



Evidence-based pediatric asthma interventions and outcome measures in a healthy homes program: An integrative review

Jeannie K. Giese

To cite this article: Jeannie K. Giese (2018): Evidence-based pediatric asthma interventions and outcome measures in a healthy homes program: An integrative review, Journal of Asthma, DOI: 10.1080/02770903.2018.1472279

To link to this article: <https://doi.org/10.1080/02770903.2018.1472279>



Accepted author version posted online: 03 May 2018.
Published online: 29 May 2018.



Submit your article to this journal [↗](#)



Article views: 48



View related articles [↗](#)



View Crossmark data [↗](#)



Evidence-based pediatric asthma interventions and outcome measures in a healthy homes program: An integrative review

Jeannie K. Giese, DNP, FNP-BC, PPCNP-BC

Belmont University School of Nursing, Nashville, Tennessee, United States

ABSTRACT

Objective: Asthma disproportionately impacts and has poorer outcomes in low-income, minority, and inner-city children. The home environment has a profound impact on a child's asthma. Home-based asthma visits have the potential to positively impact a child's asthma, especially in targeted populations. The purpose of this integrative review is 1.) to explore the effectiveness of home-based education and environmental measures and 2.) to explore specific indicators and tools to measure pediatric asthma control and program effectiveness. **Data Sources:** Medline, CINAHL, and Ovid databases were searched from 2010 to 2017 utilizing the keywords *healthy homes AND asthma* and *home based interventions AND asthma*. **Study Selections:** A total of 71 articles were retrieved of which 27 articles met the inclusion criteria of English language, human subjects, and the inclusion of pediatric populations. Three additional articles were hand-searched from previous references. In total, 30 articles were reviewed. A quality appraisal was conducted utilizing standardized appraisal tools. **Results:** Home-based asthma education and environmental interventions have proven to be effective. The programs reviewed varied in types of interventions, intensity and duration, the type of provider, length of follow-up, and outcome measures. Successful programs were patient-centered, included a home assessment and individualized education and interventions, and were collaborative. Multiple outcome indicators such as health care utilization, asthma control, missed days of school or productivity, asthma symptoms, and verification of environmental remediation have been utilized. **Conclusion:** Home-based asthma programs can be beneficial to children with poorly controlled asthma and have the potential to be cost-effective.

ARTICLE HISTORY

Received 14 December 2017

Revised 31 March 2018

Accepted 29 April 2018

KEYWORDS

Healthy Homes; home based; asthma; pediatric; asthma outcomes; and asthma interventions

Introduction

Asthma is the most common chronic condition of childhood, affecting 6.2 million children in the United States or approximately 8% of the pediatric population (1). Asthma disproportionately impacts and has poorer outcomes in low-income, minority, and inner city populations with a prevalence rate of 13.4% in African American children and 11.1% in children below poverty level (1,2). African-American children are three times more likely to be admitted to the hospital for asthma exacerbations and 2.8 times more likely to die from asthma (1). A child's health is profoundly impacted by their home environment and home life (3). Indoor environmental triggers, indoor air quality, products in the home, home structure, family composition, and knowledge have the potential to either positively or negatively impact a child's asthma.

In 2009, the Surgeon General made a call to action to promote Healthy Homes (HH) (4). The HH initiative has continued to evolve. In 2015, the annual budget for the

HH Program was \$15 million (5). Traditionally, HH programs have focused on lead, asbestos, air quality, injury and fire hazards, water contamination, and allergens. Many HH programs are expanding to include asthma education and interventions within the home. A multifaceted approach including environmental changes, trigger identification and avoidance, and education is needed to positively impact asthma outcomes (3). The Center for Disease Control (CDC) identifies asthma as one of the six most common and costly conditions in the United States (6). Increasing the availability of asthma care that occurs in the home and community must become a priority.

While the need for asthma care in the home and environmental remediation is well documented, delineating which measures are most effective and how to measure their impact is less clear. Health care costs are rising exponentially, and resources are limited. Interventions should be evidence-based, and outcome indicators should be in

CONTACT Jeannie K. Giese ✉ jeannie.giese@belmont.edu Assistant Professor, Belmont University, Inman College of Health Sciences & Nursing, 203-D, 1900 Belmont Boulevard, Nashville, TN 37212-3757, 615-460-6106.

The author is an assistant professor in graduate nursing. Healthy Homes Program, Department of Energy & Environment, Washington, DC. The author is a volunteer consultant.

© 2018 Taylor & Francis Group, LLC

place to measure the effectiveness. The aims of this integrative review are as follows:

1. To explore the effectiveness of in-home education and environmental measures to improve pediatric asthma control; and
2. To explore indicators and tools to measure pediatric asthma control and HH program effectiveness.

Methods

An integrative review was conducted to appraise the evidence related to home-based asthma interventions and outcome indicators. Inclusion criteria included studies related to pediatrics or children; home based; and asthma related interventions, education, or outcomes. Exclusion criteria included adult-only studies. The search was limited to humans and English language. Medline and CINAHL were searched from 2010 to 2017 utilizing the key words *healthy homes* **AND** *asthma*. The Medline search returned 17 articles, of which 13 articles met inclusion and exclusion criteria. The CINAHL search returned 15 articles, of which 9 were duplicates and 6 articles met inclusion and exclusion criteria. Medline and CINAHL were also searched from 2010 to 2017 utilizing the key words *home based interventions* **AND** *asthma*. The Medline search returned 6 articles, of which 2 met inclusion and exclusion criteria. The CINAHL search returned 3 articles, of which 1 article was a duplicate and 1 article met inclusion and exclusion criteria. Ovid database was searched from 2010 to 2017 utilizing the key word *healthy homes*. Twenty-nine articles were identified. Of the 29 articles, four were duplicates and 20 did not meet inclusion and exclusion criteria. Five articles were reviewed from the initial Ovid search. Ovid was also searched from 2010 to 2017 utilizing the key word *home based asthma intervention*. The search returned one article which was a duplicate. The initial appraisal consisted of 27 articles. After reviewing the literature, an additional three articles were hand-searched from previous references. In total, 30 articles were reviewed. Please see [Figure 1](#) for search details.

The evidence was comprised of the following types of articles: 11 health care initiatives or pre-post studies, two case studies, five observational studies, one economic evaluation, one literature review of economic evaluations, two systematic reviews, four articles with background or foundational information, one randomized control trial, and three psychometric analyses. A quality assessment of the articles was conducted utilizing article-specific appraisal tools if available. An article was deemed strong if it met $\geq 75\%$ of the criteria, moderate if it met 50–74%, or weak if it met $< 50\%$ of the criteria. The quality of the health care initiative articles was analyzed

utilizing the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) Statement Checklist (7). Of the 11 articles, three were deemed strong, six were moderate, and two were classified as weak. The case studies were appraised utilizing the CARE Case Report Guidelines checklist or the Consensus Standard for the Reporting of Organizational Case Studies (8,9). One case study was classified as moderate quality and the other classified as weak. The observational studies were critiqued utilizing the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Checklist (10). Two articles were considered strong. Two articles were classified as moderate, and one article was classified as weak. The economic evaluation was appraised utilizing the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) Checklist and was rated as strong evidence (11). The two systematic reviews were appraised utilizing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist and both were critiqued as being strong (12). The randomized control trial was appraised utilizing the Consolidated Standards for Reporting Trials (CONSORT) and was critiqued as being moderate strength (13). Please see [Table 1](#) for detailed information.

Results

Throughout the literature, successful HH programs targeting inner-city children have been documented. However, the programs have often varied in the type of provider for the intervention (nurses, community health workers, or lay persons), types of interventions, intensity and duration of interventions, length of follow-up, and outcome measures (14). Many of the interventions lack clarity in the explanation of interventions and/or education provided. The evidence indicates that HH programs were more likely to demonstrate a positive impact if they were community-centered, clinically connected, collaborative, designed for a specific racial or ethnic group, inclusive of environmental assessments, and provided tailored education and interventions based on the assessment and patient characteristics (14,15). Home-based interventions with multiple components focusing on multiple triggers and containing an environmental focus have proven effective in reducing asthma morbidity (16). Not surprisingly, interventions showed the greatest magnitude of improvement when targeted to individuals with poorly controlled asthma (17). Multiple outcome indicators such as health care utilization, missed days of productivity or school, quality of life, asthma symptoms, asthma control, and implementation of home environmental remediation have been appraised. Please see [Table 1](#) for a review of the studies.

Interventions

Multicomponent interventions

Crocker et al. (2011) conducted a systematic review evaluating the effectiveness of home-based, multi-trigger, multi-component asthma interventions with an environmental focus (16). The review included 23 studies of which 20 studies included pediatric participants. The most common environmental asthma triggers identified included dust, pets, cockroaches, rodents, mold, and irritants such as cigarette smoke. The review included studies with multiple approaches. Twenty-one of 23 studies included a home environmental assessment. Seventy-four percent of the studies incorporated an environmental remediation component ranging from minor to major. Twenty-one percent included some form of education with a focus on environmental remediation

or asthma self-management. The duration of follow-up in the studies varied from 1 to 48 months with the average of 12 months of duration. The authors concluded that home-based, multi-component interventions which included an environmental focus were effective. In the review, children demonstrated a reduction in symptom days by 21 symptom days per year and a reduction in missed school days by 12.3 days per year. The number of asthma acute care visits decreased by 0.57 visits per year. The review also demonstrated a reduction in trigger levels and smoke exposure as well as improved trigger reduction behavior and asthma management behavior. Most of the studies did not report an improvement in physiologic outcomes. The systematic review was well done and included a good representation of minority groups as well as low income, inner-city children.

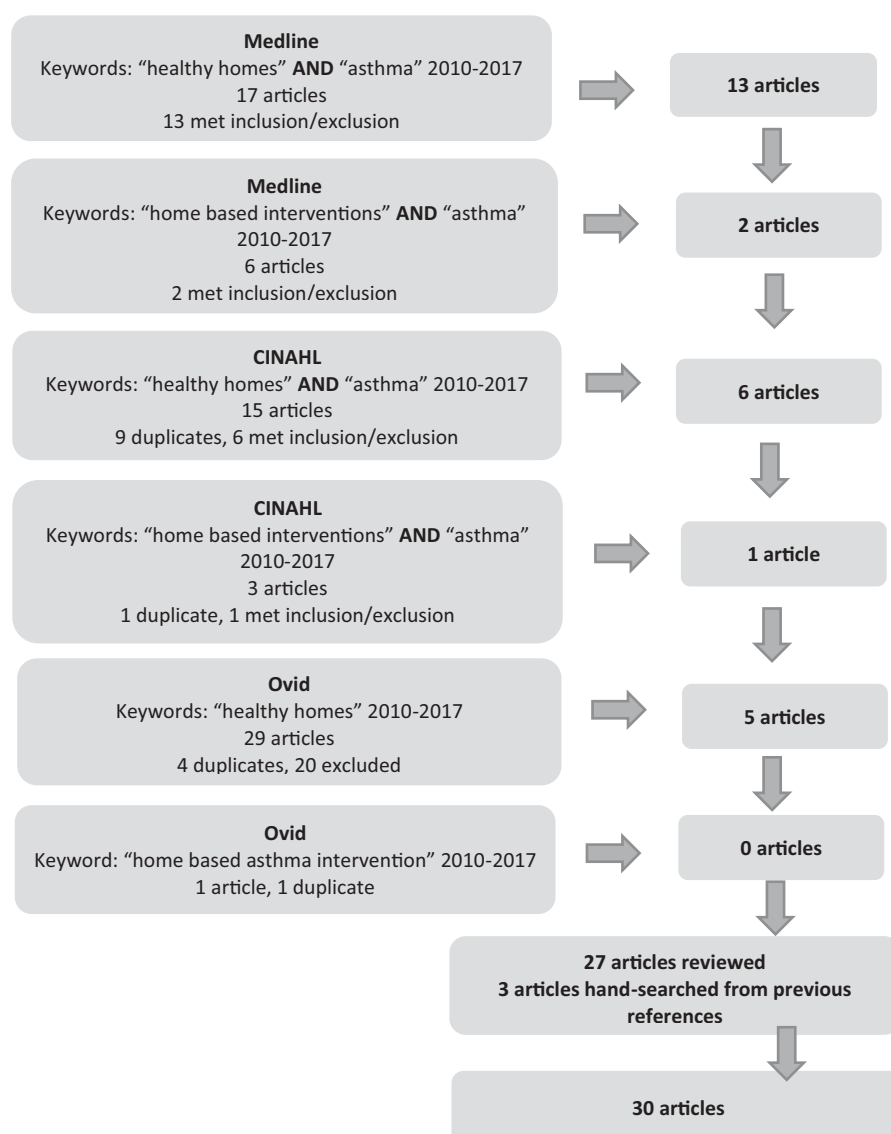


Figure 1. Search Process.

Table 1. Healthy Homes Evidence.

Author	Purpose	Sample	Methodology	Findings	Quality
Alvarez-Chavez et al., 2016	Examining methods to identify allergen sources in the home and relate to a previous clinical study	18 parents of children aged 3–6 years in previous study	Observational; follow-up to a previous study	-Association between the presence of dust in the home and sensitization to <i>dermatophagoides pteronyssinus</i> ($p = 0.001$), Kappa (0.44) moderate association	STROBE- moderate
Ashley 2015	Editorial regarding HH progress and future directions	none	Editorial	Priorities include lead, allergens, mold and moisture, radon, asbestos, indoor air quality, injury, fire hazards, and drinking water. In 2015, annual budget was \$15 million.	Background information
Ashley et al., 2017	Commentary promoting coordinated federal actions to reduce disparities in childhood asthma	None	Commentary	Increased prevalence, morbidity, and mortality of asthma in black, non-Hispanic children and children living in poverty.	Background information
Bryse et al., 2011	Evaluate the effectiveness of “green” renovations in low income housing	3 building, 60-unit apartment complex in southwest Minnesota	Pretest-posttest, health care initiative	-Significant decrease in non-asthma respiratory symptoms found in children ($p = 0.025$) -Homes easier to clean ($p < 0.001$), more comfortable ($p < 0.001$), and safer ($p = 0.008$). – 45% decreased energy use	TREND- weak
Brown et al., 2010	Review federal agency support for HH	Summary of HH activities at the CDC, HUD, EPA, and USDA	Case study	2009- Call to action CDC-incorporates asthma activities and partners with HUD EPA- incorporates some asthma activities EPA-utilizes online pediatric home assessment training	CARE-moderate
Carrillo et al., 2015	-Improve parental knowledge -Identification of triggers and provision of targeted education -Assess behavioral changes	89 parents of children ages 1–17 years with asthma	Longitudinal, non-randomized control trial	-Statistically significant increased knowledge ($p < 0.001$) – 90% made home changes	TREND-strong
Carrillo-Zuniga et al., 2012	Evaluate the effectiveness of an educational HH intervention	115 parents of children ages 3–5 in head start centers	Non-randomized longitudinal, pretest-posttest	– 98.4% made changes to their homes -Statistically significant improvement in knowledge of mold causing asthma attacks ($p < 0.001$), home as shelter ($p < 0.001$), second hand smoke ($p = 0.006$), and pesticide exposure ($p < 0.001$)	TREND-moderate
Clark et al., 2009	Identify characteristics of interventions to improve asthma outcomes	223 programs, both published and unpublished	Program evaluation utilizing structured questionnaires	Characteristics: (1) community based, (2) engaged community-based organizations, (3) integrated with clinical setting, (4) trained health care providers, (5) collaborative, (6) designed for specific ethnic/racial group, (7) individually tailored, (8) conducted environmental assessments	TREND-moderate
Crocker et al., 2011	Evaluate evidence that home interventions to reduce asthma triggers improve outcomes	20 studies (20 pediatric, 3 adult)	Systematic review	In children, symptom days reduced by 21 days per year; missed school days decreased by 12.3 days per year; number of acute asthma visits decreased by 0.57 visits per year	PRISMA-strong

(Continued on next page)

Ellis, D., King, P., & Naar-King, 2015	To assess the impact of Multi-systemic Therapy-Health Care on adolescents' asthma knowledge and competency in the use of asthma medication devices	170 adolescents with moderate to severe asthma	Randomized control trial	-Increased asthma knowledge from baseline to 6 months post intervention ($p < 0.05$) -Increased device skills over time ($p < 0.01$)	CONSORT-moderate
Everhart et al., 2015	Examine caregiver QOL related to asthma control among different ethnicities	94 children aged 6–15 years with persistent asthma and their caregiver	Observational study utilizing questionnaire (PACQLQ)	QOL varied among race/ethnicities. Non-Latino whites had the highest QOL.	STROBE-strong
Gomez et al., 2017	Economic evaluation of a HH asthma intervention	1000 households plus 791 households	Economic evaluation	-Savings of \$2.03 to \$3.58 for every dollar spent -Benefit of \$781 per asthma visit	CHEERS-strong
Herendeen & MacDonald, 2011	North Carolina HH initiative planning	none	Literature review, 3 key informant interviews, review of strategic plan	-Enforceable standards and tracking needed -Process measures: parental empowerment, behavioral change and structural change -Asthma indicators: hospitalizations and missed school days	Consensus Standards for the Reporting of Organizational Case Studies-weak
Hsu, J., Wilhelm, N., Lewis, L., & Herman, E., 2016	Review previous literature regarding economic impact of home-based asthma interventions	17 home-based asthma intervention programs	Literature review of economic impact	-3 years to achieve return on investment -Decrease in asthma related hospitalizations or emergency department visits -14/17 programs reported positive return on investment	Literature review
Largo et al., 2011	Describe and evaluate public health program to decrease asthma symptoms in children	243 low income families with pediatric asthma	Public health program implementation and evaluation	-Improvement in knowledge ($p < 0.001$); fewer reported pets in bedroom ($p < 0.05$); decreased reported mold ($p < 0.001$); decreased reported stuff toys ($p < 0.001$); smoke exposure ($p < 0.05$); use of pillow and mattress encasements ($p < 0.001$) -Statistically significant changes in asthma severity	TREND-strong
Lucio et al., 2012	Investigate the effectiveness of a Spanish asthma and HH training	85 <i>Promotoras</i>	Longitudinal, non-randomized implementation study	-Increase in asthma and HH knowledge ($p < 0.001$) -69% reported household changes at 12 months	TREND-weak
Pacheco et al., 2014	Explore the relationship of race, housing conditions and asthma	140 lower income families with severe asthmatic children	Observations, cross-sectional	-More corticosteroid use in black children ($p < 0.05$) -Greater areas of home safety and maintenance concerns in black and Latino children ($p < 0.01$ and $p < 0.05$)	STROBE-strong
Polivka et al., 2011	Evaluate a HH home visitation program	84 children	Pretest-posttest intervention	Improved asthma trigger knowledge; general knowledge; asthma trigger management; asthma symptoms 2 days/week; symptomatic 2 nights a week; activity limitations; emergency department, urgent care, or acute visits; caregiver QOL; and caregiver self-efficacy (all $p < 0.001$)	TREND-moderate
Reddel et al., 2009	Recommend standardized outcome measures for asthma control, severity, and exacerbations in clinical trials	327 studies reviewed	Narrative literature review and expert panel;	-Symptoms, variable airway obstruction, airway hyper-responsiveness, airway inflammation and risk assessment -QOL is from a patient's perspective. -Not a single "gold standard" -Composite of measures	N/A

(Continued on next page)

Table 1. Continued

Author	Purpose	Sample	Methodology	Findings	Quality
Reddy Gomez, & Dixon, 2017	Evaluate the impact of a HH program on asthma outcomes and the impact of different strategies	1465 adults and children	Pretest-posttest intervention	-Change in asthma trigger score ($p < 0.001$) -Significant improvement in self-management strategies and health care access measures -Greatest improvement in those with poorly controlled asthma	TREND-moderate
Sunshine, Song, & Krieger, 2011	Measure the association between AAP use and improved asthma outcomes	251 children from a previous RCT	Longitudinal quasi-experimental as well as a cross-sectional analysis of secondary data	No significant differences in asthma control, asthma caregiver QOL, or urgent care utilization	TREND-moderate
Sweet et al, 2013	Explore the impact of a HH intervention	115 participants	Pre-post evaluation study	-Significant improvement in 7 of 9 caregiver QOL items ($p < 0.001$) -Significant improvement in symptom days, nighttime awakenings, emergency department visits, and number of missed school days ($p < 0.001$) -Significant improvement in asthma management behaviors ($p < 0.001$)	TREND-moderate
Turcotte et al, 2014	Evaluate health outcomes associated with a HH intervention	116 low- income households with 170 asthmatic children	Observational study of before and 11–12 months after a public health intervention	-Significant improvement in CHSA scores and reduced health care utilization, medication use, emergency department use, hospitalizations, and doctor's visits -Net savings estimated at \$821,304 over 1 year	TREND-strong
Vesper et a., 2013	Quantify mold exposure in asthmatic children's homes in 3 geographically diverse cities	229 children's homes in 3 cities plus an additional 84 homes from HH survey	Observational	-Significantly higher average ERM1 in homes of asthmatic children -Average asthmatic child in these cities living with a high ERM1 - <i>Aspergillus niger</i> associated with asthmatic children's homes in all 3 cities	STROBE-weak
Welsh, E. & Hasan, M, 2013	Review the effectiveness of home-based asthma educational interventions for children and caregivers	12 randomized control trials; 2342 children ages 2–18	Systematic review	Inconsistent evidence for home-based asthma education	PRISMA-strong
Weitzman et al., 2013	Discuss the importance of home in children's lives	Number of articles not stated	Literature review	Profound impact on a child's health	Background information

Abbreviations: CHSA, Children's Health Survey for Asthma; HH, Healthy Homes; CDC, Center for Disease Control; HUD, U.S. Department of Housing and Urban Development; EPA, Environmental Protection Agency; USDA, United States Department of Agriculture; QOL, Quality of Life; PACQLQ, Pediatric Asthma Caregiver Quality of Life Questionnaire; ERM1, Environmental Relative Moldiness Index.

Education

In the 2011 systematic review by Crocker et al, the educational interventions varied in type and intensity (16). Some studies placed more emphasis on environmental remediation education and others more emphasis on asthma self-management. Studies that included 4 or more home visits reported slightly greater improvement in QOL, health care utilization, and productivity.

Welsh & Hasan conducted a 2013 systematic review of 12 randomized control trials, which included a total of 2,342 children (18). This systematic review evaluated the effectiveness of home-based asthma education alone for children and caregivers. The primary outcomes evaluated were emergency department visits and exacerbations requiring oral corticosteroids. Secondary outcome measures included functional health status, hospitalizations, missed school and work days, and lung function. Eight studies included four to six home visits, and one study included eight visits. Three of the randomized control trials evaluated only consisted of one to two home education visits. Follow-up ranged from 3 to 24 months. All of the programs included basic asthma education and asthma self-management strategies as well as a review of asthma medications and inhaler technique. The review did not demonstrate a significant difference in the primary outcomes of emergency department visits and systemic corticosteroids. The review also did not find a significant difference in quality of life, symptoms, or days missed from school. One study in the review found a decrease in hospitalizations at 24 months. Overall, the authors found the evidence to be very inconsistent and heavily dependent on the context such as type and intensity of education. This systematic review was very well done.

A randomized control trial by Ellis, King, and Naar-King evaluated the impact of asthma education combined with a Multisystemic Therapy (MST) approach in a high-risk group of African-American children with poorly controlled asthma (19). MST incorporates education with cognitive behavioral training and empowerment of the youth as well as the caregiver. The study found a significant improvement in asthma knowledge and inhaler device skills for the treatment group. Limitations of the study include the lack of objective measures and lack of generalizability.

Other literature included educational interventions ranging from one to nine sessions and encompassing a range of curricular content. Many successful programs customized their education based on the patient's home and asthma trigger assessment (14,20–22). Turcotte et al. conducted four to nine educational visits lasting one to two hours each. Home health assessment workers provided the education which focused on recognition and avoidance of asthma triggers (22). Polivika et al.

utilized health educators to conduct one personalized education session lasting two to three hours (14). The session included standardized information regarding general asthma knowledge in written and verbal format as well as demonstrations. Community health workers later followed up at two and six weeks intervals to reinforce the progress. Sweet et al. employed public health nurses to provide tailored education and a “Healthy Homes Action Plan” detailing methods to reduce asthma triggers (21). They conducted one to two follow-up visits in two-week intervals. In another study, community health workers known as *promotoras* were utilized to provide one linguistically and culturally competent 60-minute session based on the “Asthma and Healthy Homes” curriculum certified by the Texas Department of State Health and also content from the Seven Principles of Healthy Homes (23). A shortened version of the “Asthma and Healthy Homes” curriculum was also implemented with parents of children in head start (24). The curriculum was shortened to 45 minutes and still focused on asthma signs and symptoms, disease management, trigger identification and avoidance, and proper use of asthma medications. In another study, Largo et al. conducted four sessions within six months regarding trigger identification and exposure reduction (25). All of these programs demonstrated positive asthma outcomes. However, the studies varied greatly in the education provided, intensity of the intervention, the provider of the intervention, and the asthma outcomes measured. The studies were pre-post studies following public health interventions and lacked randomization and control. Please see Table 1 for detailed information.

Most programs incorporated general asthma knowledge and asthma trigger awareness and avoidance (14). Self-management strategies such as the importance of daily preventative medications, inhaler use, peak flow monitoring, and the importance of regular preventative appointments were emphasized. Sunshine, Song, and Krieger evaluated the impact of asthma action plans (AAP) on asthma control, caregiver quality of life, and health care utilization (26). They did not find that AAP use was associated with improved outcomes.

Environmental assessments and interventions

Successful HH programs reviewed in this study consisted of an individualized home environmental assessment and remediation component (15). *Aspergillus niger*, a mold, in the home has been significantly associated with asthma exacerbations in children (27). The presence of excess dust in the home has been associated with sensitization to *Dermatophagoides pteronyssinus* (28). Structural and ventilation deficits potentially can be directed to landlords and housing authorities to oversee remediation. Many home environmental measures

proven effective and utilized in the studies reviewed were lost low-cost and simple to implement. The interventions included the following: mattress and pillow encasements; HEPA vacuums and air filters; decreased tobacco smoke exposure; pest and cockroach management; and safe household cleaning products (29). Breysse et al. evaluated the impact of “green” and healthy home renovations in low-income housing (30). They reported a significant decrease in nonasthma respiratory illnesses in children ($p = 0.025$). Overall, interventions did not have to be expensive to be impactful. Crocker et al. found that the level of the environmental intervention impacted the amount of change in QOL and health care utilization (16). Moderate remediation generated the greatest improvement in QOL, and as the extensiveness of the environmental remediation increased, health care utilization decreased. Please see Table 1 for detailed information.

Indicators and outcomes

Herendeen and MacDonald suggested that outcome measures should focus on parental empowerment, behavior changes, and structural changes as well as asthma indicators (29). Indicators and outcomes reviewed in this study included economic indicators, environmental outcomes, productivity, health care utilization, knowledge, asthma control, and quality of life. Many of these indicators rely on parental self-report versus objective measures.

Economic impact

Three studies examined the economic impact of home-based asthma interventions. Turcotte et al. enrolled 116 households with 170 asthmatic children in a home-based remediation study (22). They estimated net savings of \$38 522 for the four-week period and \$821 304 savings over 12 months (22). In a 2011 literature review conducted as an initiative plan for a HH program in North Carolina, cost savings of \$2.03 to \$3.58 for every dollar spent on implementation of a HH asthma intervention were found (28). A more recent 2016 narrative review examined 17 home-based intervention programs (31). Fourteen of the 17 studies found a positive return on investment. Most of the savings were related to a decrease in hospitalizations and emergency department visits. A few programs only observed a positive return on investment for those participants with a history of higher health care utilization. Three years was the median time to achieve a positive return on investment.

Environmental outcomes

The assessment of environmental changes included direct visualization of home remediation as well as reported household changes (25, 32). The changes encompassed

structural repairs to remediate ventilation and mold issues as well as noncomplex measures such as pest management. Several studies examined reported changes in the use of pillow and mattress encasements, limiting pets in bedroom, decreased smoke exposure, changing air filters regularly, decreasing clutter, and cleaning more frequently and with fragrance-free cleaners (21,24,25,32).

Productivity

A few studies utilized productivity as an indicator of program effectiveness. In the 2011 systematic review by Crocker, missed school days were decreased by 12.3 days per year (16). Sweet et al. also found a statistically significant decrease in missed days of school ($p < 0.001$) (21). Other productivity indicators included parental missed work days and activity limitations.

Health care utilization

Health care utilization measures included emergency department visits, hospitalizations, and unscheduled acute care visits for asthma. The HH intervention evaluated by Turcotte et al. found significant improvements in all three (22). Crocker et al. found that acute asthma visits decreased by 0.57 visits per year (16). Polvika et al. found a statistically significant decrease in emergency department, urgent care, and acute visit ($p < 0.001$) post implementation of the home-based asthma intervention (14). A decrease in emergency department visits ($p < 0.001$) was also found in the HH intervention by Sweet et al (21).

Knowledge

Several studies in this review evaluated improved asthma knowledge as an outcome (19,21,24,25,32,33). Only one of these studies was a randomized control trial (19). The authors found improved knowledge and device skills after an educational program including a behavioral training component in adolescents. Most studies focused on generalized asthma knowledge, device skills, trigger knowledge, trigger management, and asthma self-management. The studies were mostly pre-post public health interventions, and the methods of knowledge assessment varied greatly and lacked validated measurement tools (19,21,24,25,32,33).

Asthma control

Historically, there has not been a gold standard for the assessment of asthma control (34). Typically, asthma control has encompassed symptoms, airway obstruction, airway hyper-responsiveness, and airway inflammation. There has been a shift in recent guidelines to incorporate risk assessment. Great variability in the measures utilized to signify asthma control in the home-based studies was noted. Asthma disability and symptoms were

often assessed with a self or parental reported recall of one to four weeks' duration. Symptoms included nighttime awakenings, reported wheezing, shortness of breath, days with activity limitations, rescue inhaler use, chest tightness, and cough (14,25). Asthma control diaries did not provide more information than an administered questionnaire, and parents often under-reported symptoms (34). While pragmatic, self-report lends itself to both under- and over-reporting of disability and symptoms. Several different validated tools were utilized in the evidence reviewed for assessment of asthma control. The tools included the following: Children's Health Survey for Asthma (CHSA); Juniper's Asthma Control Questionnaire (ACQ); Asthma Control Test (ACT); and the Asthma Therapy Assessment Questionnaire (ATAQ) (34–39). Please see Table 2.

The impact of HH programs on asthma control was inconsistent between studies. Three studies reported a decrease in asthma symptom days ((14, 16, 21). Two studies reported a decrease in nighttime awakenings (14,21). Turcotte et al. reported improved CHSA scores (22). Only one study reviewed did not find an improvement in asthma control (26).

Quality of life

Asthma-related quality of life for the child and/or the parent, which is more of a global measure from their perspective, was also evaluated in a few of the studies (21,26). Two studies found improved caregiver quality of life post intervention ((14, 21). One study reviewed did not find improved caregiver quality of life. None of the studies reviewed examined the quality of life strictly from the child's perspective. Three validated tools were identified to evaluate quality of life. The CHSA includes components of emotional health for both the child and the caregiver. The Pediatric Asthma Quality of Life Questionnaire (PAQLQ) examines the child's quality of life (38). The Pediatric Asthma Caregiver Quality of Life Questionnaire (PAQLQ) is a validated tool to evaluate the caregiver's perspective (39). Please see Table 2.

Discussion

The United States spends \$56 billion per year on asthma, and asthma is the third leading cause of hospitalization among children less than 15 years of age (40). The CDC identifies three broad aims to decrease hospitalizations and emergency department visits as well as improve asthma outcomes. The aims include improving clinical asthma management; improving personal asthma management; and improving home environments. Asthma self-management education and home visitation programs have the potential to yield a positive return on investment (41). The evidence in this review

reinforces the potential of home-based asthma interventions when education and environmental components are combined. Two systematic reviews were included in this integrative review (16,18). Welsh and Hasan did not find consistent evidence of effectiveness of home-based asthma programs that only included an educational component (18). The systematic review by Crocker et al. evaluated 20 studies which incorporated multiple components such as environmental and self-management education, environmental assessments and remediation, asthma education, social services, and care coordination (16). They did demonstrate a decrease in symptom days, school absenteeism, and acute asthma visits. Asthma self-management approaches should be designed based on the needs of the child and the intensity of those needs. Children with moderate-to-severe asthma, which is not controlled through self-management education and high quality medical care, may benefit from home visits (41). Ideally, the home visits include a home assessment as well as self-management asthma education and interventions based on the assessment and tailored to the child and parents. Home visits may also help connect the parent and child to needed social services and possibly provide low-cost interventions and remediation. Home visits may be conducted by a wide range of qualified providers including nurses, asthma educators, respiratory therapist, and trained community health workers and may range from one to multiple visits.

Currently, most HH visitation programs are funded through public health and foundational grants which vary from year to year (41). The variability in available funding has the potential to jeopardize the long-term sustainability of HH programs. In order to remain sustainable, HH programs must effectively manage their resources; utilize evidence-based interventions; utilize a variety of qualified providers; collaborate and share resources across public and private sectors; establish and monitor outcome measures; and seek additional reimbursement from other sources such as Medicaid and private insurers.

In general, the current evidence on HH asthma interventions varies greatly in interventions provided, intensity and duration, provider of intervention, outcomes measured, and consistency of results. While promising, more research is needed including randomized control trials incorporating multiple components such as education, care coordination, and environmental remediation. Future studies should evaluate multiple outcomes such as productivity, economic indicators, environmental indicators, health care utilization, quality of life, and asthma control. Validated measures such as CHSA, ACQ, PAQLQ, PACQLQ, Asthma Control Test (ACT), and Asthma Therapy Assessment Questionnaire (ATAQ) should be utilized when possible.

Table 2. Pediatric Tools.

Tool	Measure	Ages	Items	Developer/Validation
Children's Health Survey for Asthma Child version (CHSA-C)	Physical health, child activities, emotional health	7–16 years	21 items total	American Academy of Pediatrics Internal consistency: $\geq .70$ (32) Test-retest: .83–.89 (32) Intraclass correlation coefficients: .88–.91 (32)
Children's Health Survey for Asthma (CHSA)	5 domain scores: physical health, activity (child), activity (family), emotional health (child), and emotional health (family)	Parents of children ages 5–12 years	46 items	American Academy of Pediatrics Internal consistency: .81–.92 (30) Test-retest: .62–.86 (30)
Asthma Control Questionnaire	Asthma control	Aged 6–17 Aged 6–10 years- interviewer asks questions	7 items: 5 symptom control questions, 1 FEV1%, 1 rescue inhaler use; abbreviated version available without FEV1% or rescue inhaler use; scored 0–6	Juniper Validated and reliable (31) Intraclass correlation coefficient: 0.79 Responsive to change in asthma control ($p = 0.026$)
Pediatric Asthma Quality of Life Questionnaire (PAQLQ)	Child asthma related quality of life (symptoms, activity limitations, and emotional function)	7–17 years Child self-administered version and interviewer administered version	23 items original, scored with 7 point Likert scale; mini version with 13 questions available	Juniper Able to detect QOL changes ($p < 0.001$) (33) Able to differentiate those patients from those who remained stable ($p < 0.001$) (33) Reproducible (CI = 0.95) (33)
Pediatric Asthma Caregiver Quality of Life Questionnaire (PA CQLQ)	Caregiver QOL (activity limitations and emotional function)	Caregivers	13 items, scored with 7 point Likert scale	Juniper Able to detect QOL changes and able to differentiate ($p < 0.001$) (34) Reproducible (CI = .84) (34)
Asthma Control Test (ACT)	Asthma control	12 years and older	5 items, scored on 1–5 scale then summed (total 5–25)	Developed by Nathan et al. (29) Validated against specialist ratings, spirometry, and QOL (29)
Asthma Control Test Child Version (C-ACT)	Asthma control	Children aged 4–11	4 items for the child plus 3 items for the parents (range 0–27)	Developed by Nathan et al. (29)
Asthma Therapy Assessment Questionnaire (ATAQ)	Asthma control for health utilization and planning purposes	Child and adolescent version available	4-item control questions plus a longer questionnaire about barriers to asthma management	Developed by Vollmer et al. (29) Validated against QOL instruments (29)

This integrative review encompasses a broad range of literature from public health journals, environmental journals, and asthma specialty journals. The articles underwent a quality appraisal utilizing standardized tools, and over 75% of the articles reviewed appraised as strong or moderate quality. The review is limited in that only two systematic reviews and one randomized control trial were included. Most of the articles included in the review were pre-post studies from public health interventions and as such lack the rigor and the strength of randomized control trials. There are multiple inconsistencies in program components, intensity of interventions, provider of interventions, follow-up, and evaluation methods. Also, many of the outcome indicators are based on self-report rather than objective and/or validated measures.

Conclusion

Home-based asthma education and environmental remediation programs have the potential to improve asthma outcomes. Programs have often varied in interventions, implementation methods, and outcome measures. Home visitation programs can be beneficial to children with uncontrolled asthma and have the potential to be cost-effective. However, more research is needed. Interventions must be evidence-based, and programs must consistently track outcomes, preferably utilizing standardized and validated measures. Further studies are needed evaluating the economic impact of HH programs. Establishing a positive performance history and documenting cost-effectiveness will enable stakeholders to engage Medicaid and other potential payers and help ensure sustainability of the programs.

Acknowledgements

The author would like to thank Lisa Gilmore, Branch Chief, Lead-Safe and Healthy Housing Division, Department of Energy and Environment, Washington, DC.

Declaration of interest

The author reports no conflicts of interest. The author alone is responsible for the content and writing of the paper.

References

1. Most Recent Asthma Data [Internet]. 2015 [cited September 18, 2017].
2. Organization PA. The burden of children's asthma: What asthma costs nationally, locally and personally. http://www.pediatricasthma.org/about/asthma_burden2017.
3. Weitzman M, Baten A, Rosenthal DG, Hoshino R, Tohn E, Jacobs DE. Housing and child health. *Curr Probl Pediatr Adolesc Health Care*. 2013;43(8):187–224. doi:10.1016/j.cppeds.2013.06.001. PMID:23953987.
4. Brown MJ, Ammon M, Grevatt P. Federal agency support for healthy homes. *J Public Health Manag Pract: JPHMP*. 2010;16(5 Suppl):S90–S3. doi:10.1097/PHH.0b013e3181dddf63d. PMID:20689381.
5. Ashley PJ. HUD's Healthy homes program: progress and future directions. *J Environ Health*. 2015;78(2):50–53. PMID:26502568.
6. Ashley PJ, Freemer M, Garbe P, Rowson D. Coordinated federal actions are needed to reduce racial and ethnic disparities in childhood asthma. *J Public Health Manag Pract: JPHMP*. 2017;23(2):207–209. doi:10.1097/PHH.0000000000000541. PMID:28121772.
7. Des Jarlais DC, Lyles C, Crepaz N, Group TT. Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: The TREND statement. *Am J Public Health*. 2004;94:361–366. PMID:14998794.
8. Rodgers M, Thomas S, Harden M, Parker G, Street A, Eastwood A. Developing a methodological framework for organizational case studies: A rapid review and consensus development process. *Health Services and Delivery Research [Internet]*. NIHR J Library. 2016. doi:10.3310/hsdr04010.
9. Riley D, Barber M, Kienle G, Aronson J, von Schön-Angerer T, Tugwell P, Kiene H, Helfand M, Altman DG, Sox H, et al. CARE Guidelines for case reports: Explanation and elaboration document. *J Clin Epidemiol*. 2017;pii: S0895-4356(17)30037-96. Epub May 18, 2017. doi:10.1016/j.jclinepi.2017.04026. PMID:28529185.
10. von Elm E, Altman D, Egger M, Pocock S, Gøtzsche P, Vandenbroucke J, STROBE Initiative. The strengthening of reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies. *J Clin Epidemiol*. 2008;61(4):344–349. PMID:18313558.
11. Husereau D, Drummond M, Petrou S, Carswell C, Moher D, Greenberg D, Augustovski F, Briggs AH, Mauskopf J, Loder E, et al. Consolidated health economic evaluation reporting standards (CHEERS)-Explanation and elaboration: A report of the ISPOR health economic evaluations publication guidelines good reporting practices task force. *Value Health*. 2013;16:231–250. PMID:23538175.
12. Moher D, Liberati A, Tetzlaff J, Altman DG, Group TP. Preferred reporting items for the systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med*. 2009;6(7):e1000097. doi:10.1371/journal.pmed1000097. PMID:19621072.
13. Yuasa H. The CONSORT statement: explanation and elaboration. *Consolidated standards of reporting trials*. *Ann Intern Med*. 2002;136(12):926–927. PMID:12069567.
14. Polivka BJ, Chaudry RV, Crawford J, Bouton P, Sweet L. Impact of an urban healthy homes intervention. *J Environ Health*. 2011;73(9):16–20. PMID:21644481.
15. Clark N, Lachance L, Milanovich AF, Stoll S, Awad DF. Characteristics of successful asthma programs. *Public Health Rep*. 2009;124(6):797–805. doi:10.1177/003335490912400606. PMID:19894421.
16. Crocker DD, Kinyota S, Dumitru GG, Ligon CB, Herman EJ, Ferdinands JM, Hopkins DP, Lawrence BM, Sipe TA, Task Force on Community Preventive Services. 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(2 Suppl 1):S5–S32. doi: [10.1016/j.amepre.2011.05.012](https://doi.org/10.1016/j.amepre.2011.05.012). PMID:21767736.
17. Reddy AL, Gomez M, Dixon SL. An Evaluation of a State-Funded Healthy Homes Intervention on Asthma Outcomes in Adults and Children. *J Public Health Manag Pract.* 2017;23(2):219–28. doi:[10.1097/PHH.0000000000000530](https://doi.org/10.1097/PHH.0000000000000530). PMID:121191577.
 18. Welsh EJ, Hasan M, Li P. Home-based educational interventions for children with asthma. *Cochrane Database Syst Rev.* 2011(10):CD008469. doi:[10.1002/14651858.CD008469.pub2](https://doi.org/10.1002/14651858.CD008469.pub2). PMID:21975783.
 19. Ellis DA, King P, Naar-King S. Mediators of treatment effects in a randomized clinical trial of multisystemic therapy-health care in adolescents with poorly controlled asthma: disease knowledge and device use Skills. *J Pediatr Psychol.* 2016;41(5):522–530. doi:[10.1093/jpepsy/jsv114](https://doi.org/10.1093/jpepsy/jsv114). PMID:26628249.
 20. Gomez M, Reddy AL, Dixon SL, Wilson J, Jacobs DE. A cost-benefit analysis of a state-funded healthy homes program for residents with asthma: findings from the new york state healthy neighborhoods program. *J Public Health Manag Pract.* 2017;23(2):229–238. doi:[10.1097/PHH.0000000000000528](https://doi.org/10.1097/PHH.0000000000000528). PMID:28121775.
 21. Sweet LL, Polivka BJ, Chaudry RV, Bouton P. The impact of an urban home-based intervention program on asthma outcomes in children. *Public Health Nurs (Boston, Mass).* 2014;31(3):243–252. doi:[10.1111/phn.12071](https://doi.org/10.1111/phn.12071). PMID:24720657.
 22. 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(4):665–671. doi:[10.2105/AJPH.2013.301695](https://doi.org/10.2105/AJPH.2013.301695). PMID:24524511.
 23. Carrillo G, Han D, Lucio RL, Seol Y-H, Chong-Menard B, Smith K. Impacting environmental and public health through the use of dual targeted and tailored asthma educational interventions. *J Environ Public Health.* 2015;2015:476173. doi:[10.1155/2015/476173](https://doi.org/10.1155/2015/476173). PMID:26240576.
 24. Carrillo Zuniga G, Kirk S, Mier N, Garza N, Lucio R, Zuniga M. The impact of asthma health education for parents of children attending head start centers. *J Community Health.* 2012;37(6):1296–1300. doi:[10.1007/s10900-012-9571-y](https://doi.org/10.1007/s10900-012-9571-y). PMID:22648657.
 25. 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;126:14–26. doi:[10.1177/00333549111260S104](https://doi.org/10.1177/00333549111260S104). PMID:21563708.
 26. Sunshine J, Song L, Krieger J, Sunshine J, Song L, Krieger J. Written action plan use in inner-city children: is it independently associated with improved asthma outcomes? *Ann Allergy Asthma Immunol.* 2011;107(3):207–213. doi:[10.1016/j.anai.2011.04.015](https://doi.org/10.1016/j.anai.2011.04.015). PMID:21875538.
 27. Vesper S, Barnes C, Ciaccio CE, Johanns A, Kennedy K, Murphy JS, Nunez-Alvarez A, Sandel MT, Cox D, Dewalt G, et al. Higher environmental relative moldiness index (ERMI) values measured in homes of asthmatic children in Boston, Kansas City, and San Diego. *J Asthma: Official J The Associat Care Asthma.* 2013;50(2):155–161. doi:[10.3109/02770903.2012.740122](https://doi.org/10.3109/02770903.2012.740122). PMID:23137280.
 28. Álvarez-Chávez CR, Flores-Bernal JL, Esquer-Peralta J, Munguía-Vega NE, Corella-Madueño MAG, Rascón-Careaga A, et al. Detection of allergen sources in the homes of sensitized children. *Environ Health Prev Med.* 2016;21(6):531–538. doi:[10.1007/s12199-016-0566-7](https://doi.org/10.1007/s12199-016-0566-7). PMID:27699687.
 29. Herendeen LA, MacDonald A. Planning for the North Carolina healthy homes initiative. *Rev Environ Health.* 2011;26(3):149–154. PMID:22206191.
 30. Breyse J, Jacobs DE, March WW, Dixon S, Kawecki C, Aceti S, Lopez J. Health outcomes and green renovation of affordable housing. *Public Health Rep.* 2011;126:64–75. PMID:21563714.
 31. Hsu J, Wilhelm N, Lewis L, Herman E. Economic evidence for US Asthma self-management education and home-based interventions. *J Allergy Clin Immunol Pract.* 2016;4(6):1123–1134.e27. doi:[10.1016/j.jaip.2016.05.012](https://doi.org/10.1016/j.jaip.2016.05.012). PMID:27658535.
 32. Lucio R, Zuniga G, Seol Y-H, Garza N, Mier N, Trevino L. Incorporating what promotoras learn: becoming role models to effect positive change. *J Community Health.* 2012;37(5):1026–1031. doi:[10.1007/s10900-011-9526-8](https://doi.org/10.1007/s10900-011-9526-8). PMID:22160747.
 33. Carrillo G, Han D, Lucio RL, Seol Y-H, Chong-Menard B, Smith K. Impacting environmental and public health through the use of dual targeted and tailored asthma educational interventions. *J Environ Public Health.* 2015;2015:476173. doi:[10.1155/2015/476173](https://doi.org/10.1155/2015/476173). PMID:26240576.
 34. Reddel HK, Taylor DR, Bateman ED, Boulet L-P, Boushey HA, Busse WW, Casale TB, Chaney P, Enright PL, Gibson PG, et al. An official American Thoracic society/European respiratory society statement: asthma control and exacerbations: standardizing endpoints for clinical asthma trials and clinical practice. *Am J Respir Crit Care Med.* 2009;180(1):59–99. doi:[10.1164/rccm.200801-060ST](https://doi.org/10.1164/rccm.200801-060ST). PMID:19535666.
 35. Asmussen L, Olson LM, Grant EN, Fagan J, Weiss KB. Reliability and validity of the children's health survey for asthma. *Pediatrics.* 1999;104(6):e71–e. PMID:10586005.
 36. Juniper EF, Gruffydd-Jones K, Ward S, Svensson K. Asthma control questionnaire in children: validation, measurement properties, interpretation. *Eur Respir J.* 2010;36(6):1410–1416. doi:[10.1183/09031936.00117509](https://doi.org/10.1183/09031936.00117509). PMID:20530041.
 37. Radecki L, Olson LM, Frintner MP, Weiss KB. Reliability and validity of the children's health survey for asthma-child version. *Pediatric Asthma, Allergy Immunol.* 2008;21(2):89–97.
 38. Juniper EF, Guyatt GH, Feeny DH, Ferrie PJ, Griffith LE, Townsend M. Measuring quality of life in children with asthma. *Qual Life Res: Int J Qual Life Aspects Treat Care Rehabilitation.* 1996;5(1):35–46. PMID:8901365.
 39. Juniper EF, Guyatt GH, Feeny DH, Ferrie PJ, Griffith LE, Townsend M. Measuring quality of life in the parents of children with asthma. *Qual Life Res: Int J Qual Life Aspects Treat Care Rehabilitation.* 1996;5(1):27–34. PMID:8901364.
 40. Control CfD. Controlling Asthma cdc.gov2015 [cited 2017 November 3]. Available from: <https://www.cdc.gov/policy/hst/statestrategies/asthma/index.html>.
 41. F I, H T, S P. Health investments that pay off: Strategies for addressing asthma in children. Washington, D.C.: National Governors Association Center for Best Practices; 2015.