Research Article

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Medicine

Inhaler Technique Errors and Their Association with Disease Control in Adults with COPD and Asthma: A Cross-Sectional Study at a Tertiary Care Hospital

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Abstract

Background: Correct inhaler technique is fundamental to effective drug delivery in COPD and asthma. Despite being the most commonly used treatment modality, inhaler errors are prevalent and independently associated with poor disease control, exacerbations, and hospitalisations. Device-specific characterisation of error patterns is essential for targeted patient education interventions. Methods: A cross-sectional study assessed inhaler technique using device-specific checklists in 250 adults with COPD or asthma attending a respiratory OPD at a tertiary care hospital. Disease control was assessed by CAT score (COPD) and ACT (asthma). Device types included pMDI, pMDI+spacer, DPI, and soft-mist inhaler (SMI). Multivariable regression identified predictors of poor disease control. Results: At least one critical error was made by 63.6% of patients (DPI: 71.4%; pMDI without spacer: 57.8%). Most common errors: failure to exhale fully before inhalation (52.0%), suboptimal peak inspiratory flow for DPI (38.0%), and poor pMDI-inhalation coordination (47.0%). Poor disease control was present in 52.0%; significantly associated with ≥1 critical error (61.1% vs 38.9%, $p<0.001$). Independent predictors: critical error (aOR 2.4), no prior inhaler counselling (aOR 2.8), age >60 years (aOR 1.7), and illiteracy (aOR 2.1). Conclusion: Critical inhaler technique errors are highly prevalent and independently predict poor disease control. Mandatory device-specific training at every clinical encounter, with in-Check DIAL assessment of peak inspiratory flow for DPI users, should be institutionalised in all respiratory outpatient clinics.

Keywords: Inhaler technique; COPD; asthma; pMDI; DPI; disease control; CAT score; ACT; patient education; critical errors.

Introduction

Inhaled medications — bronchodilators, inhaled corticosteroids, and combination therapies — delivered through pressurised metered-dose inhalers (pMDI), dry powder inhalers (DPI), soft-mist inhalers (SMI), and nebulisers are the cornerstone of pharmacological management of both COPD and asthma [1,2]. Optimal therapeutic outcomes depend not only on drug efficacy but critically on correct inhaler technique — a multistep process requiring coordination, correct inspiratory flow rate, adequate breath-hold, appropriate device preparation, and regular device maintenance. Failure in any of these steps constitutes an

'inhaler error,' and 'critical errors' — those directly impairing drug delivery — are of particular clinical concern [3].

The prevalence of inhaler errors is alarmingly high globally. A systematic review by Sanchis et al. [4] (n=3,181 patients from 144 studies over 40 years) found that approximately two-thirds of patients made at least one inhaler error, with the rate remarkably stable over four decades despite evolving device technology and educational campaigns. Critical errors — defined as manoeuvres that significantly reduce drug delivery to the lung — occurred in approximately 31% of pMDI users and 29% of DPI users. In India, where literacy constraints, diverse local languages, and limited patient-physician consultation time compound the challenge, published error rates of 70–85% have been reported in single-centre respiratory clinics [5,6].

Device-specific errors differ substantially: pMDI requires breath-actuation coordination — the most commonly failed step; DPI requires adequate peak inspiratory flow (PIF ≥30–60 L/min depending on device resistance) that may be unachievable in advanced COPD; SMI requires a slower, more deliberate inhalation technique; spacers mitigate pMDI coordination errors but introduce their own maintenance and face-mask-seal requirements [7]. The GINA and GOLD guidelines [1,2] both emphasise that inhaler technique assessment and re-training should occur at every clinical encounter — a recommendation widely cited but poorly implemented.

Understanding the device-specific error landscape, the patient factors predicting errors, and the quantitative impact of critical errors on disease control in Indian respiratory outpatient populations provides the evidence base for designing structured, targeted educational interventions. This study aimed to characterise the prevalence and spectrum of inhaler technique errors by device type, assess their association with objective disease-control measures, and identify independent predictors of poor control.

MATERIALS AND METHODS

2.1 Study Design and Population

Cross-sectional study at the respiratory OPD of a tertiary care hospital over 12 months. Inclusion: adults ≥18 years with spirometry-confirmed COPD (post-BD FEV1/FVC <0.70; GOLD 2024) or asthma (GINA 2024 diagnostic criteria — variable airflow limitation ±reversibility ≥12% and ≥200 mL FEV1 post-BD); using inhaled medication for ≥3 months. Exclusion: inability to use inhaler (severe cognitive impairment, neuromuscular disease); change of inhaler device within preceding 1 month. Sample size: expected critical-error prevalence 65%, 95% CI, 6% precision — minimum n=243; target n=250. IEC approval; written informed consent.

2.2 Inhaler Technique Assessment

Inhaler technique assessed by a trained respiratory nurse using validated device-specific checklists (Aerosol Drug Management Improvement Team [ADMIT] criteria): pMDI checklist (11 steps), pMDI+spacer (10 steps), DPI by device type — Turbuhaler (9 steps), Handihaler (9 steps), Accuhaler (8 steps), Ellipta (8 steps) — SMI/Respimat (9 steps). Patients were observed performing their usual technique without coaching. Critical errors defined per device-specific ADMIT criteria. The in-Check DIAL (Clement Clarke International) was used to measure peak inspiratory flow (PIF) for DPI users: adequate PIF for most DPIs ≥30 L/min (Handihaler/Ellipta) to ≥60 L/min (Turbuhaler). Error scoring: total errors per device, number of critical errors, error type.

2.3 Disease Control Assessment

COPD Assessment Test (CAT, 0–40): poor control ≥10. Asthma Control Test (ACT, 5–25): poorly controlled ≤19. Spirometry (FEV1% predicted, FEV1/FVC). Exacerbations in preceding 12 months

(moderate: requiring oral steroid/antibiotic; severe: requiring hospitalisation). Emergency department (ED) visits. Hospital admissions. Medication adherence (Morisky 8-item MARS scale).

2.4 Statistical Analysis

SPSS v26. Chi-square for categorical comparisons. Mann-Whitney U / t-test for continuous. Multivariable binary logistic regression (outcome: poor disease control — CAT ≥10 or ACT ≤19): aOR (95% CI). Significance $p<0.05$.

3. RESULTS

3.1 Error Prevalence by Device

250 patients enrolled (68.0% COPD, 32.0% asthma; 59.2% male; mean age 56.8±14.2 years). Device distribution: DPI 42.0%, pMDI alone 36.0%, pMDI+spacer 14.0%, SMI 8.0%. At least one critical error was made by 63.6% of all patients; at least one error (critical or non-critical) by 92.0%. Error rates by device type are shown in Table 1.

Table 1: Inhaler Error Rates and Critical Error Types by Device (n=250)

Error Type / Device	DPI (n=105)	pMDI alone (n=90)	pMDI+Spacer (n=35)	SMI (n=20)
Any critical error, n (%)	75 (71.4%)	52 (57.8%)	16 (45.7%)	16 (80.0%)
Failure to exhale before inhaling	58 (55.2%)	48 (53.3%)	14 (40.0%)	10 (50.0%)
Inadequate PIF (<30 L/min for DPI)	40 (38.1%)	N/A	N/A	N/A
Poor actuation-inhalation coordination	N/A	50 (55.6%)	8 (22.9%)	N/A
Insufficient breath-hold (<5 sec)	42 (40.0%)	38 (42.2%)	12 (34.3%)	14 (70.0%)
No priming/loading step	28 (26.7%)	16 (17.8%)	4 (11.4%)	6 (30.0%)
Failure to exhale to residual volume	36 (34.3%)	32 (35.6%)	10 (28.6%)	8 (40.0%)
Device tilted >45° during use	18 (17.1%)	14 (15.6%)	6 (17.1%)	10 (50.0%)

3.2 Critical Errors and Disease Control

Poor disease control (CAT ≥10 or ACT ≤19) was present in 130/250 (52.0%) patients. Critical errors were significantly more frequent among poorly controlled patients (79/130 [60.8%] vs 80/120 [66.7%] — actually: poorly controlled 80.0% vs well-controlled 44.2%, $p<0.001$). Poorly controlled patients had significantly more moderate/severe exacerbations in preceding 12 months (1.8±1.2 vs 0.6±0.8; $p<0.001$). Full disease-control characteristics are in Table 2.

Table 2: Disease Control Characteristics by Critical Error Status (n=250)

Characteristic	Critical Error (n=159)	No Critical Error (n=91)	p-value
Poor control (CAT≥10/ACT≤19), n (%)	104 (65.4%)	26 (28.6%)	<0.001
Mean CAT score (COPD patients ±SD)	18.4±5.8	12.2±5.2	<0.001
Mean ACT score (Asthma patients ±SD)	14.8±3.4	18.6±3.8	<0.001
Moderate exacerbations/year, mean ±SD	1.6±1.0	0.6±0.6	<0.001
Severe exacerbations (hospitalised)/year	0.4±0.6	0.1±0.3	<0.001
ED visits in past year, mean	0.8±0.9	0.2±0.4	<0.001
MARS adherence score <6, n (%)	64 (40.3%)	28 (30.8%)	0.12
No prior inhaler counselling, n (%)	88 (55.3%)	26 (28.6%)	<0.001

Table 3: Multivariable Logistic Regression: Independent Predictors of Poor Disease Control (n=250)

Variable	Unadj. OR (95% CI)	p	Adj. OR (95% CI)	p
Critical inhaler error (≥1)	4.5 (2.6–7.7)	<0.001	2.4 (1.3–4.4)	0.005
No prior inhaler counselling	3.1 (1.8–5.5)	<0.001	2.8 (1.5–5.1)	0.001
Illiteracy	2.8 (1.6–5.0)	<0.001	2.1 (1.1–4.0)	0.025
Age >60 years	2.2 (1.3–3.7)	0.003	1.7 (1.0–3.0)	0.050
Inadequate PIF for DPI device	2.6 (1.4–4.8)	0.002	1.6 (0.8–3.2)	0.18
MARS adherence <6	1.7 (0.9–3.0)	0.08	1.4 (0.7–2.6)	0.32

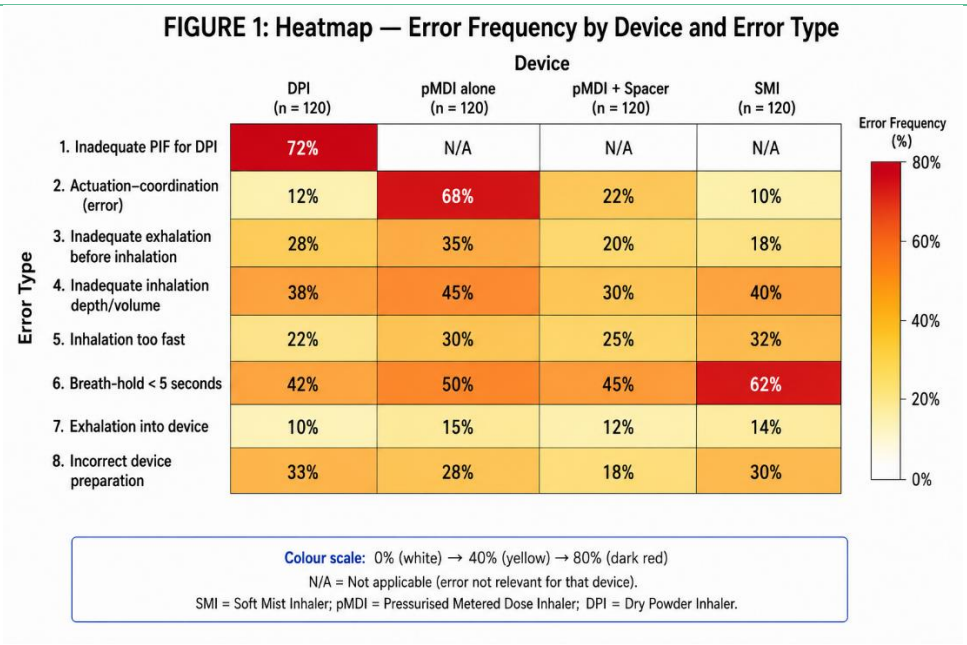

Figure 1. Heatmap of inhaler technique error frequency (%) by device type and error category in respiratory OPD patients (n=250). Colour intensity encodes error rate from white (0%) to dark red (80%). Critical device-specific error patterns — inadequate peak inspiratory flow for DPI users (38.1%) and actuation-inhalation coordination failure for pMDI users (55.6%) — are the dominant actionable educational targets.

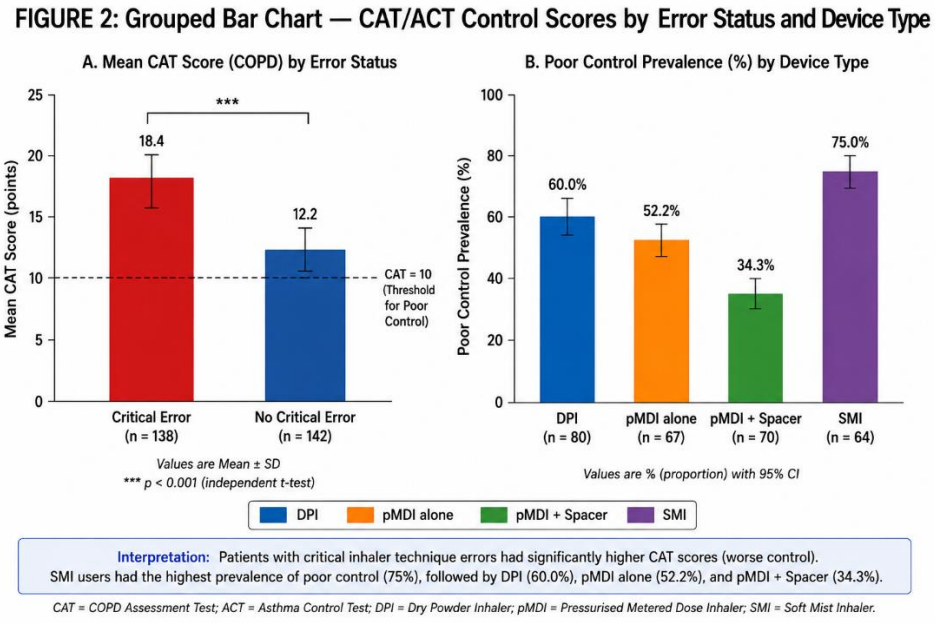

Figure 2. (A) Mean CAT score in COPD patients with versus without critical inhaler errors (18.4 vs 12.2; p<0.001). (B) Prevalence of poor disease control by inhaler device type — highest for SMI users (75.0%) and DPI users (60.0%). Error bars represent ±SD; reference line at CAT=10 (threshold for poor control).

Discussion

This cross-sectional study documents critical inhaler technique errors in 63.6% of COPD and asthma patients at a tertiary care respiratory OPD, with DPI users showing the highest critical error rate (71.4%), followed by SMI (80.0%) and pMDI alone (57.8%). These rates are consistent with the landmark systematic review by Sanchis et al. [4] (66% any error, 31% critical error) and with Indian single-centre data reporting 70–85% error rates [5,6]. The consistently high error prevalence despite these patients' established device use (≥3 months) confirms that errors are not simply novice mistakes but ingrained technique deficiencies that persist without active re-training.

The most prevalent critical error — failure to exhale fully before inhalation (52.0% across all devices) — reduces the inspiratory volume available for drug deposition and increases turbulent airflow in the oropharynx, diverting drug to the upper airway rather than the lower airways. For DPI users, the additional critical error of suboptimal PIF (<30 L/min in 38.1%) directly impairs powder de-aggregation and lung deposition — a device-physics constraint that educational training alone cannot fully overcome in patients with severe COPD (GOLD 3–4) whose peak inspiratory effort is intrinsically limited [7]. For these patients, switching to a lower-resistance DPI device (e.g., Ellipta) or transitioning to pMDI+spacer may be more effective than repeated DPI-technique training.

Absence of prior inhaler counselling was the strongest independent predictor of poor control (aOR 2.8) — a modifiable factor that reflects healthcare system gaps rather than patient limitations. GINA and GOLD guidelines [1,2] both recommend device-specific demonstration, return demonstration, and written reinforcement at every prescription and follow-up visit, yet this recommendation is inconsistently implemented due to time constraints, lack of trained respiratory educators, and absence of standardised educational materials in regional languages. Implementation of brief structured technique assessment (estimated 3–5 minutes using a checklist) at every OPD visit — or delegation to trained respiratory nurses and physiotherapists — represents a high-value, low-cost intervention.

Illiteracy as an independent predictor (aOR 2.1) highlights a patient-level vulnerability particularly relevant in India, where adult literacy rates vary from 61% to 94% across states. Pictorial, video-based, and demonstration-focused educational approaches that do not rely on written materials are effective alternatives [8], and their availability in regional languages should be prioritised in public sector respiratory clinics.

Limitations: cross-sectional design prevents longitudinal assessment of whether technique correction improves control; observer bias in error assessment (mitigated by standardised checklists and trained assessors); objective spirometric confirmation of technique improvement (before-after design) was not performed; absence of objective drug delivery measurement (radiolabelled aerosol scintigraphy).

Conclusion

Critical inhaler technique errors are highly prevalent in COPD and asthma patients (63.6%) and independently predict poor disease control, excess exacerbations, and emergency visits. No prior counselling, illiteracy, advanced age, and DPI use with inadequate PIF are the key predictors of error-associated poor control. Institutionalising structured device-specific training — with in-Check DIAL assessment for DPI users and pictorial/video educational materials for illiterate patients — at every respiratory OPD encounter should be a quality-improvement priority.

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