Original Research Article

Perfect the Puff:Reinforcing Metered-Dose Inhaler Excellence Amongst Primary Care Traineesfor Optimal Asthma Management

Abstract:

Background:
There are key gaps regarding proper metered-dose inhaler (MDI) technique during Internal Medicine Residency training. Inhaler misuse remains common, underscoring the need for continued reinforcement. This study aims to assess the efficacy of one training session, which reviews the 8 steps for MDI use.

Methods:
We recruited 30 Internal Medicine resident volunteers at an urban medical center with a high community prevalence of asthma to participate in a teaching session that included 8 core steps for proper MDI use. We administered a pre-survey asked about trainees' prior teaching and how they currently teach and assess the MDI technique. Participants completed a post-intervention survey listing the MDI steps.

Results:
Most were not previously taught the MDI technique (n=21), and whether one was previously taught the MDI technique did not differ by gender (p=0.94) nor class year (p>0.99). Of the participants who were previously taught the MDI technique (n=9), no participants were confident in assessing the technique (0%) nor providing a demonstration (0%), though most (67%) of these individuals felt they could verbally teach the MDI technique. Pre to post-survey findings demonstrated an average improvement of 3.6 to 6.6 MDI steps correctly identified (p< 0.01). **The implications of these findings underscore the need to not only teach IM residents about the MDI technique but also ensure continuous reinforcement regardless of gender or level oftraining.**

Conclusion:
Reinforcing the MDI technique through a training session is an intervention to enhance IM residents' knowledge. Future studies can assess the impact of longitudinal training through digital education tools and assess the retention of MDI technique knowledge.**Recommendations for future training sessions could assess the impact of digital education as well as other modalities such as visual aids and hands-on training.**

Key Words: Asthma, Education, Residency, MDI, Management,Medical Education, Training, Patient Education, Counseling, Teaching,

Introduction

Asthma presents a critical burden on the healthcare system. The US CHRONICLE Study has found that females, Black race, Hispanic ethnicity, and young age are particularly susceptible to severe asthma exacerbations on a national level(1). As of 2022, the age-adjusted asthma prevalence per 100 individuals is 6.2 in the Bronx, vs 3.7 in Queens, 3.8 in Brooklyn, 4.6 in Manhattan, and 5.7 in Staten Island(2). Not only are Bronx citizens more susceptible to having a diagnosis of asthma, but theybe hospitalized at the lowest ages compared to other boroughs(31 years vs 49 years in Staten Island) and primarily affects Blacksand Hispanics(2). Among Bronx citizens with severe asthma, one study has found that approximately 56% identified as Hispanic and 34% identified as non-Hispanic Black(3). This disproportionate asthma burden in the Bronx is multifactorial, likely due to residents' exposure to multiple risk factors including aerosolized allergens in housing, obesity, lower household incomes, and air pollution(2,4). Improper disease management increases the asthma burden, highlighting a critical need for healthcare providers to provide education on asthma treatment during the patient encounter.

The metered dose inhaler (MDI) is often the primary device for medication delivery to the lungs, yet inhaler misuse is a universal challenge that affects patients of all ages, contributing to poorly controlled disease(5). Examples of improper MDI use seen amongst hospitalized patients with asthmaincluded using a spacer with a mouthpiece instead of with a mask and inadequate breathing techniques(6). The adult population is susceptible to inhaler misuse, with one study

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finding that 71.6% of adults were making errors when using their inhaler, with 31.1% of the group making critical mistakes such as improper medication dose activation(7).

Collectively, these studies demonstrate the existing knowledge gap in proper MDI use amongst patients and the potential yield of additional inhaler use education.One study found that in a survey of 557 providers including internal medicine residents, pulmonary fellows, and respiratory therapists, only 55% were able to correctly identify the proper steps of MDI use with no significant difference in correct response rates between provider types(8). Providers who routinely demonstrate a technique to their patients were able to list twice as many steps correctly, underscoring the impact of teaching technique(8). Another 2021 study assessed 244 nurses and physicians on their MDI use skills, finding that only 13.5% had a good technique, and 2.5% presented with a very good technique(9). In some instances, knowledge gaps may cause physicians to hesitate to prescribe an MDI when it may be necessary and most effective. One study demonstrated that even though 62% of physicians understood that an MDI with a spacer is equally as effective as nebulization, only 28% had chosen to prescribe MDIs with a core reason forreluctance being gaps in provider knowledge (10).Among emergency medicine physicians, a single training session was able to enhance physician accuracy to 89.4% of MDI technique steps being identified correctly when assessed 2 weeks after training (11).Training providers in the proper steps of MDI use may empower them to provide better care and education for their patients. This can be particularly helpful amongst primary care physicians, who patients develop a longitudinal relationship with to help manage their chronic medical conditions. To the best of our knowledge, there is a paucity of information about assessingMDI technique knowledge in an Internal Medicine residency training program.

Impact Statement: Education on metered-dose inhaler training to primary care physicians can enhance patient management discussions and prevent severe asthma exacerbations in marginalized communities.

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Methodology

Study Design,Setting and Recruitment:

The proposed pre-post interventional study was a quality improvement project among residents (participants) in Montefiore Medical Center's Internal Medicine Residency Program in Bronx NY. **A qualitative study using open-ended surveys via questionnaires was implemented to better assess residents'knowledge of the MDI technique.**Recruitment occurred during the residents' mandatory ambulatory 2-week block rotation whichrecurs on a traditional 6+2 schedule. Residents were recruited in person and asked whether they would like to participate in a QI initiative. Before participation in the teaching session, consent was obtained for inclusion of data related toparticipant completion of pre and post-session surveys on inhaler technique.

Study Population:

Our population wasInternal Medicine residents in their first (PGY-1), second year (PGY-2), or third year (PGY-3) of training who were recruited during their curricular ambulatory rotations. A convenience sample of 20% of all (n=150) PGYInternal Medicine residents at Montefiore Medical Center, Bronx NY were selected at our institution and enrolled. There were no exclusion criteria for this study. All responses were recorded in a spreadsheet thatidentifiedparticipants. This spreadsheet was password-protected to ensure it was only accessible by Key Personnel approved by the IRB (IRB Number: 2022-14004).

Outcome measures:

The study focuses on several key aspects related to inhaler technique knowledge and assessment among residents. Residents were assessed on their comfort and ability to recognize key steps of the MDI technique which included: shaking the inhaler for 5 seconds,

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sealing around the mouthpiece, deep inhalation, holding the breath for 10 seconds, and waiting 30 seconds between puffs if a second puff is needed.

To do so, residents were given a pre and post-survey. Pre-survey questions focused on frequency and method of clinical demonstration and assessments. Residents were asked how often they assess patient MDI technique in the following scenarios: when they first prescribe an MDI to a patient, when a patient's asthma is not well controlled, and at every clinic visit. To better characterize assessment, they were questioned on whether they ask patients for a verbal description of how they use the MDI, and if they use the MDI that the patient brought to the appointment versus a placebo MDI. Post-survey questions centered around resident perceptions of clinic barriers to assessment and teaching of inhaler use and their year in post-graduate training.

Study Intervention:

The training session consisted of giving a demonstration on how to use an MDI and the post-training survey was provided immediately after the training session. One training session offered an opportunity for faculty and residents to bolster how they offer MDI education to their patients. Surveys before (Appendix 1) and after (Appendix2) MDI technique trainingwere provided while focusing on trainee knowledge, previous exposure, and confidence in teaching MDI technique in the clinic.

Statistical Analysis:

Participant characteristics were described using descriptive statistics. Chi-square or Fisher's exact test were used to determine whether participant characteristics differed for those previously taught MDI. Unadjusted linear regression was performed to determine whether the correct number of MDI steps before or after training differed based on whether someone was previously taught MDI technique prior to this study's training session. The Wilcoxon signed-rank

test was used for matched pairs, examining the change in correct number of MDI steps from before to after training, for all participants, those not previously taught MDI technique, and those previously taught MDI technique.To examine which participant characteristics were related to the change in number of correct MDI steps from before to after training, the independent samples t-test was used for dichotomous categorical variables with equal variance (or the non-parametric alternative Wilcoxon Rank Sum test if unequal variance) and analysis of variance (ANOVA) was used for categorical variables with three or more levels. Statistical analysis was performed with STATA SE 17.0 (College Station, TX).

Results

Participants:

All participants (N=30) completed both the pre and post-training intervention survey. Table 1 highlights the distribution of residents (N=30) that participated in the session amongst each post-graduate year and whether associations differed on previously being taught the MDI technique. Equal proportions were recruited each year, with a slight predominance of male participation (57%), and most participants (n=21) were previously not taught the MDI technique. There were 9participants who were previously taught the MDI technique. Gender and residency year did not differ by whether someone was previously taught the MDI technique or not (Table 1) p-value.

***Survey*:**

At baseline, while most resident respondents believed they could teach the technique verbally (67%), no one was confident in assessing the technique (0%) nor providing a demonstration (0%) (Table 2). Those who reported previously receiving MDI teaching had a 1.68 point higher number of correct MDI steps at baseline before this study's training as demonstrated on the pre-

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survey(beta=1.68, 95% CI [0.15, 3.22], p=0.03). However, there was no difference in the number of correct MDI steps post-training by whether one was previously taught the MDI technique (beta=0.21, 95% CI [-0.70, 1.11], p=0.65). Before training in the pre-survey, nine residents (two PGY-1 residents, four PGY-2 residents, and three PGY-3 residents) reported having escalated asthma therapy before assessing proper technique, but it is unclear whether this was due to knowledge gaps, which presumably should not have existed as they had received MDI training in the past.

There was an average three-point improvement in the correct number of MDI steps after training (Figure 1, p<0.01). There was a significant improvement in the correct number of MDI steps from pre to post-training in this study for all participants (p<0.01), those not previously taught MDI technique (p<0.01), and those previously taught MDI technique (p<0.01) (Table 3). When examining whether the change in MDI score from pre to post-training differed by participant characteristics, there was no difference in score change by gender (p=0.58), residency class year (p=0.18), nor previously being taught MDI technique (p=0.13).

Discussion

A total of 30 Internal Medicine residents were surveyed and were evenly distributed across class years (PGY-1: 27%, PGY-2: 37%, PGY-3: 37%). After one session, the average correct MDI steps listed increased from 3.6 to 6.6 out of 8 (p<0.01), with significant improvement regardless of prior training (p<0.01). Most(21/30) had not received prior MDI technique training. Of the 9 previously trained, none(0%) felt confident in assessment or demonstration, though 67% felt they could verbally teach. There is little data regarding their previous training and why they were trained. Changes were not linked to gender, class year, or prior training (p=0.58, p=0.18, p=0.13 respectively). **Additionally, qualitative feedback from trainees to understand their perspectives on the training's effectiveness and any challenges they**

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may have faced was never collected and could have served as valuable information in medical education practice.

This study underscores the impact of a single MDI training session on enhancing clinical knowledge among Internal Medicine residents. A recent systematic review has shown that patient inhaler technique has not improved over the past 40 years, yet providers can still feel uncomfortable teaching technique(16). Among our study participants, nine noted they did not feel confident in assessing or demonstrating the MDI technique despite previous exposure. Inadequate inhaler education raises concerns about poor clinical decision-making. We observed that a subset of residents had reported escalating asthma therapy before assessing the patient's MDI technique. MDI knowledge extends beyond various healthcare specialists who are part of medical management. A few previous studies have compared the inhaler technique of different types of medical professionals, with some studies showing no differences between the groups(9)and some studies showing that respiratory therapists and nurses performed better than other occupations(17,18). It is essential to educate as many members of the healthcare team as early as possible before they can then educate their patients.

A total of 30 Internal Medicine residents participated in sessions focusing on the Metered Dose Inhaler (MDI) technique. The distribution across postgraduate years showed no significant variations in gender or residency year and these findings are consistent with previous studies exploring the effect of gender on inhaler misuse(12). Moreover, there were no statistically significant differences noted with prior MDI training status. In other studies, demographics such as age, level of education, and seniority have also been found not to play a role in a provider's MDI technique knowledge and assessment(13). Healthcare providers across different training levels have been noted to teach technique in the clinical setting despite having an overall poor baseline of technique themselves(14). While providers understand the importance of inhaler

technique, overall competence is related to a combination of education and familiarity with its practice(15).

One session of MDI training helps to improve residents' proficiency with knowledge regarding use, but reinforcement is necessary. Our analysis revealed an improvement in the MDI technique knowledge base(based on steps correctly listed) post-training for all participants, regardless of prior training status. These findings align with previously reported brief educational interventions focused on refining healthcare personnel's ability to use and instruct MDI technique(11). This need for re-education to improve resident clinical skillhas been seen with other procedures such as paracentesis, lumbar puncture, and central venous catheterizations(19,20). Moreover, inhaler misuse still is common among residents, which highlights the need for sustained educational efforts in addition to just one re-training session(21).

Limitations of this study include the small sample size of 30 residents from the Montefiore Medicine Internal Medicine Residency program. This may limit the generalizability of results to other medical specialties or to individuals who practice in other geographical regions. Clinical errors with MDI technique have been well documented and span distinct specialties of healthcare professionals across the world such as nurses in China(22), thereby warranting interventions that can be employed universally. In addition, this study relies on self-reported data from participants on the pre-and post-intervention surveys, which could introduce recall bias and compromise the potential accuracy of study results. Surveys were also taken immediately before and after the training sessions. This is further complicated by the heterogeneity of inhaler techniques that can confound the assessment as well as the optimization process in the clinic(23). More follow-up studies are needed to determine if this improvement in knowledge of MDI technique persists beyond the short term and into patient care. Some studies suggest that MDI counseling in every clinic visit is necessary to maintain the

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recommended technique(24), thus warranting a more streamlined process to continue to bolster education amongst healthcare professionals. MDI technique error has been particularly noted in healthcare professionals who lacked technique review forover a year and had a poor to average fund of knowledge surrounding technique(25). Innovative strategies for both patient and clinician education are crucial to mitigate the asthma burden in the community.

Forming a consistent and reliable system of continuous medical education regarding MDI technique may bolster physician knowledge in MDI technique and has the potential to improve patient's clinical outcomes. The identified gaps and the persistent misuse of inhalers, even among those previously exposed to training, suggest the need for ongoing and innovative educational strategies. Digital learning tools can make the learning process more flexible and have been increasingly incorporated into many residency programs post-pandemic to help facilitate ease of access to learning resources(26). A recent study explored tablet-based training videos for both physicians and patients and found an improvement in MDI technique after being assessed immediately post-training, 3 months after, and 6 months after the training(27). Another study also demonstrated that multimedia-basedtechniqueswereas effective as in-person training for the MDI technique(28). Future studies can consider incorporating digital education tools, such as web interventions or mobile apps, to further enhance residents' proficiency in MDI techniquesand improve patient care outcomes.**Additionally, reinforcing excellence such as use of visual aids, hands-on training, and regular evaluation of trainees via audit and feedback are other modalities that can be employed to encourage further reinforcement.**

It is important to point out that this study had both strengths and limitations. The small sample size might not accurately reflect all internal medicine residents and demographic information was not collected other than gender. This could limit the generalizability across other Internal Medicine Resident training programs. Furthermore, residents were not reassessed after one training session. However, a strength of the study was that the questionnaire provided clear and interpretable results.Education and reinforcement areneeded. The practical applications of the findings will not only bolster residents' knowledge but also provide optimal care for patients with asthma.

Conclusion:

Medical education surrounding metered-dose inhaler training during residency can impact the trainee knowledge base, which can help their discussions with their patients' management of

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their asthma. While one session led to significant improvement in resident knowledge, additional sessions might be warranted for continuous reinforcement. Digital learning tools can help bridge gaps in clinical knowledge.

Ethical Approval:

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

Consent

As per international standards or university standards, Participants' written consent has been collected and preserved by the author(s).

Conflict of interests The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author, SS. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

Disclaimer (Artificial intelligence)

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Details of the AI usage are given below:

1.

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References

1. Lugogo N, Judson E, Haight E, et al. Severe asthma exacerbation rates are increased among female, Black, Hispanic, and younger adult patients: results from the US CHRONICLE study. *J Asthma*. 2022;59(12):2495-2508. doi:10.1080/02770903.2021.2018701
2. Pala D, Pagán J, Parimbelli E, Rocca MT, Bellazzi R, Casella V. Spatial Enablement to Support Environmental, Demographic, Socioeconomics, and Health Data Integration and Analysis for Big Cities: A Case Study With Asthma Hospitalizations in New York City. *Front Med (Lausanne)*. 2019;6:84. Published 2019 Apr 24. doi:10.3389/fmed.2019.00084
3.Kaur S, Rosenstreich D, Cleven KL, et al. Severe asthma in adult, inner-city predominantly African-American and latinx population: demographic, clinical and phenotypic characteristics. *J Asthma*. 2022;59(12):2341-2351. doi:10.1080/02770903.2021.2010748
4.J, Abraham R, Toh J, et al. The association of environmental, meteorological, and pollen count variables with asthma-related emergency department visits and hospitalizations in the Bronx. *J Asthma*. 2019;56(9):927-937. doi:10.1080/02770903.2018.1514627
5.Melani AS. Inhaler technique in asthma and COPD: challenges and unmet knowledge that can contribute to suboptimal use in real life. *Expert Rev Clin Pharmacol*. 2021;14(8):991-1003. doi:10.1080/17512433.2021.1929922
6.Samady W, Rodriguez VA, Gupta R, Palac H, Karamanis M, Press VG. Critical Errors in Inhaler Technique among Children Hospitalized with Asthma. *J Hosp Med*. 2019;14(6):361-365. doi:10.12788/jhm.3195
7.Maricoto T, Santos D, Carvalho C, Teles I, Correia-de-Sousa J, Taborda-Barata L. Assessment of Poor Inhaler Technique in Older Patients with Asthma or COPD: A Predictive Tool for Clinical Risk and Inhaler Performance. *Drugs Aging*. 2020;37(8):605-616. doi:10.1007/s40266-020-00779-6
8.Ethan Karle, Tarang P. Patel, Jason Zweig & Armin Krvavac (2020) Understanding the Knowledge Gap and Assessing Comfort Level among Healthcare Professionals Who Provide Inhaler Education, COPD: Journal of Chronic Obstructive Pulmonary Disease, 17:2, 197-204, DOI:10.1080/15412555.2020.1746251
9.Pérez-Malagón CD, Barrera-Rodriguez R, Medina-Casillas NG, Casillas Muñoz JP, Silva-Sánchez G, Macías-Limón C. Competence in metered-dose inhaler technique among healthcare workers of three general hospitals in Mexico: it is not good after all these years. *Adv Respir Med*. 2021;89(1):8-14. doi:10.5603/ARM.a2021.0027
10.Sakrani NF, Hussein SE, Borg M, Konstantinopoulou S. Assessing and addressing barriers towards MDI use in acute asthma exacerbations at a tertiary pediatric ED in the United Arab Emirates. *Int J PediatrAdolesc Med*. 2022;9(1):41-45. doi:10.1016/j.ijpam.2021.03.004
11.Kellman DA, Iserson KV, Levy RD, McIntosh B, Maxwell Y. Brief Education Improves Proper Metered-Dose Inhaler Use. *J Emerg Med*. 2020;58(4):667-672. doi:10.1016/j.jemermed.2020.02.011

12.Ocakli B, Ozmen I, Tuncay EA, et al. Influence of Gender on Inhaler Technique. *Respir Care*. 2020;65(10):1470-1477. doi:10.4187/respcare.06917
13.Pérez-Malagón CD, Barrera-Rodriguez R, Medina-Casillas NG, Casillas Muñoz JP, Silva-Sánchez G, Macías-Limón C. Competence in metered-dose inhaler technique among healthcare workers of three general hospitals in Mexico: it is not good after all these years. *Adv Respir Med*. 2021;89(1):8-14. doi:10.5603/ARM.a2021.0027
14.Karle E, Patel TP, Zweig J, Krvavac A. Understanding the Knowledge Gap and Assessing Comfort Level among Healthcare Professionals Who Provide Inhaler Education. *COPD*. 2020;17(2):197-204. doi:10.1080/15412555.2020.1746251
15.Cvetkovski B, Hespe C, House R, et al. Exploring General Practitioners' Preferences and Experience with Respiratory Inhaler Devices. *Pulm Ther*. 2022;8(3):283-296. doi:10.1007/s41030-022-00197-6
16.Sanchis J, Gich I, Pedersen S; Aerosol Drug Management Improvement Team (ADMIT). Systematic Review of Errors in Inhaler Use: Has Patient Technique Improved Over Time?.*Chest*. 2019;150(2):394-406. doi:10.1016/j.chest.2016.03.041
17.Al-Otaibi HM. Evaluation of health-care providers' knowledge in the science of aerosol drug delivery: Educational sessions are necessary. *J Family Community Med*. 2020;27(1):62-66. doi:10.4103/jfcm.JFCM_138_19
18.Spaggiari S, Gehri M, Di Benedetto L, et al. Inhalation technique practical skills and knowledge among physicians and nurses in two pediatric emergency settings. J Asthma. 2021;58(2):190-196. doi:10.1080/02770903.2019.1674329
19.Sall D, Warm EJ, Kinnear B, Kelleher M, Jandarov R, O'Toole J. See One, Do One, Forget One: Early Skill Decay After Paracentesis Training. *J Gen Intern Med*. 2021;36(5):1346-1351.doi:10.1007/s11606-020-06242-x
20.Meliagros P, GarberA, Sadr N, Forrest R, Qayyum R. Competency-basedassessment of procedural skills in resident training. *JHosp Med*. 2023;18(8):703-718.doi:10.1002/jhm.13167
21.Resnick DJ, Gold RL, Lee-Wong M, Feldman BR, Ramakrishnan R, Davis WJ. Physicians' metered dose inhaler technique after a single teaching session. *Ann Allergy Asthma Immunol*. 1996;76(2):145-148. doi:10.1016/S1081-1206(10)63413-8
22.Xie N, Zheng Z, Yang Q, Li M, Ye X. Nurses in China lack knowledge of inhaler devices: A cross-sectional study. *Front Pharmacol*. 2023;14:1152069. Published 2023 Apr 7. doi:10.3389/fphar.2023.1152069
23.De Vos R, Hicks A, Lomax M, et al. A systematic review of methods of scoring inhaler technique. *Respir Med*. 2023;219:107430. doi:10.1016/j.rmed.2023.107430
24.Elgendy MO, Hassan AH, Saeed H, Abdelrahim ME, Eldin RS. Asthmatic children and MDI verbal inhalation technique counseling. *PulmPharmacol Ther*. 2020;61:101900. doi:10.1016/j.pupt.2020.101900
25.Barbara SA, Kritikos V, Price DB, Bosnic-Anticevich S. Identifying patients at risk of poor asthma outcomes associated with making inhaler technique errors. *J Asthma*. 2021;58(7):967-978. doi:10.1080/02770903.2020.1742353
26.Abovarda A, Vallo Hult H, Master Östlund C, Pålsson P. E-learning as Part of Residency Education. *Stud Health Technol Inform*. 2023;302:496-497. doi:10.3233/SHTI230188
27.Mulhall AM, Zafar MA, Record S, Channell H, Panos RJ. A Tablet-Based Multimedia Education Tool Improves Provider and Subject Knowledge of Inhaler Use Techniques. *Respir Care*. 2017;62(2):163-171. doi:10.4187/respcare.05008
28.Cilekar S, Cosgun IG, Ogan N, et al. Effectiveness of multimedia-assisted training on inhaler usage technique, which is the optimum technique?.*EurRev Med PharmacolSci*. 2023;27(20):9499-9509. doi:10.26355/eurrev_202310_34123

Appendix 1: Pre-Survey Questionnaire

Please indicate your current level of training (ie. PGY2)

1)Were you ever taught the proper metered-dose inhaler (MDI) technique?

YES **NO**

2)How confident are you in teaching proper MDI technique to an asthma patient?

Very Confident **Somewhat Confident** **Not Confident**

3) Have you ever considered improper MDI use as a reason for asthma treatment failure?

YES **NO**

4)Have you ever escalated asthma therapy without assessing proper MDI technique?

YES **NO**

5)Do you teach/demonstrate metered-dose inhaler (MDI) technique in your clinic patients:

a) When you first prescribe the inhaler to the patient?

YES **NO**

b) When a patient's asthma is not well-controlled?

YES **NO**

c) At every visit, regardless of asthma control?

YES **NO**

6)Do you teach MDI technique to your clinic patients by:

a) Providing a verbal description and/or showing a video on how to use a MDI?

YES **NO**

b) Providing a demonstration on an MDI that the patient brought to the appointment?

YES **NO**

c) Providing a demonstration on a placebo/demo MDI?

YES **NO**

7)Do you assess MDI technique in your clinic patients:

a) When you first prescribe the inhaler to the patient?

YES **NO**

b) When a patient's asthma is not well-controlled?

YES **NO**

c) At every visit regardless of asthma control?

YES **NO**

8) Do you assess MDI technique in your clinic patients by:

a) Asking the patient to verbally describe how to use a MDI

YES **NO**

b) Asking them to demonstrate an MDI that they brought to the appointment?

YES **NO**

c)Providing a demonstration on a placebo/demo MDI?

YES **NO**

9)How often do you ensure that an asthma patient has a peak flow monitor at home?

None of the time **Some of the time** **Most of the time** **All of the time**

10) When you see an asthma patient in clinic, how often do you discuss peak flow monitoring?

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None of the time **Some of the time** **Most of the time** **All of the time**

11) On the back of this page, to the best of your ability, please briefly list the appropriate steps a patient should follow to self-administer two puffs of a metered-dose inhaler.

Appendix 2: Post Survey Questionnaire

Post-Intervention Survey Questions

Please indicate your current level of training (ie. PGY2)

1) Did you know that the current asthma guidelines suggest assessing MDI technique in asthmatic patients at every clinic visit?

YES **NO**

2) After this intervention, how likely are you to teach/demonstrate proper MDI use during your future clinic visits with asthma patients?

Not Likely **Somewhat Likely** **Very Likely**

3) After this intervention, how likely are you to assess proper MDI use during your future clinic visits with asthma patients?

Not Likely **Somewhat Likely** **Very Likely**

4) To the best of your ability, please write the appropriate steps that a patient should follow to self-administer two puffs of a metered-dose inhaler (MDI). Please number your responses, and limit each step to a maximum of five words.

5) Identify up to three barriers that may deter you from teaching and/or assessing proper MDI technique during your clinic visits with asthma patients:

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6) Please list any suggestions on interventions in the ambulatory setting that may improve resident ability to teach and assess proper MDI technique during clinic visits with asthma patients:

fig 1 Average number of MDI Steps out of 8 correctly identified by residents before and after MDI training. Participants correctly identified 3.60 steps (SD. 2.01) before intervention and 6.63 steps(SD 1.10), with P<0.001*

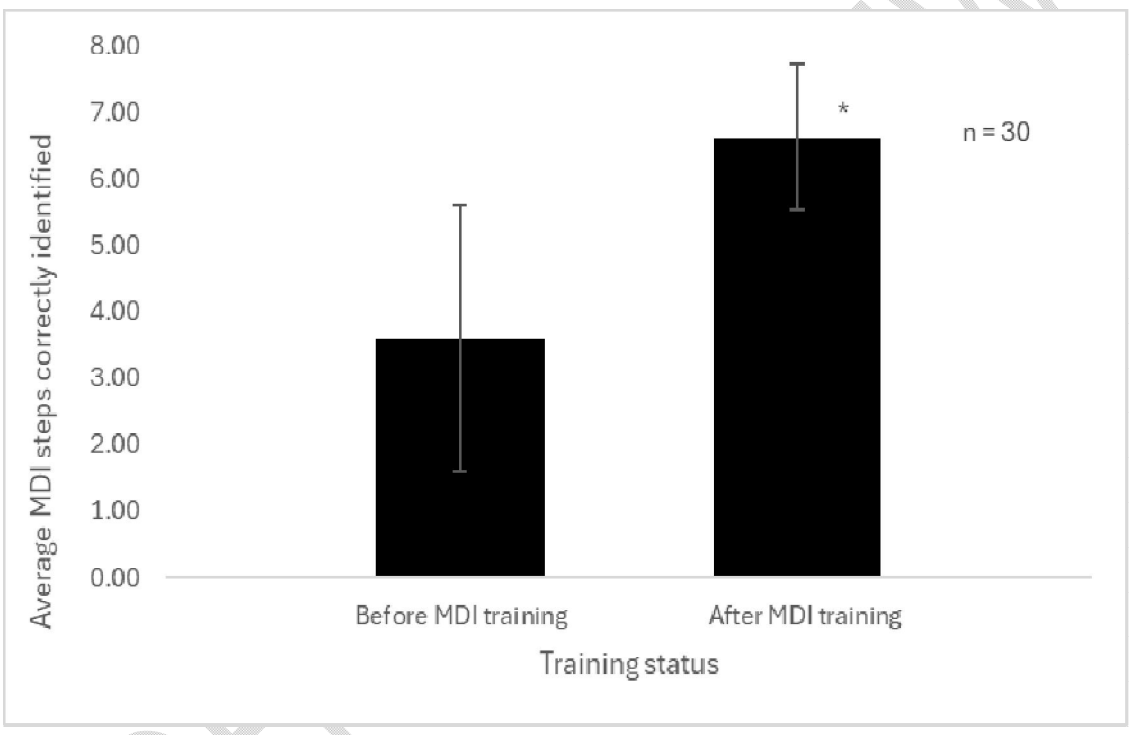

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Table 1. Baseline demographics of all participants and whether these characteristics differed if participants were previously taught MDI technique.

	Total N=30	**Not taught MDI technique previously N=21**	**Taught MDI technique previously N=9**	**P value**
Gender, n (%)				0.94
Male	17 (57)	12 (57)	5 (56)	
Female	13 (43)	9 (43)	4 (44)	
Residency class, n (%)				>0.99
PGY-1	8 (27)	6 (29)	2 (22)	
PGY-2	11 (37)	7 (33)	4 (44)	
PGY-3	11 (37)	8 (38)	3 (33)	

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Table 2. Baseline Proficiency Assessment of Sub-Cohort Previously Trained in MDI Technique

	Taught MDI technique previously N=9
Confident in assessing technique? n (%)	
No	9 (100)
Yes	0 (0)
Can you teach technique verbally? n (%)	
No	3 (33)
Yes	6 (67)
Can you provide demonstration? n (%)	
No	9 (100)
Yes	0 (0)

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Table 3 Change in the correct number of MDI steps from pre to post-training.

	Starting score	**Ending score**	**P value**
All participants	3.6 ± 2.0	6.6 ± 1.1	<0.01
Not taught MDI technique previously	3.1 ± 2.1	6.6 ± 1.2	<0.01
Taught MDI technique previously	4.8 ± 1.0	6.8 ± 0.7	<0.01

UNDER PEER REVIEW

Author's contribution

- SS - conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, validation visualization, writing – original draft, writing – review and editing
- JR - conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, validation visualization, writing – review and editing
- AH - conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, validation visualization, writing – review and editing
- DL - conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, supervision, validation visualization, writing – review and editing
- KK - investigation, methodology, resources, validation visualization, writing – original draft, writing – review and editing
- AP - investigation, methodology, resources, validation visualization, writing – original draft, writing – review and editing
- AB - data curation, formal analysis, investigation, methodology, project administration, resources, validation visualization, writing – original draft, writing – review and editing
- LR - data curation, investigation, methodology, project administration, resources, validation visualization, writing – original draft, writing – review and editing
- SJ – conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, supervision, validation visualization, writing – original draft, writing – review and editing

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