Pest and allergen exposure and abatement in inner-city asthma: A Work Group Report of the American Academy of Allergy, Asthma & Immunology Indoor Allergy/Air Pollution Committee

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Our work group report details the importance of pest allergen exposure in inner-city asthma. We will focus specifically on mouse and cockroach exposure. We will discuss how exposure to these pests is common in the inner city and what conditions exist in urban areas that might lead to increased exposure. We will discuss how exposure is associated with allergen sensitization and asthma morbidity. Finally, we will discuss different methods of intervention and the effectiveness of these tactics. (J Allergy Clin Immunol 2010;125:575-81.)

Key words: *Asthma, allergies, environmental allergens, indoor allergens, pest, rodents, inner city, abatement, mouse, cockroach*

Abbreviations used
HEPA: High-efficiency particulate air
ICAS: Inner-City Asthma Study
IPM: Integrated pest management
MUP: Mouse urinary protein
NCICAS: National Cooperative Inner-City Asthma Study

The prevalence of asthma in developed countries has been increasing in recent decades. This increase has been particularly noted in urban areas, where up to 1 in 4 children might be affected by asthma.[1] Environmental factors, including cigarette smoke, air pollution, and allergen exposure, combine to contribute to asthma morbidity. Additionally, inner-city inhabitants might not be knowledgeable of the association of indoor allergen exposures with asthma.[2] Apart from possible differences in socioeconomic status, urban areas provide a unique setting for asthma because of certain environmental conditions existing in the inner city. In this work group report we will discuss the importance of insect and rodent allergen exposure in inner-city asthma. Specifically, we will focus on mouse and cockroach allergen exposure, their effects on asthma, and reduction tactics in the inner city.

Previously, there have been many review articles focusing on the overall effect of all indoor allergens.[3-5] However, in recent years, there has been an increasing amount of research devoted specifically to exposure to insects and rodents as a major factor contributing to asthma morbidity in urban areas. Numerous studies have documented high levels of mouse (Mus m 1 and mouse urinary protein [MUP]), rat (Rat n 1), and cockroach (Bla g 1 and Bla g 2) allergens in dust samples from urban homes, schools, and day care centers.

PEST ALLERGENS: DISTRIBUTION AND EPIDEMIOLOGY

• Cockroach and mouse allergens have been detected in homes and schools of inner-city areas of multiple US cities.

Initial studies in inner-city homes focused on the presence of cockroach allergen, and then subsequent studies evaluated mouse and rat allergens. The National Cooperative Inner-City Asthma Study (NCICAS) was the first National Institutes of Health–funded, multicenter, inner-city effort to understand the role of the

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This Work Group Report has been reviewed and approved by the American Academy of Allergy, Asthma & Immunology (AAAAI) Practice, Diagnostics, and Therapeutics Committee. However, this report does not represent an official position of the AAAAI. This statement is not to be construed as dictating an exclusive course of action, nor is it intended to replace the medical judgment of health care professionals. Every patient is unique, and therefore individual circumstances and environments need to be taken into account for any diagnosis or treatment plan.

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environment in childhood asthma in the United States.[6] The NCICAS measured cockroach allergen (Bla g 1) in collected dust from children's bedrooms and found that 85.3% had detectable levels and 50.2% had what were considered high levels (>8 U/g).[6] More recently, studies in individual cities have shown 98% of homes in Gary, Indiana, with detectable cockroach allergen[7] and 56.6% of homes in New Orleans with high levels of cockroach allergen.[8]

Subsequently, Phipatanakul et al[9] reported that 95% of all the NCICAS homes had detectable levels of mouse allergen (Mus m 1) in at least one room, with the highest levels found in kitchens. Similarly, it was discovered that 33% of the inner-city homes in the NCICAS had detectable levels of rat allergen.[10] In these homes the presence of mouse and rat allergens was associated with reported rat and mouse infestation.[10] After these data, Phipatanakul et al[11] reported 42% of homes in Boston with detectable mouse allergen, and Matsui et al[12] reported that Mus m 1 was detectable in bedroom air samples among 84% of children with asthma living in Baltimore.

Expanding on these data, the Inner-City Asthma Study (ICAS) found more than 50% of homes in New York and Chicago had Bla g 1 levels greater than 2 U/g.[13] This same study found evidence of cockroaches in 62.0% and evidence of mice or rats in 23.3% of studied homes.[13] Likewise, Chew et al[14] found evidence of cockroaches in 77% and evidence of mice in 13% of public housing residences in New York City. It is expected that levels of pest allergens will vary between cities, as evidenced by both the NCICAS and ICAS cohorts.[6,9,13] However, Simons et al[15] demonstrated significantly higher rates of pest infestation and significantly higher levels of mouse and cockroach allergen in inner-city homes compared with levels found in suburban homes in the same city.

The presence of cockroach allergen is not isolated to homes but also exists in urban schools. Chew et al[16] found detectable levels of cockroach allergen (Bla g 2) in 71% of dust samples collected from 11 urban high schools. In the analysis of schoolrooms in Detroit, Houston, and Birmingham, Alabama, Abramson et al[17] found all 3 cities contained schoolrooms with levels of cockroach allergen exceeding proposed sensitization thresholds. Similar results were found in 2 separate studies in Baltimore city schools.[18,19] A study of 2 inner-city elementary schools in Minneapolis discovered the median cockroach allergen (Bla g 1) level to be approximately 1 U/g.[20] Sheehan et al[21] found 89% of dust samples from 4 inner-city schools contained detectable levels of mouse allergen (MUP). Interestingly, this study demonstrated that the school samples had significantly higher levels of MUP when compared with students' homes in the same city, although selection of the students who volunteered for the study might have introduced bias.[21] Pest allergens have not only been found in schools but also in day care centers. Arbes et al[22] studied multiple day care centers in 2 North Carolina counties and found 52% of samples with detectable cockroach allergen and 83% with detectable mouse allergen. A similar study of Head Start facilities in Arkansas revealed 100% with detectable mouse allergen.[23] This study had fewer centers with detectable cockroach allergen, but only a minority of the centers were in urban locations.

RISK FACTORS FOR PEST ALLERGEN EXPOSURE

• Inner-city conditions contribute to allergen exposure

Certain factors prevalent in inner-city areas of the United States have been associated with higher levels of mouse and cockroach infestation and subsequent exposure to these indoor allergens. These factors are mainly housing related, but it is often difficult to tease apart the social demographics, such as lower income, lower level of education, black race, and Hispanic ethnicity, that have also been associated with increased risk of allergen exposure.[11,24-29] In addition, high population density areas, such as multifamily homes and high-rise apartment buildings, have been associated with higher levels of mouse and cockroach allergen.[13,26,27,30] This is particularly true of older cities with aged and deteriorating systems (eg, gas, water and sewer, electrical, subway, and highways). Finally, deterioration of the physical condition of homes has been identified as a predictor. For example, higher mouse and cockroach exposure has been associated with increased clutter, water damage, and the presence of cracks or holes in ceilings or walls.[12,30-34] Furthermore, stone foundations that can harbor rodents, the uneven settling of older foundations, and vacant lots contribute to pest infestation. In many urban areas the combination of lower socioeconomic status, high population density, and poor physical condition of buildings provides the unfortunate ideal setting for cockroach and rodent infestation.

DIAGNOSIS OF PEST ALLERGY

Diagnostic tests for cockroach and mouse allergen sensitization include skin prick testing, intradermal testing, and *in vitro* tests for allergen-specific antibodies. Although evaluation for cockroach sensitization has been standard for some time, there have been recent advances in diagnostic approaches to patients with suspected mouse allergy.[35-38] Despite recent advances in blood tests for mouse allergy, Sharma et al[35] demonstrated that skin prick tests are the most useful in discriminating patients with and without mouse allergy. This was the first study to evaluate currently available diagnostic tests for mouse allergy. It should be noted that this study was performed in a population of laboratory workers, and therefore the diagnostic performance of these tests in an inner-city population of asthmatic subjects is not known. Finally, it is important to note that currently available mouse extracts are not standardized.

PEST ALLERGEN EXPOSURE AND SENSITIZATION

• Exposure to pest allergens has been associated with sensitization.

Exposure to these allergens is troubling; however, an understanding of the role of exposure in the development of allergic sensitization is important. In 1964, Bernton and Brown[39] reported that 44% of allergic clinic patients living in New York were sensitized to cockroach. Through a combination of standard and more recent diagnostic techniques, it has been demonstrated that exposure to mouse and cockroach antigen, especially in urban areas, is associated with allergic sensitization in patients with asthma. In general, subjects from homes with higher levels of cockroach or mouse allergen exposure have higher rates of specific allergen sensitization. The first group to demonstrate this association was the multicity NCICAS. Eggleston et al[40] demonstrated that bedroom concentrations of Bla g 1 were related to cockroach sensitization in children with asthma, as determined by means of skin testing. After this, the same cohort was used to demonstrate that asthmatic children from homes with higher mouse allergen concentrations had significantly higher rates of mouse sensitization.[41] A different multicenter trial confirmed these previous