

Healthy Homes University: A Home-Based Environmental Intervention and Education Program for Families with Pediatric Asthma in Michigan

THOMAS W. LARGO, MPH^a

MICHELE BORGIALLI, MPH,
MSW^a

COURTNEY L. WISINSKI, BS^a

ROBERT L. WAHL, DVM, MS^a

WESLEY F. PRIEM, BS^a

ABSTRACT

Environmental conditions within the home can exacerbate asthmatic children's symptoms. To improve health outcomes among this group, we implemented an in-home environmental public health program—Healthy Homes University—for low-income families in Lansing, Michigan, from 2005 to 2008. Families received four visits during a six-month intervention. Program staff assessed homes for asthma triggers and subsequently provided products and services to reduce exposures to cockroaches, dust mites, mold, tobacco smoke, and other triggers. We also provided asthma education that included identification of asthma triggers and instructions on specific behaviors to reduce exposures. Based on self-reported data collected from 243 caregivers at baseline and six months, the impact of asthma on these children was substantially reduced, and the proportion who sought acute unscheduled health care for their asthma decreased by more than 47%.

^aMichigan Department of Community Health, Division of Environmental Health, Lansing, MI

Address correspondence to: Michele Borgialli, MPH, MSW, Michigan Department of Community Health, Division of Environmental Health, Healthy Homes Section, P.O. Box 30195, Lansing, MI 48909; tel. 517-335-8948; fax 517-335-8800; e-mail <borgiallim@mi.gov>.

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Asthma prevalence, hospitalizations, and deaths have increased steadily among children over the past three decades, bringing this issue to the forefront of public health.¹⁻³ This article describes and evaluates an environmental public health program intended to decrease asthma symptoms in children through environmental trigger identification and reduction in the home, coupled with multiple, face-to-face education sessions with caregivers. The program was designed in response to a growing body of literature suggesting that the home environment is associated with asthma symptom exacerbation in children.⁴⁻⁶

Asthma is a chronic inflammatory respiratory disease that ranges in severity. Episodic acute symptoms can be induced by upper respiratory infections, exposure to environmental pollutants and allergens, exercise, emotional distress, and excitement. Environmental risk factors in the home that are known to affect childhood asthma symptoms include cockroach, dust mite, and animal-derived allergens; second-hand tobacco smoke; mold; chemicals (e.g., household cleaning products and pesticides); and combustion byproducts from wood or natural gas stoves.⁷⁻¹²

Some research studies have attempted to control for a single asthma trigger in the home environment with varying success on respiratory health outcomes.^{10,13-16} Current trends in program practice design that address multiple environmental triggers in the intervention strategies reveal promising and consistent findings. The most successful programs are those that have combined environmental interventions with face-to-face education over multiple home visits.^{7,17-21}

THE HEALTHY HOMES UNIVERSITY PROGRAM

Healthy Homes University (HHU) was a home-based environmental intervention and health promotion program whose target population was low-income families with asthmatic children residing in Ingham County, Michigan—home to Michigan State University. Household participation spanned six months from initial home assessment to completion, with four home education visits conducted within that time frame. HHU program objectives were to increase primary caregiver knowledge about asthma and its triggers, improve environmental conditions within the home, and reduce child asthma severity. The program was also designed to reduce unintentional injuries; however, this article focuses on the interventions and outcomes pertaining to asthma.

In 2005, the asthma hospitalization rate for children <18 years of age in Ingham County was significantly higher than the corresponding statewide rate (41.2

vs. 23.4 per 10,000). Among the Medicaid population in 2005, 7.2% of children living in Ingham County showed health-care usage consistent with persistent asthma, compared with the 5.3% estimate for the state (Personal communication, Elizabeth A. Wasilevich, Division of Genomics, Perinatal Health, and Chronic Disease Epidemiology, Michigan Department of Community Health, May 2010).

Demographic and housing data from the U.S. Census Bureau's Census 2000 showed that the at-risk population in Ingham County was concentrated in the city of Lansing. In 2000, the city population was 119,128 (22% black, 10% Hispanic). Twenty-four percent of Lansing's occupied housing stock was built before 1940, with renters in about one-third of these units. The city's median family income was \$28,550; less than one-third of these families made <\$14,275. According to the 2000 Comprehensive Housing Assessment Strategy Databook, 40% of renting households in Lansing had housing problems, defined as housing cost burden (affordability), overcrowding, an incomplete kitchen, or unfinished plumbing.

METHODS

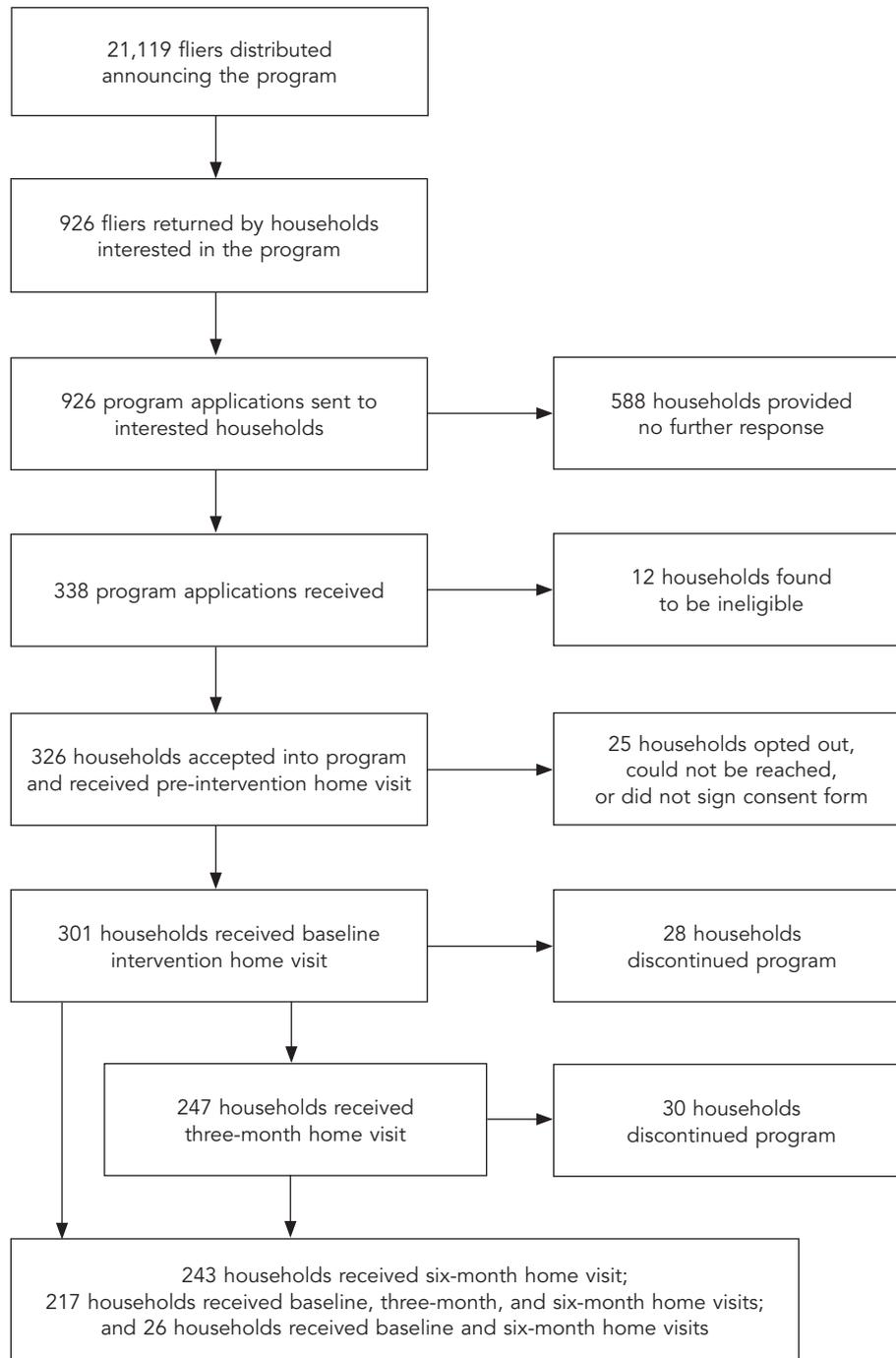
Selection of program participants

From November 2005 to March 2006, HHU staff visited neighborhood coalitions, schools, health-care providers, community organizations, and governmental agencies to market the program. We recruited households through interest fliers distributed through these venues and subsequently sent applications to interested households. A household was eligible if there was at least one resident child <18 years of age with caregiver-reported asthma and the household income was \leq 80% of the area's median income. Selection priority was based on a weighted and scored matrix of factors listed on the application, including age of housing, income status, single head of household, number of asthmatic children, asthma symptom severity, and the presence of environmental asthma triggers. The flow diagram in Figure 1 illustrates the number of participants and withdrawals at key stages throughout the program.

Interventions

We enrolled all participating households in a six-month basic intervention program, with a subset receiving custom interventions. Criteria for determining which households received custom interventions included condition of home, severity and number of residents in the home with asthma, household compliance with participation agreement, and availability of products. Households received an introductory pre-intervention

Figure 1. Recruitment and participant flow diagram illustrating number of participants and withdrawals at key stages throughout the program: HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008



HHU = Healthy Homes University

home visit, a baseline intervention home visit for health education and product installation, and three- and six-month post-intervention home visits. Figure 2 illustrates specific activities that occurred at various stages of the program. Before enrollment began, we acquired Michigan Department of Community Health Institutional Review Board clearance for human subject participation. Educational backgrounds of program field staff included degrees in biology, medical technology, and environmental science, with prior experience in clinical research, low-income housing, and environmental contaminant investigation. Additional program training entailed in-home assessment and asthma-trigger remediation, asthma management, survey techniques, and motivational speaking.

Pre-intervention home visit. Each qualified household received a one-hour introductory visit. Program staff targeted interventions and health outcomes for one subject child in each household. The purpose of the first visit was to (1) introduce HHU staff to household members, (2) discuss program expectations and timelines, (3) obtain informed consent and participation agreement, and (4) perform a visual assessment to

identify environmental asthma triggers and evaluate overall housing condition. Findings of the visual assessment determined which basic and custom intervention products we would provide to the household.

Baseline intervention home visit. Program staff conducted a three-hour baseline intervention home visit within two weeks of the introductory visit. We administered a survey, installed products, and provided asthma education to the subject child's primary caregiver.

The survey captured demographic information; family history of asthma; knowledge and presence of asthma triggers; home cleaning frequency; and the subject child's asthma symptoms, frequency of medical visits for asthma, and asthma medication usage. Staff designed the baseline questionnaire using the following nationally recognized assessment tools: the Centers for Disease Control and Prevention's Behavioral Risk Factor Surveillance System Child Asthma Call-Back Survey Questionnaire,²² the Seattle-King County Healthy Homes Project Bimonthly Interim Questionnaire,¹² and the ZAP Asthma Project Caregiver Asthma Knowledge Survey Instrument.²³

While the survey was being conducted, the basic intervention products (Figure 3) were installed. After these tasks were completed, staff took the caregiver on a walk-through of the home and provided tailored, one-on-one education based on caregiver responses to the survey. HHU staff demonstrated techniques (e.g., furnace filter replacement, cleaning, and vacuuming) to reduce asthma triggers. In addition, we gave caregivers a HHU Course Manual, which included asthma information and local resources.

Post-intervention follow-up home visits. Post-intervention follow-up visits were scheduled for three and six months after the baseline intervention home visit. Two HHU staffers were present at each two-hour home visit; one administered a survey similar to the baseline questionnaire. The staff reassessed the home for asthma triggers and determined if the intervention products provided at baseline were in use. Program staff also reinforced caregiver education based on their survey responses.

When custom intervention products (Figure 3) were allocated to a household, the staff provided them at three- or six-month follow-up visits to encourage continued program participation. Households in which all four home visits were completed received gift certificates and a program diploma.

Data analysis

We evaluated the program using survey responses provided by caregivers at the baseline and six-month visits to measure changes in each of the following

Figure 2. Program participation phases and activities: HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008

Phase	Activities
Pre-intervention home visit	<ul style="list-style-type: none"> • Complete informed consent and participation agreement. • Identify asthma triggers and safety hazards per visual assessment. • Determine basic and custom products and services for intervention.
Baseline intervention home visit	<ul style="list-style-type: none"> • Administer baseline household questionnaire. • Install basic products. • Educate on asthma-trigger reduction and injury prevention.
Three-month post-intervention home visit	<ul style="list-style-type: none"> • Assess intervention effectiveness (household questionnaire and visual assessment). • Install custom products and initiate custom services. • Repeat education on asthma-trigger reduction and injury prevention.
Six-month post-intervention home visit	<ul style="list-style-type: none"> • Assess intervention effectiveness (household questionnaire and visual assessment). • Repeat education on asthma-trigger reduction and injury prevention. • Provide program completion gift certificate and diploma.

HHU = Healthy Homes University

areas: (a) caregiver knowledge about asthma triggers, (b) frequency of various actions to reduce in-home asthma triggers, (c) environmental conditions within the home, (d) subject child's asthma severity, and (e) acute, unscheduled medical care sought for treatment of the child's asthma. We designated medical care utilization as "acute, unscheduled" to differentiate it from preventive, well-asthma medical care. In addition, we used visual assessment data collected by staff during the pre-intervention and six-month post-intervention visits to characterize key baseline home conditions and measure environmental changes. For the initial

95 home visits, these home conditions (e.g., presence of a bathroom fan) were ascertained via caregiver self-reporting. However, field staff noted discrepancies between what was observed and what was reported. Thus, for the remaining 148 participants, these environmental factors were based on staff visual assessment only. Our analyses of changes in home conditions were limited to these 148 households. We limited our analyses to households who completed the six-month program. To maximize study group size, we did not exclude households who did not receive a three-month visit. While there is a seasonality to asthma incidence,

Figure 3. Intervention products and services provided to participating households: HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008

<i>Asthma trigger-related</i>	
<i>Basic intervention products</i>	<i>Custom intervention products/services</i>
Caulk	Bathroom vent installation
Carbon monoxide detector	Beds and pillows
Trash can with lid	Clothes dryer vent repair
Door mat	Carpet removal
Fan	Dehumidifier
Foam crack sealant	Furniture slipcovers
Food containers with securing lids	Garbage removal
Furnace filters	Gutter replacement/repair
HEPA vacuum and replacement bags	HEPA air filter unit
Pest eradication gels and baits	House cleaning
Mildew-proof shower curtain	Landscaping for water drainage
Nontoxic cleaning supplies	Minor roof repair
Pillow and mattress covers	Plumbing repair
Smoking cessation kit	Pest extermination
	Stove vent installation
	Window air-conditioning unit
<i>Injury hazard-related</i>	
<i>Basic intervention products</i>	<i>Custom intervention products/services</i>
Carbon monoxide and smoke detectors	Outdoor child play area improvement
Cabinet safety locks	Dead bolt for entry door
Child safety gate	Electrical repair
Electrical outlet safety plugs	Window repair
Fire extinguisher	Stairwell repair
First aid kit	HVAC maintenance
Flashlights	Household hazardous-waste removal
Gun trigger locks	
Mercury-free thermometer	
Mini-blind cord wind-ups	
Night-lights	
Poison control sticker	
Skid-proof rug pads/rug gripper tape	
Skid-proof bathroom mat	
Step stool	

HHU = Healthy Homes University

HEPA = high-efficiency particulate air

HVAC = heating, ventilating, and air conditioning

we did not control for this potentially confounding factor because families were enrolled continuously during a 2½-year period.

We analyzed responses to survey questions pertaining to asthma knowledge, cleaning behavior, and asthma severity as continuous data. For these topics, we compared baseline and six-month means and tested for two-tailed statistical significance using the paired t-test. Data on whether subject children sought care at an emergency department, were hospitalized overnight, or had any other acute, unscheduled visit to a health-care provider for treatment of asthma were binary—either a child sought this care in the previous six months or did not. Similarly, environmental conditions either were present or not. We used McNemar's test to examine changes in the proportion of children requiring health-care visits for asthma and for the proportion of homes with environmental conditions relevant to asthma. Because our analyses involved paired data (e.g., caregiver responses at baseline and six months), a missing value at either baseline or six months necessitated excluding that data pair from analysis.

We used SAS® version 9.1.3²⁴ for statistical testing. Test results for which *p*-values were <0.05 were considered statistically significant.

RESULTS

We accepted 326 households for the intervention (Figure 1). Of the 301 households in which the baseline intervention home visit was completed, 243 (81%) completed the six-month program and comprised our study group. Table 1 characterizes the demographics of the 243 subject children and their households at baseline. Their median age was 7 years, and there were slightly more males than females. About 25% of the children were reported by their caregivers as multiracial, and 10% were reported as Hispanic. For one-quarter of the households, no other children lived in the home. Slightly more than half (56%) of the households rented their property. Median income was \$16,640, and 81% of the households were enrolled in Medicaid. The biological father did not reside within 87% of the households.

Fifty-eight households failed to complete the program because of relocation, eviction, foreclosure, or loss of contact with project staff. These 58 subject children had characteristics very similar to those seen in Table 1. The exception was that households of Hispanic children were much less likely to withdraw from the program.

Table 2 illustrates baseline intervention home conditions relevant to asthma exacerbation. Asthma triggers

associated with these conditions include mold, dust, dust mites, cockroaches, aerosol pesticides, rodent urine, and animal dander. High relative humidity provides the necessary moisture for many of these triggers. More than half of the households had experienced water damage in the previous year. In addition, many

Table 1. Characteristics of subject children, as reported by caregivers at baseline (n=243): HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008

Characteristic	N	Percent
Age (in years)		
0–4	85	35.0
5–11	109	44.9
12–17	49	20.2
Gender		
Male	134	55.1
Female	109	44.9
Race		
One race	166	68.3
White	67	27.6
African American	94	38.7
Other	5	2.1
Multiracial	63	25.9
Not reported	14	5.8
Hispanic	25	10.3
Health insurance		
Medicaid	197	81.1
Alone	123	50.6
In combination with other type	74	30.5
Parent's employer	31	12.8
Other	14	5.8
None	1	0.4
Number of other children living in home		
0	59	24.3
1–2	138	56.8
3–6	46	18.9
Room where subject child usually sleeps		
Own room	199	81.9
Parent's room	30	12.3
Other	14	5.8
Biological father does not live in home	212	87.2
Household occupancy status		
Homeowner	106	43.6
Renter	137	56.4
Annual household income		
<\$20,000	142	58.4
\$20,000–\$39,999	78	32.1
≥\$40,000	23	9.5
Caregiver education		
Did not graduate from high school	34	14.0
High school graduate; no college	72	29.6
At least some college	137	56.4

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Table 2. Characteristics commonly associated with the presence of asthma triggers in participating homes at baseline: HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008

Characteristic	N	Percent
Leak, flooding, or other water damage in the past year ^a	133	54.7
Aerosol pesticides (spray or bug bomb) used ^a	35	14.4
No working heating system ^a	10	4.1
Carpeting and rugs		
Family room has carpeting or rug ^b	110	74.3
Subject child's bedroom has wall-to-wall carpeting or area rugs ^b	122	82.4
Windows		
Family room has no windows that can open ^b	8	5.4
Kitchen has no windows that can open ^b	23	15.5
Primary bathroom ^c has neither a vent nor a window that can open ^b	12	8.1
Subject child's bedroom has no windows that can open ^b	8	5.4
Air-quality control		
Subject child's bedroom has neither central nor room air conditioning ^b	87	58.8
Subject child's bedroom has humidifier ^b	14	9.5

^aReported by all 243 caregivers

^bData for these characteristics were collected by HHU staff on the visual assessment form for 148 of the 243 homes. The original visual assessment form used for the first 95 households did not include these environmental characteristics but was revised for use on the remaining 148 homes.

^cBathroom in which the family normally showers or bathes

HHU = Healthy Homes University

rooms lacked the ability to ventilate humidity through a window or vent, and nearly one in 10 subject children had humidifiers in their bedrooms. Most homes had carpeting and/or rugs in the family room and the subject child's bedroom. Floor coverings are prime locations where children can be exposed to asthma triggers. The few homes without a working heating system presumably used an alternative heating source; many of these sources generate combustion by-products, which are also asthma triggers. Finally, air conditioning allows windows to remain closed during high-allergen seasons and filters the air. However, air conditioning was lacking in more than half of the subject children's bedrooms.

Caregiver knowledge of asthma triggers

Program staff asked caregivers 37 mostly true-false/agree-disagree questions that included identification of specific asthma triggers, appropriate ways to respond to asthma attacks, and effects of asthma on daily living

(Table 3). Overall, respondents answered an average of three more questions correctly at six months than at baseline, thereby improving their overall score from 82.5% to 90.5% ($p < 0.0001$). Scores improved for 83% of caregivers, while 10% showed no change, and 7% scored worse.

Caregivers' scores improved substantially at six months for many important topics, such as cockroaches (96.3% answered correctly) and birds (93.8%) as asthma triggers, inhaled steroids not having the same side effects as oral steroids (93.8%), and people with asthma knowing how well their lungs are working (88.6%). For several questions, however, the percent of caregivers responding correctly was low at six months. Less than half correctly indicated that asthma symptoms cannot be worsened by mosquitoes (49.0%), eggs (36.6%), and chocolate (46.1%), and that asthma episodes usually do not occur without warning (45.9%).

Home environmental conditions

During introductory and baseline assessments, staff ascertained, through caregiver reporting and staff visual observation, both the presence of particular risk factors for asthma exacerbation and the absence of products that could be used to reduce the subject child's exposure to triggers. Table 4 illustrates the percentage of households with each risk factor at baseline and six months.

Households demonstrated improvement for most of the risk factor measures. While there was no statistically significant change in the percentage of caregivers reporting the presence of household indoor pets, fewer reported allowing pets in the child's bedroom: 59.6% at baseline and 50.5% at six months ($p < 0.05$). Also, substantially fewer caregivers reported evidence of mold in the home: 58.2% vs. 38.9% ($p < 0.0001$). There was no measurable change in the reported evidence of cockroaches, but there was a decrease in the reported evidence of mice or rats: 19.8% vs. 12.8% ($p < 0.01$). Fewer households reported allowing stuffed toys in the child's bedroom: 68.3% vs. 48.3% ($p < 0.0001$). There was some reduction in reported exposure to tobacco smoke, either within the home (21.8% vs. 14.4%) or by anyone caring for the child (51.3% vs. 43.8%) ($p < 0.005$).

HHU staff visually observed that high-efficiency particulate air filters and pillow/mattress covers designed to control dust mites were generally absent in the subject children's bedrooms at baseline (absent for 98.6%, 97.9%, and 96.5%, respectively). These items were among the basic and custom products supplied or installed by HHU staff. Among the listed environmental changes, the greatest change from baseline

to six months occurred in the prevalence of pillow (absent for 9.9%) and mattress (absent for 15.6%) covers ($p < 0.0001$).

Home cleaning frequency

HHU staff encouraged caregivers to frequently perform a number of actions to improve and maintain the

Table 3. Questions used to measure asthma knowledge of the subject child's caregiver and percent of caregivers who answered correctly for each question at baseline and six months: HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008

Question ^a	Percent of caregivers who answered correctly		
	Baseline	Six months	Change
Smoking around a child with asthma may make them cough but it is not harmful.	93.0	97.5	4.5
Asthma symptoms can be made worse by:			
Dust	98.4	100.0	1.6
Cockroaches	62.8	96.3	33.5
Mosquitoes	25.5	49.0	23.5
Mold, mildew, or fungi	97.1	100.0	2.9
Tobacco smoke	99.2	99.6	0.4
Hard, crisp, or crunchy foods	65.0	86.8	21.8
Infections	93.0	99.2	6.2
Eggs	29.2	36.6	7.4
Exercise	97.1	98.8	1.7
Pet fish	66.1	84.7	18.6
Chocolate	45.3	46.1	0.8
Birds	74.5	93.8	19.3
Cats	95.5	100.0	4.5
Pollen	98.4	100.0	1.6
Air pollution	98.8	99.6	0.8
Emotional stress or excitement	92.6	97.9	5.3
Dogs	94.6	100.0	5.4
Watching television	87.7	91.8	4.1
Dust mites	95.9	98.4	2.5
Is asthma an acute or a chronic disease?	96.5	99.1	2.6
Asthma can make you feel bad even if not wheezing.	95.6	98.7	3.1
Asthma episodes usually occur without warning.	22.7	45.9	23.1
Not all asthma episodes need to be taken seriously.	96.9	99.6	2.6
Asthmatics only need to see doctor about asthma when having an attack.	97.4	98.7	1.3
People can die from having an asthma attack.	97.4	99.6	2.2
If someone takes asthma medication everyday, they do not have to stay away from things to which they are allergic.	98.3	100.0	1.7
It is best to wait and see if asthma symptoms go away on their own before taking "as needed" medications.	95.6	99.6	3.9
An inhaler will deliver a useful dose of medicine no matter how it is used.	85.6	95.6	10.0
A person with asthma can become addicted to their asthma medications.	52.0	71.6	19.6
People with asthma have no way to know how well their lungs are working.	68.1	88.6	20.5
During an asthma attack, it is hard to blow out air from the lungs.	93.0	97.8	4.8
Asthma cannot be cured, but it can be controlled.	96.1	96.9	0.9
People with asthma should not exercise.	99.1	99.6	0.4
There is nothing you can do to keep from getting an asthma attack.	79.5	90.0	10.5
Asthma is all psychological, that is, in people's heads.	99.6	99.6	0.0
Inhaled steroids have the same side effects as oral steroids.	73.1	93.8	20.7
Total	82.5	90.5	8.0

^aQuestions were true/false or agree/disagree except whether asthma was an acute or chronic disease.

HHU = Healthy Homes University

Table 4. Percent of participating households with environmental risk factors associated with asthma exacerbation at baseline and six months: HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008

Risk factor	N ^a	Percent of homes with factor			P-value
		Baseline	Six months	Change	
Per caregiver self-report					
Stuffed toys in child's bedroom	240	68.3	48.3	–20.0	<0.0001
Home has indoor feathered or furry pets	242	43.8	44.6	0.8	NS
Pets allowed in subject child's bedroom	99	59.6	50.5	–9.1	<0.05
Mold has been seen or a musty odor has been smelled in the subject child's bedroom (past 30 days)	241	8.7	5.4	–3.3	NS
Mold has been seen or a musty odor has been smelled in the rest of the home (past 30 days)	239	58.2	38.9	–19.3	<0.0001
Evidence of cockroaches inside the home (past 30 days)	243	7.0	5.8	–1.2	NS
Evidence of mice or rats inside the home (past 30 days)	242	19.8	12.8	–7.0	<0.01
Someone has smoked inside the home (past week)	243	21.8	14.4	–7.4	<0.005
Smoker among those who take care of the subject child	240	51.3	43.8	–7.5	<0.005
Per HHU staff visual assessment ^b					
No HEPA air filter ^c in subject child's bedroom	145	98.6	77.9	–20.7	<0.0001
Mattress cover for controlling dust mites ^c not used/available	141	96.5	15.6	–80.9	<0.0001
Pillow cover for controlling dust mites ^c not used/available	141	97.9	9.9	–88.0	<0.0001

^aNumber of valid baseline/six-month caregiver response or visual assessment pairs. If data for a caregiver response (or visual assessment) were missing, not applicable, or otherwise invalid for either baseline or six months, that pair was excluded from analysis.

^bVisual assessment data were collected for only 148 of the 243 homes. The original form used for the first 95 households did not capture environmental characteristics.

^cItems provided by HHU staff during the program

HHU = Healthy Homes University

NS = not statistically significant

HEPA = high-efficiency particulate air

hygiene of their homes. Table 5 lists the most relevant of these for minimizing asthma triggers.

At six months, caregivers reported that they had increased the frequency with which they performed each action. The increases were all statistically significant except for washing sheets and pillowcases. However, the degree to which they increased varied by the type of activity. They increased their dusting and washing of blankets and covers only slightly, but increased vacuuming by nearly once per month. Most notably, they nearly doubled the rate of vacuuming upholstered furniture. In addition, at six months, they reported washing their child's stuffed toys nearly once a month. The increase in the reported rate of changing their furnace filter was affected by HHU staff performing the task during the three- and six-month visits.

Subject child's asthma severity

Caregivers reported monthly frequencies for subject children experiencing negative health effects due to asthma (Table 6). For each of the listed indicators of asthma impact, the number of monthly occurrences

reported at six months was less than reported at baseline, and all improvements were statistically significant. The reductions ranged from 51% (wheezing first thing in the morning) to 71% (missed school due to asthma).

Unscheduled medical care for subject child's asthma

Caregivers were asked in baseline and six-month surveys if the subject child had visited an emergency department or been hospitalized overnight for asthma in the previous six months. They were subsequently asked if, besides these events, the child had seen a health-care provider for asthma in the past six months, in which the visit was unscheduled (i.e., not scheduled more than 24 hours in advance). Figure 4 illustrates caregiver responses for the three types of medical care queried. For each measure, the proportion of households who sought medical care for the child's asthma decreased substantially—48% for unscheduled visits to a health-care provider, 53% for emergency department visits, and 68% for hospitalizations. All three reductions were statistically significant ($p < 0.0001$).

Table 5. Changes in caregiver-reported frequency of actions to reduce in-home environmental asthma triggers from baseline to six months: HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008

Action	N ^a	Mean frequency ^b			P-value
		Baseline	Six months	Change	
Dusting the child's bedroom	241	2.7	3.1	0.4	<0.0001
Dusting the other rooms in the home	241	3.3	3.5	0.2	<0.05
Vacuuming the floor of the child's bedroom	234	3.1	4.0	0.9	<0.0001
Vacuuming the floors in the other rooms of the home	234	3.8	4.6	0.8	<0.0001
Vacuuming the upholstered furniture in the home	233	1.2	2.2	1.0	<0.0001
Washing the child's sheets and pillowcases	242	3.4	3.5	0.1	NS
Washing the blankets or covers on the child's bed	238	2.8	3.2	0.4	<0.0001
Washing the stuffed toys in the child's bedroom	109	0.5	0.8	0.3	<0.005
Changing the heating system filter	146	3.3	5.1	1.8	<0.0001

^aNumber of valid baseline/six-month caregiver response pairs. If data for a caregiver response were missing, not applicable, or otherwise invalid for either baseline or six months, that pair was excluded from analysis.

^bTimes per month, except for changing the heating system filter, for which frequency is times per year

HHU = Healthy Homes University

NS = not statistically significant

DISCUSSION

We found that families completing the HHU program had modest, yet statistically significant, improvements in asthma knowledge, self-reported cleaning habits, and in-home environmental conditions. Among asthma-knowledge gains, most noteworthy was that one-third of caregivers became aware that cockroaches are asthma triggers. The most notable gain in self-reported cleaning habits pertained to the frequency of vacuuming, especially upholstered furniture. The most impressive environmental improvement was the increase in the percentage of households in which the subject child was using pillow and mattress covers designed to control

dust mites. These items were provided by the program and required minimal behavior change by families.

Consistent with the changes described above, there were statistically significant caregiver-reported reductions in pediatric asthma severity. The number of days that subject children were negatively impacted by their asthma decreased at least 50% by all of our measures. Thus, not only were children experiencing symptoms less frequently, but also their asthma was impacting them less, specifically with missed school days and reduced physical activity. In addition, the percentage of households seeking medical care for their child's asthma substantially decreased for each of our three measures: emergency department visits,

Table 6. Changes in caregiver reports of subject child's asthma severity from baseline to six months: HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008

Impact of subject child's asthma	N ^a	Mean frequency ^b			P-value
		Baseline	Six months	Change	
Had wheezing first thing in the morning	227	6.2	3.1	−3.1	<0.0001
Woke up because of wheezing, tightness in chest, or a cough	231	8.7	3.3	−5.4	<0.0001
Had shortness of breath because of asthma	230	9.4	3.4	−6.0	<0.0001
Had wheezing, tightness in the chest, or cough	236	12.0	4.9	−7.1	<0.0001
Had to slow down or stop play or activities because of asthma, wheezing, tightness in chest, or cough	236	9.1	3.3	−5.8	<0.0001
Missed preschool or school because of asthma	141	1.9	0.5	−1.4	<0.0001

^aNumber of valid baseline/six-month caregiver response pairs. If data for a caregiver response were missing, not applicable, or otherwise invalid for either baseline or six months, that pair was excluded from analysis.

^bWithin the past 30 days

HHU = Healthy Homes University

hospitalizations, and all other acute, unscheduled medical visits. When viewed in conjunction with the fairly modest improvements in knowledge, cleaning behavior, and home environments, these reductions were striking.

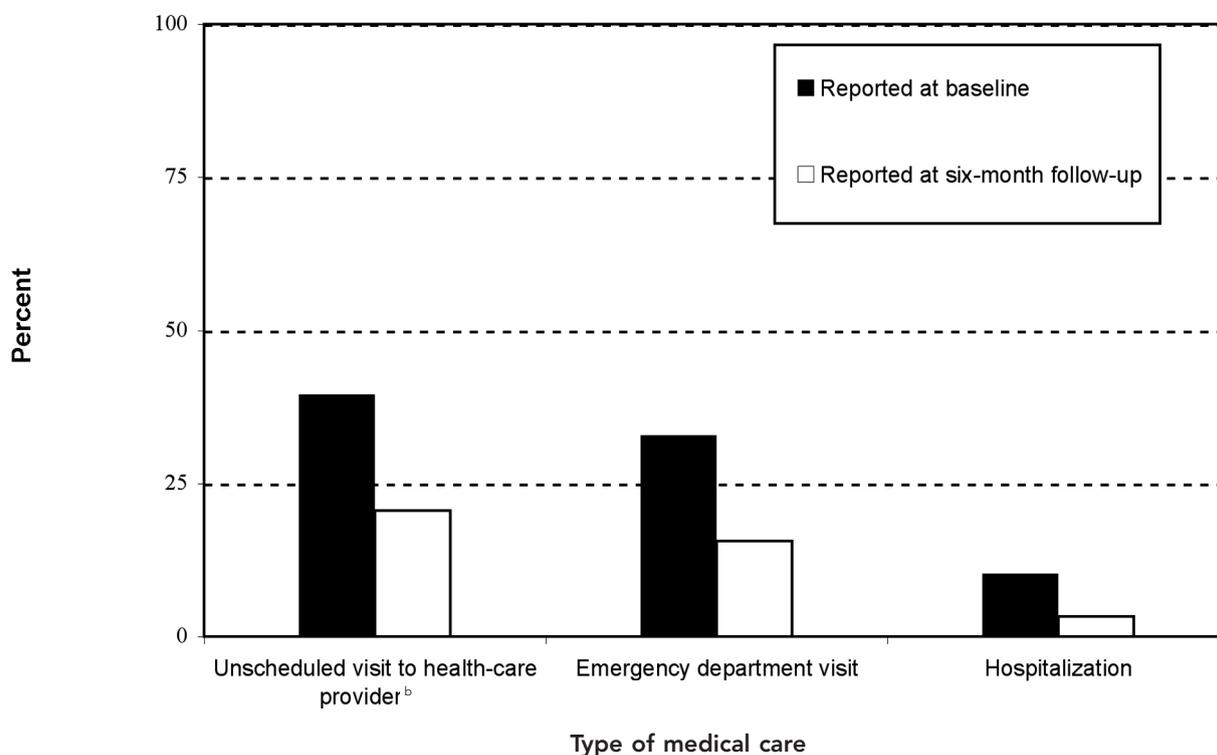
Previous studies have demonstrated that effective healthy homes intervention programs require multiple home visits.^{7,17–21} We designed our program on this premise, and staff made four in-home visits with most of the participating households. One key to program success that studies have cited is the effectiveness of outreach workers. This is important because they are the connection between the program design and human subjects. Specific characteristics that are vital to outreach worker effectiveness include empathy, subject matter expertise, and persistence. While we did not gather quantitative data evaluating our staff, one indication of their effectiveness in gaining participant trust and buy-in is that 81% of families who received the baseline visit remained in the program for the

full six months. The provision of valuable products also may have contributed to the high participant retention rate.

Healthy People 2010 is a national health-promotion and disease-prevention initiative²⁵ that includes environmental health objectives pertaining to healthy homes and healthy community issues. HHU addressed three of these national objectives:

- To reduce indoor allergen levels—HHU home visits provided asthma-trigger reduction products to households and educated caregivers on ways they could reduce indoor allergens.
- To reduce the proportion of housing units that are substandard—HHU staff corrected physical housing problems including water leaks, electrical deficiencies, pest infestations, inoperable heating equipment, cracks and holes, hand rails, and peeling lead-based paint.
- To reduce the population's exposure to pesticides—

Figure 4. Percentage of households that sought unscheduled health care for the child's asthma within the past six months, as reported by caregivers at baseline and six months, by type of medical care received (n=243 for each type): HHU pediatric asthma intervention program, Lansing, Michigan, 2005–2008^a



^aReductions were statistically significant ($p < 0.0001$) for each medical care type.

^bExcluded from this category were emergency department visits and hospitalizations. These were considered "unscheduled" visits because they were not scheduled more than 24 hours in advance.

HHU = Healthy Homes University

HHU staff educated households about integrated pest-management techniques and provided them with traps, baits, food containers, and trash cans.

Program costs

The following costs pertain to the products and services provided for asthma and injury prevention efforts implemented within the comprehensive program. The mean cost for the basic products provided for all households at the baseline visit was \$387. Twelve percent of the households received a custom service, with a mean cost of \$2,647 per household. Staffing and travel costs associated with a home visit were \$230, and administrative office function costs were \$1,055 per household.

Limitations

Our program had several limitations. Some of these could have affected our findings, while others inhibit our ability to attribute the apparent health improvement to our intervention.

The reduction in asthma severity may have been artificially inflated due to reporting bias. Caregivers could have overstated asthma severity at baseline to justify program inclusion and understated it at completion to provide “desirable” results. Improvements in cleaning habits, likewise, may have been the result of reporting bias. Because HHU staff had stressed good home hygiene, caregivers may have embellished their cleaning habits at program completion to avoid the embarrassment of not meeting perceived expectations.

Our program did not utilize a control group. In this case, an appropriate control group would have been a set of households similar to our intervention group at baseline in terms of housing conditions, child asthma severity, and availability of a local asthma coalition. Use of a control group against which to compare intervention group results is crucial because factors other than our intervention could have influenced outcomes. Without a control group, we cannot estimate the effect our program alone had on reducing asthma severity.

We did not design the program for the purpose of generalizing results to a larger population. Such a design would have required recruiting households using probability sampling methods. The 243 families evaluated here were motivated to alleviate childhood asthma, as evidenced by their self-selection into the program and their diligence to participate through the entire six months. However, our findings may be indicative of results that other similarly designed programs could have when working with motivated families.

We did not collect data on all of the factors that could have contributed to the observed reduction in

asthma severity. The National Heart, Lung, and Blood Institute—National Asthma Education and Prevention Program’s “Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma”²⁶ cites that, in addition to reducing exposure to environmental asthma triggers, the following are key to the long-term control of asthma: providing optimal pharmacotherapy, ensuring proper use of asthma medications, having children maintain normal activity levels, and maintaining effective communications between patients and their health-care providers.

Finally, we have no information on the impact of our program beyond six months, either in terms of pediatric asthma severity or improvements to the home environment. Changes in caregiver behavior may have been temporary and due to the Hawthorne effect. That is, they may have modified their behavior simply in response to the fact that they were being studied.

Current status—Healthy Homes University II

In 2008, the Michigan Department of Community Health received grant funding to continue HHU through 2011. For this second version (HHU II), several changes were made to improve the program, including redesigning the questionnaire; modifying the basic products provided; offering environmental sampling and additional products as incentives for program compliance; performing environmental sampling for dust mite, cockroach, and mouse urine allergens; requiring an asthma action plan and scheduled well-asthma doctor visits to promote proper medication usage; utilizing Medicaid claims data, rather than self-reporting, to identify health outcomes; and comparing outcomes to a control group to evaluate effectiveness.

CONCLUSIONS

Improving the health of a child with asthma requires a multifaceted strategy that addresses the physical home environment, health-care utilization, medication adherence, and other extrinsic factors (e.g., health behaviors and caregiver involvement). Through education with multiple in-home visits by trained staff, families can gain knowledge about asthma triggers, effective methods for improving their home environment to minimize these triggers, how to most effectively utilize the health-care system, and the importance of appropriate use of effective medication.

In the HHU program, we conducted multiple home visits and had very good participant retention rates, thanks to dedicated, persistent, and empathetic staff. We found that caregivers increased their awareness of important asthma topics and reported greater

frequency of trigger-reducing behaviors. The program assisted families in improving home environments by providing and directly installing certain products. Program staff did not measure changes in the use of appropriate asthma medications or regular well-asthma doctor visits, but are doing so for HHU II.

While we found statistically significant reductions in asthma severity, we cannot attribute these outcomes solely to our intervention because of the reliance on self-reported data and the lack of a control group to which we could compare outcomes. Overall, the HHU program is a promising model for reducing pediatric asthma severity among motivated families.

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