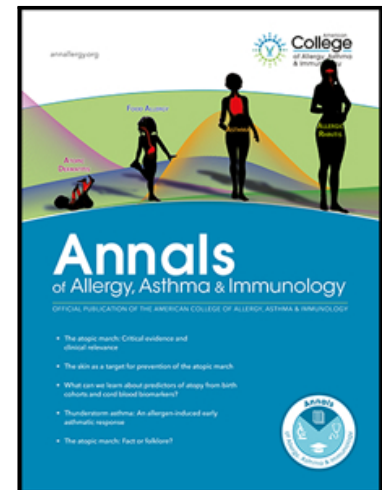


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Title: Is Guideline-Based Education Pre-Hospitalization Associated with Improved Inhaler Technique in High-Risk Children?

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Black children in the US are twice as likely as white children to experience asthma morbidity.¹ Inhaled therapy is a cornerstone of asthma care to reduce morbidity.² However, inhaler technique is poor among children, particularly among Black children, thereby accentuating disparities.^{3,4}

Because inhaler education is associated with decreased morbidity, guidelines recommend clinicians discuss, demonstrate, and assess inhaler technique at every visit.^{5,6} However, this guideline-based practice is performed at as few as 5% of clinic visits.^{7,8}

Research has identified types and frequency of inhaler education in clinical care, however no studies have examined the link between children's inhaler technique and prior education received. Understanding this link is critical to improve guideline implementation, particularly among minorities who face disparities such as limited healthcare access and increased morbidity.²

This cross-sectional study examined the association between children's inhaler technique and inhaler education received in the prior year among a largely Black population. This study utilized baseline data from a randomized controlled trial (NCT04373499) conducted between 01/2019 and 02/2020 to evaluate inhaler education strategies. Eligible children (5-10 years) with asthma and their caregivers were recruited from a single urban medical center during hospitalization for asthma or wheezing. Informed consent/assent were obtained. University of Chicago's Institutional Review Board approved this study.

Children and caregivers independently completed questionnaires about the child's asthma (control, inhaler use, comorbidities) and inhaler education received in the year pre-hospitalization, including frequency of education and form of instruction (clinician discussion, demonstration, and/or assessment). Prior education was categorized into none, some (1-2 forms), and guideline-based (all 3).

After survey completion, each child demonstrated technique with placebo metered-dose inhalers (MDI) and spacers. Two trained research assistants independently reviewed video-recordings of technique using a validated 12-step checklist (1 point per correct step; maximum=12).⁴

Cohen's kappa evaluated differences in children's and caregivers' responses.⁹ T-tests, ANOVA, and Tukey's range test examined differences in technique based on pre-hospitalization education. Simple linear regression analyzed associations between inhaler technique and prior education. Multivariate regression models included age group (5-7 versus 8-10 years), asthma severity, child-reported spacer use, and comorbidities (e.g., obesity, sleep apnea, allergies, eczema) as covariates. Significance was set at $p < 0.05$. Analyses utilized STATA 15 (College Station, TX).

Of 140 eligible children, 70 were enrolled (50%). Mean age was 7.8 years (SD=1.6). The majority of children were male (51%), Black/African-American (85.7%), and insured through Medicaid (90%). Two-thirds had visited an emergency department or been hospitalized for asthma in the year before hospitalization (67%). Most caregivers were mothers (81%), and 57% of caregivers reported their child used an inhaler independently.

Most caregivers stated the healthcare provider discussed (n=68/70, 97%), demonstrated (n=63/70, 90%), or assessed their child's technique (n=45/70, 64%) in the past year. In contrast,

fewer children reported their provider discussed (n=39/70, 56%), demonstrated (n=41/70, 59%), or assessed their technique (n=36/70, 51%). Child-caregiver pairs showed no agreement in responses about prior education (Cohen's kappa=0.02, 0.04, -0.01).

One-quarter of children reported receiving no inhaler education in the past year (n=18/70, 26%) compared to two caregivers (2.9%). One-third of children (n=23/70) versus 61% of caregivers (n=43/70) reported receiving guideline-based education.

Almost all children misused their inhalers (n=67/70, 96%). Children performed a mean of 6.3 steps correctly (SD=1.9, range=2-10). Younger children (5-7 years) performed fewer steps correctly (mean=5.8, SD=2.0, range=2-9) than older children (8-10 years; mean=6.7, SD=1.8, range=3-10), although not statistically significant (p=0.06).

Children who reported receiving guideline-based education had significantly better inhaler technique than those who received no (p=0.007) or some education (0.03) in the past year, even after multivariate analyses (p=0.01). No significant relationships between inhaler technique and prior education were found based on caregivers' reports.

This study is the first to describe the impact of pre-hospital inhaler education on high-risk children hospitalized for asthma, adding to literature about the value of guideline-based inhaler education. Implementing practical solutions to deliver comprehensive inhaler education may improve self-management and reduce morbidity.

One-third of children reported receiving guideline-based education in the past year, higher than previously reported.³ More severe asthma in our study population may have led to more healthcare visits and therefore possibilities for education. Alternatively, hospital or community-based initiatives may have led to improved education for high-risk patients. Further studies are needed to assess causal effects.

This study revealed little agreement between child and caregiver recall of inhaler education over the past year. Education may target caregivers rather than children, especially for younger children who require assistance. Additionally, caregivers may report more education due to social desirability bias.

Our results show children's--but not caregivers'--reports of education are associated with technique. Because caregivers are not routinely present for inhaler assistance (e.g., at school), children must understand and demonstrate proper technique via targeted instruction. Future interventions should apply strategies based in learning theory, such as teach-back, and optimize child-clinician communication to make education more accessible and interactive for younger patients.

Notably, hospitalizations and emergency department visits serve as warning signs and thus should be utilized as key opportunities to educate children at high-risk for exacerbations. Health systems, pharmaceutical companies, and insurers must broaden access to quality education by expanding training among team members, providing access to placebo inhalers, and ensuring reimbursement for in-person and telehealth asthma education.^{6,7} Education should be reinforced at all healthcare encounters, especially for minority populations who experience lower health literacy and higher asthma morbidity.²

Study limitations include its cross-sectional design, which cannot identify causal relationships. Inhaler education was self-reported by children and caregivers, who may misremember prior education; actual practices during healthcare visits may differ. Finally, the study occurred at a single urban academic hospital and primarily enrolled a low-income, minority population, limiting generalizability.

Overall, clinicians should offer guideline-based inhaler education at every opportunity in inpatient and outpatient settings. Large-scale studies are necessary to identify technique steps are most critical for mastery and to elucidate the impact of improved technique on clinical outcomes. Future research should identify educational forms and interventions that increased child engagement and knowledge retention. By improving inhaler technique, the therapeutic benefit of respiratory inhalers can be maximized with potential to reduce pediatric asthma morbidity.

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Table 1. Children's characteristics. (N = 70)

	N (%)
Age, mean (SD), range	7.8 (1.6), 5-10 y
5-7 years	28 (40.0)
8-10 years	42 (60.0)
Gender, boy	36 (51.4)
Race/Ethnicity (Caregiver-reported)	
Black or African American	60 (85.7)
White	2 (2.9)
Other	2 (2.9)
Multiple races	4 (5.7)
Hispanic/Latino	2 (2.9)
Insurance type	
Medicaid	63 (90.0)
Private	7 (10.0)
Asthma classification	
Intermittent	11 (15.9)
Mild	13 (18.8)
Moderate	32 (46.4)
Severe	8 (11.6)
Not documented/Unknown	5 (7.3)
Prior emergency department for asthma	
Ever	59 (86.8)
In past year	47 (67.1)
Prior hospital admission for asthma	
Ever	56 (80.0)
In past year	32 (45.7)
Presence of co-morbidities*	44 (62.9)
Uses spacer with metered dose inhaler	51 (72.9)
Uses inhaler independently	40 (57.1)

*Allergies, eczema, obesity, and sleep apnea

Data available from authors upon request.