

## UNDERSERVED POPULATIONS

**Evaluation of MDI-spacer utilization and technique in caregivers of urban minority children with persistent asthma**Marina Reznik, MD, MS, Ellen Johnson Silver, PhD, and Yu Cao, MD,<sup>†</sup>

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**Abstract**

**Objective:** Incorrect Metered-Dose Inhaler (MDI)-spacer technique can result in decreased drug delivery to distal airways and poor asthma outcomes. There is lack of research to examine whether the caregivers utilize proper technique when applying an MDI-spacer delivery system for young minority children with persistent asthma in the United States. The objective of this study was to evaluate MDI-spacer utilization and technique among the caregivers of Bronx minority children with persistent asthma and to determine characteristics associated with correct use. **Methods:** We analyzed data from 169 caregivers of urban minority children with persistent asthma (aged 2–9 years). MDI-spacer device technique was assessed using a 10-step checklist derived from the national guidelines, literature and manufacturers' instructions. Based on the median MDI-technique score of six steps demonstrated accurately, caregivers were categorized as correct (seven or more) or incorrect (six or less) users. **Results:** Of the 169 caregivers, 95% were mothers, mean age 32.3 years (SD 7.6), 56% were unemployed; 74% of the children were Hispanic, 87% had either "not well controlled" or "very poorly controlled" asthma, 92% had a spacer at home and 71% used it "all" or "most" of the time. Only one caregiver correctly demonstrated all 10 steps of the MDI-spacer technique. Child's having one or more asthma-related hospitalizations in the past 12 months and higher caregiver educational level were independent predictors of correct MDI-spacer technique. **Conclusions and relevance:** The caregivers of urban, minority children with persistent asthma lack proper MDI-spacer technique, suggesting the potential value of both targeted short- and long-term educational interventions.

**Introduction**

Inhalation is the preferred method of drug delivery in pediatric asthma management, with the pressurized metered-dose inhaler with spacer (MDI-spacer) device being the most recommended for use in young children [1,2]. Incorrect inhalation technique can significantly impair drug deposition to the patient's lungs and airways and thus, result in decreased therapeutic efficacy and a poor treatment adherence [3–6]. In particular, younger pediatric patients who may be less physically coordinated and who may react unfavorably to being fitted with an MDI-spacer with mask (e.g. cry) can be more prone to make errors in inhalation technique, even after repeated prior instruction [7–13]. These patients often depend on the caregivers to administer their asthma treatments.

Several studies have indicated that the caregivers also require repeated and frequent education and follow-up

assessments in order to maintain correct inhalation technique [8,14–16]. Furthermore, even health care providers, who routinely prescribe asthma drug regimens and delivery systems, themselves require formal instruction and assessment in device operating technique, especially as the abundance and diversity of available inhalers have increased [12,17–20].

There is lack of research to examine whether the caregivers utilize proper technique when applying an MDI-spacer delivery system for young children with persistent asthma in the United States. No such study has been done in the Bronx, New York (NY), an inner-city setting in which asthma disproportionately burdens low-income, minority Hispanic/Latino and African American children who suffer significant asthma-related morbidities and mortality. The purpose of this study was to evaluate an MDI-spacer utilization and technique among the caregivers of Bronx children with persistent asthma and to determine characteristics associated with correct use.

**Methods****Sample and procedures**

This study used cross-sectional baseline data gathered in a community-based asthma intervention trial conducted in the

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Bronx, NY. Families were eligible for participation if they had children 2–9 years of age with: (1) physician-diagnosed asthma; (2) at least one asthma exacerbation in the past 12 months requiring hospitalization, ED visit or acute (or scheduled the same day) clinic visit; (3) a current prescription for inhaled corticosteroid (ICS) medication in the MDI form; and (4) caregiver speaks English or Spanish. Children were excluded if they had significant medical conditions that could interfere with assessment of asthma outcomes. Families were recruited from two pediatric outpatient health care centers ( $n = 139$ ) with similar patient demographic characteristics, children's hospital emergency department (ED;  $n = 28$ ) or self-referred ( $n = 14$ ) by contacting the research staff after seeing a posted study flyer. We used data for analysis from a baseline assessment of the caregivers conducted prior to the intervention initiation (December 2009–October 2012).

## Measures

### Baseline survey

As part of the survey, the caregivers provided information about the children's demographic characteristics, including age, gender, race (black, white, other), and ethnicity (Hispanic, non-Hispanic), as well as the child's age at diagnosis, and several caregiver variables, including age, education (recorded as “less than high school,” “graduated high school,” “1–3 years of college,” “4-year college degree or more”), history of asthma and whether the family was a single parent household. Race/ethnicity answer choices were based on the National Institutes of Health (NIH) reporting requirements. The caregiver also reported on the child's asthma-related hospitalizations, ED and acute (or scheduled the same day) outpatient clinic visits in the past 12 months.

We asked the caregivers about child's day- and night-time asthma symptoms, interference with normal activity, frequency of short-acting  $\beta_2$ -agonist use over the past 4 weeks as well as number of exacerbations requiring oral systemic corticosteroids. We then used National Heart, Lung, and Blood Institute (NHLBI) guidelines to categorize each child's asthma control as “well,” “not well,” or “very poorly controlled” based on these caregiver-reported data [1].

### Assessment of MDI-spacer device use and technique

To assess spacer device use, we asked the caregivers if their child had a spacer and if so, frequency of its use (“all of the time,” “most of the time,” “some of the time,” “almost none of the time” and “not at all”). The caregivers were also asked whether a healthcare professional (doctor or nurse) had ever explained or demonstrated for them how to use an MDI-spacer device and if a doctor had ever asked them to show how they usually use an MDI-spacer for their child when administering an asthma medication. Then, we asked the caregivers to verbally describe and demonstrate how they would administer two puffs of Albuterol Sulfate MDI with a spacer device (AeroChamber Plus with mask, Monaghan Medical, Plattsburgh, NY) to their child using a toy and a sample MDI-spacer device. We instructed the

caregivers to pretend the toy was their child. We selected the two-way valve AeroChamber Plus with mask as it is the most commonly prescribed and used spacer device in our community.

### MDI-spacer device technique checklist

The 10 steps used to determine accurate MDI-spacer technique were adapted from the NHLBI guidelines [1], literature [15,21,22] and manufacturers' instructions that came with the AeroChamber Plus. These 10 steps comprised the MDI-spacer device technique checklist. From the 10-step checklist, based on the literature [15,22,23] and clinical practice, we defined five steps that are essential for adequate delivery of medication via MDI-spacer device. These steps are: (1) agitating the MDI (Shook inhaler before use for 5 s (at least 3 times)), (2) forming a seal (Covered mouth and nose well), (3) using a single actuation (Pressed down the top of pump once), (4) taking at least 6 breaths (Took at least 6 deep and slow breaths) and (5) timing of the second actuation (Waited at least 30 s to repeat second puff). While patient position (sitting or standing) and washing the device are important steps, these were not assessed in the current study.

### MDI-spacer device technique rating

The two research staff were trained by the first author to directly observe the caregivers demonstrating the MDI-spacer technique and record on the 10-step checklist whether each of the steps was performed correctly or incorrectly. The two raters practiced using the checklist to rate an adult's use of an MDI-spacer prior to any data collection. Five trials were required to achieve 100% agreement on all items. We then videotaped a random subset of the study participants ( $n = 18$ ) demonstrating the MDI-spacer technique. The videotaped demonstrations were independently rated by an attending pediatrician trained in the correct use of the MDI-spacer using the same checklist that the research staff used during the directly observed encounters. We determined agreement between the physician and research staff rating for each step on the MDI-spacer technique checklist. Eight of the ten steps on the checklist demonstrated perfect or almost perfect agreement (agreement on step rating in 17 of 18 videotaped cases) between the physician and research staff ratings.

### MDI-spacer device technique score

For this analysis, we calculated an MDI-spacer technique score (0–10) based on the number of correct steps. Using the MDI-spacer technique median score of 6, we defined correct users as caregivers who had an MDI-spacer technique score of 7 or above and incorrect users as caregivers with an MDI-spacer technique score of 6 or below. We also determined how many of the five “essential” steps were demonstrated correctly.

The study was approved by the university's Institutional Review Board. Written informed consent was obtained from all the caregivers and assent from all children aged 7 years and above. Informed consent process was conducted in English ( $n = 131$ ) or Spanish ( $n = 38$ ) based on the caregiver's language preference.

## Data analysis

Descriptive statistics, including means, ranges and standard deviations (SD) were calculated for all variables. To examine the bivariate associations of the caregiver and child characteristics with correct use of MDI-spacer technique, the continuous independent variables (caregiver age, child age, duration of diagnosis) were recoded as categorical variables and then Chi-square statistics were calculated for all comparisons. This was followed by a logistic regression analysis to determine the significant independent predictors of correct MDI-spacer usage. A two-sided  $\alpha \leq 0.05$  was considered statistically significant. The data were analyzed using SPSS V.20 (SPSS Inc., Chicago, IL).

## Results

Among 181 caregivers of children with persistent asthma enrolled in the intervention trial, 169 (90%) were included in this study. We excluded the caregivers with incomplete data ( $n = 12$ ). The demographic characteristics of participants are presented in Table 1.

A total of 147 (87%) of children had either “not well controlled” or “very poorly controlled” asthma as per NHLBI criteria [1]. As per parental report, 147 (87%) used ICS during the past 4 weeks. Over a third (36.7%) of the pediatric sample had an asthma-related hospitalization, 80.4% had an ED visit and 82.2% had an acute (or scheduled the same day) outpatient clinic visit in the past 12 months. Children had asthma diagnosis for an average of 4.2 (SD 2.1) years. A total of 156 (92.3%) of children had a spacer at home, of whom 120 (71.1%) used the spacer with their MDI “all of the time” or “most of the time”. While 157 (92.9%) of the caregivers reported that “a doctor or a nurse had ever explained” and 144 (85.2%) stated that “a doctor or nurse had ever demonstrated” how to use an MDI with a spacer, only 91 (53.8%) reported that a doctor had asked them to demonstrate back how they would use the MDI-spacer device.

Table 1. Demographic characteristics of children and caregivers ( $n = 169$ ).

| Characteristics                         | Number of subjects (%) |
|-----------------------------------------|------------------------|
| Child age, years (mean $\pm$ SD)        | 5.07 (2.03)            |
| Child gender                            |                        |
| Male                                    | 101 (59.8)             |
| Child race/ethnicity                    |                        |
| Hispanic (any race)                     | 125 (74.9)             |
| Black or African American, non-Hispanic | 38 (22.6)              |
| White or Caucasian, non-Hispanic        | 2 (1.2)                |
| American Indian or Alaska Native        | 2 (1.2)                |
| Asian                                   | 1 (0.6)                |
| Caregiver relationship                  |                        |
| Mother                                  | 161 (95.3)             |
| Caregiver age, years (mean $\pm$ SD)    | 32.3 (7.6)             |
| Caregiver education                     |                        |
| Less than high school                   | 47 (27.8)              |
| Graduated high school or GED            | 50 (29.6)              |
| 1–3 years of college                    | 53 (31.4)              |
| 4-year college degree or more           | 19 (11.2)              |
| Caregiver unemployed                    | 95 (56.2)              |
| Single parent household <sup>a</sup>    | 76 (48.4)              |

<sup>a</sup> $n = 157$ .

## Evaluation of the MDI-spacer device technique

The mean MDI-spacer technique score was 6.6 (SD 1.4) and the median was 6.

### MDI-spacer device technique individual steps

Figure 1 demonstrates proportion of the caregivers who correctly performed each step on the 10-step MDI-spacer technique checklist. Only 1 (0.6%) caregiver correctly demonstrated all 10 steps. Of the 10 steps, the most difficult skills were: step 7 – “exhaling before inhalation”; step 9 – “taking at least 6 deep and slow breaths”; and step 10 – “waiting at least 30 s to repeat second puff”.

### MDI-spacer device technique essential steps

Overall, six (3.6%) caregivers performed all five essential steps correctly. Of the essential steps, two steps were the most challenging: “taking at least 6 deep and slow breaths” and “waiting at least 30 s to repeat second puff”. Of the 49 (29%) caregivers who performed four essential steps correctly, 11 missed “taking at least 6 deep and slow breaths” step and 36 missed “waiting at least 30 s to repeat second puff” step.

### Predictors of correct MDI-spacer device technique use

Child and caregiver characteristics predictive of correct MDI-spacer device use are presented in Table 2. Bivariate analyses revealed child’s asthma-related hospitalization in the past 12 months and higher caregiver educational level to be significantly associated with the correct MDI-spacer technique ( $p = 0.01$  and  $p = 0.05$ , respectively). These results were confirmed by the logistic regression analyses with all predictors included in the model (Table 3). Correct use was not associated with the availability of a spacer at home and frequency of its use, or whether the health care provider explained, demonstrated or asked caregiver to show how to use the device.

## Discussion

This study evaluated MDI-spacer utilization and technique among the caregivers of Bronx children with persistent asthma and determined characteristics associated with correct use. We found that only one caregiver of a child with persistent asthma was able to correctly demonstrate all 10 steps in the MDI-spacer technique and six caregivers demonstrated five essential steps correctly. Child hospitalization in the past 12 months was significantly associated with correct MDI-spacer use. In addition, caregivers with higher level of education were more likely to demonstrate correct MDI-spacer technique.

Our study population consisted of caregivers of children with persistent asthma prescribed daily ICS medication. While MDIs in the form of Albuterol Sulfate are recommended as first-line therapy to all the patients with asthma during exacerbation [1], patients with persistent asthma who are prescribed ICS MDIs are supposed to take their ICS inhaler on a daily basis. While 87% of children in our study used ICS in the past 4 weeks and 71% used MDI-spacer all- or most of the time, we expected to find a higher

Figure 1. Proportion of caregivers who correctly demonstrated the steps of MDI-spacer use ( $n = 169$ ) (\*essential steps).

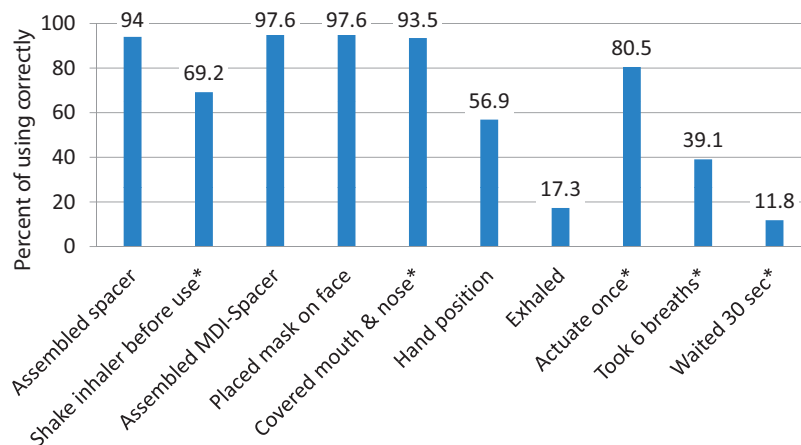


Table 2. Association of caregiver and child characteristics with correct use of MDI-spacer technique<sup>a</sup>.

| Characteristics                                      | Correct use, (n, %) | p Value           |
|------------------------------------------------------|---------------------|-------------------|
| Child age group                                      |                     |                   |
| 2–5 years ( $n = 93$ )                               | 49 (52.7)           | 0.23              |
| 6–9 years ( $n = 76$ )                               | 33 (43.4)           |                   |
| Child gender                                         |                     |                   |
| Male ( $n = 101$ )                                   | 48 (47.5)           | 0.75              |
| Female ( $n = 68$ )                                  | 34 (50.0)           |                   |
| Child race/ethnicity                                 |                     |                   |
| Hispanic, any race ( $n = 125$ )                     | 63 (49.6)           | 0.97 <sup>b</sup> |
| Black or African American, non-Hispanic ( $n = 38$ ) | 19 (50.0)           |                   |
| White or Caucasian, non-Hispanic ( $n = 2$ )         | 2 (100.0)           |                   |
| American Indian or Alaska Native ( $n = 2$ )         | 2 (100.0)           |                   |
| Asian ( $n = 2$ )                                    | 1 (100.0)           |                   |
| Caregiver age                                        |                     |                   |
| 20–29 years ( $n = 68$ )                             | 36 (52.9)           | 0.53              |
| 30–39 years ( $n = 67$ )                             | 32 (47.8)           |                   |
| 40 years or older ( $n = 34$ )                       | 14 (41.2)           |                   |
| Caregiver education                                  |                     |                   |
| Less than high school ( $n = 47$ )                   | 17 (36.2)           | <b>0.05</b>       |
| Graduated high school ( $n = 50$ )                   | 24 (48.0)           |                   |
| 1–3 years of college ( $n = 53$ )                    | 27 (50.9)           |                   |
| 4 year of college or more ( $n = 19$ )               | 14 (73.7)           |                   |
| Single parent household                              |                     |                   |
| Yes ( $n = 76$ )                                     | 31 (40.8)           | 0.09              |
| No ( $n = 81$ )                                      | 44 (54.3)           |                   |
| Duration of asthma diagnosis                         |                     |                   |
| <5 years ( $n = 109$ )                               | 58 (53.2)           | 0.10              |
| 5 years or more ( $n = 60$ )                         | 24 (40.0)           |                   |
| Asthma control                                       |                     |                   |
| Well controlled ( $n = 20$ )                         | 9 (45.0)            | 0.35              |
| Not well controlled ( $n = 75$ )                     | 33 (44.0)           |                   |
| Very poorly controlled ( $n = 72$ )                  | 40 (55.6)           |                   |
| Hospitalized in the past 12 months                   |                     |                   |
| Yes ( $n = 62$ )                                     | 38 (61.3)           | <b>0.01</b>       |
| No ( $n = 107$ )                                     | 44 (41.1)           |                   |
| ED visit in the past 12 months                       |                     |                   |
| Yes ( $n = 135$ )                                    | 67 (49.6)           | 0.46              |
| No ( $n = 33$ )                                      | 14 (42.4)           |                   |
| Same-day clinic visit in the past 12 months          |                     |                   |
| Yes ( $n = 139$ )                                    | 70 (50.4)           | 0.30              |
| No ( $n = 30$ )                                      | 12 (40.0)           |                   |
| Have been evaluated by a pulmonologist               |                     |                   |
| Yes ( $n = 61$ )                                     | 28 (45.9)           | 0.61              |
| No ( $n = 108$ )                                     | 54 (50.0)           |                   |
| Have been evaluated by an allergist                  |                     |                   |
| Yes ( $n = 45$ )                                     | 23 (51.1)           | 0.65              |
| No ( $n = 123$ )                                     | 58 (47.2)           |                   |
| Caregiver has asthma                                 |                     |                   |
| Yes ( $n = 51$ )                                     | 20 (39.2)           | 0.37              |
| No ( $n = 74$ )                                      | 35 (47.3)           |                   |

(continued)

Table 2. Continued

| Characteristics                                                                             | Correct use, (n, %) | p Value |
|---------------------------------------------------------------------------------------------|---------------------|---------|
| Availability of spacer device at home                                                       |                     |         |
| Yes ( $n = 156$ )                                                                           | 78 (50.0)           | 0.18    |
| No ( $n = 13$ )                                                                             | 4 (30.8)            |         |
| Frequency of spacer use                                                                     |                     |         |
| All or most of the time ( $n = 120$ )                                                       | 60 (50.0)           | 0.55    |
| Some/none of the time ( $n = 49$ )                                                          | 27 (55.1)           |         |
| Health care professional has ever explained how to use MDI-spacer device                    |                     |         |
| Yes ( $n = 157$ )                                                                           | 79 (50.3)           | 0.09    |
| No ( $n = 12$ )                                                                             | 3 (25.0)            |         |
| Health care professional has ever demonstrated how to use MDI-spacer device                 |                     |         |
| Yes ( $n = 144$ )                                                                           | 73 (50.7)           | 0.18    |
| No ( $n = 25$ )                                                                             | 9 (36.0)            |         |
| Health care professional has ever asked caregiver to show how they use an MDI-spacer device |                     |         |
| Yes ( $n = 91$ )                                                                            | 45 (49.5)           | 0.60    |
| No ( $n = 75$ )                                                                             | 34 (45.3)           |         |

ED, Emergency Department.

<sup>a</sup>Correct use of MDI-spacer was defined as MDI-spacer technique score of 7 or above on a 10-step checklist.

<sup>b</sup>p Value for Hispanic versus Black or African American comparison only (other group sizes insufficient for analysis).

Boldface values indicate statistically significant differences.

Table 3. Logistic regression analysis of predictors of correct MDI-spacer use.

|                                    | Adjusted OR | 95% CI    | p Value |
|------------------------------------|-------------|-----------|---------|
| Caregiver education                |             |           |         |
| Less than high school              | 0.15        | 0.02–0.96 | 0.05    |
| Graduated high school              | 0.07        | 0.01–0.47 | 0.006   |
| 1–3 years of college               | 0.29        | 0.03–1.25 | 0.084   |
| 4 year of college or more          | 1.00        |           |         |
| Hospitalized in the past 12 months |             |           |         |
| No                                 | 0.23        | 0.08–0.68 | 0.008   |
| Yes                                | 1.00        |           |         |

OR, odds ratio; CI, confidence interval.

proportion of the caregivers who demonstrated perfect MDI-spacer technique. In addition, duration and degree of illness may affect the ability of the caregivers to use the MDI-spacer device properly. However, we found no association between duration of having asthma and correct use of MDI-spacer device. In addition, asthma control was unrelated to correct technique. However, there are factors other than incorrect use of the MDI (e.g. exposure to environmental triggers) that

could exacerbate symptoms and these may have been responsible for the lack of expected association in this sample. We can only speculate at present, but this may be a worthy area for future study.

Our literature review revealed four studies that examined inhaler device technique in the caregivers of children with asthma [8,14–16]. Only one of these studies was conducted in US [16]. This published study examined the ability of caregivers of children aged 1–6 years with asthma (of unknown race/ethnicity), after being provided standardized instruction, to correctly demonstrate how to use inhaler device system prescribed for the first time [16]. The caregivers in this study were recruited from 10 outpatient allergy and asthma treatment centers representing a different group than patient population encountered in general practice [16]. In our study sample, most of the caregivers were recruited from the outpatient pediatric clinics. We found no US studies that assessed MDI-spacer device technique among caregivers of urban, minority children with persistent asthma.

In our study, child hospitalization in the past 12 months independently predicted correct MDI-spacer use. Prior study evaluating the ability of children and adolescents with acute asthma exacerbations to correctly use MDI-spacer found that the patients were more likely to use MDIs improperly if they had not been hospitalized recently [9]. Our study supports this finding. It is likely that proper MDI-spacer technique was taught and reinforced during the hospitalization and at discharge by physicians, nurses, pharmacists and respiratory therapists. Future studies may elucidate the relationship between timing of the training of the technique during hospitalization or ED visit and caregiver correct use of the MDI-spacer.

Caregiver education level has been an important factor in asthma and other chronic disease management [24]. We found that correct MDI-spacer use was associated with caregiver higher level of education. The education level of the caregivers has been reported as significant factor related to the correct technique in a study evaluating MDI technique among asthmatic children and their caregivers in Thailand [15]. Our study results support this prior report.

The most challenging steps in the MDI-spacer technique in our study included: “exhaling before inhalation”, “taking at least 6 deep and slow breaths” and “waiting at least 30 s to repeat second puff”. Only 17% of the caregivers in our study correctly performed the step of instructing the child to exhale prior to inhalation. The caregivers in our study were demonstrating the technique using a toy, and although instructed to pretend the toy was their child, they may not have remembered to verbally describe this step. Therefore, we did not consider the step of exhaling prior to inhalation essential. Different breathing techniques have been described for optimal asthma medication delivery in infants and children such as tidal breathing or taking five to six slow and deep breaths [1,25,26]. These have been demonstrated to be equivalent in children [27]. Deerojanawong et al. [15] found that the common error in their study population of caregivers from Thailand was the step of waiting for 30 s between inhalations and the step of single actuation prior to inhalation. Prior research demonstrated that a single MDI actuation followed by an inhalation delivered the

greatest amount of medication per actuation than multiple actuations without a wait period [28,29].

The NHLBI guidelines recommend that healthcare providers routinely check the patients’ or caregivers’ use of MDI-spacers and correct their technique [1]. We found that majority of caregivers reported that a doctor or a nurse had explained or demonstrated how to use an MDI with a spacer, but only about half reported that a doctor had asked them to demonstrate back how they would use the device. Prior studies showed that health care providers do not know how to correctly use an MDI-spacer device [17,30,31]. While we neither assessed the healthcare providers’ ability to use MDI-spacer devices nor their instruction given to the patients or caregivers, these in addition to other factors related to caregiver health literacy and the capacity to learn and retain instruction might have influenced outcomes. Asthma quality improvement efforts should include formal assessment of healthcare providers’ ability to use MDI-spacer devices and provide instructions to the patients. Our findings suggest the need for regular evaluation and teaching of MDI-spacer technique during clinical encounters, particularly to caregivers of children with persistent asthma.

We have made attempts to minimize the role unfamiliar equipment might have played in influencing study’s outcomes. The MDI caregivers used to demonstrate the technique was a standard Albuterol Sulfate in the MDI form. Only caregivers experienced with MDI use whose children had persistent asthma were enrolled. Finally, all caregivers were familiar with the spacer device at enrollment.

Our study had several limitations. First, this was a cross-sectional study and conclusions about causality are therefore limited. Second, the study was conducted in urban low-income community in the Bronx, NY; thus, our findings may not be generalizable to other communities. Third, despite 100% inter-rater agreement on MDI checklist ratings during training and prior to data collection, raters’ scores might have drifted over time. However, we videotaped a subset of participants’ MDI-spacer techniques throughout the study and agreement between physician and research staff’s rating remained high. We did not quantify the delivery of aerosolized medication. This was not the purpose of the study. However, aerosol deposition is critically dependent on a proper inhalation technique. Finally, this was secondary data analysis, which places limitations on the information available. For example, the questions about doctor or nurse training of the MDI-spacer technique only asked parents if they ever received this type of education so we cannot determine whether those receiving more recent training were rated higher on correct use. In addition, other unmeasured linguistic, cultural and socio-economic factors may exist that could explain the improper use of MDI-spacer among minority populations. Future research would help investigate these relationships.

## Conclusions

Poor inhalation technique in our study population is striking. Less than 1% of the caregivers in our study sample correctly performed all 10 steps on the MDI-spacer technique checklist and less than 4% of the caregivers were able to correctly

complete five essential steps. To our knowledge, this is the first study to assess MDI-spacer device technique among the caregivers of urban, minority children with persistent asthma. Targeted educational interventions for both caregivers and healthcare providers coupled with regular evaluation of caregiver inhalation technique are needed to optimize medication delivery in children with persistent asthma.

## Acknowledgements

We would like to thank all the families for participating in the study. We also thank Kathryn Scharbach, MD, MS (Children's Hospital of Montefiore, Albert Einstein College of Medicine; no compensation received) for scoring the videotaped recordings of the MDI-spacer technique and the research assistants for their work on this project.

## Declaration of interest

The study was funded by the American Lung Association Clinical Patient Care Grant (CG-120837-N, Reznik – PI), the New York Community Trust Foundation (Reznik – PI), Stony Wold-Herbert Fund (Reznik – PI), Monaghan Medical Corporation (Reznik – PI) and Department of Pediatrics, the Children's Hospital at Montefiore. Funding agencies were not involved in the design and conduct of the study; collection, management, analysis, or interpretation of the data; or preparation, review, or approval of the article. The authors have not been employed by or provided any consulting services for the pharmaceutical industry, including manufacturers of products mentioned in this article. This study was presented in part at the annual meeting of the Pediatric Academic Societies, Denver, CO, 30 April–3 May 2011. The authors report no conflicts of interests. The authors alone are responsible for the content and writing of this article.

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