

**Can Integrated Pest Management Impact
Urban Children with Asthma?**

Megan Sandel, MD, MPH*

Anne Batcheller, RN, BSN^

Ilana Richman^

Erin Hendrick, BS^

Amy Troxell-Dorgan, MPH^

Margaret Reid, RN, BSN^

John Bernardo, MD**

*** Boston University School of Medicine, Department of Pediatrics**

^ Boston Public Health Commission

****Boston University School of Medicine, Department of Pulmonary Medicine**

Corresponding Author: Megan Sandel, 91 E. Concord St, Boston MA 02118

Email megan.sandel@bmc.org, phone 617-414-3680, fax 617-414-3679

Reprints requests should be sent to M. Sandel

Objective: To assess if an integrated pest management (IPM) program can impact pest infestation levels and the health of urban children with asthma

Methods: Within a larger randomized controlled study in private and subsidized urban homes, all families who reported pest infestations were offered an Integrated Pest Management (IPM) program consisting of an in-home education session about reducing pests, supplies to seal food and trash, and two treatments from a professional pest control service. Families who completed the program were surveyed about pest infestation levels and their child's asthma severity before and after pest management services, and asked to make qualitative comments about the IPM program.

Results: 127 of 182 families (70%) reported some pest problem. Of the 127 families with pest problems, 10 % reported cockroach infestation, 66% mouse infestation, and 24% both. 90 families (71%) agreed to have pest control services and completed two extermination visits in their homes. We surveyed all families; 68 of 90 families (76%) responded. Half of families reported their infestations with mice (49%) and cockroach (50%) as "heavy" or "very heavy" prior to IPM. After IPM, few families rated their infestations with mice (11%) and cockroaches (0%) as "heavy" or "very heavy."(p<.001) Self-reported levels of mouse infestation correlated well with mouse urinary protein (MUP) levels of MUS m-1 allergen from baseline dust samples in the asthmatic child's bedroom prior to IPM treatment. Respondents who rated their infestation prior to IPM as "heavy" or "very heavy" had a significantly higher baseline MUP level (mean=14,737.0) than respondents who rated their infestation as "none," "light," or "moderate"

(mean=1,213.2) (p=0.009). 37% of families reported their child's asthma as "severe" or "very severe" prior to IPM, compared to only 9% after IPM (p=.002).

Conclusion: An IPM program may reduce pest infestations of both cockroaches and mice in urban homes. During the above IPM program, children's asthma severity, as rated by parents, improved. IPM programs may improve urban childhood asthma in the setting of pest infestations and deserve further investigation.

Key words: asthma, mouse allergen, cockroach, inner city, housing, and children

Abbreviations: IPM- Integrated Pest Management, MUP – mouse urinary protein,

BHHP- Boston Healthy Homes Partnership, BPHC- Boston Public Health

Commission

INTRODUCTION:

Asthma is the most commonly diagnosed chronic disease of childhood.[1] Over the years 1980-1996, asthma rates increased 73.9% and an estimated 14.6 million persons reported asthma during the previous 12 months in 1996.[2] Inner city children have higher rates of asthma [3], with the highest rates in the Northeast region.[4]

Epidemiological studies, such as the National Cooperative Inner City Asthma Study (NCICAS) have shown inner city children with asthma are allergic to many pest allergens, with an estimated 35% of children surveyed allergic to cockroach allergens[5] and 18% allergic to mouse allergens[6]. The Inner-city Asthma Study (ICAS) found that 69% of the study population has positive skin test for cockroach allergy and 28 % to mouse allergy.[7] Asthmatic children with cockroach allergy have three times the hospitalization rate when exposed to cockroach allergen in their home when compared to non-allergic non-exposed children[8]. Although mouse infestation has been studied more extensively in occupational settings than the home [9], mouse allergens in the home have also been postulated to have an equally deleterious effect on children with asthma [6].

Interventions to reduce cockroach infestation in the homes of asthmatic inner city children have been studied only recently [10]. Pest interventions have been performed in public housing developments[11] and on a smaller scale in private housing in inner city neighborhoods [12]. No pest intervention study has focused on mouse and cockroach infestations simultaneously and evaluated the health effects on inner city children with asthma. This study examines the effect of an integrated pest management (IPM) program

in private or subsidized Section 8 apartments on mouse and cockroach infestation rates and asthma symptoms in urban children.

METHODS:

Participants:

This study was a before and after study of the Integrated Pest Management (IPM) intervention using a survey instrument 1-13 months after the intervention. The source of the participants was a larger randomized controlled trial, the Boston Healthy Homes Partnership (BHHP), studying the impact of home environment improvement on the health of inner city children with asthma. In this larger study, families are randomized to receive either standard home interventions, such as High Efficiency Particulate Air (HEPA) filtered vacuums, integrated pest management (IPM), air conditioners and house cleanings or all standard services plus \$2500 to remove known asthma triggers, such as carpets and mold. All families regardless of assignment received IPM. Eligibility criteria for family's participation in BHHP study dictated that families must reside in Boston, live in a private or subsidized Section 8 housing, and have at least one child 0-17 years of age with doctor diagnosed asthma who has used an asthma medication within the last year. Families with children with asthma were excluded if they lived in a public housing development or were not planning on staying in their apartment for one year. Public housing was excluded because costs to fix substandard home conditions in public housing developments, such as overheating, were thought to be outside the scope of this study and a second study was already being conducted in public housing in Boston. The Boston

University Institutional Review Board approved the BHHP study, including an amendment to study the IPM services.

Integrated Pest Management:

IPM services were offered to all families regardless of group assignment who reported pest infestation during the intake interview. Other participants were offered IPM services after the home inspector made the recommendation, though there was near total agreement between the inspector and families about pest infestations in the home.

The IPM program consisted of three main components: in-home health education, professional pest control visits, and low-cost cleaning supplies. The initial health education visit focuses on pest control practices within the context of a wider asthma education curriculum. The educator introduced the participant to the concept of IPM: reducing infestation rates by eliminating pests' food source, water supply, and shelter. IPM is based on a model of shared responsibility among tenant, landlord, and pest control contractor, so the tenant's understanding of IPM is integral to the program's success.

After the initial home education session was complete, WatchAll, a professional pest control company, conducted two pest extermination visits for the BHHP study participants. Landlords were informed of the IPM services coming and when possible, asked to grant access to common areas or basements to assess areas of entry, but did not pay for IPM services which were covered by the study. WatchAll uses low-toxicity pesticide glue called hydramethylnon to eliminate cockroaches. To treat mouse

infestation, WatchAll eliminated pest entry by sealing open cracks or holes, generally with a liquid foam that would harden, and made other minor structural modifications to the home. WatchAll used sticky traps or mouse traps rather than chemical pesticides to reduce mouse infestation levels. Three to five weeks following the first visit, the WatchAll contractor visited the resident's home again to renew pesticide glues, monitor infestation rates, and continue to plug holes and cracks. Service reports were written after each visit commenting on type and amount of chemicals used, number of traps and location, sanitation level, and other relevant building issues. These reports were made available to the Healthy Homes staff so that the Program Manager could alert participants to dangerous issues, or request that the health educator focus education in a particular direction. WatchAll was only available for scheduling BHHP families on Thursdays, between 12-3 pm.

Following the two IPM treatments, the health educator returned to the home to reinforce the teaching done at the initial visit. The educator brought a cleaning kit for each family containing items which would assist them in maintaining a pest-free home: a trash can with lid, three plastic food storage containers with lids, a mop and bucket, copper gauze, and sponges. The educator demonstrated the use of each item with respect to pest-control.

Participants were felt to have completed the IPM program if they received all education services, pest supplies and IPM services from WatchAll. Most families received two pest

control visits, but in a few cases, the improvement after one visit was so dramatic that WatchAll deemed a second visit unnecessary.

Survey Data:

The IPM survey (available on request) consisted of 18 questions that asked parents about their pest infestations and children's asthma severity before and after pest management services. Participants were asked to describe pest infestation levels as none, light, moderate, heavy, or very heavy. They were also asked to rate their child's asthma severity as very mild, mild, moderate, severe, or very severe. The survey also asked participants open-ended questions about their beliefs concerning the effect of IPM.

The IPM survey was administered by phone by study staff. The survey was administered to participants in English, Spanish and Portuguese. The survey was conducted from 1-13 months after IPM services were completed, from February 2003 to July 2003. While language barriers did not interfere with conducting the survey, it may have been a barrier to accessing IPM services. Of the two families enrolled in the study that spoke Vietnamese, neither received IPM. One family eventually dropped out of the study. Also, one survey collected was eliminated because of unintelligible responses, and one family was surveyed twice and the first survey was used in data analysis.

Confirmatory Measures:

To verify whether participants' answers were consistent, we verified the pest infestation levels and asthma ratings with other data collected in the larger BHHP study. For

verification of the infestation ratings, home inspectors collected dust from each asthmatic's bedroom at the baseline visit and follow up visit. The dust was collected using a Eureka Mighty Mite vacuum and two separate one meter square areas were vacuumed in the asthmatic's bedroom for an integrated sample. It was analyzed at the Dermatology, Allergy, Clinical Immunology (DACI) laboratory at Johns Hopkins University for the presence of dust mite (Der p1, Der p2), cockroach (Bla g1, Bla g 2), mouse (Mus-m1), dog (Can f 1), and cat (Fel d 1) allergens. Radioallergosorbent test (RAST) was offered to all families enrolled in the BHHP study but not all children complied; some parents refused the test for their children while others could not be scheduled. RAST testing included the allergens stated above and a mold panel (Alternaria, Aspergillus). For verification of the asthma ratings, participants were also asked to describe their child's asthma symptoms, medication usage and health care utilization, the same questionnaire used by the Inner City Asthma Study, with permission from Rho, Inc.[7] The number of symptom days for each respondent's asthmatic child was determined by using the ICAS survey conducted separately from the IPM survey and prior to any IPM intervention. Respondents to the IPM survey were grouped into two classes according to how they rated their children's asthma prior to IPM. Then, using the data from the ICAS based survey, the average number of days wheezing was calculated for each of these groups. In the results section, we reported the correlation between the pest infestation ratings and allergen levels found in the bedrooms as well as the correlation between the asthma ratings and number of symptom days in the last 2 weeks.

Data Analysis:

Data were entered into Microsoft Excel and Microsoft ACCESS databases. Data from the IPM survey were compiled and compared with data from baseline interviews, RAST testing, and dust sampling. Data analysis was performed using Statistical Analysis Software (SAS, version 8.0; Cary, NC) and EpiInfo 2000. Differences in means between groups were tested using two tailed t-tests. Changes within the entire sample were tested using paired t-tests. P-values of 0.05 or less were interpreted as statistically significant.

Most laboratory results of the dust and RAST testing were reported as continuous values. For categorical laboratory results the value was reassigned as one unit below the cut-off (eg. a value of 9.9 was assigned to measurements reported as <10.0 g/dL).

Survey responses were categorical. As a result of the small sample size, responses with more than two categories were collapsed into two groups to maintain sufficient statistical power, however they are reported separately in Table 1 to show trend.. An example is respondents were asked to rate their infestation levels in 5 categories: none, light, moderate, heavy and very heavy. In statistical analysis, heavy and very heavy were combined, and moderate, light and none were combined.

For household level analysis in which household data was compared to multiple child or bedroom data, a mean measurement was calculated and utilized in the analysis. For example, for a household with more than one bedroom, a mean mouse allergen (MUP)

level was calculated and compared to the parental self-rating of the household mouse infestation.

RESULTS:

Housing Characteristics and Demographics:

Among BHHP participants in general, 58% self-identified as African-American, Caribbean, Cape Verdean, or African, 31% identified as Hispanic or Latino and 11% identify as White or other. Forty-seven percent of BHHP participants were born outside of the United States. While the BHHP has no income requirements, the majority of the study's participants were from a low-income population as demonstrated by the overall percentage (52%) of families renting with a Section 8 voucher, which has federally determined income requirements based on size of family. There was no significant difference between the race and tenancy data of IPM survey participants and that of the larger BHHP population.

127 of 182 families (70%) reported some pest problem. Of the 127 families with pest problems, 10 % reported cockroach infestation, 66% mouse infestation, and 24% both. 90 families (71%) agreed to have pest control services and completed two extermination visits in their homes. We surveyed all families; 68 of 90 families (76%) responded. Of the 68 respondents, 84% rent their home and 16% own their home. Of the families who rent, 62% of renters use a Section 8 voucher while 38% rent in the private market without subsidy. Housing type varied among participants with pest infestations: 10% live in single-family homes, 27% live in duplexes, 43% live in three-family dwellings, 22% live

in apartment complexes or condominiums of 4 units or more. Tenancy and housing type distributions among IPM survey respondents were consistent with those of the larger BHHP population. There was no statistical difference in housing type or tenancy between houses that reported a pest infestation and those that did not in the larger randomized study.

Infestation levels:

In an initial interview conducted upon entry into the BHHP study, 127 out of 182 homes (70%) reported a pest infestation.(see flowchart 1). Of those 127 homes, 84 (66%) had mice, 13 (10%) had cockroach, and 30 homes (24%) reported both cockroach and mice. Ninety of the 127 (71%) homes completed their course of IPM treatments. Of the remaining 37 homes, 11 missed one or both extermination appointments, 13 have had scheduling conflicts making extermination visits impossible, 9 left the BHHP study and 4 refused a second visit. Of the four respondents that refused a second visit, two respondents felt that IPM successfully eliminated her mice after one visit, though the pest contractor deemed a second visit was necessary. Another respondent said that her landlord had provided extermination services after the first BHHP IPM visit. Another stated that her landlord did not allow the service and so therefore refused the second visit. Sixty-eight of the 90 homes that completed the IPM program responded to our survey (76%).

Four respondents did not answer questions about infestation levels but did answer other questions in the survey. 44 (69%) of 64 respondents reported that IPM led to a reduction

in their pest infestation. Twenty respondents (31%) reported that IPM made no difference in the level of pest infestation. Of the 20 participants who reported no difference in infestation levels after IPM, nine rated their infestation levels as improved elsewhere in the IPM survey, for a total of 53 (83%) of families reporting somewhere during the survey an improvement in pest infestation levels. Fifty-two percent (n=33) of respondents who noticed a difference after the IPM treatment reported noticing the improvement after the first visit.

Forty-nine percent (n=31) of survey respondents who reported a mouse infestation (n=64) in the IPM survey characterized that infestation as “heavy” (n=19) or “very heavy” (n=12) prior to any IPM (Figure 1). Upon completion of the IPM treatments, 11%(n=7) of respondents (n=63) reported a “heavy” (n= 4) or “very heavy”(n=3) infestation (p<.001). Of the group that initially reported some mouse infestation, 40% of respondents (n=25) reported no mouse infestation upon completing their IPM treatment.

Fifty percent (n=11) of respondents (n=22) with a cockroach problem characterized their infestation as “heavy”(n=5) or “very heavy”(n=6) before the IPM intervention (Figure 2). After IPM, no respondents reported a having “heavy” or “very heavy” cockroach infestation. (p<.001) Of the group that initially indicated a cockroach infestation, 40% (n=9) reported being free of cockroaches upon completing the IPM program.

Correlation of Allergen Levels and Pest Infestation Ratings

Table 1 compares respondents' ratings of mouse infestation levels prior to IPM with asthmatic child's bedroom dust samples collected prior to IPM. Respondents who rated their infestation levels lower showed lower average levels of mouse urinary protein (MUP) in the dust sample (Table 1). Respondents who rated their infestation as "very heavy" had an average dust level 33 times higher than people who rated their infestation as "light." Respondents who rated their infestation as "heavy" or "very heavy" had a significantly higher baseline dust level (mean=14,737.0) than respondents who rated their infestation as "none," "light," or "moderate" (mean=1,213.2) ($p=0.009$). Cockroach infested homes represented less than a third of infested homes in this study and therefore the numbers were too small to conduct any substantive correlation analysis.

80% of asthmatic children enrolled in the study were RAST tested. Data from the RAST were compared to mouse infestation self-rating to identify trends in the prevalence of MUP allergy within a rating group using analysis of variance (ANOVA) (Table 1).

Asthma Severity:

Not all respondents answered all questions about asthma severity. Two different tests were used to see if asthma severity improved. Parents were both asked a yes no question on asthma severity and were asked to rate their child's asthma severity on a five point scale (very mild, mild, moderate, severe, very severe) before and after IPM services. Fifty-five percent ($n=36$) of survey respondents ($n=68$) reported that IPM improved their child's asthma. Thirty-seven percent ($n=20$) of parents rated their children's asthma as

“severe”(n=14) or “very severe”(n=6) before the IPM intervention (n=63) (Figure 3).

After IPM (n=60), only 9% (n=5) of parents rated their children’s asthma as

“severe”(n=4) or “very severe”(n=1) (p=.002).

Correlation of Asthma Symptom Days with Asthma Severity Ratings:

Asthma severity self-rating was compared to an external, objective measure: the average number of days wheezing in two-week period. Children whose parents rated their asthma as “very mild,” “mild,” or “moderate,” wheezed an average of 3.2 days in a 14-day period, compared to children whose parents rated their asthma “severe” or “very severe” wheezed an average of 6.2 days in a 14-day period (p=.005).

DISCUSSION:

We found that IPM reduced both mouse and cockroach infestation levels and led to improvement of asthma symptoms as reported by their parents among children living in urban housing. We are unaware of any other data that demonstrate this relationship for both mouse and cockroach infestation. Results from the Inner City Asthma Study have suggested similar findings for a package of intervention including IPM, though their interventions almost exclusively focused on cockroach infestations.(13) Intervention studies in other cities funded by the Department of Housing and Urban Development (HUD) are also using IPM to control pests, though their intervention tend to be much more or much less intensive than the one described in this paper.



Cost is always a concern in a study that uses community based outreach. In our study, each extermination visit cost the BHHP study \$100. Community-based health educators, paid by the BHHP study, dedicated time to discuss pest control methods with study participants as part of two in-home education sessions about asthma trigger reduction. These visits, including transportation and the health educator's time are estimated to cost no more than \$50. The supplies provided to the families at this visit cost approximately \$18 per home. Given those expenses, the total cost of IPM services for each family that had two visits was approximately \$270.

We recognize that this study has a number of limitations. Assessing the effectiveness of IPM by survey may be problematic. Families were asked to retrospectively recall their pest levels prior to IPM services, though analysis of MUP levels taken prior to IPM correlated well with people's ratings. Families were also asked retrospectively to rate how their children's asthma changed as a result of IPM services, though again, severity ratings prior to IPM correlated well with previous reporting of asthma symptom days over a 2 week period. The family was only about one child's asthma when in fact a few families had more than one child enrolled in the BHHP. This may have led the family to choose to answer about the child whose asthma most benefited. The potential for positive bias existed since participants may have felt that favorable responses would yield more interventions and services. They likewise may have believed that negative responses would result in a denial or slowdown of these services. However, many families were surveyed more than six months following the completion of IPM, and by that time had completed all interventions and services.

Second, we were not able to provide pest services to all families, which may limit the generalizability of the study. Of the 127 families eligible for IPM services, we were only able to provide services to 90 families and only able to survey 68 families total. There are several reasons why some families who stated a need for pest control did not receive them: some families had moved and were dropped from the study; some who originally reported a problem denied they had a pest problem when extermination visits were being scheduled. However, the majority of families (24 out of 37) had difficulty with scheduling and making the extermination visits, since WatchAll contractor was only available between 12pm and 3pm on Thursdays. The fact that we were able to schedule 71% of families during such a tight window of opportunity speaks to the great desire of families to obtain these services.

Third, our response rate was 68%. Possible explanations include lack of consistent telephone contact, some language barriers, or unwillingness to participate. It is possible that people who responded to our survey were more likely to think IPM services helped and wanted more services. However, this study was conducted in response to many participants in the BHHP study calling us to thank us for the IPM services and stating that their children's asthma was better. We felt it was important to determine more systematically if participants perceived a relative change in either infestation levels or asthma severity, though this presented a sub-optimal study design, with parents retrospectively recalling infestation and asthma severity levels. Future studies will be designed to prospectively collect this data. We did not provide IPM survey respondents with the definition of asthma or infestation levels, and, interestingly, very few

respondents asked for definitions or explanations. The fact that we were able to correlate these subjective ratings to objective measures (MUP levels in the child's bedroom) and previous responses to surveys (symptom days) suggest that parents are accurate reporters of pest infestation and consistent reporters of asthma severity.

This intervention study assesses the effects of IPM on a demographic composed entirely of home renters and owners among a high-risk population of predominantly lower income Blacks and Latinos. Because this population has been shown to have more severe asthma and most urban residents rent apartments or own their homes, the findings of this study are relevant to a substantial sector of this vulnerable population. Given the racial disparity in asthma and among inner-city children, this study has particular relevance to potential reasons for these disparity and potential solutions as well.

This study may guide future uses of IPM as it provides a model for the use of IPM in an urban setting. This study demonstrates that residents can accurately rate their level of pest infestation. Landlords need to be made aware that tenants are accurate reporters of pest infestation. Tools can be developed allowing a tenant to communicate the level and nature of infestation over the phone. A landlord could utilize the IPM services necessary to address the problem, resulting in a savings of time, money and resources on the part of landlords, city and housing agencies, while tenants receive a more effective response in a timelier manner.

This study is the first to demonstrate an effect of integrated pest management (IPM) program on mouse and cockroach infestation levels and asthma severity in children with asthma in an urban setting. Future research should focus on IPM services and cost benefit analyses. Correlations between pest infestations, sensitization and asthma and allergy symptoms must be further investigated. Given the low cost of this IPM program relative to urgent care visits and long term medication costs, this study has broad public health implications for improving asthma in urban children with pest infestations.

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Flowchart 1: Recruitment for IPM evaluation

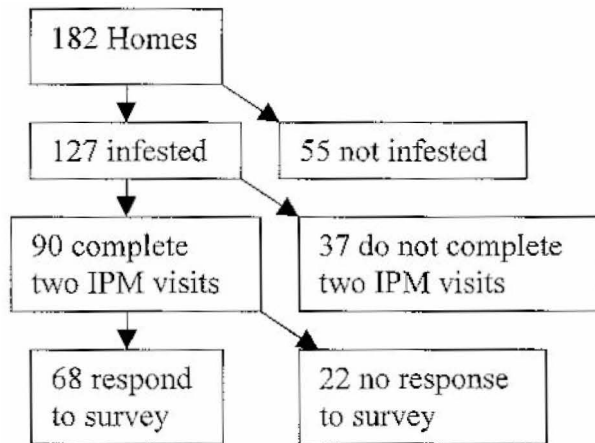


Figure 1: Self-reported infestation levels for participants with reported mouse problem before and after IPM

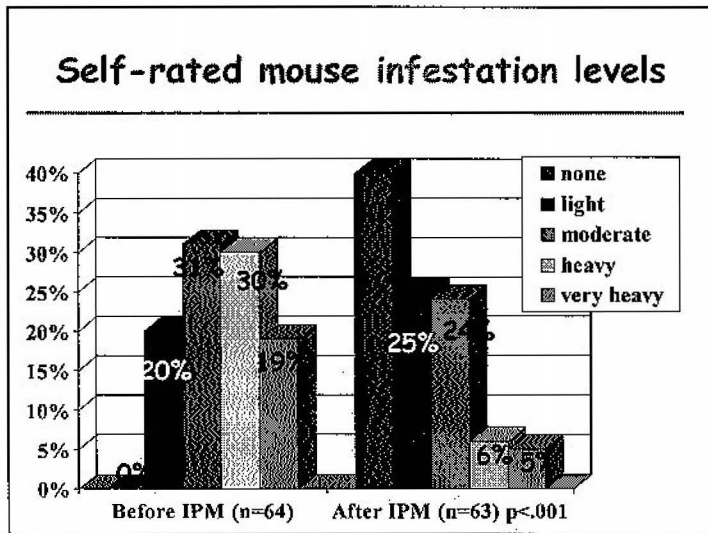


Figure 2: Self-reported infestation levels for participants with reported cockroach problem before and after IPM

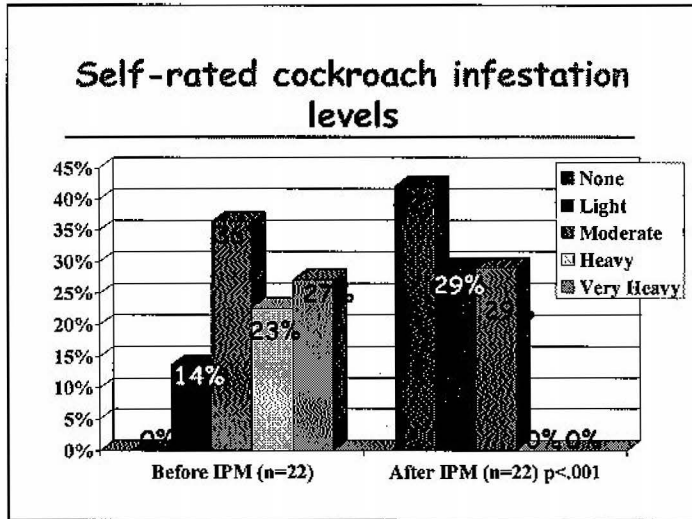


Figure 3: Parental ratings of child's asthma severity before and after IPM

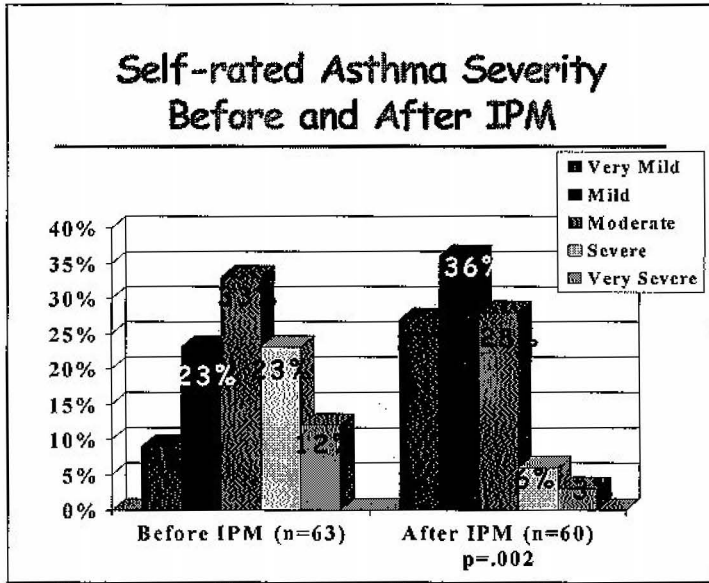


Table 1:

Mouse Infestation Self-Rating, Measured MUP Levels in bedroom dust and Percentage of Asthmatic Children With Mouse Allergies

Mouse Infestation Self-Rating (Before IPM)	Percent of Total Households (n=64) in Self-Rating Group	Avg. MUP for all bedroom samples of children (n=75)*	Percent of children within self-rating group with some MUP allergy (n= 75)*
None	3.1%	18.1 (n=2)	0% (n=2)
Light	20.3%	629.1 (n=13)	27.3% (n=11)
Moderate	29.7%	2777.2 (n=22)	9.5% (n=22)
Heavy	28.1%	5965.5 (n=25)	23.8% (n=26)
Very Heavy	18.8%	23091.69 (n=13)	50% (n=14)

* These changes in unit of analysis are necessary due to instances of multiple children and/or multiple bedrooms per household. The unit of analysis is reflected in the n value for each chart.

Endnotes

1. Mannino, D.M., et al., *Surveillance for asthma--United States, 1960-1995*. Mor Mortal Wkly Rep CDC Surveill Summ, 1998. **47**(1): p. 1-27.
2. Mannino, D.M., et al., *Surveillance for asthma--United States, 1980-1999*. MMWR Surveill Summ, 2002. **51**(1): p. 1-13.
3. Crain, E.F., et al., *An estimate of the prevalence of asthma and wheezing among inner-city children*. Pediatrics, 1994. **94**(3): p. 356-62.
4. Homa, D.M., D.M. Mannino, and S.C. Redd, *Regional differences in hospitalizations for asthma in the United States, 1988-1996*. J Asthma, 2002. **39**(5): p. 449-55.
5. Kattan, M., et al., *Characteristics of inner-city children with asthma: the National Cooperative Inner-City Asthma Study*. Pediatr Pulmonol, 1997. **24**(4): p. 253-62.
6. Phipatanakul, W., et al., *Mouse allergen. II. The relationship of mouse allergen exposure to mouse sensitization and asthma morbidity in inner-city children with asthma*. J Allergy Clin Immunol, 2000. **106**(6): p. 1075-80.
7. Crain, E.F., et al., *Home and allergic characteristics of children with asthma in seven U.S. urban communities and design of an environmental intervention: the Inner-City Asthma Study*. Environ Health Perspect, 2002. **110**(9): p. 939-45.
8. Rosenstreich, D.L., et al., *The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma*. N Engl J Med, 1997. **336**(19): p. 1356-63.
9. Phipatanakul, W., *Rodent allergens*. Curr Allergy Asthma Rep, 2002. **2**(5): p. 412-6.
10. Gergen, P.J., et al., *Results of the National Cooperative Inner-City Asthma Study (NCICAS) environmental intervention to reduce cockroach allergen exposure in inner-city homes*. J Allergy Clin Immunol, 1999. **103**(3 Pt 1): p. 501-6.
11. Brugge, D., et al., *Comparison of multiple environmental factors for asthmatic children in public housing*. Indoor Air, 2003. **13**(1): p. 18-27.
12. Kinney, P.L., et al., *On the front lines: an environmental asthma intervention in New York City*. Am J Public Health, 2002. **92**(1): p. 24-6.
13. Morgan WJ. Crain EF. Gruchalla RS. O'Connor GT. Kattan M. Evans R 3rd. Stout J. Malindzak G. Smartt E. Plaut M. Walter M. Vaughn B. Mitchell H. Inner-City Asthma Study Group. *Results of a home-based environmental intervention among urban children with asthma*. NEJM 351(11):1068-80, 2004 Sep 9.