

# Original Article

## Evaluation of the knowledge of health professionals at a pediatric hospital regarding the use of metered-dose inhalers\*

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### Abstract

**Objective:** To evaluate health professionals working at a tertiary pediatric hospital in terms of their knowledge regarding the practical use of metered-dose inhalers. **Methods:** Practical and written tests on the use of metered-dose inhalers were applied to physicians, physical therapists, nurses and nursing assistants. A score from 0 to 10 was assigned to each evaluation, and median scores were calculated for each professional category. Questions with higher and lower correct values were identified, and a descriptive comparison was made regarding the performance of the various professional categories. Statistical analysis was performed using the Kruskal-Wallis method for comparison of medians. A sequential logistic multiple regression analysis was also performed. **Results:** A total of 30 resident physicians or interns in the pediatrics department, 23 attending physicians, 29 physical therapists, 33 nurses and 31 nursing assistants were evaluated. Resident physicians, physical therapists and attending physicians performed significantly better than did nurses and nursing assistants. Only resident physicians had a median score greater than 6. **Conclusions:** The health professionals evaluated, particularly the nurses and nursing assistants, who are directly involved in the practical use of metered-dose inhalers, possess insufficient knowledge regarding the use of such inhalers.

**Keywords:** Metered dose inhalers; Inhalation spacers; Asthma; Education, public health professional.

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## Introduction

Asthma is a significant public health problem worldwide, ranging in prevalence from 1 to 18%.<sup>(1)</sup> The ISAAC project showed that, in Brazil, the mean prevalence of active asthma (defined as episodes of wheezing within the last 12 months) was 24.3% and 19%, in first graders (aged 6-7 years) and adolescents (13 to 14 years), respectively, in the 2002-2003 period.<sup>(2)</sup> In Brazil, asthma is the third leading cause of hospitalization among children and young adults, greatly increases costs to the health care system, results in school absenteeism/inability to perform physical activities and can interfere with the psychosocial development of the child.<sup>(3)</sup>

Currently, there is a near-unanimous consensus that the use of anti-inflammatory drugs is indicated for the treatment of persistent asthma, since the role of inflammation in the pathophysiology of the disease is well recognized.<sup>(1,3,4)</sup>

The use of inhaled drugs is a basic aspect of the treatment of patients with asthma, in acute episodes as well as in maintenance therapy. For years, conventional nebulizers were the only inhalers available. With the advent of pressurized metered-dose inhalers, the delivery of drugs such as bronchodilators and corticosteroids into the respiratory tract was optimized, thereby decreasing local and systemic side effects.<sup>(5,6)</sup>

Various studies have demonstrated that the metered-dose inhaler is safe and efficacious, producing particles of 1 to 50  $\mu\text{m}$  in diameter (1- to 5- $\mu\text{m}$  diameter particles reach the distal portions of the tracheobronchial tree). In addition, it is portable, does not depend on an air compressor and uses a standardized dose.<sup>(7,8)</sup>

It is recommended that the inhaler be used together with a spacer, since that minimizes the difficulties in coordinating the triggering of the device simultaneously with the beginning of the inhalation. The spacer also provides less impact of particles on the oropharynx and upper airways, resulting in an up to two-fold increase in the pulmonary deposition of the drug. Some patients, however, do not care to use them due to their size, as well as to the need for cleaning and maintenance.<sup>(7-9)</sup>

Treatment failure in individuals with asthma frequently results from the incorrect use of metered-dose inhalers, which is typically a consequence of a lack of counseling by health professionals, many

of whom are unfamiliar with the technique.<sup>(10)</sup> A multicenter study for the evaluation of inhalation technique among over 800 European health professionals and their patients, published in 1998, revealed that only 9% of patients, 15% of nurses and 28% of physicians used metered-dose inhalers correctly.<sup>(10)</sup> There have been no Brazilian or Latin-American studies regarding the skills of health professionals in the use of pressurized metered-dose inhalers.

The inhalation technique should be constantly re-evaluated, since there is evidence that it takes an average of ten visits for patients to learn it correctly, and this learning process depends on adequate technical knowledge on the part of the multiprofessional team.<sup>(11,12)</sup> The following are common errors: not exhaling before inhaling the drug; inhaling the medication either too rapidly or too slowly; and not holding the breath for 10 s after inhalation.

The correct technique for using metered-dose inhalers in school children, who should use the device standing or seated, with the thoracic and cervical spine held straight, consists of the following: shaking the inhaler; attaching it to the spacer with a mouthpiece, with the canister turned upward; exhaling calmly; placing the mouthpiece between the lips; pressing down on the inhaler and inhaling slowly and deeply; pausing, without exhaling, for 10 s; waiting (if two or more puffs are necessary) for 30 s to 1 min before repeating the process; and rinsing the mouth with running water. For suckling infants or newborn infants, who should use the device seated or standing, if possible, the procedure should be as follows: shake the inhaler; attach it to the spacer with mask, with the canister turned upward; place the mask on the face, covering nose and mouth to avoid air leaks; press down on the inhaler; count six to ten respirations, without interruption, in case the child cries, to avoid undesirable repetitions of the applied dose; if two or more puffs are necessary, repeat the process after 30 s to 1 min; and rinse the mouth with running water. As soon as children are old enough to place and keep their mouth on the mouthpiece during the procedure, the spacer with mouthpiece should be used instead of the spacer with mask.

The spacer should be cleaned once or twice a week with lukewarm running water and neutral detergent, without using brushes or towels, after which it should be allowed to air dry.

The University of São Paulo School of Medicine *Hospital das Clínicas* Institute for Children is a tertiary hospital where patients with chronic lung diseases are treated in the emergency room, intensive care unit, infirmary, outpatient clinic and nurseries. There have been no studies evaluating the knowledge regarding the use of pressurized metered-dose inhalers among the professionals working in the hospital.

Therefore, in order to determine the difficulties that might interfere with the appropriate counseling of the patients, we decided to determine the theoretical and practical knowledge of physicians, nurses and physical therapists in relation to the use of metered-dose inhalers.

## Methods

This was an observational study involving a convenience sample of professionals working at the Institute for Children. We included a total of 146 professionals: 30 resident physicians or interns in pediatrics; 23 attending physicians; 29 physical therapists; 33 nurses; and 31 nursing assistants.

All participants were interviewed by one of the authors. In the first part of the interview, a professional registration form was filled out. The form includes information on length of service, area of service and current knowledge regarding inhalers (Annex 1).<sup>(13)</sup> Subsequently, a practical evaluation on the use of the metered-dose inhaler was conducted. The interviewees were given metered-dose inhalers containing placebo, plastic spacers of approximately 250 mL in volume (Luftchamber®; Luft, São Paulo, Brazil - and Aerochamber®; Trudell Medical, Ontario, Canada), with mask and mouthpiece, and were asked to demonstrate the use of these devices. Those who worked in areas such as the outpatient clinic, infirmary, ICU and emergency room demonstrated the use of inhalers in fictitious school-age patients (8 year olds) and suckling (11-month-old) infants, using the material provided. Professionals working in the nursery demonstrated the use of the device in school children and newborn infants.

The professional was observed during each step and was given a score of 0 when the step was omitted or demonstrated incorrectly, whereas a score of 1 was given when the step was demonstrated correctly. The ten items used in the evaluation are

listed in Chart 1. The overall score ranged from 0 to 10.

The third part of the interview consisted of closed questions with direct responses regarding the following aspects: use of the spacer; type of spacer; waiting time between two consecutive puffs of the metered-dose inhaler; proper breathing technique prior to the inhalation; duration of the breath hold after inhalation; cleaning of the mouth after inhaler use (Annex 1). There were five questions, each worth 2 points, and the overall score obtained also ranged from 0 to 10.

After the evaluations, the professionals were given oral instruction on the correct use of the devices, after which printed materials, with illustrations, were provided.

Statistical analysis was performed using the Kruskal-Wallis method for comparison of medians, among the four groups of professionals and among the three intergroup tests performed. A sequential logistic multiple regression analysis included the following variables: professional category; more than five years or less than five years since graduation; having previously treated patients who used pressurized metered-dose inhalers; having asthma or having a relative who has asthma; having used pressurized metered-dose inhalers or having a relative who has. In the model, the dependent variable was the combined score on the tests, subdivided into two categories: < the median performance of the sample as a whole; and  $\geq$  the median performance of the sample as a whole. The choice of variables included in the multivariate model was based on their plausibility as possible determinants of the performance of the professional.

In all of the analyses, an  $\alpha$  of 0.05 was adopted as the cut-off point to determine statistical significance. Only statistically significant results are shown in the corresponding tables.

The study design was approved by the Ethics in Research Committee of the Institution.

## Results

The medians obtained in each type of test are presented in Table 1. The best medians, in absolute values, were obtained by resident physicians, followed by physical therapists, attending physicians, nurses and nursing assistants. Comparing the overall performance of the categories, the perform-

**Chart 1** - Clinical cases for practical evaluation.

Evaluation in practice - metered-dose inhaler with spacer and mouthpiece (school children) <sup>(1,3,13)</sup>		
Taking off the cap	0	1
Shaking the inhaler	0	1
Use of the spacer	0	1
Correct connection of the inhaler to the spacer	0	1
Exhalation technique	0	1
Correct placement of the spacer between the lips	0	1
Instruction to inhale slowly and deeply	0	1
Timing of breath hold	0	1
Cleaning of the mouth	0	1
Cleaning of the spacer	0	1
Evaluation in practice - metered-dose inhaler with spacer and mask (suckling infants and newborn infants)		
Taking off the cap	0	1
Shaking the inhaler	0	1
Use of the spacer	0	1
Correct connection of the inhaler to the spacer	0	1
Correct connection of the mask to the spacer	0	1
Correct placement of the mask on the face	0	1
Number of respirations with the system attached to the face	0	1
No interruption in case of crying	0	1
Cleaning of the mouth	0	1
Cleaning of the spacer	0	1

Case nº 1: An 8-year-old patient with asthma, whose physician has prescribed two puffs of inhaled corticosteroid, using a pressurized metered-dose inhaler, twice a day. You should instruct the patient and the companion in how to use the metered-dose inhaler and what to do after the use of the inhaler. To that end, you may choose the accessories you deem necessary from among those you are offered; Case nº 2: An 11-month-old suckling infant diagnosed with wheezy baby syndrome, whose physician has prescribed two puffs of inhaled corticosteroid, using a pressurized metered-dose inhaler, twice a day. You should instruct the companion in how to use the metered-dose inhaler, and what to do after the use of the inhaler. To that end, you may choose the accessories you deem necessary from among those you are offered; and Case nº 3: A newborn infant diagnosed with bronchopulmonary dysplasia, whose physician has prescribed two puffs of inhaled corticosteroid, using a pressurized metered-dose inhaler, twice a day. You should instruct the employee responsible for the case in how to use the metered-dose inhaler, and what to do after the use of the inhaler. To that end, you may choose the accessories you deem necessary from among those you are offered.

ance of resident physicians, physical therapists and attending physicians was significantly better than that of nurses and nursing assistants ( $p < 0.001$  for all three categories). There were no significant differences in performance when we compared attending physicians with residents ( $p > 0.05$ ), residents with physical therapists ( $p > 0.05$ ), physical therapists with attending physicians ( $p > 0.05$ ), and nurses with nursing assistants ( $p > 0.05$ ).

Analyzing each category separately, we observed that residents and physical therapists performed significantly better on the practical test for suckling infants than on that for adolescents or on the written test ( $p < 0.001$  and  $p < 0.05$ , respectively, for both categories). For these same two professional categories, there was no significant difference between their performance on the written test for

adolescents and their performance on the practical test for adolescents ( $p > 0.05$  for both categories). Attending physicians, nurses and nursing assistants performed significantly better on the practical test for suckling infants than on the practical test for adolescents ( $p < 0.001$  for the three categories), and their performance on the written test for adolescents was significantly better than their performance on the practical test for adolescents ( $p < 0.05$  for attending physicians and  $p < 0.01$  for nurses/nursing assistants). There was no significant difference between the practical test for suckling infants and the written test for suckling infants in terms of the performance of the professionals in these three categories ( $p > 0.05$  for all three).

In the sequential logistic multiple regression model, the variables most strongly associated with

**Table 1** – Medians obtained on written and practical tests.

Total (n = 146)	Attending physicians (A) (n = 23)	Resident physicians (B) (n = 30)	Nurses (C) (n = 33)	Nursing assistants (D) (n = 31)	Physical therapists (E) (n = 29)
Written test	6.00 (min 0, max 10)	7.00 (min 0, max 10)	4.00 (min 0, max 7)	4.00 (min 0, max 8)	6.00 (min 4, max 10)
Practical test	4.00 (min 0, max 10)	6.00 (min 2, max 9)	2.00 (min 0, max 7)	2.00 (min 0, max 7)	5.00 (min 0, max 9)
School children	7.00 (min 2, max 10)	8.00 (min 4, max 10)	6.00 (min 0, max 7)	5.00 (min 0, max 9)	8.00 (min 0, max 10)
Practical test	6.00 (min 0, max 10)	7.00 (min 0, max 10)	4.00 (min 0, max 10)	3.00 (min 0, max 9)	6.00 (min 0, max 10)
Suckling infants or newborn infants					
Overall medians <sup>a</sup>	6.00 (min 0, max 10)	7.00 (min 0, max 10)	4.00 (min 0, max 10)	3.00 (min 0, max 9)	6.00 (min 0, max 10)

<sup>a</sup>A or B or E better than C or D:  $p < 0.001$ .

better performance were, respectively, being a resident physician, being a physiotherapist, being an attending physician, and having previously treated patients who use metered-dose inhalers (Table 3). In all professional categories, the best medians were obtained on the practical test for suckling infants, and the worst were obtained on the practical tests for school children (Table 1).

On the practical tests for suckling infants and school children, the step most often performed incorrectly was step 10 (cleaning the spacer). On both practical tests, the steps related to shaking the inhaler and cleaning the mouth also presented high error indices. On the written tests, the question most often answered incorrectly was question 3 (regarding the waiting time between puffs).

On the practical tests for suckling infants and school children, respectively, the steps most often performed correctly were step 3 (using spacer) and step 1 (taking off the cap). On the written tests, the question most often answered correctly was question 1, which was related to the best technique for using metered-dose inhalers in suckling infants (Table 2).

Notably, the fact that the scores were higher on the practical test for suckling infants than on the practical test for school children can be, in great part, attributed to a common error made by health professionals, who do not use the spacer in school children, as was observed in 51.1% of the interviewees in the present study.

## Discussion

In the overall evaluation conducted, we observed that resident physicians, physical therapists and

attending physicians performed significantly better than did nurses and nursing assistants, who are directly involved in the practical application of medical prescriptions. It is noteworthy that only resident physicians obtained an overall median score  $>6$ .

Although we evaluated a convenience sample, the number of professionals interviewed constitutes a representative sampling of these categories of professionals working in the hospital in question.

Our results show that, principally because this is a referral center for pediatric health, the knowledge of these professionals regarding the use of metered-dose inhalers is considerably less than satisfactory, reinforcing a common finding in the medical literature: despite the greater efficiency of these devices over nebulizers for the delivery of inhaled medication (basically bronchodilators and corticosteroids), knowledge regarding their use has yet to be widely disseminated. These numbers confirm the findings of the previously mentioned multicenter study.<sup>(10)</sup> In that study, only 28% of the physicians, 15% of the nurses and 9% of the patients demonstrated the correct technique for using inhalers. The physicians performed significantly better than did the nurses and patients. Among the medical specialties studied, pediatricians performed significantly worse than did pulmonologists and allergists.<sup>(10)</sup> Other studies have obtained similar results.<sup>(14,15)</sup>

The lack of knowledge regarding this technique effectively limits the number of times that these devices are prescribed in comparison with conventional nebulizers, whether for the administration of maintenance medication, such as inhaled corticosteroids, or of bronchodilators for the treatment of exacerbations, at home or in the emergency room.

**Table 2** - Questions presenting the highest and lowest error indices.

	Practical (suckling infants)	Practical (school children)	Written
Most errors	Question 10 (103 total errors)	Question 10 (117 total errors)	Question 3 (101 total errors)
Least errors	Question 3 (18 total errors)	Question 1 (11 total errors)	Question 1 (30 total errors)

In reflection, we can analyze the advantages of pressurized metered-dose inhalers over conventional nebulization for use in emergency rooms. Respiratory diseases, including wheezing attacks (resulting from asthma or not), constitute the principal cause of childhood visits to hospitals. A patient with moderate or severe bronchospasm receives a minimum of three bronchodilator nebulizations in the emergency room. Since each nebulization is effective for 15 to 20 min, 45 min to 1 h will be spent on these procedures alone, and we cannot forget that conventional nebulizers are more costly, need periodic maintenance and need a feeding source in order to work.<sup>(16)</sup> In addition, nebulization demands up to 25 times greater doses of bronchodilators than do metered-dose inhalers.<sup>(17)</sup> If spacers and metered-dose inhalers are made available in emergency rooms, it will be possible to streamline the treatment of a great number of children, with clear benefit to clinical treatment, given the greater efficiency of these devices in delivering their medication to the respiratory tract. In addition, it is not possible to know how much drug provided by a nebulizer actually reaches the respiratory tract, since a large portion of the nebulized medication is dispersed into the air.<sup>(5,17,18)</sup> Some authors even prepared an extensive review of randomized studies, comparing the use of conventional nebulizers to that of metered-dose inhalers with spacers, in the delivery of bronchodilators for the management of acute asthma in adults and in children aged 2 or older. That review showed that children using metered-dose inhalers with spacers spent significantly less time in emergency rooms (mean, -0.47 h; 95% CI: -0.58 to -0.37), than did children treated with nebulization. In addition, the former group presented significantly lower heart rates.<sup>(16)</sup> The same authors, reviewing studies in which the use of conventional nebulizers was compared with that of metered-dose inhalers with spacers, in terms of the delivery of inhaled corticosteroids, found no quality publications on the issue regarding children.

A single, randomized controlled study, involving adults, showed that, for the delivery of budesonide, conventional nebulizers had advantages over metered-dose inhalers (higher peak expiratory flow values in the morning and afternoon, and lower rates in the use of relief bronchodilators). However, the doses of the drug delivered by the nebulizer (2000 to 8000 µg) were higher than those offered delivered by the metered-dose inhaler (1600 µg).<sup>(19)</sup>

An interesting finding is the high number of professionals (in all categories) who did not recommend the use of the spacer for school children. This results from a misconception that is widely disseminated among health professionals: that the function of the spacer is only to facilitate the use of inhaled medication by children who cannot coordinate respiratory movements during the use of the metered-dose inhaler. Although the spacer performs this function, its use also allows the larger particles (that do not reach the distal airways) to be retained in the device, whereas smaller particles are inhaled, reaching the distal airways with better treatment results.<sup>(5)</sup> Not using the spacer results in the retention of great part of the medication in the oropharynx, leading to higher risk of systemic absorption, with possible side effects, to the detriment of the desired pulmonary deposition of the medication.<sup>(5)</sup>

Oral hygiene after the use of inhaled corticosteroids is fundamental, principally in suckling infants and newborn infants. This decreases the possibility of the local side effect (oral candidiasis) and of long-term systemic side effects (retarded growth, decrease bone mineralization, etc.)<sup>(1,3)</sup> The high error index for the question regarding this issue among all professional categories indicates poor knowledge not only regarding the use of these inhalers but also regarding how to minimize the possible side effects of the inhaled corticosteroid therapy, which is generally a long-term treatment, but that, with correct professional guidance, is practically free of adverse events.<sup>(1,3)</sup>

**Table 3** – Variables associated with better performance on the tests.

Variable	p	Odds ratio	95% CI
Resident physician	<0.0001	20.9	6.4 to 68.3
Physiotherapist	<0.0001	12	4.1 to 35.3
Attending physician	<0.0001	11.2	3.5 to 35.3
Having previously treated patients who used MID	<0.004	4.3	1.6 to 11.5

95% CI: 95% confidence interval; and MID: metered-dose inhalers.

In a randomized controlled study conducted in a hospital in Philadelphia, the skills of resident physicians in the use of pressurized metered-dose inhalers with spacers were evaluated before and after the implementation of a theoretical and practical educational program. The residents were divided into two groups, a study group and a control group, those in the latter being submitted only to the application of the written and practical questionnaire, at the beginning of the study and after 2 to 3 months, without the implementation of the educational program. The residents submitted to the theoretical and practical educational program performed significantly better, both in relation to their initial performance and in relation to the performance of the control group, at the end of the study.<sup>(13)</sup>

A similar intervention would be beneficial in order to improve the skills of professionals at the Institute for Children in the use of these inhalers. Short theoretical and practical classes given by pulmonologists could be provided, addressed to all professionals who work in the hospital. In

conjunction with the dissemination of the written material provided to the participants in this study, which could be distributed to the entire hospital staff, these classes could adequately qualify these professionals in the practical application of the concepts regarding the use of pressurized metered-dose inhalers. Certainly, special attention would have to be given to the education of nurses and nursing assistants, since these professionals, who are responsible for the practical application of the inhalers, presented significantly worse performance than did the other professional categories. After this program of classes, a written and practical evaluation, similar to that shown in the present study, could be applied, with the objective of evaluating the true efficacy of this educational program.

A few limitations of the present study should be considered. Although the evaluations were not applied to professionals specializing in respiratory diseases, the fact that the population studied worked in a tertiary hospital might have affected the results. A similar study carried out in secondary hospitals or in basic health care clinics might obtain even worse results. Since Brazil is a country with a high prevalence of asthma, the knowledge of health professionals regarding techniques and inhalers should not be restricted to centers treating primarily cases of great complexity.

Future physicians, physical therapists and nurses should become familiar with these techniques as undergraduates so that, after graduation, they can not only apply their knowledge but also participate in the education of other health professionals.

**Annex 1** – Multiprofessional registration and written evaluation – Evaluation of the knowledge of health professionals at a pediatric hospital regarding the use of metered-dose inhalers.

Professional registration

Current date: \_\_\_\_ / \_\_\_\_ / \_\_\_\_

Name: \_\_\_\_\_

Address: \_\_\_\_\_ Phone: \_\_\_\_\_

Highest level of education:  High school     College     Masters     Doctorate

Graduated (year): \_\_\_\_\_ Years in this profession: \_\_\_\_\_

Sector: \_\_\_\_\_ Years in this sector: \_\_\_\_\_

Have you ever treated patients using metered-dose inhalers?     Yes     No     I don't know

Have you ever applied or prescribed metered-dose inhalers?     No     Yes     Once

One to ten times

More than ten times

Do you or one of your close relatives suffer from asthma?     No     Yes

Who? \_\_\_\_\_

Do you use metered-dose inhalers?     Yes     No

**Written evaluation<sup>(1,3,13)</sup>**

- 1) What is the best way to use a pressurized metered-dose inhaler in suckling infants?
  - a) Spray one puff from the inhaler at a distance of 30 cm from the face of the patient, without the use of a spacer, since suckling infants cannot coordinate their breathing with the timing of the spray;
  - b) Spray one puff from the inhaler using a spacer. However, leave the spacer in contact with the face of the patients for only 5 s in order to prevent them from inhaling an excessive quantity of the drug;
  - c) This type of inhaler is not appropriate for use in suckling infants; and
  - d) Spray one puff from the inhaler using a spacer and a mask. However, leave it in contact with the face of the patients until they complete six complete respirations allowing all of the available medication to be inhaled (correct).
- 2) Attach the metered-dose inhaler to the spacer . . .
  - a) With the canister upward and the outlet downward (correct);
  - b) What is important is not the position of the inhaler, but to ensure that there is no leak in the system;
  - c) With the canister downward and the outlet upward, avoiding the impact of the medication particles in the spacer, which hinders access to the airways of the patient; and

- d) The position of the inhaler in relation to the spacer does not interfere with the delivery of the drug to the respiratory tract.
- 3) The time elapsed between two puffs of spray should be . . .
- 5 s;
  - 10 s;
  - 1 min (correct); and
  - None (immediately after the first puff).
- 4) For correct inhalation of the puff, in school children, the intake of breath should be . . .
- Rapid and superficial;
  - Rapid and deep;
  - Slow and deep (correct); and
  - What is important is that patients keep their mouths attached to the spacer for 30 s.
- 5) The spacer should be cleaned . . .
- Daily, with water and detergent, and subsequently dried with a cloth;
  - Daily, only with water, and subsequently dried with a cloth;
  - Once a week, with water and detergent, and allowed to air dry (correct); and
  - Once a week, with bleach for correct disinfection.

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