

Abstract:

Asthma is responsible for significant disease burden and health care cost. A heterogeneous disease with significant environmental, genetic, and economic risk factors, asthma disproportionately affects the most vulnerable children. Effective strategies to improve individual asthma control rely on a multidisciplinary, cross-sector approach. The emergency department (ED) is a critical resource to identify children at risk for high morbidity and mortality from asthma. It is imperative to identify barriers to asthma control in the ED while being mindful of transitions and care coordination, especially as the United States moves to value-based reimbursement of health care. We review recent literature on ED-based interventions, present data on the importance of addressing housing and involving schools, and conceptualize an ideal medical home for asthma. We also provide examples of how our own institution has developed programs across sectors to improve asthma outcomes in children.

Keywords:

asthma; community; interventions; outcomes; pediatric

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Improving Asthma Outcomes in Children: From the Emergency Department and Into the Community

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In the United States, 7 million children suffer from asthma, accounting for approximately 10 billion dollars in health care costs each year.¹⁻³ As a leading cause of pediatric emergency department (ED) visits, asthma contributes to almost 700,000 visits each year.^{1,2} A heterogeneous disease with significant environmental, genetic, and economic risk factors, asthma varies in its presentation, disproportionately burdening children in poverty and minorities. Black children have the highest asthma morbidity and mortality of any US group, twice that of white children.¹

The National Institutes of Health guidelines for acute asthma exacerbations recommend that “patients at high risk of asthma-related death require special attention, particularly intensive education, monitoring, and care.” The guidelines also stress the importance of early treatment and in-home management, citing the importance of a written asthma action plan, early recognition and treatment of exacerbations with adjustments in controller medications, and removal or withdrawal from allergens or irritants in their environment.⁴

Improving asthma outcomes, especially in high-risk groups, begins in the ED. It is crucial to seize the ED visit as a time to provide access to high-risk patients with asthma. Children who present to the ED with asthma exacerbations are more likely to be impoverished, exposed to allergens, lack insurance or have public insurance, not use controller medication, have poor housing, suffer from more severe disease, or overall have a poor understanding of asthma.^{2,5-7} Unfortunately, an ED visit is limited in time and resources to address these complex issues. Moreover, rates of follow-up to primary care following an ED visit are low even when an explicit recommendation for follow-up is made at the time of ED discharge.⁸ Creative solutions to facilitate identification and mitigation of barriers to asthma control in the ED are necessary. Additionally, an intervention that starts in the ED must demonstrate reach into the community and include the medical home. Multidisciplinary care that effectively crosses transitions and sectors is imperative to narrow the health disparities in asthma.^{9,10}

We review recent literature on ED-based interventions, present data on the importance of addressing housing and involving schools, and conceptualize an ideal medical home for asthma. We also provide examples of how our own institution has developed programs across sectors to improve asthma outcomes in children.

PEDIATRIC ASTHMA AND THE ED

The ED presents a unique opportunity to connect with children and their families at the time of greatest need. Many have seized the post-ED visit as a “teachable moment” as it represents a time when a family may be most motivated and amenable to be a part of change, especially if it results in preventing a future ED visit. Innovative ED-based interventions in the area of substance abuse, assault, and asthma have all had great success.^{11,12}

A visit to the ED is a marker of poor asthma control and for many families is disruptive to daily life.⁴ One program that has effectively capitalized on the “teachable moment” while accounting for limited time while in the ED is Improving Pediatric Asthma Care in the District of Columbia (IMPACT DC).¹²

The IMPACT DC Asthma Clinic model of care was studied and validated in a randomized clinical trial by Teach et al. A single visit to the IMPACT DC Asthma Clinic, occurring 1-2 weeks post-discharge from the ED or inpatient unit, was associated with improved outcomes in multiple domains, including lowered subsequent unscheduled health care utilization for acute asthma care (including ED visits), reduction of exposure to harmful environmental triggers (like tobacco smoke), and increased use of daily controller medications to prevent symptoms. Patients in the intervention group had 40% fewer unscheduled visits (to urgent care or EDs) than patients in the control group over the 6-month follow-up period. At 1-month follow-up, more than 80% of school-aged participants in the intervention group reported no missed school days in the prior 2 weeks. The intervention group also showed more symptom-free periods and decreased asthma severity, with improvements in several measures of quality of life.¹²

A recent review summarized a few care transition interventions originating in the ED for children with uncontrolled asthma.¹³ Most of the interventions focused on care coordination and asthma management. However, they found that a majority of these interventions did not improve attendance at a primary care setting, nor did they improve asthma control or reduce health care utilization after an ED visit.

Another potential success story is The CHIGAGO Plan, a recently completed multicenter randomized pragmatic trial of children ages 5 to 11 years presenting to the ED with uncontrolled asthma. The trial is comparing the effect of an ED-focused intervention to improve the quality of care at the time of discharge with and without a community home health worker, comparing it to standard care practices. It will be interesting to see how a model that starts in the ED compares to one that continues and follows the patient into the community.¹⁴

Improving discharge communication, starting or providing medications at the time of the ED visit,¹⁵ and bringing families back within a week of care to investigate causes of poor control and propose solutions¹² are ED-based asthma interventions that are effective. The ED represents an important opportunity to engage families in asthma care and management. That engagement can yield benefits in a child’s overall health and educational status. (Table 1)

PEDIATRIC ASTHMA AND THE SCHOOL SYSTEM

Asthma significantly impacts a child’s education. According to the Centers for Disease Control and Prevention (CDC), children with asthma missed 13.8

million school days in 2013.¹⁶ Moreover, children with asthma miss more school than children without asthma, and missed school days pose a significant burden for parents and caregivers, resulting in missed days of work and loss of earnings.¹⁷ Education is a critical social determinant of health for children and a strong predictor of long-term health and economic outcomes for children. Increased levels of education correlate with a lower incidence of diabetes, smoking, and obesity. A college graduate will live 9 years longer than a high school dropout and earn nearly twice as much as a high school graduate over their lifetime.¹⁸

Children spend a substantial amount of time in school. Additionally, the school setting offers access to children who may not use the health care system consistently. The school system is therefore a critical stakeholder in asthma management for children, especially as there may be children in school who do not interact with the health care system until their first asthma exacerbation. A collaborative effort between the health care system and the schools is critical to improving asthma outcomes and reduce asthma-related barriers to learning.

To maximize educational outcomes for children with asthma, school interventions should focus on education, medication management, and school-based clinical services. Multiple studies have shown a positive impact of school-based education programs for asthma management.¹⁹ Students who receive school-based asthma education have fewer asthma-related symptoms, physician visits, and ED visits with fewer missed days from school.²⁰ In addition, a comprehensive literature review of school-based programs showed that knowledge of asthma, self-efficacy, and self-management behaviors improved.²¹

The role of school nurses in improving asthma care and outcomes is well established,²¹⁻²⁴ as is the role of school-based administration of inhaled corticosteroids (ICS).¹⁹ In our own recent pilot randomized trial of school-based ICS, 91.7% of all expected morning doses were administered by school nurses. Over the 60-day outcome period, participants experienced improvement in multiple domains of asthma-related quality of life.²⁵

An example of a school-based education program is Open Airways for Schools (OAS). OAS is a program of the American Lung Association designed to help elementary school children manage their asthma. The implementation of six 60-minute educational sessions for children with asthma in the school setting yielded a decrease in the number of symptom days for children in the intervention group and an increase in their self-efficacy and self-

management skills with regard to their asthma.²⁶ Providing direct clinical services in schools is also an effective strategy to mitigate the impact of asthma on educational outcomes and has been shown to decrease hospital and ED visits associated due to asthma.²⁰

Finally, clinicians in the ED or primary care setting are a critical member of the “circle of support” for children with asthma, as identified in the SAMPRO (School-based Asthma Management Program) resource. SAMPRO identifies 4 key elements for school management of asthma: a “circle of support” that includes cross-sector communication between physicians, school personnel, and family and community members; an asthma action plan for school management and identification for self-carry of asthma medications where appropriate; education for school staff; and remediation of any school-based asthma triggers.²⁷ In addition, the CDC identified key strategies for incorporating asthma care into the school setting, including providing asthma education, linking students to medical care, and improving indoor air quality in schools.²⁸

Strong coordination between the education and health sectors, through communication and the provision of asthma action plans, along with clinical services and health education programs in schools to treat asthma and provide education on asthma management, is necessary for improved educational outcomes for children with asthma.

PEDIATRIC ASTHMA AND HOUSING

Identifying and mitigating asthma triggers are vital components for preventing frequent pediatric asthma exacerbations and recurrent ED visits. An important source of potential triggers is the patient’s home.²⁹ Indoor allergens such as dust mites, pet dander, mice, and cockroaches have been shown to trigger asthma symptoms.³⁰⁻³⁴ Likewise, indoor irritants such as mold and environmental tobacco smoke have an association with worsening asthma symptoms.^{35,36} Discharging a patient from the ED post-asthma exacerbation to a home with these indoor allergens and irritants will only lead them to have worsening symptoms and return to the ED.

However, by creating a healthy home, the root cause of a child’s asthma exacerbations can be prevented. In 2009, the passage of the Patient Protection and Affordable Care Act created more interaction between health and housing.³⁷ For example, Medicaid coverage was expanded to new groups of low-income populations, and benefits were expanded to offer more home and community-based

TABLE 1. Examples of community-based pediatric asthma programs.

Program Name	Description	Outcomes
ED based IMPACT DC ¹²	<p>An intervention designed to occur 1 to 2 weeks following the incident ED visit or hospitalization for asthma.</p> <p>An asthma clinic that is mostly based in the ED (newer locations include primary care offices). Clinic provides comprehensive asthma care and education to high-morbidity and socioeconomically disadvantaged children. Referrals are generated from ED, inpatient units, community practitioners, school nurses, and managed care organizations.</p> <p>A core component is providing care coordination services. Although the intervention is short term, families receive booster calls to reinforce key messages, assistance with scheduling primary care provider follow-up appointments, specialty clinics referrals, access to community resources, tailored landlord letters to address environmental triggers in the home, connection to the Department of Energy and Environment's Healthy Homes program, and assistance with insurance challenges.</p>	<ul style="list-style-type: none"> ▪ Lowered subsequent unscheduled health care utilization for acute asthma care (including ED visits) ▪ Reduction of exposure to harmful environmental triggers (like tobacco smoke) and increased use of daily controller medications to prevent symptoms. ▪ Patients in the intervention group had 40% fewer unscheduled visits (to urgent care or EDs) than patients in the control group over the 6-month follow-up period. ▪ At 1-month follow-up, more than 80% of school-aged participants in the intervention group reported no missed school days in the prior 2 weeks. ▪ The intervention group also showed more symptom-free periods and decreased asthma severity, with improvements in several measures of quality of life.
The CHICAGO Plan ¹⁴	<p>Comparison of 3 groups: an ED-focused intervention to improve the quality of care on discharge to home, a second group that receives ED intervention together with a home-based community health worker-led intervention, and a third group who receives enhanced usual care. All children receive spacers for the metered dose inhaler and teaching about its use.</p>	<p>Results are pending but will look at the following:</p> <ul style="list-style-type: none"> ▪ Asthma Impact Scale (for children) and Satisfaction with Participation in Social Roles (for caregivers) at 6 months ▪ Annual frequency and average duration of self-reported asthma attacks
School centered OAS ²⁶	<p>OAS delivers six 60-min lessons for children ages 8-11 designed to increase their recognition of asthma symptoms, their capacity for self-management, and their influence over their</p>	<ul style="list-style-type: none"> ▪ Increased self-management skills and self-efficacy skills and the child's influence on parental decision making ▪ Decrease in the annual frequency and average duration of self-reported

Table 1 (continued)

Program Name	Description	Outcomes
SAMPRO ²⁷	parents' asthma management decisions and to improve attendance SAMPRO identifies 4 key elements of school-based asthma management	asthma attacks <ul style="list-style-type: none"> Number of symptom days decreased by 43% in the intervention group and 7% in the control group A "circle of support" that includes cross-sector communication between physicians, school personnel, and family and community members Asthma Action Plan for school management and identification for self-carry of asthma medications where appropriate Education for school staff Remediation of any school-based asthma triggers.
Housing centered GHHI ³⁸	GHHI delivers in-home asthma education and tailored environmental control practices to homes of low-income children with high asthma morbidity in Baltimore, MD	<ul style="list-style-type: none"> ED visits decreased by 27% Hospitalizations decreased by 65% Missed school days reduced by 27%
HNHF Realty Collaborative ³⁹	Partnership between Nationwide Children's Hospital and a community partner to rehabilitate existing homes and develop new affordable homes in South Columbus with a focus on improving pediatric asthma outcomes.	<ul style="list-style-type: none"> Vacant and debilitated homes decreased by 50%
Medical home centered Washington Heights/Inwood Network for Asthma Program ⁵⁴	Community health workers provide asthma education, home-based care, and longitudinal communication to underserved Latino families in New York.	<ul style="list-style-type: none"> ED visits decreased by 50% Hospitalizations decreased by 50% Caregiver confidence in managing child's asthma increased by 100%
Northern California Breathemobile program ⁵⁵	Comprehensive pediatric asthma care including asthma education and medication management via mobile medical vans to school-aged children in Northern California	<ul style="list-style-type: none"> \$2.5 million in future ED costs saved

services. The law also required nonprofit hospitals to conduct a community needs assessment that factors in social needs such as housing. Lastly, it created an innovation center within the Centers for Medicare and Medicaid Services to develop payment models to improve health and reduce health care costs. All of those policy levers made a robust

environment for programs that tackle pediatric asthma morbidity by improving housing.

An example of this type of program is The Green and Healthy Housing Initiative (GHHI) in Baltimore, MD, which employs a comprehensive approach to addressing poor housing leading to high pediatric asthma morbidity.³⁸ GHHI focuses on delivering 8

elements to homes: dry, clean, safe, well ventilated, pest-free, contaminant-free, well maintained, and energy efficient. GHHI delivered in-home asthma education and tailored environmental control practices to homes of low-income children (age 2-14) with asthma from 2010 to 2013.³⁸ Six months after the housing intervention, there were a 65% reduction in hospitalizations and a 27% reduction in ED visits. There was also a 27% reduction in missed school days.

In Columbus, OH, Nationwide Children's Hospital partnered with Community Development for All People to develop the Healthy Neighborhoods Healthy Families (HNHF) Realty Collaborative through a combination of public, private, and philanthropic funding.³⁹ The aim of the HNHF collaborative is to rehabilitate existing homes and develop new affordable homes in South Columbus. The HNHF collaborative reduced vacant and debilitated homes by more than 50%.

Another way to address pediatric asthma morbidity as it relates to housing is through medical-legal partnerships. A medical-legal partnership is a targeted collaboration between health care and legal entities, in which legal expertise is specifically used to address the social needs of a patient and family.⁴⁰ Currently, there are 294 of these partnerships in 41 states.⁴¹ These partnerships facilitate referrals to enforcement agencies for action on housing code violations such as pest infestation or mold and successfully mitigate pediatric asthma triggers. Lawyers may also represent families in court against landlords and owners who refuse to remediate homes. A study in New York City showed that post-medical-legal partnership intervention, there were less asthma-related ED visits and hospitalizations as well as improved asthma symptomology.⁴²

By moving upstream in asthma care with increased collaboration between housing and legal services, root causes of asthma exacerbations can be removed from the home to decrease asthma morbidity.

PEDIATRIC ASTHMA AND THE MEDICAL HOME

Well-managed outpatient pediatric asthma can lead to better asthma control and a decrease in ED use. However, in a randomized, 3-arm, parallel-group, single-blinded study of 6-month post-ED pediatric asthma visits, there was no difference in ED recurrence between the following 3 groups: standard care, primary care scheduling prior to

discharge, and case management to ensure primary care follow-up.⁴³ Other studies have shown a similar trend with ED efforts to increase connection to primary care not reducing future ED rates.^{44,45} These studies do not discount the importance of primary care but do argue that simply promoting primary care follow-up may not be enough.

Instead, the focus should be aimed at ensuring that every child with asthma is integrated within a true medical home to prevent disjointed care. According to the American Academy of Pediatrics, care within a medical home must be accessible, family-centered, continuous, comprehensive, coordinated, compassionate, and culturally effective.⁴⁶ The literature does show that these individual components of a medical home improve pediatric asthma control and have a role in reducing future ED visits.⁴⁷⁻⁵² Pediatric practices with a high Medical Home Index have been shown to have lower chronic disease hospitalizations such as asthma.⁵³

One method to enhance the medical home model is through the use of community health workers. The Washington Heights/Inwood Network for Asthma Program is an initiative based in New York City in which culturally competent community health workers work with predominantly Latino low-income families of children with high asthma morbidity and recurrent ED use.⁵⁴ Included in this program are home visits, environmental trigger identification, asthma education, and ongoing telephone or face-to-face communication for 12 months. The program leads to significant reductions in asthma-related symptoms, hospitalizations, ED visits, and missed school days.

Another example of an enhanced medical home model is through the use of mobile medical clinics. The Breathemobile program in Northern California provides comprehensive pediatric asthma care including asthma education and medical management via mobile health vans to underserved school-aged children.⁵⁵ This program has been shown to reduce recurrent ED visits with an annual cost savings of more than \$2.5 million to the health sector.⁵⁶ Similar Breathemobile programs exist in Louisiana, southern California, Arizona, and Maryland. Mobile medical clinics can be a disease-specific extension of the medical home like Breathemobile, or it can offer all the functionalities of a comprehensive medical home such as the Children's Health Fund network. The Children's Health Fund is a network of pediatric mobile medical vans offering an all-inclusive medical home to underserved children with poor access to care.⁷ The program has 53 medical vans with 266 service sites

across the United States totaling 290,000 pediatric health encounters annually.

The reintegration into primary care after an asthma exacerbation ED visit is important. Furthermore, it is critical to ensure a connection to a comprehensive medical home. Medical homes with enhanced programs to ensure high access such as community health workers and mobile medical vans have the ability to significantly reduce asthma morbidity.

Strong coordination between the education and health sectors, through communication and the provision of asthma action plans, along with clinical services and health education programs in schools to treat asthma and provide education on asthma management, is necessary to improve educational outcomes for children with asthma.

CASE STUDY:

THE EXPERIENCE AT CHILDREN'S NATIONAL

Children's National operates 2 pediatric EDs, with a total of almost 115,000 ED visits annually. Seven thousand ED visits each year are for acute asthma exacerbation, which accounts for more than 85% of all pediatric ED visits for asthma in DC and nearly 1% of *all* pediatric asthma ED visits in the nation. Since 2001, Children's National has operated IMPACT DC, a pediatric asthma care, research, advocacy, and education program. The development of the IMPACT DC Asthma Clinic and our experience studying and sustaining the intervention have been previously described.⁵⁷

IMPACT DC is based in the ED and has expanded to include cross-sector initiatives aimed at addressing the different domains described above. Our expanded partnerships with local Medicaid managed care organizations continue to grow the program through novel financing mechanisms.⁵⁸ IMPACT DC also collaborates closely with school nurses to ensure medication availability in the schools and has piloted a school-based ICS administration intervention. To address the housing challenges faced by many families within our health system, we have longstanding partnerships with organizations that conduct in-home assessments and provide home-based education, remediation, and legal advocacy. These collaborations include numerous grant applications as partners to sustain and evaluate the effectiveness of our efforts.

Perhaps most importantly, we have expanded our collaborations with primary care practices that serve large volumes of our patients. Efforts include structured quality improvement activities support-

ed by the District of Columbia Department of Health, locating an additional IMPACT DC Asthma Clinic within a primary care clinic in a neighborhood of high asthma prevalence and morbidity, and including community primary care providers as staff in the IMPACT DC Asthma Clinic. These primary care providers work closely with ED providers, hospitalists, and subspecialty providers in staffing the IMPACT DC Asthma Clinic, fostering continuity of care within and beyond our health care system.

These novel partnerships within our community support IMPACT DC's founding goal of leveraging the ED's unique role in the public health continuum to transition patients from ED-based episodic care to ongoing longitudinal care. Our experience continues to demonstrate the importance of multisector partnerships to support families within their schools, homes, and communities.

SUMMARY

The ED is an ideal setting to identify children at risk for high morbidity and mortality from asthma. Models that build on the ED visit and continue postdischarge have proven effective, although disparities in childhood asthma still exist. Newer interventions to address disparities in childhood asthma include using the school setting; applying a broader, more robust definition of the medical home for children with asthma; and partnering with community health workers and mobile clinics. Effective strategies to improve childhood asthma outcomes rely on a multidisciplinary, cross-sector approach, with an emphasis on addressing social determinants. +

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