



Inhaler training and asthma knowledge are associated with a higher proportion of patients with correct inhaler technique in young but not in elderly asthmatic patients

Eduardo Freitas Ferreira, Adriana Pascoal, Patrícia Silva, Olga Lourenço, Salete Valente, Maria Jesus Valente, Marli Loureiro, Jorge M. R. Gama, João A. Fonseca & Luís Taborda-Barata

To cite this article: Eduardo Freitas Ferreira, Adriana Pascoal, Patrícia Silva, Olga Lourenço, Salete Valente, Maria Jesus Valente, Marli Loureiro, Jorge M. R. Gama, João A. Fonseca & Luís Taborda-Barata (2019): Inhaler training and asthma knowledge are associated with a higher proportion of patients with correct inhaler technique in young but not in elderly asthmatic patients, Journal of Asthma, DOI: [10.1080/02770903.2019.1582063](https://doi.org/10.1080/02770903.2019.1582063)

To link to this article: <https://doi.org/10.1080/02770903.2019.1582063>

 View supplementary material 

 Published online: 27 Feb 2019.

 Submit your article to this journal 

 Article views: 17

 View Crossmark data 



Inhaler training and asthma knowledge are associated with a higher proportion of patients with correct inhaler technique in young but not in elderly asthmatic patients

Eduardo Freitas Ferreira, MD^a, Adriana Pascoal, MD^{a,b}, Patrícia Silva, MD^{a,c}, Olga Lourenço, PhD^{a,d} ,
Salette Valente, MD^e, Maria Jesus Valente, MD^e, Marli Loureiro, MD^f, Jorge M. R. Gama, PhD^g ,
João A. Fonseca, MD, PhD^{h,i} , and Luís Taborda-Barata, MD, PhD^{a,d,j} 

^aNuESA – Health Environment Study Group, Faculty of Health Sciences, University of Beira Interior, Covilhã, Portugal; ^bCentro de Medicina de Reabilitação da Região Centro Rovisco Pais, Tocha, Portugal; ^cDepartment of Medical Sciences, University of Aveiro, Aveiro, Portugal; ^dCICS – UBI – Health Sciences Research Centre, University of Beira Interior, Covilhã, Portugal; ^eCHUCB – Department of Pulmonology, Cova da Beira University Hospital Centre, Covilhã, Portugal; ^fCovilhã Healthcare Centre, Covilhã, Portugal; ^gCenter of Mathematics and Applications, Faculty of Sciences, University of Beira Interior, Covilhã, Portugal; ^hCentre for Research in Health Technologies and Information Systems, Faculty of Medicine, University of Porto, Porto, Portugal; ⁱAllergy Unit, CUF Porto Institute and Hospital, Porto, Portugal; ^jCHUCB – Department of Allergy & Clinical Immunology, Cova da Beira University Hospital Centre, Covilhã, Portugal

ABSTRACT

Objective: Incorrect inhaler usage is frequent, particularly in elderly asthmatic patients. This study aimed at comparing inhaler technique errors and their determinants, as well inhaler technique self-perception versus real performance, between elderly and non-elderly asthmatics. **Methods:** Cross-sectional assessment of 92 elderly and 100 non-elderly asthmatics followed at specialty clinics. A standardized questionnaire was applied and inhaler technique demonstration was requested. Errors were assessed using checklists based on manufacturers' instructions and inhaler technique was graded as correct, acceptable or incorrect. Chi-Square Test and Fischer's Exact Test were used for comparative analysis of nominal variables. A *p* value equal to or less than 0.05 was considered statistically significant. **Results:** Inhaler technique was correct in a minority of elderly and young patients, without significant differences between study groups. Only 11.1% of the elderly who classified their inhaler as easy and 12.7% who stated their technique was correct had no errors. Previous regular inhaler training was associated with better actual performance in young but not in elderly patients. **Conclusion:** Our study showed that in spite of regular follow up at specialized outpatient clinics, inhaler devices are associated with a high frequency of errors in elderly and non-elderly asthmatics. In addition, most patients tend to overestimate their technique as correct. Finally, previous, frequent training was associated with a significantly higher percentage of patients showing correct or acceptable technique but only in non-elderly asthmatics, which suggests that elderly asthmatics may need specifically tailored inhaler education programs.

ARTICLE HISTORY

Received 27 August 2018
Revised 4 February 2019
Accepted 10 February 2019

KEYWORDS

Asthma knowledge;
determinants; inhalers;
inhaler technique;
self-perception

Introduction

Asthma treatment involves both reliever and controller medications, delivered via inhaled route [1]. Two types of inhalers are used, metered-dose inhalers (MDI) and dry powder inhalers (DPI). In order to achieve optimal lung delivery, and effective asthma therapy, it is necessary to use inhalers following a specific sequence of steps, which may, overall, constitute a relatively complex procedure and involve technical errors [2–4].

In fact, various studies have shown that patients frequently use inhalers incorrectly [5–10], and this may be even more apparent in the elderly [11,12]. Furthermore, the concurrent use of several inhalers can also increment error rates [13,14]. This leads to suboptimal treatment and lack of asthma control, with stepping up to higher doses or prescribing additional therapy in patients who could be managed with their current medication [2,15–17].

CONTACT Luís Taborda-Barata, MD, PhD  tabordabarata@fcsaude.ubi.pt  CICS – Health Sciences Research Centre, Faculty of Health Sciences, University of Beira Interior, Avenida Infante D. Henrique, 6200-506 Covilhã, Portugal.

 Supplemental data for this article can be accessed on the [publisher's website](#).

© 2019 Taylor & Francis Group, LLC

Inhaler technique education is essential to reduce mishandling [18]. However, as many as 25% of patients never received inhaler training and, in those that do, quality and duration is inadequate and not reinforced frequently [10,19]. Furthermore, physicians often underestimate mishandling [10], assuming correct usage, whereas most patients do not realize that therapy efficacy depends upon their technique [19]. In addition, since patients do not maintain correct usage over time [20], it is important to frequently assess their technique. Several inhaler training techniques have been studied [19,21] and, clearly, it is not sufficient to ask patients whether they know how to use their inhalers, but practical demonstration is necessary because they tend to over-estimate performance [21,22].

As elderly asthmatics are usually excluded from studies regarding inhaler technique, there are very few reports worldwide, specifically focusing on this special population. In addition, no consensus about determinants of correct inhaler technique, namely in the elderly, exists in the literature.

We hypothesized that elderly asthmatics have more frequent inhaler technique errors in spite of previous training and factors influencing technique that are different from those in younger adult asthmatics. Thus, this study aimed at: 1) Comparing inhaler technique error frequency and type between elderly and non-elderly asthmatic patients; and 2) Evaluating factors influencing inhaler technique.

Methods

Study design and sample selection

Cross-sectional, observational study, carried out at the Immunoallergy and Pulmonology outpatient clinics of Centro Hospitalar Cova da Beira (CHCB) in Covilhã, Portugal, from March 2015 to March 2016. The target population included individuals with a confirmed clinical diagnosis of asthma, who were regularly seen (every 3–6 months) at outpatient clinics. The sample was divided into two groups according to the age: elderly (≥ 65 years) and non-elderly (18–64 years). The main study outcome was percentage of major errors, and secondary outcomes were percentage of minor errors, specific inhaler technique steps and factors affecting inhaler technique. Based upon the main variable of interest, and in view of results from similar studies [2,10,12,13,22], we estimated that we would need at least 90 elderly and 90 non-elderly asthmatics to detect a difference in major errors in the inhalational technique with an error

margin of less than 5% and a 95% confidence interval. In order to avoid possible confounders, patients with cognitive impairment and patients with clinical and spirometric features of chronic obstructive pulmonary disease (COPD) [23] were excluded. Also, it was ensured that both study groups were well matched. The study protocol was approved by the CHCB Ethics Committee and conducted in accordance with the declaration of Helsinki. STROBE recommendations for reporting observational studies were followed (Supplementary Material 1).

Patient recruitment

Adult patients registered at the outpatient clinics of CHCB with a confirmed medical diagnosis of asthma were invited to participate in the study by a telephone call. Those patients we failed to contact upon three attempts on different days were excluded. Patients who agreed to participate were assessed at CHCB after signing a written informed consent upon explanation of the study.

Instruments and data collection

In order to assess inhaler technique, a standardized questionnaire was applied. First, participants answered nine multiple-choice questions. Questions on reliever and controller medication were asked, with possible answers being short action beta agonist (SABA), long action beta agonist (LABA), inhaled corticosteroid (ICS) or none. Self-perception of difficulty in using an inhaler was assessed using the question “Which do you think is your degree of difficulty in handling inhaled devices?”, with possible answers being easy, moderate or hard. Self-perception of correct use, inhaler technique training, inhaler usage verification and frequent verification were assessed with polar questions.

At a second phase, participants were asked to demonstrate their usual inhaler technique, using a placebo inhaler. The inhaler technique was evaluated using checklists based on the manufacturers’ instructions registered with the Portuguese drug agency database (Infarmed), for MDI, Turbohaler[®] (TH), Diskus[®] (DK), Aerolizer[®] (ARL), Novolizer[®] (NVL), Miat-Haler[®] (MHL), Breezhaler[®] (BZL), Spiromax[®] (SPM) and Twisthaler[®] (TWL) [24]. All errors were recorded in accordance with previously defined criteria for major or critical (significantly interfering with lung drug deposition) and minor (not significantly interfering with lung drug deposition) errors [2,3]. The technique was classified as correct if no errors were

detectable, acceptable if at least one minor error was detectable and incorrect if at least one major error was detectable. As it was possible for one patient to have more than one inhaler, performance for different inhalers in the same individual was independently assessed. At a third phase, correct inhaler technique was explained and demonstrated by the interviewer. There were five reviewers of the technique, with a medical background, and who had been specifically trained in the reviewing process. Inter-rater reliability was assessed using Cohen's Kappa value, and reliability was regarded as substantial if Cohen's kappa lied between 0.61 and 0.80, and as almost perfect if results lied between 0.81 and 1.00 (Landis and Kich classification) [25].

We calculated inter-rater reliability for all steps in the inhaler technique review process, after all raters had been thoroughly trained in order to detect and record errors in a standardized way. Cohen's kappa values varied between 0.76 and 0.95 for all steps of the inhaler procedures, indicating substantial or almost perfect agreement.

Frequency of inhaler training was determined by analyzing clinical records since inhaler education given to patients needs to be recorded on the online outpatient records platform. Patients were generally seen every 3 or 6 months at outpatient clinics and we considered "regular" training when patient inhaler technique had been checked at every appointment in the previous 24 months, whereas any less regular checkup was considered as "Not frequent". We recorded the number of different types of inhalers currently used by each patient.

A standardized questionnaire was used to collect sociodemographic and clinical data. In addition, other validated questionnaires were used to collect the information regarding additional factors that might influence inhalation technique. These included the Geriatric Depression Scale (GDS-15), which was used to assess depression symptoms in the elderly [26], and the Centre for Epidemiological Studies Depression Scale (CES-D) which was used to assess depression in the non-elderly [27]. It also included the Mini-Mental State Examination (MMSE) questionnaire, which was used to screen for cognitive compromise [28], and the Graffar scale which was used for socioeconomic characterization of recruited volunteers [29]. All questionnaires were validated for the Portuguese population [26–28].

Self-knowledge about asthma was assessed using a standardized 20-item questionnaire (Supplementary material 2 and 3). One point was attributed to each

question answered correctly. The total score was recorded by adding up all individual question points, with a possible score ranging from zero to twenty. Asthma self-knowledge was classified in accordance with qualitative grading used by the Portuguese education system: under 10 points: Insufficient; between 10 and 13 points: Sufficient; 14 or 15 points: Good; 16 or 17 points: Very Good; and higher than 17 points: Excellent.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 23.0 software. Descriptive analysis was used for sample characterization. Chi-Square Test and Fischer's Exact Test were used for comparative analysis of nominal variables, and Mann-Whitney *U* Test was used for quantitative variables in both the study groups. Cohen's kappa results and their 95% confidence intervals were calculated for determination of inter-rater reliability. Univariate logistic regression models were developed using independent variables as risk factors for incorrect inhaler technique. Factors that were studied included age, gender, Graffar scale, years of schooling, presence of depression, presence of cognitive deficits, number of different inhalers types used and knowledge about asthma. *p* Values (*p*) equal or less than 0.05 was regarded statistically significant for all statistical tests. Missing data were approached by restricting analysis to individuals with complete data.

Results

Sample selection and characterization

In this study, out of 112 elderly patients meeting criteria for entry, 4 refused to participate, and we were unable to contact 11. Five elderly asthmatics were excluded, one due to low MMSE score, two due to COPD comorbidity (ACO/"overlap syndrome") and two due to questionnaire loss, originating a total of 92 elderly asthmatics participating in the study. In terms of non-elderly asthmatics, out of 104, we were able to contact 100. Thus, 100 non-elderly and 92 elderly individuals with a confirmed clinical diagnosis of asthma followed in CHCB outpatient clinics were interviewed (Figure 1).

As 71 non-elderly asthmatics had one inhaler, 28 had two inhalers and 1 had three inhalers, total inhaler technique demonstrations in this group were 130. Likewise, 58 elderly asthmatics had one inhaler, 27 had two inhalers and 2 had three inhalers,

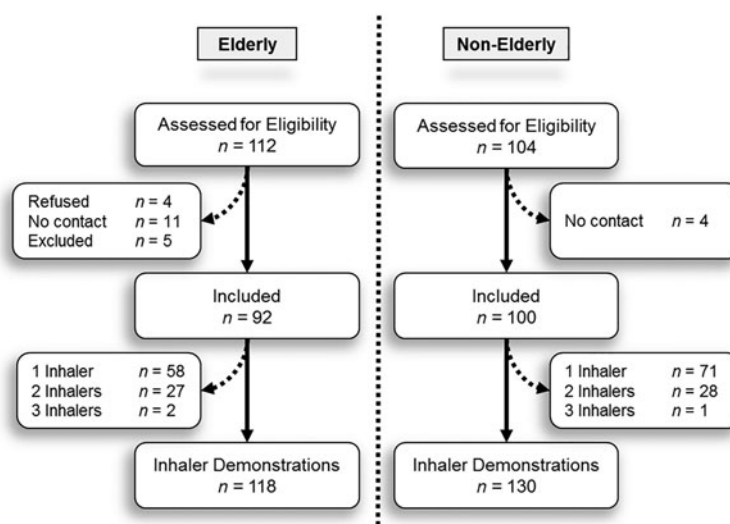


Figure 1. Patient selection flow diagram.

originating a total of 118 demonstrations in this group, although five elderly had no current inhaler and were not included in inhaler technique analysis.

Sociodemographic and clinical characterization of patients groups and usage of different inhaler types

Sociodemographic and clinical sample characteristics are shown in Table 1. Elderly and non-elderly patients did not differ in terms of gender, urban or rural residence, prevalence of depression or cognitive deficits. However, elderly patients had significantly lower level of schooling and social class, and a lower frequency of atopy.

Almost all patients were on an ICS. SABA was prescribed more frequently in the non-elderly whereas LABA was more prevalent in the elderly.

In non-elderly patients, the most frequent inhaler was MDI (46.0%), closely followed by TH (43.0%) with DK being the least prevalent (21.0%). In contrast, in elderly asthmatics, the most used inhaler was DK (44.6%), followed by TH (31.5%) and MDI (28.3%). From this point onwards, we focused our attention on these three main inhaler devices.

Inhaler technique

First, we wanted to see if inhaler technique was different between elderly and non-elderly asthmatics, in terms of the three most used inhalers – DPI, TH and DK (Table 2). Overall, no significant differences were found between the two study groups.

MDI was the inhaler associated with the worst performance in both study groups, showing a high proportion of major errors. In contrast, DK was the inhaler associated with the lowest proportion of major errors.

Next, we wanted to check whether there was a different distribution of errors according to each technique step between elderly and non-elderly asthmatics (Table 3). The most frequently missed step in both groups was a minor error, consisting of failure to tilt the head back when inhaling, with no significant difference between elderly and non-elderly asthmatics. Failure to place MDI mouthpiece correctly, which is a major error, and failure to exhale slowly after DK inhalation, were significantly more frequent step errors in the elderly compared with the non-elderly asthmatics.

Auto-perception of inhaler handling

Next, we aimed to study the relationship between perceived device handling difficulty and inhaler technique (Table 4). Similar perceived difficulty was found in both groups. It should be stressed that a high proportion (70%) of the elderly who showed major errors perceived their inhaler as easy. In addition, only a low proportion of both elderly and non-elderly patients who classified device manipulation as easy had a totally correct technique. Finally, almost a quarter of both elderly and non-elderly patients who considered their device easy demonstrated major errors, without significant differences between groups. Similar results were observed in terms of self-perceived performance and actual technique (Supplementary material 4 – Table 7).

Inhaler training

Next, we analyzed the relationship between initial training and observed inhaler technique (Table 5). Over 95% of patients had received previous inhaler training; yet, errors were still common in both groups.

Table 1. Sociodemographic and clinical characterization of elderly and non-elderly asthmatics, and usage of different inhaler types.

		Non-elderly (n = 100)	Elderly (n = 92)	p ^a
Age (years)	Mean ± SD	45.2 ± 13.2	72.9 ± 5.5	–
	(max, min)	(19, 64)	(65, 86)	
Gender	Male	19 (19%)	16 (17%)	0.773
	Female	81 (81%)	76 (83%)	
Schooling	No schooling	2 (2%)	5 (5%)	<0.001
	4 years	21 (21%)	67 (73%)	
	5–9 years	23 (23%)	10 (11%)	
	10–12 years	28 (28%)	6 (7%)	
	>12 years	26 (26%)	4 (4%)	
Graffar	Class I	11 (11%)	0 (0%)	<0.001
	Class II	25 (25%)	5 (5%)	
	Class III	50 (50%)	24 (26%)	
	Class IV	14 (14%)	63 (69%)	
	Class V	0 (0.0%)	0 (0%)	
Atopy	Atopic	88 (88.0%)	58 (63.0%)	<0.001 ^a
	Non-atopic	12 (12.0%)	34 (37.0%)	
Asthma Onset	Childhood (<18 years old)	37 (37%)	20 (22%)	0.021 ^a
	Adult (>18 years old)	63 (63%)	72 (78%)	
Therapy	SABA	75 (75%)	41 (45%)	<0.001 ^a
	LABA	41 (41%)	60 (65%)	0.001 ^a
	ICS	91 (91%)	86 (94%)	0.523 ^a
	Oral Corticosteroid	6 (6%)	5 (5%)	0.866 ^a
Number of current different Inhaler types	None	0 (0%)	5 (5%)	0.072 ^c
	1	71 (71%)	58 (63%)	
	2	28 (28%)	27 (29%)	
	3	1 (1%)	2 (2%)	
Inhaler type	MDI	46 (46%)	26 (28%)	0.011 ^a
	TH	43 (43%)	29 (32%)	0.101 ^a
	DK	21 (21%)	41 (45%)	<0.001 ^a
	ARL	7 (7%)	13 (14%)	0.106 ^a
	NVL	2 (2%)	0 (0%)	0.498 ^c
	MHL	10 (10%)	4 (4%)	0.132 ^a
	BZL	0 (0%)	3 (3%)	0.108 ^c
	SPM	0 (0%)	2 (2%)	0.228 ^c
	TWL	1 (1%)	0 (0%)	1.00 ^c

^aChi-square test.^bMann–Whitney *U* test.^cFisher's exact test.**Table 2.** Comparison of inhaler performance with the three most used inhalers (DPI, TH, DK) between elderly and non-elderly patients.

		Non-elderly (n = 130)	Elderly (n = 118)	p
Total for 3 most used inhalers (MDI, TH, DK)	Correct technique	18 (16.4%)	10 (10.4%)	0.454 ^a
	Acceptable technique	63 (57.3%)	60 (62.5%)	
	Incorrect technique	29 (26.4%)	26 (27.8%)	
MDI	Correct technique	9 (19.6%)	2 (7.7%)	0.477 ^b
	Acceptable technique	20 (43.5%)	13 (50.0%)	
	Incorrect technique	17 (37.0%)	11 (42.3%)	
TH	Correct technique	5 (11.6%)	3 (10.3%)	0.935 ^b
	Acceptable technique	29 (67.4%)	19 (65.5%)	
	Incorrect technique	9 (20.9%)	7 (24.1%)	
DK	Correct technique	4 (19.0%)	5 (12.2%)	0.782 ^b
	Acceptable technique	14 (66.7%)	28 (68.3%)	
	Incorrect technique	3 (14.3%)	8 (19.5%)	

^aChi-square test.^bFisher's exact test.

We next analyzed whether there was a relationship between frequency of inhaler training and observed technique (Table 5). Only about half of the elderly and non-elderly patients received regular training. Importantly, previous regular training was associated with a significantly higher percentage of patients showing correct or acceptable technique but only in non-elderly asthmatics.

Technique determinants

We subsequently studied which factors might affect inhaler technique (Table 6). No significant association was found between technique and gender, schooling, social class or number of different types of inhalers in any study group. However, higher knowledge about asthma was significantly associated with a better technique in non-elderly but not in elderly asthmatics.

Table 3. Detailed step errors for MDI, TH and DK observed in elderly and non-elderly asthmatics.

		Non-elderly		Elderly		<i>p</i>
		Correct	Incorrect	Correct	Incorrect	
MDI	Shakes the inhaler ^a	35 (79.5%)	9 (20.5%)	18 (72.0%)	7 (28.0%)	0.475 ^c
	Removes the lid ^a	44 (100.0%)	0 (0.0%)	25 (100.0%)	0 (0.0%)	–
	Exhales ^b	31 (70.5%)	13 (29.5%)	15 (60.0%)	10 (40.0%)	0.376 ^c
	Tilts the head back ^b	15 (34.1%)	29 (65.9%)	7 (28.0%)	18 (72.0%)	0.602 ^c
	Places the mouthpiece correctly ^a	44 (100.0%)	0 (0.0%)	22 (88.0%)	3 (12.0%)	0.012 ^d
	Simultaneously presses the inhaler and breathes in ^a	37 (84.1%)	7 (15.9%)	22 (88.0%)	3 (12.0%)	0.654 ^d
	Inhales slowly and deeply ^a	36 (81.8%)	8 (18.2%)	21 (84.0%)	4 (16.0%)	0.817 ^c
	Removes the inhaler	44 (100.0%)	0 (0.0%)	25 (100.0%)	0 (0.0%)	–
	Maintains chest full of air for ten seconds ^b	22 (50.0%)	22 (50.0%)	14 (56.0%)	11 (44.0%)	0.632 ^c
TH	Exhales slowly with semi-closed lips ^b	28 (63.6%)	16 (36.4%)	15 (60.0%)	10 (40.0%)	0.764 ^c
	Removes the lid ^a	40 (95.2%)	2 (4.8%)	28 (100.0%)	0 (0.0%)	0.140 ^d
	Rotates base clockwise ^a	40 (95.2%)	2 (4.8%)	24 (85.7%)	4 (14.3%)	0.168 ^d
	Rotates base counterclockwise until a click is heard ^a	35 (83.3%)	7 (16.7%)	23 (82.1%)	5 (17.9%)	0.897 ^d
	Breathes out the air ^b	26 (61.9%)	16 (38.1%)	17 (60.7%)	11 (39.3%)	0.920 ^c
	Tilts the head back ^b	13 (31.0%)	29 (69.0%)	7 (25.0%)	21 (75.0%)	0.589 ^c
	Places the mouthpiece ^a	41 (97.6%)	1 (2.4%)	26 (92.9%)	2 (7.1%)	0.341 ^d
	Inhales quickly and strongly ^a	37 (88.1%)	5 (11.9%)	25 (89.3%)	3 (10.7%)	0.878 ^d
	Removes the inhaler	41 (97.6%)	1 (2.4%)	26 (92.9%)	2 (7.1%)	0.341 ^d
DK	Maintains chest full of air for ten seconds ^b	26 (61.9%)	16 (38.1%)	18 (64.3%)	10 (35.7%)	0.840 ^c
	Exhales slowly with semi-closed lips ^b	20 (47.6%)	22 (52.4%)	17 (60.7%)	11 (39.3%)	0.282 ^c
	Pushes thumb grip back ^a	21 (100.0%)	0 (0.0%)	41 (100.0%)	0 (0.0%)	–
	Pushes lever back ^a	20 (95.2%)	1 (4.8%)	38 (92.7%)	3 (7.3%)	0.691 ^d
	Breathes out the air ^b	14 (66.7%)	7 (33.3%)	20 (48.8%)	21 (51.2%)	0.180 ^c
	Tilts the head back ^b	5 (23.8%)	16 (76.2%)	8 (19.5%)	33 (80.5%)	0.696 ^d
	Places the mouthpiece ^a	20 (95.2%)	1 (4.8%)	41 (100.0%)	0 (0.0%)	0.138 ^d
	Inhales quickly and strongly ^a	20 (95.2%)	1 (4.8%)	36 (87.8%)	5 (12.2%)	0.323 ^d
	Removes the inhaler	21 (100.0%)	0 (0.0%)	40 (97.6%)	1 (2.4%)	0.671 ^d
	Maintains chest full of air for ten seconds ^b	15 (71.4%)	6 (28.6%)	24 (52.5%)	17 (41.5%)	0.320 ^c
	Exhales slowly with semi-closed lips ^b	15 (71.4%)	6 (28.6%)	16 (39.0%)	26 (61.0%)	0.016 ^c
	Pushes thumb grip forward	21 (100.0%)	0 (0.0%)	37 (90.2%)	4 (9.8%)	0.063 ^d

^aMajor error.^bMinor error.^cChi-square test.^dFisher's exact test.**Table 4.** Relationship between perceived difficulty and technique in elderly and non-elderly asthmatics.

		Perceived difficulty				<i>p</i> ^a
		Easy	Moderate	Hard	Does not Know	
Non-elderly (<i>n</i> =130)	Correct technique	20 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.031
	Acceptable technique	63 (87.5%)	8 (11.1%)	1 (1.4%)	0 (0.0%)	
	Incorrect technique	27 (71.1%)	6 (15.8%)	4 (10.5%)	1 (2.6%)	
	Total	110 (84.6%)	14 (10.8%)	5 (3.8%)	1 (0.8%)	
Elderly (<i>n</i> =118)	Correct technique	13 (81.3%)	1 (6.3%)	2 (12.5%)	0 (0.0%)	0.047
	Acceptable technique	66 (91.7%)	4 (5.6%)	2 (2.8%)	0 (0.0%)	
	Incorrect technique	21 (70.0%)	4 (13.3%)	4 (50.0%)	1 (3.3%)	
	Total	100 (84.7%)	9 (7.6%)	8 (6.8%)	1 (0.8%)	

^aFisher's exact test.**Table 5.** Relationship between inhaler training and technique in elderly and non-elderly asthmatics.

		Regular Training		<i>p</i> ^b
		Yes	No	
Non-elderly (<i>n</i> =130)	Correct technique	16 (80.0%)	4 (20.0%)	0.012
	Acceptable technique	41 (56.9%)	31 (43.1%)	
	Incorrect technique	15 (39.5%)	23 (60.5%)	
	Total	72 (55.4%)	58 (44.6%)	
Elderly (<i>n</i> =118)	Correct technique	11 (68.8%)	5 (31.3%)	0.114
	Acceptable technique	36 (50.0%)	36 (50.0%)	
	Incorrect technique	11 (36.7%)	19 (63.3%)	
	Total	58 (49.2%)	60 (50.8%)	

^aFisher's exact test.^bChi-square test.

Discussion

In this cross-sectional, observational study, a thorough assessment of inhaler technique, applicable in clinical practice, was compared between elderly and non-elderly asthmatics. It is one of few studies, worldwide, that have specifically focused upon inhaler technique in elderly patients. No significant differences were found between the two study groups, in terms of overall inhaler technique. However, one major error (mouthpiece misplacement) with MDIs and one minor error (failure to exhale slowly) with DK inhaler

Table 6. Factors influencing inhaler technique in elderly and non-elderly asthmatics.

	Non-elderly (n = 130)			p^a	Elderly (n = 118)			p^a
	Correct technique	Acceptable technique	Incorrect technique		Correct technique	Acceptable technique	Incorrect technique	
Gender								
Male	3 (12.0%)	15 (60.0%)	7 (28.0%)	0.866	9 (9.2%)	63 (64.3%)	26 (26.5%)	0.057
Female	17 (16.2%)	57 (54.3%)	31 (29.5%)		6 (30.0%)	10 (50.0%)	4 (20.0%)	
Schooling								
None	0 (0.0%)	2 (50.0%)	2 (50.0%)	0.065	1 (20.0%)	3 (60.0%)	1 (20.0%)	0.960
4 years	1 (3.4%)	22 (75.9%)	6 (20.7%)		12 (14.1%)	51 (60.0%)	22 (25.9%)	
4–9 years	9 (30.0%)	15 (50.0%)	6 (20.0%)		2 (14.3%)	9 (64.3%)	3 (21.4%)	
9–12 years	4 (11.8%)	19 (55.9%)	11 (32.4%)		0 (0.0%)	7 (77.8%)	2 (22.2%)	
>12 years	6 (18.2%)	14 (42.4%)	13 (39.4%)		0 (0.0%)	3 (60.0%)	2 (40.0%)	
Knowledge								
Insufficient	0 (0.0%)	0 (0.0%)	1 (100.0%)	0.050	0 (0.0%)	1 (100.0%)	0 (0.0%)	0.849
Sufficient	0 (0.0%)	4 (50.0%)	4 (50.0%)		1 (7.7%)	9 (69.2%)	3 (23.1%)	
Good	3 (12.0%)	17 (68.0%)	5 (20.0%)		2 (11.1%)	10 (55.6%)	6 (33.3%)	
Very Good	2 (5.1%)	23 (59.0%)	14 (35.9%)		6 (20.0%)	19 (63.3%)	5 (16.7%)	
Excellent	15 (26.3%)	28 (49.1%)	14 (24.6%)		6 (10.7%)	34 (60.7%)	16 (28.3%)	
Graffar								
Class I	4 (30.8%)	4 (30.8%)	5 (38.5%)	0.256	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.343
Class II	3 (9.1%)	19 (57.6%)	11 (33.3%)		0 (0.0%)	4 (66.7%)	2 (33.3%)	
Class III	12 (18.8%)	35 (54.7%)	17 (26.6%)		1 (3.7%)	17 (63.0%)	9 (33.3%)	
Class IV	1 (5.0%)	14 (70.0%)	5 (25.0%)		14 (16.5%)	52 (61.2%)	19 (22.4%)	
Class V	0 (0.0%)	0 (0.0%)	0 (0.0%)		0 (0.0%)	0 (0.0%)	0 (0.0%)	
Types of Inhalers								
1	13 (18.3%)	35 (49.3%)	23 (32.4%)	0.573	7 (12.5%)	34 (58.6%)	17 (29.3%)	0.504
2	7 (12.5%)	35 (62.5%)	14 (25.0%)		8 (14.8%)	33 (61.1%)	13 (24.1%)	
3	0 (0.0%)	2 (66.7%)	1 (33.3%)		0 (0.0%)	6 (100.0%)	0 (0.0%)	

^aFisher's exact test.

were significantly more frequent in elderly asthmatics. Our results are novel and also showed that in elderly patients, previous regular training was not associated with a higher percentage of patients showing correct or acceptable technique; in addition, higher knowledge about asthma was associated with better performance in younger but not in elderly asthmatics.

A high error rate in inhaler technique was found in both groups of patients. This is consistent with findings in Portugal [30], throughout Europe [31], and outside of Europe [15,22,32,33]. Several studies have proposed that mishandling is associated with poor clinical outcomes [9,16,17,21,34]. Thus, finding a low percentage of correct technique is a matter for concern. However, in our study, elderly patients did not show significantly lower correct technique when compared with non-elderly asthmatics, which is in disagreement with some studies that found a significant association between age and worse inhaler performance [13,30,34,35]. This may be because none of those studies included patients older than 75 years old and no direct comparison was made between elderly and non-elderly asthmatics. Also, some of these studies [30,34] included patients with COPD and no comparison between age groups was made separately. These studies were carried out in Italy [34], Brazil [13], Korea [35] and seaside Portugal [30] which represent different geographical and cultural environments from our study, which may interfere with technique. Some of these studies [13,30,34,35]

included more patients and a few [34,35] had a different sample selection method. Finally, in our study, both elderly and non-elderly asthmatics had similar regular follow up at a specialty clinic, with technique reinforcement, which may be responsible, at least in part, for similar technique between groups. Lack of difference between study groups was not attributed to differences in asthma treatment as ICS had similar usage and frequency in both groups.

Observational studies evaluating patients' abilities in inhaler handling are inconsistent, with some reporting errors more commonly with MDI than DPI [5,18,22,30,34,36,37] and others reporting a similar proportion of inhaler misuse with both devices [38,39]. In our study, although no significant differences were found between study groups, a higher proportion of errors were found with MDI compared to DPI, making this device less user friendly. DK was the inhaler with the lowest error percentage in both groups, making it the most user friendly device.

We identified many errors of inhaler technique, although the relevance of minor errors is of unclear clinical relevance. These findings are consistent with results from previous studies [10,15,32,34]. In fact, whereas major/critical errors have been shown to reduce inhaled drug delivery [40] and are clearly associated with poorer clinical outcomes [16,17], such evidence is less apparent for minor, non-critical errors. Nevertheless, it is possible that patients who make various minor errors may also have a similar

deposition problem but this still needs to be ascertained. In our study, the most common major error using MDI was failure to shake the inhaler before usage. This may be due to misperception of the importance of this critical step in order to permit drug gas to be mobilized to the lungs [41]. Another major error, failure to place the mouthpiece correctly with the container facing up and tightening lips around the mouthpiece, was significantly more frequent in the elderly compared with the non-elderly. This may be due to many factors namely lower cognitive function level, which determines the ability to learn and retain a correct technique as well as lower motor coordination, which is essential for correct handling [31]. In our study, no significant cognitive deficits were detected (we only had to exclude one patient, due to cognitive deficits) in the elderly patients. Nevertheless, it is still possible that minor cognitive impairment may not have been detected by MMSE, whose sensitivity is variable [28]. Alternatively, attention span or focus in the elderly may be different, which may become more apparent when multistep techniques are being taught. Thus, different techniques for training the elderly may be needed [21,42]. The most common major error in manipulating DK was failure to make a strong and rapid inhalation, a respiration dependent error. This may be due to easier device handling compared to other inhalers, with fewer wrong steps in physical device performance, consistent with Melzer et al [43], who found that the majority of errors handling inhalers are related to breathing. Above all, major errors should be specifically addressed in clinical practice [44,45] and, in our study, we have shown that elderly patients need to be more thoroughly or specifically instructed on how to avoid major errors.

Only a minority of the elderly and non-elderly patients who classified their inhaler as easy had a totally correct technique, and around one fifth of all patients demonstrated, in fact, major errors. Furthermore, a high percentage of all patients tended to overestimate their technique as correct when compared to observed performance. Thus, in clinical practice, it is not sufficient to ask patients whether they know how to use their inhalers, and practical demonstration and technique correction are necessary because they tend to overestimate performance [12,22].

We showed that previous regular assessment of the inhaler technique was significantly associated with a better inhaler technique, but only in non-elderly and not in elderly asthmatics. This might be due to lower cognitive function, naturally occurring with age,

becoming harder to retain technical information. Thus, more frequent assessment and demonstration are necessary in the elderly compared with the non-elderly. These results are consistent with previous studies [9,34] and suggest that frequent inhaler technique evaluation is necessary to reduce mishandling.

In the literature, there is no consensus about determinants of correct inhaler technique [34]. Although lower education has been significantly associated with worse inhaler technique in some studies [13,34,35,43], no significant association with schooling was found in our study. However, higher knowledge about asthma was significantly associated with a better technique in non-elderly but not in elderly asthmatics. This is consistent with Fayas et al. [46] who concluded that it was knowledge about asthma and not academic education level that was associated with better technique. Finally, although some studies suggest that having more than one inhaler type was significantly associated with worse inhaler performance [14,22,47], such significant association was not found in this study. However, the Aerosol Drug Management Improvement Team considers that, although there is evidence that using a single inhaler reduces error, there is a paucity of evidence showing a corresponding favorable clinical outcome [41]. Thus, further studies are necessary to elucidate these relationships.

This study has some limitations that may hinder generalization. Not all devices available in the market were evaluated because some were used infrequently. Findings in inhaler technique may be biased due to criteria chosen to define mishandling because no universal standardization has been made so far and error definition varies between studies. Interviewer bias cannot be excluded because results concerning inhaler technique were based on investigators' judgment and, although coordination was attempted to reduce variability, subjective bias may persist. Evaluating strength and speed inspiration through observation is subjective, but represents a real clinical context where inspiratory flow measurement equipment is not available and decisions are based on observation alone. Furthermore, selection bias cannot be excluded because all patients were followed at a single health-care institution. Finally, the sample included patients with different levels of severity and frequency of symptoms of asthma, namely some, albeit a minor proportion, who only had mild intermittent asthma and who only used the inhalers infrequently, as rescue medication. This heterogeneity may have influenced some of the results.

Conclusions

Although incorrect inhaler technique is similarly common in elderly and non-elderly asthmatics, some step errors with some inhalers may be more frequent in the former. Regular previous inhaler training and disease literacy are significant determinants of correct technique but only in non-elderly and not in elderly patients. Thus, different techniques for inhaler training in the elderly may be needed.

Declaration of Interest & Acknowledgements

Eduardo Ferreira, Adriana Pascoal, Patrícia Silva, Olga Lourenço, Salette Valente, M^a Jesus Valente, Marli Loureiro, and Jorge M.R. Gama declare that they have no conflicts of interest in relation to this article. João A. Fonseca has received lecture fees from several pharmaceutical companies that market inhaled products. These include AstraZeneca, GlaxoSmithKline, and Novartis. He has also participated in advisory boards of Novartis. Luis Taborda-Barata has received honoraria for scientific presentations, from several pharmaceutical companies that market inhaled products. These include AstraZeneca, Boehringer Ingelheim, GlaxoSmithKline, Mundipharma, Novartis, Laboratorios Vitoria. None of the authors have any shares in any pharmaceutical company.

Data availability

Data, in anonymized format may be available directly from the corresponding author.

Funding

This work was supported by FEDER funds through the POCI - COMPETE 2020 - Operational Programme Competitiveness and Internationalization in Axis I - Strengthening research, technological development and innovation (Project No. 007491) and National Funds by FCT - Foundation for Science and Technology (Project UID/Multi /00709).

ORCID

Olga Lourenço  <http://orcid.org/0000-0002-8401-5976>
 Jorge M. R. Gama  <http://orcid.org/0000-0003-3926-580X>
 João A. Fonseca  <http://orcid.org/0000-0002-0887-8796>
 Luís Taborda-Barata  <http://orcid.org/0000-0001-6649-8890>

References

- Newhouse MT, Dolovich MB. Control of asthma by aerosols. *N Engl J Med* 1986;315:870–874. doi:10.1056/NEJM198610023151406.
- Price D, Bosnic-Anticevich S, Briggs A, Chrystyn H, Rand C, Scheuch G, Bousquet J, et al. Inhaler competence in asthma: common errors, barriers to use and recommended solutions. *Respir Med* 2013;107:37–46. doi:10.1016/j.rmed.2012.09.017.
- Möller M, Fritsche D, Rivera D, Libertus H. Improvement of asthma therapy by a novel budesonide multidose dry powder inhaler. *Arz-Forsch* 2003; 53:562–567. doi:10.1055/s-0031-1297150.
- Fink JB, Rubin BK. Problems with inhaler use: a call for improved clinician and patient education. *Respir Care* 2005;50:1360–1374.
- Molimard M, Raheison C, Lignot S, Depont F, Abouelfath A, Moore N. Assessment of handling of inhaler devices in real life: an observational study in 3811 patients in primary care. *J Aerosol Med* 2003;16: 249–254. doi:10.1089/089426803769017613.
- Hilton S. An audit of inhaler technique among asthma patients of 34 general practitioners. *Br J Gen Pract* 1990;40:505–506.
- van der Palen J, Klein JJ, Kerkhoff AH, van Herwaarden CL. Evaluation of the effectiveness of four different inhalers in patients with chronic obstructive pulmonary disease. *Thorax* 1995;50: 1183–1187.
- Kesten S, Elias M, Cartier A, Chapman KR. Patient handling of a multidose dry powder inhalation device for albuterol. *Chest* 1994;105:1077–1081.
- Giraud V, Roche N. Misuse of corticosteroid metered-dose inhaler is associated with decreased asthma stability. *Eur Respir J* 2002;19:246–251.
- Lavorini F, Magnan A, Christophe Dubus J, Voshaar T, Corbetta L, Broeders M, Dekhuijzen R, et al. Effect of incorrect use of dry powder inhalers on management of patients with asthma and COPD. *Respir Med* 2008;102:593–604. doi:10.1016/j.rmed.2007.11.003.
- Hanania NA, King MJ, Braman SS, Saltoun C, Wise RA, Enright P, Falsey AR, et al. Asthma in the elderly: current understanding and future research needs – a report of a national institute on aging (NIA) workshop. *J Allergy Clin Immunol* 2011;128:S4–S24. doi:10.1016/j.jaci.2011.06.048.
- Ho SF, O'Mahony MS, Steward JA, Breay P, Burr ML. Inhaler technique in older people in the community. *Age Ageing* 2004;33:185–188. doi:10.1093/ageing/afh062.
- Coelho ACC, Souza-Machado A, Leite M, Almeida P, Castro L, Cruz CS, Stelmach R, et al. Use of inhaler devices and asthma control in severe asthma patients at a referral center in the city of Salvador, Brazil. *J Brasil Pneumol* 2011;37:720–728. doi:10.1590/S1806-37132011000600004.
- van der Palen J, Klein JJ, van Herwaarden CL, Zielhuis GA, Seydel ER. Multiple inhalers confuse asthma patients. *Eur Respir J* 1999;14:1034–1037.
- Basheti IA, Qunaibi E, Bosnic-Anticevich SZ, Armour CL, Khater S, Omar M, et al. User error with diskus and turbuhaler by asthma patients and pharmacists in Jordan and Australia. *Respir Care* 2011;56:1916–1923. doi:10.4187/respcare.01205.
- Westerik JAM, Carter V, Chrystyn H, Burden A, Thompson SL, Ryan D, Gruffydd-Jones K, et al.

- Characteristics of patients making serious inhaler errors with a dry powder inhaler and association with asthma-related events in a primary care setting. *J Asthma* 2016;53:321–329. doi:10.3109/02770903.2015.1099160.
17. Usmani OS, Lavorini F, Marshall J. Critical inhaler errors in asthma and COPD: a systematic review of impact on health outcomes. *Respir Res* 2018;19:10. doi:10.1186/s12931-017-0710-y.
 18. Dalcin PT, Grutcki DM, Laporte PP, Lima PB, Menegotto SM, Pereira RP. Factors related to the incorrect use of inhalers by asthma patients. *J Brasil Pneumol* 2014;40:13–20. doi:10.1590/S1806-37132014000100003.
 19. Basheti IA, Reddel HK, Armour CL, Bosnic-Anticevich SZ. Counseling about turbuhaler technique: needs assessment and effective strategies for community pharmacists. *Respir Care* 2005;50:617–623.
 20. Bosnic-Anticevich SZ, Sinha H, So S, Reddel HK. Metered-dose inhaler technique: the effect of two educational interventions delivered in community pharmacy over time. *J Asthma* 2010;47:251–256. doi:10.3109/02770900903580843.
 21. Maricoto T, Monteiro L, Gama JMR, 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. doi:10.1111/jgs.15602.
 22. Souza ML, Meneghini AC, Ferraz E, Vianna EO, Borges MC. Knowledge of and technique for using inhalation devices among asthma patients and COPD patients. *J Brasil Pneumol* 2009;35:824–831.
 23. Global Strategy for the Diagnosis, Management and Prevention of COPD. GOLD COPD Committee; 2014. Available from: <http://www.goldcopd.org/> [last accessed January 2015].
 24. Infarmed – Autoridade Nacional do Medicamento e Produtos de Saúde, I.P., Infomed – drugs for human use database. Available from: <http://www.infarmed.pt/informed/inicio.php> [accessed December 2015].
 25. Wongpakaran N, Wongpakaran T, Wedding D, Gwet KL. A comparison of Cohen's Kappa and Gwet's AC1 when calculating inter-rater reliability coefficients: a study conducted with personality disorder samples. *BMC Med Res Methodol* 2013;13:61. doi:10.1186/1471-2288-13-61.
 26. Pocinho M, Farate C, Dias C, Lee T, Yesavage J. Clinical and psychometric validation of the Geriatric Depression Scale (GDS) for Portuguese elders. *Clin Gerontol* 2009;32:223–236. doi:10.1080/07317110802678680.
 27. Gonçalves B, Fagulha T. The Portuguese version of the Center for Epidemiologic Studies Depression Scale (CES-D). *Eur J Psychol Assess* 2004;20:339–348. doi:10.1027/1015-5759.20.4.339.
 28. Guerreiro M, Silva A, Botelho M. Translation and adaptation of the MMSE to the Portuguese population. *Rev Port Neurol* 1994;1:9–10.
 29. Graffar M, Corbier J. Contribution to the study of the influence of socioeconomic conditions in growth and development of children. *Rev Chil Pediatr* 1966;37:801–802.
 30. Chorão P, Pereira AM, Fonseca JA. Inhaler devices in asthma and COPD – an assessment of inhaler technique and patient preferences. *Respir Med* 2014;108:968–975. doi:10.1016/j.rmed.2014.04.019.
 31. Crompton GK, Barnes PJ, Broeders M, Corrigan C, Corbetta L, Dekhuijzen R, Dubus JC, et al. The need to improve inhalation technique in Europe: a report from the aerosol drug management improvement team. *Respir Med* 2006;100:1479–1494. doi:10.1016/j.rmed.2006.01.008.
 32. Yildiz F. Importance of inhaler device use status in the control of asthma in adults: the asthma inhaler treatment study. *Respir Care* 2014;59:223–230. doi:10.4187/respcare.02478.
 33. Song WS, Mullon J, Regan NA, Roth BJ. Instruction of hospitalized patients by respiratory therapists on metered-dose inhaler use leads to decrease in patient errors. *Respir Care* 2005;50:1040–1045.
 34. Melani AS, Bonavia M, Cilenti V, Cinti C, Lodi M, Martucci P, Serra M, et al. Inhaler mishandling remains common in real life and is associated with reduced disease control. *Respir Med* 2011;105:930–938. doi:10.1016/j.rmed.2011.01.005.
 35. Lee SM, Chang Y-S, Kim C-W, Kim T-B, Kim S-H, Kwon Y-E, Lee J-M, et al. Skills in handling turbuhaler, diskus, and pressurized metered-dose inhaler in Korean asthmatic patients. *Allergy Asthma Immunol Res* 2011;3:46–52. doi:10.4168/aaair.2011.3.1.46.
 36. Lenney J, Innes JA, Crompton GK. Inappropriate inhaler use: assessment of use and patient preference of seven inhalation devices. *Respir Med* 2000;94:496–500.
 37. Price D, Haughney J, Sims E, Ali M, von Ziegenweidt J, Hillyer EV, et al. Effectiveness of inhaler types for real-world asthma management: retrospective observational study using the GPRD. *J Asthma Allergy* 2011;4:37–47. doi:10.2147/JAA.S17709.
 38. Melani AS, Zanchetta D, Barbato N, Sestini P, Cinti C, Canessa PA, Aiolfi S, et al. Inhalation technique and variables associated with misuse of conventional metered-dose inhalers and newer dry powder inhalers in experienced adults. *Ann Allergy Asthma Immunol* 2004;93:439–446.
 39. Sestini P, Cappiello V, Aliani M, Martucci P, Sena A, Vaghi A, Canessa PA, et al. Prescription bias and factors associated with improper use of inhalers. *J Aerosol Med* 2006;19:127–136. doi:10.1089/jam.2006.19.127.
 40. Sulaiman I, Seheult J, Sadasivuni N, MacHale E, Killane I, Giannoutsos S, et al. The impact of common inhaler errors on drug delivery: investigating critical errors with a dry powder inhaler. *J Aerosol Med Pulm Drug Deliv* 2017;30:1–9. doi:10.1089/jamp.2016.1334.
 41. Levy ML, Dekhuijzen PN, Barnes PJ, Broeders M, Corrigan CJ, Chawes BL, et al. Inhaler technique: facts and fantasies. A view from the Aerosol Drug Management Improvement Team (ADMIT). *NPJ Primary Care Respir Medicine* 2016;26:16017. doi:10.1038/npjpcrm.2016.17.

42. Bouwmeester C, Kraft J, Bungay KM. Optimizing inhaler use by pharmacist-provided education to community-dwelling elderly. *Respir Med* 2015; 109: 1363–1368. doi:[10.1016/j.rmed.2015.07.013](https://doi.org/10.1016/j.rmed.2015.07.013).
43. Melzer AC, Ghassemieh BJ, Gillespie SE, Lindenauer PK, McBurnie MA, Mularski RA, et al. Patient characteristics associated with poor inhaler technique among a cohort of patients with COPD. *Respir Med* 2016;123:123–130. doi:[10.1016/j.rmed.2016.12.011](https://doi.org/10.1016/j.rmed.2016.12.011).
44. Brocklebank D, Ram F, Wright J, Barry P, Cates C, Davies L, et al. 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.
45. Dolovich MB, Ahrens RC, Hess DR, Anderson P, Dhand R, Rau JL, Smaldone GC, et al. 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. doi:[10.1378/chest.127.1.335](https://doi.org/10.1378/chest.127.1.335).
46. Fayas S, Estivals M, Gontier B, Têtu L, Rafalimanana G, Didier A. Facteurs déterminants la qualité de la prise des traitements inhalés dans l'asthme. *Rev Française Allergol* 2003;43:364–368. doi:[10.1016/S0335-7457\(03\)00207-7](https://doi.org/10.1016/S0335-7457(03)00207-7).
47. Rootmensen GN, van Keimpema AR, Jansen HM, de Haan RJ. Predictors of incorrect inhalation technique in patients with asthma or COPD: a study using a validated videotaped scoring method. *J Aerosol Med Pulm Drug Deliv* 2010;23:323–328. doi:[10.1089/jamp.2009.0785](https://doi.org/10.1089/jamp.2009.0785).