

Removing asthma triggers and improving children's health: The Asthma Partnership Demonstration project

By: [Kenneth J. Gruber](#), Beth McKee-Huger, April Richard, Brett Byerly, Jana L. Raczkowski, Thomas C. Wall

Gruber, K. J., McKee-Huger, B., Richard, A., Byerly, B., Raczkowski, J. L., & Wall, T. C. (2016). Removing asthma triggers and improving children's health: The Asthma Partnership Demonstration project. *Annals of Allergy, Asthma & Immunology*, 116(5), 408-414.

Made available courtesy of Elsevier: <http://dx.doi.org/10.1016/j.anai.2016.03.025>

***© American College of Allergy, Asthma & Immunology. Reprinted with permission. No further reproduction is authorized without written permission from Elsevier. This version of the document is not the version of record. Figures and/or pictures may be missing from this format of the document. ***



This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](#).

Abstract:

Background

Studies have revealed the efficacy of home-based environmental interventions on reduction of asthma symptoms as a strategy for managing asthma in children. A focus on education and behavior change alone is generally too limited to reduce exposure to asthma triggers that exist because of adverse housing conditions.

Objective

To demonstrate that housing conditions as a focus of a health intervention should be considered more widely as an effective means of addressing serious health problems such as asthma.

Methods

Residences of 41 families of children identified with some of the highest rates of asthma-related hospital visits were assessed for the presence of asthma triggers.

Results

The intervention had a positive effect on lessening the effect of the child's asthma on the family's lives and activities. Reductions in frequency of negative effects of children's asthma on sleeping, job or work around the house, and family activity plans, fewer worries or concerns about children getting enough sleep and performing normal daily activities, and fewer adverse effects of children's asthma medications were reported. Reduced use of asthma medication, medication applications, and health visits were noted. Households with return visits had 50% lower hospital bills for childhood asthma treatment.

Conclusion

Home environment conditions that lead to or exacerbate asthma may be reduced or eliminated by making minor repairs and introducing reasonable cleaning regimens that address sources of asthma triggers. This can produce greater awareness on the part of families about the presence of asthma triggers and motivate future action to address the conditions associated with these triggers.

Keywords: asthma | children | environmental triggers | health | housing conditions

Article:

Introduction

Asthma is the leading chronic illness of childhood^{1,2} and an increasingly prevalent disease that disproportionately affects low-income children.³ According to the Centers for Disease Control and Prevention,³ an estimated 10.5 million (14.0%) of children in the United States have been diagnosed as having asthma. Asthma develops through the interaction of genetic factors with environmental exposures. Numerous studies have linked the prevalence of asthma attacks and other asthma symptoms to a range of indoor (dust mites, mold, rodents, pets, scents, tobacco smoke, chemical particulate matter) and outdoor (pollen, pollution) allergens, as well as food, medicine, exercise, changes in seasons, and weather.⁴⁻⁸

Many children at risk for asthma are from low-income or minority families. Concurrently, a large percentage of low-income and minority families in the United States live in substandard housing. Most studies that report on the home environment of children with asthma note the homes often have conditions, such as plumbing or roof leaks, inadequate ventilation, faulty or inoperative exhaust systems, unclean floors and other surfaces, presence of rodents or cockroaches, or building structure issues, that promote the presence of asthma triggers.⁹⁻¹⁴

Given the important role allergens play in producing asthma inequities, decreasing them has emerged as a major goal.⁷ Studies have revealed the efficacy of home-based environmental interventions on reduction of asthma symptoms and as a strategy for managing asthma in children.^{10,11,13,15,16} In recent years, home-based education and support have emerged as an effective strategy for reducing indoor asthma triggers, improving medical aspects of asthma management, lowering psychosocial stress, and improving asthma-related health outcomes.¹² However, a focus on education and behavior change is generally too limited in its ability to reduce exposure to asthma triggers that exist because of adverse housing conditions. Therefore, a more effective strategy is to also address substandard housing conditions that affect or are related to asthma.⁷

An increasing number of studies have found that interventions that decrease home environment asthma triggers are producing substantial reductions in health expenditures.^{8,17,18} These savings are due to fewer hospitalizations, emergency visits, and physician visits, resulting from lower occurrences of asthma attacks and reductions in severity of attack symptoms. They also are manifesting in lower expenses by families paying for fewer medicines and other health care aides typically associated with controlling or treating an asthma event.

The purpose of this study was 2-fold: (1) to contribute to the increasing evidence that physical and educational interventions targeted toward remediating home environment asthma triggers can result in lower incidence of asthma events, asthma reactions, and asthma-related health costs and (2) to demonstrate that housing conditions as a focus of a health intervention should be considered more widely as an effective means of identifying conditions that contribute to a serious health problem, reducing or controlling conditions that are known causal factors of that health problem, and reducing health costs in a practical way.

Methods

Participant Selection and Recruitment

Eligibility for participation in the study was limited to cases with children (aged 2-18 years) who had been hospitalized with an asthma diagnosis or had been to the emergency department at least twice and received an asthma diagnosis in the previous 12 months. Table 1 presents a breakdown of the number of cases that met the study inclusion criterion of hospital visits for asthma-related symptoms. There were initially 482 cases, but only 288 were identified for possible participation because of missing or outdated contact information on file for the patients. Qualifying families were given a description of the study and if interested were scheduled for the initial visit. As an incentive to participate, the families were informed that they would receive a \$50 gift card at the time of the home visit. A total of 60 cases initially agreed to participate, but 18 (30.0%) changed their mind or were unresponsive to attempts made by project staff to schedule assessments (Table 1). Families (n = 42) who agreed to participate were informed that their participation would include completing a survey about asthma and their child's triggers and information about their home and a visual assessment. Their agreement also included completing an informed consent form as part of institutional review board approval of the study by the local hospital. One family was dropped from the study after determining the home was not the child's usual residence, resulting in a final sample of 41.

Table 1. Case Population, Sampling, and Recruitment Results

Variable	No. (%) of children
All cases with children aged 2e18 years seen in the ED (≥ 2 visits) or hospitalized with an asthma diagnosis in 2012e2013 (December-November)	482
Children hospitalized with an asthma diagnosis	118 (24.5)
Cases with ED visits (≥ 2) relating to asthma	364 (75.5)
Cases in initial contact pool	288
Refused to participate	32 (11.1)
Child not in home	8 (2.8)
Could not contact	188 (65.3)
Referred to GHC for study recruitment	60 (20.8)
Cases in initial sample pool	60
Refused or could not contact	18 (30.0)
Contacted for interview	42 (70.0)

Abbreviations: ED, emergency department; GHC, Greensboro Housing Coalition.

Table 2 presents the demographics of the sample at initial and follow-up study contact. For the initial full sample, approximately three-fifths of the children were male and approximately 8 years of age. A little less than a fourth of the families lived in public or Section 8 housing. Nearly 90.0% of the children were covered by Medicaid.

Table 2. Sample Demographics^a

Demographic	Initial sample (n = 41)	Matched initial follow-up sample (n = 28)	
		At study entry	At follow-up
Age, mean (median) [range], y		7.9 (7.2) [2.9-15.2]	8.4 (7.7) [3.5-15.6]
Males	25 (61.0)	18 (64.3)	18 (64.3)
Females	16 (39.0)	10 (35.7)	10 (35.7)
Medicaid	36 (87.8)	24 (85.7)	23 (82.1)
Private	4 (9.8)	3 (10.7)	4 (14.3)
Not reported	1 (2.4)	1 (3.6)	1 (3.6)
Public housing	4 (9.8)	3 (10.7)	3 (10.7)
Section 8 housing	5 (12.2)	2 (7.1)	2 (7.1)
Any housing subsidy	9 (22.0)	5 (17.9)	5 (17.9)
Mother	37 (90.2)	25 (89.3)	26 (92.9)
Father	3 (7.3)	2 (7.1)	1 (3.6)
Grandmother	1 (2.4)	1 (3.6)	1 (3.6)

^aData are presented as number (percentage) unless otherwise indicated.

Intervention and Remediation

Because the objective was to reduce the presence of asthma triggers, the study targeted several lines of intervention and remediation: (1) education, (2) products, and (3) repairs. The study interventions were based on the Healthy Home Rating System (US Department of Housing and Urban Development),²⁰ which is a tool that allows assessors to determine the level of severity and potential risk of harm to occupants of the home being assessed. Project staff modified the use of the output of the analysis of the tool to focus primarily on the hazards and conditions of the home that were most likely to trigger asthma.

Housing Conditions Assessment

As part of the initial visit, a comprehensive visual assessment of the residence was conducted. On the basis of the findings of this assessment, families were offered repairs, products, and education about conditions in their homes that related to the presence of asthma triggers. Homeowners had the option to accept products, assistance, and repairs. Renters had the option to allow project personnel to discuss recommended repairs (and cost sharing) with their landlords. Sometimes changes to the home (pest management, roof repairs, ventilation, carpet removal) required property owners to pay part of the repair cost.

Educational Intervention

During the initial home visit, project staff provided education about the potential asthma triggers identified in the assessment process. This involved a discussion of the potential asthma trigger issues; the most common topics discussed were air filter changes, ventilation issues, pest infestations, and mold or moisture issues. Each household was provided with a green cleaning kit, which was composed of a microfiber mop, bucket, spray bottles, microfiber cloths, distilled white vinegar, baking soda, peroxide, Simple Green All-Purpose Cleaner, and Murphy's Oil Soap. The kits also contained a recipe sheet that provided instructions on how to mix the products to clean certain areas in the home.

Repair and Improvement Assessment

Issues for repair, replacement, or installation were prioritized for each residence based on assessment and potential effects of issue on asthmatic child. Mold or moisture and pest infestations problems were given highest priority. The next set of priority issues involved installing or repairing dryer ventilation, repairing heating, ventilation, and air conditioning (HVAC) ducts, installing vapor barriers, and/or installing or repairing ventilation systems in bathrooms and kitchens. A third level of priority ranking was given to replacing or removing carpeting from the sleeping area of the asthmatic child. Residences that did not require repairs or other installation-related interventions to address sources of asthma triggers were provided with high-efficiency particulate air (HEPA) vacuum cleaners, allergen barrier pillow and mattress covers, HVAC filters, and window-mounted air conditioning units where appropriate. Repairs and installations (ie, kitchen and bathroom fans) were made using local contractors, local maintenance professionals, a company that specialized in energy efficient and ventilation repairs, pest control companies, and heating and air companies. The maximum limit for repair costs per household was \$5,000.

Follow-up Contacts

Follow-up visits were scheduled approximately 90 days after the date of the initial visit (if an assessment was made that no repairs or other intervention action by project staff was needed) or 90 days from the completion of the planned repair or intervention.

Statistical Analysis

Comparison of frequencies by group were tested for statistical differences using χ^2 tests. Mean comparisons were tested using t test analyses. Level of significance was set at $P < .05$.

Results

Possible Triggers That Affect Child's Asthma

Table 3 presents the families' report of their belief of an association of their child's asthma attacks with a listing of commonly known asthma triggers. The triggers are coded in terms of representing outside the home (outside environment), inside the home (inside home environment), activities of the residents of the home not housing related (resident behavior), and child activities (child specific). The most frequently reported perceived trigger sources of the children's asthma were not home related (pollen, tobacco smoke, children's physical activity);

the most frequently reported home related possible trigger sources were dust and mold (both reported by >50% of the sample). For the matched initial follow-up sample data, the results were similar to those of the initial full sample. Results at follow-up revealed an increase in general knowledge and identification of inside home environment asthma triggers (dust, dust mites, and mold) and resident behavior (cooking odors).

Table 3. Possible Triggers That Affect Child’s Asthma by Parent Report

Asthma trigger	No. (%) identified as triggers		Trigger source	
	Full initial sample (n = 41)	Matched initial follow-up sample (n = 28)		
		Initial assessment	Follow-up assessment	
Exercise	29 (70.7)	20 (71.4)	19 (70.4)	Child specific
Food	16 (39.0)	9 (32.1)	8 (29.6)	Child specific
Medications	6 (14.6)	5 (17.9)	4 (14.8)	Child specific
Dust	26 (63.4)	14 (50.0)	19 (70.4)	Inside home environment
Mold	25 (61.0)	14 (50.0)	16 (59.3)	Inside home environment
Dust mites	19 (46.3)	11 (39.3)	13 (48.1)	Inside home environment
Pets	15 (36.6)	10 (35.7)	8 (29.6)	Inside home environment
Roaches	12 (29.3)	7 (25.0)	7 (25.9)	Inside home environment
Paint	10 (24.4)	6 (21.4)	3 (11.1)	Inside home environment
Pollen	38 (92.7)	26 (92.9)	25 (92.6)	Outside environment
Cold air	22 (53.7)	12 (42.9)	18 (66.7)	Outside environment
Pollution	25 (61.0)	16 (57.1)	9 (33.3)	Outside environment
Tobacco smoke	30 (73.2)	19 (67.9)	19 (70.4)	Resident behavior
Scents	20 (48.8)	13 (46.4)	10 (37.0)	Resident behavior
Cooking odors	6 (14.6)	4 (14.3)	6 (22.2)	Resident behavior

Effect of Asthma on the Family

Data representing the effect of the child’s asthma on the routines of the parents and other family members are presented in Table 4. The ratings were made on a 5-point scale; lower ratings were

associated with perceived effect to be less frequent. The results indicate the 5 areas of family functioning most affected were (1) respondent's sleep, (2) interference with job or work around the house, (3) family needing to change plans because of the child's asthma, and (4) being stressed in response to child's asthma symptoms. At follow-up, only 1 item received a moderately high frequency rating (mean, 3.0) relating to the parent's sleep. All but 2 items, frustration or irritability in response to the child's asthma and child's asthma interfering with the family's relationships, were found to have significant decreases in frequency of occurrence. The change in the rating of the item reflecting the need of the family to change plans was significantly lower at follow-up.

Table 4. Effect of Asthma on the Family^a

Frequency of being an issue in past 30 days	Full initial sample			Matched initial follow-up sample				
	No. of respondents	Mean rating	Those reporting most or all of the time, % ^b	No. of respondents	Mean rating		Those reporting most or all of the time, % ^b	
					Initial	Follow-up	Initial	Follow-up
You experienced trouble sleeping because of your child's asthma?	38	3.50	39.0	21	3.43	3.00	46.4	25.0
Your child's asthma interfered with your job or work around the house?	38	3.21	29.3	21	3.00	2.52	32.1	25.0
Family needed to change plans because your child was irritable due to asthma?	38	3.21	31.7	20	3.35	2.15 ^c	32.1	7.1
You were upset because of your child's cough,	38	3.13	29.3	21	3.05	2.71	32.1	25.0

wheeze, or breathlessness?								
Felt frustrated or impatient because your child was irritable due to asthma?	37	2.73	17.1	18	2.83	2.78	17.9	25.0
Felt helpless or frightened when your child experienced coughing, wheezing or breathlessness?	38	2.71	29.3	21	2.90	2.52	28.6	17.9
Your child's asthma interfered with family relationships?	37	1.86	9.8	20	1.80	1.80	7.1	0.0

^aMean rating was determined on a 5-point scale, with 1 indicating none of the time and 5 indicating all the time. ^bLower ratings associated with effect perceived to be less frequent. ^cP < .05.

Effect of Asthma on the Child

Ratings of parents' level of worry or concern about their child's asthma are presented in Table 5. Ratings were made on a 5-point scale from 1 (not worried or concerned) to 5 (very worried or concerned); lower ratings were associated with perceived effect being less concerning or worrisome. For the matched initial-follow-up sample, there was a marked reduction in rating level for 4 of the 5 items. Only the ratings for the question asking about their child being able to lead a normal life were not substantially different between initial and follow-up data collection. Ratings for the question relating to their worry or concern of child's performance of normal daily activities decreased significantly from initial visit to follow-up. Less than 20% of families reported no worries or concerns regarding their child (1) getting enough sleep, (2) performing normal daily activities, and (3) having to be focused on their child's medications and possible adverse effects of those medications.

Table 5. Effect of Asthma on the Child

Worried or concerned about in past 30 days	Full initial sample	Matched initial follow-up sample		
		No. of respondents	Mean rating ^a	Those reporting concerned or worried

	No. of respondents	Mean rating ^a	Those reporting concerned or worried or very concerned or worried, % ^b				or very concerned or worried, % ^b	
					Initial	Follow-up	Initial	Follow-up
About your child being able to lead a normal life?	38	2.95	29.3	25	2.68	2.60	32.1	32.1
About your child getting enough sleep?	38	2.92	34.2	25	2.84	2.00	32.1	17.9
About your child's performance of normal daily activities?	38	2.92	26.8	25	2.80	1.88 ^c	28.6	17.9
About being overprotective of your child?	38	2.84	31.7	25	2.80	2.28	35.7	25.0
About your child's asthma medications and adverse effects?	38	2.68	31.7	25	2.52	2.04	28.6	14.3

^aMean rating was determined on a 5-point scale, with 1 indicating not worried or concerned - and 5 indicating very worried or concerned. ^bLower ratings associated with perceived effect being less concerning or worrisome. ^cP < .05.

Asthma Medicine Use, Symptom Improvement, and Medical Visits Related to Asthma

Table 6 presents data on asthma control and physician medical visits due to the child's asthma. Examination of the matched sample results indicates reduced use of asthma medication, medication applications, and health visits after the intervention. In the case of the number of times rescue medicine was used in the past 14 days, the change in mean use from follow-up from initial report was significantly lower.

Repairs and Service Costs

Table 7 lists the number and cost of repairs and other expenditures. The most frequent expenditures were for cleaning kits and supplies (n = 41 homes), sleep protection (n = 21 homes), and HVAC repair (n = 10 homes). The most costly expenditures were for removing carpet and installing hard floors, HVAC repair, ventilation repairs (air flow), and cleaning

supplies, including HEPA filters and vacuum cleaners. Slightly less than one-fourth of the homes in the study received assistance to treat, repair, or replace items or conditions that were likely sources of asthma triggers (eg, moisture, mold, pests). In most cases, bathrooms and kitchens were the rooms that needed repair (moisture issues) or item installation or replacement (kitchen and bathroom fans).

Table 6. Asthma Medicine Use, Symptom Improvement, and Medical Visits Related to Asthma^a

Variable	Full initial sample			Matched initial follow-up sample			
	No.	Maximum	Mean	No.	Initial mean	Follow-up mean	Maximum
Asthma symptoms in past 14 days	41	14	4.90	28	4.50	3.36	14
Asthma symptoms in daytime past 14 days	41	14	4.24	28	3.82	2.57	14
Asthma symptoms in nighttime past 14 days	41	14	3.90	28	3.54	2.29	14
No. of times refilled inhaler in past year	39	12	3.18	27	3.19	3.33	12
No. of times per week uses inhaler	36	56	5.50	24	5.96	2.96	56
No. of times use rescue medicine past 14 days	40	20	5.08	27	5.26	2.89 ^b	14
No. of times use controller medicine past 14 days	36	14	10.86	24	11.63	11.38	14
No. of times had an asthma attack in past 3 months	41	60	4.41	28	2.86	1.18	60
No. of times had an asthma attack in past year	40	240	15.95	27	11.57	6.68	15

No. of nonemergency visits to physician for asthma issues	40	20	4.25	27	4.07	2.96	52
No. of nonemergency visits to physician for asthma attacks	40	20	3.13	26	2.84	1.52	14

^aLower values associated with lower use. ^bP < .05.

Table 7. Service Costs

Service	No. of homes ^a	Costs, US\$
Air flow	5	3,885
HVAC	10	4,263
Mold control	5	1,165
Plumbing repairs	3	460
Carpet and floors	4	4,619
Pest management	8	2,629
Organization	7	750
Sleep protection	21	1,021
Cleaning kits and supplies	41	3,831
Total charges		22,623
Range of costs	30	4,997

Abbreviation: HVAC, heating, ventilation, and air conditioning. ^aOne additional home received repair assistance (air flow, \$235; plumbing repairs, \$490; total costs, \$1,225) but was dropped from the study after it was determined the child was living only occasionally in the home.

Safety of Home against Asthma Triggers

Families were asked, “If your child’s asthma has improved, what do you think was the cause?” Of 28 respondents, 1 reported no change, and 1 reported being not sure. Most frequently given reasons for their child’s improvement in asthma were (1) asthma trigger control (42.9%), (2) housing (35.7%), (3) healthy and green cleaning products (28.6%), (4) medication management (28.6%), and (5) education received about home environment conditions that can trigger asthma reactions (21.4%).

Child Asthma Hospital Charge Data

Hospital charge data for children’s asthma treatment are presented in Table 8. The hospital charge data are based only on hospital stays or visits associated with an asthma condition (diagnosis code 493.XX). Separate mean hospital charges were calculated: (1) for only cases with preintervention and postintervention asthma treatment hospital charge data and (2) for all cases with preintervention and postintervention asthma treatment hospital charge data plus cases without asthma-related treatment charges (charge data, \$0). This second computed mean

represented the mean asthma-related cost for the participants in the study whether they used the hospital for asthma treatment services or not. For 4 cases, no preintervention hospital charge data were available.

On the basis of comparison of the hospital charge data, the housing intervention caused substantial reductions in mean hospital cost charges (\$8,650 before intervention and \$4,100 after intervention for a 52.6% reduction). Comparison of hospital costs for 11 cases that had preintervention (mean, \$5,198) and postintervention (mean, \$2,565) data revealed a 59.2% reduction. An even greater reduction was realized when cases for which no postintervention hospital asthma treatment services were included in the comparison (n = 20), resulting in a mean preintervention cost of \$9,607 vs \$1,199 after intervention, leading to a total of 82.5% reduction in hospital costs.

Table 8. Hospital Charge Data

Variable	All cases		Matched cases	
	Before (2012-2013)	After (2014-2015)	Before (2012-2013)	After (2014-2015)
No. of cases with asthma-related hospital charges before and after intervention	37	12	11	11
Total charges, \$	320,061	49,206	192,142	33,598
Lowest, \$	2,098	1,069	2,098	1,069
Highest, \$	43,685	15,608	43,685	7,616
Median, \$	5,507	2,577	5,198	2,565
Mean, \$			20	20
No. of cases with asthma-related hospital charges, including cases with no asthma-related hospital charges, before and after intervention				
Mean, \$			9,607	1,680

Discussion

Residences of 41 families of children identified with some of the highest rates of asthma-related hospital visits were assessed for the presence of asthma triggers. Depending on the findings from the initial assessment, families were provided appropriate interventions, ranging from education to actual home improvement projects, to address probable triggers. All participants received educational materials, healthy home cleaning items, and a follow-up assessment once the intervention to their residence was completed. Follow-up assessments and data analysis found

notable decreases in the presence of asthma triggers in the home as reported by the program participants and hospital costs.

Results of the families' ratings suggest the intervention had a positive effect on lessening the effect of their child's asthma on their lives and family activities. The ratings indicate a reduction in frequency of negative effects of their children's asthma on sleeping, job or work around the house, family activity plans, child and family stress, and worry about the child's well-being. Similarly, the families tended to report fewer worries or concerns about their child getting enough sleep, performing normal daily activities, need to be protective of the child, and about the effects of their children's asthma medications.

The study intervention produced several points of effect and change for the participant families. By educating the families on the basic upkeep and maintenance needed to maintain a healthy home for reducing conditions that may trigger asthma attacks, they acquired a better understanding of how to assess a home for asthma triggers. In addition, much of the education about upkeep and maintenance addressed actions that the families had considerable control over (ie, did not require structural replacement or repair or installation of costly equipment). Rather the interventions were mostly fixes families could do themselves or have done at modest costs.

Results of the comparison of hospital charge data for children's asthma treatment suggest an association with an improved home environment (lesser presence of asthma triggers after the home assessment, repair intervention, and education delivered in this demonstration project). Participant families had 50% lower hospital bills for childhood asthma treatment after the intervention. These findings suggest a substantial finding of the positive effect based on the intervention delivered in this study.

The families' ratings on the effect on the child and the family suggest the intervention had a positive effect on lessening the effect of their child's asthma on their lives and family activities. There was a clear positive pattern of improvement in terms of symptoms, medication use, asthma attacks, and physician visits after the intervention. Although it is not possible to conclude that the intervention was the change factor for these improvements, the focus that the intervention placed on environmental conditions that were triggering or exacerbating factors of asthma attacks conceivably played an important role in families paying attention and taking action against these conditions. All but 1 respondent family identified a change in knowledge or action toward improving their homes to remove conditions that likely instigate their child's asthma attacks or worsen their symptoms. The improved health conditions were associated with a reduced number of asthma attacks experienced, use of rescue medications, and use of emergency health care services. The reduced need for emergency health care likely translated into reduced costs to the local hospital or emergency department practitioner. Other than asking about medication use included on the surveys, there was no discussion of use of medication by project staff (they were not community health workers), yet most patients reported substantial reductions in use of medication and inhalers. This points to the effect that a nonmedical intervention that relates to a health issue can have on that issue.

The study has several notable limitations. First, it was conducted as a demonstration project, and the procedures and data collection instruments were not validated tools for data collection. Although this is a limitation to the generalizability and possibly the replicability of the results, the instrument was adapted from existing asthma data collection measures, and the data were collected by personnel with considerable direct experience interviewing families about their housing situations who were all trained on the Healthy Homes curriculum.

Second, the sample was not randomly selected, participation was voluntary, and there was not a control group. The objective of the project was to demonstrate the health outcomes achievable by partnership between the health care professional and healthy homes specialists by delivering some level of remediation of asthma trigger conditions in the homes of families with a child who had been hospitalized or visited the emergency department due to an asthma attack. This focus limited the target sample to patients who met a narrow inclusion criterion, and it was not feasible within the budget and capacity of the project to try to identify a comparable group of children with none hospital-diagnosed asthma for comparison purposes. The analytic strategy to partially make up for this limitation using initial follow-up comparisons (each case as its own control) provided a basis for examining the data for change associated with the project interventions.

Third, the sample size was relatively small, and statistical testing for differences was limited. Nevertheless, the results yielded clear patterns of the positive effect across the sample, which provides at least preliminary evidence that the intervention resulted in reduced exposure to asthma triggers, better control over asthma-triggering conditions or events, lower hospital costs, and overall better management of children's exposure to asthma triggering conditions.

Lastly, because a reasonable number of participants in this study are likely to change residences, assessing their actions to limit the effect of asthma triggers in their subsequent housing would provide a measure of the information they received as study participants. Although we cannot expect those with limited choices in their housing to obtain asthma trigger-free housing, we would expect that the educational component of the intervention would carry over to subsequent housing selections and participant behaviors that relate to controlling environmental housing triggers. Therefore, the knowledge and skills obtained from the intervention should increase the participants' ability to evaluate the conditions of prospect housing options so that they may negotiate repairs or other conditions before moving in. Follow-up contact with the sample could provide valuable information regarding participants' retention and application of information from their study experience.

The results of the approaches used to intervene and address known asthma triggers found present in the residence, mainly the repairing or removing of physical environment conditions that contributed to asthma attacks, as well as the education and basic cleaning tools provided to prevent home-related environmental triggers have several important implications. Home environment conditions that lead to or exacerbate asthma may be reduced or eliminated by making minor repairs and introducing reasonable cleaning regimens that address sources of asthma triggers.²¹⁻²³ Basic education about the types of routine maintenance needed to ensure the health and safety of the home can increase the capacity of residents to reduce or eliminate the presence of asthma triggers using low-cost and minimal modification solutions.^{24,25} Greater

awareness on the part of the families of the presence and potential effect of asthma triggers has implications for taking action to address the conditions that associated with these triggers. The use of a none health care worker intervention model may be a cost effective supplemental approach to reducing asthma in populations for which their housing conditions may be a primary source for instigating asthma attacks.

The Asthma Partnership Demonstration project examined the health outcomes achievable through a partnership among health care professionals, healthy home specialists, and university researchers working together to identify and remediate housing related risks for children with asthma. It is our belief that partnerships like the one developed for this project are critical for addressing asthma and other health issues that require not just medical treatment but a more comprehensive response that can prevent or reduce the environmental conditions that are responsible for the occurrence of serious but controllable diseases. This project has resulted in increased community interest in addressing childhood asthma through collaborative problem solving, which has produced a local asthma partnership network that is looking to develop community-based solutions for reducing the incidence of childhood asthma. Through this network we will seek opportunities to conduct larger-scale studies that will enable us to implement improved design and data collection regarding feasible and effective strategies (especially for individuals of extremely low to moderate income) that can address the presence of asthma triggers, empower families to use proactive measures to control their housing conditions, and motivate tenants, landlords, and homeowners to remove conditions or extinguish behaviors that invoke asthma reactions.

References

- [1] Akinbami LJ, Moorman JE, Garbe PL, Sondik EJ. Status of childhood asthma in the United States, 1980e2007. *Pediatrics*. 2009;123(suppl 3):S131-S145.
- [2] Gupta RS, Zhang X, Sharp LK, Shannon JJ, Weiss KB. The protective effect of community factors on childhood asthma. *J Allergy Clin Immunol*. 2009;123:1297-1304.
- [3] Centers for Disease Control and Prevention. Asthma Facts CDC's National Asthma Control Program Grantees. Atlanta, GA: US Dept of Health and Human Services, Centers for Disease Control and Prevention; 2013.
- [4] Breyse PN, Diette GB, Matsui EC, Butz AM, Hansel NN, McCormack MC. Indoor air pollution and asthma in children. *Proc Am Thorac Soc*. 2010;7:102-106.
- [5] Breyse J, Wendt J, Dixon S, et al. Nurse case management and housing interventions reduce allergen exposures: the Milwaukee randomized controlled trial. *Public Health Rep*. 2011;126(suppl 1):89-99.
- [6] Crocker DD, Kinyota S, Dumitru GG, et al. Effectiveness of home-based, multi-trigger, multicomponent interventions with an environmental focus for reducing asthma morbidity: a community guide systematic review. *Am J Prev Med*. 2011;41:S5-S32.

- [7] Krieger JW, Takaro TK, Rabkin JC. Breathing easier in Seattle: addressing asthma disparities through healthier housing. In: *Healthcare Disparities at the Crossroads with Healthcare Reform*. New York, NY: Springer; 2011:359-383.
- [8] Turcotte DA, Alker H, Chaves E, Gore R, Woskie S. Healthy homes: in-home environmental asthma intervention in a diverse urban community. *Am J Public Health*. 2014;104:665-671.
- [9] Beck AF, Klein MD, Schaffzin JK, Tallent V, Gillam M, Kahn RS. Identifying and treating a substandard housing cluster using a medical-legal partnership. *Pediatrics*. 2012;130:831-838.
- [10] Eggleston PA, Butz A, Rand C, et al. Home environmental intervention in inner-city asthma: a randomized controlled clinical trial. *Ann Allergy Asthma Immunol*. 2005;95:518-524.
- [11] Kercksmar CM, Dearborn DG, Schluchter M, et al. Reduction in asthma morbidity in children as a result of home remediation aimed at moisture sources. *Environ Health Perspect*. 2006;114:1574-1580.
- [12] Krieger J. Home is where the triggers are: increasing asthma control by improving the home environment. *Pediatr Allergy Immunol Pulmonol*. 2010;23:139-145.
- [13] Morgan WJ, Crain EF, Gruchalla RS, et al. Results of a home-based environmental intervention among urban children with asthma. *N Engl J Med*. 2004; 351:1068-1080.
- [14] Rosenfeld L, Chew GL, Rudd R, et al. Are building-level characteristics associated with indoor allergens in the household? *J Urban Health*. 2011;88: 14-29.
- [15] Krieger JW, Takaro TK, Song L, Weaver M. The Seattle-King County Healthy Homes Project: a randomized, controlled trial of a community health worker intervention to decrease exposure to indoor asthma triggers. *Am J Public Health*. 2005;95:652-659.
- [16] Sheehan WJ, Rangsihienchai PA, Wood RA, et al. Pest and allergen exposure and abatement in inner-city asthma: a work group report of the American Academy of Allergy, Asthma & Immunology Indoor Allergy/Air Pollution Committee. *J Allergy Clin Immunol*. 2010;125:575-581.
- [17] Shani Z, Scott RG, Schofield LS, et al. Effect of a home intervention program on pediatric asthma in an environmental justice community. *Health Promot Pract*. 2015;16:291-298.
- [18] Woods ER, Bhaumik U, Sommer SJ, et al. Community asthma initiative: evaluation of a quality improvement program for comprehensive asthma care. *Pediatrics*. 2012;129:465-472.
- [19] US Environmental Protection Agency. Asthma Home Environment Checklist. 2004. Publication EPA 402-F-03e030.
http://www.epa.gov/asthma/pdfs/home_environment_checklist.pdf. Accessed July 16, 2015.
- [20] Healthy Home Rating System. US Department of Housing and Urban Development.
http://portal.hud.gov/hudportal/HUD?src¼/program_offices/healthy_homes/hhrs. Accessed July 16, 2015.

- [21] Beck AF, Huang B, Chundur R, Kahn RS. Housing code violation density associated with emergency department and hospital use by children with asthma. *Health Aff (Millwood)*. 2014;33:1993-2002.
- [22] Krieger J, Jacobs DE, Ashley PJ, et al. Housing interventions and control of asthma-related indoor biologic agents: a review of the evidence. *J Public Health Manage Pract*. 2010;16:S11-S20.
- [23] Takaro TK, Krieger J, Song L, Sharify D, Beaudet N. The Breathe-Easy Home: the impact of asthma-friendly home construction on clinical outcomes and trigger exposure. *Am J Public Health*. 2011;101:55-62.
- [24] Largo TW, Borgialli M, Wisinski CL, Wahl RL, Priem WF. Healthy Homes University: a home-based environmental intervention and education program for families with pediatric asthma in Michigan. *Public Health Rep*. 2011; 126(suppl 1):14-26.
- [25] Wright LS, Phipatanakul W. Environmental remediation in the treatment of allergy and asthma: latest updates. *Curr Allerg Asthma Rep*. 2014;14: 1-10.