Putting it into Practice: Pediatric Environmental Health Training Resource

Environmental Management of Pediatric Asthma: Guidelines for Health Care Providers

User Guide

Children's Environmental Health Network

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Environmental Management of Pediatric Asthma: Guidelines for Health Care Providers is a product of the National Environmental Education Foundation's Pediatric Asthma Initiative aimed at facilitating the integration of environmental management into pediatric health care. It was developed by the Pediatric Asthma Initiative's Expert Steering Committee, chaired by James R. Roberts, MD, MPH, who is also the author of this PowerPoint module.

I. Introduction

The development of asthma is multifactorial and likely involves the interplay between genetic factors and environmental exposures that occur while the immune system is developing. The most important factors in the development, persistence and severity of asthma are airborne allergens and viral respiratory infections.[1] Other environmental factors associated with asthma severity include tobacco smoke (in utero exposure especially), air pollution (high ozone, nitrogen dioxide and particulate matter), diet (obesity is a comorbid condition and overweight children are at an increased risk for the development of asthma and for being hospitalized for asthma[2,3,] vitamin D deficiency associated with increased steroid use and decreased pulmonary function[5]) and irritants (cleaning products, formaldehyde, perfumes, etc). Infants who were exclusively breastfed for 6 months or greater are less likely to develop symptoms of asthma in early childhood.[4]

The prevalence of asthma continues to increase.[6] In the U.S. the rate raised from 8.7% in 2001 to 9.6% in 2009. The biggest increase was noted in African American children, up from 11.4% to 17% (Slide 4). African American and Latino children have worse asthma status and have less use of preventive asthma medications than white children, even among children in managed care (Slide 6).[7] The use of urgent care is strongly associated with race/ethnicity and income; African American and Latino children have an increased risk of urgent care use compared to whites and living in a low income household is a strong predictor of urgent care use (Slide 6).[8]

The National Survey on Environmental Management of Asthma and Children's Exposure to Environmental Tobacco Smoke (ETS) was conducted by the Environmental Protection Agency (EPA) in 2003. The EPA surveyed 2,353 individuals with asthma or the primary caregivers of children with asthma. People from low income, low education households were more likely to have asthma and were significantly more likely to be exposed to ETS. Only 30% of those surveyed had a written asthma management plan. Lack of a management plan and physician-identified triggers is associated with poorer management of environmental triggers (Slide 7).

II. Learning Objectives

1. To promote the education of the environmental management of pediatric asthma and to integrate these guidelines into pediatric health care;
2. To advise patients with asthma and their families on ways to reduce exposure to allergens, irritants and pollutants;
3. To use a multifaceted approach for the management of asthma triggers as the most effective way to control asthma severity; and
4. To understand the Guidelines Implementation Plan (GIP) and the recommendations and strategies of the six priority messages.

III. The Expert Panel Report 3 and the Guidelines Implementation Panel

Expert panels periodically convened by the National Heart, Lung, and Blood Institute, conduct systematic reviews of the scientific literature and prepare reports that provide recommendations for appropriate asthma care. The most recent report, the Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma (EPR-3), was released in August 2007. The goal of the EPR-3 is to improve the quality of care and outcomes of those who have asthma (Slide 8).

Key Points for the Clinician

- The Guidelines Implementation Panel (GIP) Report for EPR-3 was published in December 2008. The report identified barriers that prohibited primary care providers from implementing the NAEPP's clinical practice guidelines. The GIP developed recommendations to overcome these barriers. The heart of the GIP report included six priority messages which were associated with successful healthcare interventions and had a positive impact on patient outcomes (Slides 9-17).
- **GIP Message #1: Use of Inhaled Corticosteroids (ICSs)**. ICSs are the gold standard for treating persistent asthma and are the most effective long-term control therapy. The benefits of ICS outweigh the risk of adverse effects.
- **GIP Message #2: Use a Written Asthma Action Plan (AAP).** A written AAP provides instructions for use of controller and rescue medications, management of asthma during exacerbation of symptoms (how to adjust medications and when to seek medical care), and identifies exposures to allergens and irritants with avoidance strategies.
- **GIP Message #3: Assess Asthma Severity**. All patients should have an initial assessment based on measures of current impairment and future risk. A severity assessment ensures the appropriate initiation of medications. The NAEPP EPR-3 uses the "rule of 2s" for classifying asthma severity.

- **GIP Message #4: Assess and Monitor Asthma Control**. At planned follow-up visits, healthcare providers should review the level of asthma control on multiple measures of current impairment and future risk to guide decisions to either maintain or adjust therapy.
- **GIP Message #5: Schedule Follow-up Visits.** Planned follow up visits at periodic intervals should be scheduled in order to assess the patient's asthma control and modify treatment if needed.
- **GIP Message #6:** Control Environmental Exposures. Exposure to allergens and irritants should be reviewed for all patients. Provide strategies to reduce exposure to those allergens and irritants that the patient is sensitized to which are associated with increased symptoms and increased use of healthcare services. Consider exposure of allergens and irritants at home, school, work, and daycare when assessing exposures. A patient's effort to reduce these exposures can determine a provider's decision to step up or down treatment.

IV. Asthma and Its Association with Indoor Air Exposures

The Committee on the Assessment of Asthma and Indoor Air, Division of Health Promotion and Disease Prevention with the Institute of Medicine, published Clearing the Air: Asthma and Indoor Air Exposures in 2000. This executive summary evaluated scientific evidence on indoor air quality and the exacerbation and development of asthma (Slide 18). The committee concluded that there is a causal relationship between exposure to cat, cockroach, and house dust mite allergens and exacerbations of asthma in sensitized individuals, and ETS exposure and exacerbations of asthma in preschool children.

There is also evidence of an association between dog and fungal allergen exposure exacerbating asthma in sensitized individuals. Rhinovirus infection is associated with wheezing and exacerbations in individuals with asthma and exposure to NO2 increases airway responsiveness among subjects with asthma.

Some evidence suggests an association between infections with respiratory syncytial virus, chlamydia and mycoplasma and asthma exacerbations. Chronic and acute ETS exposure has a limited association with exacerbations of asthma in older children and adults. Formaldehyde and certain fragrances have limited association with wheezing and respiratory symptoms.

V. What is the Evidence of Environmental Trigger Control?

Dust Mite Allergen Control

House dust mites infest fabrics and bedding and their allergens are carried on particles (10-30 micrometers) that do not remain airborne for long.[9] Effective measures of reducing house dust mite allergen levels in the home include allergen-proof bedding encasements, vacuum cleaning,

and washing all bedding (sheets, blankets, pillow cases, bedspreads) in hot water. More than a dozen clinical trials on the use of bedding encasements report reduced allergen levels (Slides 20-22), application of acaricides and tannic acid have not been effective in reducing dust mite allergen.[10, 11]

A narrative review of over 30 clinical trials evaluated the efficacy of bedding encasements as an asthma treatment. Four reported significant reduction in dust-mite allergen exposure and concomitant bronchial hyper-responsiveness (BHR) in treatment groups. Ten studies showed a decrease in dust-mite allergen exposure without a change in BHR in the treatment group. Five other studies reported no significant effect in exposure or BHR. The overall conclusion was that bedding encasements may be an effective asthma treatment under some conditions (especially where resource constraints are significant). However when implemented in clinical trials by patients with asthma, its effectiveness is modest but inconsistent.[12] This review raises the following question: Is a multifaceted approach for the management of asthma triggers more effective in controlling asthma severity?

Pet Allergen Control

Allergic sensitization to cat or dog allergen has been found in 22% to 67% of children with asthma.[13] Dog and cat allergens are carried on small particles that can become airborne and adhere to clothing and household surfaces.[14] Pet allergens can also be distributed to other locations such as schools; sensitized children can be exposed and asthma may be exacerbated (Slide 23).

Many pet owners are unwilling to remove their pets from the home due to an emotional attachment. However, this is the most effective method for reducing exposure and disease activity in patients with asthma sensitized to cats and/or dogs.[15] Several studies have looked at washing cats to reduce allergen. Reductions in cat allergen levels are short lived and is not an effective means of reducing allergen exposure (Slide 62).[16]

Multiple studies have evaluated the relationship between dog and cat exposure in the first year of life and the development of allergies and asthma later in childhood. One study found that exposure to 2 or more dogs or cats in the first year of life may reduce subsequent risk of allergic sensitization to multiple allergens during childhood.[17] One study found that pet ownership offered some protection against sensitization to pollen only.[18] Another study showed that pet ownership in early life did not appear to either increase or reduce the risk of asthma or allergic rhinitis symptoms in children.[19] It is unclear how to advise atopic families on the value of pet ownership for the prevention for sensitization, and is beyond the scope of this module.

Control of cat and dog allergen by other means besides removing the pet from the home has been studied. The use of high efficiency particulate air (HEPA) filters may reduce airborne allergen levels. A double-blind, placebo-controlled study found that application of air cleaners in living rooms and bedrooms significantly improved airway hyper-responsiveness and decreased peak flow amplitude in young patients with asthma. A significant amount of airborne cat and dog allergen were captured in the air cleaners however, levels in floor dust

were unchanged.[20] A randomized placebo-controlled trial found that using the combination of a HEPA room air cleaner, mattress and pillow covers, and cat exclusion from the bedroom did reduce airborne cat-allergen levels but no effect on disease activity was detected (Slide 24). Another randomized controlled study using a HEPA air cleaner only as the intervention, showed no change in bulk dust allergen concentrations from home samples and no significant effect on disease activity was found. However, there was a reduction in nocturnal asthma symptoms (Slide 25). Use of impermeable encasements for bedding is recommended for prevention of pet allergen as cat allergen can persist in mattresses for years after a cat has been removed from the home.[21]

In cat allergic individuals with asthma, intranasal corticosteroids can significantly reduce both upper and lower airway responses to cat exposure.[22] Montelukast also has a protective effect against both lower and upper airway responses during exposure to cat allergen.[23, 24] Another study showed that the severity of acute airway reactions and symptoms caused by cat exposure was significantly reduced by treatment with omalizumab.[25]

Rodent Allergen Control

Mouse allergen exposure is prevalent in both inner-city and suburban homes and is associated with an increased risk of sensitivity in children with asthma.[26, 27] Infants with a parental history of atopy are commonly exposed to mouse allergen in their homes. Predictors of increased mouse allergen included back race, reported mouse exposure, and moderate levels of cockroach allergen (Slide 26). Like pet allergens, mouse allergen is carried on small airborne particles and is commonly found in homes that are not infested with rodents.[28] There is potentially greater mouse allergen exposure in some Northeastern inner city schools. School samples had significantly higher levels of mouse allergen when compared to the home samples of student with asthma (Slide 26). Integrated Pest Management can significantly reduce the source of the allergens.

- **Integrated Pest Management (IPM):** Pest control strategy that involves the targeted application of pesticides, often in the form of gels or bait traps that are less toxic. Strategies also may include mousetraps, sealing cracks and crevices that give pests access into the house, protection of food sources in plastic storage containers and covered garbage cans, resident education and generalized cleaning (Slide 31).

One controlled clinical trial showed that IPM was effective in reducing mouse allergen during a 5 month period compared to controls in which levels actually increased (Slide 27).

Cockroach Allergen Control

Cockroach allergens are similar to dust mite allergens in that they are airborne only briefly after being disturbed.[29] Allergen is widely spread throughout the home due to the cockroach's mobility but is concentrated behind appliances and in cracks. Cockroach allergen can persist for months even with appropriate cleaning after successful extermination.[9]

The Inner-City Asthma Study (ICAS) found that the majority of homes studied had evidence of cockroaches with detectable levels of allergen (Bla g 1).[30] Inner-city children who were both allergic to cockroach allergen and exposed to high levels of this allergen had significantly more days of asthma symptoms, increased missed school days, more unscheduled medical visits and hospitalizations due to their asthma when compared to controls. This may partially explain the frequency of asthma-related health problems in the inner-city children.[31]

Removal of cockroach allergen typically begins with insecticide treatment to exterminate the allergen source.[32] As part of the National Cooperative Inner-City Asthma Study intervention; one study looked at the use of professional home extermination combined with directed education on cockroach allergen removal. Despite a significant, but short-lived, decrease the cockroach allergen burden at the 12-month visit had returned to or exceeded baseline levels (Slide 29). Another study demonstrated that substantial reductions in cockroach allergen levels can be achieved in inner-city homes through occupant education, placement of insecticide bait, and professional cleaning (Slide 30). These results were maintained with continued cockroach control by insecticide application alone.[33] Effective cockroach allergen reduction can be achieved by the combination of professional cleaning and bait traps both with and without insecticide (Slide 30).

Two studies looked at IPM in effectively decreasing cockroach allergen in public housing. IPM significantly reduced allergens (Bla g 1 and Bla g 2) by 6 months; however concentrations began to increase beyond 6 months of intervention (Slide 32). Another study found that a single IPM visit was more effective in reducing cockroach allergen then the regular application of pesticides alone (Slide 33). IPM methods can reduce the adverse effects typically associated with frequent application of some highly or moderately toxic pesticides such as organophosphates which can cause significant neurologic effects, and pyrethroids, which can result in contact dermatitis and asthma-like reactions.

Mold Allergen Control

Home dampness and the presence of mold have also been associated with asthma, cough, and wheeze.[34] Exposure to home molds during infancy was associated with the development of wheeze and persistent cough in the first year of life when there was a maternal history of asthma.[35] Inner-city children with asthma often spend a large amount of time indoors and live in decaying housing that may be prone to water damage. Therefore, they may be at increased risk for asthma morbidity due to exposure to indoor mold allergens.[36]

One randomized control trail looked at construction remediation of mold exposure and its impact on children with asthma. Remediation included household repairs, reduction of water infiltration, removal of water-damaged building materials, and heating/ventilation/air-conditioning alterations combined with a medical/behavioral intervention. This significantly reduced symptom days and health care use for children with asthma who live in homes with a documented mold problem (Slide 34).

A Cochrane review looked at existing studies to determine the effectiveness of remediating buildings damaged by dampness and mold in order to reduce or prevent respiratory tract symptoms, infections and symptoms of asthma. Eight studies were included and the interventions varied from thorough renovation to cleaning only. There was moderate-quality evidence in adults that repairing houses decreased asthma-related and respiratory infections. For children, there was moderate-quality evidence that the number of acute care visits decreased in the group receiving thorough remediation.[37]

Combined Asthma Trigger Management

Children with asthma living in both urban and suburban homes are often exposed to multiple indoor allergens and environmental tobacco smoke is more common among those living in inner-city homes.[38] Most children with moderate to severe asthma who live in the inner city are sensitized to multiple indoor allergens and environmental factors known to be associated with asthma severity are commonly present in their homes.[39] Previous environmental intervention studies such as those described above, have focused on a single allergen rather than on the multiple exposures. Improving the indoor environment as a whole could improve asthma related outcomes. The Centers for Disease Control Asthma Control Task Force has found strong evidence which supports the use of multicomponent interventions of the home environment to reduce symptom days, improve quality of life and reduce school days missed (Slide 34).

A randomized controlled trial was conducted to reduce environmental pollutant and allergen exposure in the homes of children with asthma living in the inner city. The treatment group received home-based education, cockroach and rodent extermination, mattress and pillow encasings, and high-efficiency particulate air cleaner. Levels of particulate matter declined by up to 39% in the treatment group but increased in the control group ($P < .001$). Cockroach allergen levels decreased by 51% in the treatment group. Daytime symptoms increased in the control group and decreased in the treatment group ($P = .04$). Other measures of morbidity, such as spirometry findings, nighttime symptoms, and emergency department use, did not change (Slides 36, 37).

The Inner-City Asthma Study evaluated the effectiveness of a multifaceted, home-based, environmental intervention for inner-city children with asthma to determine if there was improvement of asthma symptoms and a decrease in the use of health care services. Investigators tailored specific environmental intervention to each child's sensitization and environmental risk profile which included education and remediation for exposure to both allergens and environmental tobacco smoke. The intervention group had fewer days with symptoms than did the control group both during the intervention year ($P<0.001$) and the year afterward ($P<0.001$), as well as greater declines in the levels of allergens at home (Slide 38).

The intervention of the Inner-City Asthma Study, which cost under $1500 per family, led to a significant reduction in days of asthma symptoms (38 more symptom free days), a significant reduction in unscheduled clinic visits (19% reduction relative to the control group), and a reduction in the number of Beta-agonist inhaler use per year (13% reduction). The cost per symptom free day was $27.57 (Slide 38). The intervention is cost-effective when considering

the reduction in potential associated costs of an emergency department visit or an inpatient hospital stay for an acute asthma exacerbation.

Outdoor Asthma Triggers and Air Pollution

Multiple studies have demonstrated significant associations between days with high ozone levels and increased rates of asthma exacerbations. One study found that associations between pediatric ED visits and outdoor ozone concentrations were significant and strongest for the 5-12 year age group, especially those living in high poverty zip codes.[40]

A study on air quality and childhood asthma during the 1996 Olympic Games in Atlanta supports these findings. During the period of the Games when the traffic counts significantly dropped due to city wide changes in transportation and commuting, the ozone and PM10 concentrations in the outdoor air also dropped. There was a corresponding reduction in emergency department visits for asthma and overall reduction in Medicaid claims associated with asthma. Importantly, there was not a drop in overall ED visits or claims, just those with asthma (Slides 40-43). Another study produced the same results. Health benefits of decreased air pollution concentration due to reduced traffic flow during a citywide intervention for the 2002 Summer Asian Games decreased hospitalizations for childhood asthma (Slide 44).

VI. Environmental Management of Pediatric Asthma: Guidelines for Health Care Providers

These guidelines are the product of the Pediatric Asthma Initiative aimed at integrating environmental management of asthma into pediatric health care and are founded upon the National Asthma Education and Prevention Program's (NAEPP) "Guidelines for the Diagnosis and Management of Asthma." It is a useful tool for helping primary health care providers incorporate environmental history taking and it gives guidance on how to advise families about environmental interventions that can reduce or eliminate triggers for children with asthma. The guidelines list references on asthma health outcomes due to environmental interventions and list sources with web-links for additional information. It is available in English and Spanish online, in hard copy, and on CD-ROM (Slides 45-48, 53).

The guidelines contain three components (Slide 48):

Competencies: The knowledge and skills that a health care provider should master for incorporating environmental education and management of triggers.

Environmental History Form: A quick and easy document for the patient and family to fill out that is an intake tool to determine environmental asthma triggers (Slides 49-52).

Environmental Intervention Guidelines: Additional history questions that supplement the history form and intervention solutions to environmental asthma triggers.

The guidelines were developed for children already diagnosed with asthma and apply to any setting where they spend time, including home, school, vehicles, outdoors, even occupational exposures their parents may be exposing them to. The environmental asthma triggers include indoor and outdoor allergens; dust mites (Slides 56-59), animal allergens (Slides 60-62), cockroaches (Slide 63), molds (Slides 64-65), and pollens. Indoor and outdoor pollutants and irritants are also considered; environmental tobacco smoke (Slide 66), chemicals, combustion by-products, particulate matter (Slide 67), and ozone (Slide 68). Educational materials and patient handouts are listed under each trigger in the guidelines.

Referral to an asthma specialist (allergist or pulmonologist) should be considered in helping improve the care of children with persistent asthma. Primary care providers should refer patients for allergy testing to confirm allergies if complicated or expensive interventions are considered. Simple and low cost recommendations may be reasonable to implement in areas where widespread exposure to cockroaches or dust mites is known (Slide 55). Patients with asthma seen by an allergist had significantly greater knowledge of environmental allergens and had made environmental changes in their homes compared to patients seen by a pediatrician (Slide 69). Primary care providers should work together with asthma specialists in evaluating the child with asthma, educating the family, and developing appropriate therapies and interventions.

VII. Case Study

A 10 year old male is brought in to the clinic for worsening asthma symptoms over the past 2 months. The family has just moved into his grandmother's house and since this time he has been waking up two times per week with asthma symptoms (cough, wheeze, chest tightness and chest pain), he has required daily use of his albuterol due to his symptoms. He gets winded with exercise and has to stop and use his rescue medication in order to breath normally again.

He previously had intermittent symptoms without any exercise limitations and no exacerbations requiring systemic steroids over the past year. The only medication he currently takes is albuterol inhaler which he uses with a spacer as needed for his symptoms. He was diagnosed with asthma at 4 years of age, he has never been hospitalized but he did require oral steroids in the past for an exacerbation when he was 5 years old. His mother has a history of asthma and her symptoms are currently under poor control as well since their move.

Discussion questions:

- What further symptoms relating to his atopy should be considered?
- What environmental questions and potential exposures should be asked about?
- What would be helpful in determining what his triggers are?

Upon further questioning he is having nasal congestion, clear rhinorrhea, sneezing, itching of his nose and eyes every day since their move to his Grandmother's house. The Environmental History Form reveals the following; there are two cats, the house is old with visible mold in the

basement where it has flooded in the past. The grandmother smokes tobacco inside the house, she has difficulty cleaning and dusting due to her limitations in activity, the carpets are very old throughout the bedrooms. He has a down comforter on his bed. There is no central air conditioner and the house is very humid in the summer time. They have seen cockroaches in the kitchen as well as evidence of rodents. Weather changes affect his asthma and mom has noticed that his symptoms are worse when the smog is worse outside. They do not live near a major highway.

Discussion questions:

- What immediate recommendations and interventions can you suggest that would be simple and low cost?
- What advice and education would you give the family regarding their current environment?
- What medications would you consider starting him on to control his asthma and allergy symptoms?
- When would you consider referring him to an asthma specialist?
- When would you bring him back to the clinic for follow-up?
- When would you write an asthma action plan for this patient?
- When would you consider stepping up on his controller medications?
- When would you send him for pulmonary function testing?

It was recommended for the grandmother to make her home smoke free at all times in which she complied. IPM was used to clean up the house and eradicate the rodent and cockroach infestations. Allergen impermeable covers were used for the bed mattresses and pillows, and the family bought a dehumidifier for the house. The cat was kept out of his bedroom. His bedding was replaced with synthetic materials. The patient was started on an inhaled corticosteroid (medium dose) as an asthma controller medication, intranasal steroids daily and an antihistamine as needed for his allergy symptoms. An asthma action plan was written and discussed. On follow up in one month his asthma is better controlled with all of his symptoms, but he is still waking up once per week and has some exercise limitations despite using his short acting beta 2 agonist prior to running and sports. He was started on montelukast at this time. He was referred to an allergist who determined with skin testing that he was allergic to dust mites, mold, cockroaches and rodents. He is not allergic to cats. His pulmonary function tests revealed that his FEV_1 was 70 % predicted.

Discussion questions:

- What further environmental recommendations could you make at this point?
- If he becomes well controlled at what point could you consider stepping down on his therapy?

They have subsequently made more expensive changes to their household with removal of the rug and curtains in his room. The mold was removed and remediation work was done by professionals. The family purchased a HEPA vacuum cleaner and is using this several times per

week. A subsequent 3 month follow up visit to the office showed that the patient has been well controlled with his asthma symptoms for three months and a step down on his therapy was initiated with a decreased dose of inhaled corticosteroid.

KEY RESOURCES FOR FURTHER READING

(These references represent a comprehensive overview, as well as some landmark articles):

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The Community Guide: Asthma Control: Home-Based Multi-Trigger, Multicomponent Environmental Interventions. Centers for Disease Control & Prevention Task Force Findings and

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***Note:** This User Guide is intended to accompany the PowerPoint module of the same name. It elaborates on some studies which may require more in-depth information than what is provided on the slides. However, the contents of all slides in the module are equally important to present.*

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