plus spacer (30.88%) and DPI (31.22%) (p=0.003).

Conclusion: Incorrect inhaler technique was highly prevalent among patients with asthma and COPD and was strongly associated with greater symptom burden and lower PEFR. Routine assessment of inhaler technique, individualized device selection, hands-on demonstration, and periodic reassessment should be integral components of obstructive airway disease management.

Keywords: asthma; COPD; inhaler technique; metered-dose inhaler; dry-powder inhaler; spacer; TEIT; CAAT; PEFR; disease control.

INTRODUCTION

Asthma and chronic obstructive pulmonary disease (COPD) represent two of the most important chronic respiratory disorders worldwide and contribute substantially to morbidity, healthcare utilization, disability, and mortality. Although the disorders differ in their underlying pathophysiology and patterns of airflow limitation, inhaled pharmacotherapy forms the cornerstone of long-term treatment for both conditions. Contemporary asthma and COPD management therefore depends not only on selection of appropriate pharmacological therapy but also on successful delivery of medication to the respiratory tract.[1,2]

Inhaled treatment offers several pharmacological advantages. It allows medication to be delivered directly to the airways, permits relatively rapid onset of action, and limits systemic exposure compared with many oral therapies. These advantages, however, depend strongly on correct operation of the delivery device. Errors during inhaler use can substantially alter aerosol generation, inspiratory flow, drug deposition and ultimately the amount of medication reaching the lower respiratory tract. Consequently, an appropriate drug prescribed at an appropriate dose may still provide inadequate benefit when the inhaler is used incorrectly.

Several inhaler systems are available, of which pressurized metered-dose inhalers (pMDIs/MDIs), MDIs used with a spacer or valved holding chamber, and dry-powder inhalers (DPIs) are widely employed. Each device has distinct operational requirements. Conventional MDIs require coordination between device actuation and slow inhalation, whereas DPIs depend more strongly on the patient's ability to generate sufficient inspiratory flow. Spacers can reduce the coordination requirements of MDIs and may improve medication delivery in patients who have difficulty synchronizing actuation with inhalation.[3]

Despite decades of clinical use and repeated efforts to educate patients, inhaler errors remain remarkably common. A systematic review by Sanchis et al. reported that only approximately one-third of evaluated patients demonstrated correct inhaler technique and that technique had shown little improvement over several decades.[4] Another systematic review by Usmani et al. emphasized that critical inhaler errors are associated with poorer disease outcomes and greater healthcare utilization.[5] Errors involving pre-inhalation exhalation, inhalation speed, hand-breath coordination, inspiratory effort and post-inhalation breath holding can all compromise effective drug delivery.

The clinical consequence of poor inhaler technique is particularly important because apparent pharmacological treatment failure may lead clinicians to unnecessarily intensify treatment. Before increasing medication dose or adding additional agents, confirming that the patient is able to use the prescribed device correctly is therefore an important component of rational pharmacotherapy.

Disease control in obstructive airway disease can be evaluated from complementary perspectives. Patient-reported tools quantify symptom burden and the effect of respiratory disease on daily life, whereas measures of expiratory airflow provide an objective physiological assessment. The Chronic Airways Assessment Test (CAAT), adapted for application across chronic airway diseases, has demonstrated validity and psychometric performance in asthma, asthma+COPD and COPD.[6,8] Peak Expiratory Flow Rate (PEFR), although less comprehensive than formal spirometry, provides a simple, rapid measure of expiratory airflow and is used in clinical monitoring, particularly in asthma.[1]

Evaluating inhaler technique together with both CAAT and PEFR may therefore provide clinically useful information about whether errors in medication delivery are associated simultaneously with subjective disease burden and objective airway function. Evidence examining these relationships in a North Indian clinical population remains limited.

The present study was therefore undertaken to assess inhaler technique among patients with asthma and COPD and to examine the relationship between inhaler technique errors and disease-control parameters, particularly CAAT score and PEFR. A secondary objective was to evaluate whether technique accuracy and clinical parameters differed according to the type of inhaler device used.

MATERIALS AND METHODS

Study design and setting

A hospital-based cross-sectional study was conducted at the Department of Pharmacology in collaboration with the Departments of Pulmonary Medicine and General Medicine at Dr. Bhimrao Ramji Ambedkar Government Medical College, Kannauj, a tertiary-care hospital in Uttar Pradesh, India. The study was conducted over 12 months from November 2024 to October 2025.

Study population

Patients attending the Pulmonary Medicine and General Medicine outpatient departments were screened for eligibility. Adults aged 18–65 years with a confirmed diagnosis of asthma or COPD who had been prescribed an MDI, MDI with spacer, or DPI were considered for inclusion.

Inclusion criteria

Patients were eligible when they were aged 18–65 years, had a diagnosis of asthma or COPD, and had been prescribed an MDI, MDI with spacer, or DPI.

Exclusion criteria

Patients were excluded if they had asthma or COPD with other comorbid conditions specified in the study protocol; chronic disabling conditions such as tuberculosis, structural/surgical lung abnormalities, AIDS or cancer; respiratory failure or critical illness; pregnancy or lactation; or unwillingness to provide consent.

Sample-size calculation

The sample size was calculated using an anticipated prevalence of incorrect inhaler technique of 89.72%, derived from previously available estimates ranging from 82.3% to 97.14%. Using a 95% confidence level (Z=1.96) and 5% absolute precision, the calculated sample size was 142. After allowance for approximately 10% attrition/non-participation, the final targeted sample was 156.

Data collection

Sociodemographic and clinical information was collected using a pretested semi-structured schedule. Recorded variables included age, sex, educational status, occupation, monthly income, smoking status, BMI, history of atopy, diagnosis, and type of inhaler device. Each participant was asked to demonstrate inhaler use in the manner in which the prescribed device was normally used.

Assessment of inhaler technique

Technique was assessed using the Typical Errors in Inhaler Technique (TEIT) checklist adapted from Morton et al,[7] The assessment incorporated device-specific errors including inadequate preparation of the inhaler, improper shaking where applicable, poor actuation-inhalation coordination, inadequate inspiratory effort, failure to appropriately exhale before inhalation, insufficient post-inhalation breath holding, and other device-specific errors.

TEIT scoring and user classification

Maximum possible error counts were 7 for MDI, 14 for MDI with spacer, and 13 for DPI. For each patient, the observed number of errors was converted into an error percentage according to the relevant device-specific denominator. Participants with an error percentage >15% were categorized as incorrect/wrong inhaler users, while those at or below the threshold were categorized as correct/right users.

Assessment of disease-control parameters

The CAAT questionnaire was used to assess symptom burden and the impact of chronic airway disease on daily functioning; its use across asthma and COPD is supported by published validation and psychometric studies.[6,8] Higher scores indicated greater disease impact and poorer clinical status. PEFR was measured using a Breathometer™ EU Scale Peak Flow Meter conforming to EN13826:2003 standards and recorded in litres per minute.

Patient education

After evaluation, documented technique errors were explained to participants. Individualized education and demonstration were provided using the standardized checklist relevant to the patient's inhaler device. Because the study was cross-sectional, post-education longitudinal clinical outcomes were not included in the primary analysis.

Outcome measures

The primary analytical objective was to evaluate the relationship between TEIT error percentage and the two disease-control parameters, CAAT score and PEFR. Secondary analyses evaluated differences according to inhaler-user classification and inhaler device.

Statistical analysis

Data were anonymized, coded, cleaned and analyzed using IBM SPSS Statistics version 29. Categorical variables were summarized as frequency and percentage. Continuous variables were presented as mean ± standard deviation or median with interquartile range depending on distribution. Normality was assessed using the Shapiro–Wilk test. TEIT error percentage was normally distributed; consequently, the independent-samples Student's t-test and one-way analysis of variance (ANOVA), with Bonferroni post-hoc comparison where applicable, were used. CAAT score and PEFR were non-normally distributed and were analyzed using Mann–Whitney U and Kruskal–Wallis tests. Associations between categorical variables were evaluated using Pearson's chi-square test. Spearman rank correlation was used to assess relationships among TEIT error percentage, CAAT and PEFR. Multivariable linear regression models evaluated TEIT error percentage, age and BMI as predictors of CAAT and PEFR. Statistical significance was defined as a two-sided $p<0.05$.

Ethical considerations

Ethical approval was obtained from the Institutional Ethics Committee of Government Medical College, Kannauj (IEC/GMC, Kannauj/52, dated 10 September 2024). Written informed consent was obtained after participants received information

about study procedures, voluntary participation and the right to withdraw. Privacy and confidentiality were maintained.

RESULTS

A total of 156 patients were analyzed. Mean age was 42.29 ± 13.97 years, with an age range of 18–65 years, and mean BMI was 24.78 ± 3.72 kg/m². There were 83 (53.21%) men and 73 (46.79%) women. Bronchial asthma accounted for 110 (70.51%) participants, while 46 (29.49%) had COPD. MDI was the most frequently used inhaler device, used by 105 (67.31%) patients; 34 (21.79%) used an MDI with spacer and 17 (10.90%) used a DPI. A history of atopy was reported in 84 (53.85%) patients.

Table 1: Baseline sociodemographic and clinical characteristics of the study population (N=156)

Characteristic	Category	n (%)
Sex	Male	83 (53.21)
	Female	73 (46.79)
Diagnosis	Bronchial asthma	110 (70.51)
	COPD	46 (29.49)
Education	Illiterate	31 (19.87)
	Primary	42 (26.92)
	Secondary	47 (30.13)
	Graduate	36 (23.08)
Occupation	Business	6 (3.85)
	Driver	23 (14.74)
	Farmer	24 (15.38)
	Housewife	35 (22.44)
	Labourer	15 (9.62)
	Shopkeeper	25 (16.03)
	Teacher	28 (17.95)
Smoking status	Ex-smoker	63 (40.38)
	Current smoker	47 (30.13)
	Non-smoker	46 (29.49)
History of atopy	Yes	84 (53.85)
	No	72 (46.15)
Inhaler device	MDI	105 (67.31)
	MDI with spacer	34 (21.79)
	DPI	17 (10.90)
Inhaler-user classification	Correct user	43 (27.56)
	Incorrect user	113 (72.44)

Abbreviations: COPD, chronic obstructive pulmonary disease; MDI, metered-dose inhaler; DPI, dry-powder inhaler.

The population was predominantly composed of patients with asthma, and approximately two-thirds were using standard MDI devices. Importantly, almost three-fourths of all participants were classified as incorrect inhaler users.

Baseline continuous parameters and inhaler-error burden

The overall mean number of TEIT errors was 3.57 ± 2.29, while mean TEIT error percentage was 41.36 ± 26.78%. Mean CAAT score was 20.64 ± 8.79, and mean PEFR was 318.90 ± 106.21 L/min.

Table 2: Continuous clinical and inhaler-technique characteristics (N=156)

Variable	Mean ± SD	Minimum	Maximum
Age (years)	42.29 ± 13.97	18	65
BMI (kg/m²)	24.78 ± 3.72	18.2	31.8
Monthly income (INR)	11,108.97 ± 8,514.56	0	25,000
TEIT errors, count	3.57 ± 2.29	0	11
TEIT error percentage (%)	41.36 ± 26.78	0	85.71
CAAT score	20.64 ± 8.79	5	35
PEFR (L/min)	318.90 ± 106.21	181	543

Abbreviations: BMI, body mass index; TEIT, Typical Errors in Inhaler Technique; CAAT, Chronic Airways Assessment Test; PEFR, Peak Expiratory Flow Rate.

The magnitude of inhaler technique errors was substantial, with a mean error percentage exceeding 40%. At the same time, the wide standard deviation indicated considerable variability in technique across participants.

Inhaler technique according to diagnosis and device

Mean TEIT error percentage did not differ significantly between asthma and COPD. Patients with asthma had a mean error percentage of 40.78 ± 26.78%, compared with 42.75 ± 27.03% among patients with COPD (p=0.677). In contrast, inhaler device type was significantly associated with technique errors. Mean error percentage was highest in standard MDI users (46.39 ± 28.21%), compared with MDI-with-spacer users (30.88 ± 17.74%) and DPI users (31.22 ± 24.85%; overall p=0.003).

Table 3: Comparison of TEIT error percentage according to diagnosis and inhaler device

Comparison	n	Mean TEIT error % ± SD	Test statistic	p-value
Diagnosis: Bronchial asthma	110	40.78 ± 26.78	t = −0.418	0.677
Diagnosis: COPD	46	42.75 ± 27.03		
Device: MDI	105	46.39 ± 28.21	F = 6.05	0.003
Device: MDI with spacer	34	30.88 ± 17.74		
Device: DPI	17	31.22 ± 24.85		

Post-hoc Bonferroni comparison: MDI vs MDI with spacer, p=0.009; MDI vs DPI, p=0.080; MDI with spacer vs DPI, p=1.000.

These findings suggest that the frequency of technique errors was more closely related to device characteristics than to whether the underlying diagnosis was asthma or COPD. In particular, use of a spacer was associated with a substantially lower mean error percentage than use of a conventional MDI alone.

Sociodemographic factors and inhaler-user classification

Educational status was not significantly associated with correct versus incorrect inhaler technique (χ^2=5.497, p=0.139), although graduates showed the highest proportion of correct use (41.67%). Occupational status was likewise not significantly associated with technique (χ^2=8.619, p=0.196). Teachers had the greatest proportion of correct users (42.86%), whereas only 6.67% of labourers demonstrated correct technique. These patterns may indicate potentially important educational and behavioural influences, but the present sample did not provide sufficient evidence to establish an independent sociodemographic association.

Disease control according to correct versus incorrect inhaler use

Table 4: Disease-control parameters among correct and incorrect inhaler users (N=156)

Parameter	Correct users (n=43), median (IQR)	Incorrect users (n=113), median (IQR)	Z statistic	p-value
CAAT score	9.0 (6.0–14.0)	24.0 (21.0–29.0)	−8.653	<0.001
PEFR (L/min)	483 (394–504)	253 (226–293)	8.425	<0.001

Mann–Whitney U test. IQR = interquartile range.

Patients demonstrating correct inhaler technique had markedly lower symptom burden. The median CAAT score among correct users was 9 compared with 24 among incorrect users. Similarly, median PEFR was 230 L/min higher in correct users than in incorrect users. Both differences were statistically significant at p<0.001.

Correlation between inhaler technique and disease-control parameters

TEIT error percentage showed a very strong positive correlation with CAAT score (ρ=0.926), indicating that greater inhaler technique error burden was associated with greater respiratory symptom burden. Conversely, TEIT error percentage showed a very strong inverse correlation with PEFR (ρ=−0.921). CAAT score was itself strongly inversely correlated with PEFR (ρ=−0.936).

Table 5: Spearman rank correlations between TEIT error percentage and disease-control parameters

Variables	TEIT error %	CAAT score	PEFR
TEIT error %	1.000		
CAAT score	0.926	1.000	
PEFR	−0.921	−0.936	1.000

All reported correlations were statistically significant according to the thesis analysis.

Multivariable associations with CAAT score and PEFR

Multivariable linear regression was performed to determine whether the relationship between technique errors and disease-control parameters persisted after accounting for age and BMI.

Table 6: Multivariable linear regression models for CAAT score and PEFR (N=156)

Outcome	Predictor	β coefficient	95% CI	t	p-value
CAAT score	TEIT error %	0.296	0.274 to 0.319	25.96	<0.001
	Age	−0.020	−0.064 to 0.023	−0.93	0.353
	BMI	−0.052	−0.214 to 0.111	−0.63	0.531
	Constant	10.533	6.028 to 15.038	4.62	<0.001
PEFR (L/min)	TEIT error %	−3.453	−3.765 to −3.140	−21.86	<0.001
	Age	−0.065	−0.663 to 0.533	−0.21	0.831
	BMI	0.436	−1.815 to 2.688	0.38	0.702
	Constant	453.619	391.243 to 515.994	14.37	<0.001

CAAT model: R^2=0.818; overall p<0.001. PEFR model: R^2=0.760; overall p<0.001.

For CAAT score, TEIT error percentage was the only statistically significant predictor among the variables included. Each one-percentage-point increase in TEIT error percentage was associated with an estimated 0.296-point increase in CAAT score, whereas age and BMI were not significant

predictors. The model explained approximately 81.8% of the variation in CAAT score.

Similarly, TEIT error percentage was independently associated with PEFR. Each one-percentage-point increase in technique error percentage was associated with approximately 3.45 L/min lower PEFR, independent of age and BMI. The model explained approximately 76.0% of the variation in PEFR.

Device-specific clinical outcomes

Table 7: Inhaler device, technique error and clinical outcomes

Device	Mean TEIT error %	Median CAAT score	Median PEFR (L/min)
MDI	46.39	23.0	266
MDI with spacer	30.88	10.5	422
DPI	31.22	24.0	291
Overall comparison	F=6.05; p=0.003	χ^2=14.283; p<0.001	χ^2=18.585; p<0.001

Post-hoc comparisons (Bonferroni threshold p<0.0167): MDI vs MDI with spacer—CAAT p=0.0002 and PEFR p<0.0001; other pairwise comparisons were not significant after correction.

Participants using MDI with spacer demonstrated the lowest technique-error percentage, lowest median CAAT score and highest median PEFR. Device-level differences in CAAT and PEFR were statistically significant. Post-hoc comparisons indicated that MDI-with-spacer users had significantly lower CAAT scores and significantly higher PEFR than standard MDI users.

DISCUSSION

The present study demonstrates a substantial burden of incorrect inhaler technique among patients with asthma and COPD attending a tertiary-care centre in North India. Nearly three-fourths of participants were categorized as incorrect inhaler users, and mean TEIT error percentage exceeded 40%. More importantly, inhaler errors were closely associated with both components of disease assessment evaluated in this study: higher patient-reported symptom burden measured by CAAT and poorer expiratory airflow measured by PEFR.

The clinical relevance of this observation is considerable. Inhaled pharmacotherapy depends on appropriate drug delivery to the target airways, and mechanical failure at any critical stage of inhalation may reduce effective pulmonary deposition. Consequently, patients may remain symptomatic despite being prescribed pharmacologically appropriate treatment. The findings of the present study support the principle that persistent symptoms in asthma or COPD should prompt reassessment of inhaler technique before treatment is automatically escalated.

Only 27.56% of participants demonstrated correct inhaler technique, whereas 72.44% had an error percentage above the prespecified threshold. This finding is consistent with the broader literature indicating that inhaler misuse remains extremely common despite the long-standing availability of inhaled therapies. Sanchis et al., in a systematic review encompassing 144 studies and 59,584 observed inhaler tests, reported correct technique in only approximately 31% of patients and found little evidence of improvement over several decades.[4] Common errors included poor coordination, inappropriate inhalation speed, failure to exhale before inhalation and inadequate breath holding. Chrystyn et al. likewise reported a high burden of device errors across asthma and COPD studies.[9]

The prevalence observed in this cohort is also comparable with recent Indian data. Kumari et al. reported incorrect inhaler technique in 75.23% of patients with asthma or COPD, while Azeez et al. documented substantial technique errors among Indian patients using inhaler devices.[10,11] These findings support the persistence of inhaler-use problems across different Indian clinical settings.

Mean TEIT error percentage was numerically higher in patients with COPD than in those with asthma, but the difference was small and statistically non-significant. This suggests that inhaler misuse should not be regarded as a problem confined to one obstructive airway diagnosis. The mechanical demands of the device itself apply across diagnostic categories, and inhaler technique should therefore be systematically assessed in both asthma and COPD.

Device type showed a significant relationship with technique-error percentage. Standard MDI users had the highest mean TEIT error burden, whereas error rates were lower among users of MDI with spacer and DPI. Efficient MDI use requires appropriate device preparation, coordinated actuation and inhalation, suitable inhalation velocity and adequate breath holding. Failure of synchronization can result in suboptimal pulmonary delivery, and coordination-related MDI errors are well documented in the literature.[3,12]

The addition of a spacer decreases the need for precise hand-breath coordination and provides a chamber from which aerosol can be inhaled after actuation. In the present study, mean error percentage was approximately 15 percentage points lower with MDI plus spacer than with MDI alone, and the post-hoc difference was statistically significant. Nevertheless, these findings should not be interpreted to mean that one device is universally superior. Device selection should reflect individual patient characteristics, including inspiratory ability, manual dexterity, cognition, preference, availability and cost.[17]

The strongest clinical finding was the large difference in CAAT scores according to inhaler technique. Correct users had a median CAAT score of 9, whereas incorrect users had a median score of 24. TEIT error percentage also correlated very strongly with CAAT score (ρ=0.926). The multivariable model further supported this relationship: each one-percentage-point increase in TEIT error percentage was associated with a 0.296-point higher CAAT score after accounting for age and BMI.

These observations are clinically plausible because inadequate pulmonary drug delivery can result in incomplete bronchodilation and/or anti-inflammatory treatment, thereby contributing to persistent cough, dyspnoea, activity limitation and other symptoms captured by patient-reported disease-impact measures. However, because the study was cross-sectional, these findings establish association rather than causation. Poor disease control itself may also make device use more difficult, and unmeasured factors such as adherence, disease severity, medication regimen and previous training could contribute to both technique and symptoms.

Correct inhaler users also demonstrated substantially higher PEFR. The median PEFR difference between correct and incorrect users was 230 L/min, and TEIT error percentage correlated inversely with PEFR (ρ=−0.921). The adjusted regression analysis provides an additional quantitative interpretation. Each one-percentage-point increase in TEIT error percentage was associated with an estimated 3.453 L/min reduction in PEFR, independent of age and BMI. Neither age nor BMI was statistically significant in the model.

This result strengthens the observation that poor technique was associated not only with subjective symptom burden but also with an objective physiological parameter. The simultaneous relationship with CAAT and PEFR gives internal coherence to the findings: greater technique-error burden was associated with worse patient-reported respiratory status and lower expiratory airflow, while CAAT and PEFR were themselves strongly inversely correlated.

Usmani et al. systematically reviewed critical inhaler errors in asthma and COPD and reported significant associations between inhaler errors and adverse health outcomes.[5] Sanchis et al. demonstrated the long-standing persistence of inhaler misuse despite decades of clinical experience.[4] These reports reinforce the concept that correct device operation is an essential component of treatment effectiveness rather than a minor technical consideration.

The current findings are also consistent with the cross-sectional study by Shrinath et al., which identified a significant association between better inhaler technique and improved asthma control.[13] Ravikumar et al. similarly emphasized the importance of correct pressurized MDI-with-spacer technique in patients with asthma.[14] An important contribution of the present study is the simultaneous evaluation of technique, patient-reported disease burden and PEFR in a mixed population of asthma and COPD patients.

Educational level and occupation were not statistically associated with inhaler-user classification. Nevertheless, graduates and teachers showed numerically greater proportions of correct use. The absence of statistical significance does not necessarily exclude an influence of health literacy or occupational background, particularly because subgroup sample sizes were relatively small.

The findings have several practical implications. Inhaler technique should be regarded as a routinely measurable component of disease management. A patient prescribed an appropriate inhaled drug but unable to effectively operate the device may receive a reduced effective pulmonary dose. Clinicians should consider the principle of 'check technique before escalating therapy', consistent with current guideline-based management and inhaler-device literature.[1,2,17] Persistent symptoms or apparently inadequate response should prompt observation of the patient's inhaler use before higher doses or additional medicines are prescribed.

Education should be practical rather than exclusively verbal. Demonstration followed by patient return-demonstration or teach-back permits direct identification of mechanical errors. Evidence shows that structured inhaler training can improve technique, supporting repeated hands-on education rather than one-time verbal instruction.[15,16] A standardized checklist can further ensure that critical steps are consistently evaluated. Competence should not be assumed to persist indefinitely; technique can deteriorate with time, and reassessment should occur at subsequent clinical encounters, particularly when disease control worsens or the prescribed device changes. Device selection should also be individualized.[17]

Strengths and Limitations

This study has several strengths. Inhaler technique was evaluated using a structured TEIT approach rather than relying solely on patient self-report. Multiple commonly used inhaler devices were represented. Disease status was assessed using both a patient-reported measure (CAAT) and an objective airflow parameter (PEFR), allowing complementary evaluation of clinical status. The study also employed correlation and multivariable regression rather than restricting the analysis to simple descriptive comparisons.

Several limitations must nevertheless be considered. First, the study was cross-sectional, preventing determination of temporal sequence or causal relationships between inhaler technique and disease control. Second, it was conducted at a single tertiary-care centre, which may limit generalizability to other healthcare settings or populations. Third, device-specific subgroups, particularly the DPI group, were relatively small. Fourth, PEFR is effort

dependent and does not provide the comprehensive physiological information available from formal spirometry. Fifth, although patients received inhaler education following assessment, the study did not prospectively reassess technique and clinical outcomes after intervention. Finally, residual confounding from factors not included in the reported regression models cannot be excluded.

CONCLUSION

Incorrect inhaler technique was highly prevalent among patients with asthma and COPD, affecting approximately three-fourths of the study population. Greater TEIT error burden was strongly associated with higher CAAT scores and lower PEFR, and these associations remained evident after adjustment for age and BMI. Standard MDI users demonstrated the greatest mean technique-error percentage, while MDI use with a spacer was associated with fewer errors and more favourable clinical parameters. These results support routine direct observation of inhaler technique as an integral component of asthma and COPD management. Structured demonstration, return-demonstration, periodic reassessment and individualized device selection should accompany pharmacological prescribing. Longitudinal multicentre studies are required to determine the extent to which sustained correction of inhaler errors translates into improvement in disease control and pulmonary function.

Declarations

Ethics approval and consent to participate

The study was approved by the Institutional Ethics Committee of Government Medical College, Kannauj (IEC/GMC, Kannauj/52 dated 10/09/2024). Written informed consent was obtained from all participants.

Consent for publication

Not applicable for individually identifiable patient information.

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Conflict of interest: None

Data availability

The data supporting the findings of this study are contained within the study records/master chart and may be made available by the corresponding author subject to institutional and ethical requirements.

Author contributions

1. Conceptualization, methodology, investigation, data collection, data curation, formal analysis, writing original draft and writing – review & editing.
2. Investigation, data collection, Resources, Writing – original draft
3. Conceptualization, Project administration, Writing – original draft, Writing – review & editing
4. Data Curation, Supervision
5. Writing – review & editing
6. Interpretation of clinical findings, Validation
7. Formal analysis, Statistical analysis, Validation of results

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