

# Cockroach allergy in Kentucky: a comparison of inner city, suburban, and rural small town populations

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The cockroach has been reported as a major allergen in inner city asthmatic patients. The retrospective chart review of 799 patients tested over a 10-year period (1981-1991) derived from a private allergy practice and a university allergy clinic is reported. Patients from both groups were divided geographically by home zip codes into inner city, suburban, or rural small town populations. Criteria for positive skin tests were wheal greater than 5 mm for prick and greater than 10 mm for intradermal tests with flare. Overall, 36.9% (295/799) of all patients surveyed were positive by either prick or intradermal skin testing. Cockroach reactivity was observed in 38.6% (95/246) of the private patients tested with 36.2% (200/553) of the university patients showing positive results. The inner city populations in both groups of patients were similar with 43.7% and 40.3% of the private and university patients, respectively, testing positive, with an overall positivity of 41% for all inner city patients. Inner city and rural small town populations for both study groups demonstrated almost identical reactivity with 41% and 43% overall positivity, respectively. Of the suburban group, 37.5% of the private patients and 28.8% of the university patients had reactive skin tests results with an overall rate of positivity of 30.1%. This rate (30.1%) is significantly less than the rate for either inner city (41.0%,  $P < .05$ ) or rural small town (43.6%,  $P < .01$ ) populations. Cockroach was not a common allergen in children under 3 years of age (skin tests positive in 15%); however, all cockroach allergic patients under 3 years of age had a diagnosis of bronchial asthma or reactive airway disease. The greatest prevalence of cockroach sensitivity (42%) was for children between 7 and 12 years of age. This rate was significantly higher than for all other age groups ( $P < .05$ ). Of all patients with a diagnosis of asthma 51.3% had a positive cockroach skin test as compared with 32.7% with allergic rhinitis only ( $P < .001$ ). Cockroach allergy is, therefore, a common sensitizer in both inner city and rural populations in Kentucky with allergic airway disease and is more commonly encountered in patients with asthma. Since cockroach may be asthmagenic, similar to dust mite via domestic infestation and respirable house dust, we suggest that cockroach antigen needs to be included in the routine battery of inhalant skin tests for both adults and children of all ages and geographic locations.

## INTRODUCTION

Insects have been recognized as inhalant allergens long before mites came to the foreground.<sup>1</sup> The cockroach has received increased attention over the last three decades as an important aeroallergen.<sup>1</sup> Although there have been described over 4,000 species of cockroach worldwide, most are in the wild and

are only occasionally encountered by man.<sup>2</sup> Cockroach belongs to the class Insecta, order Orthoptera, and family, Blattida. The most commonly encountered roaches are *Blattella germanica* (German); the most common in the United States, *Periplaneta americana* (American) and the oriental cockroach, *Blattella orientalis*.<sup>3-5</sup> A new roach described in the 1980s, *Blattella asahinai* (Asian), has demonstrated considerable cross-reacting allergenic components to the German and, to a lesser degree the American and Oriental roach, but clinical significance in cockroach sensitive individuals remains to be determined.<sup>5</sup>

In urban dwellings, particularly in lower socioeconomic communities,

cockroach debris can be a major component of house dust allergen.<sup>6</sup> Numerous investigators have implicated cockroach allergy in patients with asthma in lower socioeconomic conditions, for example, in Atlanta, Lexington, New York, Chicago, Washington, DC, Kansas City, Detroit, Charlottesville and Taiwan.<sup>6-12</sup> Cockroach-specific IgE antibody levels are markedly elevated in the sera of these patients<sup>1,9,12-16</sup> and the association of skin sensitivity to cockroach antigen with allergic bronchial asthma has been demonstrated by bronchial provocation testing.<sup>13,17,18</sup> This cockroach-induced asthmatic response to challenge appears to be specific, considering that no bron-

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chospasm was appreciated in either the asthmatic or nonatopic group of patients studied with negative skin tests.<sup>9,13</sup> Kang et al<sup>13,19</sup> demonstrated that cockroach antigen inhalation produced acute immediate asthmatic reactions in 90% of the cockroach-sensitive asthmatic patients and late asthmatic reactions in 68% of the patients studied, suggesting that cockroach antigen induces a dual asthmatic response following experimental antigen exposure.

Our study was undertaken in a retrospective fashion to evaluate the frequency of prick and intradermal skin test reactivity to cockroach extract in patients derived from both a university allergy clinic and a private allergy practice patient population,<sup>2</sup> investigate the age and geographic distribution of the patient populations tested and the relationship, if any, to skin test results, and<sup>3</sup> investigate the relationship, if any, of sensitivity to cockroach and allergic respiratory diagnoses.

## PATIENTS AND METHODS

A 10-year (1981-1991) retrospective chart review was undertaken from a population derived from the University of Louisville School of Medicine, Section of Allergy and Immunology, and a Louisville based private practice devoted to clinical allergy and immunology with five outlying satellite offices. All records were systematically reviewed with particular attention to the patient's age, sex, skin testing methods, and their interpretation. Criteria for positive skin tests were a prick skin test using a 1:20 wt/vol extract of mixed cockroach antigen (Hollister-Stier, Spokane, WA) of greater than 5 mm wheal with flare; or an intradermal skin test of greater than 10-mm wheal with flare using a 1:1000 wt/vol concentration. A total of 799 patients were studied and divided geographically by zip codes. Results of all skin tests were computerized and divided into inner city (Louisville), suburban and rural/small town populations.

## RESULTS

### Patients

The private practice subgroup included a total of 246 patients composed of seven inner city, 51 suburban, and 188 rural/small town. The clinic population comprised a total of 553 patients, with 281 subjects being inner city, 269 suburban and the remaining 249 patients being derived from rural/small localities (Table 1). Patient ages ranged from 7 months to 77 years.

### Skin Test Results by Patient Source

Positive skin test reactivity was observed in almost 40% (95/246) of the private patients tested. This number represented 39 of 246 patients being positive by prick method with the remaining 56 of 207 patients testing positive by intradermal tests. Of the university patients, 36.2% (200/553) demonstrated positive results by either prick (36/553) or intradermal methods (164/527). Overall, 36.9% (295/799) of all patients surveyed in both patient populations ( $P < .05$ ) were positive by either prick or intradermal skin tests (Table 2).

### Skin Test Results by Age

The greatest prevalence of cockroach sensitivity was observed in the 7-12 year age group (Table 3 and Fig 1). This positive proportion

(41.9%) was significantly higher ( $P < .05$ ) than the percentage positive in other age groups. Of the 52 children under the age of 3 years, 16.6% and 12.5% of the private and university patients, respectively, were positive by skin test criteria, with an overall positivity of 15.0%.

### Skin Test Results by Geographic Distribution

When analyzed by geographic distribution, the inner city populations in both groups of patients were similar with 43.7% and 40.3% of the private and university patients, respectively, testing positive, with an overall positivity of 41.0% for all inner city patients. Of the suburban group, 37.5% of the private patients and 28.8% of the university patients had reactive skin test results with an overall positivity of 30.1%. This was significantly lower than both inner city ( $P < .05$ ) and rural/small town patients ( $P < .01$ ). Inner city and rural small town populations for both study groups demonstrated almost identical reactivity with 41% and 43% positivity, respectively, (Table 2).

### Correlation of Skin Test Reactivity and Primary Diagnosis

Table 4 demonstrates the skin test reactivity of the total patient population in relation to primary diagnosis (the suspected diagnosis for which they were referred). In the

Table 1. Patient Population and Geographic Distribution

|                      | Private<br>n = 246 | University<br>n = 553 | Total<br>n = 799 |
|----------------------|--------------------|-----------------------|------------------|
| Inner city (n)       | 7                  | 274                   | 281              |
| Suburban (n)         | 51                 | 218                   | 269              |
| Rural-small town (n) | 188                | 61                    | 249              |

Table 2. Prevalence of Cockroach Sensitivity by Skin Testing in Various Geographic Locations

|                            | Private<br>%Pos | University<br>%Pos | Overall<br>%Pos |         |
|----------------------------|-----------------|--------------------|-----------------|---------|
| Inner city (n = 281)       | 43.7%           | 40.3%              | 41.0%           | p < .05 |
| Suburban (n = 269)         | 37.5%           | 28.8%              | 30.1%           |         |
| Rural-small town (n = 249) | 41.5%           | 45.7%              | 43.6%           | p < .01 |
| Summary                    | 36.6%           | 36.2%              | 36.9%           |         |
| # pos/# tested             | (95/246)        | (200/553)          | (295/799)       |         |

Table 3. Prevalence of Cockroach Sensitivity by Age Distribution

| Age Ranges, yr     | Private        | University      | Overall |
|--------------------|----------------|-----------------|---------|
| 3 (n = 52)         | 16.6% (6/36)   | 12.5% (2/16)    | 15.0%   |
| 3 to 6 (n = 142)   | 33.3% (16/47)  | 33.7% (32/95)   | 34.0%   |
| 7 to 12 (n = 317)  | 50.0% (19/38)  | 40.9% (114/279) | 42.0%   |
| 13 to 21 (n = 102) | 35.3% (6/17)   | 40.0% (34/85)   | 29.0%   |
| 22 to 45 (n = 132) | 50.0% (36/72)  | 21.6% (13/60)   | 37.0%   |
| 45 (n = 54)        | 33.3% (12/36)  | 27.8% (5/18)    | 31.0%   |
| Summary (n = 799)  | 38.6% (95/246) | 36.2% (200/553) | 36.9%   |

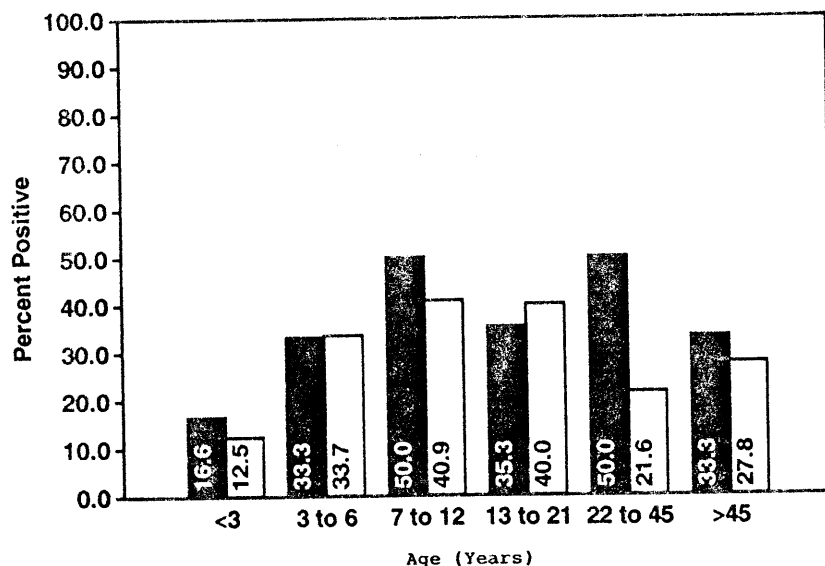


Figure 1. Distribution of private and university skin test positive patients by age. Solid bars indicate the private patients, open bars indicate the university population.

Table 4. Correlation of Skin Test Reactivity and Diagnosis

|         | Private<br># pos | University<br># pos | Total<br># pos  |
|---------|------------------|---------------------|-----------------|
| BA-RAD* | 58/113 (51.3%)   | 82/169 (48.5%)      | 140/282 (49.6%) |
| AR†     | 36/131 (27.5%)   | 118/377 (31.3%)     | 154/508 (30.3%) |
| Other‡  | 1/2 (50.0%)      | 0/7 (0.0%)          | 1/9 (11.1%)     |
| Total   |                  |                     | 295/799 (36.9%) |

\* BA-RAD: asthma or reactive airway disease.

† AR: allergic rhinitis.

‡ Croup, NARES, urticaria, chronic cough.

private group of 113 patients with the diagnosis of asthma/reactive airway disease, 51.3% (58 of 113 patients) had positive cockroach skin tests compared with 48.5% (82 of 169 patients) of the clinic population with the same diagnosis, with an overall rate of reactivity of 49.6%. Of patients with the diag-

nosis of allergic rhinitis, 27.5% (36 of 131 patients) and 31.3% (118 of 377 patients) of the private and university subjects, respectively, were positive with an overall 30.3% (154 of 508 patients) reactive rate in patients with the diagnosis of AR ( $P < .001$ ). These results were significantly lower than the 49.6% overall

reactivity for the patients with asthma. All six patients under the age of 3 years in the private population who demonstrated reactivity to cockroach antigen, had asthma as their diagnosis. Of the 295 skin reactors in the study, 140 (47.6%) subjects had asthma as their diagnosis as opposed to 154 patients with AR (52.2%). In summary, almost 50% of all subjects with skin test positivity to mixed cockroach antigen extract had asthma as their diagnosis and the prevalence of cockroach sensitivity had greater significance in the asthmatic population when compared with patients with allergic rhinitis only.

## DISCUSSION

Insect hypersensitivity is a term that is used to describe an allergy to a variety of insects and arthropods, to include mites, ticks, spiders, bees, cockroaches, and others.<sup>1</sup> Sensitization to these insects may be by occupational or home exposure. Over the last 25–30 years, the cockroach has received a great deal of attention as an important source of antigen for the development of a variety of disorders, including asthma and allergic rhinitis.<sup>10,13,17,19</sup>

There have been numerous attempts to isolate and characterize the major allergens of the cockroach.<sup>2,8,11,12,14,20–23</sup> Three major antigenic fractions designated as Cr-I, Cr-II, and Cr-III have been described with respective weights of 64,000, 25,000, and 10,000 daltons.<sup>24</sup> Subsequent studies have confirmed these results, and it has been found that Cr-I contains three subfractions and was capable of eliciting reactions in 100% of cockroach-sensitive atopic subjects.<sup>10</sup> Helin et al<sup>2</sup> using gel electrophoresis immunoblot analysis suggested that the allergenic components with molecular weights of 25,000 and 67,000 daltons in both Asian and German whole-body extracts may be similar to the components described in the earlier studies of Twarog et al,<sup>24</sup> and that cockroach allergens with apparent molecular

weights of 25,000, 36,000, 67,000, and 92,000 daltons may be considered as the principle cockroach antigens. Using monoclonal antibody technique, it has been demonstrated that commercial extracts vary significantly in the content of major antigens.<sup>22</sup>

Human exposure to the cockroach may be in the home or workplace even without overt evidence of infestation.<sup>11</sup> The German cockroach has been regarded as the most widespread of all roaches and has the highest immunogenic potential; however, exposure to any species of cockroach can play an important role in cockroach hypersensitivity.<sup>2</sup> Cockroaches can produce a variety of materials that may have potential allergenic consequence. Various secretions, egg casings, bodyparts, as well as excrement, all can be incorporated into dust and could contribute to cockroach allergy. In fact, fecal material may be a more important source of cockroach allergen than decayed body parts, since desiccated cockroach excrement is more likely to crumble and become airborne as disseminated dust.<sup>25</sup> Although there is significant cross-reactivity of whole body and fecal allergens,<sup>25</sup> whole body extracts may contain unique allergens or allergens in concentrations different from concentrations in fecal extracts.<sup>23,25</sup>

Although cockroach infestation is ubiquitous, it is greatest in urban areas<sup>23,26</sup> and numerous studies have confirmed the fact that cockroach allergens play a significant role as sensitizing agents for the induction and exacerbation of urban asthma.<sup>12,13,19,24,27-30</sup> Stankus<sup>23</sup> demonstrated that nearly 50% of inner city atopic patients when tested to commercial or prepared whole body extracts of the German and American cockroach had immediate wheal-and-flare reactions, and of the atopic asthmatic patients tested, as many as 70% were positive.<sup>31</sup>

Although the optimal treatment of cockroach allergies is avoidance,

the presence of cockroach antigen in respirable house dust has been verified<sup>16,8,19,32-34</sup> and may be a significant allergen even without overt evidence of cockroach infestation.<sup>11</sup> It therefore becomes increasingly difficult for the cockroach allergic patient whose dwelling is infested to minimize exposure despite pest control maneuvers and individual cleanliness.

Kang et al<sup>35</sup> studied the role of cockroach-specific immunotherapy in 28 cockroach-sensitive asthmatics and found a significant reduction in both symptom and medication scores and that cockroach immunotherapy resulted in specific cockroach blocking antibody of the IgG type and reduced anaphylactic leukocyte sensitivity. In addition, it was demonstrated that toward the end of the first year of therapy, the number of emergency room visits and hospitalizations were significantly reduced and after the third year all steroid-dependent patients were subsequently tapered off their medication.

In agreement with previous studies, our investigation demonstrates that cockroach antigen was not equally allergenic in inner city (41.0%) and suburban (30.1%,  $P < .05$ ) populations and is presumably reflective of the variable rates of home infestation and population densities. In addition, it was interesting to note that of the patients living in rural small town locations, 43.6% were skin test positive to cockroach. The overall rate of positivity for all three patient populations surveyed was 36.9% (295 of 799 patients).

Of the 52 patients studied under the age of three years, cockroach was not found to be a common allergen, with less than 15% of patients demonstrating positive wheal-and-flare reactions. These results were similar to those of Bernton,<sup>38</sup> and although this may suggest skin tests are sometimes less useful in children in this age group,<sup>36</sup> we know that children develop an in-

creased capacity to elicit skin sensitizing antibodies with increasing age and exposure.<sup>37</sup> Sensitization by an inhalant allergen is probably a more gradual process than for example ingestant allergens.<sup>38</sup> After birth IgE levels have been shown to rise along with other immunoglobulins with maximal values apparent in normal children between the ages of 10-15 years,<sup>40</sup> and atopic infants have an earlier and steeper rise in serum IgE levels during the early years of life as compared with nonatopic controls.<sup>40</sup>

Bernton<sup>38</sup> in 1970 studied the age of onset of cockroach skin sensitivity under the age of 4 years and demonstrated 18% reactivity in atopic children with no skin reactors in the nonallergic group of 46 children. Of the reactors found (six out of 31 patients), all were between 36 and 48 months of age. The clinical evaluation of specific IgE by skin testing should be, therefore, the principal method by which environmental causes of IgE-dependent diseases are identified and should still constitute an essential step toward proper diagnosis and management.

When reviewing the overall prevalence of positive skin tests by age (Table 3), it can be noted that the 7-12 year age group was significantly higher than other age groups (42%,  $P < .05$ ). These results are in agreement with Hannaway and Hyde<sup>37</sup> who, when testing 250 patients from 1-21 years of age with a battery of common inhalants, found that the greatest number of reactors to most allergens tested were in the 7-15 year age population.

Of the 282 asthmatic patients (113 private and 169 clinic), 140 were positive upon skin testing to cockroach antigen representing an overall positivity of 49.6% among the asthmatic population (Table 4). Of the 508 patients with AR from both patient populations (131 private, 508 clinic), 154 or 30.3% showed positive skin tests. Thus, a significantly higher sensitivity to cockroach antigen existed in those

patients having asthma verses allergic rhinitis as their diagnosis ( $P < .001$ ). These findings are almost identical to Kang,<sup>10</sup> who reported a greater than 50% reactivity rate among 385 asthmatic patients tested to cockroach antigen.

## CONCLUSION

In conclusion, from the present retrospective study of 799 patients surveyed for inhalant allergies from both a private and university practice population, we conclude that cockroach allergies are prevalent because of the ubiquitous existence of cockroaches, and that cockroach allergy may play an important role in nearly 40% of patients in both urban and rural Kentucky with allergic airway disease. In addition, cockroach skin hypersensitivity is more prevalent in patients with asthma, cockroach allergy may be asthmagenic in young children similar to dust mite via domestic infestation and respirable house dust. Because recognition and identification of cockroach allergy is necessary to guide proper management of cockroach-induced atopic diseases, especially asthma, we suggest that cockroach antigen should be included in the routine battery of inhalant skin tests for both adults and children of all ages, and geographic locations.

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