

EDUCATION

A multifaceted community-based asthma intervention in Chicago: effects of trigger reduction and self-management education on asthma morbidity

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Abstract

Objectives: Home-based, multifaceted interventions have been effective in reducing asthma morbidity in children. However, identification of independent components that contribute to outcomes and delineating effectiveness by level of asthma symptoms would help to refine the intervention and target appropriate populations. **Methods:** A community health educator led asthma intervention implemented in a low-income African-American neighborhood included asthma management education, individually tailored low-cost asthma home trigger remediation, and referrals to social and medical agencies, when appropriate. Changes in asthma morbidity measures were assessed in relation to implementation of individual intervention components using multivariable logistic regression. **Results:** Among the 218 children who completed the year-long program, there were significant reductions in measures of asthma morbidity, including symptoms, urgent care visits, emergency department (ED) visits, hospitalizations, missed school days, and missed work days for caretakers. We also found significant decreases in the prevalence of many home asthma triggers and improvements in asthma management practices. Improvement in caretaker's ability to manage the child's asthma was associated with reduction in ED visits for asthma and uncontrolled asthma. Specific home interventions, such as repair of water leaks and reduced exposure to plants, dust, clutter and stuffed toys, may be related to reduction in asthma morbidity. **Conclusions:** This program was effective in reducing asthma morbidity in low-income African-American children and identified specific interventions as possible areas to target in future projects. Furthermore, the intervention was useful in children with persistent asthma symptoms as well as those with less frequent asthma exacerbations.

Keywords

Asthma, children, community health worker, environmental remediation, low-income housing

History

Received 19 April 2012
Revised 15 March 2013
Accepted 14 April 2013
Published online 20 June 2013

Introduction

Currently, it is estimated that 9.3% of the US children have asthma, with higher rates among African-Americans (14.6%), and low-income populations (11.7%) [1]. The at-risk-based asthma hospitalization rate for African-American children is double that for white children (5.6 versus 2.3/100 with current asthma) [2]. Contributing to large differentials in asthma morbidity among minority and low-income populations are differences in asthma knowledge, access to appropriate medical care, and exposure to asthma triggers. Poor housing quality is linked with poor asthma control and factors contributing to asthma morbidity that are amenable to intervention; these include pets, dust mites, tobacco smoke,

water leaks and poor housing conditions related to dampness, rodents, pests and mold [3].

Previous studies have demonstrated that case management and home visit programs are effective strategies in decreasing asthma morbidity among children with asthma. Identifying specific elements of these programs that are effective, however, has been challenging [4]. Studies have varied in design, level of symptom severity, endpoints addressed and integration with service providers. Two large multicenter trials have demonstrated that case-management by trained social workers [5] and research assistants focused on modification of the home environment [6] can reduce asthma symptoms in children. Smaller trials focused on home visit intervention by community health educators (CHEs) demonstrated that multiple versus fewer home visits [7] and the addition of community educator home visits to clinic-based nurse education [8] decreased asthma symptoms. Home visit programs that successfully decreased asthma morbidity and/or healthcare use have been integrated with clinic-based

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education [9], public housing education [10], home remediation [11], school screening [12] and community-based healthcare providers [13,14]. Most programs have selected children with some measure of asthma severity, including use of controller medication [14], unscheduled physician or hospital visits [5,6,11] and level of current symptoms [9,12]. Some studies included children with both intermittent and persistent disease [7,8,10]. Overall, these asthma case management and home visit programs demonstrated effects on one or several measures of asthma morbidity, although there was not always consistency in outcomes. In most of these studies, interventions were multifaceted, without stratification by level of disease severity and with effects of environmental changes not clearly distinguished from general asthma education or changes in medical management [15].

The current manuscript describes the findings of the Addressing Asthma in Englewood Project (AAEP) Phase I, which was a community-based asthma intervention with several components including school screenings, community and provider education and an individualized home visit program delivered by CHEs. Because of its community focus in an area of high asthma prevalence and economic disadvantage, the home visit program was not a randomized trial and included children with all levels of asthma severity. AAEP included detailed assessments before, during and one year after intervention and thus provides an opportunity to identify components of the intervention associated with changes in asthma morbidity, specifically ED visits for asthma and uncontrolled asthma, and to examine the effect of the intervention in children with various levels of initial symptoms.

Methods

Community

Located just 7 miles south of downtown Chicago, the targeted community, Englewood and West Englewood, covers 20 street blocks from north to south and 22 street blocks from east to west. Englewood's population is 98% African-American and is a community that struggles with issues of poverty, high crime rates, high prevalence of pediatric asthma and poor access to quality healthcare. In 2000, there were 30 284 children, aged 0–17, comprising 35% of the population. At the time AAEP began in 2005, according to Chicago Department of Health data, in the project area 66% of children lived with just one parent (versus 40% for the city) and 18% lived with neither parent (versus 10.6% for the city). In 2005, the asthma hospitalization rate was 44/10 000 for children 2–17 years of age living in Englewood, and 21/10 000 for children 2–17 years of age living in the rest of Chicago (unpublished data, Illinois Department of Public Health).

Training of community health educators

Field staffing consisted of three women from or with close ties to the community. The field manager was a nurse and pastor widely respected in Englewood who exhibited a level of experience and maturity in the interview process. She oversaw the two other CHEs who had bachelor degrees. All received an initial week-long training with ongoing technical assistance provided by a nurse, asthma education

through conference support, and close supervision by the project director, a nationally certified asthma educator lodged at the Respiratory Health Association of Metropolitan Chicago. Field and evaluation staff were trained in human subjects protection, and the evaluation protocol was approved by the University of Illinois at Chicago Human Subjects Institutional Review Board.

Participant selection

A total of 387 children from 253 families enrolled in the home visit program; 87 children from 59 families were excluded from this evaluation because the data from one of the educators was not thought to be reliable. Families were recruited from a variety of sources; the largest referral sources were school screenings and healthcare providers. Included were children ≤ 18 years of age with diagnosed asthma of all degrees of severity, living in or in near proximity to the targeted community. Of the 300 children enrolled 52% were 5–11 years of age, 21% were 0–4 and 27% were ≥ 12 . Overall 58% were male. Demographics of the targeted community were similar, with 52% males and 42% of the children aged 5–11 years. A total of 218 children (73%) from 138 families completed the program. Reasons for loss to follow-up were unresponsive ($n = 20$), unreachable ($n = 7$), change in living situation ($n = 9$), moved ($n = 8$), not interested ($n = 7$) and child subsequently determined not to have asthma ($n = 4$). Children lost to follow-up were similar to those who completed the study with respect to measures of asthma morbidity and home environment, with the exception of more plants in the home and clutter in the child's bedroom in those lost to follow-up.

Home visit program

The home visit program included asthma management education, individually tailored low-cost home asthma trigger remediation, and referrals to social and medical agencies, when appropriate. The CHE remained in regular contact with families through mutually agreed upon method of phone calls or in-person visits.

Environmental interventions were designed to be low cost and portable in light of the mobility of the population, with 33% of the families completing the program changing residence during the year-long study period.

The initial home visit (HV1) was designed to describe the program, obtain consent and initiate asthma education with the caretaker and child if he/she was available. A follow-up home visit (HV2) was scheduled with each family; at this visit, more in-depth asthma management education was provided. Topics included general asthma knowledge and medication; proper medication administration; a review of asthma triggers; use of an asthma action plan (AAP) to promote better understanding of controllers and relievers and appropriate times to administer medication; and use of peak flow meters, inhalers and spacers. Barriers to appropriate care and disease management were also discussed. A written AAP was sent to the child's medical provider with a cover sheet to return to the CHE indicating the provider's approval or disapproval of the AAP. Additionally, every enrolled participant received allergen proof bedding covers, and a

home walkthrough that covered reduction in asthma triggers, including mold, dust, pests, clutter, smoking, odors, water leaks, pets, etc. Families were then provided environmental remediation tools such as caulk and steel wool for integrated pest management activities, if needed, to assist in achieving identified changes. If further assistance was needed that could not be addressed by the CHE, outside referrals were made to medical and social service agencies that could provide appropriate assistance. Families were referred for medical care if they did not have a medical home, needed asthma or allergy medications, or had other medical issues. If the child's asthma was poorly controlled, referrals for specialist care were predominantly to pulmonologists or allergists.

Each family was then scheduled for follow-up in person or by phone at 1, 3, 6 and 9 months and a final home visit at 12 months. Some families, depending on the complexity of social and health education barriers, and home environmental challenges, required more frequent follow-up.

Assessment

At initial assessment, HV1, caretakers were surveyed by a CHE regarding their child's asthma symptoms, healthcare utilization, quality of life and asthma history. Prior to receiving asthma education at this visit, caretakers also completed an asthma knowledge survey and the CHE assessed the caretaker's overall competency and self-efficacy in managing their child's asthma (asthma knowledge, trigger remediation activities, understanding and correctly administering their child's medication plan).

At home visit 2 (HV2), the CHE visited the caretaker's home and administered additional questions on medications, symptoms and knowledge; rated the ability of the child in the use of peak flow, spacer and inhaled medication; and performed a home environmental inspection using visual assessment and with additional verbal probes for certain conditions such as smoking in the home. Based on the home inspection, the Home Survey, Interventions, and Education Evaluation (HSIEE) form was completed. The HSIEE is a list of proposed interventions tailored to the family's situation that the caretaker signs and agrees to work on over the next year. A report of the medications being taken by the child was completed and faxed to the child's medical doctor to be faxed back to the CHE with any corrections. After HV2, a follow-up HSIEE and symptom update was completed, either during a phone call or a home visit, at 1, 3, 6 and 9 months from the date of HV2. Approximately 12 months from the date of HV2, caretakers and homes were reassessed for the information collected at HV1 and HV2.

Data management and analysis

Data from the evaluation forms were reviewed at UIC and responses were clarified if necessary with the CHEs. Data were entered in Microsoft Access databases. Double checking of data entry was performed on selected surveys that assessed asthma symptoms and medical services; use of peak flow, spacer and inhaled medication; and home environment.

Bivariate associations were evaluated using chi-square tests or Wilcoxon rank-sum tests, as appropriate. Changes in

symptoms, medical services, home triggers and asthma management practices during the study were evaluated with paired McNemar's tests or Sign tests, as appropriate. Associations were examined in all children and following stratification by asthma severity at baseline, with "persistent symptoms" defined from questionnaire data as more than 2 days quick relief medication per week and/or more than 2 nights of disturbed sleep in the last month [16].

ED visits for asthma during the 12 months prior to enrollment and during the 12 months of the intervention were assessed by parental report. Uncontrolled asthma was defined from questionnaire data as at least one of the following: >2 days quick relief medication/week; >2 nights of disturbed sleep in last month; hospitalized overnight for asthma in last 12 months; prednisone burst for asthma in last 12 months. The odds of having any asthma ED visits during the intervention period or having uncontrolled asthma at 12 months, in relation to intervention activities, was estimated using multivariable logistic regression models with a random intercept to account for clustering of children within families (SAS PROC GENMOD). Each intervention activity was coded as "improved" for a positive change in the condition and "not improved" for no change or a negative change in the condition. Models were adjusted for asthma morbidity at baseline (any asthma ED visits or uncontrolled asthma, as appropriate), the presence of the intervention target at baseline, gender and age group (<5 years, 5–11 years and >11 years). Models predicting uncontrolled asthma at 12 months were also adjusted for the season at 12 months by including variables indicating fall, winter and summer months versus spring months. *p* Values <0.05 were considered to be statistically significant, and those $0.05 < p < 0.10$ of borderline significance.

Results

Table 1 presents the baseline demographics of the children who completed the program. All children were African-American. Children with persistent symptoms at the start of the study were younger (mean (standard deviation; SD), persistent = 6.9 (4.1), not persistent = 9.4 (4.3), $p < 0.0001$, Student's *t*-test), had more family members (mean (SD), persistent = 5.6 (2.6), not persistent = 5.1 (1.7), $p = 0.07$, Student's *t*-test), and were more likely to move during the study $p = 0.005$, Table 1). Approximately 67% of the children began the study in the summer and fall seasons. Average length of follow-up for the children who completed the program was 12.9 months (range 6.5, 17.4).

Among the 218 children who completed the program there were striking reductions in all measures of asthma morbidity (Table 2). Hospitalizations in the last year decreased from 16% to 5%, ED visits in the last year from 47% to 24%, and urgent care visits in the last year decreased from 46% to 19%. Number of days of missed school by the child and missed work by the caretaker because of child's asthma also decreased significantly. Overall, uncontrolled asthma decreased from 63% to 30%. Although these measures of asthma morbidity were significantly higher in children with persistent symptoms at the start of the study than in those without, significant decreases were seen in morbidity

Table 1. Participant characteristics in all children and in those with and without persistent asthma symptoms.

		All participants		Persistent symptoms at study start ^a				
		<i>N</i> = 218		Yes (<i>n</i> = 93)		No (<i>n</i> = 125)		
Characteristics	Category	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>p</i> Value ^b
Age	<5 years	53	24.3	31	33.3	22	17.6	0.003
	5 to 11 years	102	46.8	45	48.4	57	45.6	
	>12 years	63	28.9	17	18.3	46	36.8	
Gender	Male	122	56.0	57	61.3	65	52.0	0.172
	Female	96	44.0	36	38.7	60	48.0	
Season at study start	Spring	33	15.1	20	21.5	13	10.4	0.049
	Summer	74	33.9	24	25.8	50	40.0	
	Fall	72	33.0	33	35.5	39	31.2	
	Winter	39	18.0	16	17.2	23	18.4	
Season at study end	Spring	44	20.2	25	26.9	19	15.2	0.006
	Summer	42	19.3	12	12.9	30	24.0	
	Fall	72	33.0	24	25.8	48	38.4	
	Winter	60	27.5	32	34.4	28	22.4	
Number of family members	2 to 4	87	39.9	37	39.8	50	40.0	0.042
	5 to 6	86	39.5	30	32.3	56	44.8	
	>6	45	20.6	26	28.0	19	15.2	
Moved during study	Yes	85	39.2	46	50.0	39	31.2	0.005
	No	132	60.8	46	50.0	86	68.8	

^aPersistent symptoms defined as more than 2 days quick relief medication per week and/or more than 2 nights of disturbed sleep in the last month;^b*p* Value from chi-square test for persistent versus non-persistent symptoms.

Table 2. Asthma morbidity at baseline and during the study period in all children and children with and without persistent symptoms at study start.

	All children		Persistent symptoms at study start ^a				
Asthma-specific morbidity Measure	<i>n</i> = 218		Yes (<i>n</i> = 93)		No (<i>n</i> = 125)		<i>p</i> Value ^b
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	
Hospitalization in last 12 months							
baseline	34	15.6	21	22.6	13	10.4	0.01
end of study	10	4.6	5	5.4	5	4.0	0.63
paired <i>p</i> value ^c		<0.0001		<0.0001		0.02	
ED visit in last 12 months							
baseline	102	46.8	56	60.2	46	36.8	0.0006
end of study	52	23.9	28	30.1	24	19.2	0.06
paired <i>p</i> value ^c		<0.0001		<0.0001		0.0005	
Urgent care in last 12 months							
baseline	100	46.1	56	60.2	44	35.5	0.0003
end of study	42	19.4	26	28.6	16	12.8	0.004
paired <i>p</i> value ^c		<0.0001		<0.0001		<0.0001	
Uncontrolled asthma ^d							
baseline	135	62.8	93	100	42	34.4	<0.0001
end of study	66	30.4	43	46.7	23	18.4	<0.0001
paired <i>p</i> value ^c		<0.0001		na		0.002	
	Mean	Range	Mean	Range	Mean	Range	<i>p</i> Value
Missed school days, number in last 12 months							
baseline	4.3	0–45	6.0	0–30	3.2	0–45	0.004
end of study	1.3	0–20	1.7	0–15	1.0	0–20	0.02
paired <i>p</i> value ^c	<0.0001		<0.0001		<0.0001		
Missed caretaker work days for child's asthma, number in last 12 months							
baseline	2.5	0–22	4.2	0–22	1.4	0–20	0.009
end of study	0.9	0–15	1.3	0–15	0.6	0–15	0.02
paired <i>p</i> value ^c	<0.0001		0.0002		0.02		

^aPersistent symptoms defined as more than 2 days quick relief medication per week and/or more than 2 nights of disturbed sleep in the last month;^b*p* Value for persistent versus non-persistent symptoms from chi-square test or Wilcoxon rank-sum test, as appropriate;^cPaired *p* value for change in asthma morbidity measure during study from McNemar's test or Sign test, as appropriate;^dUncontrolled asthma defined as at least one of the following: >2 days quick relief medication/week; >2 nights of disturbed sleep in last month; hospitalized overnight for asthma in last 12 months; prednisone burst for asthma in last 12 months.

measures in children both with and without persistent symptoms at the start of the study (Table 2).

The prevalence of many conditions in the home related to asthma triggers were significantly decreased at the end of the intervention, compared with baseline levels, while asthma management practices and the caretaker's ability to manage the child's asthma, as assessed by the CHE, were significantly increased at the end of the intervention (Table 3). Both at baseline and at the end of the study, having controller medication prescribed, using controller medication daily, and using a spacer when taking inhaled medication were more frequent in children who began the study with persistent symptoms (not shown). In general, the prevalence of most home triggers did not differ significantly between children with and without persistent symptoms at baseline (not shown).

The proportion of children with improvement, defined as a positive change in the condition versus no change or a negative change, in asthma management practices and families with improvement in home asthma triggers during the study are shown in Table 3. Caretaker's asthma ability, which was assessed by the CHE and is a reflection of overall competency, asthma knowledge, trigger remediation activities, and understanding and administering their child's medication plan, was improved in 78.3% of participants. Improved caretaker's asthma ability was associated with improvement in leaks in the home ($p=0.02$) and conditions in the bedroom, including peeling wall coverings or holes in walls or floor ($p=0.11$), dusty surfaces ($p=0.10$), and food consumption ($p=0.04$), but not in improvements in medical management activities, such as frequency of use of control medication and spacer use with medication, ability to use

Table 3. Prevalence of asthma home triggers and asthma management practices at baseline and study end and improvement during study period.

Asthma trigger or asthma management practice	Prevalence of trigger/management practice					Improvement at study end ^b	
	Baseline		End		Paired <i>p</i> Value ^a		
	<i>n</i>	%	<i>n</i>	%			
A. Child level variables (<i>n</i> = 218 children)							
1. Asthma management							
Controller medication use	94	43.1	123	56.7	<0.0001	41	18.9
Takes controller medication daily	37	17.0	57	26.2	0.01	40	18.4
Uses spacer often/usually for inhaler medication	39	18.9	81	39.1	<0.0001	54	27.6
Inhaled medication spacer ability ^c	56	25.7	145	66.5	<0.0001	84	38.5
Peak flow ability ^c	43	19.7	154	70.6	<0.0001	115	52.8
B. Family level variables (<i>n</i> = 138 families)							
1. Asthma management							
Caretaker's asthma ability: capable	4	2.9	80	58.4	<0.0001	108	78.3
Caretaker's asthma ability: somewhat capable	83	60.1	54	39.4			
Caretaker's asthma ability: not capable	51	37.2	3	2.2			
Followed through on referral for medical specialist ^d	40	29.0	22	15.9	na	na	
Followed through on referral for medical treatment ^d	74	53.6	50	36.2	na	na	
2. Triggers in home							
Smoking in home (residents and/or visitors)	59	42.8	37	26.8	0.0002	29	21.0
Peeling wall coverings or paint	42	30.7	14	10.3	<0.0001	33	24.4
Holes in walls or floors	52	38.2	17	12.9	<0.0001	41	31.3
Water leak	40	29.2	13	9.5	<0.0001	31	22.8
Mold	59	43.1	10	7.4	<0.0001	49	36.3
Uses a humidifier	38	27.6	26	19.0	0.02	20	14.7
Plants	40	29.2	46	33.8	0.27	12	8.9
Cockroaches	27	19.6	9	6.6	0.0001	20	14.6
Rodents	40	29.0	14	10.2	<0.0001	32	23.4
Pets with fur	44	32.1	35	25.6	0.03	16	11.8
Clutter	89	65.4	48	35.3	<0.0001	45	33.6
Dusty surfaces	80	58.4	38	27.9	<0.0001	47	34.8
Wall to wall carpeting	71	51.5	51	37.2	0.0003	25	18.3
3. Triggers in bedroom							
Peeling wall coverings or holes in walls or floor	19	13.8	4	2.9	0.0003	16	11.6
Pests or pets	14	10.1	2	1.5	0.001	13	9.6
Clutter	88	63.8	55	39.9	<0.0001	45	32.6
Dusty surfaces	78	57.4	37	26.8	<0.0001	49	36.0
Stuffed toys	49	35.8	32	23.4	0.005	27	19.9
Wall to wall carpeting	55	39.9	40	29.4	0.004	21	15.4
Bed sheets washed in cold/warm versus hot water	74	56.1	23	16.7	<0.0001	56	42.4
Food eaten in bedroom	42	30.9	12	8.8	<0.0001	32	23.9

^aPaired *p* value from McNemar's test;

^bEach intervention activity was coded as "improved" for a positive change in the condition and "not improved" for no change or a negative change in the condition; caretaker's asthma ability improvement was coded as a change from not capable to somewhat capable or capable or from somewhat capable to capable;

^cImprovement at end of study = increase in ability by >50%; only children >5 years tested;

^dBaseline = number of families given a referral to a medical practitioner, End = number of families that followed up on the referral to the medical practitioner.

spacers or peak flow meters, and following through on referrals for medical or specialist care for asthma (not shown).

Table 4 examines associations of improvement in home environment, educator assessment of caretaker ability and asthma management with any ED use during the year-long study, controlling for age group of child, gender, any ED visits in year prior to study, and prevalence of home or medical management variable being assessed at start of study. A reduction in ED visits for asthma was associated with improvement in the caretaker's ability to manage the child's asthma, as assessed by the CHE, ($p=0.04$) and with following through on a referral to have the child examined by a medical specialist ($p=0.001$). Improvements in the child's ability to use spacers or peak flow meters or in use or frequency of use of controller medication were not associated with ED visits (not shown). Among the home environmental variables, reduction in ED visits was associated with reduction in water leaks ($p=0.07$) and exposure to stuffed toys in the child's bedroom ($p=0.05$). Improvements in other home

triggers detailed in Table 3, were not associated with ED visits during the study ($p \geq 0.12$, not shown).

Table 5 shows associations of improvement in home conditions, educator assessment of caretaker ability and asthma medical management with uncontrolled asthma at the end of the study, adjusted for age group of child, gender, season at the end of the study, uncontrolled asthma at the start of the study, and prevalence of home or medical management variable being assessed at the start of the study. Improvement in the caretaker's asthma management ability was associated with reduction in uncontrolled asthma ($p=0.01$). Starting controller medication, improvement in frequency of use of control medication, frequency of spacer use with medication, ability to use spacers or peak flow meters, understanding the appropriate use of control medication, and following through on referrals for medical or specialist care for asthma were not significantly associated with uncontrolled asthma (not shown). Among the home environmental variables, decreased uncontrolled asthma was associated with reduction

Table 4. Association of having an ED visit during the study period with changes in asthma management practices or home triggers.

Intervention activity	Condition improved	ED visit for asthma		Adjusted odds ratio ^a OR (95% CI)	p Value
		N/total	%		
1. Asthma management					
Caretaker's asthma ability	yes	33/164	20.1	0.34	0.04
	no	19/54	35.2	(0.12, 0.96)	
Followed through on medical specialist referral	yes	5/37	13.5	0.16	0.001
	no	47/181	26.0	(0.05, 0.48)	
2. Home triggers					
Water leaks	yes	6/46	13.0	0.23	0.07
	no	45/170	26.5	(0.05, 1.15)	
Pets with fur	yes	5/24	20.8	0.39	0.20
	no	46/192	24.0	(0.09, 1.67)	
3. Bedroom triggers					
Clutter	yes	22/82	26.8	2.38	0.12
	no	30/136	22.1	(0.81, 7.01)	
Stuffed toys	yes	5/41	12.2	0.23	0.05
	no	47/173	27.2	(0.05, 0.97)	

^aOdds ratio for association of improvement in trigger or management with any ED visit for asthma during study. Adjusted for age group, gender, baseline ED visits for asthma, presence of intervention target at baseline and clustering of children within families.

Table 5. Association of having uncontrolled asthma at the end of the study with changes in asthma management practices or home triggers.

Intervention activity	Condition improved	Uncontrolled asthma		Adjusted odds ratio ^a	
		N/total	%	OR (95% CI)	p Value
1. Asthma management					
Caretaker's asthma ability	yes	44/163	27.0	0.36	0.01
	no	22/54	40.7	(0.16, 0.79)	
2. Home triggers					
Holes in walls or floor	yes	29/71	40.9	5.95	0.07
	no	37/138	26.8	(0.87, 40.55)	
Plants	yes	2/17	11.8	0.11	0.01
	no	62/193	32.1	(0.02, 0.62)	
Clutter	yes	22/78	28.2	0.48	0.05
	no	44/135	32.6	(0.23, 1.01)	
3. Bedroom triggers					
Dusty surfaces	yes	18/80	22.5	0.46	0.11
	no	46/132	34.9	(0.18, 1.18)	
Stuffed toys	yes	7/41	17.1	0.24	0.03
	no	58/172	33.7	(0.06, 0.88)	

^aOdds ratio for association of improvement in trigger or management with uncontrolled asthma during study. Adjusted for age group, gender, baseline uncontrolled asthma, presence of intervention target at baseline, season of study and clustering of children within families.

in plants ($p=0.01$) and clutter ($p=0.05$) in the home. We found an association of borderline significance for reduction in holes in the walls or floors being positively associated with uncontrolled asthma ($p=0.07$). Uncontrolled asthma was decreased in the children with decreased exposure to stuffed toys in the bedroom ($p=0.03$). Uncontrolled asthma tended to decrease, but not significantly, in the children sleeping in bedrooms with a reduction in dusty surfaces. Improvements in other home triggers detailed in Table 3 were not associated with uncontrolled asthma during the study (not shown).

Discussion

A recent systematic review found evidence that environmental home-based, multifaceted interventions targeting children with asthma were effective in improving quality of life and decreasing missed school, and borderline effective in reducing acute healthcare visits for asthma [4]. However, the authors identified several important research questions for further studies including determination of independent intervention components that contribute to outcomes and delineating intervention effectiveness by level of severity of asthma symptoms.

This study confirms previous findings that home visit intervention by CHEs is effective in reducing asthma morbidity in children with asthma [7–9,14,12]. Some previous studies showing improvement in asthma morbidity have used more aggressive environmental interventions, including professional cleaning or remediation [6,11], and HEPA filters and vacuum cleaners [7,12]. Others tailored the intervention to allergen sensitization [5,6]. Some, like ours, combined low-cost home environmental interventions with general asthma education [14]. In AAEP, it appears that improvement in caretaker's ability and in the home environment overall and the environment in which the child sleeps were effective in reducing asthma morbidity. This study, unlike most previous papers, delineates specific interventions, such as repair of water leaks and reduced exposure to plants, dust, clutter and stuffed toys, as possible areas to target in future projects.

Effectiveness of AAEP by level of asthma severity was examined, with "persistent symptoms" defined from questionnaire data as more than 2 days quick relief medication per week and/or more than 2 nights of disturbed sleep in the last month [16]. This analysis suggested that even children without persistent symptoms have acute exacerbations requiring ED visits and hospitalizations, as well as other measures of morbidity, such as missed school days and missed work days for caretakers, and that low-cost, multifaceted interventions can be effective in this group as well as in children with persistent symptoms.

The lack of association of improvement in controller medication use and other asthma management activities with ED visits for asthma and uncontrolled asthma during intervention is of concern. In this program only 19% of the children reported an increase in controller use, which was similar in children with and without persistent symptoms at baseline. However, by the end of the project persistent symptoms had decreased from 43% to 16%,

and of the 16% with persistent symptoms, 76% had controller medication (use of controller medication in children with persistent symptoms at baseline was 67%). It is possible that the evaluation questions did not identify regularity of use with enough precision, although questions did include frequency of medication use and spacer use. The strength of the associations of improvements of asthma morbidity with caretaker ability suggests that factors not measured by the questionnaire were operative, such as understanding of controller versus reliever medication or overall caretaker management skills that allow for more continuous control. It is also possible that, because the project was community-based, integration with individual healthcare providers was not sufficient to achieve use of controllers in all who could benefit. For example, drafts of AAPs were developed for all participants and sent to providers, with only 1% returned with provider's signature. Furthermore, access to medical care was a substantial issue in the population, as illustrated by high rates of ED visits (47%) and urgent care office visits (46%) for asthma at baseline, and families were referred for medical care if they did not have a medical home, needed asthma or allergy medications, or had other medical issues. Of note, a reduction in ED visits for asthma during follow-up was found for participants who acted on referrals for specialist asthma care, generally to pulmonologists or allergists.

While the multifaceted, individually tailored intervention design resulted in substantial decreases in asthma morbidity, it also complicated the analysis of the efficacy of individual intervention components. We were unable to evaluate the effects of some interventions that all children received, such as mattress and pillow covers and AAPs. Changes observed in the home environments were related to remediation activities and in some cases to relocation of the home, because the mobility rate was high, with 21% of families moving once and 12% moving two to six times during the follow-up period. However, further adjustment of models for mobility during the study did not substantially change effect estimates. Finally, our power was low to detect some associations, and the use of a before and after comparison study design, rather than randomization, may have overestimated intervention effects [4].

This study is limited by the lack of data on allergen sensitization and pulmonary function tests and use of visual rather than measured environmental assessments. Outcomes are also determined by self-report. Use of symptom diaries and/or review of medical records would have increased the precision of the evaluation.

Strengths of the AAEP include the integration of the program in the community, administration of the program by CHEs with strong ties to the community, extensive initial and ongoing training of field staff, the experience and stability of the project staff and evaluation team, and the intervention program tailored to community demographics and needs. Key features of the intervention that may have led to its success in this setting were the low-cost, individually tailored remediation plans, reinforcement of education during the year-long follow-up, and flexibility to address the complex social, health, education, mobility and housing quality challenges in the population.

Conclusions

This evaluation suggests that a multifaceted program including asthma management education, general home assessments and low-cost interventions can be effective in reducing asthma morbidity in a low-income African-American population. Furthermore, these interventions, while somewhat more effective in children with higher symptom frequency, can also be useful in those with less frequent exacerbations. AAEP Phase I underscore the importance of CHEs in the complex interface of families with asthma and the diverse group of institutions serving their children.

Acknowledgements

We would like to acknowledge the assistance of our many community and medical partners in carrying out the program. We would also like to thank the families that participated in the program.

Declaration of interest

The authors declare they have no actual or potential competing financial interests. Funding for this project included grants from the Merck Childhood Asthma Network, Inc. (MCAN), funded by the Merck Company Foundation, and the Lloyd A. Fry Foundation.

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