

MDRC Working Paper

**The Effectiveness of Interventions to Address
Childhood Asthma**

A Scan of the Literature and Current Approaches

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Contents

List of Exhibits	v
Acknowledgments	vii
Summary	ix
I. Introduction	1
II. Review of the Evidence	4
Types of Interventions	
Focus of Meta-Analysis	
Findings on Health Care Outcomes	
Findings on Morbidity and Quality of Life Outcomes	
Findings on Asthma Management Outcomes	
Costs and Savings	
III. Local Program Case Studies	21
IV. Case Studies of State Initiatives	26
Models with State-Level Origins	
Models with Local Origins	
V. Summary and Implications	35
Appendixes	
A Methodology for Literature Review	41
B Summaries of Asthma Studies	45
C Detailed Case Studies of Local Asthma Programs	67
D Detailed State-Based Case Studies	83
References	109
Supplemental Sources	117

List of Exhibits

Table

1	Summary of Effects of Asthma Interventions on Health Care Use	11
2	Summary of Effects of Asthma Interventions on Morbidity and Quality of Life	15
3	Summary of Effects of Asthma Interventions on Management Behaviors	18
4	Key Features of Local Asthma Programs	23
5	State-Based Case Studies of Asthma Programs	28
B.1	Summary of Studies with an Education and Self-Management Focus	47
B.2	Summary of Studies with a Home Environment Focus	54
B.3	Summary of Studies with a Health Care Practice Focus	62

Figure

1	Trends in Childhood Asthma (Ever Diagnosed)	2
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Box

1	Key Categories and Components of Childhood Asthma Interventions	6
2	Understanding Effect Sizes	9

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Summary

Asthma is the leading chronic health condition among children in the United States and a major cause of childhood disability. It is also a condition that disproportionately affects low-income and racial and ethnic minorities. Over the years, a wide range of interventions have been implemented to improve asthma-related outcomes among socioeconomically disadvantaged and minority children. Yet, disparities among children with asthma have persisted.

A clear foundation of evidence-based guidelines and clinical protocols exists to steer the management of asthma among children. But gaps remain in translating what *should* work for managing asthma — theoretically — into actual changes and meaningful improvements for disadvantaged families.

The purpose of this paper, which was commissioned by the JPB Foundation and conducted by MDRC in partnership with the National Academy for State Health Policy, is to explore the state of the research evidence regarding efforts to improve the management of asthma among children in low-income families. The review standardizes and compares effects from rigorous evaluations across three main types of interventions: those that focus on improving education and self-management, those that focus on addressing remediation of the conditions that trigger asthma in the home environment, and those that focus on improving health care provider practice. While prior reviews have summarized findings for each intervention type, this review systematically compares findings across a range of outcomes and a spectrum of different approaches to addressing childhood asthma, drawing from about 30 independent studies and earlier published reviews. In addition, the paper includes case studies of various local programs and state-level policy initiatives to illuminate current efforts to address childhood asthma in low-income communities. These case studies highlight both local innovations and barriers faced in sustaining asthma programs.

The main findings of this review are as follows:

- **Providing education on how to manage asthma is fundamental to improving outcomes.**

Teaching low-income families and children who struggle with persistent asthma about strategies for self-management — including controlling asthma by adhering to medication regimens, seeking appropriate care, and reducing triggers — is the most common element across numerous interventions that have been implemented. Interventions that focus on providing education to children and families have small to modest impacts on reducing the number of days that children experience symptoms, have functional limitations, and miss school. Education-based interventions also reduce the risk of urgent and serious health

care encounters, although effects are often small and it is unknown whether benefits extend beyond 12 months. Thus, while education is fundamental, it may not be enough to alleviate disparities in asthma management.

- **Some local programs are clearly bridging informational gaps among low-income families in their communities, and are going beyond information sharing to help families maintain a safe home environment for their children with asthma.**

Front-line service providers explained that a core component of the initial home visits with a family is to explain the distinctions between the different prescription medications, demonstrate how to ensure proper dosage with “spacers” (devices that can help ensure inhaled medication reaches the lungs), and emphasize the importance of using medications to control the condition (even when asymptomatic) and the dangers of over-reliance on medication that is administered in an emergency or *after* an acute event has occurred. In addition to bridging informational gaps, these multicomponent programs are providing tools and resources to assist families in ensuring that their home environment does not exacerbate conditions in children’s vulnerable lungs. In order to achieve this objective, some programs have adapted their services so they can tackle conditions and systems that are beyond the family’s control and that are often endemic to living in old and deteriorating housing.

- **However, the health care benefits of interventions that go beyond education are unclear.**

Programs that focus on improving the home environment reduce the levels of allergens (“triggers”) in the home. They also appear to produce greater reductions of asthma symptoms and functional limitations than other types of approaches. But there is limited evidence demonstrating that these more intensive and costly programs are more effective at reducing urgent and serious health care encounters than less expensive approaches. Unfortunately, there are too few head-to-head comparisons of education-only interventions with the more intensive, multicomponent home environment interventions to provide definitive answers to questions of relative impacts and cost-effectiveness.

- **Barriers to medication management are complex.**

Asthma is a controllable disease with the proper medication, but the steps needed to keep inflammation under control can be complicated. They can also change over time. Even when educational programs fill in health information gaps among children with poorly controlled asthma, barriers to medication management remain. This review suggests that, on the one hand, educational programs slightly improve the regular use of medications that are intend-

ed to control asthma symptoms. On the other hand, home environment interventions appear to reduce the frequency of use of rescue medications, as do provider-practice interventions. However, these impacts on medication use, across intervention types, are based on only a handful of rigorous evaluations. This limitation suggests the need for future evaluations to consider the importance of measuring and monitoring asthma management behaviors as an outcome of interest. At the very least, these findings also suggest that medication adherence is a complicated behavior and difficult to influence. Because medication plays such a fundamental role in the treatment of asthma, investigating ways to improve its proper and consistent use is a critical area for future research.

- **The role of the state, and the Medicaid program in particular, is relevant for the financing and sustainability of asthma programs for low-income children.**

Given that cost-saving initiatives are of particular importance to payers (including the federal government), programs must be able to demonstrate a short-term positive return on investment before they can be replicated. However, the vast majority of published studies do not report information on cost savings or cost-effectiveness; as a consequence, the frequently cited cost-savings statistics are based on a handful of studies with potentially limited generalizability. It is essential for future research to collect better information on program costs relative to program effectiveness in order to identify potential tradeoffs as well as ways to improve efficiency. Future practice and policy should enhance current health care data systems to accurately track outcomes, improve care for patients by allowing providers access to real-time data, and strengthen the capacity for population health management.

• • •

In sum, the higher prevalence of asthma among children in low-income and minority families remains a troubling concern, despite decades of research. While the explanation for these health disparities remains unclear, as does the etiology of asthma, this review identifies several issues that may be influential in addressing persistent health disparities. One important point is that education on asthma management — particularly on proper medication management — is a fundamental component of effective asthma interventions. At the same time, there is considerable room for improvement in ensuring proper, up-to-date, and sustained medication regimes among low-income children and families. Also critical is the need to establish the cost-effectiveness of current programs so they can be replicated and expanded, or redesigned to be more cost-efficient. State-run Medicaid programs, for one, reflect the importance of maintaining a funding stream for asthma programs. Although the long-run sustainability of some of the programs highlighted in this report is uncertain, what is clear is that combating the disparities in the prevalence of asthma among different populations will require more than an agreement on standard asthma management practices within the medical community.

I. Introduction

Asthma is a chronic disorder, characterized by an excessive sensitivity and inflammation of the lungs. It is the leading health condition among children and a major cause of childhood disability.¹ About 7 million children below the age of 18 had asthma in 2012, which translates to about 1 in 10 children in the United States living with this condition. Across age groups, the highest prevalence rate is found among children 5 to 11 years old (11 percent), although rates are similarly high for children ages 12 to 18 years (10 percent).² These statistics, however, mask troubling differences by race/ethnicity and socioeconomic status. In 2006 to 2008, the prevalence of asthma was 8 percent among non-Hispanic white children compared with about 15 percent for non-Hispanic black children.³ The asthma prevalence for children in poverty (whose family incomes are below the federal poverty level) was 12 percent; the rate among the nonpoor (whose incomes were above 200 percent of the poverty level) was 8 percent.⁴

Of considerable policy concern is the persistence of these disparities over time. Figure 1 displays trends in asthma (ever diagnosed) for all children, and by race and poverty status, since the late 1990s.⁵ Nationally, the percentage of children ever diagnosed with asthma has slightly increased since 1997. And, if anything, black-white disparities have widened, as has the gap between the nonpoor and the poor.⁶ Although the estimates over time for Hispanic children are very similar to those for white children (not shown), separate estimates by Hispanic subgroups, when available, reveal that asthma prevalence in Puerto Rican children is similar to or even higher than in non-Hispanic black children.⁷ Explanations for both the increase in asthma prevalence population-wide and the faster increase among black children in particular remain unclear.⁸

¹Akinbami (2006).

²Bloom, Cohen, and Freeman (2013). Although adults have or can develop asthma, it most commonly emerges, both in symptoms and diagnoses, in childhood, as asthma is tightly connected to lung functioning, and children's lungs are still developing and sensitive to external stimuli. The diagnosis of asthma typically is made in the elementary school years, although symptoms often appear earlier. This is because children in the preschool ages may not be able to complete diagnostic airflow tests, nor are they able to describe symptoms to their parents and providers.

³Moorman, Zahran, Truman, and Molla (2011).

⁴Moorman, Zahran, Truman, and Molla (2011).

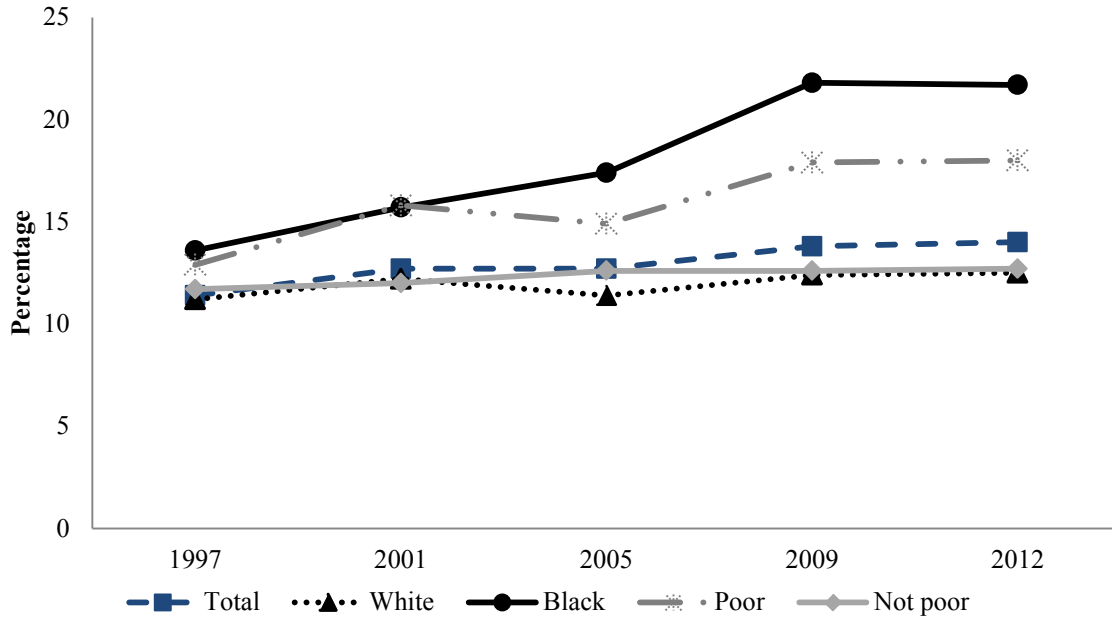
⁵Note that "ever diagnosed" percentages are typically about 4 to 5 percentage points higher than "currently has asthma" reports since it is possible (albeit unpredictable) to "grow out" of asthma. Questions on current asthma were not asked the same way over time in the National Health Interview Survey (NHIS) waves (the data source for the estimates), which is why Figure 1 shows only "ever diagnosed" trends. Disparity trends for the most recent surveys that included the same questions on current asthma suggest similar patterns to what is seen in Figure 1.

⁶Mehta, Lee, and Ylitalo (2013).

⁷Moorman, Zahran, Truman, and Molla (2011).

⁸One national-level analysis of child asthma trends from 1998 to 2009 found that the growth in black-white disparities could not be explained by socioeconomic status (captured by the highest education level of the

Figure 1. Trends in Childhood Asthma (Ever Diagnosed)



SOURCE: National Health Interview Surveys (NHIS), 1997-2012, Centers for Disease Control and Prevention (CDC).

NOTES: Based on parental reports of whether they have ever been told that their child has asthma by a health care professional. Reported for children ages 0 to 18 years. Poverty is based on the federal poverty level (FPL); poor = families with incomes below FPL; not poor = families with incomes above 200 percent of the FPL.

The consequences of these trends and patterns are numerous. It has been estimated that asthma costs the nation \$56 billion annually and accounts for \$50.1 billion in direct health care costs.⁹ Hospitalizations and frequent emergency department (ED) visits account for a large proportion of these costs. Children with asthma need access to regular ambulatory care to closely monitor and manage the condition, even when symptoms are dormant. However, children having asthma attacks visit the ED frequently, which indicates that the disease is uncontrolled, and often reflects a lack of access to adequate primary or specialist care or inappropriate use of emergency services.¹⁰ Some of these ED visits will result in a hospital admission due to the

parents), insurance coverage, and other factors correlated with asthma diagnosis (Mehta, Lee, and Ylitalo, 2013).

⁹Barnett and Nurmagambetov (2011).

¹⁰Akinbami (2006).

severity of the attack.¹¹ In fact, asthma is the third leading cause of hospital admissions among children. Medicaid is the single largest payer for childhood asthma care, including ED visits and hospital stays.¹²

Asthma has been shown to compromise the overall quality of life for both the child with asthma and the caregiver.¹³ Not only are children with asthma more likely than nonasthmatic children to miss school due to illness, parents of asthmatic children also miss more workdays.¹⁴ Children with persistent asthma are more likely to be constrained in their day-to-day activities, affecting both their physical and emotional well-being.¹⁵ Thus, alongside high health care costs, untreated or poorly managed asthma results in heavy tolls on overall well-being for children and their caregivers. As a condition that is more likely to occur among the poor, asthma may also exacerbate existing health inequalities if left unmanaged.

Given these concerns, it is perhaps unsurprising that many asthma interventions have been implemented and tested over the years among low-income and high-risk populations. As the causes of asthma remain unknown, interventions have focused squarely on improving treatment and the management of symptoms and triggers. Many of these efforts support the implementation of evidence-based clinical guidelines on proper asthma care, and they aim to improve the conditions and behaviors that affect short- and long-term management. At the same time, the persistence of asthma-related disparities among low-income children suggests either that sustained improvements in asthma outcomes are somewhat resistant to current intervention approaches, or that the strongest components of asthma interventions have been difficult to replicate, finance, and target appropriately.¹⁶ In short, the field seems to know what *should* work to address childhood asthma from a clinical perspective. However, without a clear understanding of what actually *does* work consistently to improve asthma outcomes among all children, convincing stakeholders to translate practices into policy action is likely to be challenging.

This paper explores the state of the research evidence on a range of asthma interventions that seek to improve outcomes among low-income children, and it highlights several programs and policies in place across different states and communities. Specifically, the review is framed around three questions:

1. What is the strength of the evidence of effectiveness across various asthma interventions in improving outcomes for low-income children and families?

¹¹One analysis of 23 states suggests that about 12 percent of pediatric ED visits for asthma result in a hospital stay (Merrill, Owens, and Stocks, 2008).

¹²Stranges, Merrill, and Steiner (2008).

¹³Halterman et al. (2004).

¹⁴Diette et al. (2000); Moonie, Sterling, Figgs, and Castro (2006).

¹⁵Nocon (1991); Milton, Whitehead, Holland, and Hamilton (2004).

¹⁶Akinbami (2006).

2. How are locally developed programs addressing childhood asthma in low-income communities? What adaptations have they made to sustain or improve their programs, and what barriers have they encountered?
3. How have different states developed and financed particular asthma programs? How are they incorporating evidence to support their efforts?

To answer these questions, the paper relies on different data sources and strategies. A literature review of childhood asthma program evaluations (published between 2004 and 2014) was conducted to understand the existing research evidence on asthma interventions focused on low-income children. Because each study produced somewhat different impacts and was conducted in different settings, MDRC undertook a meta-analysis of previously published randomized control trials (RCTs) in order to effectively synthesize the evidence across independent evaluations. This technique allows a researcher to combine and compare the impacts on similar outcomes across different studies and samples. Further, MDRC conducted case studies of community-based asthma programs to shed light on locally driven efforts to alleviate childhood asthma among low-income or underserved populations. In addition, the National Academy for State Health Policy (NASHP) led and completed a detailed review of six different state policy initiatives to provide a portrait of the types of policy efforts that are currently under way in the asthma field. Finally, MDRC interviewed a number of leading experts in the field of childhood asthma to guide and supplement the scan of the research evidence, programs, and policies.

The paper is organized as follows: Section II presents a review of the research evidence from existing evaluations of various asthma interventions targeting low-income children that have been implemented in different contexts. Section III presents findings from case studies of four different community-based asthma programs that are navigating and adapting services to families in real-world settings. Section IV highlights current efforts in six different states to reform health care delivery and financing to address uncontrolled pediatric asthma in high-risk populations. Section V summarizes key findings from this scan and offers some implications for research and practice.

II. Review of the Evidence

Despite decades of research, the causes of asthma remain unclear. This gap in knowledge makes it challenging to identify and mitigate the precipitating conditions that may drive asthma disparities. For example, the hygiene hypothesis suggests that reducing children's exposure to infectious agents and microbial contamination leads to increased risks of asthma (and the prevalence of allergies in general) in industrialized countries. But as noted in a recent review of child health variations in the United States, this theory does not explain widening

black-white and income disparities in asthma.¹⁷ Instead, other explanations that are rooted in identifying differences in the treatment and management of the condition may be much more relevant to understanding and addressing inequalities.

Types of Interventions

Before presenting findings on the strength of the evidence of current asthma interventions, this section first describes the broad categories of approaches. The evaluation studies examined fall mainly into three categories:¹⁸

- interventions that focus on **education and self-management** among families
- interventions that focus on addressing the **home environment** (which almost always includes an educational component as well)
- interventions that focus on **health care provider and practice** changes

Box 1 provides a brief description of the common elements of the intervention types, although programs within each category may differ in the particular services that are provided, the type(s) of service provider(s) used to implement the program, and the intensity (and costs) of services. There is also some degree of overlap in intervention components.

One approach focuses primarily on improving the management of asthma through providing education to the family — motivated by the fact that while there are proven strategies for the clinical management of asthma, there also appears to be a lack of adherence to or compliance with these standard practices among families with the highest risk for poor outcomes. Noncompliance with standard medication guidelines is an example of this disconnect. Children with persistent asthma are given controller medication (which decreases inflammations of the airways over time) and rescue or “quick-relief” medication (which alleviates symptoms immediately) to manage their condition. While controller medication is used on a daily basis, even if asymptomatic, rescue medication should be taken sparingly, as frequent use can actually cause more severe attacks.¹⁹ A study among Medicaid families with asthma found that nearly three-

¹⁷Mehta, Lee, and Ylitalo (2013). Others (Greenwood, 2011) have argued that although the hygiene hypothesis might explain the emergence of allergies, it does not explain the rise in asthma in developed countries (and although correlated, some studies suggest that about half of asthma cases do *not* have an allergic component).

¹⁸There is some overlap between these categories. For example, some studies included in the self-management category provided tools and education to address the home environment or were conducted in the home setting. Some provider-focused interventions also included an educational component for parents. Our categorization of studies was ultimately based on the primary focus of the intervention.

¹⁹Short-acting bronchodilators (also called beta-2 agonists) or rescue medications relieve asthma symptoms rapidly by relaxing the muscles around closing airways, and are typically delivered with a nebulizer or an inhaler with an attached spacer to ensure proper dosage.

Box 1

Key Categories and Components of Childhood Asthma Interventions

Educational

- Provides education and explanation about the condition, symptoms, and triggers
- Focus is primarily on management strategies, including medication adherence, having an asthma action plan, and trigger reduction
- May include strategies to improve patient-provider interaction and communication
- Some offer provision of materials, such as trigger remediation supplies

Home environment

- Includes standard asthma education and self-management information
- Environmental assessment of the home conducted by trained staff
- May also include skin tests to identify triggers
- Supplies and strategies for indoor trigger remediation given to families
- Resources and referrals provided to improve conditions in home, such as integrated pest management, cleaning services, or mold removal, and may include assistance with landlords and housing authorities

Health care practice

- Focus is typically on improving quality of care delivered to patients
- Encompasses a range of interventions, including
 - encouraging physician-specific feedback on prescriptions and asthma action plan
 - enhanced monitoring of patient care via health information technology and feedback loops
 - case management or care coordination

fourths underused controller medication (that is, they used it on less than a daily basis).²⁰ Another study found that significantly fewer black and Hispanic children reported using controller medication compared with white children; they were more likely to receive a daily dose of rescue medication instead.²¹ Other research documents confusion among parents and children

²⁰Finkelstein et al. (2002).

²¹Crocker et al. (2009).

about the difference between medications, parental resistance to giving children a steroidal medication, and parental beliefs that their child will “grow out” of asthma, suggesting a lack of understanding of the chronic and potentially severe nature of the condition.²²

Asthma is exacerbated by various stimuli that trigger hyperreactivity of the lungs. Triggers can include viral infections (for example, the flu), allergies (including allergens from pets, cockroaches, dust mites, mice and rats, and mold), certain gases and particles in the air (including wood-burning smoke and pollen), seasonal changes in temperature (such as colder temperatures or sudden temperature shifts), secondhand smoke, strenuous exercise, and stress. Living in urban environments exacerbates many of the external triggers. Thus, a number of interventions have focused on remediating home environment triggers, especially among inner-city, low-income families, who often reside in older or deteriorating housing and lack resources to mitigate environmental triggers. Most important, different children have different levels of sensitivity, and thus varying reactions to triggers; some programs tailor their remediations based on particular sensitivities.

Not only are there gaps in the management of asthma among low-income families, there are related gaps in the health care delivery system. Some of these disparities are not well understood, such as the lower use of regular, preventive health care among high-risk families. Others appear to stem from inadequacies in the care that is received. For example, research has shown that health care providers do not routinely follow standard asthma care guidelines, including those of the National Asthma Education and Prevention Program (NAEPP). These guidelines recommend writing or updating an asthma action plan (a tailored management protocol developed by the patient and physician), monitoring symptoms and medication regularly; referring patients to specialists if needed, and ensuring that patients understand how to use medication and monitoring devices. One of the limitations of asthma guidelines is that health care providers are not given tools or supports to implement the recommended care.²³ Thus, some interventions have focused on changing provider practices to improve the apparent disconnect between patients and clinicians in asthma management.

Focus of Meta-Analysis

The findings from the literature summarized in this section are based on a review of program impact evaluations that were published 2004 to 2014. Although initial searches were not limited by sample characteristics (other than the focus on children), the vast majority of reviewed studies focused on low-income or racial/ethnic minority children in urban environments. In total, 33 original articles were reviewed: 26 experimental studies, or RCTs, and 7 nonexperimental (before-and-after comparison) studies. Because random assignment studies

²²Conn et al. (2005); Horne and Weinman (2002); Mansour, Lanphear, and DeWitt (2000).

²³Okelo et al. (2013).

are considered the most rigorous of study designs, the meta-analysis results are based on evaluations that used this design.

Although the reviewed studies reported findings on a wide range of outcomes, the summaries focus on the most commonly examined and policy-relevant outcomes, including the following:

- *health care usage* (for example, ED use, hospitalizations, unscheduled or acute care visits, and scheduled asthma visits to providers)
- *morbidity and quality of life*,²⁴ which broadly includes measures of health status (for example, days or nights the child experienced symptoms), parental or child self-reports of functional and emotional well-being, and missed school or parental workdays
- *asthma management and remediation*, which includes outcomes related to medication adherence and the presence or use of an asthma action plan. Under this category, some home environment-focused studies report impacts on trigger reduction in children's homes (such as reductions in allergens or indoor smoke exposure)

We also discuss information on costs and cost-effectiveness, although very few studies have examined cost factors.

A significant challenge to summarizing the reviewed studies is that the outcomes they examined vary in how they were measured or reported (for example, as means, medians, ratios, percentages, or changes in scores or incidences), how they were defined (with some studies using slightly different questions), and when they were assessed (from six months to two years). Sample sizes also varied considerably across studies (from 62 to 1,561). To compare impacts across the different studies, the estimates from both individual RCTs and group RCTs were standardized as effect sizes for outcomes that were measured in a consistent way.²⁵ Results from 22 of the 26 experimental studies measured and reported impacts on similar outcomes in a consistent enough way to include them in the meta-analysis.

²⁴Quality of life (QOL) measures are often based on self-reports (either of the caretaker or the child) of symptoms, activity limitations, and emotional functioning that either are shown separately or are summed into a total QOL score.

²⁵The control group comparison varied across studies, which is noted in the detailed summaries of individual studies (Appendix B). In almost all cases, the control group was either usual care or a lower-intensity group (which ranged from the provision of basic education materials to single home visits and minimal services). We did not include in our summary estimates studies where the control group appeared to receive more intensive services, making them akin to the program group in other studies (although the services provided may have been less intense compared with the program group's services).

The effect sizes for outcomes were then pooled, so that substantive impacts could be compared across a heterogeneous mix of studies. (Box 2 provides more information on understanding effect sizes.) This is particularly valuable not only for comparing the magnitude of effects across the numerous experimental studies included, but also for allowing comparisons by the three main intervention categories.

Box 2

Understanding Effect Sizes

An effect size is a way to characterize the effectiveness — or *impact* — of an intervention on an outcome of interest relative to some comparison. It takes into account both the magnitude of the impact (or the difference between the program and control group outcomes) and the dispersion (spread of values) in the estimate, rather than relying on the statistical significance. It is routinely used in meta-analyses, in order to compare and integrate the results from independent studies where impacts may have been reported differently, but it was rarely reported in the studies that are reviewed in this paper.

Using the estimates and sample statistics found in the published articles that are reviewed here, effect sizes were estimated for the main outcomes of each study. Effect sizes are either standardized mean differences (SMDs) for outcomes that are means (for example, number of emergency department visits) or risk ratios (RRs) for outcomes that are reported as a proportion (for example, percentage who have visited the emergency department at least once).

An SMD of zero means that the intervention had no impact. If the SMD is greater than zero, the intervention increased the outcome; if it is less than zero, the intervention reduced the outcome. Interpreting the meaning of the effect size is somewhat ambiguous, as there are no clear benchmarks for asthma-related outcomes (to our knowledge). Generally, an effect size of 0.20 (or two-tenths of a standard deviation unit) or less is considered to be small; an effect size of about 0.5 is considered moderate; and an effect size of 0.8 is considered large.*

For effects that are summarized as a risk ratio, a risk ratio of 1.0 indicates that the intervention had no impact. A risk ratio greater than 1.0 means that the intervention increased the risk of an event compared with the control group outcome, whereas a risk ratio less than 1.0 means that the intervention lowered the risk of an event.

For each outcome, pooled effect sizes are reported, which have been weighted by the inverse of the sample variance and calculated by fixed-effects models. However, for outcomes with statistically significant heterogeneity across studies, random-effects models were estimated. For more detail on the calculation and pooling of effect sizes in this review, see Appendix A.

*Cohen (1988).

Although effect sizes were not calculated for nonexperimental studies, the results of several articles from before-and-after analyses were also reviewed to shed further light on the interventions and outcomes they may be able to improve. Seven separate previously published meta-analyses were examined as well. Although these meta-analyses often included evaluations that were published before 2004 (as early as 1976 and as late as 2008), they provide a critical source of additional information for contextualizing the findings within the larger evidence base. This is important because the pooled effect sizes are based on only a few RCTs for some outcomes. More information on the methodology for selecting studies, estimating effect sizes, and summarizing effects can be found in Appendix A. More details on each individual study reviewed (both those that are included in summary estimates and those that are not), including the setting, sample, intervention components, and main findings, are presented in Appendix B.

Findings on Health Care Outcomes

Across the RCTs examined, 14 measured and reported enough data on impacts on at least one of the health care outcomes shown in Table 1, including the number of ED visits, risk of any ED visit, number of hospitalizations, risk of hospitalization, number of unscheduled or urgent care visits, and number of regular, scheduled care visits. These evaluations include a mix of the different types of interventions, although there are more educational program evaluations for health care outcomes than the other intervention categories.

Emergency Department Use

Impacts pooled across 11 evaluations suggest they have modest effects on reducing the number of ED visits (standardized mean difference [SMD] of -0.17; 95 percent confidence interval [CI]: -0.24 to -0.11).²⁶ The pooled effect size for educational interventions of -0.30 is statistically significant at the 5 percent level. One study of provider practice change, which consisted of training providers on NAEPP guidelines, monitoring children's symptoms through phone calls, and updating providers on changes, found statistically significant impacts as well, although not as large.²⁷ Home environment interventions also show small reductions in ED visits, although the combined effect size of -0.07 is notably lower than that of educational interventions. When measured as a binary outcome (any ED visit versus none at the time of follow-up), no notable reduction in risk is found across the five studies representing the various intervention models.²⁸

²⁶For number of ED visits, the studies include Butz et al. (2010), Horn et al. (2014), Joseph et al. (2007), Kamick et al. (2007), and Teach et al. (2006) (educational); Bryant-Stephens and Li (2008), Gorelick et al. (2006), Kercsmar et al. (2006), Klinnert et al. (2005), and Morgan et al. (2004) (home environment); and Kattan et al. (2006) (provider practice).

²⁷Kattan et al. (2006).

²⁸For any ED visit, the studies summarized include Butz et al. (2005a) and Fisher et al. (2009) (educational); Gorelick et al. (2006) and Kercsmar et al. (2006) (home environment); and Halterman et al. (2012) (provider practice).

Table 1. Summary of Effects of Asthma Interventions on Health Care Use

Select Outcomes	Effect Size (ES) Type ^a	Overall Effects			Type of Intervention					
		ES	95% CI	Number of Studies (N)	Education		Home Environment		Provider Practice	
					ES	N	ES	N	ES	N
Any ED visit	RR	1.04	(0.86, 1.26)	5	1.12	2	0.84	2	1.33	1
Number of ED visits	SMD	-0.17 *	(-0.24, -0.11)	11	-0.30 *	5	-0.07	5	-0.17 *	1
Any hospitalization	RR	0.85	(0.68, 1.04)	5	0.66 *	3	1.10	1	1.00	1
Number of hospitalizations	SMD	-0.10 *	(-0.18, -0.01)	6	-0.18 *	4	0.06	1	-0.03	1
Number of unscheduled primary care visits	SMD	-0.16 *	(-0.24, -0.09)	5	-0.38 *	2	-0.11	2	-0.10	1
Number of regular primary care visits	SMD	0.06	(-0.09, 0.20)	3	0.06	3		0		0
Total number of RCTs included				14	7		5		2	

NOTES: ES = effect size; RR = risk ratio; SMD = standardized mean difference; CI = confidence interval; ED = emergency department; RCT = randomized controlled trial.

*Denotes that the effect size is significantly different from 0 if reported as a standardized mean difference or different from 1 if reported as a risk ratio ($p < 0.05$).

^aRR is reported for binary outcomes; SMD is reported for outcomes reported as means.

Hospitalization

The estimates for hospitalization outcomes suggest that the interventions reviewed significantly reduce the number of hospitalizations (six studies),²⁹ although the effect size is small. No reduction in the risk of any hospitalization was found across five studies.³⁰ Turning to the effects for specific intervention types, it appears that educational programs are, as a whole, effective in reducing the number of hospitalizations (SMD = -0.18, $p < 0.05$) and decreasing the risk of any hospitalization by about 34 percent (RR = 0.66, $p < 0.05$). One home environment intervention (based on the Inner-City Asthma Study) examined the proportion of children with any hospitalization at one and two years following the intervention. This study, representing the

²⁹These include Butz et al. (2010), Joseph et al. (2007), Karnick et al. (2007), and Teach et al. (2006) (educational); Klinnert et al. (2005) (home environment); and Kattan et al. (2006) (provider practice).

³⁰These include Butz et al. (2005a), Fisher et al. (2009), and Horn et al. (2014) (educational); Morgan et al. (2004) (home environment); and Halterman et al. (2012) (provider practice).

largest home environment-focused intervention reviewed (sample size of ~850), provided numerous home visits and services to reduce the levels of in-home allergen triggers among inner-city families. Although the results at Year 2 suggested a trend toward reduced risk of hospitalization for the intervention group, this impact was not significantly different from that of the control group.³¹

Unscheduled and Regular Primary Care Visits

Overall impacts on the use of unscheduled, urgent care visits to primary care providers (not including hospital admissions and ED visits) suggest that the interventions reduce the number of unscheduled visits (SMD = -0.16, 95 percent CI: -0.24, -0.09).³² The educational interventions (n = 2) appear to produce the largest reductions in unscheduled visits (SMD = -0.38, p < 0.05). In particular, the IMPACT-DC study, which consisted of a single session with an asthma educator and a physician shortly after a child had an ED visit, found a 40 percent reduction in unscheduled visits after six months.³³ Two home environment evaluations (one of which was from the Inner-City Asthma Study) and one evaluation of a provider-based intervention did not find significant effects on reducing the number of unscheduled visits, although the impacts are in the right direction.³⁴

Interventions that aim to reduce costly and urgent health care use often encourage families to visit primary care providers on a regular basis, in order to monitor asthma severity and symptoms. However, no improvement was found across the three studies where effect sizes were calculated, all of which were evaluations of educational interventions.³⁵

Earlier Meta-Analyses Findings on Health Care Use

Findings from the extant meta-analyses reviewed have documented mixed results on health care outcomes. For example, two meta-analyses of educational interventions for asthmatic children found reductions in the number of ED visits: one prior review found an SMD of -0.21 across 12 studies,³⁶ and the other found an SMD of -0.17 across 13 studies.³⁷ These

³¹Morgan et al. (2004).

³²These include Horn et al. (2014) and Teach et al. (2006) (educational); Bryant-Stephens and Li (2008) and Morgan et al. (2004) (home environment); and Kattan et al. (2006) (provider practice).

³³Teach et al. (2006).

³⁴These include Morgan et al. (2004) and Eggleston et al. (2005) (home environment). Two other evaluations based on a Seattle-based home environment remediation program examined risk of any urgent care-related visit (but this measure included ED visits and hospitalizations, and thus is not comparable to the other studies). These studies — Krieger, Takaro, Song, and Weaver (2005) and Krieger et al. (2009) — found reductions for the program group.

³⁵These include Butz et al. (2010), Horn et al. (2014), and Teach et al. (2006).

³⁶Wolf et al. (2008).

³⁷Coffman, Cabana, Halpin, and Yelin (2008).

estimates are consistent with the findings presented in Table 1. But prior meta-analyses have produced inconsistent effects on the proportion of patients who experienced an ED visit.³⁸ On the outcome of hospitalization, one meta-analysis of educational interventions found a lower risk of experiencing any hospitalization across 18 studies,³⁹ which is consistent with the effects of the educational studies reviewed for this paper. No effects on the risk of any hospitalization were found in two other meta-analyses of educational interventions (based on eight studies⁴⁰ and four studies,⁴¹ respectively). There are also divergent findings from earlier meta-analyses of educational interventions on number of hospitalizations.⁴²

These meta-analyses included different studies that were conducted and published in earlier decades (1970s, 1980s, and 1990s), which might explain some of the divergence in findings across different meta-analyses. There is also some overlap in the reviewed studies, both across meta-analyses and for some of the studies included in this review.⁴³

One meta-analysis of home environment interventions was examined, although this review included nonexperimental studies (pre- and post-intervention analysis without a comparison group) and combined ED, hospitalization, and unscheduled visits as an acute care composite outcome.⁴⁴ The authors also reported outcomes as medians rather than means. They found an overall median reduction of 0.57 acute care visits per year across 10 home environment evaluations. When analyzed by study design, the median reduction was considerably greater in nonexperimental studies (a decrease of 3.38 visits) than in RCTs (a decrease of 0.37 visits). Not surprisingly, the nonexperimental studies reviewed as part of this paper also yield larger impacts compared with experimental studies using a randomly selected control group. This underscores the importance of understanding and comparing outcomes against the counterfactual of usual care when possible.

³⁸Coffman, Cabana, Halpin, and Yelin (2008) and Boyd et al. (2009) found statistically significant reductions in the risk of an ED visit across 10 and 17 studies reviewing educational-focused asthma interventions, respectively. Wolf et al. (2008) estimated that the odds of an ED visit across six studies was actually 1.3 times higher for the program group in educational interventions (although this difference was not significant at the 5 percent level).

³⁹Boyd et al. (2009).

⁴⁰Coffman, Cabana, Halpin, and Yelin (2008).

⁴¹Wolf et al. (2008).

⁴²Coffman, Cabana, Halpin, and Yelin (2008) found reductions, whereas Wolf et al. (2008) did not.

⁴³These include Brown et al. (2006), Butz et al. (2005a), Butz et al. (2010), Fisher et al. (2009), Gerald et al. (2006), Joseph et al. (2007), Karnick et al. (2007), and Teach et al. (2006) (educational); Eggleston et al. (2005), Kercksmar et al. (2006), Klinnert et al. (2005), Krieger, Takaro, Song, and Weaver (2005), Krieger et al. (2009), Levy et al. (2006), and Morgan et al. (2004) (home environment); and Gorelick et al. (2006) and Kattan et al. (2006) (provider practice).

⁴⁴Crocker et al. (2011).

A meta-analysis that reviewed provider practice interventions noted that while some individual studies were able to examine and demonstrate improved patient outcomes, there was insufficient evidence across studies to comment more generally on the effectiveness of these interventions on health status or health care use.⁴⁵ MDRC's review of the literature on provider practice included only four RCTs, as evaluations of educational and home environment interventions are much more common.

Findings on Morbidity and Quality of Life Outcomes

Twelve studies reviewed examined impacts of interventions on improving asthma-related functioning and morbidity (Table 2), which includes the prevalence and frequency of days or nights with asthma symptoms, and days with functional limitations (that is, compromises to daily activity). Measures of quality of life (which most commonly include parental reports of emotional and functional well-being based on standardized instruments) and missed school days were also examined. The impacts on missed workdays for parents were not often examined (only in two studies) and are thus not shown in Table 2.

Symptom Days and Nights

Parental reports of the presence and number of days that the child experienced asthma symptoms and the presence and number of nighttime interruptions caused by asthma symptoms are commonly used indicators to assess asthma morbidity. Higher prevalence or numbers of symptom days or nights suggest greater asthma severity, but they are also indicative of poorly controlled asthma. Results pooled across seven studies indicate that interventions significantly reduced the number of symptom days experienced (SMD = -0.20, 95 percent CI: -0.27, -0.13).⁴⁶ There are also reductions, based on four studies, in the number of symptom nights experienced (SMD = -0.31, 95 percent CI: -0.41, -0.20).⁴⁷ However, when measured as the risk of experiencing any symptom days or symptom nights, no reductions across evaluations are found.⁴⁸

Turning to the effects for the different intervention types, it appears that educational, home environment, and provider practice interventions produce small to moderate-sized effects on reducing the number of nights that children experience symptoms. The largest effects are found in one home environment trial (the Inner-City Asthma Study) and on a provider practice trial.⁴⁹ For the outcome of number of days with symptoms, the largest effects are found for

⁴⁵Okele et al. (2013).

⁴⁶These include Butz et al. (2010) and Joseph et al. (2007) (educational); Krieger, Takaro, Song, and Weaver (2005), Krieger et al. (2009), and Morgan et al. (2004) (home environment); and Halterman et al. (2012) and Kattan et al. (2006) (provider practice).

⁴⁷These include Butz et al. (2010) and Joseph et al. (2007) (educational); Morgan et al. (2004) (home environment); and Halterman et al. (2012) (provider practice).

⁴⁸These include Teach et al. (2006) (educational) and Eggleston et al. (2005) (home environment).

⁴⁹Morgan et al. (2004) and Halterman et al. (2012).

Table 2. Summary of Effects of Asthma Interventions on Morbidity and Quality of Life

Select Outcomes	Effect Size (ES) Type ^a	Overall Effects			Type of Intervention					
		ES	95% CI	Number of Studies (N)	Education		Home Environment		Provider Practice	
					ES	N	ES	N	ES	N
Any symptom days	RR	0.94	(0.81, 1.10)	2	0.95	1	0.93	1		0
Number of symptom days	SMD	-0.20 *	(-0.27, -0.13)	7	-0.15	2	-0.32 *	3	-0.06	2
Any symptom nights	RR	1.07	(0.86, 1.31)	2	1.08	1	0.97	1		0
Number of symptom nights	SMD	-0.31 *	(-0.41, -0.20)	4	-0.17	2	-0.37 *	1	-0.41 *	1
Number of functional limitation days	SMD	-0.21 *	(-0.28, -0.13)	6	-0.35 *	1	-0.23 *	3	-0.14 *	2
Number of missed school days	SMD	-0.13 *	(-0.20, -0.05)	5	-0.09	2	-0.20 *	1	-0.10	2
Caregiver QOL score	SMD	0.12	(0.00, 0.24)	6	0.01	1	0.13	4	0.19	1
Total number of RCTs included				12	6		4		2	

NOTES: ES = effect size; RR = risk ratio; SMD = standardized mean difference; CI = confidence interval; QOL = quality of life; RCT = randomized controlled trial.

*Denotes that the effect size is significantly different from 0 if reported as a standardized mean difference or different from 1 if reported as a risk ratio ($p < 0.05$).

^aRR is reported for binary outcomes; SMD is reported for outcomes reported as means.

home environment interventions (SMD = -0.32, $p < 0.05$), although two RCTs of educational interventions found small effects as well (not statistically significant).⁵⁰

Functional Limitation Days

A related measure of days with symptoms is the extent to which a child (as reported by parents) experiences days when he or she is compromised in normal activity levels or physical functioning. The six studies for which effect sizes could be calculated on this outcome reveal significant reductions in the number of days when a child experienced functional limitations

⁵⁰These include Krieger, Takaro, Song, and Weaver (2005), Krieger et al. (2009), and Morgan et al. (2004) (home environment); and Butz et al. (2010) and Joseph et al. (2007) (educational).

(SMD = -0.21, 95 percent CI: -0.28, -0.13).⁵¹ In addition, significant impacts on functional limitation days are found across all intervention categories. In particular, a study of the Seattle Healthy Homes program compared outcomes for a high-intensity group (which received four to eight home visits by a community health worker [CHW], supplies to remediate triggers, and referrals to smoking cessation services) with those for a low-intensity group (which received one CHW visit, an environmental assessment, an asthma action plan, and bedding encasements).⁵² This evaluation found that while both groups exhibited reductions in functional limitation days, the difference was much larger for the high-intensity group.

Quality of Life

Six studies have examined impacts on caregivers' quality of life scores, which are based on standardized questions that assess the problems most troublesome to a parent or caregiver of a child with asthma.⁵³ The effect sizes on caregiver quality of life are generally consistent across the different intervention types, and they suggest positive improvements in self-rated well-being (although none of these effect sizes is significantly different from zero).

Although most researchers categorize missed school days as a productivity measure, it is also related to quality of life and long-term well-being. There are significant but small reductions in the number of school days missed across the five studies pooled (including two education intervention evaluations, two evaluations of home environment programs, and one evaluation of a provider practice program).⁵⁴ Although not shown in Table 2, two studies measured missed school days as the percentage of children missing any school over the past two weeks.⁵⁵ These studies, including one home environment intervention and one educational intervention, did not find risk reductions. Two RCTs also examined impacts on missed workdays for parents (not shown in tables), both of which are based on the Seattle Healthy Homes program model.⁵⁶ No impacts were found.

Earlier Meta-Analyses Findings on Asthma Morbidity and Quality of Life

The results on morbidity and quality of life outcomes from earlier meta-analyses of educational interventions are largely aligned with the effects of the education-focused evaluations

⁵¹These include Joseph et al. (2007) (educational); Krieger, Takaro, Song, and Weaver (2005), Krieger et al. (2009), and Morgan et al. (2004) (home environment); and Halterman et al. (2012) and Kattan et al. (2006) (provider practice).

⁵²Krieger, Takaro, Song, and Weaver (2005).

⁵³These include Butz et al. (2005a) (educational); Eggleston et al. (2005), Klinnert et al. (2005), Krieger, Takaro, Song, and Weaver (2005), and Krieger et al. (2009) (home environment); and Halterman et al. (2012) (provider practice).

⁵⁴These include Gerald et al. (2006) and Joseph et al. (2007) (educational); Morgan et al. (2004) (home environment); and Halterman et al. (2012) and Kattan et al. (2006) (provider practice).

⁵⁵Krieger et al. (2009); Teach et al. (2006).

⁵⁶Krieger, Takaro, Song, and Weaver (2005); Krieger et al. (2009).

reviewed in Table 2. For example, one study found no reduction in the proportion of patients experiencing nights disturbed by asthma, but the authors reported moderate effects (reductions) in the number of nights disturbed by asthma across three studies (SMD = -0.39, 95 percent CI -1.07 to 0.28).⁵⁷ The authors also examined the number of days with restricted activity (functional limitations) and found modest-sized effects (SMD = -0.29) based on six studies of educational interventions. There were small but significant reductions (SMD = -0.14) of school absences as well (based on 16 studies). However, no significant reductions were found in asthma severity scores (SMD = -0.15, 95 percent CI: -0.43 to 0.12), which is an important outcome that was not consistently or commonly measured enough across the studies reviewed to be examined in this paper. Another meta-analysis of educational interventions targeting children with a recent ED visit found no impacts on quality of life scores across two RCTs.⁵⁸

The meta-analysis of home environment interventions generally noted reductions in morbidity and improvements in quality of life measures across studies, although (similar to the findings for health care use) the magnitude of the overall impact is greatly affected by the inclusion of nonexperimental studies in the estimates. For example, the authors estimated a median absolute reduction of 15.4 percentage points across four studies for the prevalence of any symptom days. However, this estimate was only 5.2 percentage points in the RCTs. The median improvement in quality of life was 16.5 percent across nine studies, but was much smaller for RCTs (3 percent) and not particularly meaningful.⁵⁹

Findings on Asthma Management Outcomes

Self-management behaviors are not often examined or reported in the interventions reviewed, perhaps because these types of behaviors are seen as intermediary to the other outcomes targeted by programs. As noted earlier, the underuse of controller medication and overreliance on rescue medication among low-income and minority families is indicative of a disconnect between clinical recommendations and patient behavior. Table 3 thus presents information from the studies that examined management practices.

Medication and Asthma Action Plans

Three management-related behaviors were measured across different intervention trials with enough consistency to compare: controller medication use, rescue medication use, and availability of an asthma action plan. Pooled effects across five studies examining the regular use of controller medication at follow-up (that is, “yes” versus “no”) found no differ-

⁵⁷Wolf et al. (2008).

⁵⁸Boyd et al. (2009).

⁵⁹Crocker et al. (2011).

Table 3. Summary of Effects of Asthma Interventions on Management Behaviors

Select Outcomes	Effect Size (ES) Type ^a	Overall Effects			Type of Intervention					
		ES	95% CI	Number of Studies (N)	Education		Home Environment		Provider Practice	
					ES	N	ES	N	ES	N
Regular use of controller medication	RR	1.13	(0.92, 1.40)	5	1.21	3	1.04	2		0
Has current asthma action plan	RR	1.26 *	(1.07, 1.48)	3	1.21	1	1.06	1	1.46 *	1
Days used rescue medication in past 2 weeks	SMD	-0.28 *	(-0.45, -0.12)	3		0	-0.27 *	2	-0.34	1
Total number of RCTs included				9		3		5		1

NOTES: ES = effect size; RR = risk ratio; SMD = standardized mean difference; CI = confidence interval; RCT = randomized controlled trial.

*Denotes that the effect size is significantly different from 0 if reported as a standardized mean difference or different from 1 if reported as a risk ratio ($p < 0.05$).

^aRR is reported for binary outcomes; SMD is reported for outcomes reported as means.

ence between program and control groups.⁶⁰ Significant reductions in the number of days that parents reported using rescue medication are found across three RCTs (two home environment studies and one provider practice study).⁶¹ The interventions ($n = 34$) reviewed increase the prevalence of having a current asthma action plan among program group children compared with the control group (RR = 1.26, 95 percent CI: 1.07, 1.48),⁶² with the strongest results coming from a provider practice-based intervention.

Trigger Remediation

Although not shown in Table 3, reductions in household exposure to a variety of allergens represent a set of outcomes that are often measured and monitored in home environment-

⁶⁰These include Butz et al. (2005a), Horn et al. (2014), and Teach et al. (2006) (educational); and Bryant-Stephens and Li (2008) and Krieger et al. (2009) (home environment).

⁶¹These include Krieger, Takaro, Song, and Weaver (2005) and Krieger et al. (2009) (home environment); and Halterman et al. (2012) (provider practice).

⁶²These include Butz et al. (2005a) (educational), Krieger et al. (2009) (home environment); and Splett, Erickson, Belseth, and Jensen (2006) (provider practice).

focused evaluations.⁶³ These can include concentration measures of dust mite, cockroach, rat, mice, cat, dog, and mold allergens. Some studies also collect information on cotinine (a biological marker of tobacco exposure) and particulate matter. Our review (of both RCTs and non-RCTs) suggests that home environment interventions are generally successful in reducing allergen triggers in the home. Because of their focus on remediating airborne triggers, most of the reviewed studies collected objective measures of allergen levels for various rooms in the house as part of their assessments. Most home environment interventions were able to maintain the reduction in the measured level of dust mite and cockroach allergen concentrations. However, one study — in which the home intervention group received pest baits and instructions for proper use — noted reductions in observations of cockroaches in the short term (6 months) that disappeared by 12 months.⁶⁴ Impacts on rodents and furry pets are mixed, although the Inner-City Asthma Study documented sustained reductions in the level of cat allergens in the child's bed over two years (the intervention emphasized the importance of not allowing pets to be in or sleep in the child's bedroom). The one notable exception to these positive findings is indoor smoke exposure, which proves to be very challenging to improve.

Costs and Savings

Summaries of program costs and, in a few studies, measures of cost-benefit or cost-effectiveness are reported in some of the reviewed studies. It is far more common for studies to document program costs than for evaluations to examine whether program costs were offset by direct or indirect medical costs. Program costs were reported in three education-focused interventions, ranging from a low of \$12 per person (based on a Web-based education conducted in schools) to a high of \$663 per person (based on a study that incorporated intensive case management).⁶⁵ Five studies examining home environment-focused interventions reported program costs ranging from \$500 to \$6,550 per person.⁶⁶ It is unsurprising that the range of costs is higher for these programs than for the education-focused interventions, given their emphasis on trigger remediation in the home environment. The highest estimate of \$6,550 may be an anomaly in the range of program costs; the intervention that accrued this program cost provided major remediation to address structural housing issues (including roofing, air-conditioning, and heating).⁶⁷ Program costs for provider-based studies were reported in two studies and were relatively inexpensive (about \$60 to \$70 per child).⁶⁸

⁶³Measurement of impacts on different allergens varied considerably across studies, which is why these results were not included in the meta-analysis.

⁶⁴Bryant-Stephens and Li (2008).

⁶⁵Joseph et al. (2007) and Karnick et al. (2007).

⁶⁶These studies include Bryant-Stephens and Li (2008), Eggleston et al. (2005), Kerckmar et al. (2006), Krieger, Takaro, Song, and Weaver (2005), and Morgan et al. (2004).

⁶⁷Kerckmar et al. (2006).

⁶⁸Kattan et al. (2006); Lozano et al. (2004).

With the caveat that the methods and economic data used vary in their rigor and specificity, the four reviewed studies that examined some measure of cost savings generally find that savings are produced by the intervention. A home remediation study using CHWs found that the savings in urgent care costs over a two-month period ranged from \$57 to \$80 per child.⁶⁹ In a three-arm intervention testing different intensities of provider practice change, the authors found that compared with usual care, the incremental cost-effectiveness ratio was \$18 per symptom-free day gained for the lower-intensity arm, and \$68 per symptom-free day gained for the higher-intensity arm.⁷⁰ In another three-arm intervention testing different intensities of asthma education, the cost savings for each dollar spent on the program was found to decrease with increasing intensity of the asthma education program. The high-intensity group — which received asthma case management along with asthma education and monthly reminders — experienced savings of only \$8 per dollar spent; the lowest-intensity group — which received only one educational session on asthma management and triggers — experienced savings of about \$43 for every dollar spent.⁷¹ Only one study out of the four — a notable study because of its large, multisite nature; two-year follow-up; and inner-city focus — reported that the direct health care savings did not offset the costs per child (which ranged from \$1,500 to \$2,000).⁷²

Researchers who have reviewed a wider range of studies on the cost-effectiveness of asthma programs have reported varying results. A review of 13 home environment-remediation interventions found that for studies with a pre-post design ($n = 3$), the benefit-to-cost ratio was higher than 1, ranging from 5.3 to 14.⁷³ Although preferable, cost-effectiveness was not calculated for the studies due to insufficient information. The authors of the review, however, were able to calculate the incremental cost-effectiveness ratio for three RCTs and found that ratios ranged from \$12 to \$57 per additional symptom-free day. To be able to compare the RCT results with the non-RCT results, the authors also calculated the benefit-to-cost ratio for the experimental studies, which ranged from 0.09 to 0.32. While positive, these estimates are considerably lower than those derived from nonexperimental studies; this again underscores the importance of a counterfactual or usual-care comparison. Another review found that of the seven RCTs that targeted asthma self-management (that is, primarily education-focused interventions), six produced savings in medical costs.⁷⁴ However, only two had savings that were high enough to result in a positive return on investment (ROI), and those two studies had very few cases. This finding led the authors to conclude that the cost-effectiveness of asthma management programs was unclear.

⁶⁹Kreiger, Takaro, Song, and Weaver (2005).

⁷⁰Lozano et al. (2004).

⁷¹Karnick et al. (2007).

⁷²Morgan et al. (2004).

⁷³Nurmagambetov et al. (2011).

⁷⁴Goetzal, Ozminkowski, Duffy, and Villagra (2005).

III. Local Program Case Studies

The review of the effect of childhood asthma programs on a range of outcomes generally supports the premise that there is evidence of what works for managing asthma among low-income and minority families. The findings discussed in the prior section also raise questions about whether multicomponent home remediation strategies are more effective at improving health-related outcomes than single-component educational models. There is no clear consensus on this question in the literature and among the research community. As part of this review, leading pediatric asthma experts (n = 7) were interviewed to gain their perspectives on the state of the evidence.⁷⁵ Experts agreed universally that standard education about asthma symptoms, triggers, and medication to families is imperative. Most also reported they believe that environmental trigger remediation is a critical intervention component, but to varying degrees: some experts asserted that it should be the primary focus of an intervention, while others stressed asthma education over all else.

Research debates about what intervention models or what components of models matter for improving childhood asthma among the socioeconomically disadvantaged will undoubtedly continue. The reality, of course, is that in low-income communities across the country, local asthma programs are being implemented every day — reaching out to high-risk families and providing services. As indicated by the range of intervention models and components found in the literature review, individual programs may be approaching the common goal of mitigating childhood asthma in different ways. Understanding what is currently being done in low-income communities provides a foundation from which to explore avenues to further support and improve locally grounded efforts.

With this context in mind, this section highlights and describes four community-based asthma programs providing services to low-income children in major urban centers: a.i.r. nyc in New York City,⁷⁶ the Community Asthma Initiative (CAI) in Boston, the Green and Healthy Homes Initiative[®] (GHHI) in Baltimore, and Sinai Urban Health Institute’s Asthma Program in Chicago.⁷⁷ These case studies offer illustrative examples of what is currently being done to address the problem of childhood asthma in different settings. To shed light on how local pro-

⁷⁵Experts interviewed included Arlene Butz (Professor, Schools of Medicine and Nursing, Johns Hopkins University), Lynn Gerald (Associate Dean for Research, University of Arizona), Wayne Morgan (Professor of Pediatrics and Physiology, Chief of Pediatric Pulmonary Medicine, University of Arizona) Megan Sandel (Associate Professor, Boston University Schools of Medicine and Public Health), Susan Sommer (Clinical Director, Community Asthma Initiative, Boston Children’s Hospital), Stephen Teach (Chief, Division of Allergy and Immunology, Children’s Research Institute and Chair of Department of Pediatrics, George Washington University), and Elizabeth Woods (Chief, Division of Adolescent Medicine at Boston Children’s Hospital and Professor of Pediatrics, Harvard University).

⁷⁶The abbreviation *a.i.r.* stands for “asthma intervention relief.”

⁷⁷For more detailed descriptions of the local programs highlighted in this section, Appendix C provides additional information on each case study.

grams are implementing asthma management services, commonalities and differences in the focus, adaptations, and concerns of the four community-based programs are highlighted.

The four local programs included as case studies were identified using various strategies, including reviewing the literature on current asthma programs (both experimental and nonexperimental research), asking asthma experts to identify interesting models and programs, and conducting Internet searches of programs operating in low-income and high-asthma-prevalence areas. Information on program operations and implementation was collected through in-person, half-day visits to each site. These consisted of structured meetings with program staff (including the program director or leader, managers, and direct service staff) to learn about the core elements of their program, a review of tool kits and program materials, and an assessment of impacts. When available, publications and studies of the program were also reviewed.

Table 4 presents an overview of the key characteristics of the four local programs, including their history, service components, capacity, and financing; estimates of programs' cost-savings or ROIs were also included when they were available. As can be seen, these programs share some common features. First and foremost, they are all multicomponent programs that aim to address gaps in asthma education, asthma management, and the conditions of the home environment. Services are typically delivered by lay health educators or CHWs, who often reside within the targeted communities and are familiar with the particular concerns and dynamics of the neighborhoods served. Through home visits, health workers interact with families to provide asthma education, assess medication regimes and adherence, conduct environmental assessments, provide trigger remediation tools, and refer families to community resources such as housing or tenants' rights organizations.

CAI, a.i.r nyc, and Sinai Asthma Program emerged in hospital-based settings. Both CAI and Sinai Asthma Program continue to operate in affiliation with or embedded within hospitals. However, a.i.r nyc now operates in independent offices in the Bronx and Harlem (with a Brooklyn office to be added). GHHI emerged from the Coalition to End Childhood Lead Poisoning, a housing intervention effort focused on removing lead hazards prevalent in older homes.

The most important distinction among the four programs lies in the primary focus of GHHI on the housing structure itself, a reflection of its unique history. After remediation crew members from the Coalition to End Childhood Lead Poisoning reported consistently that pediatric asthma was a concerning health problem for their clients, the Coalition began to diversify its program services to include Healthy Homes and was one of the first programs to receive a Healthy Homes grant from the U.S. Department of Housing and Urban Development (HUD).⁷⁸

⁷⁸U.S. Department of Housing and Urban Development (n.d.).

Table 4. Key Features of Local Asthma Programs

	Community Asthma Initiative (CAI)	a.i.r. nyc	Green and Healthy Homes Initiative (GHHI)	Sinai Urban Health Institute's Sinai Asthma Program
History	Created in 2005 by Boston Children's Hospital to serve asthmatic children in surrounding neighborhoods	Started in 2001, housed in Harlem Hospital; in 2010 opened two independent offices in the Bronx and Harlem	Formed from the Coalition to End Childhood Lead Poisoning, asthma reduction work began in 1998. GHHI began as official program of the Coalition in 2008	Began in 2011 as a partnership between the Sinai Urban Health Institute in Mt. Sinai Hospital and two insurance plans to address asthma care concerns and costs
Features	<p>In-home intervention targeting low-income children with asthma ages 2 to 18 years:</p> <ul style="list-style-type: none"> • 3 home visits over 1 year • CHWs and nurse practitioners provide asthma education and trigger remediation • Vacuums, bedding covers, and cleaning materials • Referrals to community resources 	<p>In-home intervention targeting children with asthma ages 0 to 17 years and their parents:</p> <ul style="list-style-type: none"> • 3 home visits over 1 year • CHWs provide asthma education and trigger remediation • Free legal assistance for families facing housing issues • School-based efforts to provide asthma education to classrooms 	<p>Housing-focused intervention targeting homes of children with asthma ages 2 to 14 years:</p> <ul style="list-style-type: none"> • Assessment technicians provide home assessment and structural remediation services • Health educators provide asthma education and case management • Legal services for tenants with housing issues 	<p>In-home intervention targeting adults and children on Medicaid:</p> <ul style="list-style-type: none"> • 5 to 6 visits over 1 year • CHWs provide asthma education and trigger remediation • Cleaning supplies, education on cleaning techniques • Referrals to tenants' rights organizations and other community resources
Capacity	About 1,500 patients served since 2005; patients referred from hospital ED, health centers, and community organizations	1,000 families served each year; patients referred from hospitals, community organizations or parent self-referral	25 GHHI sites around the country serve hundreds of families; clients referred from health centers, local agencies, other community service providers, and self-referral	10 to 12 CHWs serve 120 active clients; patients referred directly to program by partner managed care organization
Funding	Mix of federal, foundation, and hospital funding; received a CMS Innovation Award; some payer reimbursement	Primarily foundation funding; recently negotiated contract with a managed care organization for fee-for-service reimbursement	Mix of federal, foundation, and social impact bond funding; local government funding provided from various agencies	Reimbursement from a local managed care organization, paid out quarterly via fee for service
ROI	ROI of 1.39 per dollar over 2 years and 2.08 over 3 years	Cost analysis currently under way	6-year study on asthma-related cost savings is currently under way	Preliminary analysis found \$5 saved per dollar

NOTES: CHW = community health worker; CMS= Centers for Medicare & Medicaid Services; ED = emergency department; ROI = return on investment.

The Coalition started its asthma reduction work in 1998, with GHHI becoming an official program.⁷⁹ Thus, GHHI was — and remains — a model that is housing centered, and over the years, it has incorporated elements of various health and environmental programs to create a “whole-house” approach. Although a.i.r. nyc, Sinai Asthma Program, and CAI also target housing conditions among their clients, they are rooted in and framed around a person-centered approach.

This difference is clearly illustrated by variations in the intensity of the services that are provided. For example, while all programs, as noted earlier, include health educators, the GHHI model also includes an assessment technician as part of a one-time comprehensive home visit. Assessment technicians conduct an in-depth assessment of the home, while the health educator reviews home triggers and remediation techniques with the family. The scope of remediation services includes integrated pest management; mold remediation; ventilation; removal and steam cleaning of carpets; and installation of air-filter systems, air-conditioning, dehumidifiers, CO₂ detectors, and smoke detectors. Many of these services should reduce the levels of allergens in the home. Other services, however, such as energy-efficient updates, are not tied to asthma management. Remediation services can also include significant and much more expensive modifications (such as roof replacement or extreme mold remediation). Investments such as these are likely not cost-effective for managing asthma vis-à-vis other approaches, but the model’s focus on the home incorporates a broader view of improving the housing quality, housing infrastructure, and urban development of disadvantaged communities. The outcomes of GHHI thus include and go beyond asthma management.

The three other local programs — a.i.r. nyc, Sinai Asthma Program, and CAI — represent a home environment-intervention model that largely parallels (and was informed by) the experimental programs reviewed in this paper and in earlier meta-analyses. In all cases, their development emerged from a concern about the disproportionate prevalence of asthma in their communities and differences in the risk of serious health care events. Their focus underscores a philosophy that addressing triggers and conditions in the home is an essential means to manage asthma. Frontline staff workers recounted different stories about observing cockroach infestations, overcrowded bedrooms, and mold in home visits. These health educators also noted that such conditions would have been difficult to assess and remediate without actually visiting the family’s home and showing the family how to address different triggers.

Although they operate under the same philosophy and employ similar service components, each of the three home environment models has adjusted its intervention based on early experiences with program implementation. They have also capitalized on other efforts at the local and state levels to support program operations.

⁷⁹As of 2014, GHHI became the trade name for the Coalition.

For example, while many home environment-focused programs provide referrals to a range of services, a.i.r. nyc offers free legal assistance through a local law firm to families who face significant housing issues — issues that cannot be resolved through basic trigger remediation services alone. This was not an original component of the program but was deemed a necessary service to incorporate, based on both the health workers' and families' frustrations with unsuccessful efforts to pressure landlords into rectifying housing concerns and adhering to housing codes. In this manner, a.i.r. nyc is filling a social service gap that extends beyond asthma education and trigger reduction. a.i.r. nyc has also incorporated a school-based component, in which a CHW goes into classrooms to provide asthma education to all children, with the motivation to provide broader awareness and information to families they cannot serve otherwise.

At the program's onset, CAI pulled in CHWs from a local agency that used them for various other purposes. This staffing process, however, resulted in constraints on the health workers' time and resources. Consequently, the program decided to hire and house CHWs within Boston Children's Hospital, so that the health educators' sole focus could be on serving the families on the program's caseload. The costs of the workers' salaries was (and still is, as of this writing) subsidized by the hospital administration and various grants. Program leadership noted that this shift provided stability to the program and allowed them to serve more families. CAI also capitalized on the city's broader efforts to develop asthma registries throughout community health centers by working with centers to identify their high-risk pediatric patients and refer them to the program.

Not unexpectedly, a common concern across programs centered on sustainable financing. This is a particular challenge for CAI, as its funding is inconsistent and largely foundation based. Because fee-for-service reimbursement generally does not cover the costs of trigger remediation supplies or CHW salaries, CAI has ascertained that bundled payments or per-member per-month payments are more attuned to the nature of community-based asthma interventions. For this reason, Boston Children's Hospital Office of Government Relations approached the state legislature in 2011 and convinced policymakers to include a line item in the annual budget to cover home-based asthma interventions via Medicaid bundled payments. CAI was approved for a Medicaid Bundled Payment Pilot in 2015. Contractual negotiations are under way, representing an important step toward sustainability.

Sinai Asthma Program is unique among the programs in that at its inception, Sinai Urban Health Institute negotiated contracts with two local health plans serving large shares of Medicaid patients to reimburse for in-home services. However, this program illustrates that Medicaid reimbursement is not the only ingredient for sustainable financing. Program leadership at Sinai Urban Health Institute noted that patients' shifting insurance coverage constitutes a challenge, as Sinai Asthma Program participants frequently lose their coverage or switch to a different managed care organization. In instances where participants' coverage temporarily

lapses, they must reenroll in the program, which can result in delays in treatment and gaps in the continuity of care. These, in turn, could potentially undermine improvement in an individual's asthma management.

As GHHI focuses heavily on housing and structural remediation, the program has had difficulty with Medicaid financing options. However, the GHHI Baltimore program is currently conducting a Pay for Success cost-benefit study in partnership with Johns Hopkins Health System. GHHI will be providing services to “frequent flyer” asthma patients of select priority partners, including Johns Hopkins Health System's Medicaid managed care organization. The study will include Medicaid claims data, and the researchers plan to compare participant outcomes with the outcomes of Medicaid patients from similar zip codes and demographic backgrounds. This type of analysis will help strengthen the evidence of the program's benefits both to patients and to payers. Although a.i.r. nyc has successfully negotiated a contract with a managed care organization to reimburse services provided, the program staff understand the need to build a business case for ROIs to broaden the scope of support. Similar to GHHI, a.i.r. nyc is currently conducting a cost analysis, as is the Sinai Asthma Program. CAI has previously published a cost analysis using a matched comparison group of children in neighboring zip codes and found an ROI of \$1.39 over two years.⁸⁰

As noted in the last section, good information on cost-effectiveness is sorely lacking in the literature. These efforts to demonstrate financial returns on program investments, or at the very least cost-benefit neutrality, are critical for long-term sustainability. The state-based initiatives described in the next section shed light on how stakeholders are using such evidence and partnerships to braid funding streams in order to expand efforts to address uncontrolled asthma.

IV. Case Studies of State Initiatives

While federal and local grants, research funding, and philanthropic dollars have enabled local programs — including the four programs highlighted in the previous section — to provide services to low-income families with asthma, effective interventions will face challenges in large-scale implementation and sustainability without buy-in from insurers. Thus far, support from insurance providers has been slight, undoubtedly because the “bottom line” in terms of cost savings is somewhat unclear.

However, some states and locales have been able to implement payment reforms (through Medicaid or negotiations with particular health plans) that encourage better management of asthma, which enables reimbursement for services that are not generally included in Medicaid fee schedules (such as home visits or environmental remediation). The high preva-

⁸⁰Woods et al. (2012).

lence of uncontrolled asthma among children served by Medicaid programs and the associated rising costs are often the impetus for state and local governments to improve the quality of care provided to children with asthma. Many of these initiatives focus on achieving the “Triple Aim” of better quality health care, lower costs, and improved population health.⁸¹

This section highlights six state initiatives’ approaches to addressing uncontrolled pediatric asthma through innovative health care — particularly Medicaid — financing or delivery strategies.⁸² The National Academy for State Health Policy (NASHP), through a subcontract with MDRC, led the effort to investigate these state-based case studies in detail, drawing on their extensive knowledge of various state-based health initiatives and policy levers. By highlighting programs that stem from broader state initiatives or leverage state Medicaid funding to sustain and expand operations, these case studies offer insight into potential options for pediatric asthma interventions to enhance the financing and sustainability of their models. The case studies also provide experiential evidence on possible practices for asthma programs that are attempting to obtain sustainable funding.

The six models explored are operating in Arkansas, Iowa, Michigan, North Carolina, Oregon, and Rhode Island. Key elements of these initiatives are described and summarized in the following pages. More detailed descriptions of each case study can be found in Appendix D.

Table 5 presents key intervention and programmatic components as well as financing strategies for the six state-based case studies. The initiatives are distinguished by the location where services are provided. Specifically, they entail **community-based interventions**, which include activities occurring outside the primary health care setting and geared at changing the social, environmental, and medical factors contributing to asthma. Community-based interventions often incorporate home-based case management. **Clinic-based interventions** occur in a medical setting and consist of activities focused primarily on treating the medical factors that affect asthma, with more limited activities addressing the social and environmental factors.

As seen in Table 5, most of the initiatives have leveraged funding mechanisms within the Medicaid program.⁸³ States have the option to deliver Medicaid services to beneficiaries through two methods: fee for service and managed care (though the two models are not mutually exclusive, and states often use both methods, depending on the population and service).

⁸¹Institute for Healthcare Improvement (n.d.).

⁸²The case studies focus on asthma initiatives leveraging Medicaid financing strategies. For more information on public health asthma initiatives, see Centers for Disease Control and Prevention (2013).

⁸³Medicaid is administered by states within federal requirements and jointly funded by states and the federal government. And, each state has a Medicaid State Plan — an agreement with the federal government that details how the state will administer its Medicaid program (and the Children’s Health Insurance Program, or CHIP).

Table 5. State-Based Case Studies of Asthma Programs

Description	Arkansas Health Care Payment Improvement Initiative	Iowa Health Home Program	Michigan Asthma Network of West Michigan	North Carolina Community Care of North Carolina	Oregon Healthy Homes	Rhode Island Home Asthma Response Program
Intervention elements						
Setting	Clinic	Clinic	Clinic; community	Clinic; community	Community	Clinic; community
Asthma plans, education, care coordination	✓	✓	✓	✓	✓	✓
Home visits			✓ (up to 32)	✓	✓	✓ (3)
Referrals	✓ (e.g., smoking cessation)	✓ (e.g., smoking cessation)	✓ (e.g., housing, transportation, counseling, prescriptions)	✓ (e.g., child care, health consultants, transportation)	✓ (e.g., food assistance, housing, weatherization, legal aid, transportation, mental health)	✓ (e.g., WIC, adult education, weatherization, smoking cessation, mental health)
Other services			Visits to school, child care, extended family		Supplies for trigger remediation	Supplies for trigger remediation
Program overview						
Target population	<ul style="list-style-type: none"> • Children and adults with qualifying episodes of care • All Medicaid patients (patient-centered medical home) 	Medicaid-eligible adults and children with either two chronic conditions or one condition and at risk for second	Children and adults with moderate to severe uncontrolled asthma	Medicaid-eligible children and adults with asthma, prioritizing high-risk patients	Children <19 years with asthma diagnosis, in specific county and meeting Medicaid income requirement	Children ages 2 to 8 years with recent ED visit or hospitalization residing in 3 specific cities

(continued)

Table 5 (continued)

	Arkansas Health Care Payment Improvement Initiative	Iowa Health Home Program	Michigan Asthma Network of West Michigan	North Carolina Community Care of North Carolina	Oregon Healthy Homes	Rhode Island Home Asthma Response Program
Providers	Hospital physicians, PCP, or pulmonologist	Designated practitioner, care coordinator, health coach, support staff	Certified asthma educator (regis- tered nurse or res- piratory therapist), licensed medical social worker	Care manager (e.g., nurse, social worker, pharma- cist), PCP	Nurse, communi- ty health worker, environment health and safety worker	Nurse educator, community health worker
Financing						
Medicaid re- imbursement	<ul style="list-style-type: none"> • Retrospective episode- based payment • Patient-centered medi- cal home per-member per- month 	Tiered per- member per- month payment	Skilled nursing visits (4 managed care plans)	Per-member per- month payment	Targeted case management (specific counties)	Not applicable
Other	Private insurer ^a	N/A	Local grants	Varies by network	County funds; federal grants	Federal grants

NOTES: ED = emergency department; PCP = primary care provider; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

^aFor episode-based care.

Through the more traditional fee-for-service system, participating providers bill state Medicaid agencies directly for each service delivered to Medicaid patients. Under managed care, managed care organizations contract with state Medicaid agencies to deliver a defined set of health benefits and additional services to Medicaid beneficiaries. In these models, managed care organizations receive a capitated payment from the state Medicaid agency — a fixed payment per enrollee regardless of whether each enrollee gets health care services. Most important, payment does not vary based on services delivered, meaning that the managed care organization assumes financial risk for its enrolled population. The managed care organization has the discretion to determine a model for reimbursing providers serving patients.

The concentration of health concerns among Medicaid beneficiaries has prompted many states to combine elements of the fee-for-service and managed care payment models to develop new methods that pay Medicaid providers a fixed amount to deliver integrated, high-quality care. Under models such as the patient-centered medical home (PCMH) and health home,⁸⁴ participating providers receive a capitated per-member per-month payment on top of standard reimbursement to provide enhanced primary care with a focus on coordination across care settings and providers. Given the numerous factors that contribute to poorly controlled asthma, these innovative models can be an effective tool for delivering well-coordinated care to children.

Models with State-Level Origins

Three of the six states (Arkansas, Iowa, and North Carolina) are examples of health care delivery reform that originated at the state level and were adapted by local communities. In these cases, the states developed a payment or delivery system framework for their Medicaid program that specifies the operational expectations for participating providers but allows flexibility for individual medical practices or communities to adopt processes, partnerships, and priorities that address local needs. Asthma is typically a component of this broader delivery system reform. Asthma may be included as one of several targeted conditions for improved care coordination; it is a community's choice to tailor such a program to prioritize improving asthma care. For example, the health home statute in Section 2703 of the Affordable Care Act specifies that states may provide health home services to “eligible individuals with chronic conditions” and includes asthma as one of six qualifying conditions.⁸⁵ In Iowa, pediatric practices identifying a gap in asthma care have been able to leverage the state health home program to improve care specifically for children with asthma.

⁸⁴The PCMH is a primary care model for delivering team-based and coordinated care. PCMH providers typically receive enhanced payments for high-quality care. For more information, see Agency for Healthcare Research and Quality (n.d.).

⁸⁵U.S. Department of Health and Human Services, Centers for Medicare & Medicaid Services (2010a).

States typically operate such care coordination programs under the authority of legislation, Medicaid State Plan Amendments⁸⁶ or waivers,⁸⁷ or other policy levers. They do so through the enhanced use of health information technology (HIT) to track and monitor patient needs or through the adoption of new staffing or workforce models to better manage patient care and service referrals. These programs tend to focus on clinic-based interventions, although some (such as North Carolina's program) may deliver services in other settings.

- Through its Health Care Payment Improvement Initiative, **Arkansas** has restructured Medicaid payment and care delivery with PCMHs and episode-based care to improve care in primary and acute care settings. The state selected a number of conditions for episode-based care, including asthma. While PCMHs focus on improving primary care generally, specific practices have made pediatric asthma a priority.
- **Iowa** selected asthma as one of seven conditions that qualify children and adults for services under its chronic condition health home program.⁸⁸ Participating providers can leverage the health home staffing and HIT requirements and reimbursement to provide better coordinated, clinic-based care to their pediatric asthma patients.
- **North Carolina** has established an asthma disease management program through its statewide Medicaid primary care network, Community Care of North Carolina (CCNC). Participating providers are rewarded for implementing quality-improvement strategies that emphasize the use of care managers who work with families in the practice, on the telephone, or via home visits to promote self-management and assess environmental triggers.

Financing and Measurement

Programs originating at the state level tend to align with statewide delivery reform initiatives that entail specific payment and reporting requirements. The initiatives with state origins (Arkansas, Iowa, and North Carolina) incorporate per-member per-month payments from the state Medicaid agency to support primary care practices in transforming into PCMHs or health

⁸⁶State Medicaid Plan changes, such as implementing a health home or targeted case management program, must be approved by the Centers for Medicare & Medicaid Services through a State Plan Amendment.

⁸⁷Medicaid waivers are a mechanism used by the federal government to provide states with greater flexibility in the design of their Medicaid programs.

⁸⁸Available to states as a state plan option under Section 2703 of the Affordable Care Act, Medicaid health homes are designed to improve care provided to and outcomes for Medicaid beneficiaries with multiple chronic conditions. Iowa's State Plan Amendment outlines explicit requirements for participating providers related to health home staff, achieving PCMH recognition, and using enhanced HIT for individual care management as well as population management. In Iowa's health home program, asthma is one of seven qualifying conditions a Medicaid beneficiary must have to be eligible to participate.

homes and providing specified services such as care coordination. For example, in Iowa, many health homes use per-member per-month payments to fund health coaches (required in Iowa's health home State Plan Amendment) to provide disease management and care coordination services. Per-member per-month payment amounts vary by state and usually within a state depending on the severity or complexity of a patient population's medical needs and available practice services. For example, Iowa's chronic condition health home per-member per-month payments range from \$12.80 to \$76.81, depending on an enrollee's number of chronic conditions.⁸⁹

In addition to its per-member per-month payments for primary care medical providers participating in the PCMH program, Arkansas has implemented a separate episode-based care delivery initiative that uses retrospective episode-based payments for acute asthma care. Any time an eligible individual visits the hospital seeking treatment for asthma, it triggers the asthma episode of care, beginning on the day of the hospital visit through 30 days after the patient is discharged. In the asthma episode of care, the hospital acts as the principal accountable provider for the episode and is responsible for the quality and cost of all relevant care provided during the episode. Similar to the per-member per-month system, the episode-based payment system in Arkansas works in the fee-for-service environment, meaning providers are still reimbursed for services through standard payment arrangements. However, providers can receive additional dollars through the episode-based payment system by delivering high-quality, low-cost care. Providers share in savings to the system if they deliver care at an appropriate cost level (as determined by the state) and meet benchmarks on quality measures for an episode of care (also determined by the state); on the other hand, providers may be responsible for any excess costs if they deliver care that is more expensive than the state deems appropriate.

Programs established under a state-level framework are typically required to implement advanced HIT. For example, the Arkansas episode-based care initiative and the CCNC program give providers access to provider portals that contain patient- and practice-level data on quality and costs, which allows practices to implement specific care management and population health strategies.

Most important, data on outcomes (such as health care use and costs) are not readily available for the programs with state origins. This may be due in part to the complexity of gathering and analyzing statewide information. With the exception of the CCNC, the state-level initiatives have been implemented relatively recently, and it takes time to collect sufficient outcome data. Analysis of chart review and claims data revealed that the CCNC asthma disease management program experienced a 40 percent decrease in asthma-related hospitalizations and a 17 percent decrease in asthma-related emergency visits between 2003 and 2006, which is

⁸⁹Iowa Department of Human Services (n.d.).

promising.⁹⁰ Asthma-specific data on cost savings and patient outcomes are not currently available in Iowa and Arkansas.

Models with Local Origins

In instances where programs originate at the local level (Michigan, Oregon, and Rhode Island), communities develop asthma-specific programs and seek sustainability by leveraging state Medicaid funding, at times through payment or delivery reform initiatives. These models typically begin in response to a high prevalence of poorly controlled asthma among children and a dearth of comprehensive asthma care and support resources in one community. In some programs, such as Healthy Homes in Oregon, the need to address asthma specifically may be identified through a community needs assessment. Key local leaders, including physician champions and representatives from health and housing organizations, play an instrumental role in advocating for funding and launching community-based programs. These local models are initially financed through a combination of local or federal grants; once programs show consistent positive outcomes in reducing the burden and health care costs associated with asthma, they establish contracts with payers, including Medicaid, Medicaid managed care organizations, and private insurers, to attain partial reimbursement for their services. These programs often begin by providing community-based services, particularly home visiting services, and may expand to collaborate with primary care providers for clinic-based interventions.

- The Asthma Network of West **Michigan** (ANWM) includes home visits for a child or adult with uncontrolled asthma to educate about the disease, teach management techniques, and assess environmental triggers. ANWM also includes psychosocial interventions and care coordination with a primary care physician.
- **Oregon's** Healthy Homes program provides community-based interventions for children with uncontrolled asthma in Multnomah County. Staff conduct home visits to provide education, referrals to community resources, environmental supplies, and nursing and environmental assessments.
- Following a hospital visit in three cities in **Rhode Island**, Home Asthma Response Program (HARP) staff visit a child's home to provide asthma education, assess asthma triggers, provide environmental supplies, and refer families to other services. Program staff also work with a child's primary care physician to develop an updated asthma action plan.

⁹⁰Tilson (2013).

Financing and Measurement

Whereas programs that originate at the state level tend to align with statewide delivery reform initiatives, programs originating at the community level seek to leverage more traditional Medicaid financing strategies that are limited to specific regions or managed care organizations and use varying resources to measure impact. All of the programs originating at the community level in the case studies initially depended on grant funding during their start-up phase and have since pursued Medicaid financing mechanisms that permit greater predictability and sustainability. For example, once Healthy Homes of Multnomah County was able to demonstrate positive outcomes in reducing the cost and burden of asthma for children, it negotiated with Medicaid to obtain targeted case management reimbursement. This financing mechanism is under the authority of a State Plan Amendment that specifically authorizes Multnomah County to bill Medicaid for asthma home visits. ANWM has secured some Medicaid funding by contracting with several Medicaid managed care plans that reimburse asthma educator and social worker visits through a skilled nursing visit code. ANWM currently contracts with four health plans, including Medicaid, commercial, and Medicare partners. Most important, the Medicaid funding strategies used by ANWM and Healthy Homes do not cover all program costs, and the programs must supplement these sources with grants from local hospitals and foundations, Housing and Urban Development, Community Development Block Grants, and county funding. HARP does not yet have Medicaid funding, but staff are exploring options as part of a regional pilot funded by the Center for Medicare & Medicaid Innovation (CMMI).⁹¹ HARP was previously funded through a grant from the Centers for Disease Control and Prevention (CDC).

The community-level initiatives independently track data from sources including parental reports, case manager home visits, and claims data, when available. The three programs collect data on hospital visits, medications, asthma action plans, and missed school and workdays. Through collaboration with a local PCMH project, ANWM has enhanced its measurement capacity and uses the practice's Web-based database to track data on asthma action plans, asthma control test scores, follow-up visits, medication refills, primary care visits, missed school days, and quality of life. The case manager is able to collect some data through parental reports, and ANWM has also been able to acquire certain usage data from hospitals. HARP collects survey and claims data on participants and is currently awaiting the results of the New England Asthma Innovations Collaborative, a CMMI grant that aims to improve asthma outcomes, quality of care, and health care costs.

To date, several of the locally initiated programs have demonstrated progress in improving management of childhood asthma, such as decreased hospitalizations, fewer ED visits, and fewer missed school days. These improvements also have arguably led to cost savings in

⁹¹Asthma Regional Council of New England (n.d.).

health care encounters and hospitalizations and a positive ROI, which is of particular interest to public payers. These results come from various types of evaluations, and most, it should be noted, were conducted using program-specific data without a comparison group and did not include randomized controlled trials. With this caveat in mind, results have been promising. Using claims data and information collected via parents' reports, HARP has calculated a \$2.52 ROI for every \$1.00 spent on the intervention due to reduced ED visits and hospitalizations, based on an analysis of data from one year before and after the intervention.⁹² An analysis of case management data pooling three successive two-year before-after cohorts revealed a 60 percent decrease in hospitalization and a 40 percent decrease in ED visits in the ANWM program.⁹³

V. Summary and Implications

Childhood asthma is a well-researched field. In conducting both the literature review and the case study investigations of local programs and state initiatives, there was an abundance of information to consult. As part of this review, MDRC interviewed a handful of researchers who have led some of the most well-known asthma intervention trials conducted specifically among low-income children. During these interviews, asthma experts were asked whether we know what works and just need to find ways to implement evidence-based practices more broadly, or whether there are significant puzzles or gaps in knowledge to be investigated further.

Many of the experts noted that the evidence base for standard asthma management practices is solid and that, for the most part, what is needed are mechanisms to support the scale-up and wider adoption of programs and practices that focus on supporting families. However, there was a divergence in opinions about what types of programs and practices — from basic asthma educational sessions to more intensive home remediation strategies — are needed to move the needle in improving the health and well-being of the low-income children who suffer disproportionately from the condition of asthma.

Across the spectrum of programmatic approaches, it is clear that many low-income families with asthmatic children are in need of a “translator” to explain clinical protocols and their importance. Asthma is a controllable disease, but the steps needed to properly keep inflammation under control can be complicated; they can also change over time. Extant research has demonstrated gaps both in communication between health care providers and caretakers and in follow-up among high-risk, disadvantaged populations. In many ways, the interventions that focus primarily on providing education to families are bridging this informational gap. The meta-analysis results revealed that in doing so, the educational interventions (which primarily

⁹²McQuaid, Garro, Koinis-Mitchell, and Rourangeau (2014).

⁹³Meyerson (2013).

constitute a low-intensity level of services) can produce small to modest impacts in improving quality of life, mitigating asthma symptoms, and reducing ED visits and hospitalizations. These findings are supported in earlier, systematic reviews of educational interventions as well. Thus, it appears that education on asthma management is fundamental, as it represents a need that the health care system is not meeting systematically.

The local programs highlighted as case studies in this paper are also bridging informational gaps among low-income families in their communities. Front-line service providers explained that core components of the initial home visits with a family are to explain the distinctions between the different prescription medications, demonstrate how to ensure proper dosage with the use of spacers, and emphasize the importance of controller medication use (even when a child is asymptomatic) and the dangers of overreliance on rescue medication. These multi-component programs are also providing tools and resources to assist families in ensuring that their homes do not further challenge vulnerable children and exacerbate their condition. In order to achieve this objective, some programs have adapted their services to tackle conditions and systems that are beyond the family's control and that are often endemic to living in old and deteriorating housing. In some essential ways, these real-world efforts to address and ameliorate living conditions among the poor represent a recognition that poverty itself is a fundamental cause of disease.⁹⁴

At the same time, the meta-analysis findings revealed that although multicomponent home environment programs appear to have moderate impacts on reducing asthma symptoms and functional limitations, their impacts on ED visits and hospitalizations vis-à-vis simpler educational interventions are smaller. This finding was surprising, particularly because the services provided through home environment programs are generally more intensive in terms of dosage (for example, the number of interactions with caregivers and children), the provision of supplies (such as HEPA-filter vacuums and “safe” cleaning kits), and connections to other service providers (such as integrated pest management and mold removal services). Most important, there are potentially more comprehensive benefits to health and well-being from home environment programs than are currently measured or examined in existing research evaluations. But based on reviewing the outcomes that are measurable, particularly for health care use, the findings call into question whether a more intensive model warrants the price tag compared with less intense alternatives. Unfortunately, there are few head-to-head comparisons of education-only interventions with the more intensive, multicomponent home environment interventions. Such a study could provide a clear answer to the question of whether the broader components of a home environment-remediation approach offers added benefits.

⁹⁴Link and Phelan (1995).

Proponents of home environment programs have noted that through entering the home, a service provider is able to identify and address issues that may not have been evident otherwise. However, families who take up home-based services may be a select group: some families may be uncomfortable with program staff coming into their homes, and these families may be particularly high risk. Very few studies — across all intervention types — have been able to examine differences in program effectiveness based on familial characteristics. Such information could shed light on whether particular types of families respond more favorably to one approach than another. From a practice standpoint, community-based programs, including the programs highlighted in the case studies, may find it fruitful to explore ways to engage and tailor services to children and families who may not otherwise embrace a home visitation approach.

Notably, across all types of interventions reviewed, surprisingly few were able to show sizable impacts on improving medication management after one year. As indicated by some of the authors of the studies reviewed, it is unlikely that medication management barriers are driven by differential access to health insurance coverage, as most low-income children are eligible for and enrolled in Medicaid. Although physician prescribing practices may differ for Medicaid and privately insured children, a study of Medicaid and privately covered children in the same managed care organization found no differences in provider prescribing practices.⁹⁵ At the very least, given that proper use of medication is both challenging for low-income families and a fundamental component of managing asthma symptoms, finding ways to improve medication management is a critical area for future research.

Efforts to improve outcomes for children with asthma are also situated within larger policy contexts. States play a key role in promoting public health education, encouraging surveillance, and providing tools and coordinating support for local asthma programs. The role of the state, and the Medicaid program in particular, is relevant for the financing and sustainability of asthma programs for low-income children, as highlighted in the six state-based case studies. Some of these programs innovated by negotiating and incorporating per-member per-month payments from the state Medicaid agency to support primary care practices in transforming into PCMHs or health homes and providing specified services, such as care coordination and management that extends beyond the clinic. In other states, the local programs were able to establish contracts with payers, Medicaid, Medicaid managed care organizations, and private insurers to attain partial reimbursement for services (such as home visits and individualized asthma education by CHWs), after first demonstrating positive outcomes among program patients with asthma.

⁹⁵Finkelstein et al. (2000).

Despite the generally positive outcomes that asthma programs have yielded to date, the locally developed models showcased in the state-based case study reviews have yet to be actually replicated statewide. Given that cost-saving initiatives are of particular importance to payers (including the federal government), programs must be able to demonstrate a short-term positive ROI before they can be replicated. If a program is unable to show a validated ROI, perhaps due to data limitations, expanding the scope and reach of a model can prove challenging. Unfortunately, our review of prior evaluations revealed that the vast majority of studies do not report information on cost savings or cost-effectiveness; as a consequence, the frequently cited cost-savings statistics are based on a handful of studies with potentially limited generalizability. It is essential for future research to collect better information on cost-effectiveness. Future practice and policy should enhance current health care data systems to accurately track outcomes, improve care for patients by allowing providers access to real-time data, and strengthen the capacity for population health management.

The community-level initiatives described in this paper built their programs using evidence-based strategies and collaborated with key community partners, including hospitals, physician champions, and environmental organizations. Capitalizing on opportunities to partner and braid funding streams is also critical at the state level, where multiple agencies, such as Medicaid and public health authorities, can consider combining strengths to build more robust programs. Additionally, while programs developed at the state level provide the necessary framework for communities to implement programs, it is crucial for states to educate providers about opportunities to improve care for specific populations. For example, though all health homes can serve children and adults, most states implementing the model have enrolled a far greater percentage of adults in the program due to the nature of qualifying chronic conditions. Iowa found that making sure providers were aware they could enroll children in health homes has been a helpful step in leveraging the model to improve care for children with asthma.

In sum, the higher prevalence of asthma among children of low-income families remains a troubling concern, despite decades of research. While explanations for these health disparities remain unclear, as does the etiology of asthma, this review has identified several issues that may be influential in addressing persistent health disparities. One important lesson is that the role of health education and clear patient-provider communication cannot be taken lightly — while those more educated and with more resources not only have access to better and high-quality health care, they are also more likely to be treated and act as active partners in their care. Thus, educational interventions may provide not only needed information on care management among low-income families, but also an avenue by which to empower families in their interactions with health care and other service providers. Another key takeaway, as highlighted in the state-based case studies, is the importance of demonstrating cost-effectiveness for replication and scale-up of current programs. The state-based case studies in particular reveal the relevancy of state-run Medicaid programs in sustaining a funding stream

for asthma programs. Although there is uncertainty about the long-run sustainability of some of the programs highlighted in this paper, what is clear is that combating these disparities in the prevalence of asthma will require more than an agreement on standard asthma management practices among the medical community.

Appendix A

Methodology for Literature Review

The literature scan began in early 2015. We searched the Cochrane database and MEDLINE for research reviews and original studies published from 2004 to 2014. We then searched for relevant articles identified in the reference list of earlier meta-analyses. Searches were also conducted for specific journals, including *Pediatrics*, *American Journal of Public Health*, *CHEST*, *New England Journal of Medicine*, *Journal of Asthma*, *JAMA*, *Archives of Pediatrics and Adolescent Medicine*, *Journal of School Health*, and *Thorax*.

The following key words were used to identify relevant studies: *childhood asthma management*, *pediatric asthma management*, *childhood asthma intervention*, *pediatric asthma intervention*, *pediatric asthma program eval**, *childhood asthma program eval**, *childhood asthma random**, *pediatric asthma random**, *asthma clinical**, *asthma (education or educational)*, *asthma (education or educational) program**, *asthma (educat* or self-manag* or “self-manag”*)*, *childhood asthma study*, and *pediatric asthma study*.

From this list, we were primarily interested in rigorous evaluations — that is, evaluations that employed a randomized controlled trial (RCT) — because they offer the strongest evidence of impacts of an intervention by comparing outcomes among those who received the intervention with a randomly assigned control group (the counterfactual). However, in order to incorporate potentially promising interventions, we also included studies that were not RCTs, including those that used a nonexperimental comparison group or a pre-post analysis. While we did not limit our initial searches to evaluations focused on low-income children in urban contexts, an overwhelming number of studies have focused particularly on low-income children with asthma symptoms living in urban and inner-city environments. Many studies included a sizable number of racial and ethnic minority children.

Of the many articles that could have been included in this review, not all were. We primarily excluded studies for three reasons: (1) the intervention was not clearly described; (2) the primary outcomes examined were not of key interest (for example, there were measures of parental attitudes and knowledge about asthma care but not of health status or health care use); and (3) the study design was weak (too small a sample size, too short a period of follow-up, or the sample selection and attrition processes were unclear or concerning). Generally, we excluded studies with fewer than 100 participants (most studies had more than 250 participants), though some studies were included that did not reach this number, either because of the unique intervention model used or the intervention’s targeting of an especially high-risk population.

Methodology for Calculating Effect Sizes

Standardized effect sizes for outcomes were calculated by the authors by pulling information from the published studies. If the outcome was reported as a mean or average, the means and standard deviations were used to calculate effect sizes, analogous to Cohen’s *d* statistic. Effect

sizes were calculated based on unadjusted data if available or adjusted data if not. However, sometimes impacts were measured as change scores or values (the mean increase or decrease over time in the outcome, from baseline to follow-up, of the program group compared with the control group). In these cases, we estimated effect sizes using the change score estimate and the standard deviation of the change score, but we had to make assumptions about the pre-post correlation because it was not reported. Specifically, an assumption of a 0.5 correlation (which could theoretically range from 0 to 1) between pre- and post-means for both the program and control groups was made for some of the outcomes reported in two studies.¹ Dropping these studies in the meta-analysis results did not alter the findings reported in the main text. In several circumstances, the standard deviation for the impact result was not reported (or not estimable based on what was published) for either the mean or the change score. In these cases, we made the assumption that the standard deviation was similar to the other studies reviewed (but that did report standard deviations) for that outcome and within the same intervention category type (for example, home environment versus educational).² Some studies also reported outcomes at multiple time points — in these cases, impacts from the last follow-up period were analyzed. It is important to note that the Inner-City Asthma Study was unusual in that it was the only random assignment study reviewed that measured outcomes at two years.³ Almost all studies examined impacts somewhere between 6 and 12 months. So, for the Inner-City Asthma results, we relied on the estimates from Year 1 in the meta-analysis, although we incorporated a discussion of the effect sizes from Year 2 when relevant. Finally, for three-arm randomized controlled trials, we used the results from comparisons between the high-intensity group and the control group in our meta-analysis. In these studies, the lower-intensity intervention group (the third group) received minimal additional services compared with the control group of usual care (and the services described were more akin to the control group in the other two-arm studies reviewed, when the control was not usual care).⁴

For binary outcomes, we calculated risk ratios. Once effect sizes for individual outcomes and studies were calculated, we applied Hedges' small sample correction to all effect sizes before analysis and weighted each by the inverse of the variance using Stata 14.0.

¹These studies include Butz et al. (2010) for the outcomes of number of emergency department visits, number of regular care visits, number of symptom days, and number of symptom nights, and Krieger et al. (2005) for the outcome of care-giver quality-of-life scores. In Krieger et al. (2005), both “change” measures and follow-up means were reported in tables for the outcomes of interest, and for these outcomes, we calculated effect sizes based on the follow-up measures. However, we used the change score for caregiver quality of life because there were statistically significant and nontrivial differences at baseline in quality-of-life scores between the program and control groups at baseline.

²These studies include Teach et al. (2006) (educational intervention) and Klinnert et al. (2005), Krieger et al. (2005), and Krieger et al. (2009) (home environment intervention).

³Morgan et al. (2004).

⁴These studies include Karnick et al. (2007) and Gorelick et al. (2005).

Appendix B
Summaries of Asthma Studies

Appendix Table B.1

Summary of Studies with an Education and Self-Management Focus

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
RANDOMIZED CONTROLLED TRIALS				
Brown et al. (2006) Individual RCT Clinic-based setting	248	Adults and children with moderate to severe persistent asthma or who had used ED for asthma care at least once in year prior to enrollment Location: Grand Rapids, MI	Following ED visit for asthma, nurse-educator joined patient at primary care visit to review and recommend treatments based on current guidelines, create AAP, and provide patient with asthma education. Additional home visit conducted by nurse-educator to review medication and triggers and reinforce education. Control group received usual care	<u>Health care use:</u> Reductions in use of urgent asthma care in the 6 months following the intervention were found, although not statistically significant (22.7% for program group vs. 38% for control group, p = 0.29).
Butz et al. (2005a) Cluster RCT (county level) School-based setting	221	Children ages 6 to 12 years taking asthma medication with night awakening due to symptoms Location: Rural counties in MD	Parents attended 1-hour education session on identifying warning signs; reducing environmental exposure; proper use of medication, AAPs, and peak flow meters; and communicating with PCP. Children received 4 hours of education on asthma management and trigger awareness, received peak flow meter and spacer device. Control group received usual care.	<u>Health care use:</u> No impact on percentage with any ED visits (13.4% [program] vs 18% [control], p = 0.34), any hospitalization (3.6% [program] vs. 5.6% [control], p = 0.62), or regular asthma care visits (72.3% [program] vs. 71.9% [control], p = 0.55) at 10 months follow-up. <u>Morbidity and quality of life:</u> Improvement on change of asthma severity scores (reduction of 0.40 on a 1-4 range [program] vs. change of 0.01 [control], p = 0.01) from baseline. No impact found on caregiver or child QOL scores. <u>Management and remediation practices:</u> Intervention effects found for controller medication use at follow-up (52.7% [program] vs. 62.9% [control]; p = 0.05)

(continued)

Appendix Table B.1 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Butz et al. (2005b) Individual RCT Home-based setting	221	Children ages 2 to 8 years who use a nebulizer, recruited from hospital-affiliated pediatric practices serving inner-city children Location: Baltimore, MD	Families received 6 home visits with a nurse, who provided standard asthma education; symptom identification training; and protocols on how to manage symptoms with nebulizer therapy. Control group received low-intensity intervention (3 home visits with standard asthma education).	<u>Management and remediation practices:</u> Improvements in symptom identification and medication management found for both educational groups after intervention. For example, use of medicine when child unable to talk improved from 85.8% to 97.9% for total sample. Cleaning of nebulizer after each use improved from 75.9% to 83.1%. In general, no significant differences found between more intensive and less intensive educational groups. Follow-up period unclear.
Butz et al. (2010) Individual RCT Home-based setting	231	Children ages 6 to 12 years using controller and/or agonist medication with a recent asthma-related hospitalization or ED visit Location: Baltimore, MD	Families received 4 home visits over 8 weeks emphasizing patient-provider communication skills. Children were accompanied by a nurse/health educator to PCP visits over first 6 months. Control group received low-intensity intervention (3 home visits with standard asthma education).	<u>Health care use:</u> After 1 year, no impacts (difference between 2 groups) found for number of ED visits (mean decrease of 1.16 visits [program] vs. 0.95 [control], p = 0.55) or number of PCP visits for asthma within last 6 months. <u>Morbidity and quality of life:</u> No impact found on number of symptom-days over last 30 days (-1.11 [program] vs. -1.58 [control] days, p = 0.75). <u>Management and remediation practices:</u> No impact on prescription medication fills. Trend noted for program group (high-intensity) children to have better ratio of controller medication to total asthma medication pharmacy fills compared to control (low-intensity) group (ratio of 0.54 [program] vs. 0.45 [control], p = 0.07).

(continued)

Appendix Table B.1 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Clark et al. (2004) Cluster RCT (school level) School-based setting	835	Children in grades 2 to 5 in elementary schools that were primarily African American and had high poverty Location: Detroit, MI	Asthmatic children in program group schools were provided asthma management education through "Open Airways for Schools." Education on asthma control strategies and potential environmental triggers for school administration, custodial staff, and parents of asthmatic children was also provided. Control group received usual care.	<u>Morbidity and quality of life:</u> Program group experienced 17% reduction in annual daytime symptoms compared to control group ($p < 0.01$) at Year 2. Opposite effects were found for nighttime symptoms (40% increase in program group, $p < 0.01$); this finding appears to be driven by asthma severity, with intervention reductions found for those with persistent asthma (15% reduction) but increases found for intermittent severity compared to control group. Reductions were found in program group school absences (8% fewer absences over prior 12 months [$p < 0.01$] and 34% fewer absences in prior 3 months [$p < 0.01$]).
Fisher et al. (2009) Individual RCT Home-based setting	191	Children ages 2 to 8 years on Medicaid, who reside in zip codes with largely African American populations Location: St. Louis, MO	Community health workers conducted an initial home visit. During this and a second visit, they reviewed 7 key asthma behaviors and assessed the parents' readiness to adopt each. Control group received usual care.	<u>Health care use:</u> Impacts were found on reductions in any hospitalization over 2-year period (36.5% of program group hospitalized at least once vs. 59.1% of control group; AOR = 0.61, $p < 0.01$). No significant reductions found in any ED visits (AOR = 1.19, $p = 0.11$).
Gerald et al. (2006) Cluster RCT (school level) School-based setting	736	Children from 54 elementary schools Location: Birmingham, AL	Intervention included six, 40-minute "Open Airways for Schools" education sessions for asthmatic children. Two separate educational programs on asthma awareness were provided for school staff and general student body. Control group eventually received the intervention after data collection (delayed intervention group).	<u>Health care use:</u> No impacts found on median ED visits (unadjusted difference of 0.01) and median number of hospitalizations (unadjusted difference of 0.02). Follow-up period unclear. <u>Morbidity and quality of life:</u> No impacts found on changes in mean number of school absences (0.07 increase [program] vs. 0.08 decrease [control]) based on school records (but reductions were found when based on parent reports).

(continued)

Appendix Table B.1 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Horn et al. (2014) Individual RCT Clinic-based setting	150	Children ages 1 to 12 years referred from ED to the IMPACT-DC clinic (see Teach et al. 2006) Location: Washington, DC	Intervention included IMPACT-DC curriculum supplemented with educational piece on strategies to improve provider-parent communication for caregivers. Control group received education sessions from IMPACT-DC curriculum.	<u>Health care use:</u> No effect on number of hospital admissions at 2 and 6 months. Short-term reductions in ED visits at 2 months (0.2 visits [program] vs. 0.4 [control], p = 0.02) but not sustained at 6 months. No impact on number of scheduled PCP visits (ARR = 1.0, p = 0.85) or acute care visits (ARR = 0.8, p = 0.42). <u>Management and remediation practices:</u> No impact on use of controller medication in past 2 days (AOR = 1.3, p = 0.43), AAP adherence, or indoor smoke exposure (AOR = 0.8, p = 0.56).
Joseph et al. (2007) Cluster RCT (school level) School-based setting	314	Children grades 9 to 11 with asthma diagnosis and recent symptoms, medication use, or health care encounter Location: Detroit, MI	Intervention consisted of Web-based educational sessions focused on 3 core behaviors: controller adherence, rescue inhaler availability, and smoking cessation/reduction. Control group was given four, 30-minute online sessions to access various generic asthma websites	<u>Health care use:</u> Significant reductions (ARR = 0.2, p < 0.01) found for number of hospitalizations at 1 year (unadjusted mean comparison = 0.2 events [program] vs. 0.6 visits [control]). Marginally significant reductions also noted for ED visits (ARR = 0.5, p = 0.08; unadjusted mean comparison = 0.5 visits [program] vs. 0.8 visits [control]). <u>Morbidity and quality of life:</u> Significant reductions were found for both symptom days (ARR = 0.5, p < 0.01) and nights (ARR = 0.4, p < 0.01) over past 2 weeks, and missed school days for past 30 days (ARR = 0.3, p < 0.01). <u>Management and remediation practices:</u> No impacts found for smoking cessation or reduction.

(continued)

Appendix Table B.1 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Karnick et al. (2007) Individual RCT (three-arm study) Clinic-based setting	212	Children ages 1 to 16 years with diagnosed asthma, recruited from an urban ED Location: Chicago, IL	High-intensity group received basic asthma education, reinforcement, and case management services by a health worker and nurse practitioner. Low-intensity group received same asthma education as control group and reinforcement at monthly calls. Control group received basic asthma education.	<u>Health care use:</u> All 3 groups achieved reductions in hospitalizations, days in hospital, ED visits, and clinic visits at 9 months. Only clinic visits significantly differed (was lower) for the high-intensity group compared to the low-intensity and the control group (decrease of 2.8 visits for high-intensity group vs. 1.2 visits for low-intensity group and 1.2 visits for control group). <u>Costs:</u> Cost savings were produced for all 3 groups, with greatest savings in high-intensity group (\$4,503/person), although the analysis was based on average state wide reimbursements (vs. actual claims data).
Smith et al. (2006) Individual RCT Clinic-based setting	92	Parents of children ages 2 to 12 years on Medicaid or with no insurance presenting to hospital ED with acute asthma exacerbation Location: St. Louis, MO	Social worker discussed importance of follow-up care at ED visit, discussed parents' perceived barriers to follow-up care, and coached parents on strategies for overcoming these barriers. Also, a \$15 incentive was mailed to parents who completed follow-up visit within 2 weeks. Control group received usual care	<u>Health care use:</u> At 1 month following the ED visit, there were no differences detected in the proportion of children who received a follow-up care appointment with their PCP (22% for program group vs. 24% for control group, p = 0.99).

(continued)

Appendix Table B.1 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Teach et al. (2006) Individual RCT Clinic-based setting	490	Children ages 1 to 17 years recruited in ED, with at least 1 unscheduled visit for asthma (past 6 months) or at least 1 hospitalization for asthma (past year). Location: Washington, DC	Single visit to IMPACT-DC (program-built) asthma clinic where each family met with an asthma educator and physician shortly after an ED visit (2-15 days). Program group was provided an updated personalized action plan, training on devices (e.g., spacers) and medication management, environmental trigger education, and bed casings. Control group received asthma educational booklet.	<p><u>Health care use:</u> At 6 months, reductions found in ED visits (0.64 visits [program] vs. 1.19 visits [control], $p < 0.05$) and for unscheduled visits to a provider (0.68 visits [program] vs. 1.13 visits [control], $p < 0.05$) but no impacts found for hospital admissions (0.10 events [program] vs. 0.18 events [control]). No impacts were found on scheduled asthma care visits.</p> <p><u>Morbidity and quality of life:</u> Positive impacts on number of symptom-free days at 1 month, but not sustained at 3 or 6 months. Small, consistent impacts on reductions in missed school days but not statistically significant. At 6 months, impacts found for absence of functional limitations over the past 4 weeks (ARR = 1.33, $p < 0.05$).</p> <p><u>Management and remediation practices:</u> AAP adherence, measured only at 1 month, was greater among program group (ARR = 1.53, $p < 0.05$).</p>

(continued)

Appendix Table B.1 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Walders et al. (2006) Individual RCT Clinic-based setting	175	Children ages 4 to 12 years with physician-diagnosed asthma and 2 or more ED visits for asthma in last year or 1 or more asthma-related hospitalizations in past year. Location: Cleveland, OH	In addition to control group services, which provided basic asthma education, AAPs, prescription medication (1 month), and medication delivery supplies, the program group received an educational visit with a nurse or asthma social worker and the number for a 24-hour nurse advice line. Control group received AAPs, metered dose inhalers, peak flow meters and 1 month of prescription medication.	<u>Health care use:</u> At 12 months, impacts were found on the proportion of patients who had at least 1 ED visit or 1 hospital admission (28% in the program group vs. 41% in the control group, p = 0.05). The authors did not report results for ED visits and hospitalizations separately. <u>Morbidity and quality of life:</u> At 12 months, no differences were found in the mean number of days with symptoms between the program and control groups (3.4 days [program] vs. 2.9 days [control]). Both groups showed improvements in symptom scores; these differences were not significantly different from each other.
NONRANDOMIZED TRIALS				
Liao, Morphew, Amaro, and Galant (2006) Pre-post analysis School-based setting	1,321	Children at 20 elementary public schools with poor asthma management. Location: Orange County, CA	Mobile unit staffed by allergist visited schools to provide education on asthma pathophysiology, medication/devices, environmental controls, and AAPs. Each child was given a peak flow meter, and more challenging families were offered home visits for further education and assistance.	<u>Health care use:</u> At 1 year, hospitalization decreased (19% [baseline] to 3%) as did ED use (38% [baseline] to 16%), based on parental reports. <u>Morbidity and quality of life:</u> Increase in use of daily controller medication observed at 3 months (24% [baseline] vs. 78%). Reduction found for any missed school days over 1 year (60% to 26%), based on parental reports.

NOTES: ED = emergency department; AAP = asthma action plan; PCP = primary care provider; QOL = quality of life; RCT = randomized controlled trial; p = p-value, report of significance; AOR = adjusted odds ratio; ARR = adjusted risk ratio.

Appendix Table B.2

Summary of Studies with a Home Environment Focus

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
RANDOMIZED CONTROLLED TRIALS				
<p>Bryant-Stephens and Li (2008)</p> <p>Individual RCT (three-arm study)</p>	<p>280</p>	<p>Children ages 2 to 16 years with at least 1 asthma-related inpatient or 2 ED or urgent care visits in the past year, residing in low-income or primarily African American neighborhoods</p> <p>Location: Philadelphia, PA</p>	<p>Intensive intervention group (program) received home visits by lay health workers (conducted weekly for first 5 weeks, followed by monthly visits) focusing on medication management, AAPs, and home assessments. Trigger remediation supplies given to families.</p> <p>Observation group had initial home assessments and given basic information on asthma self-management classes, followed by monthly home visits to collect symptom diaries.</p> <p>Control group received usual care (outcomes are available only for comparisons on health care use).</p>	<p><u>Health care use:</u> Declines in number of ED visits found for intensive and observation groups (change of -0.97 visits [intensive] and -1.11 visits [observation] at 1 year), but not for control group (increase of 0.79); differences between intensive and control groups were significantly significant ($p < 0.05$) but not between intensive and observation groups. Significant reductions in hospital days in both intensive and observation groups compared to control group.</p> <p><u>Morbidity and quality of life:</u> Intensive group had reductions in symptom nights, but not significantly different from observation group.</p> <p><u>Management and remediation practices:</u> Intensive and observation groups had similar declines in rescue medication use; no changes in controller use. Lower presence of carpets and rodent allergens in intensive group, but no changes in smoking.</p>

(continued)

Appendix Table B.2 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Bryant-Stephens, Kurian, Guo, and Zhao (2009)	264	Children ages 2 to 16 years with at least 1 asthma-related inpatient or 2 ED or urgent care visits in the past year, residing in low-income or primarily African American neighborhoods	Lay health educators conducted home visits to teach families asthma physiology, recognition and avoidance of triggers, and appropriate treatment. The intervention targeted dust, pests, pets, and smoke.	<u>Health care use:</u> Mean number of ED visits after 1 year for the total sample decreased 30%, from 2.3 to 1.6 visits ($p < 0.01$). Mean total inpatient visits decreased by 53%, from 0.89 to 0.43 visits ($p < 0.01$). No differences found for the two groups.
Individual randomized crossover design (analysis focuses on pre-post differences for the two groups)		Location: Philadelphia, PA	Control group received usual care. Intervention was offered after 6 months.	<u>Management and remediation practices:</u> No difference in albuterol use for groups. Both groups had reductions in dust antigens; delayed group had greater reductions. Improved usage of pillow and mattress covers and reduction of roaches and rodents found in both groups; only use of pillow and mattress covers was higher in the immediate intervention group. Smoking and presence of furry pets not improved in either group.
Eggleston et al. (2005)	100	Children ages 6 to 12 years with asthma, current symptoms, and no other lung disease, and who were graduates of a school-based asthma education program	Environmental educators conducted 3 home visits and 1 phone call to educate families on trigger remediation. Children were given allergen tests and a home evaluation. Families were given a HEPA air filter, mattress and pillow encasings, plastic food containers to reduce pest infestation, free professional extermination, and bait traps (for mice).	<u>Health care use:</u> No impact on acute care visits (decline from 32% to 15% [program] vs. 36% to 13% [control]) or hospitalizations at 1 year (data not shown). <u>Morbidity and quality of life:</u> Significant reduction in percentage reporting any symptoms from baseline to 6 months found only in program group (58% to 50% [program] vs. 50% to 66% [control], $p < 0.01$), but impacts were marginally significant at 12 months (55% [program] vs. 59% [control]; AOR = 0.62, $p = 0.07$). No impacts were found on caregiver quality of life.
Individual RCT		Location: Baltimore, MD	Control group received usual care.	<u>Management and remediation practices:</u> Impacts found on airborne particulate concentrations (39% reduction [program] vs. 8% increase [control], $p < 0.01$) and cockroach allergens in bedroom were also lower in program group. No impacts on concentrations of mice allergens.

(continued)

Appendix Table B.2 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Gorelick et al. (2006) Individual RCT (three-arm study)	352	Children ages 2 to 17 years with acute asthma being treated at pediatric ED Location: Milwaukee, WI	High-intensity group received care coordination and case management, in which a nurse or social worker conducted home environmental assessment and helped coordinate with social services and clinicians via home visits (up to 6). Lower-intensity group received primary care linkage services in which ED chart and recommendations for asthma care plan were faxed to health care provider. Case managers also made outreach attempts. Control group received standard asthma education.	<u>Health care use:</u> No differences found on any ED visit at 6 months (17.3% [high-intensity] vs. 17.9% [low-intensity] vs. 19.2% [control]) or mean number of ED visits (0.57 [high-intensity] vs. 0.56 [low-intensity] vs. 0.60 [control]). <u>Morbidity and quality of life:</u> Similar improvements found in QOL scores across all groups. <u>Management and remediation practices:</u> Reports of use of controller medication varied at follow-up (68.9% [high-intensity] vs. 88.6% [low-intensity] vs. 84.8% [control group]), but no significant differences were found across all three groups. No change in smoke exposure found across all three groups.
Kercsmar et al. (2006) Individual RCT	62	Children ages 2 to 17 years with at least 2 ED visits or 1 hospitalization due to asthma in year prior to enrollment Location: Cleveland, OH	All participants received clinic visit and AAP, medication management education, and 1 home visit conducted by sanitarians to test for and educate families on allergens. Randomization occurred after home visit if mold was found. Intervention homes received services focused on mold, ventilation, lead, and cleaning. Control group received information on improving indoor air quality. At the end of the study, control group was offered home remediation.	<u>Health care use:</u> No significant impacts found on any ED use at 12 months (17.2% [program] and 36.4% [control], p = 0.15). Number of ED visits was lower in the program group at 12 months (0.28 visits [program] vs. 0.91 visits [control], p = 0.06). <u>Morbidity and quality of life:</u> Program group reported fewer days experiencing symptoms, but not significantly significant. <u>Management and remediation practices:</u> No impacts in mean allergen levels in the home, although program group trend toward greater reduction in mouse allergen levels and mold noted.

(continued)

Appendix Table B.2 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Klinnert et al. (2005) Individual RCT	181	Children 9 to 24 months, Medicaid-eligible, with 3 recorded wheezing episodes recruited from pediatric rooms and clinics Location: Denver, CO	Nurses conducted an average of 15 home visits to offer trigger remediation to intervention group. Education video and coaching provided on parent-child interaction and caregiver mental health. Control group received only the education video, home environment testing, and feedback letters regarding allergens and cotinine levels.	<u>Health care use:</u> No impacts found on ED visits or hospitalizations. <u>Morbidity and quality of life:</u> Maternal reports of functional severity were similar at follow-up. Caregiver QOL score was slightly higher for program group but not significantly different from control group for full sample (6.47 on a scale of 1-7 [program] vs. 6.34 [control]). <u>Management and remediation practices:</u> Significant impacts found for reductions in cockroach allergen levels (p < 0.03). No program-control differences found for changes in cat or dog dander levels.
Krieger et al. (2005) Individual RCT	274	Children ages 4 to 12 years on Medicaid Location: King County, Washington	High-intensity group received environmental assessments by community health workers, with 4 to 8 home visits to provide trigger remediation materials (mattress cases, low-emission vacuums, roach bait and rodent traps, cleaning kit), education, and referrals to smoking cessation counseling. Low-intensity group received limited services, including one visit by a community health worker who conducted an environmental assessment, completed an asthma action plan, provided limited education and bedding encasements.	<u>Health care use:</u> Greater reductions in urgent health care use found in high-intensity group at 1 year (absolute change of 17% reduction [high-intensity] vs. 4.6% [low-intensity], p < 0.05) <u>Morbidity and quality of life:</u> Symptom days (over 2 weeks) decreased more in high-intensity group, but the difference between high- and low-intensity group was not significant. Caregiver QOL improved more in high-intensity group (p < 0.05). Reductions found for both groups in days with activity limitations, but reductions were significantly greater for high-intensity group. No statistically significant differences in missed school days or missed parental workdays. <u>Management and remediation practices:</u> Need for controller medication decreased in high-intensity group but was not significantly different from low-intensity group.

(continued)

Appendix Table B.2 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Krieger et al. (2009) Individual RCT	309	Children ages 3 to 13 years in households with income below 200% of the poverty level or enrolled in Medicaid Location: King County, WA	High-intensity group received 1 intake visit and an average of 4.5 follow-up home visits. Nurse and community health workers provided asthma and environmental assessments, bed encasements, vacuum/filters/bags, doormats, cleaning kits, and plastic medicine boxes. Low-intensity group received 3 visits with asthma nurses at 3-month intervals. Elements included allergy tests, referrals, and assistance with making medical appointments. All participants received spacers and bedding encasements; children 7 years or older received peak flow meters.	Results based on baseline-to-exit changes at 1 year between the 2 intervention groups. <u>Health care use:</u> Decreases in use of urgent health services in previous 3 months found for both groups (49% to 31.4% in the low-intensity group; 47.4% to 24.4% in the high-intensity group). Intervention (adjusted) effects found no significant differences between the 2 groups. <u>Morbidity and quality of life:</u> Mean symptom-free days increased in both groups (9.5 to 10.8 days in the low-intensity group; 9.3 to 11.3 days in the high-intensity group). Improvement in symptom-free days was significantly higher in the high-intensity group (p < 0.05). No impacts on missed school days. <u>Management and remediation practices:</u> Caretakers QOL scores improved in both groups; increase was significantly higher in high-intensity group.

(continued)

Appendix Table B.2 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Morgan et al. (2004) Individual RCT	937	Children ages 5 to 11 years from low-income families and with either a recent hospitalization or 2 unscheduled visits to the clinic or ED in past 6 months Locations: Bronx, Boston, Chicago, Dallas, New York City, Seattle area and Tucson	Research assistants conducted 5 to 7 home visits, in which they performed home assessment and created an environmental risk profile, taught the caretaker about child-specific triggers and medication management, and provided a tailored environmental intervention plan (including HEPA-filter vacuums, bedding encasements, and integrated pest control). Control group received usual care.	<p><u>Health care use:</u> No significant impact found on ED visits (difference of -0.14 [Year 1] and -0.07 [Year 2]) or any hospitalizations (1.6 percentage point increase [Year 1] and 2.6 percentage point decrease [Year 2]). No significant differences in acute care clinic visits at Year 1 or Year 2.</p> <p><u>Morbidity and quality of life:</u> Impacts found on days with symptoms over past 2 weeks (3.4 [program] vs. 4.2 [control], $p < 0.01$), and missed school days (0.65 [program] vs. 0.82 [control], $p < 0.01$) at Year 1; these results were sustained at Year 2.</p> <p><u>Management and remediation practices:</u> Cockroach, dust mite, and cat allergen levels declined in program group and were significantly different from control group in Year 1. Only dust mite levels in beds and bedrooms and cat allergens in bed remained significantly lower in Year 2. No differences in smoke exposure.</p> <p><u>Costs:</u> Intervention costs ranged from \$1,500 to \$2,000 per child.</p>

(continued)

Appendix Table B.2 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
NONRANDOMIZED TRIALS				
Levy et al. (2006) Pre-post analysis	78	Children ages 4 to 17 years with asthma, living in public housing Location: Boston, MA	Community health workers provided home environmental assessment, peak flow meters, trigger remediation materials (mattresses, food and storage bins, traps, sealants), and pest reduction education over 1-5 visits. Health workers facilitated linkages with providers.	<p><u>Health care use:</u> Longitudinal (pre-post) analysis found no change in hospitalizations at about 11 months (data not shown) or having an acute asthma care visit.</p> <p><u>Morbidity and quality of life:</u> Significant reductions over 6 months in found in symptom scores. Improvement over time found in QOL.</p> <p><u>Management and remediation practices:</u> Cockroach allergen concentrations decreased significantly, as did dust mite allergens and cat allergens at about 6 months post intervention.</p>
Norton and Brown (2014) Pre-post analysis	201	Children ages 2 to 14 years, from low-income families who were referred to Green and Healthy Homes Initiative for asthma complications due to environmental factors Location: Baltimore, MD	Full housing assessment completed along with education on environmental triggers and asthma management. Housing program addresses lead poisoning, weatherization, mold, pests, and other conditions found in substandard housing. Families provided with services to address structural housing issues.	<p><u>Health care use:</u> Baseline to follow-up differences (6 months) were found in number of ED visits (0.94 visits to 0.70 visits, $p < 0.05$) and hospitalizations (0.36 to 0.14, $p < 0.01$). These comparisons were not adjusted for other factors (such as seasonality).</p> <p><u>Morbidity and quality of life:</u> Presence of any daytime asthma symptoms improved (11% to 22%) as did night symptoms. Missed school days and missed workdays also improved at 6 months.</p>

(continued)

Appendix Table B.2 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Spielman et al. (2006) Pre-post analysis	314	Children ages 1 to 12 years with recent asthma symptoms Location: Harlem, NY	Children and families were provided spacers and AAPs, education on effective ways to eliminate or reduce common asthma triggers, and referrals to various community resources. Families were provided dust covers for mattresses and pest remediation services.	<p><u>Health care use:</u> Reductions were found in any ED visit and any hospitalization between baseline and 12 months.</p> <p><u>Morbidity and quality of life:</u> Asthma symptoms limiting daily activities declined at 12 months, but results were not significant. Percentages of any missed school days improved significantly (33.4% to 10.9%, $p < 0.01$).</p> <p><u>Management or remediation practices:</u> Use of any medication did not improve. However, use of controller medication did significantly improve from baseline to follow-up.</p>
19 Woods et al. (2012) Pre-post analysis Matched comparison of hospital records used for cost calculations	283	Children ages 2 to 18 years with recent ED visit or hospitalization Location: Boston, MA	Nurse case management and coordination of care with primary care and referral services provided. Nurse or nurse-supervised community health worker home visits conducted for education, environmental assessment, remediation materials (HEPA-filter vacuum, bedding encasements, and cleaning materials), and referrals to an exterminator or inspectional services.	<p><u>Health care use:</u> Baseline to 12 month decreases found for number of ED visits (68% decrease from, 1 visit to 0.3, $p < 0.01$), and number of hospitalizations (85% decrease, from 0.5 to 0.1, $p < 0.01$). These are unadjusted differences.</p> <p><u>Morbidity and quality of life:</u> Days of limited activity decreased by 42%. Number of missed school days improved significantly, and missed workdays also declined.</p> <p><u>Costs:</u> Children served by same hospital in surrounding zip codes with similar demographics were used as comparison group. Costs were calculated using hospital admission data. Costs for program = \$2,529/child. Savings for the intervention group to comparison group = \$3,829/child. Return on investment = 1.46.</p>

NOTES: ED = emergency department; AAP = asthma action plan; PCP = primary care provider; QOL = quality of life; RCT = randomized controlled trial; p = p-value, report of significance; AOR = adjusted odds ratio; ARR = adjusted risk ratio.

Appendix Table B.3

Summary of Studies with a Health Care Practice Focus

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
RANDOMIZED CONTROLLED TRIALS				
Halterman et al. (2012) Individual RCT	100	Children ages 3 to 10 years with persistent symptoms, recruited in schools Location: Rochester, NY	Schools generated reports and engaged in electronic communication with PCPs. Prescription medication delivered to child's school and home by a local pharmacy; medicine administered by a school nurse/aide each school day. A nurse with additional training served as asthma care coordinator to facilitate communication between school health staff, health care providers, and caregivers. Control group received usual care.	<u>Health care use:</u> At 6-8 months, no impacts found for any ED visits (8% [program] vs 6% [control]), any hospitalization (2% for both groups), and any acute asthma-related visits (19% [program] vs. 22% [control]). <u>Morbidity and quality of life:</u> No impact on symptom days or QOL, but impacts found on symptom nights over past 2 weeks (1.52 [program] vs. 2.34 [control], $p < 0.05$). Impacts also found on days with activity limitations (1.21 [program] vs 2.04 [control]) and missed school days (0.37 [program] vs. 0.85 [control]) over past 2 weeks.
Kattan et al. (2006) Individual RCT	937	Children ages 5 to 11 years who had an asthma-related hospitalization or 2 acute visits to the clinic or ED during the past 6 months Locations: Bronx, Boston, Chicago, Dallas, New York City, Seattle area and Tucson	Feedback letters for PCPs were generated during bimonthly calls with caregiver to determine symptoms and medication and health care use. Letters were sent to PCPs of children in program group with recommendation from NAEPP guidelines, therapy guidelines, and NAEPP severity classifications. PCPs of control group children did not receive feedback letters.	<u>Health care use:</u> Impact found on number of ED visits (0.87 visits [program] vs. 1.14 visits [control], $p = 0.01$) at 1 year. No impact on hospitalizations or unscheduled clinic visits. <u>Morbidity and quality of life:</u> No impact found on symptom days over past 2 weeks or missed school days. Slight reductions, although not significant, noted for days with functional limitations for program group. <u>Costs:</u> Savings of \$337 per year per child in the program group.

(continued)

Appendix Table B.3 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Lozano et al. (2004) Cluster RCT (clinic-level; three-arm study)	368	Children ages 3 to 17 with mild to moderate persistent asthma enrolled in 42 primary care practices Locations: Chicago, Seattle, and eastern Massachusetts	<p>"Practice-based redesign" group included trained asthma nurses who attempted to schedule 4-5 visits during the 2 years of the study in conjunction with visits to the PCP and phone follow-ups.</p> <p>Peer leadership model consisted of one physician at each site who was trained in asthma care and served as an "asthma champion," sharing guidelines and information with colleagues. Champion received physician-specific feedback on anti-inflammatory prescribing by colleagues.</p> <p>Control group received usual care.</p>	<p><u>Morbidity and quality of life:</u> Symptom-days decreased more in practice-based redesign group (13.3 fewer days per year compared to control group, $p = 0.02$). Differences between peer leadership group and control group not significant. Improvements in activity-level scores found for both peer leadership and practice-based redesign group compared to control group.</p> <p><u>Management or remediation practices:</u> Practice-based redesign group reported higher prevalence of regular use of controller medication (46.7%) compared to control group (36.5%). No statistically significant differences found for peer leadership group and control group.</p> <p><u>Costs:</u> Compared with control group, the incremental cost-effectiveness ratio was \$18 (peer leadership group) and \$68 (practice-based redesign group) per symptom-free day gained.</p>

(continued)

Appendix Table B.3 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Splett, Erickson, Belseth, and Jensen (2006) Cluster RCT (school level)	1,561	Children in grades K to 12 in 16 schools, who were identified as having poorly controlled asthma by school nurses and staff Location: Minneapolis, MN	A health related services director communicated with public school leadership and local clinics or providers to implement evidence-based protocols and coordinate trainings. Trainings provided to clinic staff began with a half-day session, followed with quarterly trainings on various asthma topics. Asthma nurses visited schools once or twice a month to provide coaching to school health staff. Control group received usual care.	<u>Health care use:</u> Mean health visits for students with asthma was significantly higher in control schools (91 visits/month [program] vs. 121 visits/month [control], p < 0.05), although unclear if these are adjusted differences. <u>Morbidity and quality of life:</u> No impacts on missed school days. <u>Management or remediation practices:</u> Program group more likely to have an AAP (18.4% [program] vs. 12.6% [control], p < 0.05), have rescue medication available (27.2% [program] vs. 25.6% [control], p < 0.05) and use controller medication (3.4% [program] vs. 2.0% [control] p < 0.05).
NONRANDOMIZED TRIALS				
Boychuck et al. (2006) Pre-post analysis	1,059	Children ages 1 to 18 years who presented at 1 of 4 EDs with signs of asthma Location: Honolulu, HI	Implementation of Child Asthma Research to Elevate Standards (CARES) educational program for ED staff, patients, families, and community-based health care providers, focusing on severity classification, compliance with AAPs, and controller medication Educational program delivered to patients and families during ED visit.	<u>Morbidity and quality of life:</u> QOL scores improved over 3-month period (no statistical adjustments appear to have been made or significance tests comparing pre-post). <u>Management or remediation practices:</u> Controller medication use in children with persistent asthma appeared to improve at 3 months (18.2% to 36.6%; no statistical adjustments appear to have been made).

(continued)

Appendix Table B.3 (continued)

Study, Design, and Setting	Sample Size	Population Studied	Description of Intervention	Summary of Key Findings
Lob et al. (2011) Pre-post analysis with matched-clinic pairs	314	Children ages 0 to 18 years with asthma being served by 1 of 17 community health centers Location: California	Site-specific intervention that included the introduction of asthma flow sheets, use of AAPs, clinician pocket guide for care, site-level provider and staff training on NAEPP guidelines, and creating communication channels with local schools. Clinic-based health workers provided asthma education to some parents and children, gave community referrals, and performed at least 1 visit to assess the home environment.	<p><u>Health care use:</u> Using matched pair (clinic-level) comparisons of patient data, percentage with any ED visit or hospitalization (in last 6 months) was significantly lower at Years 1 and 2 (e.g., from ~30% with any ED visit at baseline to 8% [Year 1] to 9% [Year 2]).</p> <p><u>Morbidity and quality of life:</u> Significant reductions found in percentage of patients who reported daytime symptoms. Statistically significant improvements also found for missed school days, missed workdays, and for QOL scores.</p> <p><u>Management or remediation practices:</u> Access to and use of controller and rescue medication significantly improved at Year 1 and 2.</p>

NOTES: ED = emergency department; AAP = asthma action plan; PCP = primary care provider; QOL = quality of life; RCT = randomized controlled trial; p = p-value, report of significance; AOR = adjusted odds ratio; ARR = adjusted risk ratio; NAEPP = National Asthma Education and Prevention Program.

Appendix C

Detailed Case Studies of Local Asthma Programs

Local Program Case Study: a.i.r. nyc

Overview and Program History

a.i.r. nyc employs a technology-savvy, data-driven, community-based model to deliver evidence-based, home-visiting services to asthmatic children and adults in New York City. With community health workers (CHWs) as the key agents in motivating families to control asthma, stay healthy, and stay out of the hospital, a.i.r. nyc prioritizes cultural and linguistic competency, hiring native speakers of Spanish, French, Mandingo, Susu, and more. CHWs are equipped with tablets and smartphones for real-time data management during home interventions. Data are analyzed for quality assurance and improvement, which leads to measureable health outcomes, including reduced hospitalizations, emergency department (ED) visits, and absenteeism.

Previously known as the Harlem Children's Zone Asthma Initiative, a.i.r. nyc (the *a.i.r.* stands for "asthma intervention relief") was started in 2001 in collaboration with the Mailman School of Public Health at Columbia University, Harlem Children's Zone, and Harlem Hospital Center in order to address the high burden of asthma among children in Harlem. Since its inception, the organization has remained focused on its mission of keeping asthmatic New Yorkers healthy, active, and out of the hospital. Today, a.i.r. nyc serves families in Harlem, the Bronx, and Brooklyn. a.i.r. nyc has received requests to open offices in other parts of New York City, as well as other states, such as New Jersey, where asthma prevalence is high.

a.i.r. nyc uses a multifaceted approach to help families address the many factors that lead to an asthma exacerbation and other related difficulties. The organization's intervention strategy includes customized asthma education, medication management, environmental assessment, integrated pest management, mold and dust mitigation, and referrals to other social service organizations as needed. One of the critical referral pathways a.i.r. nyc opens for families is connecting them to pro bono legal assistance in cases where landlords allow tenants to reside in unhealthy conditions where mold, dust, pest infestations, and other interior environmental triggers can lead to asthma.

In addition to causing alarmingly high rates of hospitalizations, asthma is the number one reason children miss school. To address this problem, a.i.r. nyc created a school-based component, Asthma Control Training (ACT), in which a health educator goes into classrooms to provide asthma education to students (not just those with asthma), educators, and parents. a.i.r. nyc serves children from more than 350 New York City schools.

Impacts

Currently, a.i.r. nyc serves over 1,000 families. Based on reports from caregivers, a.i.r. nyc's intervention has shown an 81 percent decrease in asthma-related hospitalizations and a 68 percent decrease in ED visits due to asthma, as well as a 61 percent decrease in school absences. These results are based on pre- and post-comparisons of enrollees.

Financing

a.i.r. nyc was originally funded through the Robin Hood Foundation and has since received support from the New York Community Trust, the EPA's Environmental Justice Program, and individual donors. But the real value of the program in recent years is that it is beginning to demonstrate a return on investment (ROI) and has started to develop a social profit approach to make a business case for its charitable services. a.i.r. nyc executed contracts with two managed care organizations in 2015 and began receiving its first reimbursement dollars this year. Reimbursement currently comes in the form of fee-for-service per visit, but other models are also under consideration.

Additionally, New York State's Medicaid Redesign Team waiver amendment, the Delivery System Reform Incentive Payment Program (DSIRP), has identified asthma as one of 10 priorities in New York City to be addressed by Medicaid reform. City hospitals are expected to reduce hospitalizations by 25 percent by 2020, which has created a window of opportunity for a.i.r. nyc to explore new funding mechanisms beginning in 2016.

Challenges

Until 2015, a.i.r. nyc relied exclusively on philanthropy to support program operations. While the program has signed contracts with two insurance providers, funding continues to be the major challenge facing the organization. Citing high-quality and measurable services, a.i.r. nyc is approached daily by hospitals, clinics, schools, and community-based organizations asking whether there is capacity to serve new clients. And, although a.i.r. nyc has developed detailed operational plans for building capacity to meet this growing demand, the organization's major challenge is to raise enough resources to hire and train staff and purchase the equipment and supplies needed for the organization to grow.

Lessons Learned and Next Steps

In order to maximize program quality, efficiency, and effectiveness, a.i.r. nyc made the transition from paper-based record keeping to a custom-built, Web-enabled data system for care coordination and case management. The Salesforce-based platform provides real-time analytics

for case management and reporting purposes. The system is able to generate reports based on specific criteria, such as patients with the highest need or families who are due for their second visit. The system also includes a workflow functionality in which specific responses trigger specific tasks. For example, a missing medical administration form would trigger a reminder to the child's CHW to discuss this in his or her next phone call with the family. The system can also generate various reports and graphs and can be linked to other databases.

Over time, a.i.r. nyc has recalibrated its model so that the first, baseline visit is the most intensive, addressing all of the best practices for controlling asthma. This front-loaded intervention model ensures that families who are later lost to attrition receive as much education as possible. Additionally, CHWs generally try to schedule the second visit within one month of the first, while the family's motivation is strong and the new information is fresh and easier to reinforce.

a.i.r. nyc has worked hard to adapt the original Harlem-based model to the Bronx in recent years. It recently started a program in Brooklyn, where asthma prevalence is also disproportionately high.

Finally, a.i.r. nyc offers a strong value proposition to dramatically reduce avoidable hospital use and increase asthma self-management among New York City's most vulnerable families. The model has been well received by managed care organizations and other bottom line-oriented organizations that are interested in reducing the cost of health care while also providing quality services.

Local Program Case Study: Sinai Asthma Program

Overview and Program History

The Sinai Urban Health Institute (SUHI) is the community research arm of Mt. Sinai Hospital in Chicago. SUHI was founded in 2000 to examine and address the ways in which broader social issues affect health. Following its first annual Community Health Survey in 2002, asthma was identified as a key health concern in the city, which resulted in several SUHI-based asthma initiatives over the subsequent 13 years. As of 2016, SUHI has several community-based asthma initiatives under way across the city and surrounding suburbs. Asthma CarePartners (ACP) started in 2011 after SUHI formed partnerships with both public and private providers in Chicago, including Family Health Network (FHN), a Medicaid managed care provider. ACP embeds the CHW model into standard health care delivery. The program, which serves about 120 Medicaid-insured patients at any one time, targets adults and children with asthma who are identified as high risk by FHN. The ACP intervention is delivered in the participant's home by a CHW and includes asthma education focused on proper medication use, the correct device technique, the identification of asthma triggers, basic cleaning supplies and instructions on how to use them, and referrals to a tenants' rights organization and other community resources as needed. Participants receive five or six home visits over the course of 12 months, with additional telephonic check-ins every nonvisit month.

In addition to the ACP program, SUHI participates in two other asthma research studies that involve the examination of the CHW model. The first, the Coordinated Health Care Interventions for Childhood Asthma Gaps in Outcomes (CHICAGO) Plan, is a multisite comparative effectiveness study funded by the Patient-Centered Outcomes Research Institute (PCORI). SUHI is both a clinical site and the CHW-arm Coordinating Center. CHICAGO is a six-site, three-arm randomized controlled trial that examines the degree, quality, and impact of asthma education that children ages 5 to 11 years receive when seeking asthma care in the emergency department (ED). Intervention groups receive either enhanced asthma education in the ED or a home-based educational intervention delivered by a CHW. The first home visit takes place two or three days after the ED visit, with additional visits at 14, 30, 60, 90, and 180 days. The second, the U.S. Department of Housing and Urban Development (HUD)-funded Helping Chicago's Westside Adults Breathe and Thrive (HCWABT), is a study aimed at examining the effectiveness feasibility of SUHI's asthma CHW model with adults. The intervention is modeled after SUHI's previous HUD-funded asthma initiative, Helping Children Breathe and Thrive in Chicago Public Housing (HCBT). In both programs, CHWs conduct five or six home visits over the course of 12 months to offer asthma education, thorough home environmental assessments twice during the program, and subsequent environmental trigger remediation. Program

referrals come from the Chicago Housing Authority (CHA), Sinai's ED and health care offices, and community organizations.

Impacts

Following are select outcomes from the ACP program for child participants (self-reported, pre- and post-data from the year before and the year following the ACP intervention):

- a 60.0 percent reduction in daytime symptoms in the two weeks prior (p = 0.002)
- a 69.6 percent reduction in nighttime symptoms in the two weeks prior (p = 0.0001)
- a 71.0 percent reduction in asthma-related ED visits in the past year (p = 0.0001)
- a 57.1 percent reduction in asthma-related hospitalizations in the past year (p = 0.0012)
- a 76.2 percent reduction in asthma-related hospital days in the past year (p = 0.0021)
- an 81.0 percent reduction in asthma-related urgent care visits in the past year (p = 0.001)

Preliminary cost-savings analyses demonstrate a cost savings of \$5 per every dollar spent on the program.

Financing

SUHI's current asthma programs are primarily supported through federal grant dollars and payer reimbursement. After seeing improvements in their members' asthma (and the subsequent cost savings) as a result of participating in SUHI's past asthma initiatives, FHN approached SUHI to propose a partnership aimed at addressing uncontrolled asthma in its patient population for both children and adults. Using bundled payments, FHN pays SUHI quarterly for the in-home, CHW-delivered ACP intervention. The CHICAGO Plan is funded through a PCORI grant (University of Illinois Hospitals & Health Sciences System is the lead grantee), and HCBT and HCWCBT are both funded by HUD. Previous asthma initiatives at SUHI have been funded by the Centers for Disease Control and Prevention (CDC), the Illinois Department of Public Health, and the Michael Reese Health Trust.

Challenges

SUHI identified shifting insurance coverage as one of the biggest challenges for ACP participants. Participants in ACP frequently lose FHN coverage or switch to a different managed care organization. In instances where participants' coverage temporarily lapses, they must reenroll in the ACP program, which can result in delays in treatment and could potentially undermine improvement in an individual's asthma management.

ACP's niche is to serve those with poorly controlled asthma, and as such, one challenge concerns the complex lives of those SUHI seeks to engage. Often participants most in need of interventions such as ACP are those with the most barriers to participation. It is precisely for this reason that the program uses CHWs, who arguably are in the best position to conduct outreach and work with such populations. CHWs are trusted members of a community, often resemble their clients culturally, and are skilled at quickly developing honest relationships with the people they work with. Thus, they are able to break down barriers to effective disease management by approaching the disease within the context of the person's life. They approach suggested changes the participant or family needs to make with sensitivity and a cultural understanding of the participant's perspective. Another challenge is the basic economic hardship faced by participants, which may impede commitment to the intervention. ACP addresses this barrier via well-established referral relationships that allow SUHI to troubleshoot some of these challenges. Furthermore, the transiency of the Medicaid population creates many challenges as participants change their cell phone numbers regularly and move often, sometimes into the homes of relatives or friends who do not welcome visitors such as CHWs. SUHI has learned from its many interventions that meeting at a neutral location, such as a local library, enables participants to continue in the program while dealing with unstable living conditions. CHWs during the baseline visit request additional contact phone numbers, such as for family or friends, so they are sometimes able to find those whose cell phone numbers have changed or who have become difficult to reach.

Lessons Learned and Next Steps

SUHI has been partnering with FHN to bring the ACP program to its members for four years and is embarking on another two-year contract. Concurrently, SUHI is currently working on forming partnerships with additional managed care organizations to continue and expand the ACP program. HCWABT ended recruitment at the end of August 2015, but a third grant from HUD has now been received to assess the long-term effectiveness of the intervention model. Thanks to an additional grant from HUD, Helping Chicago's Westside Adults Breathe and Thrive: Long Term Effectiveness of a Healthy Homes Approach to Improving Respiratory Health (HCWABT II) will allow for the enrollment of an additional 100 adults into the active intervention, as well as a 12-month randomized study of maintained effect following comple-

tion of the active phase. The HCWABT intervention is ongoing as participants move through the program, and preliminary program outcomes are pending. Both recruitment and study activities are ongoing for the CHICAGO Plan.

Local Program Case Study: Community Asthma Initiative

Overview and Program History

Boston Children’s Hospital created the Community Asthma Initiative (CAI) in October 2005 following a community needs assessment conducted by the Boston Children’s Office of Community Health in which community members and community-based organizations identified asthma as one of the top four health concerns facing children in the Boston area. In addition, asthma was noted to be the leading admitting diagnosis at Boston Children’s Hospital. The CAI program model currently uses CHWs, and occasionally a nurse, to deliver in-home asthma education and environmental trigger remediation to children with asthma ages 2 to 18 years and their parents. HEPA vacuums, bedding encasements, storage bins to help with de-cluttering, and integrated pest management materials are provided. Home visitors make an average of three visits to the home, though the intervention is tailored to the individual family’s risk profile and may constitute additional visits as needed. Telephonic check-ins are conducted between visits and routinely at 6 and 12 months following enrollment in the program. While CAI will take referrals from providers outside of Boston Children’s Hospital, it also make uses of an internal primary care asthma registry that allows it to identify high-risk patients and access patients in the emergency department (ED) or patients who are admitted for asthma in order to capitalize on the “teachable moment.”

In addition to providing in-home asthma education and environmental assessment and remediation, CAI’s home visitors act as case managers and refer patients to other community resources, such as legal services or the Boston Public Health Commission’s (BPHC) Breathe Easy At Home (BEAH) program. BEAH coordinates housing inspections conducted by the City of Boston Inspectional Services Department for tenants whose apartments are known or suspected to have housing code violations, such as pests or mold, that can trigger the patient’s asthma. Inspectors can then use their enforcement power to cite landlords and require them to correct these violations.

CAI also addresses community-wide issues by conducting educational workshops for parents and children. It works with municipal and state coalitions to support payment for asthma home visits, as well as educate policymakers about the connection between asthma and social determinants of health — such as poor environmental conditions in housing and schools, or diesel emissions that disproportionately affect high-traffic poorer neighborhoods of color — in order to establish policies that will improve the places where children with asthma live, learn, and play. CAI is also a member of the Boston Asthma Home Visiting Collaborative, a group facilitated by the Boston Public Health Commission that brings together organizations that are

providing asthma home visits throughout Boston to standardize CHW visits and allow for inter-agency referrals to easily provide home visits in multiple languages.

Impacts

Since its inception, CAI has served more than 1,470 patients across Boston and has conducted more than 1,150 home visits. Using comparison data from four low-income, demographically similar areas in Boston, CAI has demonstrated that among those served, there is a 68 percent decrease in patients with any (≥ 1) ED visits and an 85 percent decrease in patients with any (≥ 1) hospital admissions due to asthma over a 12-month period, resulting in an ROI of 1.39 per dollar over two years and 2.08 over three years (calculated by comparing the cost savings to society due to reductions in hospitalizations and ED use with the cost of the clinical program). Over the same time period, a 41 percent decrease in children with any (≥ 1) missed school days and a 50 percent decrease in children with any (≥ 1) missed parent/guardian workdays were found, according to parental reports. When considering the admissions outcomes with the decreases in missed school and workdays, a social ROI of 1.77 over two years and an ROI of 2.63 over three years was found. Program costs are estimated at approximately \$2,000 per patient.¹

Financing

CAI funding includes a mix of federal grants, foundation financing, and funding from Boston Children's Hospital's Office of Community Health (OCH). The program received funding from 2012 to 2015 from the Health Resources in Action (HRiA) CMS Innovation Award, known as the New England Asthma Innovation Collaborative (NEAIC), with the goal of advancing home-based asthma interventions using sustainable payment systems. While NEAIC funding has ended, HRiA has received a no-cost extension to continue to work with Medicaid payer organizations to access their claims data and complete the outcomes and cost analyses, which will inform future discussions about reimbursement for home visits.

Challenges

Sustainable funding is the most pressing challenge facing CAI. Funding is inconsistent and largely grant- and foundation-based. In order to stabilize and sustain the program, insurers will need to start reimbursing for the home visiting services. Given current payment reform efforts in Massachusetts and nationally, Boston Children's is putting its greatest efforts into integrating CAI into a bundle of care for enhanced population management, rather than seeking fee-for-service payments from individual payers.

¹See Woods et al. (2012).

Lessons Learned and Next Steps

At the program's onset, CHWs were subcontracted through a local community agency that used the CHWs for various other purposes, which resulted in constraints on their time and resources. Through this experience, CAI learned the value of keeping CHWs in-house at Boston Children's, so that their sole focus could be on serving the families on CAI's caseload. This decision provided stability to the program and allowed it to serve more families.

Because fee-for-service reimbursement generally does not cover the costs of trigger remediation supplies or CHW salaries, CAI has learned that bundled payments or per member per month payments are more attuned to the nature of community-based asthma interventions. For this reason, Boston Children's Office of Government Relations approached the state legislature in 2011 and convinced policymakers to include a Medicaid bundled payment pilot to support home-based asthma interventions. CAI was chosen as a pilot site in 2014, and contractual negotiations are under way.

CAI also recently received claims data from payers that include medication costs, which will allow Boston Children's to calculate a more comprehensive ROI of the CAI program.

Local Program Case Study: Green and Healthy Homes Initiative

Overview and Program History

The Green and Healthy Homes Initiative[®] (GHHI) was formed out of the Coalition to End Childhood Lead Poisoning. After Coalition remediation crew members consistently reported that pediatric asthma was a prevalent health problem for their clients, the organization began to diversify its program services to address asthma triggers and household injury risks. GHHI's Healthy Homes Program was one of the first in the nation and was one of the early programs to receive a Healthy Homes Demonstration Grant from the U.S. Department of Housing and Urban Development (HUD). The Coalition started its Healthy Homes asthma reduction program in 1999, GHHI began as a program of the Coalition in 2008, and the official GHHI model was launched nationally in 2009. In late 2008, GHHI proposed a shift in how federal, state, and local governments and other housing partners delivered services for low-income families through an integrated housing assessment and intervention model. GHHI began in Baltimore, Maryland, but has now expanded to 25 partner sites across the country, with a goal of reaching 60 sites and 300,000 GHHI housing units produced by 2017. While the GHHI model is designed to address several housing-related health issues, pediatric asthma (with an emphasis on children ages 2 to 14 years) is a primary focus of the GHHI program. Clients are referred to the program through their health clinics or insurer, other local agencies (such as weatherization service providers), and self-referral.

The GHHI asthma program model consists of a comprehensive home visit to assess the home environment for asthma triggers and other home-based environmental hazards and to educate parents and children on how to maintain a safe and healthy home. Environmental assessment technicians conduct an in-depth, 2.5-hour environmental assessment of the home while an environmental health educator reviews home asthma triggers and behavioral remediation techniques with the family as part of resident education. The scope of Healthy Homes remediation services conducted by GHHI's in-house crew includes integrated pest management; mold remediation; ventilation; removal and steam cleaning of carpets; installation of air-filtering systems, air conditioning, and dehumidifiers; and basic safety measures such CO₂ detectors and smoke detectors. Larger home modifications (such as roof replacement or extreme mold remediation) are also available through GHHI and its partners by leveraging funding. Services are delivered via additional intervention visits to the home. GHHI triages families based on the degree of needed remediation, which is both efficient and cost-effective. As part of the asthma intervention, families are provided with Healthy Homes indoor allergen reduction cleaning kits, mattress covers and pillow cases, sponges, mop heads, radon testing kits, and vacuums. Ongoing case management is conducted via follow-up home visits and

phone calls at 1, 3, 6, 9, and 12 months. Referrals to community resources are made as needed, and a GHHI-employed attorney assists families facing more serious housing issues.

A key component of the GHHI model is the braiding and sequencing of care delivery. The organization learned early on that certain remediation programs would not address particular issues if they co-occurred with others (for example, weatherization versus mold remediation, or lead paint removal), with the result that families were being deferred for services by governmental programs. These programs also featured different income-based eligibility criteria and were supported through different funding streams. GHHI and the city of Baltimore were able to implement a “No Wrong Door” model that they refer to as “Align — Braid — Coordinate.” This model combines multiple programs and funding streams to deliver a single intervention that does not require families to navigate multiple programs housed at different agencies. The comprehensive home assessment generates a scope of work that covers all services required in the home and delineates which source of funds covers which pieces of the integrated, tailored intervention.

Impacts

The following outcomes are based on self-reported data from six months pre- and post-intervention for the Baltimore GHHI program:

- a 66 percent reduction in hospitalizations due to asthma in the past six months
- a 28 percent reduction in ED visits due to asthma in the past six months
- a 50 percent increase in reports of never visiting the doctor’s office for asthma in the past six months
- a 62 percent increase in reporting no asthma-related school absences or perfect attendance for a child in the past six months
- an 85 percent increase in reports by parents of not having missed work or normal activities due to asthma in the past six months

Financing

GHHI is supported through a diverse set of funding streams. Early funding came in the form of HUD Healthy Homes grants and foundation and philanthropic support. Federal and philanthropic dollars continue to support GHHI’s operations, but innovative financing streams at the local and state levels have also provided funding to various GHHI sites around the country. In the city of Baltimore, GHHI’s work has been supported in part by Constellation Energy, a local

utilities provider. Maryland's Public Service Commission has used consumer investment funds to support GHHI's interventions in Baltimore and the surrounding counties. The state attorney generals in New York and in Rhode Island have allocated money to GHHI sites in their states to complete comprehensive interventions using the GHHI model. GHHI is exploring the promise of social impact bonds (SIBs) through a Pay for Success initiative that is currently under way with six jurisdictions that could provide private financing for resident education and housing interventions for children who are diagnosed with asthma.

Challenges

As GHHI focuses heavily on housing and structural remediation in addition to providing asthma education, the program has had difficulty getting Medicaid to contribute to the program through reimbursement. However, the GHHI Baltimore program is currently conducting a HUD-funded Green and Healthy Homes cost-benefit study that will include Medicaid claims data, which it hopes will help strengthen the evidence base on the program's benefits both to patients and to payers. The study, which is set to run through 2017, will include analyses of utility bills, school records, and Medicaid records and will compare participant outcomes with the outcomes of Medicaid patients from similar zip codes and demographic backgrounds who did not receive program services.

Next Steps

GHHI Baltimore is currently developing an asthma Pay for Success transaction in partnership with Johns Hopkins Hospital and Health System, specifically with the Priority Partners Managed Care Organization (PPMCO), Hopkins' managed care organization that covers the Medicaid population. Under the proposed Pay for Success project, GHHI will be providing services to "frequent flyer" asthma patients covered by PPMCO. Services for the Pay for Success project will be paid for by investors, who will recoup their investment through a portion of medical cost savings from PPMCO.

In addition to increasing preventive services for frequent users of asthma medical services, the two primary aims of the Green and Healthy Homes study and the asthma Pay for Success project are to build a strong evidence base for Medicaid financing of the GHHI asthma model and to bend the arc for asthma-related school attendance. Outcomes to be examined include asthma-related school attendance, ED visits, hospitalizations, and doctor visits.

Appendix D

Detailed State-Based Case Studies

State Case Study: Arkansas

Program Overview

In 2011, Arkansas Medicaid, the Arkansas Department of Human Services, Arkansas Blue Cross Blue Shield, and QualChoice of Arkansas partnered to form the Health Care Payment Improvement Initiative (HCPII). The initiative aims to transform the state's health care delivery and payment system and ultimately improve health outcomes for Arkansans using a combination of population health and episode-based care strategies. HCPII has a two-pronged approach that includes (1) patient-centered medical homes (PCMHs) or "health homes,"¹ and (2) episodes of care (described in the following section).

The Arkansas PCMH model is designed to deliver team-based primary care that focuses on prevention and chronic disease management. PCMH providers are expected to improve the effectiveness of referrals, care coordination, and consumer engagement. HCPII's PCMH model provides a statewide framework that allows individual primary care medical providers to decide what conditions to focus on and what services to offer to improve health outcomes for their patients.

HCPII Fast Facts

Medicaid PCMHs Implemented: 2014

Asthma Episode of Care Implemented: 2014

Populations Served:

- Asthma episodes of care: Adult and child Medicaid beneficiaries ages 5+ meeting specific criteria
- PCMHs: >80 percent of all Medicaid beneficiaries are eligible; 60 percent of PCMHs are located in rural sites
- 65 percent of Arkansas children are covered by Medicaid

Arkansas Medicaid Child Eligibility Level:

- Ages birth to 18: 211 percent of federal poverty level (FPL)

Facilities:

- Asthma episode of care: 70 hospitals providing five episodes of care or more a year
- PCMHs: 145 practices in the state

Medicaid Reimbursement:

- PCMH: Per member per month care coordination payment of \$4 on average
- Shared savings available
- Episode of care: Retrospective payment based on predetermined, varying thresholds

Intervention type: Clinic-based

¹Medicaid health homes are an option under Section 2703 of the Affordable Care Act. States implementing health homes receive an enhanced 90-10 federal-state match for the first eight consecutive quarters of providing health home services and then the state's regular match resumes. All health home programs must be approved by the Centers for Medicare & Medicaid Services by submitting a State Plan Amendment (SPA). State plans are agreements between states and the federal government that detail how states administer their Medicaid and CHIP programs. State plan changes must be approved through a SPA.

An “episode of care” is the collection of care provided to treat a particular condition for a given length of time; it focuses on, and is triggered by, acute events such as an asthma-related emergency department (ED) visit or hospitalization. Within an episode of care, a principle accountable provider (PAP), typically a hospital, is responsible for coordinating and providing high-quality care. Arkansas identified asthma as one of the 12 current episodes of care,² based on clinical advisors’ input and the high number of asthma cases in the state. While asthma episodes of care can include adults and children, 62 percent of patients involved in an asthma episode of care are under the age of 21, and 55 percent of the costs are for children between the ages of 5 and 10 years.³

Episodes of care complement PCMH services by offering specialized care for a defined period of time in the midst of the ongoing care managed by the patient’s primary care medical provider. Through HCPII, providers use PCMHs and asthma episodes of care — which are both clinic-based interventions — to improve care for asthma patients. PCMHs provide care coordination, care management with a focus on preventive services and chronic disease management, and referrals to social services such as smoking cessation services. An asthma episode of care involves a PAP, who is responsible for coordinating the patient’s care for 30 days following an asthma-related ED visit or hospitalization. Specific services can include inpatient services, related family services, observation, labs, outpatient visits, and medication. Services are provided by hospital physicians, primary care providers, or pulmonologists.

Financing and Measurement

PCMHs are financed through both per-member per-month (PMPM) population-based payments and shared savings. PCMHs qualify for Medicaid shared savings incentive payments by improving their panel’s performance on total cost of care compared to their baseline, or by achieving cost thresholds set by Medicaid. In addition to achieving savings on the cost of patient care, practices must be eligible for PMPM payments and meet at least two-thirds of the shared savings quality metrics. Metrics for 2014 included the percentage of patients prescribed appropriate asthma medications, and the percentage of patients who have at least one wellness visit during the year. All PCMHs have an opportunity to participate in Medicaid shared savings, either by having a panel of at least 5,000 Medicaid patients, voluntarily pooling panels with other small practices, or participating in the statewide default pool.

Asthma episodes of care are financed through an innovative mechanism that compares the quality and cost of care for a PAP’s episodes over the course of a year to predetermined

²The remaining episodes of care can be found at Health Care Payment Improvement Initiative (2012).

³Interview with William Golden, MD, March 18, 2015.

thresholds.⁴ PAPs can share in the savings for care that was of high quality and cost below the “commendable” threshold, and they are responsible for contributing a share of the costs for care that falls below what is deemed “acceptable.”⁵ Adjustments are made on shared savings between the PCMH and the PAP if there is overlap. Blue Cross Blue Shield of Arkansas offers a separate reimbursement for privately insured patients who undergo an episode of care. While this system is similar, Blue Cross Blue Shield uses its own data, operates its own program, and follows a different reimbursement schedule than Medicaid.

Providers caring for patients through PCMHs and in all episodes of care use a provider portal to track patient data and view reports that demonstrate the overall quality of care delivered and the average cost of care over a certain time period. Portal data include quality metrics, the number of patients, and the number of times a patient is seen by participating providers, and providers are able to view quarterly performance reports. The provider portal also calculates the average cost per episode, allowing payers to determine the “commendable” and “acceptable” thresholds for PAPs.

Lessons Learned and Next Steps

Arkansas’s HCPII is a recent undertaking, and key parts have been rolled out in stages. The state plans to expand the PCMH model to cover most of Arkansas Medicaid, which will subsequently allow for a greater number of practices to adopt asthma as a priority. Arkansas acknowledges the importance of practice coaching and setting attainable goals for practices, and it is committed to using evidence-based guidelines to do so.

⁴This mechanism is called a retrospective episode-based payment, or REBP.

⁵Arkansas Department of Human Services (2012).

Spotlight on Conway Children's Clinic

Conway Children's Clinic in Conway, Arkansas, has leveraged the Health Care Payment Improvement Initiative's PCMH framework and is identified as a leader in managing asthma patients. Conway Children's Clinic first enrolled in a PCMH program in February of 2013. In 2014, clinic staff transformed the delivery of care to asthma patients by identifying such patients using an electronic health record and tracking them using a custom spreadsheet. The spreadsheet is used to ensure that patients are seen every six months for an asthma evaluation, that children over the age of 6 years receive yearly pulmonary function tests, and that all asthma patients have a copy of an updated asthma action plan with them at home and at school. Staff use clinical alerts to flag patients due for pulmonary function tests and flu shots.

Clinic staff have developed numerous policies and procedures to provide better asthma care. Establishing care teams has been a crucial step. Every care team consists of a provider, either a doctor or advanced practice registered nurse, a nurse, and an up-front staff member. Clinic staff now encourage patients to choose a provider and care team to see for all preventive care. Acknowledging the racial and ethnic disparities often found among pediatric asthma patients, Conway Children's Clinic offers all asthma education material, including asthma action plans, in Spanish, and several staff are fluent in Spanish. Conway Children's Clinic also seeks to address the social and environmental issues associated with asthma by tracking cigarette smoke exposure and offering smoking cessation referrals to parents and caregivers.

The clinic received technical assistance on quality improvement via webinars, site visits, and workshops from the state (through Qualis Health and the Arkansas Foundation for Medical Care) during its practice transformation. Clinic staff report being able to offer more personalized care to high-priority beneficiaries as a result of participating in the state's PCMH program.

Looking forward, staff at Conway Children's Clinic are working to promote their patient portal, a tool that allows staff to send patients care plans, forms, and educational resources and allows patients to submit medication refill requests, appointment requests, and questions for their care team. Staff are hopeful that portal use will improve disease management and patient health.

State Case Study: Iowa

Program Overview

In 2012, Iowa launched a statewide chronic condition health home program to serve adult and child Medicaid beneficiaries with qualifying chronic conditions, including asthma.⁶ Operating under the authority of a State Plan Amendment (SPA), the health home program strives to improve the overall health of its members by providing coordinated, patient-centered care in a primary care setting.⁷ To participate in this health home, Medicaid beneficiaries must have at least two qualifying chronic conditions or one condition and risk for a second.⁸

Iowa's health home program provides a statewide framework but allows participating providers the flexibility to tailor their services to improve health outcomes for patients with qualifying conditions, such as asthma. (See the "Spotlight" on Covenant Clinic-Pediatrics on page 91.) Participating providers use the following clinic-based interventions:

- care coordination
- care management with a focus on self-care support
- referrals to community and social support services

Iowa Chronic Condition Health Home Fast Facts

Implemented: 2012

Populations Served:

- Adult and child Medicaid beneficiaries
- 6,237 members; 23 percent are children

Iowa Medicaid Child Eligibility Levels:

- Ages birth to 1 year: 375 percent of the federal poverty level (FPL)
- Ages 1 to 18 years: 167 percent FPL

Medicaid Reimbursement to Providers:

- Care coordination per member per month (PMPM) payments ranging from \$12.80 to \$76.81
- Optional incentive payments based on performance on quality measures (pending)

Intervention Type:

- Clinic-based

⁶All health home references in this case study refer to Iowa's chronic condition health home. Iowa also has an integrated health home for adults with a serious mental illness and children with a serious emotional disturbance.

⁷Medicaid health homes are an option under Section 2703 of the Affordable Care Act. States implementing health homes receive an enhanced 90-10 federal-state match for the first eight consecutive quarters of providing health home services and then the state's regular match resumes. All health home programs must be approved by the Centers for Medicare & Medicaid Services by submitting a State Plan Amendment (SPA). State plans are agreements between states and the federal government that detail how states administer their Medicaid and CHIP programs. State plan changes must be approved through a SPA.

⁸In addition to asthma, other qualifying conditions include hypertension, being overweight, heart disease, diabetes, substance abuse, and mental health conditions.

All participating health home providers in Iowa must meet key specified criteria outlined in the SPA. First, providers must attain patient-centered medical home (PCMH) recognition within 12 months of becoming a health home and employ the necessary staff to perform specific health home functions.⁹ Health homes must include a designated practitioner, designated care coordinator, health coach, and clinic support staff. In addition, providers are required to use enhanced health information technology, including an electronic health record (EHR) system to support care coordination activities (for example, maintaining a comprehensive medication list and disseminating wellness education), link to evidence-based practices, track referrals, and implement population management strategies (for example, registries).¹⁰ Health home practices are also required to meet other standards, such as providing coordinated and integrated care that is culturally appropriate and family centered.¹¹

Financing and Measurement

Participating providers receive a tiered per-member per-month (PMPM) payment to support health home services, in addition to standard fee-for-service reimbursement. The PMPM payment amount is based on a member's disease burden and is highest for members with the greatest number of chronic conditions.¹² In addition to PMPM payments, the state is developing a second payment component that will allow providers to receive additional incentive-based payments. Providers will have the option to participate in this program, and payments will be based on their performance on a set of quality metrics that cover preventive care, chronic disease, and mental health. Practices will have the option to specifically report on two asthma measures: use of appropriate asthma medication and assessment of asthma severity.¹³ Iowa originally intended for providers to report quality measures to the state through the Iowa Health Information Network (IHIN) but is exploring other reporting methods due to system compatibility issues.

Lessons Learned and Next Steps

While numerous states are implementing the health home option to serve Medicaid patients with chronic conditions, not all states have leveraged the model as Iowa has done to specifically serve children with asthma. This is in part because not all states have selected asthma as a quali-

⁹The PCMH is a primary care model for delivering team-based and coordinated care. PCMH providers typically receive enhanced payments for high-quality care (Agency for Healthcare Research and Quality, n.d.).

¹⁰While provider practices are required to have an EHR system in place before they can enroll as a health home, they may receive technical assistance from the Telling Health Information Technology Regional Extension Center.

¹¹U.S. Department of Health and Human Services, Centers for Medicare and Medicaid Services (2014).

¹²Iowa Department of Human Services (n.d.).

¹³Iowa Department of Human Services (2013).

fyng condition. Furthermore, though children are technically eligible to participate in all health home programs, many states report that the vast majority of patients enrolled in the program are adults. Educating practices that they can enroll pediatric patients in the health home has been a key factor to Iowa's success. Additionally, the state has encouraged practices to create a best practice evidence-based guideline process for caring for their asthma population.

Spotlight on Covenant Clinic-Pediatrics

Covenant Clinic-Pediatrics, located in urban Waterloo, has leveraged Iowa's health home option to improve care for pediatric asthma patients. The practice first chose to focus on asthma after it completed the PCMH accreditation process, which required the identification of a group of children for care improvement efforts. The clinic identified a large gap in care for asthma patients and adapted components of the health home to serve this group. Approximately 1,000 children currently participate in its health home for qualifying conditions, including asthma, obesity, and exposure to secondhand smoke; approximately 300 of those children have an asthma diagnosis.

Each of the required health home staff members plays a defined role in delivering care to children with asthma. The health coach is responsible for reviewing patients' charts before visits to develop an asthma action plan that assists the family in managing the disease. The health coordinator develops the disease registry to identify patients with asthma and track their wellness exams and doctor visits. The health coach and health coordinator also handle referrals to community and social support services such as First 5, an organization that supports healthy mental development in the first five years of a child's life, and smoking cessation programs for parents. The clinic leverages other health home requirements, such as providing culturally appropriate care to its patients, by having on-site Bosnian and Spanish interpreters and by connecting with an interpretation organization that offers 180 languages.

One of the critical success factors for the clinic's ability to function as a health home has been implementing its EHR system, an important health home requirement. The new system allows providers to accurately identify children with multiple chronic conditions and facilitates care coordination. Providers in Covenant Clinic are now able to track referrals to outside services, regardless of whether or not they use the same EHR system, and they are able to see when a visit has been completed. The system also allows providers to see if there is a plan in place to manage a child's asthma and to track hospitalizations in local hospitals.

Looking forward, the clinic would like to continue to improve its EHR system to be able to track hospitalizations in additional hospitals and to more easily identify vulnerable populations. The clinic would also like to build its capacity to report quality measures to the IHIN in order to participate in Iowa's health home incentive payment program.

State Case Study: Michigan

Program Overview

The Asthma Network of West Michigan (ANWM) was established in 1994 in response to a dramatic increase in the prevalence of pediatric asthma in West Michigan. The organization was founded by a team of health professionals from local health care institutions and asthma support groups seeking to create a centralized resource for asthma education and management.¹⁴ Most important, this team included individuals in community leadership roles and a physician champion who were able to combine their strengths to advocate for the program and garner initial grant funding from local hospitals and foundations.¹⁵

The Asthma Network has been providing its home-based case management services in West Michigan since 1996, and developed the model known as MATCH — Managing Asthma Through Case Management in Homes.¹⁶ Recognizing the success of MATCH and the ANWM asthma case management program, the Michigan Department of Health and Human Services (MDHHS) Asthma Prevention and Control Program pursued replicating the model in other areas of the state. ANWM continues to work with the MDHHS and other MATCH programs on sustainability efforts: supporting a payer summit to help the Genesee County program establish health plan contracts, helping the Washtenaw County program transform from a school-based to a home-based case management program, and sharing MATCH fundamentals with health systems and community part-

ANWM Fast Facts

Established: 1994

Location:

- Based in Grand Rapids, Michigan
- Services provided in urban areas, specifically Kent, Ottawa, and Muskegon counties

Populations Served:

- Targets children and adolescents with uncontrolled asthma from low-income families
- Over 80 percent of children served are ethnic minorities
- 78 percent Medicaid patients, 20 percent uninsured/underinsured
- 300 families served to date, 75 to 80 percent pediatric patients

Medicaid Reimbursement:

- Asthma educator and social worker visits are billed to health plans as skilled nursing visits for \$80 to \$85

Intervention Type:

- Clinic-based and community-based

¹⁴Asthma Network of West Michigan (2012).

¹⁵U.S. Environmental Protection Agency (2016).

¹⁶Asthma Initiative of Michigan (n.d.).

ners in additional asthma high-burden communities. Four programs in six communities in Michigan now use the MATCH model.¹⁷

ANWM's MATCH model takes a multifaceted case management approach to addressing uncontrolled pediatric asthma by focusing on the medical, environmental, and social conditions affecting asthma. ANWM primarily targets children from low-income families with uncontrolled asthma resulting in missed school days, emergency department visits, or hospitalizations. Children are referred to the program from a variety of sources, including hospital-based and primary care providers, health plans, school nurses, and families. Though the program serves children regardless of insurance status, there is a waiting list for uninsured and underinsured children due to financial constraints. However, these children will be served by the program eventually, as it does not turn away anyone who has been referred for asthma case management in its service area.¹⁸

To achieve its goal of improving the overall health and quality of life of asthma patients, ANWM employs a combination of the following community-based and clinic-based interventions.

Community-Based Interventions

- The central component of the ANWM program is its home-based case management services, in which certified asthma educators (either a registered nurse or registered respiratory therapist) visit the home of a patient to educate the patient and family on asthma, assess environmental triggers of asthma, and provide case management support. Asthma educators teach self-management techniques, instruct families on proper use of medications and medical equipment, and review a written asthma action plan — an evidence-based practice for reducing the burden of the disease. Asthma educator home visits are usually biweekly for 3 months and then monthly for up to 6-12 months.
- Asthma educators can visit with a child's school, childcare providers, and extended family to identify asthma triggers and educate caregivers on how to handle attacks and use medication.

¹⁷An evaluation of the model across three MATCH programs (including ANWM) suggested that participants needed fewer urgent and extended care visits and experienced greater ability to manage their asthma, and indicated that the model can be successfully replicated in areas with high need and the capacity to support such a program.

¹⁸Meyerson (2013).

- For high-need families, a licensed master social worker (LMSW) performs assessments, provides psychosocial interventions, and coordinates social services such as housing and transportation. The LMSW also makes referrals to financial resources or mental health agencies.

Clinic-Based Interventions

- The ANWM case managers work closely with a patient’s medical home to coordinate care; many referrals to ANWM come from a medical home. ANWM also works to connect referred children to a medical home if they do not have a primary care physician.
- ANWM case managers meet with a child’s primary care physician to coordinate an asthma action plan.

Recognizing that significant disparities in asthma outcomes exist among racially and ethnically diverse populations, ANWM strives to provide culturally appropriate services. ANWM has interpreters available for non-English-speaking families through a local medical interpretation service. The program also provides asthma action plans in the family’s native language. Through a medical home pilot, ANWM was able to incorporate community health workers into the ANWM team to provide interpretation and translation and ensure that asthma education is culturally appropriate.

Financing and Measurement

Though ANWM was originally funded entirely through local hospital grants, in 1999 ANWM entered into an agreement with a Medicaid managed care organization, Priority Health, and became the first nonprofit asthma coalition to contract with a health plan in the nation. Since then, ANWM has contracted with three additional Medicaid managed care plans and one private health plan. ANWM bills health plans for skilled nursing visits, revenue code 551, which covers asthma educator and social worker visits with the family, primary care physician care conferences,

<p>ANWM Outcomes</p> <ul style="list-style-type: none"> • 60 percent decrease in hospitalizations • 40 percent decrease in emergency department visits <p>MATCH Outcomes</p> <ul style="list-style-type: none"> • 83 percent decrease in hospitalizations • 60 percent decrease in emergency department visits • 42 percent increase in pediatric quality of life scores <p><i>NOTE: These results come from case management data analyzed from three successive, combined, two-year before-after cohorts. Results were significant when contrasted with a non-random comparison group.</i></p>
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school visits, and visits with extended family members and child care providers. Reimbursement for skilled nursing visits covers about one-third of the ANWM budget, and the remaining costs (for uninsured patients and other nonreimbursable services such as mileage) are covered through grants from local hospitals, foundations, and the United Way. The other programs implementing the MATCH model also contract with health plans on an individual basis.

ANWM collaborates with the local Children's Healthcare Access Program, part of Health Net of West Michigan in Grand Rapids, to measure outcomes through a web-based database. The Health Net database allows ANWM to track data on asthma action plans, asthma control test scores, follow-up visits, flu shots, spirometry, medication refills, primary care visits, missed school days, and quality of life. The case manager is able to collect some data through parental reports, and ANWM has also been able to acquire certain usage data from hospitals.

Lessons Learned and Next Steps

Looking forward, ANWM is focusing on building its measurement capacity by working with Health Net to allow nurses to track home-visit data in real time through electronic medical records. ANWM also plans to explore additional reimbursement strategies such as contracting with additional payers or adopting new bundled or risk-based payment models to support sustainability.

Despite the success ANWM has experienced in addressing uncontrolled pediatric asthma, the model has not yet been adopted across the entire state. Key barriers to widespread adoption of models such as ANWM include a lack of awareness, a lack of understanding of how to start, and a need for asthma champions. Other interested states and communities can leverage existing models and partner with existing organizations. For initiatives starting at the community level, local health plans and hospitals are valuable partners for exploring and sustaining funding. State-level agencies, such as Medicaid and state health departments, can play an important role in supporting locally driven asthma initiatives by convening health plans and supporting evaluation to secure additional plan involvement and facilitate long-term sustainability.

State Case Study: North Carolina

Program Overview

North Carolina launched the Asthma Disease Management Program in 1998 through its statewide provider-led primary care system, Community Care of North Carolina (CCNC).¹⁹ CCNC is composed of 14 regional networks that include various medical providers, health departments, social service agencies, and community partners. Each network serves the Medicaid and (Children’s Health Insurance Program (CHIP) low-income populations in its area using the patient-centered medical home (PCMH) model of care.²⁰ CCNC chose to implement the Asthma Disease Management Program as its first statewide quality improvement program in response to the growing prevalence of asthma among Medicaid beneficiaries, a high number of pediatric asthma-related hospital visits, and elevated Medicaid asthma expenses; North Carolina Medicaid spent over \$23 million on asthma-related care in 1998 alone.²¹ The program serves Medicaid-eligible children and adults with asthma and prioritizes high-risk patients.

CCNC takes a comprehensive, evidence-based approach to addressing asthma through this program,²² which has four central goals:

- build capacity for routine asthma assessment

CCNC Fast Facts

Implemented: 1998

Populations Served:

- 1.13 million Medicaid/CHIP-eligible children
- 54 percent ethnic minorities (37 percent African-American, 17 percent Hispanic)
- 122,000 (11 percent) have asthma

North Carolina Medical Child Eligibility Levels

- Ages birth to 5 years: 210 percent of the federal poverty level (FPL)
- Ages 6 to 18 years: 133 percent FPL

CCNC Medicaid Reimbursement:

- \$3.72 per member per month (PMPM) payments for CCNC network practice support and management activities for the non-aged, blind, and disabled (ABD) population.
- \$2.50 PMPM care management payments to medical providers for the non-ABD population

Intervention Type:

- Clinic-based and community-based

¹⁹See the Community Care of North Carolina website (www.communitycarenc.com).

²⁰The PCMH is a primary care model for delivering team-based and coordinated care. PCMH providers typically receive enhanced payments for high-quality care (Agency for Healthcare Research and Quality, n.d.).

²¹Community Care of North Carolina (2010).

²²CCNC’s asthma initiative is based on the National Heart, Lung, and Blood Institute’s Guidelines for the Diagnosis and Management of Asthma (National Heart, Lung, and Blood Institute, 2007).

- reduce unintended variation in care and establish consistency of care
- build capacity to educate patients, families, and school personnel about asthma
- report outcomes and process measures to all providers and staff regularly²³

CCNC provides primary care medical practices with crucial resources and supports to achieve these goals. For example, all CCNC network providers can learn about best-practice guidelines through educational sessions, receive asthma symptom questionnaires to help gauge asthma control levels, and receive asthma management plans and education materials, available in English and Spanish, to distribute to patients.²⁴ Quality improvement specialists help practices incorporate asthma management tools in their daily activities, use data to improve patient care, and connect to community resources.

CCNC networks employ the following clinic-based and community-based interventions.

Clinic-Based Interventions

- Care managers, including nurses, social workers, and pharmacists, are available to work with high-risk patients in the practice or by phone on asthma education and self-management techniques. They can help children and families better understand their condition; educate them on asthma triggers and symptoms and proper medication and equipment use; and help them adhere to asthma management plans.
- Care managers help strengthen children and families' relationships with health care providers by accompanying them to their visits with medical providers to gain a better understanding of medical needs and helping patients implement provider care plans.

Community-Based Interventions

- Care managers can also conduct home visits to help families understand the social and environmental obstacles to controlling asthma. During home visits, care managers can assess environmental triggers and provide guidance to families on how to alleviate such triggers. Care managers can also help families reorganize their homes to better manage asthma by ensuring medications and asthma management plans are visible and easily available.

²³Community Care of North Carolina (2010).

²⁴CCNC has made Point of Care Resources available in English and Spanish to assist providers educate their patients with asthma (Community Care of North Carolina, 2014).

- Care managers can identify barriers in access to care and connect families with social services such as transportation or make referrals to community organizations.

Though CCNC's asthma program has been adopted across all networks, some have modified or enhanced the above components to best meet the needs of their communities. (See the "Spotlight" on Community Care of Wake and Johnston Counties, on page 99, for an example.)

Financing and Measurement

The North Carolina Division of Medical Assistance (Medicaid) provides physicians with a per-member per-month (PMPM) payment that supplements fee-for-service reimbursement and supports PCMH services such as care management and prevention for all conditions, including asthma. The state also provides CCNC networks with PMPM payments for additional management activities.

CCNC stresses the importance of measurement to accurately track disease burden; it collects medical chart review and claims data on asthma measures such as the percentage of patients who receive a written management plan, the rate of asthma-related emergency department (ED) visits, and the rate of asthma-related hospitalizations.²⁵ Providers access patient- and practice-level data through a CCNC provider portal. In addition to tracking the care of individual patients, practices can use the data to implement population management strategies for patients with asthma by tracking who has asthma-related ED visits or frequent asthma medication refills, for example.

The asthma disease management program has yielded positive results from claims data analysis, including a 16.6 percent decrease in ED visits and a 40 percent decrease in inpatient admissions for CCNC patients with asthma from 2003 to 2006. Additionally, data from 2012 indicate that Medicaid beneficiaries with asthma who were enrolled in the CCNC program had a 38 percent lower ED visit rate and a 65 percent lower inpatient admission rate than Medicaid beneficiaries who were not enrolled in the program.²⁶ Other quality metrics have also shown improvement. In 2011, 93.6 percent of CCNC patients with persistent asthma were prescribed a controller medication. This percentage increased to 97.2 percent in 2013. These percentages exceed the national 2012 Healthcare Effectiveness Data and Information Set (HEDIS) mean for Medicaid Managed Care Organizations of 83.9 percent and the HEDIS 90th percentile of 89.8 percent.

²⁵Tilson (2013).

²⁶<http://classic.ncmedicaljournal.com/wp-content/uploads/2013/09/74505.pdf>.

Lessons Learned and Next Steps

CCNC emphasizes the importance of quality improvement and is currently developing an asthma disease registry that will allow practices to better monitor patients with asthma by combining claims data with clinical data from electronic health records to form a comprehensive patient dashboard. CCNC also plans to use a grant from the Patient-Centered Outcomes Research Institute to disseminate an asthma shared decision-making tool kit that will guide providers as they educate patients about asthma and discuss treatment options.

Spotlight on Community Care of Wake and Johnston Counties

Since 2008, Community Care of Wake and Johnston Counties has leveraged CCNC's Asthma Disease Management Program to provide enhanced services through a home-based environmental trigger assessment and mitigation initiative. The initiative operates through a partnership with Wake County Environmental Services and Wake County Human Services. In addition to providing educational home visits by a nurse care manager, the program includes visits from a Registered Environmental Health Specialist who assesses triggers in the home such as dust mites, chemical irritants, pests, second-hand smoke, mold, and warm-blooded pets. Families then receive tailored education and support to mitigate the effects of identified triggers. The program also provides medication reconciliation services by a network pharmacist; written reports to families, primary care providers, and landlords (if necessary); and resources for renters' advocacy. Wake County Human Services provides funding to Wake County Environmental Services to cover the costs of 0.5 FTE of the Registered Environmental Health Specialist. CCNC covers remaining expenses.

All Wake County Medicaid and Healthchoice (CHIP)-covered patients with an asthma diagnosis are eligible for the program, which prioritizes people at high risk for poor asthma outcomes as determined by asthma literacy level, asthma control, medication compliance, ED visits, hospitalizations, and environmental triggers. Patients can be referred to the program by medical providers or identified based on real-time asthma-related hospital visit data or claims data analysis flagging high-risk patients.

The program has conducted over 600 environmental assessments, with the vast majority done for children. The program has demonstrated a cost savings of \$703 per person, which is largely attributed to decreased hospital visits. Specifically, the program led to a network-wide decrease in asthma ED visits from 40 to 17 per 1,000 member-months from 2003 to 2012. Hospital admission rates decreased from 8.3 to 1.9 hospitalizations per member-months in the same time period.*

*Results taken from www.ncmedicaljournal.com/wp-content/uploads/2013/08/74505.pdf.

State Case Study: Oregon

Program Overview

Healthy Homes of Multnomah County, Oregon, was established after a needs assessment conducted by Multnomah County Environmental Health revealed that asthma and a lack of healthy housing were two of the largest issues affecting the community. Healthy Homes works to address uncontrolled pediatric asthma by focusing on the medical, environmental, and social origins of asthma. Healthy Homes targets children who are either Medicaid eligible or at a comparable income level, and it accepts referrals from providers, families, and community partners such as community-based social service agencies; Head Start; schools; health programs such as the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and field nurses; and housing providers such as landlords. Healthy Homes prioritizes children with more serious cases of uncontrolled asthma, acknowledging that there is a greater need and impact among sicker patients.²⁷

Healthy Homes uses several community-based interventions:

- A nurse case manager and a community health worker (CHW) visit the home of a child an average of four times each over a six-month period, totaling an average of eight visits. The nurse case manager typically makes the first few visits to assess the family's situation and knowledge of the disease, review the

Healthy Homes of Multnomah County Fast Facts

Established: 2005

Location:

- 8 cities, including Portland, in the state's most populous county

Populations Served:

- Targets children under the age of 18 with uncontrolled asthma from low-income families (≤ 185 percent of the federal poverty level)
- 60 to 70 percent of families served are Hispanic
- Serve refugee and immigrant families
- Aim to serve 142 children per year

Medicaid Reimbursement:

- Targeted case management, billing \$716 per visit

Intervention Type:

- Community-based

²⁷Risk factors for children with poorly controlled asthma could include, but are not limited to, unscheduled visits for emergency or urgent care; one or more in-patient stays; a history of intubation or intensive care unit visits; a medication ratio of control medications to rescue medications of less than or equal to 0.33, indicating less than desirable control of asthma; environmental or psychosocial concerns raised by a medical home; school day loss greater than two school days per year; inability to participate in sports or other activities due to asthma; homelessness; or inadequate housing, heating, or sanitation (U.S. Department of Health and Human Services, Centers for Medicare & Medicaid Services, 2010b).

child's medical chart and pharmacy records, and provide necessary asthma education such as medication management.

- A CHW makes subsequent home visits to conduct an environmental assessment of all potential asthma triggers in the home and address any potential safety issues.
- Healthy Homes provides approximately \$330 worth of supplies per family, including vacuums, humidifiers, encasements, pulseoximeters, integrated pest management supplies, furniture, and green cleaning kits, and the CHW teaches families how to properly use them during the home visits. Supplies are dictated by the needs of the clients to meet their asthma action plan, and as a result may vary widely depending on the family.
- The nurse is responsible for maintaining communication with a child's school, medical care providers, and the hospital if need be, while both the nurse and the CHW are able to assist families with referrals to social services such as weatherization or relocation.²⁸

Healthy Homes aims to provide culturally and linguistically appropriate services to its patients. Most of Healthy Homes' staff is bilingual in Spanish, and they offer interpreters for other languages. In an effort to increase outreach and referrals for those in need, some of the CHWs at Healthy Homes work at community-based organizations located in disadvantaged neighborhoods.

Financing and Measurement

While originally funded entirely through grants, Healthy Homes began working with the deputy director of Oregon's Department of Medical Assistance Program (Medicaid) in 2009 to develop a more sustainable financing strategy through Medicaid reimbursement. A year later, Oregon's Medicaid State Plan Amendment (SPA) included Healthy Homes services as part of a new targeted case management (TCM) program for children meeting certain asthma or respiratory distress criteria.²⁹ Healthy Homes researched other existing TCM examples and identified key service components necessary for reimbursement (for example, assessment, care plan development, service linkage and coordination, monitoring/follow-up, and reassess-

²⁸Service referrals can also include medical and mental health, legal, tenant rights, home repair, and transportation services.

²⁹State plans are agreements between states and the federal government that detail how states administer their Medicaid and CHIP programs. Any changes to the state plan must be approved by the federal government through a SPA.

ment).³⁰ TCM covers approximately two-thirds of the Healthy Homes program costs, with the nurse educators and CHWs receiving reimbursement at the same rate. The remaining one-third of program costs are currently covered by Multnomah County General Fund dollars, which cover non-Medicaid-covered patients and costs not covered by Medicaid (such as the provision of supplies).

Healthy Homes staff use iPads to maintain patient charts and collect data such as environmental scores, emergency department visits, hospitalizations, medication ratios, and missed school and workdays both before and after patients complete the Healthy Homes program. During a previous grant period, Healthy Homes contracted with a principal investigator who determined the costs associated with the parental lost wages information for the data they'd collected. While collection of these data has helped to demonstrate the success of the Healthy Homes model, staff have expressed interest in assistance with future program evaluation. Healthy Homes has been able to collect some data from the state, while other types of data, such as medication ratio information, have been more challenging to collect. They have had more success in collecting data through the HMO/Oregon Health Plan provider and have received emergency room and hospitalization data six months before and after program participation from this source. Staff expect that future funding will be dependent on improvements in data collection and evaluation.

Program Results for 100 Children (2013)

- 39 percent decrease in emergency department visits
- \$1,281,377 saved in hospitalizations
- \$108,567 saved in emergency department visits
- \$97,600 saved in parental lost wages

SOURCE:
www.asthmacommunitynetwork.org/system/files/7-c-Harris-Tierney-Exisiting-Programs.pdf

Lessons Learned and Next Steps

While Healthy Homes is currently operating only in Multnomah County, staff are hopeful that it will expand to other parts of Oregon in the future. Oregon's SPA was written to allow two counties to receive TCM reimbursement, but since then Oregon has launched statewide Medicaid payment and delivery reform that provides a potential opportunity for spread. Medicaid providers are now organized within a network of community-based coordinated care organizations (CCOs) that provide coordinated, integrated, high-value care to beneficiaries. CCOs operate under a fixed global budget from the state that allows them flexibility to create alternative payment methodologies for providers and support community-specific transformation goals.³¹ Healthy Homes has recently partnered with local CCOs in Oregon to explore alternative fund-

³⁰Lyons-Eubanks (2010).

³¹National Academy for State Health Policy (2012).

ing for Healthy Homes services and to expand the model to other counties. Both Washington and Clackamas counties have adopted the Healthy Homes model with training from Multnomah County, and the three counties are joining together to work with Health Share of Oregon, one of their local CCOs. Staff at Healthy Homes acknowledge that the TCM reimbursement rate is subject to change as they begin working and possibly contracting with CCOs to provide program services to children with asthma.

State Case Study: Rhode Island

Program Overview

The Home Asthma Response Program (HARP) was established through the Rhode Island Department of Health's Asthma Control Plan. HARP is a partnership between Hasbro Children's Hospital and St. Joseph's Health Services' Clinic, and was launched in response to the need for sustainable, comprehensive care for vulnerable children with poorly controlled asthma. HARP operates out of Hasbro Children's Hospital in Providence, a city in which 37.3 percent of children live in poverty and where there is a high concentration of racial and ethnic minorities. The majority of children with an acute asthma exacerbation either visit the emergency department or are hospitalized at Hasbro, the only children's hospital in the state; HARP targets these children through record review and a telephonic screening process.³²

HARP's core components include the following community-based and clinic-based interventions following an emergency department (ED) visit or hospitalization.

Community-Based Interventions

- Each child receives three home visits. A certified asthma educator (AE-C) and a community health worker (CHW) perform the first home visit. Subsequent visits are conducted by a CHW.
- The first home visit includes a home assessment to evaluate potential asthma triggers and referrals to necessary community resources by the CHW, and asthma education from the AE-C. This includes information on medication use, trigger avoidance, and asthma management.

HARP Fast Facts

Established: 2010

Location:

- Providence, Pawtucket, and Central Falls, Rhode Island

Populations Served:

- Targets children ages 2 to 8 years who have had a recent emergency department visit or hospitalization for asthma
- 64 percent Hispanic; 12 percent African-American
- > 80 percent insured by Medicaid

Number of Children Served: 382 out of over 5,000 prescreened and over 1,500 deemed initially eligible

Funding:

- CDC and CMMI grants

Intervention Type:

- Clinic-based and community-based

³²Of the more than 1,500 children originally deemed eligible to participate in HARP, the families that did not participate either refused, were found ineligible after contact with HARP staff, or were not able to be contacted by HARP staff. Those who were found ineligible after contact with HARP staff had no asthma diagnosis, lived out of state, or were outside of the 2-to-8-year age range.

- During the second visit, a HARP CHW provides supplies such as HEPA-filter vacuums, hypoallergenic bed coverings, and asthma-friendly cleaning supplies to families, along with brief instructions on how to use the supplies.
- During the third visit, the CHW reviews the asthma management plan, reassesses any asthma triggers in the home, and follows up on any referrals to community resources.
- CHWs can make referrals to organizations for weatherization services, affordable housing, smoking cessation, counseling, mental health services for children or other family members, and adult education. CHWs can also make referrals to programs including the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC); Supplemental Nutrition Assistance Program (SNAP); or Breathe Easy at Home, a Rhode Island Department of Health program that allows health care providers to refer asthma patients to housing officials for home inspections.³³

Clinic-Based Interventions

- HARP asthma educators evaluate whether a family has an asthma action plan and reach out to a child's primary care physician (PCP) when a plan is not in place. (Only about 20 percent of families have an asthma action plan at the start of the HARP intervention.) Asthma educators will either work with the child's PCP to develop an updated asthma action plan or will have the child and family return to the PCP to create one. If a child does not have a PCP, HARP staff will help families link to one.
- After the third home visit, HARP staff will fax or mail reports to the child's PCP indicating which referrals were made through the program and what services were provided.

In order to address the significant racial and ethnic disparities that exist among asthma patients, the HARP program is currently offered to English- and Spanish-speaking families. HARP also has a diverse staff and requires cultural awareness training.

Financing and Measurement

From 2010 to 2014, HARP was financed through a Centers for Disease Control and Prevention (CDC) grant to the Rhode Island Department of Health for its Asthma Control Plan. Since

³³State of Rhode Island Department of Health (2016).

2012, HARP has also been financed through a Center for Medicare & Medicaid Innovation (CMMI) grant as part of the New England Asthma Innovations Collaborative (NEAIC), a partnership of five New England states working to promote sustainable financing models for the delivery of home-based care and education for uncontrolled pediatric asthma.³⁴ NEAIC has been an important venue for furthering this work, and HARP staff are in the process of presenting data on quality and outcomes to make the case for payers to reimburse the program.

HARP collects data on asthma patients and families in three ways. The first is a parent report of the symptoms. This baseline assessment can include information such as the presence of smokers in the family and home environmental characteristics. The second is an environmental assessment by a CHW during the home visit. The CHW walks through the family's home and observes and documents any changes to the home throughout the program. The third data source is claims data. All data are input electronically; the CHWs do an initial screening over the phone prior to the patient's first home visit and then use an iPad during home visits to document the remaining information.

All information is separated into two data sets based on HARP's two funding sources. The Department of Health has analyzed a year of pre- and post-intervention data and found promising results, as shown in the box at right. NEAIC data have not yet been fully analyzed, as the Collaborative is awaiting 12 months of data from all participating states. HARP staff believe that NEAIC data will be ready by summer 2016.

Department of Health Analysis of HARP Outcomes as of December 2012 (n = 68)

- ROI is \$2.52 for every \$1.00 spent on intervention for more severe patients (inpatient hospitalizations)
- \$1,046 saved in ED visits per child
- \$3,013 saved in hospitalizations per child
- Net savings of \$2,856 per child
- 2.5 more symptom-free days per month per child

SOURCE: Home Asthma Response Program (HARP); Elizabeth McQuaid, Aris Garro, Daphne Koinis-Mitchell, June Rourangeau, and the HARP team; August 25, 2014.

Lessons Learned and Next Steps

HARP staff consider their model to be very effective and recognize that home visiting is a particularly successful strategy for reaching the highest-risk families in urban communities who face multiple barriers to accessing care. HARP's recent increased collaboration with PCPs to coordinate referrals and to ensure that families have an asthma action plan has been a huge success; 80 percent of patients finish the HARP program with an asthma action plan.

³⁴Health Resources in Action (2014).

HARP has stopped enrolling children under the current grant, but staff are working to analyze data and make the case to payers to sustain the model. Acknowledging that health care payment and delivery systems are in the midst of change, staff are considering both short- and long-term approaches for extending HARP. These approaches include conversing with health plan staff to explore reimbursement for the current model and considering working with patient-centered medical homes as a possible longer-term strategy.³⁵ After securing sustainable funding, HARP staff hope to expand the model to other parts of the state and to include children who speak a language other than English.

³⁵The PCMH is a primary care model for delivering team-based and coordinated care. PCMH providers typically receive enhanced payments for high-quality care (Agency for Healthcare Research and Quality, n.d.).

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