THE ATLANTIC Journal of Medical Science and Research

Atlantic J Med Sci Res 2026;6(3):278-84
DOI: 10.5455/atjmed.2026.03.024

Original Article

Inhaler technique, training source, and waste-disposal behavior among inhaler users: A retrospective analysis

Sabri Serhan Olcay, Fatih Alasan

Muğla Sıtkı Koçman University, Faculty of Medicine, Department of Chest Diseases, Muğla, Türkiye

Received: 10 March, 2026
Accepted: 02 June, 2026
Published: 04 September, 2026

Corresponding Author: Sabri Serhan Olcay, Muğla Sıtkı Koçman University, Faculty of Medicine, Department of Chest Diseases, Muğla, Türkiye
Email: serhanolcay@mu.edu.tr

CITATION
Olcay SS, Alasan F. Inhaler technique, training source, and waste-disposal behavior among inhaler users: A retrospective analysis. Atlantic J Med Sci Res. 2026;6(3):278-84. DOI: 10.5455/atjmed.2026.03.024

Abstract

Aim: Despite the widespread availability of inhaler therapy, more than half of patients make critical errors during inhaler use, leading to suboptimal drug delivery and poor disease control. The environmental impact of inhaler use has also gained global attention, highlighting the need for sustainable disposal and waste-management practices. However, studies simultaneously evaluating inhaler technique, formal education level, training source, and inhaler waste-management behaviors remain limited.

Materials and Methods: This retrospective descriptive study included 90 adult patients treated with inhaler therapy at Muğla Training and Research Hospital between July 2024 and June 2025. Data were obtained from standardized "Inhaler Treatment User Control Forms," including demographic characteristics, diagnosis, disease duration, smoking status, inhaler type, training status, and inhaler performance scores across five technique steps. The disposal behavior of used inhalers was also recorded. Statistical analyses were performed using the Mann–Whitney U, Kruskal–Wallis H, and Spearman correlation tests, with a significance level of $p < 0.05$. Multivariable linear regression was performed to assess independent associations with total inhaler technique score.

Results: 48.9% of inhaler users reported that they had not received training. Physician-led training was associated with significantly higher total inhaler technique scores compared with untrained patients or those trained by pharmacist/pharmacy technicians ($p < 0.001$). In multivariable linear regression, physician-led training remained independently associated with higher total inhaler technique scores after adjustment for age, education level, disease duration, and inhaler type ($B = 4.323$, 95% CI: 3.120 – 5.526, $p < 0.001$). The total score showed a moderate positive correlation with inhaler duration ($r = 0.446$, $p < 0.001$). All participants reported disposing of used inhalers in household trash, indicating low awareness of appropriate medical or recycling waste practices.

Conclusion: Physician-led inhaler education was independently associated with higher inhaler technique scores, whereas awareness of appropriate inhaler disposal appeared insufficient. Future prospective studies should evaluate whether integrating environmental disposal education into inhaler training can improve disposal behavior and support more sustainable respiratory care.

Keywords: Education, inhaler technique, medical waste, training

INTRODUCTION

Effective use of inhaler devices is crucial for managing chronic respiratory diseases such as asthma and chronic obstructive pulmonary disease (COPD). Despite the widespread availability of inhaler therapy, studies have consistently reported that more than half of patients make critical errors while using their inhalers, leading to suboptimal drug delivery and poor disease control (1-3). These findings highlight a significant challenge in patient care. For instance, Trela et al. (2022) demonstrated that even after structured education, patients with low health literacy continued to make inhaler errors, indicating a need for tailored educational interventions (4). Similarly, Vitacca et al. (2023) reported that structured training programs significantly improved inhaler technique knowledge and practical skills (5).

Beyond clinical effectiveness, environmental considerations of inhaler use have recently gained attention. Pilot inhaler recovery initiatives in the United Kingdom, including postal inhaler recovery schemes (5), have demonstrated that organised take-back systems can recover thousands of used devices and may help reduce greenhouse gas emissions. Such projects underscore the importance of integrating environmentally sustainable waste-management practices into respiratory care.

In Türkiye, prior studies have found that only about half of patients use their inhalers correctly, even before receiving formal training (6). Other national studies evaluating adult populations have reported similar findings (7,8). Although the international literature has extensively explored inhaler technique and education, data that simultaneously address formal education level, training source, and waste-management behavior remain scarce in the Turkish context. Understanding these relationships is essential for improving both therapeutic outcomes and environmental responsibility.

The present study therefore aimed to retrospectively evaluate inhaler technique performance, training source, and waste-disposal behavior among patients using inhaler therapy, and to assess their associations with patient and treatment-related characteristics.

MATERIALS AND METHODS

This retrospective, descriptive study included 90 adult patients treated with inhaler therapy at the Department of Pulmonology, Muğla Training and Research Hospital, between July 2024 and June 2025. Data were obtained from standardized "Inhaler Treatment User Control Forms" (HB.FR.116), which are routinely completed during patient evaluations. Adult patients aged ≥ 18 years who had complete form data were included. Patients with missing key variables (such as age, education level, or inhaler performance score) or duplicate entries were excluded. A total of 90 eligible patients were analyzed. Inhaler technique scores reflected direct clinical observation by a single pulmonologist who assessed each of the five steps during routine patient evaluation and recorded the findings on the standardized form (HB.FR.116). The HB.FR.116 form was developed locally based on the inhaler technique assessment steps recommended in the GOLD 2024 guidelines and national respiratory society publications (9,10); it has not been independently validated as a standalone instrument.

Extracted variables included age, gender, education level, diagnosis (COPD or asthma), disease duration, smoking history (never, former, or current) and exposure (pack-years), inhaler type [dry-powder inhaler (DPI) or metered-dose inhaler (MDI)], duration of inhaler use, number of device changes, inhaler training status (trained or untrained), and the source of training (physician, pharmacist/pharmacy technician, or none). While training status and source were documented on the standardized form, the specific content, duration, and delivery methods of training sessions were not systematically recorded, which is a limitation inherent to the retrospective design.

Inhaler technique was evaluated according to five standardized steps—preparation (shake/open cap for MDI before use; correct capsule placement and puncturing for capsule-based dry-powder inhalers; correct setup of device for other DPI), exhalation (before using the medication), inhalation coordination (hand-lung coordination, standing or sitting upright), breath holding (up to 10 seconds) and exhalation (outside the device) and device control (close the cap remove the capsule from the device)—each scored from 0 to 2. The total performance score ranged from 0 to 10, with higher scores indicating better technique. This scoring approach was adapted from validated inhaler technique assessment frameworks described in the literature (1,2). Inter-rater reliability was not formally assessed in this retrospective study, as data were extracted from standardized forms completed by a single pulmonologist as part of routine clinical care.

Patients were asked to specify where they discarded their used inhalers, with three response options: medical waste, plastic recycling, or household trash. After their responses were recorded, patients were informed about appropriate medical-waste disposal of used inhalers. Responses were recorded by the pulmonologist on the standardized form (HB.FR.116) during routine patient evaluation as a self-reported measure. Potential social desirability or reporting bias cannot be excluded, as patients may have underreported inappropriate disposal behaviors.

All data were anonymized prior to analysis. Statistical analyses were performed using SPSS v27.0 (IBM Corp., Chicago, IL, USA). Quantitative variables were tested for normality using the Kolmogorov–Smirnov test and are expressed as median (25th – 75th percentile) or mean ± standard deviation, as appropriate. Categorical variables are expressed as frequency and percentage [n (%)]. Group comparisons were conducted using the chi-square, Mann–Whitney U, or Kruskal–Wallis H tests. Correlations were evaluated using Spearman's correlation analysis. A p-value < 0.05 was considered statistically significant. For statistically significant Kruskal–Wallis H test results, post-hoc pairwise comparisons were performed using Dunn's test with Bonferroni correction to identify which groups differed significantly. To assess independent predictors of inhaler technique, a multivariable linear regression model was constructed with total inhaler technique score as the dependent variable and training source (dummy-coded with no training as reference), age, education level (dummy-coded with no formal education as reference), disease duration, and inhaler type (dummy-coded with MDI as reference) as independent variables. Unstandardized B coefficients with 95% confidence intervals are reported. As a sensitivity analysis, inhaler use duration was additionally included in the multivariable model because it showed the strongest unadjusted correlation with total score ($r = 0.446$). It was not included in the primary model

because the primary model was constructed according to the reviewer-requested covariates and because inhaler use duration showed substantial overlap with disease duration (Spearman r = 0.766).

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Medical Sciences Ethics Committee of Muğla Sıtkı Koçman University (Approval Date: 09.09.2025; Protocol No: 250192; Decision No: 179). As the study was retrospective, the requirement for informed patient consent was waived. The study was conducted in accordance with local data protection regulations, and all patient data were anonymized prior to analysis.

RESULTS

A total of 90 patients were included in the study. The study population consisted predominantly of hospitalized, elderly males, with a median age of 68.5 years. COPD was the most common diagnosis (82.2%), and the median disease duration was 8.0 years. The majority of participants were former smokers with a substantial median smoking history of 39.0 pack-years. Dry-powder inhalers were more frequently used than pressurized metered-dose inhalers (66.7% vs. 33.3%). Just over half of the patients (51.1%) had received prior training on inhaler use. The full demographic and clinical characteristics of the participants are detailed in Table 1.

Table 1. Demographic and clinical characteristics of the study participants

Characteristic		Value - n (%) Median (25th – 75th percentile)
Setting, n (%)	**Inpatient**	76 (84.4)
	Outpatient	14 (15.6)
Age (years)		68.5 (59.8 – 75.0)
Gender, n (%)	**Male**	65 (72.2)
	Female	25 (27.8)
Education level, n (%)	**No formal education**	12 (13.3)
	Primary school	63 (70.0)
	High school or higher	15 (16.7)
Diagnosis, n (%)	**COPD**	74 (82.2)
	Asthma	16 (17.8)
Disease duration (years)		8.0 (2.0 – 20.0)
Smoking status, n (%)	**Never smoked**	17 (18.9)
	Former smoker	60 (66.7)
	Current smoker	13 (14.4)
Smoking exposure (pack-years)		39.0 (12.8 – 55.3)
Inhaler type, n (%)	**MDI**	30 (33.3)
	DPI	60 (66.7)
Inhaler use duration (years)		4.0 (2.0 – 15.0)
Number of device changes		2.0 (1.0 – 2.3)
Training status, n (%)	**Trained**	46 (51.1)
	Not trained	44 (48.9)
Training source, n (%)	**None**	44 (48.9)
	Physician	18 (20.0)
	Pharmacist/pharmacy technician	28 (31.1)

Data are presented as n (%) or median (25th – 75th percentile); COPD: Chronic obstructive pulmonary disease; MDI: Metered-dose inhaler; DPI: Dry-powder inhaler; Number of device changes = total device type changes since initiation of inhaler therapy

Inhaler technique performance did not differ significantly by gender (p = 0.064), smoking status (p = 0.543), or clinical setting (inpatient vs. outpatient: 4.0 [3.0 – 6.0] vs. 3.0 [2.8 – 5.0], p = 0.241). The assessment of inhaler technique revealed that structured training was associated with higher overall performance. Patients trained by physicians achieved the highest median total score of 8.5 (5.0 – 10.0), followed by those trained by pharmacist/pharmacy technicians at 4.5 (3.0 – 6.0), and untrained patients at 3.0 (2.0 – 4.0) (p < 0.001) (Table 2). While educational background was associated with improved device control performance (p = 0.015), total scores did not differ significantly across education levels (p = 0.139) (Table 3).

Table 2. Comparison of total scores by demographic and clinical characteristics

Variable	Group	Total score Median (25th – 75th)	Test statistic	p-value
Setting	**Inpatient**	4.0 (3.0 – 6.0)	U = 428.0	0.241
	Outpatient	3.0 (2.8 – 5.0)		
Gender	**Male**	4.0 (3.0 – 6.0)	U = 609.5	0.064
	Female	3.0 (1.5 – 5.0)		
Education level	**No formal education**	3.0 (2.3 – 5.8)	H = 3.947	0.139
	Primary school	4.0 (3.0 – 5.0)		
	High school or higher	6.0 (3.0 – 10.0)		
Diagnosis	**COPD**	4.0 (3.0 – 6.0)	U = 464.5	0.173
	Asthma	3.0 (2.3 – 4.8)		
Smoking status	**Never smoked**	4.0 (1.5 – 5.0)	H = 1.221	0.543
	Former smoker	4.0 (3.0 – 6.0)		
	Current smoker	3.0 (2.0 – 6.0)		
Inhaler type	**DPI**	3.0 (2.8 – 5.3)	U = 786.0	0.323
	MDI	4.0 (3.0 – 6.0)		
Training source	**None**	3.0 (2.0 – 4.0)[a]	H = 29.707	< 0.001
	Physician	8.5 (5.0 – 10.0)[b]		
	Pharmacist/pharmacy technician	4.5 (3.0 – 6.0)[c]		

U: Mann–Whitney U test statistic, H: Kruskal–Wallis H test statistic; Values sharing the same superscript letter indicate statistical similarity; differing letters indicate significant difference; Descriptive statistics are expressed as median (25th – 75th percentile); COPD: Chronic obstructive pulmonary disease, MDI: Metered-dose inhaler, DPI: Dry-powder inhaler

Table 3. Comparison of step and total scores by education level

Step	No formal education Median (25th – 75th)	Primary school Median (25th – 75th)	High school or higher Median (25th – 75th)	Test statistic	p-value
Preparation	1.0 (1.0 – 2.0)	1.0 (1.0 – 1.0)	1.0 (0 – 2.0)	H = 0.428	0.807
Exhalation	0 (0 – 1.0)	0 (0 – 1.0)	0 (0 – 2.0)	H = 3.922	0.141
Inhalation coordination	1.0 (0.3 – 1.0)	1.0 (1.0 – 1.0)	2.0 (1.0 – 2.0)	H = 5.019	0.081
Breath holding	0 (0 – 1.0)	1.0 (0 – 1.0)	2.0 (0 – 2.0)	H = 5.616	0.060
Device control	1.0 (0.3 – 1.0)[a]	1.0 (1.0 – 1.0)[a]	1.0 (1.0 – 2.0)[b]	H = 8.359	0.015
Total score	3.0 (2.3 – 5.8)	4.0 (3.0 – 5.0)	6.0 (3.0 – 10.0)	H = 3.947	0.139

H: Kruskal–Wallis H test statistic; Values sharing the same superscript letter indicate statistical similarity; differing letters indicate significant difference; Descriptive statistics are expressed as median (25th – 75th percentile); COPD: Chronic obstructive pulmonary disease, MDI: Metered-dose inhaler, DPI: Dry-powder inhaler

Weak positive correlations were observed between the total inhaler performance score and disease duration (r = 0.309, p = 0.003), smoking exposure (r = 0.231, p = 0.028), and the number of device changes (r = 0.223, p = 0.035). A moderate positive correlation was found with the duration of inhaler use (r = 0.446, p < 0.001) (Table 4).

Table 4. Correlation between total score and quantitative variables

Variable	r	p-value
Age	-0.203	0.055
Disease duration (years)	0.309	0.003
Smoking (pack-years)	0.231	0.028
Inhaler duration (years)	0.446	< 0.001
Number of device changes	0.223	0.035

r: Spearman correlation coefficient; A positive r value indicates a positive association with total inhaler technique score

All patients reported disposing of their used inhalers in household trash. None reported using medical waste or plastic recycling channels. This uniform behavior indicates a widespread lack of awareness regarding environmentally appropriate disposal practices among the studied inhaler users.

Multivariable linear regression was performed to assess independent predictors of total inhaler technique score (Table 5). In the primary model (training source, age, education level, disease duration, and inhaler type), physician-led training was independently associated with higher total inhaler technique scores compared with no training (B = 4.323, 95% CI: 3.120 to 5.526, $p < 0.001$). Pharmacist/pharmacy technician-led training was also independently associated with higher scores compared with no training (B = 1.306, 95% CI: 0.253 to 2.359, p = 0.016). Older age was independently associated with lower scores (B = -0.054, 95% CI: -0.096 to -0.012, p = 0.013), and longer disease duration was independently associated with higher scores (B = 0.042, 95% CI: 0.002 to 0.082, p = 0.041). Education level and inhaler type were not independently associated with total score in the primary model. The primary model explained 46.3% of the variance in total inhaler technique score ($R^2 = 0.463$, Adjusted $R^2 = 0.417$, $F(7, 82) = 10.11$, $p < 0.001$). Variance inflation factor (VIF) values ranged from 1.05 to 2.47, indicating no multicollinearity problem. In a sensitivity analysis additionally adjusting for inhaler use duration, physician-led training remained independently associated with higher total inhaler technique scores compared with no training (B = 4.087, 95% CI: 2.874 to 5.300, $p < 0.001$), supporting the robustness of the primary finding. The magnitude of the physician-led training coefficient changed only modestly after additional adjustment for inhaler use duration.

Table 5. Multivariable linear regression analysis for total inhaler technique score (primary model)

Variable	B coefficient	95% CI	p-value
Training source (ref: no training)			
Physician-led	4.323	3.120 – 5.526	< 0.001
Pharmacist/pharmacy technician-led	1.306	0.253 – 2.359	0.016
Education level (ref: no formal education)			
Primary school	0.130	-1.222 – 1.482	0.848
High school or higher	0.003	-1.861 – 1.867	0.997
Inhaler type (ref: MDI)			
DPI	0.298	-0.662 – 1.258	0.538
Age (years)	-0.054	-0.096 – -0.012	0.013
Disease duration (years)	0.042	0.002 – 0.082	0.041
Constant	**5.965**	**2.591 – 9.339**	**0.001**

CI: Confidence interval, MDI: Metered-dose inhaler, DPI: Dry-powder inhaler, Ref: Reference category, VIF: Variance inflation factor, R^2: Coefficient of determination; Unstandardized B coefficients are reported; Model: $R^2 = 0.463$, Adjusted $R^2 = 0.417$, $F(7, 82) = 10.11$, $p < 0.001$, n = 90

DISCUSSION

This study demonstrates that structured education, particularly when delivered by physicians, was independently associated with higher inhaler technique proficiency. These findings reinforce existing evidence that repeated, supervised, and professional training sessions are crucial for minimizing critical errors and optimizing drug delivery efficiency (1-5,11). The results underscore the value of systematic, hands-on education in achieving correct inhaler use. It should be noted, however, that the cohort was predominantly inpatient (84%), elderly, male, and COPD-dominant (82%), which may limit generalizability. Although inhaler technique scores did not differ significantly between inpatients and outpatients (4.0 [3.0 – 6.0] vs. 3.0 [2.8 – 5.0], p = 0.241), the outpatient subgroup was small (n = 14), limiting the interpretation of this comparison. Inpatients may have had greater cumulative exposure to physician-led education during hospitalization, potentially amplifying the observed training effect. Therefore, caution is needed when generalizing these findings to outpatient or community settings. Although a higher education level was associated with improved device-control performance, total inhaler technique scores did not differ significantly across educational categories. This suggests that general literacy alone is insufficient to ensure correct inhaler use; instead, technical proficiency appears to rely more on specific, hands-on training supported by direct demonstration and feedback. The significant association between education level and device-control scores specifically (p = 0.015, Table 3) suggests that higher educational attainment may facilitate procedural aspects of device handling, such as following sequential post-inhalation steps, reading instructions, or understanding device assembly. However, education level appeared less relevant for the habitual motor-skill components of inhaler technique, which may depend more on repeated hands-on training and feedback. This observation aligns with the work of Trela et al. (2022), who found that low health literacy was associated with persistent inhaler errors even after structured education (4,11),

and with Vitacca et al. (2023), who showed that organized training programs were associated with improved inhaler technique knowledge and practical skills (4). Furthermore, the positive correlation between the total score and the duration of inhaler use implies that repeated experience and reinforcement over time may enhance patient competence and confidence. However, these weak correlations should be interpreted cautiously and may have limited clinical relevance.

The environmental aspect of inhaler use also warrants emphasis. All participants in this study reported disposing of their used inhalers in household trash, revealing a critical gap in awareness regarding appropriate medical or recyclable waste streams. Disposal behavior was assessed using a single self-reported item on the standardized form, in which patients were asked where they usually discarded used inhalers, with three predefined response options: medical waste, plastic recycling, or household trash. After the response was recorded, patients were informed about appropriate medical-waste disposal of used inhalers. However, the standardized form did not include additional items assessing whether patients had prior awareness of alternative disposal options, such as pharmacy take-back schemes or medical waste bins, or whether they had access to such infrastructure. This limits the interpretation of the waste-disposal finding and should be addressed in future studies.

In the present cohort, 33.3% of patients used MDIs and 66.7% used DPIs. Because all participants in both device groups reported household-trash disposal, comparative statistical analysis by inhaler type was not possible. In other words, there was no variability in disposal behavior to compare between MDI and DPI users. Nevertheless, separating these device types remains clinically and environmentally important. MDIs contain hydrofluorocarbon propellants that are potent greenhouse gases, whereas DPIs do not contain these propellants and mainly contribute to plastic and other device-related solid waste rather than direct propellant-related greenhouse-gas emissions (12). Therefore, although disposal behavior was identical across device groups in this study, the environmental implications of inappropriate disposal may differ by inhaler type. Future studies should use more detailed environmental assessment instruments that evaluate not only disposal behavior but also awareness of disposal alternatives, access to take-back systems, device type, and willingness to return used inhalers. This issue is not unique to our setting; the environmental impact of improper inhaler disposal has been recognized in European settings (12,13). Recent pilot initiatives in the United Kingdom, such as postal inhaler recovery schemes (5), have demonstrated that inhaler return systems can prevent substantial carbon dioxide emissions by collecting and recycling thousands of used devices. The current absence of routine inhaler-specific take-back pathways in our clinical setting underscores the urgent need to integrate environmental education into routine respiratory care and to establish national inhaler recycling policies as in the United Kingdom (14).

Given that educational level was linked only to specific steps and not to overall scores, targeted training appears more influential than formal schooling in mastering inhaler technique. Therefore, implementing structured educational programs—supported by checklists, visual aids, and periodic reassessments—should be a priority in clinical practice. Physicians and respiratory nurses must take an active role in reinforcing both proper inhaler technique and environmental responsibility during patient follow-ups.

The present findings indicate that improving inhaler technique and promoting sustainability should be integrated objectives of respiratory care education. Incorporating brief instructions on eco-friendly inhaler disposal into standard training sessions may be a feasible strategy for improving disposal awareness; however, its effects on adherence and environmental outcomes should be tested in future prospective studies. Given that physician-led training yielded superior technique scores in the present study, physician-delivered education should be prioritized where resources allow. In settings where physician-delivered training is not scalable, nurse- or pharmacist-led models may serve as complementary approaches, provided that structured protocols and competency checks are in place to ensure training quality. Collaboration with recycling programs could further extend the reach of environmental education efforts.

This study has several limitations that should be considered when interpreting the findings. First, the retrospective, single-center design may limit the generalizability of the results to broader patient populations. Second, the relatively small sample size (n = 90) was not determined by a formal prospective power calculation; the absence of an a priori power analysis is a methodological limitation. Although the primary Kruskal-Wallis comparison yielded a large effect size ($H = 29.707$, $p < 0.001$), this does not substitute for a formal power calculation and results should be interpreted with appropriate caution. Third, the specific content, duration, and delivery methods of inhaler training sessions were not recorded on the standardized form, preventing a detailed assessment of training quality or standardization across providers. Fourth, the physician-trained subgroup was small (n = 18), resulting in wider confidence intervals for that estimate; findings from this subgroup should be interpreted with appropriate caution. Fifth, waste-disposal behavior was assessed by self-report, and social desirability bias may have influenced responses, potentially underestimating inappropriate disposal practices. Sixth, inhaler technique was assessed by a single pulmonologist using the standardized HB.FR.116 form. Although this approach may have improved consistency across assessments, inter-rater reliability could not be evaluated. Despite these limitations, the use of a standardized hospital form (HB.FR.116) ensured data consistency, and the inclusion of waste-management behavior adds a novel environmental dimension to the inhaler-technique literature.

CONCLUSION

In conclusion, in this retrospective single-center study, physician-led inhaler education was independently associated with higher inhaler technique scores, whereas all patients reported disposing of used inhalers in household trash. These findings support the need for structured inhaler technique assessment and suggest that environmental disposal education should be incorporated into respiratory care. Future prospective studies using validated assessment tools and standardized training protocols are needed to confirm these findings.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that there is no financial support.

Ethical Approval
The study protocol was approved by the Medical Sciences Ethics Committee of Muğla Sıtkı Koçman University (Approval Date: September 9, 2025; Protocol No: 250192; Decision No: 179).

Informed Consent
Due to the retrospective design of the study and the use of anonymized routine clinical data, the requirement for written informed patient consent was waived by the ethics committee.

REFERENCES

1. Lavorini F, Magnan A, Dubus JC, et al. Effect of incorrect use of dry powder inhalers on management of patients with asthma and COPD. Respir Med. 2008;102:593-604.
2. Inhaler Error Steering Committee; Price D, Bosnic-Anticevich S, Briggs A, et al. Inhaler competence in asthma: common errors, barriers to use and recommended solutions. Respir Med. 2013;107:37-46.
3. Price DB, Román-Rodríguez M, McQueen RB, et al. Inhaler errors in the CRITIKAL study: type, frequency, and association with asthma outcomes. J Allergy Clin Immunol Pract. 2017;5:1071-81.e9.
4. Trela KC, Zajac P, Zhu M, Press VG. Health literacy and type of education intervention predicting post-education metered-dose inhaler misuse. Respir Med. 2022;200:106930.
5. Vitacca M, Paneroni M, Fracassi M, et al. Inhaler technique knowledge and skills before and after an educational program in obstructive respiratory disease patients: A real-life pilot study. Pulmonology. 2023;29:130-7.
6. Murphy A, Howlett D, Gowson A, Lewis H. Understanding the feasibility and environmental effectiveness of a pilot postal inhaler recovery and recycling scheme. NPJ Prim Care Respir Med. 2023;33:5.
7. Aydemir Y. Misuse of inhalation devices-effective parameters and the role of education. Eurasian J Pulmonol. 2013;15:32-8.
8. Ocakli B, Ozmen I, Tunçay EA, et al. A comparative analysis of errors in inhaler technique among COPD versus asthma patients. Int J Chron Obstruct Pulmon Dis. 2018;13:2941-7.
9. Yildiz F; Asthma Inhaler Treatment Study Group. Importance of inhaler device use status in the control of asthma in adults: the asthma inhaler treatment study. Respir Care. 2014;59:223-30.
10. Global Initiative for Chronic Obstructive Lung Disease (GOLD). Global Strategy for Prevention, Diagnosis and Management of COPD: 2024 Report. Available from: https://goldcopd.org. Accessed April 2024.
11. Beatty CR, Flynn LA, Costello TJ. The impact of health literacy level on inhaler technique in patients with chronic obstructive pulmonary disease. J Pharm Pract. 2017;30:25-30.
12. Janson C, Henderson R, Löfdahl M, et al. Carbon footprint impact of the choice of inhalers for asthma and COPD. Thorax. 2020;75:82-4.
13. Wilkinson AJK, Braggins R, Steinbach I, Smith J. Costs of switching to low global warming potential inhalers. An economic and carbon footprint analysis of NHS prescription data in England. BMJ Open. 2019;9:e028763.
14. Wilkinson A, Maslova E, Janson C, et al. Environmental sustainability in respiratory care: an overview of the healthcare-based environmental cost of treatment (CARBON) programme. Adv Ther. 2022;39:2270-80.