

ORIGINAL ARTICLE

Impact of a multi-trigger intervention on seasonal patterns of asthma symptoms in inner city childrenTyra Bryant-Stephens, MD¹, Caroline West, MPAff, MA², and Gary Klein, PhD²¹The Children's Hospital of Philadelphia, Philadelphia, PA, USA and ²Philadelphia Health Management Corporation, Philadelphia, PA, USA**Abstract**

Objectives: Peaks in childhood asthma symptoms and asthma morbidity occur universally in the fall and late winter/early spring. This study examines whether there is a time of the year best suited to implement environmental interventions to attenuate this pattern. **Methods:** From September 2006 to June 2010, mid-Atlantic inner-city children asthmatics with 1 asthma-related hospitalization (IP) or 2 emergency (ED) visits the year prior to enrollment received 5 in-home self-management education sessions which included multi-trigger avoidance techniques and supplies. Children's daily asthma symptoms were recorded for 12 months by caregivers. **Results:** One-hundred and thirty-six children (48%) completed 12 months of symptoms diaries. Symptom days were reduced by 4.5 days at 12 months follow-up ($p < 0.001$). Symptom severity improved with a decreased severity score of 29.0 to 7.9 at month 12 ($p < 0.001$). Sixty-one percent of patients with ≥ 2 ED visits at baseline dropped to 0–1 visits ($p < 0.001$). Eighty percent of patients with ≥ 1 IP visits dropped to 0 visits at 12 months ($p < 0.001$). Patients who received intervention in the summer months had half the average monthly symptoms score (10.8) as those who received intervention in the spring months (20.8). When controlling for environment and morbidity, the summer enrolled group had a significantly lower ($p = 0.021$) symptom score than those in other seasons. **Conclusion:** Home self-management/environmental interventions for this cohort appear to have the greatest effect for those receiving the intervention in the summer and fall. The largest impact occurs in the summer cohort. Further studies with a control group are necessary to confirm these findings.

Keywords

Morbidity and mortality, pediatrics, prevention

History

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Introduction

Asthma triggers in homes and school environments are influenced by overcrowding, housing density, geographical isolation, lack of community resources, blightedness and poor ventilation [1–4]. The high cost of home maintenance contributes to the exposure of children to common triggers such as cockroach, dust, pets, mice and mold [5,6]. Additionally urban poor neighborhoods have fewer supportive and essential resources and are characterized by high stress, high crime rates and violence which may result in geographic isolation [7–9]. Community Health Workers (CHWs) and/or promoters have been proven in numerous studies to be effective in improving outcomes for various chronic diseases and in asthma they have been utilized extensively and effectively to provide asthma education and home environmental interventions [10,11]. Typically, people employed as CHWs are selected because they are members of the community they are intended to serve. They are also hired for qualities such as

leadership and caring rather than specific education and training [5]. In a comprehensive review of CHWs utilized in randomized control trials, Dower et al. [12] report that CHWs were able to effectively implement health interventions to improve health behaviors and clinical measures among minority groups.

In the Seattle-King County Healthy Homes project Krieger et al. [13] found a significant increase in Quality of Life scores and a decrease in asthma-related urgent care use in a CHW high intensity intervention group (7 home visits over 12 months) compared with a CHW low intensity intervention (1 visit). In addition, a recent meta-analysis by the CDC found that interventions that utilize CHWs to implement multi-level environmental interventions to reduce asthma triggers are effective in improving asthma outcomes [14].

Previous studies have reported seasonal variations in asthma admissions to the hospital and emergency room [15,16]. Most studies have found that the peak of these admissions usually occurs in September. It has been suggested that the fall peak can be attributed to going back to school but the peak is more pronounced in younger children who are not yet in school [17,18]. There appears to be a second peak in the winter which has been attributed to viral infections – primarily rhinovirus

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and RSV infections [19,20]. In a retrospective analysis of primary care visits in Ontario, the primary care visits for respiratory ailments peaked in December–February, associated with the winter peak in hospitalizations [21]. To date, environmental interventions have not been shown to attenuate these seasonal peaks in symptoms.

The objective of this study was to observe when children benefit the most from home interventions through caregiver recording of daily symptoms over a course of one year. In this paper we report the results of this study where caregivers are asked to complete daily diaries for 12 months, collected on a biweekly basis, recording daytime and nighttime asthma symptoms. To our knowledge there has not been a study examining the most beneficial times to intervene with home visits. The study was approved by the Joseph Stokes Institutional Review Board of the Children's Hospital of Philadelphia.

Methods

Inner-city children with a diagnosis of asthma and one asthma-related hospitalization or two asthma-related emergency visits in the year prior to the enrollment were recruited. These children were then followed for 12 months in a prospective longitudinal cohort study. After consent was obtained, the intervention occurred over five visits by a trained and experienced community health worker. At the home visits CHW's conducted asthma education and asthma trigger reduction sessions for caregivers and children over 6 years old. Educational session topics were: what is asthma, how does asthma affect my airways, common asthma triggers and avoidance techniques, asthma medication, asthma action plan and school/psychosocial concerns related to asthma. CHWs tailored intervention on asthma trigger reduction methods based on the child's exposure to common asthma indoor triggers including dust, tobacco smoke, pests, mold and pets. The primary areas of focus for asthma trigger reduction were the child's bedroom, the kitchen and the general living area. Supplies to facilitate asthma trigger reduction were given to families included dust-avoidance supplies (storage bins, hypoallergenic mattress and pillow covers, shades to replace blinds, tiles to replace carpet, electrostatic dust cloths,) and pest-avoidance supplies (roach and mouse traps). Families were also given referrals to smoking cessation classes if interested. Caregivers were given daily diaries to record their children's symptoms which were daytime cough and wheeze, nighttime cough and wheeze and activity. These diaries were distributed and collected on a bi-weekly basis. Once the five sessions were completed, the CHW made monthly visits for twelve months to reinforce environmental interventions, review medications and asthma care plans and provide resources as needed. CHWs also collected biweekly symptom diaries in person or via telephone calls based on the preference of the caregiver. CHWs completed at least three bedroom observation visits at baseline, six and 12 months after the intervention was completed to record trigger reduction intervention maintenance in child's bedroom.

Symptom diaries were given at enrollment and collected for one year following enrollment. Caregivers were asked to record their child's daily asthma symptoms in a daily "asthma diary [22] which was collected by home visitors every other

week. Five types of symptoms were recorded in the diaries each day, including day wheezing, night wheezing, day coughing, night coughing and day activity level (0-normal, 1-can run short distance, 2-can walk only, 3- missed school or stayed indoors). Caregivers estimated their child's symptoms each day using a numeric score of 0 (no symptoms, normal activity) to 3 (continuous symptoms, missed school/stayed indoors). A symptom scale was then constructed by summing these five daily symptom types separately, as well as together, over each two-week period. The maximum symptom score (3 for most severe) for all symptoms (5 types) over a biweekly period (14 days) was 210.

Statistical methodology

For monthly symptom scores, Repeated Measures analysis was performed, using a mixed-model design that contained between-group effects for season, ED visits in the prior year, and hospital stays in the prior year. A mixed-model Repeated Measures analysis was conducted on the Symptom Severity Score incorporating the within-subject effects of month sequence, the between-group effects of season, age group (2–4, 5–12, 13–16), ED visits (0–1, 2+ in past year) and hospitalizations (0, 1+ in past year) and the interaction effects of month sequence with these between-group factors. For the peak month symptom score, Linear Multiple Regression was performed, with season of enrollment the independent variable and prior ED visits, prior hospitalizations, and home environmental conditions (presence or absence of roaches, rodents, pets, smoking and carpets) serving as controls. Changes from baseline to follow-up in patient characteristics (smokers in household, has action plan, missed school days and parent report of asthma control) and health care utilization (ED visits, hospitalization visits and use of rescue meds) were examined using McNemar Chi-Square and changes in ED and hospitalization visits controlling for baseline environmental conditions were analyzed with the Mantel–Haenszel Chi-Square statistic.

Results

Symptom diaries were completed for 282 children during the home visit program, and a full twelve months of diaries was completed for 136 of these children (48%). This analysis includes these 136 children whose parents completed 12 consecutive months of asthma diaries.

In order to conduct an analysis by month and season of program participation, the biweekly diary scores were each assigned to a calendar month, and then to a season (Fall, Winter, Spring and Summer).¹ Of the 136 cases, 34 commenced in the winter (December 21–March 20), 32 in the spring (March 21–June 20), 35 in the summer (June 21–September 22) and 35 in the fall (September 23–December 20). Three cases that were very near the border of an adjoining season were moved to that season to enable an equal number of cases per season for comparison.

Tables 1–3 show the baseline demographics, characteristics and health care utilization of the patients who participated in the home visiting study, and who successfully completed

¹Biweekly diaries that began in the same month were averaged.

Table 1. Patient demographics ($n = 136$).

Variable	Category	<i>N</i>	%
Ethnicity	Latino	18	13.4
	African-American	112	83.6
	Other	4	3.0
	Unknown	2	—
Age	2–4 years	54	39.7
	5–12 years	63	46.3
	13–16 years	19	14.0
Gender	Male	75	55.1
	Female	61	44.9
Caregiver education	HS grad	86	63.2
	Not HS grad	50	36.8
	Total	136	100.0
Caregiver primary language	Other than English	22	16.3
	English	113	83.7
	unknown	1	—
# of People living in home	4 or fewer	70	51.5
	>4	66	48.5
	unknown	3	—
Enrollment Season	Spring	32	23.5
	Summer	35	25.7
	Fall	35	25.7
	Winter	34	25.0

Table 2. Patient characteristics at baseline and follow-up^a.

	Baseline		Follow-up		McNemar Chi-Square
Smokers in household					
Yes	34	28.6	24	20.2	$p = 0.013$
No	85	71.4	95	79.8	
Total	119	100.0	119	100.0	
Has action plan					
Yes	91	68.4	133	100.0	$p < 0.001$
No	42	31.6	0	0.0	
Total	133	100.0	133	100.0	
Missed school days (Past 12 months for school-age children)					
0	38	36.2	51	48.6	$p = 0.015$ (0 versus 1+)
1–9	37	35.2	26	24.8	
10+	30	28.6	28	26.6	
Total	105	100.0	105	100.0	
Parent report of asthma control					
Strongly agree/Agree	97	71.3	131	100.0	$p < 0.001$
Disagree/Strongly Disagree	34	28.7	0	0.0	
Total	131	100.0	131	100.0	

^aTwelve months before intervention, and 12 months following enrollment, with missing cases on pre- or post-intervention removed.

twelve months of bi-weekly asthma symptoms diaries. There were no significant differences in race, ethnicity, language spoken or age between the larger group and the cohort that completed the 12 months of diaries for this analysis. Over a quarter (28.6%) of families had a smoker in the home at baseline versus 20.2% at 12 months, and most children had an asthma action plan at baseline (Table 2). Most children enrolled in the home visit program missed school because of their asthma in the past year, and over a quarter of school-age children (28.6%) missed more than 10 days. Although this number did not drop significantly after 12 months, the percent of children who missed any school days did drop significantly ($p = 0.015$). At twelve months asthma triggers overall were reduced from average of 3.99 triggers at home at baseline to 3.49 triggers at last home visit ($p < 0.001$).

All the children who were eligible for the home visit program had at least one ED visit or a hospitalization because of asthma within the past year. At baseline, approximately 60% of the children had emergency room visits within the year prior to enrollment, with 35.6% having more than one, compared to 13.6% at follow-up, and 40% had inpatient visits within the year prior to enrollment compared to 16.7% at follow-up (Table 3). Nearly one in five of these children had three or more ED visits, or two or more hospitalizations (19.1% each) within the year prior to enrollment.

Daily symptom levels for 136 children were analyzed over twelve months of program enrollment. Symptom days were reduced by 4.5 days from a baseline mean of 7 days to a mean of 2.5 days at 12 months follow-up ($p < 0.001$). The average decrease was two days within a month of baseline ($p < 0.05$) and the combination of a one day decrease between the 1st and 3rd month and another one day decrease between the 3rd and 8th month also resulted in a statistically significant drop ($p < 0.05$). Between the 8th and 12 months, the mean dropped another half-day to 2.5 symptom days. Wheezing/coughing, nighttime and activity symptom levels were analyzed separately, and also combined into an overall symptom severity score for each child.

Figure 1 illustrates that overall symptom severity improved from the first month of enrollment, where the average score on the symptom severity score was 29.0, to Month 12, by which point the mean symptom severity score had dropped to 7.9. The rate of improvement varied, however, as symptom levels improved significantly in the first six months of program enrollment, but slowed in the last six months. This pattern is consistent across all symptom sub-types (wheezing/coughing, nighttime, activity). The within-subject effect of month-sequence on the Symptom Severity Score was highly significant ($p < 0.001$), and showed significant linear ($p < 0.001$), quadratic ($p < 0.05$) and cubic ($p < 0.05$) trends. The linear trend is revealed in Figure 1, with the sharp decrease in Symptom severity over time. After 3 months, however, the decrease is less sharp, forming a curve, which is the quadratic trend. This trend has two noticeable bumps between the month 6 and month 9, resulting in additional significance for a cubic trend.

The other significant effect was the interaction of season with month-sequence ($p < 0.01$). Children enrolled in winter/spring had higher symptoms in March/April. People who began in summer or fall had their peak symptoms in September/October unless they started after October. But the symptom peaks were much lower for those enrolled in summer and fall.

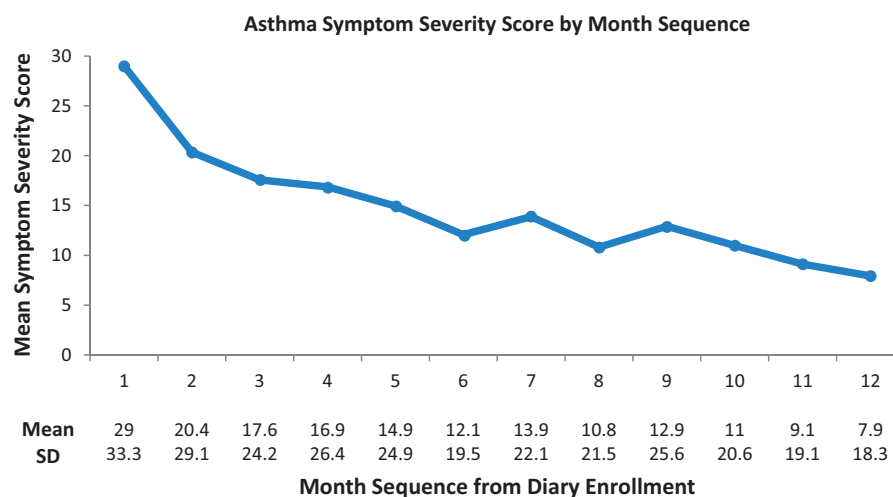
Figure 2 shows symptom improvements were made over 12 months for children enrolled throughout the year, but drop offs from the beginning of enrollment to the end of enrollment were most notable for children who were enrolled in the winter and spring, when initial symptom scores were the highest (Figure 2). The patients enrolled in summer had slight elevations in symptoms in the late summer and early fall, but symptoms were low by the winter perhaps due to the impact of the home visiting intervention. The summer enrollees also had the lowest score after 12 months. It appears these lower scores for summer enrollees cannot be attributed to being less sick in the prior year, as even though they had less ED visits,

Table 3. Patient health care utilization^b.

	Baseline		Follow-up		McNemar Chi-Square
	N	%	N	%	
ED visits in past year	0–1	85	64.4	114	86.4
	2+	47	35.6	18	13.6
	Total	132	100.0	132	100.0
Inpatient admissions in past year	0	80	60.6	122	83.3
	1+	52	39.4	10	16.7
	Total	132	100.0	132	100.0
Rescue med use in past 2 weeks	<2 days	58	43.6	100	75.7
	2+ days	75	56.4	33	24.3
	Total	133	100.0	133	100.0

^bTwelve-months before intervention and 12 months following enrollment, with missing cases on pre- or post-intervention removed.

Figure 1. Mean asthma symptom scale score by month sequence. Month sequence from dairy commencement.



50% were hospitalized in the prior year, compared to 35.3% of the winter, 29.4% of the spring and 44.1% of the fall enrollees.

When linear regression is performed on the peak monthly symptom score, summer enrollee symptoms are significantly lower ($p = 0.021$) than the remainder seasons, controlling for baseline ED visits and Hospitalization stays, as well as home environmental conditions (presence or absence of roaches, rodents, pets, smoking and carpets). Of the control variables, smoking ($p = 0.005$) and wall-to-wall carpets ($p = 0.005$) have the most predictive influence on the asthma symptom score at the peak month.

Symptom levels were also analyzed by the season of patient enrollment. Figure 2 shows that patients enrolled in the winter had much higher peaks of symptom activity in the spring (during the beginning of their program participation), and these levels had then improved by the fall. The patients enrolled in summer had slight elevations in symptoms in the late summer and early fall, but symptoms were low by the winter perhaps due to the impact of the home visiting intervention.

Discussion

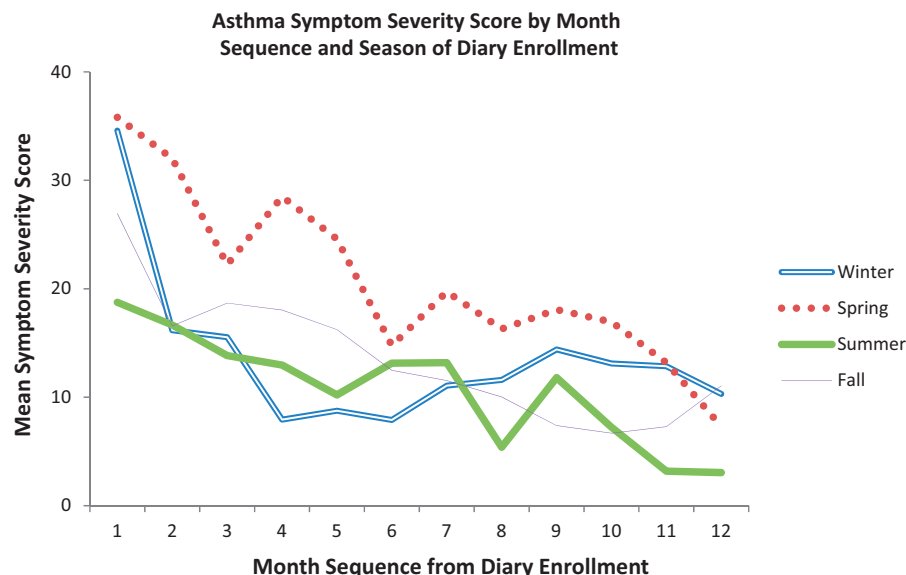
In this cohort of inner-city children with persistent asthma who enrolled in a home visit asthma environmental mitigation program, we have shown that independent of season, asthma

symptom severity dropped by 75% and symptom days dropped by 64% over time with the greatest change occurring in the first six months of enrollment.

These findings parallel the seasonal pattern of emergency department visits and hospitalizations. Most studies show a peak in hospital admissions in September and trough in the summer [19,20]. Fleming compared seasonal patterns of general practitioner episodes to hospital admissions and death and found that the peak for General Practitioner visits was in early December and the hospital visit peak was in late September for patients less than 14 years old [17]. In a retrospective analysis, Moineddin found that the children from birth to 4 years of age were the most frequent group to visit Primary Care Providers and the peak time for those visits was in the winter season (December to February) [21]. The mean age for our cohort was 7.3 years which may explain a smaller spike in the winter season we saw in this study.

The interventions in our study targeted indoor aeroallergens and irritants in the first five weeks of enrollment. As demonstrated, the drop in symptoms occurred soon after the home environmental and educational interventions. Indoor allergens are known to be affected by climate and temperature both indoors and outdoors [23–26]. In Vancouver children, exposure to maternal tobacco smoke was found to be associated with lower pulmonary function in the cold/wet season than in the warm/dry season [27]. It was postulated

Figure 2. Mean asthma symptom score by month sequence and season of diary commencement. Month sequence from dairy commencement.



that windows are opened in the warm/dry season which improves air exchange. In contrast in a survey of 1725 children, Han in Taiwan found that although there was a peak in asthma attacks in the winter, secondhand smoke was related to spring and summer/fall asthma attacks. In this same group cockroach presence was related to the summer/fall asthma attacks, and visible mold was related to winter and spring asthma attacks [28].

Other studies have suggested that residential characteristics were more important than measured aeroallergen levels. In a study of northeastern home allergen exposures, Chew found that dust dander peaked in the fall months, cat peaked in the winter and spring months and cockroach was highest in the summer. However, the influence of housing type and presence of cats outweighed any affect of seasonal variation. They found that the strongest predictor for dust mite allergen concentration was whether family lived in a house or apartment. Similar presence of cat in the home was a stronger influence than those seasonal differences. In general, season was a weaker predictor of allergen levels than other factors associated with the residence and physical presence of cats in houses [29]. Again in the National Inner City Asthma Study, seasonal pattern of asthma symptoms was not related to atopy, secondhand smoke or air pollutants pattern [30].

A limitation of this study is the small sample size for each seasonal cohort, but the large sample of diary symptoms with daily symptoms collected over an entire year yielded a large number of days to examine. Also, the caregivers were asked to record daily symptoms in a diary which may have led to over- or underreporting. We attempted to minimize this effect by having the CHW collect diaries in person on a biweekly basis so even if caregivers did not keep the diary on a daily basis, at most diaries reflected a 2-week recall. Another limitation is lack of control group, but these findings support a longer randomized control trial. Finally we did not do allergy testing but instead did a generalized low-cost common asthma trigger removal intervention. Tailoring the intervention to the patient may have resulted in higher motivation to remove triggers.

Conclusion

In this inner-city cohort we observed two peaks in asthma symptoms which occurred in the spring and fall. The consistency in findings, regardless of when child enrolled in the study, suggests that this home educational and environmental intervention is effective in reducing asthma symptoms even in peak seasons, although summer enrollment appeared to pay the most dividends. This suggests that the progression of seasonal symptoms that lead to emergency room and hospital visits may be attenuated by environmental and educational interventions in the home. The findings in this study also support previous studies in which multi-trigger approaches to removal of indoor asthma triggers have been shown to be effective in reducing asthma symptoms [14]. Furthermore this suggests that routinely scheduling patients with their primary care physician and providing environmental education in the summer may reduce subsequent hospitalizations and emergency visits during the fall and winter. Future studies should examine these findings and whether implementation of environmental education and interventions in the summer will result in the greatest impact on asthma symptoms and morbidity.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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