

## ORIGINAL ARTICLE

### COMPETENCE OF PEDIATRIC RESIDENTS AND NURSES IN METERED-DOSE INHALER TECHNIQUES FOR ASTHMA PATIENTS AT TIKUR ANBESSA SPECIALIZED HOSPITAL

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#### ABSTRACT

**Introduction:** A Metered Dose Inhaler (MDI) is a device containing dissolved or suspended drugs to deliver drugs for pulmonary diseases efficiently. However, studies in Ethiopia show low competency among health professionals. Thus, we assessed the competency of residents and nurses working in a tertiary hospital.

**Methods:** From June to September 2022, 181 pediatrics and child health department residents and nurses participated in a pretested questionnaire and MDI technique practice. The knowledge score for residents and nurses was determined based on correct answers to questions from 0 to 6 for residents and 0 to 5 for nurses. Good knowledge was defined as a score of 80–100%, moderate knowledge from 60–79%, and poor knowledge from <60% of the total score. The good practice was  $\geq 7$  from 11 and all essential steps, while the poor practice was <7 of the total score and skipped essential steps. The chi-square or Fisher exact test was employed to compare groups as appropriate. The 95% confidence interval and a p-value of 0.05 were used to determine statistical significance. .

**Results:** Of the 181 study participants, 103 (56.9%) were residents. The participants' mean age was 32. MDI technique knowledge was poor for more than half of the residents (52.4%) and 46.4% of the nurses. Twenty-six (14.4%) of participants practiced the MDI technique steps, scoring 7 out of 11 steps. However, only 3.3% practiced the technique correctly. Whereas only 5.8% of residents and 0% of nurses practiced the essential steps of the MDI technique. When using a new inhaler drug, nearly half of the participants (47%) did not assess the patients' practice.

**Citation :** Tafa G., Etissa E. K., Kebede R. A. Competence of pediatric residents and nurses in metered-dose inhaler techniques for asthma patients at Tikur Anbessa Specialized Hospital. *Ethiop J Pediatr Child Health*. 2023;18 (2):163-177

**Submission date:** 23 November 2023 **Accepted:** 20 December 2023 **Published:** 29 December 2023

**Conclusion:** *Healthcare professionals' competency in performing the MDI technique is low. Appropriate training programs are needed to enhance their ability to use inhaled devices and ensure successful drug delivery.*

**Keywords:** Knowledge, Practice, Asthma, Metered Dose Inhaler, Competency, TASH

## Introduction

Asthma is a serious health issue that affects people of all ages. It is estimated that 300 million people are affected worldwide, according to the Global Initiative for Asthma Network (GINA) 2023. Asthma keeps putting an unbearable burden on the healthcare system and society because it results in lost productivity at work and family disruption (especially in the case of pediatric asthma). Around the world, asthma is still a leading cause of mortality. About 96% of deaths in low- and middle-income countries are related to asthma (1). Despite reduced cases in low and middle-income countries, higher deaths are due to healthcare-seeking behavior, limited resources, poor adherence to asthma medications, and limited diagnosis resources. (2, 3).

In Ethiopia, non-communicable diseases caused 711 deaths per 100,000 people, according to the Global Burden of Disease, making them the main cause of age-standardized mortality rates. About 5% of deaths result from chronic respiratory diseases (4). In a study conducted in 2015 in Addis Ababa, Ethiopia, in over 20 primary schools, among children aged 6-7 years old, the prevalence of ever wheezing was found to be 13.1% (5). The prevalence of wheezing was 11.5% in a study of 1-year-old children in a birth cohort from Butajira, Ethiopia, collected from the mother via an interview-administered

questionnaire (6). A recent study in Addis Ababa found 31% of children with uncontrolled asthma, with inappropriate inhaler technique significantly affecting their asthma control (7).

In a recent GINA research, children account for 30–40% of all severe asthma exacerbations (2). Inhaled corticosteroid-containing medication lowers the likelihood of exacerbation. Poor inhalation technique is however one modifiable factor that frequently contributes to poor asthma management (8). Utilizing multiple techniques for correct inhaled drug delivery is crucial for asthma control. MDIs are essential for effective drug administration for pulmonary diseases, consisting of a canister, metering valve, and actuator mouthpiece. They provide dissolved or suspended medications for accurate dosing and aerosol conveyance (9).

A systematic review of 55 studies published between 1975 and 2014 found that only 15.5% of Health Care Professionals (HCPs) inhaler proficiency scores were considered accurate. The following errors were made most frequently when using MDIs: failing to fully exhale before inhaling (75%), being uncoordinated (64%), and holding the breath after inhaling (63%) (10). A study demonstrated practical skills and knowledge among

physicians and nurses in two pediatric emergency settings in Switzerland, with 49% mastering it and 34% almost perfecting it. Nurses demonstrated the technique better than doctors, but common errors included forgetting to shake the MDI between puffs and placing the patient incorrectly (11). Evaluation of Nigerian pediatric residents' knowledge of the metered MDI device technique and usage shows that of the participants, only 14.5% had a good knowledge score (12). In Ethiopia, a significant proportion of patients with asthma suffer from poor control of asthma symptoms. Improper inhalant technique is identified as a risk factor for poor asthma control (13-15). Health professionals in Ethiopia are demonstrating inadequate competency in inhalant technique, as evidenced by studies on drug dispensers, indicating a lack of knowledge in proper inhalation device usage. (16, 17).

Numerous studies have found that Health Care Workers (HCWs) have poor MDI techniques (18-22). This study aimed to evaluate the competency and techniques of pediatric residents and nurses at Tikur Anbessa Specialized Hospital (TASH) in the proper administration of inhaled medications, as their successful use requires both practical skills and theoretical knowledge for optimal pulmonary disease management.

## **Method and materials**

### **Study area and period**

The study was conducted at TASH, Ethiopia's largest referral and teaching hospital, from June 1 to September 30, 2022. The hospital,

located in Addis Ababa, offers undergraduate and postgraduate teaching services, and treats around 400,000 patients annually having over 760 beds. With 123 pediatric residents and 92 pediatric staff nurses, the hospital provides care in various wards, including emergency, Pediatric Intensive Care Unit (PICU), chest clinic, and wards. Chest clinics, pediatrics wards, and emergencies were the study settings where MDI techniques were frequently used.

### **Study design**

A hospital-based, cross-sectional study was conducted.

### **Source and study Population**

- Source population

All pediatrics residents and nurses working at the Department of Pediatrics and Child Health in Tikur Anbessa Specialized Hospital.

- Study population

All enrolled pediatrics residents, first to final year, and all nurses who are working at the chest clinic, emergency ward, pediatric ICU, and pediatric wards.

### **Inclusion and exclusion criteria**

- Inclusion criteria

All pediatric residents and nurses who were willing to participate in this study and who had given written consent were included in the study.

- Exclusion criteria

Residents who were on study leave and nurses on annual leave.

### **Sample size determination**

Using the single population proportion

calculation, the sample size was calculated with a 95% confidence level, a 5% margin of error, and a 50% p-value (because no previous studies had been conducted). The sample size was determined to be 384. There were a total of 215 nurses and residents. The population reduction calculation was used because there were fewer than 10,000. With a 10% non-response rate added to the calculated minimum sample size of 138, a total sample size of

152 was calculated. However, every nurse and resident who met the requirements for inclusion was included. Hence, 181 was the sample size used.

**Sampling technique and procedure**

There were 215 residents and nurses. All residents and nurses who met the inclusion criteria were included in our study. We ended up with 181 samples.

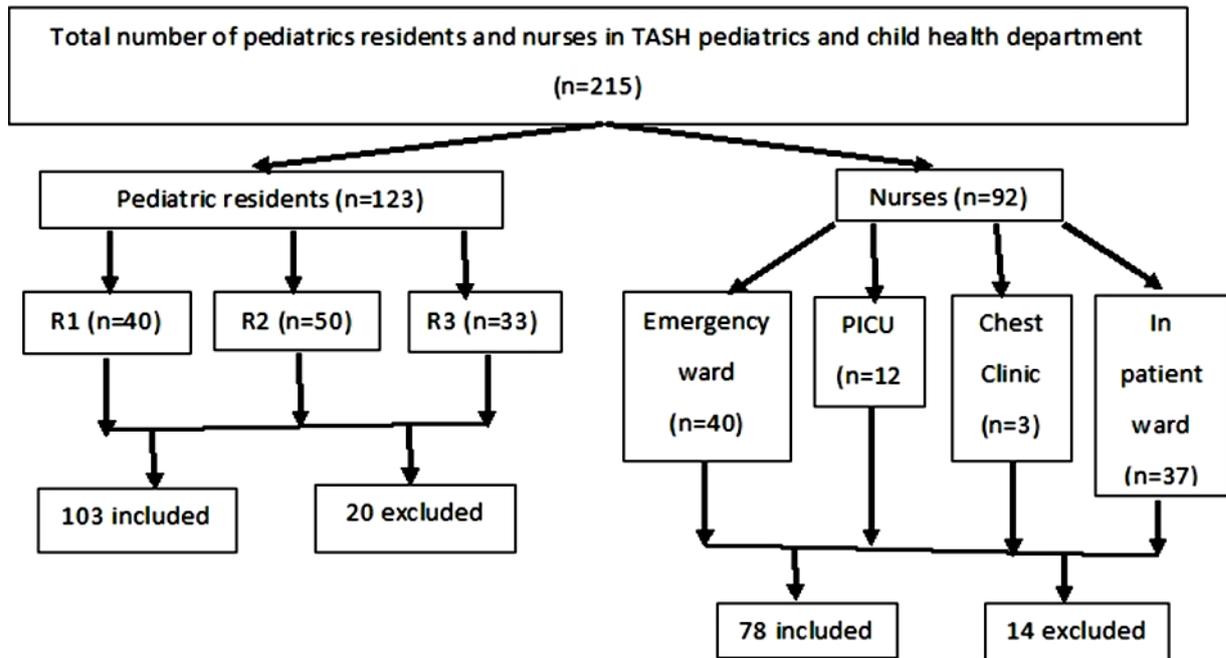


Figure 1: Flow diagram of study participant selection illustrating participants.

**Study variables**

• **Dependent variable**

Competency of health professionals towards MDI techniques.

• **Independent variables**

Socio-demographic characteristics (Age, sex, self-asthma diagnosis)

Professional characteristics (year of experience, level of education, years in Residency, and nurses

Training on MDI, source of information for MDI use

Attachment to the chest clinic

Knowledge

Practice

**Operational definitions**

Based on the correct answers to the 6 and 5 knowledge questions, respectively, the knowledge score, ranging from 0 to 6 for residents and 0 to 5 for nurses, was determined

using Bloom's cut-off point, and the practice score, which ranged from 0 to 11 classified according to NAEPP (National Asthma Education and Prevention Program of America) (23).

- Good knowledge = 80-100% of the total score
- Moderate knowledge = 60-79% of the total score
- Poor knowledge = <60% of the total score
- Good demonstration =  $\geq 7$  from 11 and all essential steps step 1,2,5,6,7,8
- Poor demonstration = < 7 of the total score and if essential steps
- Competence: - is the knowledge that enables a person to practice a concept (MDI techniques).

#### **Data collection procedures, and quality assurance**

The data was obtained using a self-administered questionnaire written in English. The evaluation tool was adapted from the National Asthma Education and Prevention Programs of America (NAEPP) step criteria for administering a metered dose inhaler to score the subjects' practice level in using MDIs (23). Study subjects were to be given an MDI device after they completed the knowledge and were asked to practice the technique. The healthcare professionals were asked to practice the technique as if they were telling it to a patient-facing individual.

Assessments and scoring were done by trained health professionals while the subjects were demonstrating. Data collectors were pharmacy

professionals who received two days of training on MDI technique demonstrations. They simply observed the technique and ticked off a checklist while offering a sample of puff. Scores were assigned as "1" for correctly demonstrated steps and "0" for steps that were incorrectly demonstrated or skipped. Inhalational technique adequacy was demonstrated by their ability to demonstrate all the essential steps (Steps 1, 2, 5, 6, 7, and 8), a total score of 7 or more, and those who did not demonstrate all the essential steps correctly and scored less than 7 were considered to have poor inhalational technique practice.

For the knowledge portion, residents and nurses were assessed separately. It had 6 questions for residents and 5 questions for nurses, measured by the Bloom scale. Those who scored less than 60% were considered poor, 60% to 79% were considered moderate, and above 80% were considered good.

Data collectors and supervisors underwent two-day training on basic data collection skills, with structured checklists tested on 5% of the sample. Pre-test problems were corrected, and each question was properly coded. The principal investigator provided continuous supervision during both pre-test and data collection periods, and data was checked for consistency and completeness daily.

#### **Data management and analysis**

The collected data on Open Data Kit (ODK) version 1.25.2 was exported directly into Statistical Package for Social Science (SPSS) version 25.0 for statistical analysis after each

completed form was checked for completeness. Continuous variables were reported as the mean with the standard deviation (SD), whereas categorical variables were presented as frequency and percentages. The Chi-square or Fisher exact test for expected frequency less than 5 was used to compare groups for categorical variables. Statistical significance was established using a p-value of <0.05 and a 95% confidence interval. Text and tables were used to present the findings.

## Results

### Demographic data, MDI, and work experience

The study involved 181 participants, with 114 (63.0%) being male and a mean age of  $31.8 \pm$

3.5 years. Over half were residents, with 44 (42.7%) being year II residents and 38 (48.7%) being BSc nurses. Nearly one-third had a service year of 5 years or more. Only 11.6% received MDI technique training, with over half learning from books and articles. 53% of participants assessed patients' MDI technique when using new inhaler drugs or on visits, while 85 (47%) didn't. Nearly 25% of participants said it was easy and patients could do it. (Table 1)

Table 1: Baseline characteristics of pediatric residents and nurses at TASH.

Variables	Categories	Frequency (%)
Age	20 to 29 years	49 (27.1)
	30 to 39 years	125 (69.1)
	40 to 50 years	7 (3.9)
Sex	Male	114 (63.0)
	Female	67 (37.0)
Profession	I. Resident	103 (56.9)
	A. Year 1	34 (33.0)
	B. Year 2	44 (42.7)
	C. Year 3	25 (24.3)
	II. Nurse	78 (43.1)
	A. Bsc	38 (48.7)
B. Diploma	25 (32.1)	
D. Masters	15 (19.2)	
Year of experience	< 5 years	118 (65.2)
	≥ 5 years	63 (34.8)
Have asthma	Yes	4 (2.2)
	No	177 (97.8)
Assigned to the chest clinic	Yes	51 (28.2)
	No	130 (71.8)
Training on MDI technique	Yes	21 (11.6)
	no	160 (88.4)
Acquired the skill (Multiple responses)	Scientific societies	11 (3.8)
	Workshops organized by pharmaceutical industries	62 (21.5)
	Reading articles or books	100 (55.2)
	Reading the leaflet	76 (26.5)
	Directly from personal	39 (13.5)
Did you assess the patients' skills when they used the new inhaler drug?	Yes	96 (53)
	No	85 (47)
If you don't asses' what was your reason	I don't know myself	7 (3.9)
	It's not my job	8 (4.4)
	I guess it's easy they can do it	45 (24.9)
	Unknown	25 (13.8)

### Knowledge towards MDI

The study found that over half of residents (52.4%) and nurses (46.4%) had poor knowledge of the MDI technique. The profession had a significant effect on knowledge levels ( $P = 0.002$ ). A significant proportion of

nurses had good knowledge (11.5% versus 0% compared to residents), while a significant proportion of residents had moderate knowledge (47.6% versus 41.0% compared to nurses). (Table 2)

Table 2: Chi-square comparison of MDI technique knowledge level in TASH pediatrics residents and nurses

Variables		Knowledge level			P value
		Poor	Moderate	Good	
Profession	Residents	54(52.4%)	49(47.6%)	0(0%)	0.002
	Nurses	37(47.4%)	32(41.0%)	9(11.5%)	
Year of Residency (n=103)	Year 1	22(64.7%)	12(35.3%)	0(0%)	0.093
	Year 2	23(52.3%)	21(47.7%)	0(0%)	
	Year 3	9(36%)	16(64%)	0(0%)	
Nurse (n=78)	BSC	19(50%)	16(42.1%)	3(7.9%)	0.247
	Diploma	14(56%)	7(28%)	4(16%)	
	Masters	4(26.7%)	9(60%)	2(13.3%)	

**Practice level**

The study found that 14.4% of participants practiced the MDI technique steps, scoring 7 out of 11 steps. However, only 3.3% practiced the technique correctly. The mean  $\pm$  SD practice score for all participants was  $4.09 \pm 1.8$ , while the mean scores for residents and nurses in using the proper inhaler technique were  $3.37 \pm 0.8$  and  $2.53 \pm 0.8$ , respectively.

Whereas only 5.8% of residents and 0% of nurses practiced the essential steps of the MDI technique, with 91% of participants correctly practicing step 2 (removing the cap), 52% wrongly practicing step 7, and 82% skipping step 4 (tilt the head back slightly). (Table 3)

Table 3: Evaluation of each step practice of the MDI technique among pediatric residents and nurses at TASH.

Steps	Resident			Nurses			p-value
	Yes	No	Skipped	Yes	No	Skip	
1 * Shake the contents well	71 (68.9%)	1 (1%)	31 (30.1%)	34 (43.6%)	1 (1.3%)	43 (55.1%)	0.001
2 * Remove the cap	96 (93.2%)	3 (2.9%)	4 (3.9%)	68 (87.2%)	0 (0%)	10 (12.8%)	0.023
3 Hold the inhaler upright	52 (50.5%)	25 (24.3%)	26 (25.2%)	24 (30.8%)	32 (41%)	22 (28.2%)	0.016
4 Tilt the head back slightly	9 (8.7%)	7 (6.8%)	87 (84.5%)	2 (2.6%)	15 (19.2%)	61 (78.2%)	0.014
5 * Breath out slowly	29 (28.2%)	9 (8.7%)	65 (63.1%)	12 (15.4%)	9 (11.5%)	57 (73.1%)	0.115
6 * Open mouth with inhaler 1 to 2 inches away or in the mouth with the lips tightly sealed around it	54 (52.4%)	30 (29.1%)	19 (18.4%)	18 (23.1%)	22 (28.2%)	38 (48.7%)	0
7 * Begin breath in slowly and deeply through the mouth and actuate the canister once	29 (28.2%)	49 (47%)	25 (24.3%)	23 (29.5%)	45 (57.7%)	10 (12.8%)	0.065
8 * Hold breath for 10–20 sec	19 (18.4%)	39 (37.9%)	45 (43.7%)	6 (7.7%)	28 (35.9%)	44 (56.4%)	0.073
9 Exhale & wait one minute before the second dose	21 (20.4%)	19 (18.4%)	63 (61.2%)	9 (11.5%)	15 (19.2%)	54 (69.2%)	0.267
10 Shake again before the second dose	21 (20.4%)	23 (22.3%)	59 (57.3%)	12 (15.4%)	14 (17.9%)	52 (66.7%)	0.433
11 After use, replace the mouthpiece cover	75 (72.8%)	21 (20.4%)	7 (6.8%)	131 (72.4%)	37 (20.4%)	13 (7.2%)	0.972

A chi-square test result revealed a statistically significant difference in practice level for es-

sential steps based on profession ( $P < 0.05$ ). A statistically significant proportion of nurses had poor practice (100% versus 94.2%,  $p = 0.038$ ) compared to residents. (Table 4).

Table 4: Chi-square comparison of MDI technique practice level in TASH pediatric residents and nurses.

Variables		Practice level (with essential		
		Poor Demonstration n=175	Good demonstration n=6	P-value
Profession	Residents	97 (94.2)	6 (5.8)	0.038
	Nurses	78 (100.0)	0 (0.0)	
Year of residency	R1	33(97.1%)	1(2.9%)	0.563
	R2	40(90.9%)	4(9.1%)	
	R3	24(96%)	1(4%)	
Nurse	BSC	38(100%)	0 (0.0)	-
	Diploma	25(100%)	0 (0.0)	
	masters	15(100%)	0 (0.0)	
Work experience	< 5 years	115 (97.5)	3 (2.5)	0.421
	≥ 5 years	60 (95.2)	3 (4.8)	
Assign to chest clinic	Yes	47(92.2%)	4(7.8%)	0.054
	No	128(98.5%)	2(1.5%)	
Asthmatic	Yes	3(75%)	1(25%)	0.127
	No	172(97.2%)	5(2.8%)	
Close family with asthma	Yes	24(92.3%)	2(7.7%)	0.207
	No	151(97.4%)	4(2.6%)	
Training	Yes	20(95.2%)	1(4.8%)	0.528
	No	155(96.9%)	5(3.1%)	
Knowledge level of residents	Poor	53(98.1%)	1(1.9%)	0.100
	Moderate	44(89.8%)	5(10.2%)	
Knowledge level of nurses	Poor	37(100%)	0(0%)	-
	Moderate	32(100%)	0(0%)	
	Good	9(100%)	0(0%)	

## Discussion

Our study finding shows that the practice towards the steps of MDI technique, of 181 participants, 26 (14.4%) scored  $\geq 7$  from 11 steps. However, based on practice on essential steps for the optimum therapeutic value of MDI, only six (3.3%) study participants had adequate practice skills in metered dose inhaling, and no one got all steps right in this study, and none

of the nurses practiced all essential steps correctly.

Only six (3.3%) study participants had good practice in MDI technique. This result is comparable to a study conducted among pharmacy professionals in the towns of Mekelle and Gondar, which revealed a good practice of MDI technique, including the essential steps 2 (1.9%) and 3 (4.8%) respectively (16, 17).

However, it is substantially less than the study carried out in Oman, where 22 participants (15%) correctly completed all steps (19). The disparity could be attributed to the different health professions included in the Oman study, such as internists, emergency physicians, and pharmacists; most of them perform well.

It is perhaps not surprising that patients frequently use their device(s) incorrectly since healthcare professionals' understanding of the proper use of these devices is also poor. Only 7% of healthcare professionals, including pharmacists, could accurately demonstrate all the steps in MDI use, according to a recent UK study (24). According to one study, the under-education of patients by healthcare professionals has contributed to poor inhaler use skills among asthmatic patients (25).

Among the steps, more than half of the participants (52%) wrongly practiced step 7 (begin breathing in slowly and deeply through the mouth and actuate the canister once). According to an Iranian study, the high frequency of error was like depressing the canister. A study from Mekelle and Gondar showed step 7 was the most skipped (65% and 77%, respectively) (16, 17). The most skipped step in our study was step 4 (tilt the head back slightly) (82%), which is also similar to Nepal's study (21). In addition, the most correctly performed step was Step 2 (remove the cap), which 164 (91%) of the participants practiced correctly, which is comparable with the study done in Mekelle. (88%) (16).

The majority of participants (55.2%) learned the MDI technique by reading books and articles, while 76 (26.4%) learned it through reading the leaflet. Contrary to a study conducted in Nigeria (26), which revealed that basic knowledge regarding the use of inhalers was acquired through postgraduate studies in 32.7% of cases and medical school in 23.6%, this is most likely because of the Nigerian postgraduate. It's possible that the variation results from different medical school curricula. Another finding of the study was that nearly half of the participants (47%) don't assess patients when they use new inhaler drugs or check during follow-up. From a quarter (24.9%) of them, the most common reason they mentioned was that it was easy, and the patients could do it themselves. This is consistent with the study done in Gauteng province, South Africa. Over 50% of participants did not show MDI technique to patients or check their patients' technique at every hospital-related visit (22); This finding was also similar to that of a recent study that suggested around 25% of patients had not received any verbal instructions for the use of their prescribed inhaler (27). When given, instructions were often hurried, of poor quality, and not reinforced. Only an estimated 11 percent of patients received follow-up assessment and education about their device use techniques. This can lead a patient to have a poor understanding and improper administration of the drug, which can lead to poor control of asthma exacerbations.

Several factors have been cited for inadequate patient education on asthma inhalers. Among these, the most serious concerns were lack of regular periodic assessment of patients' inhaler technique, lack of time for educating patients, and lack of awareness about the importance of patient education. Studies have shown that training that includes instructions and demonstrations of the inhaler technique improves the skills of both patients and providers (28). The very poor inhaler technique observed in our study is most probably due to the lack of any formal training for healthcare providers on the correct use of inhalers.

This study has some limitations, even if it shows a lack of competency in the MDI technique. Even though pediatric residents and nurses may not be comparable in terms of education, work exposure, or experience, they are the key players in managing children with asthma in TASH. The other limitation is that, while collecting data, there was a fear of showing the steps of the techniques for fear of being judged.

The study reveals a low level of competency in performing the MDI technique among healthcare professionals, with most lacking formal training, and identifies the gaps in MDI techniques as they are essential for asthma control. They often don't teach or demonstrate steps during initial orders or follow-up visits. It's recommended that ongoing training programs be implemented to improve their ability to use inhaled devices, ensuring proper inhalation techniques and successful drug delivery,

and further research is needed to understand the factors contributing to poor healthcare competency towards MDI techniques.

## **Declarations**

### **Ethics approval and consent to participate.**

Before data collection Ethical approval was obtained from the Department of Pediatrics and Child Health at Addis Ababa University, as well as the College of Health Sciences' institutional review board. Before administering the questionnaire during data collection, signed consent was obtained. The study's objectives and the fact that they had the right to refuse participation were explained to the participants. At every stage of the study, confidentiality was maintained, and the collected data was kept confidential.

### **Availability of data and materials**

All data from this study will be available in this published article.

### **Competing interests**

There were no conflicting interests stated by the authors.

### **Funding**

Addis Ababa University

### **Authors' contributions**

RAK, and GT conception and designed the research. GT performed the research and data collection. GT analyzed data, and interpretation and wrote the paper. EKE wrote the manuscript.

## Acknowledgment

We'd like to thank the pediatric residents and nurses at TASH for their enthusiastic participation in our study.

## References

1. Reports - Global Initiative for Asthma - GINA. (2023, September 1). Global Initiative for Asthma - GINA. <https://ginasthma.org/reports>.
2. Global Strategy for Asthma Management and Prevention. <https://ginasthma.org/wp-content/uploads/2021/05/GINA-Main-Report-2021-V2-WMS.pdf>, Date: May 2, 2021, Date Accessed: May 7, 2022.
3. Serebrisky D, Wiznia A. Pediatric Asthma: A Global Epidemic. *Ann Glob Health*. 2019;85(1).
4. Misganaw A, Haregu TN, Deribe K, Tessema GA, Deribew A, Melaku YA, et al. National mortality burden due to communicable, non-communicable, and other diseases in Ethiopia, 1990–2015: findings from the Global Burden of Disease Study 2015. *Population Health Metrics*. 2017;15(1):29.
5. Demissie M, Kumie A. Prevalence of symptoms of asthma and associated factors among primary school children in Addis Ababa. *Ethiopian Medical Journal*. 2018;56:301-8.
6. Belyhun Y, Amberbir A, Medhin G, Erko B, Hanlon C, Venn A, et al. Prevalence and risk factors of wheeze and eczema in 1-year-old children: the Butajira birth cohort, Ethiopia. *Clin Exp Allergy*. 2010;40(4):619-26.
7. Aschalew A, Kebed R, Demie T, Weldetsadik A. Assessment of level of asthma control and related factors in children attending pediatric respiratory clinics in Addis Ababa, Ethiopia. *BMC Pulmonary Medicine*. 2022;22.
8. Rodriguez-Martinez CE, Sossa-Briceño MP, Sinha IP. When adherence and inhalation technique matter: Difficult-to-control pediatric asthma in low- to middle-income countries. *Pediatr Pulmonol*. 2021;56(6):1366-73.
9. Stein SW, Sheth P, Hodson PD, Myrdal PB. Advances in metered dose inhaler technology: hardware development. *AAPS PharmSciTech*. 2014;15(2):326-38.
10. Plaza V, Giner J, Rodrigo GJ, Dolovich MB, Sanchis J. Errors in the Use of Inhalers by Health Care Professionals: A Systematic Review. *J Allergy Clin Immunol Pract*. 2018;6(3):987-95.
11. Spaggiari S, Gehri M, Di Benedetto L, Hafen GM, Pauchard JY, Gervaix A, et al. Inhalation technique practical skills and knowledge among physicians and nurses in two pediatric emergency settings. *J Asthma*. 2021;58(2):190-6.
12. Ndukwu C, Elo-Ilo J, Mbachu C, Ayuk A, Ugwu NO, Ngonadi S. Assessment of Paediatric resident doctors' knowledge of metered dose inhaler (MDI) device technique and use. *Nigerian Journal of Paediatrics*. 2017;44:168.

13. Aschalew A, Kebed RA, Demie TG, Weldetsadik AY. Assessment of level of asthma control and related factors in children attending pediatric respiratory clinics in Addis Ababa, Ethiopia. *BMC Pulmonary Medicine*. 2022;22(1):70.
14. Mulugeta T, Ayele T, Zeleke G, Tesfay G. Asthma control and its predictors in Ethiopia: Systematic review and meta-analysis. *PLOS ONE*. 2022;17(1):e0262566.
15. Tadesse DB, Negash M, Kiros KG, Ayele E, Hailay A, Haile TG, et al. Uncontrolled asthma in Ethiopia: a systematic review and meta-analysis. *Adv Respir Med*. 2020;88(6):495-503.
16. Ali HD, Worku GS, Alemayehu AA, Gebrehiwot WH. Competence in metered dose inhaler technique among dispensers in Mekelle. *Allergy Asthma Clin Immunol*. 2014;10(1):18.
17. Belachew SA, Tilahun F, Ketsela T, Achaw Ayele A, Kassie Netere A, Getnet Mersha A, et al. Competence in metered dose inhaler technique among community pharmacy professionals in Gondar town, Northwest Ethiopia: Knowledge and skill gap analysis. *PLoS One*. 2017;12(11):e0188360.
18. Nduka SO, Anetoh MU, Amorha KC, Henry OO, Okonta MJ. Use of simulated patient approach to assess the community pharmacists' knowledge of appropriate use of metered dose inhaler. *J Basic Clin Pharm*. 2016;7(4):116-9.
19. Baddar SA, Al-Rawas OA, Al-Riyami KA, Worthing EA, Hanssens YI, Taqi AM, et al. Metered-dose inhaler technique among healthcare providers practising in Oman. *J Sci Res Med Sci*. 2001;3(1):39-43.
20. Ns L, editor A study of knowledge assessment and competence in asthma and inhaler technique of nurses employed at university teaching hospital 2012.
21. Kishore PV, Palaian S, Alam K, Shankar PR, Bajracharya B, Van den Ende JV. Correct use of a metered dose inhaler: a prospective interventional study among healthcare professionals in a Nepalese teaching hospital. *Journal of Clinical and Diagnostic Research*. 2008;2(2):720-725.
22. Maepa HM, Wong ML, Menezes CN. Evaluation of the knowledge and correct use of metered-dose inhalers by healthcare professionals and medical students in Gauteng Province. *Afr J Thorac Crit Care Med*. 2019;25(3).
23. Guidelines for the Diagnosis and Management of Asthma 2007 (EPR-3).” NHLBI, NIH, 3 Dec. 2020, [www.nhlbi.nih.gov/health-topics/guidelines-for-diagnosis-management-of-asthma](http://www.nhlbi.nih.gov/health-topics/guidelines-for-diagnosis-management-of-asthma).
24. Baverstock M, Woodhall N, Maarman V. P94 Do healthcare professionals have sufficient knowledge of inhaler techniques in order to educate their patients effectively in their use? *Thorax*. 2010;65:A117 - A8.

25. Basheti IA, Hamadi SA, Reddel HK. Inter-professional education unveiling significant association between asthma knowledge and inhaler technique. *Pharm Pract (Granada)*. 2016;14(1):713.
26. Ndukwu C, Elo-Ilo J, Mbachu C, Ayuk A, Ugwu N, Ngonadi S. Assessment of Paediatric resident doctors' knowledge of metered dose inhaler (MDI) device technique and use. *Nigerian Journal of Paediatrics*. 2017;44(3):168.
27. Lavorini F, Magnan A, Dubus JC, Voshaar T, Corbetta L, Broeders M, et al. Effect of incorrect use of dry powder inhalers on management of patients with asthma and COPD. *Respir Med*. 2008;102(4):593-604.
28. Desalu OO, Abdurrahman AB, Adeoti AO, Oyedepo OO. Impact of Short-Term Educational Interventions on Asthma Knowledge and metered-dose Inhaler Techniques among Post Basic Nursing Students in Ilorin, Nigeria- Result of a Pilot study. *Sudan journal of medical sciences*. 2013;8:77-84.