



Article

Effectiveness of an Educational Intervention on Inhaler Technique Proficiency in Chronic Obstructive Pulmonary Disease: A Single-Center Quality Improvement Study

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Abstract: Albeit inhalation therapy is the cornerstone in chronic obstructive pulmonary disease (COPD) treatment, inhaler technique is rarely evaluated, and training materials are often insufficient. In this single-center study, we aimed to evaluate the effectiveness of a teaching session complemented by a flyer on inhaler technique in COPD patients and to evaluate the perceived quality of the flyer. A total of 30 participants with stable COPD who had never used a soft mist inhaler before (Respimat[®], Boehringer Ingelheim) received a brief teaching session on proper inhaler technique complemented by a flyer (visit 1). The teaching intervention was completed by a pulmonologist. Epidemiological and clinical characteristics of COPD were collected by a questionnaire, and the ability to properly handle the inhaler was assessed. After 14 days, inhaler handling was re-evaluated, and patients were asked to rate the flyer (visit 2). After the initial training, proper inhaler handling was achieved in 80.0% of patients. Inhaler proficiency was maintained after 14 days (83.0% of the patients used the Respimat[®] correctly, p -value > 0.99). The flyer was considered at least good by 27 patients (90.0%). This study indicated that the administration of an educational intervention resulted in persistent good competence in inhaler technique at a 14-day follow-up.

Keywords: inhaler handling; Respimat; soft mist inhaler; chronic obstructive pulmonary disease (COPD); teaching; flyer; educational intervention



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1. Introduction

Chronic obstructive pulmonary disease (COPD) is a common (with a global estimated prevalence of 13.1%) [1], preventable, and treatable disease, whose main characteristics are persistent respiratory symptoms and airflow obstruction. COPD is a global health problem that causes significant morbidity and mortality. It is the third leading cause of death worldwide [2]. The natural history of COPD frequently includes acute exacerbations, which is an acute deterioration of respiratory symptoms beyond the normal daily variation, warranting a treatment [3]. Although most exacerbations are infectious, usually due to viral—or less commonly, bacterial triggers—many other factors can precipitate an exacerbation, such as suboptimal inhaler technique [4,5]. Since early reports, the Global Initiative for Chronic Obstructive Lung Disease (GOLD) has emphasized the importance of assessing inhalation technique and adherence at every opportunity [6]. Inhaler technique comprises manipulation, preparation, and inhalation. Several subsequent studies have reported discouraging data on the rate of inhaler device mishandling [7,8]. As clearly reported by Molimard et al. [9], inhaler handling errors are very common, being described in as many as 89.3% of patients using an inhaler, and critical errors (defined as errors that prevent the drug from reaching its target) in up to 46.9% of patients. Thus, overall capacity in inhaler use appears to be at least poor, regardless of the inhaler device used.

Other studies have confirmed these data [10,11]. For the above reasons, a comprehensive approach to inhaler device handling technique is urgently needed.

2. Materials and Methods

2.1. Case Definition

COPD was diagnosed according to the presence of obstructive respiratory disease as defined by the Global Lung Initiative (GLI) [12] in patients with characteristic symptoms and a history of exposure to risk factors. Stability of COPD was defined as the absence of acute exacerbations in the preceding 4 weeks.

2.2. Participants and Study Design

Participants with stable COPD were enrolled consecutively during pulmonary outpatient visits. Patients included had to be older than 18 years, have a formal diagnosis of COPD made by spirometry, and have a new prescription for a soft mist inhaler (Respimat[®], Boehringer Ingelheim). We planned to enroll a limited number of patients in this exploratory local quality improvement project, as this practice was reported to be preferable for rapid process improvement [13]. Overall, two visits were planned (Figure 1): at recruitment and at a complimentary follow-up visit after 14 days. During the first visit, patients underwent a teaching session by a pulmonologist on how to appropriately manage their inhaler device and received a flyer with written instructions and an attached therapy diary. We distributed the standard 3-page Respimat[®] flyer provided by Boehringer Ingelheim (available in the Supplementary Materials, Figure S1). This flyer was developed by a group of respiratory physiotherapists based on patient needs to make it as practical as possible. Subsequently, patients were administered a questionnaire to collect key epidemiological and clinical characteristics, and an assessment of their ability to handle the inhaler device correctly was performed at the end of the teaching session. At the follow-up visit, an evaluation of newly acquired inhaler technique was performed, and a second questionnaire was administered to assess the perceived quality of the flyer in addition to the effective use of the diary.

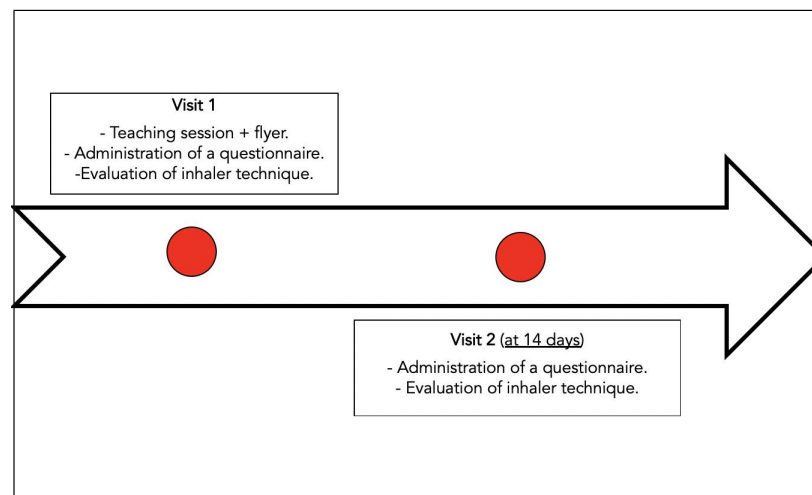


Figure 1. Study design and visit schedule.

The primary aim of the study was to evaluate the effectiveness of a structured educational intervention on inhaler technique proficiency and on the maintenance of the acquired proficiency in the short term. We defined inhaler technique proficiency as the ability of a patient to comply with all the steps explained during visit 1 and resumed in the flyer. The secondary aim was to assess the perceived quality of the flyer. Our hypothesis was that a brief structured intervention would improve inhaler technique and that the acquired skill would be maintained at a 14-day follow-up.

2.3. Statistical Analysis

Qualitative data were summarized as absolute values with the corresponding percentages. The inhaler technique at the two timepoints was evaluated by Fisher's exact test. All tests were performed two-sided, and a p -value < 0.05 was considered statistically significant. Statistical analysis was performed using GraphPad Prism 8 software (GraphPad Software, Inc., La Jolla, CA, USA).

3. Results

We enrolled 30 consecutive patients with stable COPD from February to October 2019. An overview of the relevant demographic and clinical characteristics of participants is provided in Table 1. All enrolled patient attended the second visit ($n = 30, 100.0\%$).

Table 1. Patient demographics and clinical characteristics at visit 1.

Questionnaire Visit 1	n (%)
Number of patients	30 (100.00)
Age	
≤ 50	1 (3.33)
51–60	5 (16.67)
61–70	6 (20.00)
71–80	15 (50.00)
81–90	3 (10.00)
Sex	
Female	19 (63.33)
Male	11 (36.67)
Year COPD was diagnosed	
2007	1 (3.33)
2015	1 (3.33)
2016	2 (6.67)
2017	6 (20.00)
2018	9 (30.00)
2019	11 (36.67)
GOLD stage	
1	3 (10.00)
2	20 (66.66)
3	7 (23.33)
Was the explanation with the flyer successful?	
Yes	30 (100.00)
Did the patients ask questions?	
Yes	22 (73.33)
No	8 (26.37)
If yes: at which step	
1	6 (27.27)
2	11 (50)
3	6 (27.27)
4	6 (27.27)
5	3 (13.63)
6	5 (22.72)
7	3 (13.63)
8	2 (9.1)
Did the Patient follow each step in the flyer instructions?	
Yes	24 (80.00)
No	5 (16.67)
Missing	1 (3.33)
If not: which step(s) should be better explained in the flyer?	
2	2 (6.66)
3	1 (3.33)
4	1 (3.33)
6	2 (6.66)
8	1 (3.33)
Was the use of the diary explained?	
Yes	29 (96.67)
No	1 (3.33)

Regarding inhaler technique (manipulation, preparation, and inhalation), at visit 1, at the end of the teaching session, 24 patients (80.0%) used the inhaler device correctly.

At visit 2, after two weeks, twenty-five patients (83.3%) used the inhaler device correctly (p -value > 0.99).

In Figure 2, we report the usage instructions contained in the Respimat® flyer. During the first visit, the flyer was explained to each enrolled patient, and 22 (73.3%) patients asked questions about the content of the flyer, especially about step 2 ($n = 11$, 45.8%). The steps considered the most poorly explained were steps 2 and 6. The use and usefulness of the diary were explained to 29 patients (96.7%). At visit 2, the flyer was rated as very good by 21 patients (70.0%) and good by 6 patients (20.0%). On this occasion, the steps considered the most poorly explained were steps 4 and 6. Twenty-nine patients (96.7%) used the diary between the two visits. The results of the questionnaires administered at visits 1 and 2 are presented in Tables 1 and 2, respectively.

COME USARE BENE IL DISPOSITIVO RESPIMAT® – Punti chiave da ricordare

Prima di cominciare

- impiegare il tempo sufficiente per la corretta applicazione del medicamento
- assumere la posizione eretta o seduta
- verificare il numero di dosi rimanenti
- chiudere il cappuccio

1 Ruotare la base trasparente di mezzo giro, fino a percepire un clic.

2 Controllare che la cartuccia sia in posizione 2.

posizione 1 posizione 2

3 Aprire completamente il cappuccio.

4 Espirare a fondo al di fuori del boccalio.

5 Serrare le labbra attorno al boccalio, senza coprire le 2 aperture, mantenendo RESPIMAT® orizzontalmente.

6 «clic!» Avviare una lenta inspirazione e premere il pulsante. Continuare a inspirare a fondo e poi trattenere il respiro per 5–10 secondi.

7 Richiudere il cappuccio e controllare che la cartuccia sia in posizione 1 (figura 2).

8 Ripetere i punti da 1 a 7 (2 spruzzi 1 volta al giorno).

Pulire il boccalio almeno una volta la settimana. Utilizzare solo un panno o un fazzolettino di carta inumidito. Tenere RESPIMAT® in un luogo asciutto e a temperatura ambiente.

Figure 2. Device handling instructions (as in Respimat® flyer). Handling instructions are shown in pictures and supported by short text passages. The correct order is ensured by sequential numbering of the individual handling steps.

Table 2. Questionnaire at visit 2.

Questionnaire Visit 1	n (%)
Number of patients	30 (100.00)
Did the patient use the diary?	
Yes	29 (96.67)
No	1 (3.33)
Patient Evaluation of the flyer (Scale 1–6 = very bad to very good)	
≤4	3 (10.00)
5	6 (20.00)
6	21 (70.00)
Did the patient follow each step in the flyer instructions for the Respimat®?	
Yes	25 (83.33)
No	4 (13.33)
missing	1 (3.33)
If not: which step(s) should be better explained in the flyer	
Before	1 (3.33)
1	1 (3.33)
2	1 (3.33)
4	2 (6.66)
5	1 (3.33)
6	2 (6.66)
Has the last page (Preparation of Respimat®) been shown to the patient, and did he understand it?	
Yes	29 (96.67)
No	1 (3.33)

4. Discussion

Our study showed that a simple, rapid, and structured educational intervention, such as a teaching session complemented by a flyer developed pragmatically by a group of respiratory physiotherapists based on patient needs, resulted in good overall inhaler application (80.0% of the COPD patients used the inhaler correctly). Patients' acquired ability was maintained for up to 14 days (83.0%, *p*-value > 0.99). These findings show the effectiveness of the proposed intervention in developing proficiency in inhaler technique and maintaining this proficiency in the short term and are of importance considering the error rate reported in the literature and its dismal consequences. Molimard et al. and Navaie et al. indicated an overall inhaler handling error rate of up to 89.3%, with critical errors preventing the drug from working in up to 46.9% of patients [9,10]. Sanchis et al., in a systematic review, showed that over the past four decades, the overall prevalence of correct handling was 31%, and this figure has not improved over time, prompting the implementation of structured educational interventions [14]. On the other hand, poor inhaler technique was reported to be linked to poor clinical control [7,15] and to increased health costs [16]. In general, all inhalers, when correctly used, show no significant differences in treatment efficacy [17,18].

Few studies have looked at the effect of interventions in creating and maintaining proficiency in inhaler technique. A seminal study by Kessel et al., which included 4529 patients aged 6 years and older in a primary care setting, showed that, after professional instruction and despite adequate use at the initial visit, up to 10.2% of elderly patients and 3.2% of patients in general were using their device incorrectly at a 2-week follow-up [19].

Our results further emphasize the importance of teaching, supported by the use of appropriate information material, to reduce errors in the use of inhalers.

Recently, several innovative developments have advanced the field of inhaler device design. Inhaler devices require the coordination of patients between actuation and inspiration regardless of the type and characteristics of the inhaler. Therefore, the patient's

ability to properly use the device is critical to providing successful treatment. In fact, the perfect inhaler does not yet exist, and each inhaler device has its pros and cons. It is well-established that successful treatment depends as much on the inhaler device and the chosen drug as it does on the patient's ability to handle the inhaler itself. It has been shown in three randomized controlled trials (RCT) that various educational interventions effectively improve patient proficiency and proper handling of inhaler devices, although two of these trials did not evaluate the maintenance of this proficiency [20,21]. Park et al. showed that video education was not inferior to face-to-face education in terms of the number of critical handling errors at 4- and 12-week follow-ups [22]. GOLD guidelines have taken these findings into consideration and therefore recommend that proper inhalation technique is checked at each visit. However, the frequency of inhaler technique re-evaluation has not yet been established, as most studies have not addressed this issue. Various types of educational interventions have proven useful, including video intervention, the delivery of a flyer, and face-to-face teaching by a physician or health care provider. However, the impact of an educational intervention to improve inhalation techniques on hard clinical outcomes has not yet been demonstrated, and further research in this area is therefore warranted [23–25].

In summary, more than the intervention itself, it is important to systematically monitor inhalation technique and ideally implement a standardized intervention to ensure reproducibility in daily clinical practice. We propose that a face-to-face education complemented by a flyer develops proficiency in inhaler technique and maintains this proficiency at a 2-week follow-up.

Our study has several limitations. The sample size is small, the follow-up period of 14 days could be seen as too short, the study was conducted in only one center, a control arm and randomization were not planned, and selection biases may have occurred because of the inclusion of patients attending a pulmonary visit. However, we think that these limitations can be justified by the local quality improvement aim of the study, and a 2-week follow-up has already been used in the literature. Our study has the merit of showing that even a brief teaching session, complemented by a flyer, can achieve adequate levels of effectiveness in inhaler technique proficiency and maintain it at a 2-week follow-up. Although we used the Respimat[®] device exclusively, we expect our results to be generalizable to other devices.

5. Conclusions

In conclusion, we report that a simple, structured, and inexpensive educational intervention (teaching session complemented by a flyer) showed efficacy in developing proficiency in inhaler technique and maintaining this proficiency in the short term.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/jor2030012/s1>, Figure S1: Respimat[®] flyer (Italian version).

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki. This study was notified to the ethics committee; however, ethical review and approval were waived (ethics committee decision: CER-VD/Req-2017-00753).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: All data from the study are available within the manuscript or be provided within the Supplementary Materials (see in the previous section: Supplementary Materials).

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References

- Blanco, I.; Diego, I.; Bueno, P.; Casas-Maldonado, F.; Miravittles, M. Geographic distribution of COPD prevalence in the world displayed by Geographic Information System maps. *Eur. Respir. J.* **2019**, *54*, 1900610. [CrossRef] [PubMed]
- World Health Organization. The Top 10 Causes of Death. Available online: <https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death> (accessed on 16 February 2022).
- O'Donnell, D.E.; Parker, C.M. COPD exacerbations. 3: Pathophysiology. *Thorax* **2006**, *61*, 354–361. [CrossRef] [PubMed]
- Wedzicha, J.A.; Seemungal, T.A. COPD exacerbations: Defining their cause and prevention. *Lancet* **2007**, *370*, 786–796. [CrossRef]
- Donaldson, G.C.; Seemungal, T.A.; Bhowmik, A.; Wedzicha, J.A. Relationship between exacerbation frequency and lung function decline in chronic obstructive pulmonary disease. *Thorax* **2002**, *57*, 847–852, Erratum in: *Thorax* **2008**, *63*, 753. [CrossRef]
- The Global Initiative for Chronic Obstructive Lung Diseases (GOLD). Global Strategy for Prevention, Diagnosis and Management of COPD: 2022 Report. Available online: <https://goldcopd.org/2022-gold-reports-2/> (accessed on 8 June 2022).
- Melani, A.S.; Bonavia, M.; Cilenti, V.; Cinti, C.; Lodi, M.; Martucci, P.; Serra, M.; Scichilone, N.; Sestini, P.; Aliani, M.; et al. Inhaler mishandling remains common in real life and is associated with reduced disease control. *Respir. Med.* **2011**, *105*, 930–938, Erratum in: *Respir. Med.* **2012**, *106*, 757. [CrossRef] [PubMed]
- Lavorini, F.; Magnan, A.; Dubus, J.C.; Voshaar, T.; Corbetta, L.; Broeders, M.; Dekhuijzen, R.; Sanchis, J.; Viejo, J.L.; Barnes, P.; et al. Effect of incorrect use of dry powder inhalers on management of patients with asthma and COPD. *Respir. Med.* **2008**, *102*, 593–604. [CrossRef] [PubMed]
- Molimard, M.; Raheison, C.; Lignot, S.; Balestra, A.; Lamarque, S.; Chartier, A.; Droz-Perroteau, C.; Lassalle, R.; Moore, N.; Girodet, P.O. Chronic obstructive pulmonary disease exacerbation and inhaler device handling: Real-life assessment of 2935 patients. *Eur. Respir. J.* **2017**, *49*, 1601794. [CrossRef] [PubMed]
- Navaie, M.; Dembek, C.; Cho-Reyes, S.; Yeh, K.; Celli, B.R. Device use errors with soft mist inhalers: A global systematic literature review and meta-analysis. *Chron Respir. Dis.* **2020**, *17*, 1479973119901234. [CrossRef] [PubMed]
- Vanoverschelde, A.; van der Wel, P.; Putman, B.; Lahousse, L. Determinants of poor inhaler technique and poor therapy adherence in obstructive lung diseases: A cross-sectional study in community pharmacies. *BMJ Open Respir. Res.* **2021**, *8*, e000823. [CrossRef]
- Quanjer, P.H.; Stanojevic, S.; Cole, T.J.; Baur, X.; Hall, G.L.; Culver, B.H.; Enright, P.L.; Hankinson, J.L.; Ip, M.S.; Zheng, J.; et al. ERS Global Lung Function Initiative. Multi-ethnic reference values for spirometry for the 3–95-yr age range: The global lung function 2012 equations. *Eur. Respir. J.* **2012**, *40*, 1324–1343. [CrossRef]
- Etchells, E.; Ho, M.; Shojania, K.G. Value of small sample sizes in rapid-cycle quality improvement projects. *BMJ Qual. Saf.* **2016**, *25*, 202–206. [CrossRef]
- Sanchis, J.; Gich, I.; Pedersen, S. Aerosol Drug Management Improvement Team (ADMIT). Systematic Review of Errors in Inhaler Use: Has Patient Technique Improved Over Time? *Chest* **2016**, *150*, 394–406. [CrossRef]
- Giraud, V.; Roche, N. Misuse of corticosteroid metered-dose inhaler is associated with decreased asthma stability. *Eur. Respir. J.* **2002**, *19*, 246–251. [CrossRef] [PubMed]
- Roggeri, A.; Micheletto, C.; Roggeri, D.P. Inhalation errors due to device switch in patients with chronic obstructive pulmonary disease and asthma: Critical health and economic issues. *Int. J. Chronic Obstr. Pulm. Dis.* **2016**, *11*, 597–602. [CrossRef] [PubMed]
- Brocklebank, D.; Ram, F.; Wright, J.; Barry, P.; Cates, C.; Davies, L.; Douglas, G.; Muers, M.; Smith, D.; White, J. Comparison of the effectiveness of inhaler devices in asthma and chronic obstructive airways disease: A systematic review of the literature. *Health Technol. Assess.* **2001**, *5*, 1–149. [CrossRef]
- Dolovich, M.B.; Ahrens, R.C.; Hess, D.R.; Anderson, P.; Dhand, R.; Rau, J.L.; Smaldone, G.C.; Guyatt, G. Device selection and outcomes of aerosol therapy: Evidence-based guidelines: American college of chest physicians/american college of asthma, allergy, and immunology. *Chest* **2005**, *127*, 335–371. [CrossRef] [PubMed]
- Kesten, S.; Elias, M.; Cartier, A.; Chapman, K.R. Patient handling of a multidose dry powder inhalation device for albuterol. *Chest* **1994**, *105*, 1077–1081. [CrossRef]
- Axtell, S.; Haines, S.; Fairclough, J. Effectiveness of Various Methods of Teaching Proper Inhaler Technique. *J. Pharm. Pract.* **2017**, *30*, 195–201. [CrossRef]
- Dabrowska, M.; Luczak-Wozniak, K.; Miszczuk, M.; Domagala, I.; Lubanski, W.; Leszczynski, A.; Maskey-Warzechowska, M.; Rubinsztajn, R.; Hermanowicz-Salamon, J.; Krenke, R. Impact of a Single Session of Inhalation Technique Training on Inhalation Skills and the Course of Asthma and COPD. *Respir. Care* **2019**, *64*, 1250–1260. [CrossRef]
- Park, H.J.; Byun, M.K.; Kwon, J.W.; Kim, W.K.; Nahm, D.H.; Lee, M.G.; Lee, S.P.; Lee, S.Y.; Lee, J.H.; Jeong, Y.Y.; et al. Video education versus face-to-face education on inhaler technique for patients with well-controlled or partly-controlled asthma: A phase IV, open-label, non-inferiority, multicenter, randomized, controlled trial. *PLoS ONE* **2018**, *13*, e0197358. [CrossRef]

23. Normansell, R.; Kew, K.M.; Mathioudakis, A.G. Interventions to improve inhaler technique for people with asthma. *Cochrane Database Syst. Rev.* **2017**, *3*, CD012286. [[CrossRef](#)] [[PubMed](#)]
24. Klijn, S.L.; Hiligsmann, M.; Evers, S.M.A.A.; Román-Rodríguez, M.; van der Molen, T.; van Boven, J.F.M. Effectiveness and success factors of educational inhaler technique interventions in asthma & COPD patients: A systematic review. *NPJ Prim. Care Respir. Med.* **2017**, *27*, 24. [[CrossRef](#)] [[PubMed](#)]
25. Maricoto, T.; Monteiro, L.; Gama, J.M.R.; Correia-de-Sousa, J.; Taborda-Barata, L. Inhaler Technique Education and Exacerbation Risk in Older Adults with Asthma or Chronic Obstructive Pulmonary Disease: A Meta-Analysis. *J. Am. Geriatr. Soc.* **2019**, *67*, 57–66. [[CrossRef](#)] [[PubMed](#)]