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Community health workers providing asthma education

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ABSTRACT

Objectives: Children living in urban areas experience disproportionate rates of asthma. Substandard housing conditions in some urban areas contribute to greater exposure to household asthma triggers. This article examines the geographic connection between pediatric asthma and substandard housing in one mid-sized city in Pennsylvania and the effectiveness of a home-based Community Health Worker (CHW) intervention targeted at this high-risk area to improve families' abilities to manage their children's asthma.

Methods: The CHWs provided education and resources to families of children diagnosed with mild, moderate or severe persistent asthma. A pre and post-test design was implemented to evaluate if the CHW intervention improved the family's ability to successfully manage their child's asthma. Eighty-one patients completed the program over a six-month period.

Results: Results showed significant improvements in the areas of asthma knowledge, fewer missed days of school, fewer days with asthma symptoms, reduction in wheezing and fewer sleep disturbances. There was also a significant decrease in the number of Emergency Department visits and hospital days.

Conclusions: By teaching asthma management skills and by addressing in-home triggers, home-based CHW led interventions can be an affordable and effective way for caregivers and children with asthma to improve asthma management.

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Introduction

Asthma is one of the most common chronic diseases in childhood (1), with the Center for Disease Control (CDC) estimating the pediatric prevalence in the United States at 8.4% (2). In the state of Pennsylvania, this prevalence is estimated to be 9.4%, and in Lehigh County there are a reported 7,250 children diagnosed with asthma (3). Uncontrolled pediatric asthma can significantly impact a child's overall health and quality of life (QOL) (4,5), including a higher likelihood of school absenteeism (6), outpatient doctor visits, emergency department visits, and hospitalizations (7–9). For parents, this can equate to missed work, lost wages, and increased risk of unemployment as well as higher health care costs (5,10). Despite the challenges of chronic, persistent asthma, there is a strong evidence base for short-term interventions that equip patients and caregivers with the knowledge and tools to manage asthma better and improve outcomes. This article adds to this evidence base, highlighting a

home-based, Community Health Worker intervention implemented in an urban area. A geospatial analysis perspective was used to target the sample population with the aim of improving pediatric asthma control.

Evidence-base of effective pediatric asthma interventions

Effective pediatric asthma intervention models provide education and care coordination as well as address asthma triggers in the home. Healthcare systems in numerous major cities have well-established asthma intervention programs, including the Boston Children's Hospital Children's Asthma Initiative (11), the Healthy Neighborhoods Program in NY State (12), The Chicago Plan (13,14), and the Community Asthma Prevention Program at the Children's Hospital of Philadelphia (15,16). These programs focus on patients living in low-income neighborhoods, where the quality of housing is typically poorer, with

increased household asthma triggers such as dust, mold, and pests.

Some interventions utilize a home-visiting approach, deploying Community Health Workers (CHWs), or other lay providers, to provide asthma education and teach management techniques in the home as well as connect families to community resources to address their health and social needs (14,17). The effectiveness of CHWs is based on their ability to build trusting relationships with patients that result in patients being able to effectively advocate for themselves and improve their life and health outcomes (13,14,18,19). Positive health impacts of these CHW-led interventions include reduced exposure to triggers (12–14), improved inhaler technique (13), reduction in emergency department utilization (11,13,14,19,20), and reduction in asthma hospitalizations (11,19). Improvements in quality of life (QOL) for both child and caregiver are reflected by fewer missed days of work and school and fewer activity limitations for children (13,14,19,20). In addition, these approaches have been shown to be cost-effective (17,21). One study noted saving \$5.58 in health care costs for every dollar spent on the intervention (22); another study found a \$2.04 return on investment (ROI) for pediatric patients served (23).

Understanding the relationship between asthma and housing conditions through geography

Geographic spatial analyses of data can identify differences in neighborhood characteristics and health outcomes between geographic areas such as cities, zip codes, or census tracts. Research shows that the average life expectancy of individuals varies by community; people living just a few blocks apart may have radically different life expectancies. These differences are partly based on characteristics of their neighborhoods, including quality of housing (24). About 33.75% of the US population, including one third of Pennsylvanians, live in substandard housing conditions, defined as, “owner- and renter-occupied housing units having at least one of the following conditions: 1) lacking complete plumbing facilities, 2) lacking complete kitchen facilities, 3) housing 1.01 or more occupants per room, 4) selected monthly owner costs as a percentage of household income greater than 30%, and 5) gross rent as a percentage of household income greater than 30%” (25). Given the adverse effects that household triggers such as dust mites and mold have on asthma control and the increased prevalence of these triggers in substandard

housing, identifying the neighborhoods with a high rate of substandard housing conditions can assist with identification of patients who are at increased risk of having poorly controlled asthma.

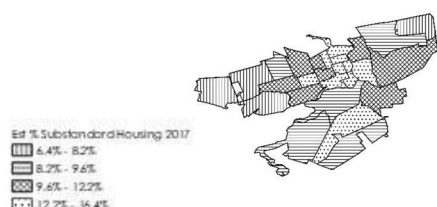
Therefore, a geospatial framework was used to investigate the connection between asthma, housing conditions and health outcomes in Allentown, Pennsylvania. Maps a-c in [Figure 1](#) highlight three key indicators of the population in Allentown. Substandard housing rates in Allentown exceed both state and national levels at 47.37% (25) (Map a). Map b ([Figure 1](#)) displays the Childhood Opportunity Index (COI), an index reflecting socioeconomic and health outcomes for children living within defined communities or urban areas (26). The COI map for Allentown indicates a lower childhood opportunity, particularly in the center city area. Map c, which displays pediatric asthma prevalence rates by block group in Lehigh County, indicates spatial disparities in asthma prevalence, with higher prevalence subgroups in Allentown center city. Maps a & b show the overlapping occurrence of poorer housing conditions and poorer socioeconomic opportunities in Allentown. Map c shows a higher prevalence of childhood asthma in those same overlapping areas within center city Allentown, suggesting a prime geographic area for an asthma control intervention.

Pilot intervention

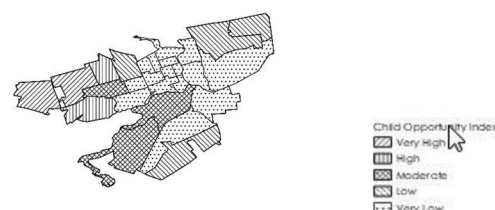
This identified intervention area became the focus of a targeted, CHW-led intervention for pediatric asthma patients and their families. The Community Asthma Education Program (CAEP) was a home-based intervention in which CHWs provided asthma education and resources to families of children diagnosed with mild, moderate, or severe persistent asthma. The Children’s Clinic, associated with Lehigh Valley Children’s Hospital (LVCH) provides medical care to children in Allentown, the majority of whom have Medicaid insurance, and provides specialized care for children with asthma. In 2017, LVCH had 12 275 pediatric patients who were diagnosed with asthma from a 5-county region in northeast Pennsylvania (LVCH’s catchment area). Just under 16% of these patients ($N=1,925$), the highest percentage of patients from any one city or town on the registry, resided in the city of Allentown, mainly within three zip codes.

Pediatric patients residing in Allentown who received their asthma care from this Children’s Clinic or were referred to the pediatric pulmonology practice were offered the intervention. [Figure 1](#) Map d shows a

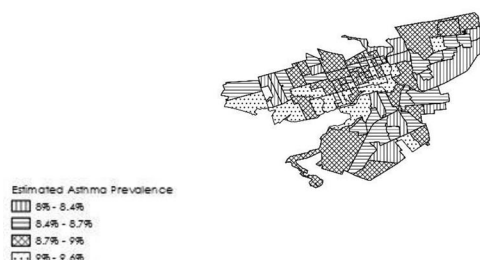
Map a. Substandard Housing by Census Tract in Allentown



Map b. Child Opportunity Index by Census Tract Allentown



Map c. Pediatric Asthma Prevalence by Block Group in Allentown



Map d. Optimized Hot spot analysis of patients enrolled in CAEP

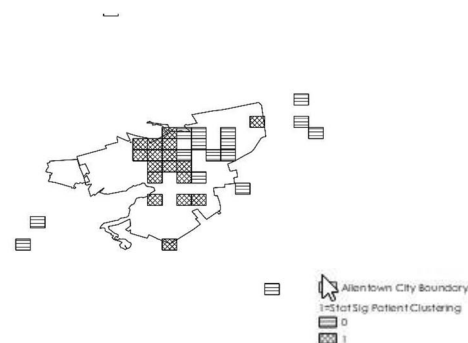


Figure 1. Maps a-d are of the city of Allentown, displaying four interrelated factors that influenced the target area for the intervention. Maps a & b show the overlapping occurrence of poorer housing conditions and poorer socioeconomic opportunities in Allentown, and Map c highlights the higher prevalence of childhood asthma in the same areas within downtown Allentown, suggesting a prime intervention area (Map d).

cluster analysis of addresses for patients who participated in CAEP. The cluster analysis indicates a statistically significant concentration of families residing in center city Allentown, more specifically, in the area identified in Maps a and b as having a higher prevalence of poorer housing conditions and lower COI.

Three Community Health Workers provided the intervention. The CHWs all lived in Allentown, as lived experience in the community wherein the CHW is working is key to the effectiveness of the CHW role. Two of the CHWs were female and one was male. They were all hired within the healthcare network as a general CHW because of their background and experience with community resources. Through national asthma organizations, on-site training, and direct observations, they were trained in asthma education specifically for this program. All three CHWs were also bilingual, enabling them to easily serve the large Hispanic population within Allentown.

Once a family was enrolled, CHWs met with the caregiver in the home over four sessions. During these home visits, the CHW discussed the following educational topics: asthma symptoms, common asthma

triggers and steps to avoid them, the different types of medications that can be prescribed and their purpose (controller vs. quick-relief), potential side effects of asthma medications, how to promote the child's physical activity and maximize daily functioning, and indications for calling the primary care doctor or seeking emergency care. The educational curriculum was based on LVCH's educational standards and utilized the *Breathing Free* book (27), a low literacy book geared toward parents of children with asthma. In addition, the CHW reviewed the details of the asthma care plan provided by the practice and demonstrated proper medication administration. The caregiver and patient then practiced administering the asthma medication with supervision by the CHW. Finally, the CHW confirmed with the family that the prescribed medications were covered by their insurance and obtained from the pharmacy. Discrepancies in coverage or availability were communicated back to the prescribing medical provider.

Families had the option of receiving two additional home visits to assess for asthma triggers in the home environment, including dust, mold, pests, chemicals,

pets, or secondhand smoke exposure. CHWs provided instructions and supplies (e.g. natural cleaning supplies, mattress/pillow covers, and plastic bins) directed at minimizing these triggers during the first home assessment and then evaluated improvements during the second assessment a month later.

Methods

A pre-post design was implemented to evaluate the intervention. Caregivers enrolled in CAEP completed a pretest at the time of intake and a post-test about two months later upon completion of the four in-home education sessions.

Sample

A total of 142 families participated in the CAEP program between June 2016 and April 2017. This analysis presents findings for 81 families who completed the CAEP program, including the pre- and post-measures (57%). For each family who participated in the program, there was one target child who was the focus of the intervention and about whom the program measures were completed (referred to as the patient moving forward). Table 1 presents a summary of the demographic and other characteristics for the sample. The majority of enrolled patients had mild or moderate persistent asthma and were between the ages of 1 and 3 or 10 and 12 years old. Forty percent of the patients were recruited from the pediatric clinic and 41% were referred from the pediatric pulmonology practice. Sixty-six percent of patients completed the education sessions as well as the two home assessment visits. The remainder received only the education sessions.

Measures

Assessments were based on publicly available tools used in other published pediatric asthma initiatives.

Asthma knowledge test (AKT)

The AKT is a 17-item multiple choice questionnaire, based on the education provided in the home and in the *Breathing Free* book (27), that assessed knowledge of asthma triggers, medication administration, and symptom recognition and management. Caregivers received one point for every correct answer, resulting in a total score ranging from 0 to 17.

Table 1. Demographics ($n = 81$).

Indicator	Variable	n	%
Age	1-3	27	33.3
	4-6	11	13.6
	7-9	15	18.5
	10-12	20	24.7
	13-15	8	9.8
Practice	The Children's Clinic	40	49.4
	Pediatric Pulmonology	33	40.7
	Other	8	9.8
Asthma Severity	Intermittent	1	1.2
	Mild Persistent	23	28.4
	Moderate Persistent	55	67.9
	Severe Persistent	1	1.2
	Unspecified Persistent	1	1.2

Missed school or work days

Caregivers self-reported the number of missed days of school/daycare or work due to asthma in the last 30 days.

Asthma control test (ACT)

The ACT is a well-established tool consisting of a five-point Likert Scale (28). This five-item measure assessed frequency (i.e. the number of days in the past month) of asthma symptoms and frequency with which asthma symptoms impacted the child's sleep and activity levels. Scores range between five and twenty-five, with scores of nineteen or less indicating that the patient's asthma may not be adequately controlled.

Healthcare utilization

Emergency Department visits and hospital stays were documented from the electronic medical record for all patients in the study for the six months prior to their enrollment date (pre) and for the six months after (post) their program participation ended, beginning at the date of program completion.

Pediatric asthma caregiver's quality of life (PACQOL)

Caregiver Quality of Life was measured using an adapted version of a standard measure developed by Juniper et al. (29). The measure includes 13 questions with the first nine questions addressing the degree to which the child's asthma had interfered with the caregiver's normal daily activities and the last four questions assessing the caregiver's level of concern regarding the impact of asthma for his/her child. Questions are answered on a scale of 1 to 4 with higher scores reflecting less impairment. An average total score is calculated for the measure.

Table 2. Asthma intervention evaluation metrics ($n = 81$).

Measure	Variables	Mean Pretest	Mean Post-test	t	df	p
Asthma Knowledge Test	Knowledge	14.24	16.15	−9.45	78	.001*
Missed Days of Work and School	School	1.62	.56	2.63	71	.011*
	Work	.78	.31	1.64	70	.106
Asthma Control Test	Experience asthma symptoms	7.15	3.26	4.93	77	<.001*
	Wheeze during the days because of asthma	4.38	2.32	2.60	77	.011*
	Wake up during the night because of asthma	4.37	1.32	4.10	77	<.001*
	Slow down or stop play or activity because of asthma-related symptoms	5.23	2.78	2.37	77	.02
	Use the rescue inhaler or nebulizer treatment	9.78	7.96	1.03	77	.31
Healthcare Utilization	Emergency Department Visits	1.3	0.74	2.68	57	.01*
	Hospital Admissions	0.85	0.10	6.49	38	<.001*
PAC-QOL	Quality of Life	2.03	1.96	1.86	63	.07

Home assessment

The home assessment is a 35-item questionnaire, based on a number of publicly available home assessments (30–32), consisting of multiple choice and yes/no questions related to environmental housing conditions which can trigger asthma symptoms. Responses were recorded based on caregiver report and CHW observation. A selection of six questions was analyzed for this evaluation.

Statistical analysis plan

Frequency and percentages were calculated to determine the demographic information of intervention participants. Paired sample t-tests were conducted to examine changes in knowledge, medication adherence, quality of life, asthma control, and healthcare utilization from the beginning (Time 1) to the end (Time 2) of the intervention. When multiple t-tests were being conducted, a Bonferroni correction was used to account for Type I error due to multiple comparisons. A one-way ANOVA was also conducted to compare those who completed and those who dropped out of the program on healthcare utilization before and after the program. Chi-square analyses were conducted to assess the questions on the home assessment.

Results

Caregivers demonstrated a significant increase in asthma knowledge from pre- to post-program enrollment with average scores increasing from 14.2 at Time 1 to 16.2 at Time 2 ($t(78) = -9.45$, $p < 0.001$). The number of missed days of school/daycare for children significantly decreased from 1.62 to 0.56 and the number of days of work missed by caregivers also decreased, although not significantly. See Table 2 for a summary of all analyses.

To test for a decrease in asthma symptoms from before the intervention to after the intervention, five

t-tests were conducted for each of the five questions from the ACT, using a Bonferroni correction ($\alpha = 0.01$). Significant reductions were reported in the number of days that children experienced asthma symptoms ($t(77) = 4.93$, $p < 0.001$), wheezed during the day due to asthma ($t(77) = 2.60$, $p = 0.01$), and experienced asthma-related sleep disturbances at night ($t(77) = 4.10$, $p < 0.001$). The average number of days that children experienced asthma symptoms decreased by more than 50% from pretest to post-test. The number of days a child had to modify his/her play or activity due to asthma and the child's use of rescue inhaler or nebulizer also decreased, but the differences did not reach statistical significance.

Program participants had an average of 1.3 emergency department visits prior to the intervention and 0.74 emergency department (ED) visits after the intervention, a significant decrease ($t(57) = 2.68$, $p = 0.01$). Hospital admissions for enrolled patients significantly decreased from an average of 0.85 admissions in the 6 months prior to the intervention to an average of 0.10 admissions in the six months after the intervention ($t(38) = 6.49$, $p < 0.001$). Notably, about a quarter of participants did not have any ED visits and about half of participants did not have any hospital stays during both the pre- and post-period. In comparing those who dropped out of the program versus those who completed the program, one-way ANOVA analysis did not show a significant difference in terms of ED visits (with both groups decreasing; $F(1,99) = 3.40$, $p = 0.561$), but there was a significant difference in terms of hospital admissions ($F(1, 37) = 5.06$, $p = 0.031$). Those who dropped out of the program had an average of 0.74 admissions 6 months before program involvement, decreasing to 0.21 admissions during the 6 months after leaving the program. Those who completed the program had an average of 0.95 hospital admissions prior to program participation and 0 hospital admissions during the 6 months post program completion. Caregiver quality of life did not

Table 3. Pre- and post-test home assessment data ($n = 35$).

Home Assessment Questions	Pre	Post	χ^2	df	p
Evidence of rodents	23	10	25.64	1	<.001
Evidence of cockroaches	26	7	14.27	1	<.001
Pets in the home	16	15	23.99	1	<.001
Evidence of mold or mildew	15	8	13.83	1	<.001
Child exposed to any second or third hand smoke	14	9	18.17	1	<.001

improve significantly from pre to post-test. Finally, participants showed improvements in 4 of 6 areas within the home assessment: evidence of rodents, cockroaches, mold or mildew, and exposure to second and third hand smoke (Table 3).

Discussion

This two-month, home-based asthma intervention utilizing CHWs to provide individualized asthma education and asthma trigger assessments to families of children with persistent asthma resulted in significant improvements in asthma control. The CHWs were deployed in a diverse urban area with a high proportion of low-income, minority families living in a neighborhood with a high percentage of substandard housing and low Childhood Opportunity Index. GIS mapping revealed that patients were concentrated within that urban area in a smaller hot spot (Figure 1) that has a high prevalence of asthma and the lowest COI (Figure 1).

Despite these barriers, the CHWs effectively intervened by increasing parental knowledge of asthma, reducing exposure to asthma triggers in the home, and improving control of asthma symptoms. Specifically, the frequency of daytime and nighttime asthma symptoms significantly decreased, as did the impact of asthma on the study patients' physical activity. These improvements in asthma control resulted in significantly reduced school/daycare absenteeism and a reduction in health care utilization in the form of emergency department visits and hospitalizations. These findings are in line with a previous meta-analysis of studies looking at the impact of education intervention on pediatric asthma patients' use of acute care (33), which found that education occurring over a number of sessions and individualized to the patient tended to have a greater impact.

This study suggests that, similar to findings by Butz and colleagues (34), Community Health Workers, who live in the same neighborhoods as the patients they serve, can effectively implement educational interventions. Certain components of this intervention, especially those pertaining to the skills of the CHWs, may be particularly important to the success of the program. The CHWs built trusting relationships with the families and, through this relationship,

provided both education and coaching. The CHWs were able to reinforce and further discuss the materials, guidance, and instructions given to the family during the healthcare system visit with a provider, allowing family members to ask questions or clarify instructions. The CHWs coached families to ensure that medications were being given in the correct manner; they provided guidance to minimize triggers in the home; and they provided instruction on specific actions to improve control of the patient's asthma. In addition, they partnered with the medical provider to coordinate care between the home and healthcare environment and served as a liaison between the family and the medical care team.

The evaluation highlighted an improvement in caregiver knowledge of asthma, reduction in home environment triggers, and decreased emergency department visits. These results suggest that behavior modifications occurred in the prevention and/or management of the child's asthma, leading to changes in the home environment that resulted in fewer asthma exacerbations requiring urgent or emergency access to medical care. Utilization of a CHW as a health educator who is embedded in the healthcare system, as compared to other types of health educators, e.g. nurse, social worker, should be validated in future studies.

Limitations to this study include the small sample size. While over one hundred and forty families enrolled in the program, only 57% completed the program. Some families who completed the program declined the home assessment for triggers component, further decreasing the sample size for that analysis. Those who enrolled and completed the program may be a uniquely different group compared to those who dropped out or never enrolled. The lack of data on the comparison group, the drop-out group, is a limitation of the study. There was a significant difference in hospitalizations but not ED visits among those participants who dropped out, compared to those who completed the program. This suggests that for those who dropped out, the intervention was still beneficial; however, this would need to be examined further.

Funding constraints limited the extent of allergen resistant resources that could be provided to intervention families. The grant funding for the program

enabled the CHWs to provide lower cost supplies such as plastic bins, mattress and pillow covers, and natural cleaning supplies. However, it did not enable us to provide HEPA filters for the families nor to conduct high-cost housing renovations to improve the home environment such as mold remediation, which limited the number of triggers that could be addressed completely.

Conclusions

Future directions for home-based asthma interventions utilizing CHWs in our community include expanding the size and geographic location of the patient population and extending the duration of the intervention and follow-up period. CHWs were the core intervention in this program, and further demonstration of the role of a CHW in healthcare as a successful intervention mechanism with low-income, high-risk families will help to validate the trust and rapport-building that is presumed to occur between CHWs and patients. CHWs are a viable healthcare resource to reinforce health messaging, to provide guidance pertaining to chronic disease management in the home environment and to facilitate connections to medical care through the healthcare system when needed. The identification of key indicators are vital to establishing long-term, sustainable strategies for health care systems that reflect both financial and social return on investment and pinpoint behavioral changes that occur within the family unit.

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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 the paper.

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