

# Comprehensive environmental management of asthma and pediatric preventive care

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**To cite this article:** Roy A, Downes MJ, Wisnivesky JP. Comprehensive environmental management of asthma and pediatric preventive care. *Pediatr Allergy Immunol* 2011; **22**: 277–282.

## Keywords:

asthma/prevention and control;  
environmental exposure

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Accepted for publication 31 August 2010

DOI:10.1111/j.1399-3038.2010.01103.x

Indoor environmental triggers can increase asthma morbidity. National guidelines recommend comprehensive use of environmental control practices (ECPs) as a component of asthma management. The purpose of this study was to examine the association between preventive asthma care and comprehensive ECP use among children with asthma. We used data from the National Asthma Survey, including 1,921 children with asthma. Comprehensive use was defined as using at least five of eight ECPs: (i) air filter, (ii) dehumidifier, (iii) mattress cover, (iv) pillow cover, (v) pet avoidance, (vi) smoke avoidance, (vii) removing carpets, and (viii) washing sheets in hot water. Univariate and multiple regression analyses were conducted to examine the association between comprehensive use of ECPs and receipt of preventive asthma care, as measured by number of routine asthma visits in the prior year and physician advice to modify the environment. Overall, 17% (95% CI: 14–19%) of participants had comprehensive ECP use. The most commonly used practices were 'smoke avoidance' (85%), 'pet avoidance' (59%), and 'washing sheets in hot water' (46%). Comprehensive use of ECPs was associated with having received physician advice [odds ratio (OR) 3.1, 95% CI: 2.2–4.4] and increased asthma visits (1–2 visits: OR 1.5, 95% CI: 1.0–2.4; 3–4 visits: OR 2.2, 95% CI: 1.3–3.8;  $\geq 5$  visits: OR 2.7, 95% CI: 1.5–4.8). Only a minority of parents implement comprehensive ECPs, and receipt of preventive asthma care is associated with comprehensive use. Further research is needed to determine the factors mediating these associations in order to inform more effective asthma counseling.

Asthma currently affects about 9% of children in the United States (1), with inner-city populations suffering disproportionately high rates of morbidity (2–4). Mounting evidence shows that indoor environmental triggers such as allergens and irritants, sometimes associated with poor housing conditions, play an important role in worsening asthma outcomes (5–7). The Institute of Medicine has concluded that exposure to cockroaches, cats, house dust mites, and environmental tobacco smoke can cause asthma exacerbations in individuals who are sensitized (8). This is important because sensitization is quite common among children with asthma. According to results of the National Cooperative Inner City Asthma Survey (NCICAS), 77% of children were sensitized to at least one allergen, while 47% were sensitized to three or more (9). In the Inner City Asthma Study (ICAS), 95% of children with asthma had a positive skin test to at least one allergen (6).

Environmental modifications provide an important opportunity to improve asthma morbidity. Environmental control practices (ECPs) directed toward specific triggers are more effective in children sensitized to that trigger. A number of randomized controlled trials have shown that using a comprehensive environmental intervention program to address potential triggers in the home can improve asthma outcomes (10–13). In these trials, a core set of interventions were used, regardless of allergen sensitization status: all families were given mattress and pillow covers as well as education regarding smoke avoidance. There were other ECPs that were also universally implemented in the different trials, including use of a HEPA filter (10), avoidance of pet exposure (11), and assistance with roach and rodent control (12). The results of these interventions showed improved asthma health outcomes, and in line with these findings, current national guidelines from the National Heart Lung and Blood Institute

(NHLBI), updated in 2007, recommend a multi-faceted, comprehensive approach to indoor environmental management of asthma (14). Prior studies have shown that receiving physician advice about modifying the environment is associated with increased use of a single ECP (15, 16). Although prior studies have evaluated factors associated with increased use of single ECPs, there is no data on the predictors of comprehensive ECP use. The purpose of this observational study was to use population-based data to examine the effect of preventive asthma care on comprehensive ECP use among asthmatic children.

## Methods

This study used data from the National Asthma Survey (NAS), conducted by the Centers for Disease Control and Prevention's National Center for Health Statistics between March 1, 2003, and March 10, 2004. NAS employed a State and Local Area Integrated Telephone Survey design, using the same sampling frame as the Center for Disease Control's National Immunization Survey. Approximately 95% of the four-state surveys were conducted in English, the remainder in Spanish.

Participating households were screened for the presence of any members with asthma with the following question: 'Has anyone living in your household ever been told by a doctor or other health professional that they have asthma?' A total of 5741 respondents with a reported diagnosis of asthma were drawn from four states (California, Texas, Illinois, and Alabama). In each household, up to one adult and one child with asthma were randomly selected for interview. Our analyses were restricted to children  $\leq 17$  yr of age. The parent or guardian who was primarily responsible for the sampled child's health care completed an interview on asthma management and treatment. Participants were asked 'How long has it been since (*child*) last took asthma medication' and 'How long has it been (*child*) last had any symptoms of asthma?' Those who reported neither asthma symptoms nor asthma medication use in the past 5 yr were excluded.

## Study outcome

Our outcome of interest was the comprehensive use of ECPs. We selected eight ECPs that have either been evaluated previously as part of multifaceted environmental interventions (10–13) or are recommended by the NHLBI guidelines (14). These included the following: (i) use of an air filter, (ii) use of a dehumidifier, (iii) use of mattress covers, (iv) use of pillow covers, (v) avoidance of pets in the home, (vi) avoidance of smoke exposure, (vii) removal of carpets in the home, and (viii) washing sheets in hot water. Prior randomized controlled studies showing improvement in asthma outcomes with environmental modifications used at least five ECPs as part of the intervention (7–10). Based on these findings, we defined those patients using  $\geq 5$  ECPs as following a comprehensive environmental control of allergens. Secondary analyses were conducted using  $\geq 4$  and  $\geq 6$  ECPs as definitions for comprehensive use.

## Predictors

As part of the survey, information was collected on age, gender, and residence in a metropolitan statistical area (MSA), which is designated as an area with a population  $\geq 500,000$ , based on each participant's home zip code. Age was classified as either  $< 5$  or 5–17 yr as provided in the survey. Parents reported whether the child had health insurance at the time of the interview and if there was any time in the previous year when the child did not have insurance. Annual household income was categorized based on approximate quartiles of the sample, as follows:  $< \$25,000$ ,  $\$25,000$  to  $\$44,999$ ,  $\$45,000$  to  $\$74,999$ , and  $\geq \$75,000$ . The child's race/ethnicity was categorized as white, black, Hispanic, multiracial, or other race. Parents were also asked whether there were others living in the home with a diagnosis of asthma.

Asthma symptoms were reported as frequency per month. Asthma control was categorized based on the frequency of symptoms and degree of activity limitation, using the NHLBI guidelines as an outline (14). Categories included well controlled (symptoms 0–8 days and/or 0–2 nights per month and/or no activity limitation), not well controlled (symptoms  $\geq 9$  days and/or 3–7 nights per month and/or mild to moderate activity limitation), and poorly controlled (daily symptoms and/or  $\geq 8$  nights per month and/or severe activity limitation).

Our predictor of interest was preventive asthma care. We used two markers for preventive asthma care reported in the NAS. The first was the number of physician visits during the prior year for the routine care of asthma (not urgent visits or emergency room visits). Based on the distribution of data, routine asthma visits was categorized as follows: 0, 1–2, 3–4, and  $\geq 5$  visits in the prior year. The second marker of preventive care was whether participants had ever received physician advice to change their environment to improve the child's asthma.

## Statistical analysis

We used the chi-square test to evaluate differences in the baseline characteristics of patients practicing or not practicing comprehensive environmental control. The univariate association between comprehensive use and physician advice as well as number of routine visits was also tested using the chi-square test.

Multiple logistic regression was conducted to assess whether comprehensive ECP use was associated with receiving physician advice and number of routine visits after adjusting for age, gender, race/ethnicity, MSA, income level, insurance status, presence of others in the home with asthma, and asthma control category. To assess the robustness of our findings regarding ECP use, we performed secondary analyses using different cutoffs to define comprehensive use:  $\geq 4$  ECPs as well as  $\geq 6$  ECPs. Odds ratios are presented with 95% confidence intervals (CIs).

Variance estimates were adjusted for the complex survey design by using statistical techniques which allow for complex design specifications incorporating weights provided with the

NAS data. These are person-level weights that incorporated a base sampling weight, an adjustment for multiple telephone lines within a household, and various adjustments for non-response (17). All results are reported as weighted percentages, used two-tailed significance levels of  $p < 0.05$ , and were conducted with SAS statistical software (SAS Institute, Cary, NC).

The study was approved by the Institutional Review Board of Mount Sinai School of Medicine.

## Results

Of the 5741 participants in the four-state sample, 2,003 (35%) were children. We excluded 82 participants (4%) because of lack of asthma symptoms or asthma medication use in the prior 5 yr, leaving a cohort of 1921 children with asthma. Of these, 83% were 5–17 yr old and 60% were boys; 41% were white, 29% Hispanic, 18% black, 3% multiracial, and 6% other race. Approximately 90% lived in a MSA. In regards to income, 26%, 22%, 20%, and 28% reported an income of <\$25,000, \$25,000–45,000, 45,000–75,000, and >\$75,000, respectively. Asthma was well controlled in 31%, not well controlled in 51%, and poorly controlled in 15%.

Overall, 16.5% (95% CI: 14.3–18.7%) reported using  $\geq 5$  ECPs. As shown in Fig. 1, the most frequently used ECPs were avoiding smoking exposure, avoiding pets in the home, and washing sheets in hot water. Conversely, use of an air filter, dehumidifier, and mattress and pillow covers were less common among participants. Baseline sociodemographic characteristics were similar among respondents who did and did not use comprehensive ECPs (Table 1). There were no significant differences in terms of age, gender, race/ethnicity, living in a MSA, income, insurance, others in the home with asthma, and asthma control classification ( $p > 0.1$  for all comparisons).

Unadjusted analyses showed that comprehensive use of ECPs was significantly associated with receiving physician advice as well as the number of routine care asthma visits in the prior year (Table 1). Among patients who had compre-

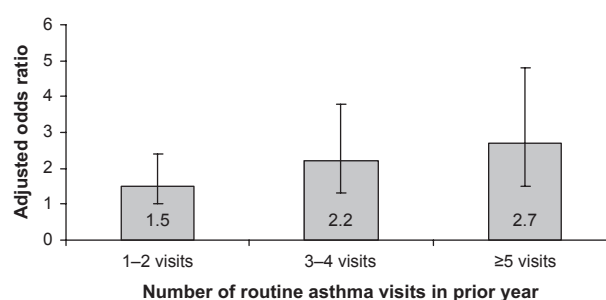


**Figure 2** Odds of comprehensive environmental management according to number of routine asthma visits in prior year. No visits in prior year was used as the reference. Comprehensive management was defined as implementing  $\leq 5$  environmental control practices. Odds ratios are adjusted for age, gender, race/ethnicity, metropolitan statistical area, income level, insurance status, presence of others in the home with asthma, and asthma control category.

hensive use, 66% had received advice whereas 41% of those who did not have comprehensive use had ever received advice to change their environment ( $p < 0.0001$ ). Similarly, 16% of patients with comprehensive use had five or more routine asthma visits in the prior year compared to 10% without comprehensive use ( $p = 0.005$ ). Multivariable analyses showed that physician advice and the number of routine visits remained significantly associated with comprehensive use of ECPs after adjusting for potential confounders (Table 2). Those who had received physician advice had approximately three times the odds of comprehensive use compared to those who had not received advice (OR 3.1, 95% CI: 2.2–4.4). Similarly, an increasing number of routine care visits for asthma was associated with higher odds of comprehensive ECP use compared to those children with no routine visits in the prior year (1–2 visits: OR 1.5, 95% CI: 1.0–2.4; 3–4 visits: OR 2.2, 95% CI: 1.3–3.8; 5 or more visits: OR 2.7, 95% CI: 1.5–4.8). Similar results were found in secondary adjusted analyses using  $\geq 4$  ECPs and  $\geq 6$  ECPs as the outcome.

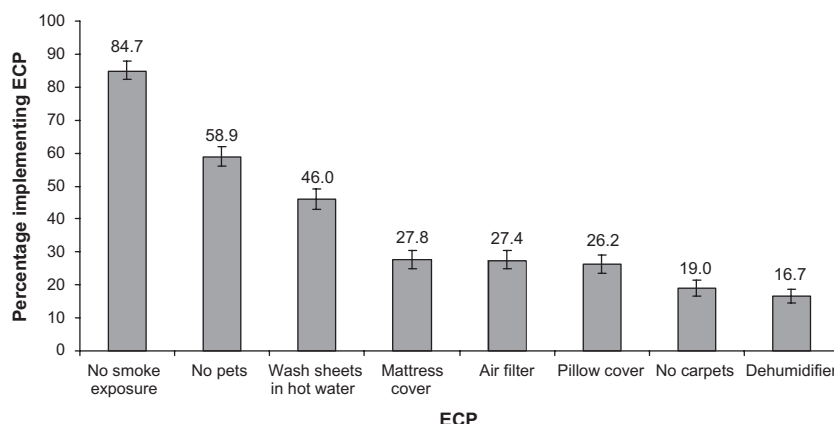


**Figure 1** Implementation of environmental control practices among children with asthma (N = 1921) in the four-state sample

of the national asthma survey (California, Alabama, Texas, and Illinois).

**Table 1** Participant characteristics according to comprehensive environmental management\* among children in the four-state sample† of the national asthma survey

|                                               | Uses <5<br>environmental<br>control practices<br>(ECPs) (n = 1549)<br>weighted % | Uses ≥5<br>ECPs<br>(n = 392)<br>weighted % | p value |
|-----------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------|---------|
| <i>Age, years</i>                             |                                                                                  |                                            |         |
| <5                                            | 16.5                                                                             | 17.0                                       | 0.86    |
| 5–17                                          | 83.5                                                                             | 82.9                                       |         |
| <i>Sex</i>                                    |                                                                                  |                                            |         |
| Male                                          | 59.3                                                                             | 62.7                                       | 0.38    |
| Female                                        | 40.7                                                                             | 35.3                                       |         |
| <i>Race/ethnicity</i>                         |                                                                                  |                                            |         |
| White                                         | 41.4                                                                             | 39.6                                       | 0.07    |
| Black                                         | 18.3                                                                             | 19.1                                       |         |
| Hispanic                                      | 28.9                                                                             | 26.2                                       |         |
| Multiple                                      | 2.6                                                                              | 7.4                                        |         |
| Other                                         | 6.1                                                                              | 5.5                                        |         |
| Unknown                                       | 2.8                                                                              | 1.6                                        |         |
| <i>Metropolitan statistical area</i>          |                                                                                  |                                            |         |
| Yes                                           | 89.2                                                                             | 89.1                                       | 0.96    |
| No                                            | 10.8                                                                             | 10.9                                       |         |
| <i>Income</i>                                 |                                                                                  |                                            |         |
| <\$25,000                                     | 27.7                                                                             | 24.4                                       | 0.19    |
| \$25–44,999                                   | 24.2                                                                             | 18.7                                       |         |
| \$45–74,999                                   | 19.9                                                                             | 22.1                                       |         |
| >\$75,000                                     | 28.2                                                                             | 34.8                                       |         |
| <i>Insurance status</i>                       |                                                                                  |                                            |         |
| Insured                                       | 84.7                                                                             | 89.6                                       | 0.14    |
| Unstable insurance‡                           | 8.6                                                                              | 4.6                                        |         |
| Uninsured                                     | 6.7                                                                              | 5.8                                        |         |
| <i>Others in house with asthma</i>            |                                                                                  |                                            |         |
| No                                            | 48.5                                                                             | 44.9                                       | 0.37    |
| Yes                                           | 51.5                                                                             | 55.0                                       |         |
| <i>Asthma classification</i>                  |                                                                                  |                                            |         |
| Well controlled                               | 32.7                                                                             | 27.4                                       | 0.34    |
| Not well controlled                           | 52.2                                                                             | 55.9                                       |         |
| Poorly controlled                             | 15.1                                                                             | 16.7                                       |         |
| <i>Routine asthma visits in past year</i>     |                                                                                  |                                            |         |
| 0                                             | 33.1                                                                             | 20.1                                       | 0.005   |
| 1–2                                           | 39.7                                                                             | 40.7                                       |         |
| 3–4                                           | 14.5                                                                             | 19.4                                       |         |
| ≥5                                            | 10.4                                                                             | 16.4                                       |         |
| <i>Physician advice to change environment</i> |                                                                                  |                                            |         |
| Yes                                           | 40.8                                                                             | 65.8                                       | <0.0001 |
| No                                            | 59.1                                                                             | 34.2                                       |         |

\*Comprehensive management was defined as ≥5 ECPs.

†California, Alabama, Texas, and Illinois.

‡Has insurance, but did not have insurance at some point during prior year.

## Discussion

Asthma is a common chronic illness causing significant morbidity among children in the United States (2–4). There is

**Table 2** Adjusted odds of comprehensive environmental management\* among children in the four-state sample† of the national asthma survey

| Variable                                  | Odds<br>ratio | 95% confidence<br>interval |
|-------------------------------------------|---------------|----------------------------|
| Physician advice to change environment    | 3.1           | 2.2–4.4                    |
| <i>Routine asthma visits in past year</i> |               |                            |
| 0                                         | Reference     |                            |
| 1–2                                       | 1.5           | 1.0–2.4                    |
| 3–4                                       | 2.2           | 1.3–3.8                    |
| ≥5                                        | 2.7           | 1.5–4.8                    |
| Age <5 yr                                 | 1.0           | 0.7–1.6                    |
| Male gender                               | 1.2           | 0.8–1.6                    |
| <i>Race/ethnicity</i>                     |               |                            |
| White                                     | Reference     |                            |
| Black                                     | 1.1           | 0.7–1.7                    |
| Hispanic                                  | 1.1           | 0.7–1.6                    |
| Multiple                                  | 2.7           | 1.1–6.6                    |
| Other                                     | 1.1           | 0.4–3.1                    |
| Unknown                                   | 0.5           | 0.2–2.8                    |
| Living in metropolitan statistical area   | 1.1           | 0.7–1.9                    |
| <i>Income</i>                             |               |                            |
| <\$25,000                                 | Reference     |                            |
| \$25–44,999                               | 0.8           | 0.5–1.2                    |
| \$45–74,999                               | 1.2           | 0.7–2.0                    |
| >\$75,000                                 | 1.4           | 0.9–2.2                    |
| <i>Insurance</i>                          |               |                            |
| Insured                                   | Reference     |                            |
| Unstable insurance‡                       | 0.5           | 0.2–1.1                    |
| Uninsured                                 | 0.9           | 0.5–1.8                    |
| Others in home with asthma                | 1.0           | 0.8–1.5                    |
| <i>Asthma control</i>                     |               |                            |
| Well controlled                           | Reference     |                            |
| Not well controlled                       | 1.0           | 0.7–1.5                    |
| Poorly controlled                         | 0.8           | 0.5–1.3                    |

\*Comprehensive management was defined as ≥5 environmental control practices.

†California, Alabama, Texas, and Illinois.

‡Has insurance, but did not have insurance at some point during prior year.

strong evidence that environmental modifications, especially used in a comprehensive manner, can help improve asthma outcomes (10–13). This study examined the association between preventive asthma care and comprehensive ECP use in a large, population-based sample of children with asthma. We found that few households (17%) were practicing comprehensive environmental management. Two factors associated with comprehensive use of ECPs were receipt of physician advice to modify the environment and number of routine asthma visits in the prior year. These results indicate that patients would benefit from increased education during clinic visits specifically focused on the environmental control of asthma.

There is limited data in the literature about ECP use and asthma care in children (15, 16). Cabana et al. evaluated predictors of use of at least one ECP (15). This study showed

that children who received asthma education had 80% higher odds of pursuing any action to address an environmental trigger, and those with more primary care office visits had 5% higher odds of addressing a trigger. Similarly, Hansel et al. showed that those children who received physician advice regarding a specific ECP were more likely to use that ECP to improve their asthma (16). However, children with asthma are frequently sensitized to multiple allergens and there is limited evidence that use of a single ECP leads to improved asthma outcomes. Our findings extend these results by showing that asthma education and interaction with health care providers are associated with increased comprehensive ECP use among children with asthma, a well-established asthma management behavior.

These findings have important implications for asthma counseling and management. Over the past number of years, there has been an important effort to improve pharmacologic management of asthma, in particular use of inhaled corticosteroids for persistent asthmatics (14, 18). These efforts have translated into increased rates of inhaled corticosteroid prescriptions for patients with persistent asthma (18). However, less emphasis has been placed on the role of environmental modifications for improving asthma control. To address this issue, the updated national guidelines underscore the importance of comprehensive environmental management and encourage physicians to discuss these issues with their patients. Our results highlight the importance of increased patient education about the environmental control of asthma.

Appropriate asthma management is complex and requires health care providers to build an ongoing partnership with patients. Physicians must treat acute symptoms, choose the appropriate long-term medications, educate about the disease process, as well as counsel on multiple aspects of disease management (e.g. peak flow use, asthma action plans, and environmental control). All of these tasks can be difficult to accomplish during one visit, particularly if there is a need to discuss other preventive care issues or if the child is acutely ill. Developing a partnership over the course of repeated office visits allows the opportunity to adequately discuss and reinforce the many issues involved in asthma management, such as environmental modifications. Because physicians are often busy and may not have adequate time to address issues involving environmental modifications, it would be best for this type of patient education to also come from different sources, such as nurse educators or social workers. Many public health departments around the country have also invested in public education programs for families of children with asthma to ensure that those who have not received the proper education from their physicians also have other sources of information.

Some strengths and limitations to this study should be acknowledged. First, this is a cross-sectional study, and

therefore, we cannot conclude that routine asthma visits and physician recommendations increase comprehensive ECP use. We have conducted an observational study on intervention measures. To further validate these associations, prospective interventional studies are required. However, these associations were found using a large, population-based dataset, which should improve the generalizability of our findings. Another limitation is that the children's allergen sensitization status is unknown. ECPs are more effective when targeted toward sensitized children. However, studies have shown that the vast majority of children with asthma are sensitized to at least one allergen (6, 9), and more than half are sensitized to multiple allergens (9). Therefore, most of these children would benefit from a comprehensive ECP approach. There is also a lack of details available about the quantity and quality of physician-patient interactions. Participants were asked if they had ever received any advice from a physician to change something in their environment to improve their child's asthma, but there was no information about the advice that was given. More detailed information would be helpful to better understand the association and guide more effective asthma counseling. Although the ultimate goal of asthma management is improved health outcomes, the association with outcomes cannot be appropriately examined in a cross-sectional study such as this one. We did not find a significant association between asthma control and comprehensive ECP use, as shown in Table 2. However, these associations are best studied using randomized controlled trials and prior studies have shown that comprehensive ECPs can lead to improved health outcomes. An additional limitation is that there is no previous characterization of what constitutes comprehensive ECP use. However, our classification was based on environmental interventions used in prior randomized controlled trials showing improved asthma outcomes. Additionally, secondary analyses using different cutoffs for comprehensive use yielded similar results, further validating our findings.

In summary, we found significant associations between comprehensive ECP use and physician advice as well as increasing number of routine asthma visits. These are two important areas of preventive asthma care that can promote improved environmental control. Further research is needed to elucidate the specific mediators of the associations, such as the quality and type of physician advice given, to guide more effective and efficient asthma monitoring and education.

## Acknowledgments

The authors thank Lawrence C. Kleinman, MD, MPH, FAAP and Richard E. Adams, Ph.D. whose help was invaluable to this study. The study was funded by the National Institutes of Health Research Training Grant in Environmental Pediatrics [NIH 5T32 HD049311].

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