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Repetitive instructions at short intervals contribute to the improvement of inhalation technique

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Conflict of interest
Koichi Fukunaga has received lecture fees from Boehringer Ingelheim and AstraZeneca. The

ABSTRACT

Background: Inhaled medicines are key drugs for the treatment of asthma or chronic obstructive pulmonary disease. However, the variety of inhaler devices and complicated inhalation procedures have created confusion among patients, affecting their correct understanding of inhalation. Recent studies reported that up to 80% of patients made technical errors in inhalation and emphasized the necessity for patient education.
Objective: We aimed to assess the importance of inhalation-related instructions and to find clinical factors associated with improvements in the inhalation technique.
Methods: We conducted a retrospective, single-center study at a regional core hospital in Japan. Physicians and community pharmacists constructed an interactive instruction system and shared a common inhalation procedure manual. Patients who received instructions for the inhalation technique at least 3 times were recruited.
Results: A total of 125 patients were analyzed in this study. The median age was 73 years (interquartile range, 67–80 years). At the second visit, 67 patients (53.6%) failed to correctly perform the technique despite being guided at the first visit. At the third visit, 48.8% of patients made some errors. After excluding 40 patients who were not subjected to analysis, the remaining 85 were divided into "improvement" and "no-improvement" groups. The total improvement rate was 57.6%. The median time interval between consecutive instructions in the "improvement" groups was 84 days, whereas that in the "no-improvement" group was 128 days ($p < 0.05$, U test). No significant difference in the age, sex, or primary disease was seen between these groups.
Conclusion: Repetitive instructions at shorter intervals may be helpful for patients to develop and maintain an improved inhalation technique.

Keywords: Asthma; Chronic obstructive pulmonary disease; Inhalation technique; Pharmacy practice; Patient education

INTRODUCTION

Inhaled medicines are a mainstay treatment for chronic pulmonary diseases including asthma and chronic obstructive pulmonary disease (COPD). The major advantage of

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remaining authors declare that they have no competing interests.

Author Contributions

Conceptualization: Rie Baba, Ichiro Nakachi, Katsunori Masaki, Koichi Fukunaga. Data curation: Hatsuyo Takaoka, Tetsuro Kamo, Daisuke Arai, Hidenori Takahashi, Hiromi Shinoda. Formal analysis: Rie Baba, Takuya Amagai. Methodology: Takuya Amagai, Rintaro Ohno. Project administration: Ichiro Nakachi, Koichi Fukunaga. Visualization: Rie Baba, Takuya Amagai. Writing - original draft: Rie Baba. Writing - review & editing: Ichiro Nakachi, Katsunori Masaki.

using inhaler devices is the direct delivery of chemical compounds to the bronchial tracts, achieving higher concentrations of drugs in peripheral small airways with a lower risk of systematic adverse events [1]. A variety of inhaler devices are available with differing efficacy and usability [2]. Currently, physicians have many choices of inhaled drugs, depending on patients' lifestyles and comorbidities [3, 4]. However, the availability of multiple devices has raised novel problems: (1) the large number of inhalers and complicated inhalation procedures have created confusion among patients, affecting their correct understanding of inhalation; and (2) patients occasionally use a combination of different inhaler types, such as dry powder inhaler (DPI) and pressurized metered dose inhaler (pMDI), often with different inhalation techniques [5-8].

The appropriate use of inhalers consists of stepwise technical procedures [9, 10]. Failure to perform even one inhalation step can affect not only effective drug delivery but also the safety of using inhalers [11]. Recent studies reported that up to 80% of patients made technical errors in inhalation and emphasized the necessity of patient education by health care workers [12, 13]. Such medical circumstances suggest the development of an inhalation instruction system led by physicians or pharmacists and the importance of delivering correct instructions for inhalation [14, 15]. However, the type of education or what type of patients should be focused on to achieve and maintain correct inhalation technique have not been studied. Here, we constructed an interactive instruction system involving physicians in hospital and community pharmacists (CPs). Using the clinical experience and evidence accumulated through this system, we assessed the importance of providing inhalation instructions and sought to find clinical factors associated with improvements in the inhalation technique.

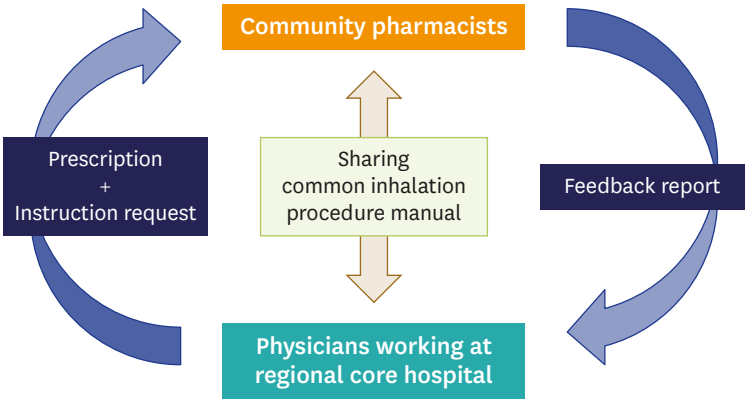
MATERIALS AND METHODS

Study design and subjects

This was a retrospective single-center study conducted at Saiseikai Utsunomiya Hospital, a regional core hospital in Tochigi, Japan. Adult asthma and COPD patients prescribed any inhaled drug were recruited for this study. All the patients met the definitions of bronchial asthma and/or COPD, which are described in the Global Initiative for Asthma (GINA) [16] and the Global Initiative for Chronic Obstructive Lung Disease (GOLD) [17] guidelines. Regarding the description of asthma and COPD overlap (ACO), we referred to the proposal described in a joint project of GINA and GOLD [18]. Inhaled drugs were prescribed according to the treatment guidelines for asthma and COPD. Each device was selected by physicians. CPs working at regional pharmacies were called prior to starting this study and completed a training program for handling inhaler devices and instructing patients in the inhalation technique. This study was approved by our hospital Institutional Review Board (approval number: #2019-75), and we used the "opt out" method as an alternative for informed consent for the study.

Inhalation technique instruction system

In April 2017, physicians worked together with CPs in constructing a collaborative instruction system (**Fig. 1**), then shared a common inhalation procedure manual (Supplementary material 1) as well as a feedback checklist form (Supplementary material 2) to facilitate communication on inhalation instruction. The procedures were as follows: at the end of a medical examination, the patients provided written informed consent to receive the



1. Physicians obtain written informed consent for lectures and hand out request forms together with the prescription.
2. CPs explain to the patients how to correctly use their devices.
3. CPs send feedback reports to the physicians.
4. Procedures 2 and 3 are repeated as necessary for each patient.

Fig. 1. Collaborative instruction system. CP, community pharmacist.

instruction lectures, and the physician gave him/her a form requesting inhalation instruction, together with a prescription. Subsequently, at the pharmacy counter, the pharmacist explained how to make the correct use of the patient's inhaler device(s) and how to avoid common errors in using inhaler devices. Next, the pharmacist sent a feedback report to the physician. These procedures were repeated at least 3 times for each patient.

At the first visit, the CP provided instruction on the proper use of inhaler devices according to the procedure manual. This consisted of verbal instructions and a face-to-face demonstration. At the same time, the CP checked whether the patient's inhaler flow speed was enough to take the medicine, by using inhaler trainers when the patient was prescribed Diskus, Elipta, or Turbuhaler. If the patient did not have a sufficient inhaler flow speed, the CP reported the fact to the physician and recommended that he/she consider changing inhaler devices (i.e., from DPI to pMDI). At the second visit, the patient's inhalation technique was evaluated referring to the standardized checklist. The CP checked each step to see if the patient used the inhaler device correctly. In the case of any error, the CP reviewed the correct inhalation technique and reinstructed the patient. On the third and subsequent visits, the CP reassessed the patient's technique in the same way and provided instructions again, if required. Patients were divided into the following 3 groups: “improvement,” “unchanged,” and “deterioration.” Patients who showed any improvement in the stepwise inhalation technique between visits were assigned to the “improvement” group. Those who showed the same error at 2 visits were assigned to the “unchanged” group, whereas those with a worsened technique were assigned to the “deterioration” group. Feedback data from April 2017 to October 2019 were collected and analyzed.

Statistical evaluation

We used GraphPad Prism statistical software, version 4.0 (GraphPad Software Inc., San Diego, CA, USA) for all analyses. According to data scaling, comparison of 2 subgroups was performed by means of the chi-square test. Comparisons of quantitative variables were performed using the Mann-Whitney *U* test. A value of $p < 0.05$ was considered to be significant.

RESULTS

Study population

A total of 125 patients who received instructions in the inhalation technique at least 3 times, were recruited for this study. Their feedback reports sent from the CP were collected and analyzed. Patient characteristics are summarized in **Table 1**. The median age was 73 years (interquartile range [IQR], 67–80 years), and the sample included a preponderance of men. Subjects in this study were all adult patients with chronic pulmonary disease with a prescription for any types of inhaled drug. The breakdown of primary illness was asthma in 48 patients (38.4%), COPD in 63 patients (50.4%), and ACO in 14 patients (11.2%). The severity of asthma was classified according to the asthma treatment steps in the GINA guideline; the details are described in **Table 1**. Airflow limitation severity in COPD was classified according to the GOLD guideline (**Table 1**). Of 125 participants, moderate or severe acute exacerbations over the last year were seen in 12 subjects. There were no associations between these factors and achievement of inhalation techniques (data not shown).

Distribution of inhaler devices

Fig. 2 shows the distribution of the devices used in this study. Devices used for this study included Respimat (Boehringer Ingelheim Pharma, Ingelheim am Rhein, Germany), Ellipta (GlaxoSmithKline, London, UK), Swinghaler (Otsuka Pharm, Tokyo, Japan), pMDIs, Turbuhaler (AstraZeneca, Cambridge, UK), Diskus (GlaxoSmithKline, London, UK), Breezhaler (Novartis AG, Basel, Switzerland), and Genuair (AstraZeneca, Cambridge, UK) in 33%, 25%, 17%, 8%, 7%, 7%, 2%, and 1% of patients, respectively. The percentage of pMDI was low compared to that in other countries; however, distribution of the inhaler type varies considerably worldwide [19]. Thirty percent of patients (37 of 125) used multiple devices.

Evaluation of inhaler technique at the second and third visits

At the second visit, 67 patients (53.6%) failed to perform the correct use of inhaled drugs (making at least one error in the handling and inhalation step) despite the fact that they had had instruction at the first visit (**Fig. 3**). Overall, incorrect use was detected regardless of devices. There was no significant difference in age, sex, or types of diseases (asthma or COPD) in the groups with and without error (data not shown).

Table 1. Study population

Characteristic	Value
No. of patients	125
Age (yr), median (IQR)	73 (67–80)
Sex, n (%)	
Female:male	44 (35.2):81 (64.8)
Primary illness, n (%)	
Asthma:COPD:ACO	48 (38.4):63 (50.4):14 (11.2)
Severity	
Asthma: GINA, n (%)	
1:2:3:4:5	0 (0):3 (6.3):17 (35.4):15 (31.3):13 (27.1)
COPD: GOLD, n (%)	
NA:1:2:3:4	8 (12.7):21 (33.3):23 (36.5):11 (17.5):0 (0)

IQR, interquartile range; COPD, chronic obstructive pulmonary disease; ACO, Asthma and COPD overlap; GINA, Global Initiative for Asthma, Classification by Asthma Treatment Steps; GOLD; Global Initiative for Chronic Obstructive Lung Disease, Classification of airflow limitation severity in COPD; NA, Not available.

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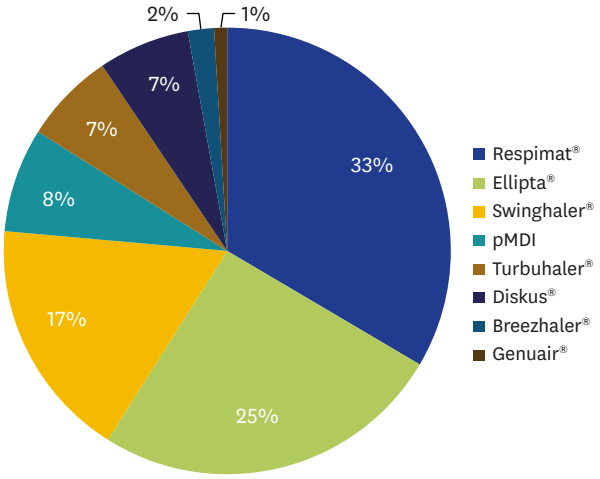

Fig. 2. Distribution of inhaler devices. pMDI, pressurized metered dose inhaler.

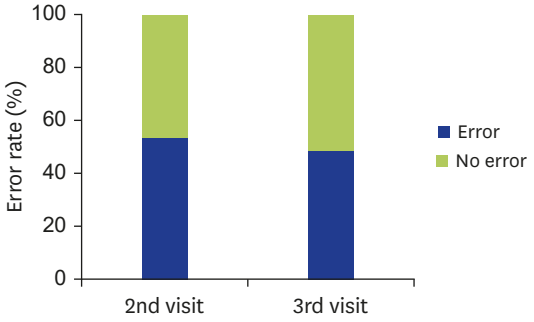

Fig. 3. Frequency of overall inhalation errors. The error rate decreased from 54.3% to 48.8% owing to the instruction at the second visit. Data are presented as relative numbers (%).

At the third visit, 48.8% of patients (61 of 125) made some errors (**Fig. 3**) and received instructions again. The error rate decreased from 53.6% to 48.8% owing to the instructions provided at the second visit.

Factors associated with inhalation improvement at the third visit

To clarify factors associated with improvement in the inhalation technique between the second and third visits, the 85 patients who made any errors at the second visit or showed any difference in the technique between the second and third visits were studied in detail. The other 40 patients who showed no errors at either the second or third visits were excluded from this analysis. The total improvement rate was 57.6% (49 of 85) (**Fig. 4**).

In the comparison of the "improvement" group and the "no-improvement" group ("unchanged" and "deterioration"), there was no significant difference in age (73 years [IQR, 68–80 years] vs. 75.5 years [IQR, 69.5–81 years], $p = 0.53$) (**Fig. 5A**). Likewise, sex, primary lung disease, and number of devices used did not show any significant difference (**Fig. 5B-D**).

The median time interval between the 2 instruction visits in the "improvement" group was 84 days, whereas that in the "no-improvement" group was 128 days ($p < 0.05$, *U* test) (**Fig. 5E**). These data were statistically significant.

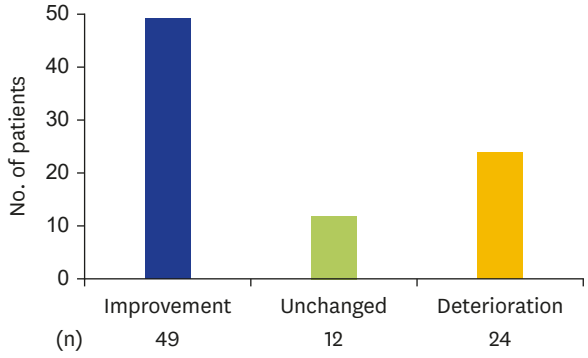

Fig. 4. Improvement of inhalation technique at the third visit. The total number of improved patients was 49 (57.6%). Data are presented as absolute numbers (n).

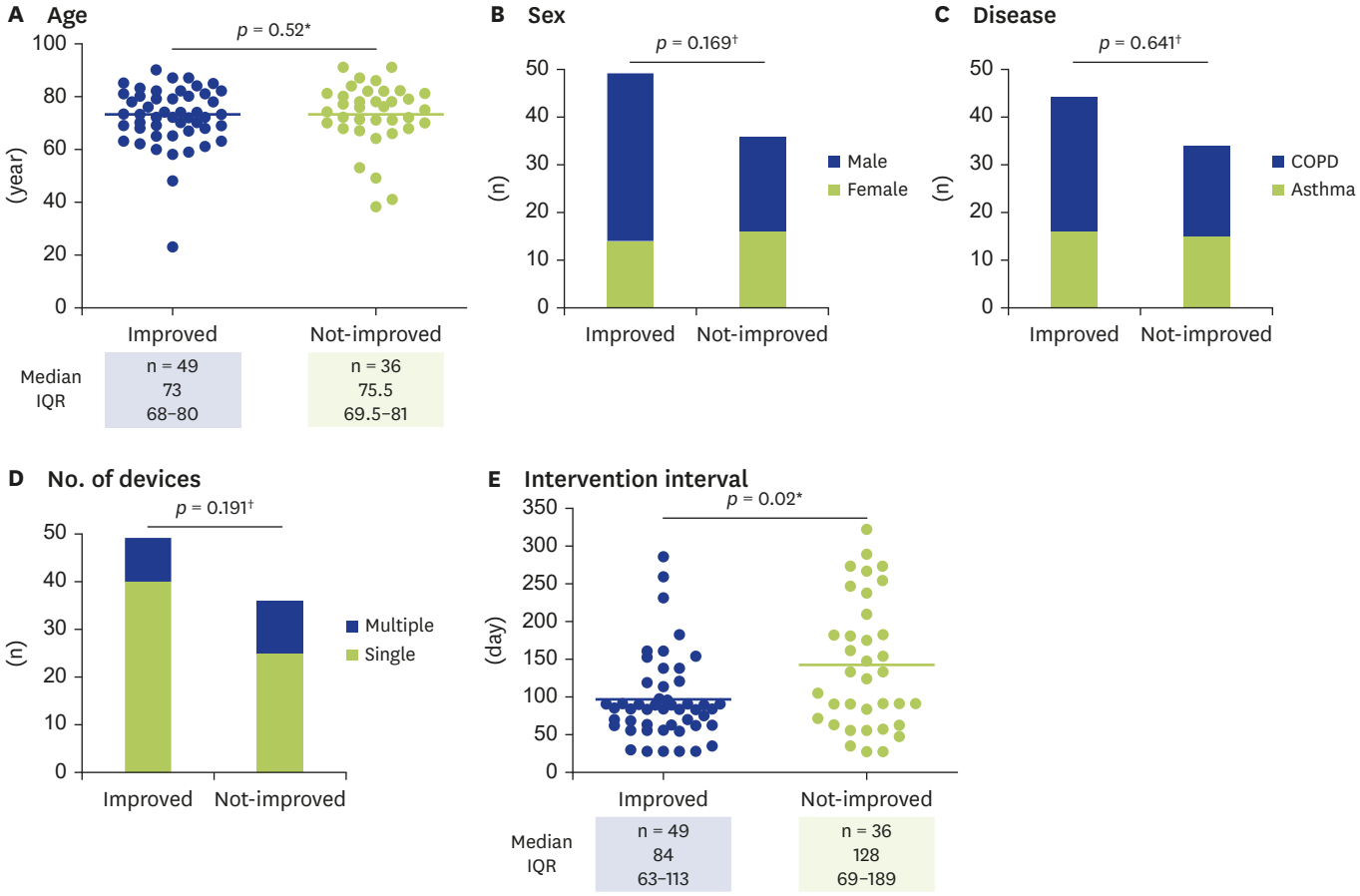

Fig. 5. Factors contributing to the improvement of errors. (A) Age. (B) Sex. (C) Primary lung disease. (D) Number of devices. (E) Intervention interval. IQR, interquartile range. *p value was calculated by the Mann-Whitney U test. †p value was calculated by the chi-squared test.

DISCUSSION

Evidence suggests that many patients with asthma or COPD do not use their inhaler devices correctly. Studies evaluating the parameters that affect incorrect inhaler use have reported different results. Some researchers indicated that aging leads to a decrease in the improvement of the inhalation technique, while others reported that age is not relevant [5].

Mismatches of the results have also been reported for sex [5]. Differences between studies and heterogeneity of the results make it difficult to draw conclusions. Although previous studies have emphasized the importance of patient education in the use of inhaler devices [20, 21], we still lack practical indicators to decide what would be the most optimal way to help patients to understand how to use inhaler devices correctly. In the recruitment of 125 patients with asthma, COPD, or ACO, we have assessed the patients' understanding of inhalation and collected their clinical data.

The required number of instruction visits to correct inhalation errors has been discussed by Takaku et al. [22]. Based on the results from their study, we decided to collect data from patients who had had at least 3 inhaler instruction visits. Although study participants were instructed during the first visit from the CP on how to use the inhaled drug prescribed by their physicians, incorrect use was observed in 53.6% of patients at the second visit. A prospective study reported that in patients with asthma and COPD who were treated with various devices such as pMDI, soft mist inhaler, and DPI, approximately 60% were regarded as misusers after the initial guidance, regardless of the device type [22]. Our study showed similar results in the frequency of errors. Furthermore, even at the third visit, 48.8% of patients still made some errors. Although the rate of misuse had decreased, nearly half of the patients remained misusers. This relatively small improvement in our study is somewhat different from that noted in previous studies that demonstrated a significant improvement rate after repetitive instructions [23].

However, 57.6% of patients in our study showed some degree of improvement at the third visit after excluding “smart” patients who maintained perfect inhalation skills at both the second and third visits. This indicates that the patient's inhalation skill could be developed and improved with multiple instruction visits. Repetitive training accompanied by the assessment of technique at every patient visit is important for the proper use of inhaler devices [24].

No significant difference was seen in common clinical background factors such as age, sex, primary lung disease, or the number of devices between the improvement and not-improvement groups. This fact suggests that most clinical factors are not related to the improvement of the inhalation technique, as patients received instructions multiple times. Additionally, short intervals between instruction visits were significantly associated with the correction of errors during inhalation. Therefore, not only repetitive but also close interventions are essential to improve or maintain the patient's inhalation skills.

In previous prospective studies, intervention was performed every 2 or 4 weeks, and further inhalation improvement in the third and later instruction visits was reported. In our study, the median time interval between instruction visits in the improvement group was 84 days. Weekly rather than monthly instruction visits might be more appropriate for the improvement of the inhalation technique. However, the long-term effectiveness of repeated visits remains unclear, and the maintenance of improved inhalation skill is another issue to be addressed [25-29]. Our study suggests that patients can still improve or at least maintain their inhalation technique even with instruction visits every 3 months. In summary, the most important point in daily practice is to provide the opportunity for patients to have inhaler instruction at no longer than 3-month intervals.

This study had some limitations: (1) data were obtained from a single regional hospital and several community pharmacies near the hospital; (2) most participants were elderly,

and a lack of their socio-educational data may have affected the results; and (3) although we reported the importance of providing frequent instructions, most interventions were performed monthly rather than weekly, depending on patients' scheduled visits. A large-scale prospective study to assess the effectiveness of the instruction interval is required. The strengths of this study are as follows: (1) to the best of our knowledge, this is the first cooperative trial in a real-world setting to share a common inhaler procedure between physicians in the hospital and CP outside the hospital and (2) an optimal and practical interventional interval was proposed for the improvement and maintenance of appropriate inhalation technique.

In conclusion, an interactive instruction system shared between physicians and CP is helpful for clarifying and correcting patients' technical errors during inhalation. Repeated instruction visits at shorter intervals may result in better inhalation techniques.

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SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://apallergy.org/src/sm/apallergy-10-e19-s001.pdf.

Supplementary Material 1
Instruction Manual

Click here to view

Supplementary Material 2
Check List and Feedback Report (Pharmacist→Physician)

Click here to view

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SUPPLEMENTARY MATERIALS

Supplementary Material 1.

Instruction Manual

Inhalation procedure	Inhaler device	Contents	Note
1. Drug name & Usage	DPI, pMDI, SMI	Pointing and calling	
2. Check dose counter	DPI, pMDI, SMI	Pointing and calling	
3. Preparation	DPI, pMDI, SMI	Straighten posture	
	pMDI	Shake the inhaler before use	Not all devices are needed to be shaken. However, all devices including pMDI are intended to be shaken to avoid patient's confusion.
4. Breathe out enough	DPI, pMDI, SMI	Until just before full exhalation	
5. Breathe in adequate speed and depth	DPI	Breathe in quickly (for 2 to 3 seconds) and deeply	
	pMDI, SMI	Breathe in slowly (for 5 seconds) and deeply with closed mouth	If a patient has difficulty of synchronization or feels choked on a mist, consider the use of spacer.
6. Hold breath	DPI, pMDI, SMI	At least 5 seconds	
7. Breathe out gently	DPI, pMDI, SMI	Exhale from the mouth or nose slowly.	
※If 2 or more inhalations are needed at one inhalation step,	DPI, pMDI, SMI	Keep at least 1-minute interval between inhalations	
8. Gargling & Rinsing	DPI, pMDI, SMI	Gargling: 3 times each for 5 seconds Rinsing: 3 times each for 5 seconds	

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Supplementary Material 2.

Check List and Feedback Report (Pharmacist→Physician)

Patient's name	Pharmacy's name
(Patient's ID)	FAX / TEL

Selected device

□ Diskus □ Ellipta □ Turbuhaler □ Respimat

□ Twisthaler □ pMDI □ pMDI + Spacer □ Handihaler

□ Swinghaler □ Genuair □ Breezhaler

Pharmacist's sign _____ _____ _____ _____

1st 2nd 3rd 4th

Date (/) (/) (/) (/)

Device's name :				
1. Drug name & Usage		○ ×	○ ×	○ ×
2. Check dose counter		○ ×	○ ×	○ ×
3. Preparation		○ ×	○ ×	○ ×
4. Breathe out enough		○ ×	○ ×	○ ×
5. Breathe in adequate speed and depth		○ ×	○ ×	○ ×

6. Hold breath		○ ×	○ ×	○ ×
7. Breathe out gently		○ ×	○ ×	○ ×
8. Gargling & Rinsing		○ ×	○ ×	○ ×

1st time: Put a check mark after the instruction.

2nd time~: Check and evaluate the patient's technique.

Communication column
1st
2nd
3rd
4th

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