Integrated Pest Management in an Urban Community: A Successful Partnership for Prevention

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Pesticides, applied in large quantities in urban communities to control cockroaches, pose potential threats to health, especially to children, who have proportionately greater exposures and unique, developmentally determined vulnerabilities. Integrated pest management (IPM) relies on nonchemical tools—cleaning of food residues, removal of potential nutrients, and sealing cracks and crevices. Least toxic pesticides are used sparingly. To evaluate IPM's effectiveness, the Mount Sinai Children's Environmental Health and Disease Prevention Research Center, in partnership with two community health centers in East Harlem, New York City (NY, USA), undertook a prospective intervention trial. Families (*n* = 131) enrolled when mothers came to the centers for prenatal care. Household cockroach infestation was measured by glue traps at baseline and 6 months afterward. The intervention group received individually tailored IPM education, repairs, least-toxic pest control application, and supplies, with biweekly pest monitoring for 2 months and monthly for 4 months. The control group, residing in East Harlem and demographically and socioeconomically similar to the intervention group, received an injury prevention intervention. The proportion of intervention households with cockroaches declined significantly after 6 months (from 80.5 to 39.0%). Control group levels were essentially unchanged (from 78.1 to 81.3%). The cost, including repairs, of individually tailored IPM was equal to or lower than traditional chemically based pest control. These findings demonstrate that individually tailored IPM can be successful and cost-effective in an urban community. *Key words:* children's environmental health, cockroach, community intervention trial, integrated pest management, pesticides, urban built environment. ***Environ Health Perspect* 111:1649–1653 (2003). doi:10.1289/ehp.6069 available via *http://dx.doi.org/* [Online 2 July 2003]**

Cockroaches, rats, and mice are major problems in the urban built environment. These vermin thrive in multifamily dwellings where excessive moisture, extensive cracks and crevices, abundant food sources, overcrowded closets, and stacks of paper provide them nutrition and shelter.

Pesticides are applied in large quantities in urban communities to control vermin (Landrigan et al. 1999). In 1997, a statewide survey in New York found the two counties that used the largest total amounts of pesticides to be Kings (Brooklyn) and New York (Manhattan) counties. In Manhattan, the total quantity of pesticides applied by commercial applicators in 1998 was 270,633 pounds (Thier 2000). Household studies have confirmed this pattern and have shown repeatedly that chemical pesticide use is common in urban communities (Adgate et al. 2000; Berkowitz et al. 2003; Whyatt et al. 2002). A household exposure survey found that 100% of a population of pregnant women in northern Manhattan and the South Bronx had detectable airborne exposures to each of three insecticides—the organophosphate insecticides diazinon and chlorpyrifos and the carbamate propoxur—as well as to the fungicide *o*-phenylphenol (Whyatt et al. 2002).

Organophosphate pesticides, including those used in urban apartments, appear to be neurodevelopmental toxicants. Studies of organophosphate exposure in laboratory animals, particularly evaluations of exposures in early life, have found associations with developmental delays, hyperactivity, motor dysfunction, behavioral disorders, and brain cell death (Campbell et al. 1997; Dam et al. 2000; Levin et al. 2001). These findings led the U.S. Environmental Protection Agency (U.S. EPA) to restrict residential uses of the organophosphates chlorpyrifos and diazinon, and they have prompted epidemiologic studies of possible neurodevelopmental effects of pesticides in several population cohorts in rural and urban communities in the United States (Berkowitz et al. 2003; Eskenazi et al. 1999; Perera et al. 2002; Whyatt et al. 2002).

Integrated pest management (IPM) is an alternative to conventional, chemical-based pest control (Olkowski et al. 1991). It relies on nonchemical approaches plus education and uses comprehensive information on the life cycles of pests and their interactions with the environment to guide pest control. The concept underlying IPM is that pest populations can be controlled by removing their basic survival elements, such as air, moisture, food, and shelter, by blocking their access to apartments by sealing cracks and crevices and by the careful placement of least toxic baits and gels. Maintenance, sanitation, education, and training are the cornerstones of IPM. Few systematic studies of IPM have been undertaken in the urban setting. Some have produced positive results, but others report limited success (Campbell et al. 1999; Kass and Outwater 2002; Kinney et al. 2002; Surgan et al. 2002).

In this article we describe the successful implementation of IPM in East Harlem, New York City (NY, USA). The work was undertaken through the Mount Sinai Children's Environmental Health and Disease Prevention Research Center in partnership with Boriken Neighborhood Health Center and Settlement Health, two neighborhood health centers. The study design was a two-armed prevention intervention trial designed to test whether IPM techniques and targeted education at the household level can reduce cockroach infestation and exposure to chemical pesticides in urban households.

Study Design and Methods

Overview. This project, titled Growing Up Healthy in East Harlem, is an intervention trial designed to test whether IPM techniques and targeted IPM education at the household level can effectively reduce cockroach infestation and indoor exposure to chemical pesticides in an urban community. The study contained an intervention as well as a control group. Both intervention and control group families reside in East Harlem, a neighborhood

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in northern Manhattan (zip codes 10029 and 10035). The intervention group was recruited at the Boriken Neighborhood Health Center. The control group was recruited initially at Mount Sinai Hospital and then at Settlement Health. Outcomes were assessed in each group by comparing cockroach levels in households that received an individually tailored IPM intervention with levels in control group households that received no pest control intervention. Evaluations were performed at baseline and then at 6 months. Additional follow-ups will be undertaken at 1-year and 2-year intervals.

Field studies. Recruitment and enrollment of families into this study began in September 1999 and ended in June 2002. Before and throughout the study, design and methods were discussed and reviewed by the Mount Sinai School of Medicine investigators with their community partners, Boriken Neighborhood Health Center and Settlement Health. The study was reviewed and approved by Mount Sinai's institutional review board.

The intervention (IPM) group was recruited from among women who received prenatal care at the Boriken Neighborhood Health Center over a 30-month period (September 1999 through March 2002). The control group was recruited from women who received prenatal care at the Mount Sinai Hospital Prenatal Clinic from January 2000 through December 2000 (12 months) and at Settlement Health from May 2001 through June 2002 (14 months). Different recruitment venues were used for the two groups to minimize cross-communication. Both intervention and control participants received a $25 compensation for the time and effort involved in the initial enrollment interview and for each subsequent home exposure assessment visit.

A total of 131 women (76 intervention group and 55 control group participants) enrolled in the Growing Up Healthy in East Harlem study. Intervention and control group participants at all sites were enrolled after signing a written informed consent (in English and Spanish). Upon enrollment, bilingual study personnel administered a 122-item questionnaire, in English or Spanish as appropriate, to obtain information on characteristics such as home environmental conditions and sociodemographic characteristics. The questionnaire was a modified version of the American Lung Association's Home Environment Assessment List (HEAL; American Lung Association of Washington 1992). A home visit was arranged to collect baseline cockroach levels and conduct a visual inspection of the home. All participants identified East Harlem as place of residence.

Of the 131 enrolled women who participated in the baseline cockroach assessment, 88 (67.2%) remained in the study at the 6-month follow-up visit (50 intervention, 38 control homes). Of the 43 who dropped out, 35 did so because they moved out of the East Harlem community, four because they were "too busy," and four because they were concerned that their landlord would object to their continued participation. The distribution of these causes was similar in both groups. In the present analysis, we included the 73 mothers in 41 intervention and 32 control households that had both a baseline visit that occurred 1–21 days enrollment and a 6-month follow-up visit that occurred 180–230 days after baseline (Table 1). Participants who were excluded from the study either dropped out of the study entirely (26 intervention households and 17 control households) or were excluded because they had delayed cockroach monitoring visits (9 intervention households and 6 control households).

The intervention group. During the home visit, a visual inspection, using a standardized checklist, was performed to identify sources of pest entry and sustenance and to note needed home repairs. Based on this inspection, each intervention participant received an individually tailored IPM program with a range of services, including education and instruction in nontoxic IPM methods by the project health educator; instruction in better housekeeping and sanitation and garbage removal practices; repair services to seal cracks and crevices by a project handyman; fixing plumbing leaks; least-toxic supplies, including zone monitors, plastic bait stations, and gel rather than pesticide sprays; expert advice from pest control experts; and advocacy with building management to introduce safe pest control practices.

A second home visit was made by a health educator approximately 1 month after the initial home visit to discuss the health effects of pesticides, pests, and other neurotoxins; to outline the basic principles of IPM; and to develop a plan to control pests and reduce household exposure to pesticides. Households were also instructed in the use of safer products to control lice, fleas, and ticks.

An appointment was scheduled for a professional exterminator specializing in IPM and least-toxic pest control methods to visit the home to apply baits and gel (with the active ingredient hydramethylnon) in strategic locations and to place cockroach monitors. The monitors were rectangular pieces of cardboard, 2.5 × 4.5 inches, folded as a tent, to which an adhesive is applied (model M327; Victor Roach Trap & Monitors, Utitz, PA; U.S. EPA 47629-PA-01). Roaches are trapped on the monitor when they step on the adhesive. A monitor was considered positive if it had one or more roaches. Initially, cockroach monitors were located in as few as seven and as many as 16 locations at pest entrance sites. However, after the first 35 households had been monitored, a decision was made to place monitors in eight standardized locations: six in the kitchen and two in the bathroom. This decision was based on the fact that virtually all roaches were captured in either kitchens or bathrooms, and monitors placed elsewhere were largely uninformative. Monitors were placed in tight, enclosed, warm, and moist spaces, such as drawers, kitchen cabinets, and closets and under the sink, where roaches are likely to inhabit and find food. The specific location of each monitor for each household was entered on a pest monitoring form, which was used to record the number and location of cockroaches at baseline and at subsequent monitoring visits.

The exterminator used no pesticide sprays. Least-toxic pesticides such as gels and baits were used only when deemed necessary by the exterminator. If repairs were required (e.g., sealing cracks and crevices or closing holes), the project handyman provided repair service at no cost to the family. Participants also had the option of contacting their landlord to make the repairs. Referrals were made as necessary to a neighborhood advocacy organization that helps tenants with housing-related issues and complaints, including negotiating with landlords for housing repairs and/or taking complaints to the New York City Housing Court for legal remediation.

For both intervention and control groups, monitors were placed during the initial home visit and recovered 2 weeks later (baseline assessment). In addition, to track the efficacy

Table 1. Time-line of cockroach assessments, days [median (range)] after enrollment in study.

	Followed study population		Population lost to follow-up	
Time line	Intervention (n = 41)	Control (n = 32)	Intervention	Control
Baseline	14 (13–21)	14 (1–24)	14 (13–72) (n = 35)[a]	14 (1–33) (n = 23)[b]
4–6 weeks	29 (27–40)	—	29 (27–59) (n = 8)	—
6–8 weeks	44 (42–63)	—	56 (41–104) (n = 9)	—
8–10 weeks	59 (56–84)	—	77 (64–125) (n = 9)	—
3 months (10–12 weeks)	90 (70–112)[c]	—	111 (97–175) (n = 9)	—
4 months (12–16 weeks)	120 (99–143)	—	158 (128–206) (n = 9)	—
5 months (16–20 weeks)	152 (126–173)	—	188 (160–242) (n = 9)	—
6 months (20–24 weeks)	181 (149–203)	—	234 (190–294) (n = 9)	—
6-month follow-up	197 (164–228)	203 (195–230)	250 (204–327) (n = 9)	247 (238–274) (n = 6)

[a]n = 26 had no 6-month follow-up; n = 9 with baseline > 21 days, 6-month follow-up > 230 days, or both. [b]Seventeen had no 6-month follow-up; six had late baseline or 6-month follow-up. [c]n = 40.

of IPM, pest monitoring visits were made every 2 weeks for the first 2 months to each home in the intervention group by the community outreach coordinator and the exterminator and once a month for the next 4 months. For the intervention homes, at the 2-week visit, another set of monitors were placed (2–4-week monitors). Subsequently, intervention homes had monitors placed and collected at 4–6, 6–8, and 8–10 weeks and at 3 months (10–12 weeks), 4 months (12–16 weeks), 5 months (16–20 weeks), and 6 months (20–24 weeks). During the 6-month visit, the community outreach coordinator visited the home to encourage the participant to continue practicing IPM and to place the 6-month evaluation monitors. These monitors were collected 2 weeks later (6-month follow-up visit; Table 1).

The control group. Control group participants received a home visit within 1 month after their enrollment for the placement of six cockroach monitors in the kitchen and two in the bathroom. These monitors were collected 2 weeks later. Follow-up visits with repeat monitoring were made after 6 months. As an incentive to participate, control group participants from Settlement Health received a home injury prevention intervention program 1 month after sample collection, consisting of one-on-one education about steps to follow in case of an emergency, how to choose a good babysitter, and how to prevent accidents such as sudden infant death syndrome, fire, and poisonings. Participants were provided educational materials in English and Spanish and a set of home safety products, including a smoke detector, fire extinguisher, and first aid kit. Home injury prevention lessons were reinforced at the 6-month visit.

Statistical methods. The significance of differences between the study groups for categorical sociodemographic variables, dwelling characteristics, and reported baseline pesticide problems and pesticide use was assessed by chi-square analysis. Cockroach infestation at each visit was measured by the number of positive cockroach monitors and by the percentage of households with any cockroaches. A monitor was considered positive if it contained at least one cockroach. Because the number of monitors placed was not uniform across all households, a percentage of positive monitors out of the total monitors placed was also calculated. The difference between the groups in proportion of households with cockroaches at baseline and at 6 months was assessed using the chi-square test. Comparisons within a group between proportion of households with cockroaches at baseline and the proportion with cockroaches at 6-month follow-up were done using McNemar's test. Wilcoxon's rank-sum test was used to assess the equality of medians between the groups for the variable percentage of positive cockroach monitors at baseline and at 6 months. In the intervention group, the Cochran-Armitage trend test was performed to assess decrease in proportion of households with cockroaches over 6 months. The difference in decline of percent positive monitors between the IPM and control group was assessed by analysis of covariance with PROC GLM (SAS Institute, Inc., Cary, NC) adjusting for baseline cockroach infestation levels. Tests of significance were two sided at baseline and one sided for change over 6 months. SAS (version 8.02) software was used for all statistical analyses (SAS Institute, Inc.).

Table 2. Distribution of maternal sociodemographic characteristics: pesticide intervention project, New York City, 1999–2002.

	Followed study population		Population lost to follow-up	
Characteristics	Intervention (n = 41)	Control (n = 32)	Intervention (n = 35)	Control (n = 23)
Age (mean ± SD)	26.0 ± 5.4	27.9 ± 6.6	26.6 ± 6.9	26.9 ± 5.2
Race/ethnicity/country of origin (%)				
African American	12.2*	15.6	17.1	30.4
Mexican	41.5	15.6	42.9	13.0
Puerto Rican	26.8	56.3	31.4	39.1
Hispanic/other	19.5	12.5	5.7	17.4
Other (non-Hispanic)	—	—	2.9	0.0
Marital status (%)				
Married	12.2	9.4	14.3	13.0
Living with baby's father	53.7	40.6	37.1	30.4
Divorced/widowed/separated/single	34.2	50.0	48.6	56.5
Education (%)				
Elementary/junior high	9.8	9.4	17.1	8.7
Some high school	34.2	46.9	25.7	30.4
High school	31.7	25.0	37.1	34.8
Some college to doctoral degree	24.4	18.8	20.0	26.1
Type of housing (%)				
High-rise apartment	31.7	46.9	36.4	47.8
Low-rise apartment	65.9	53.1	60.6	52.2
Private house	2.4	0.0	3.0	0.0
Other	—	—	—	—
Residential ownership (%)	(n = 40)	—	—	—
Public housing	40.0	50.0	34.4	39.1
Rental/private	60.0	46.9	65.6	56.5
Owner occupied	0.0	3.1	0.0	4.4
Year housing built (%)	(n = 28)	(n = 30)	(n = 18)	(n = 22)
Before 1960	60.7	53.3	50.0	50.0
After 1960	39.3	46.7	50.0	50.0

*Chi-square test was significant, $p < 0.05$, within the subgroup; there was no significant difference between the followed study population and those not followed.

Table 3. Baseline prevalence of cockroach infestation and indoor pesticide exposure reported by questionnaire: pesticide intervention project, New York City, 1999–2002.

	Study population followed		Population lost to follow-up	
Questionnaire items	Intervention (n = 41)	Control (n = 32)	Intervention (n = 35)	Control (n = 23)
Cockroach problem in home (%)	75.6	75.0	94.3*	56.5
Pesticide used (%)[a]	55.0[b]	64.5[c]	62.9	56.5

[a]Includes any insecticide used by exterminator, landlord, self-use, or fumigation. [b]n = 40. [c]n = 31.*Chi-square test was significant, $p < 0.05$, within the subgroup; there was no significant difference between the followed study population and those not followed.

Results

Table 2 summarizes baseline demographic and housing characteristics of the study cohort and includes a comparison between the families who remained in the study and those who were lost to follow-up, for both the intervention and control groups. Among the families who remained in the study, the intervention and control groups differed only by country of origin, in that among the Latina population there were more Mexicans in the intervention group and more Puerto Ricans in the control group. There were few demographic differences between persons who were followed and those not followed, and none reached statistical significance.

Three-quarters of the families in both the intervention and control groups who were followed in this study reported a cockroach problem in the home at baseline (Table 3). Because persons were recruited at different seasons of the year, we examined baseline cockroach counts to determine whether any seasonal differences existed between the groups in either frequency or intensity of cockroach infestation. No seasonal differences between the groups were observed. Approximately 60% of households in both groups reported that pesticides had been applied in their homes during their pregnancy by an exterminator, landlord, or someone in the household, including the participant. Among the families who were lost to follow-up, nearly all (94.3%) of the intervention households reported having a problem with insect infestation in the home at baseline, a rate significantly higher than the reported rate of infestation in the control households that were not followed (56.5%; Table 3).

The monitors showed that cockroaches were present at baseline in approximately 80% of both intervention and control households in the population that was followed (Table 4). This prevalence is slightly higher than the level of infestation in the population lost to follow-up, but not statistically different.

After 6 months of IPM, there was a marked and significant decrease in cockroach infestation among intervention households (from 80.5 to 39.0% of households; p < 0.0001, McNemar's test). By contrast, control households showed no reduction (from 78.1 to 81.3%; Table 4). Table 3 illustrates that infestation levels in the intervention group at the 6-month follow-up (39.0%) were significantly lower than in the control group at the same time (81.3%; p < 0.001, chi-square test). We saw no change in these results when the 15 households that had been excluded from analysis because of late second visits were included in the calculation.

Figure 1 shows the visit-by-visit change in cockroach infestation measures in intervention households during the 6 months of the study. A significant decrease in percentage of households with any cockroaches was noted (p < 0.0001, trend test). Most of this decline occurred within the first 6 weeks after introduction of IPM. In half of the homes, the cockroach count fell to zero. The decline persisted throughout the 6-month period.

The costs of adopting buildingwide IPM in a typical East Harlem apartment building were calculated to be $46–69 per unit in the first year (including repairs) and $24 per unit per year in subsequent years. In comparison, the costs of traditional, chemically based pest control are estimated to be $24–46 per unit per year, not including repairs, because repairs are not typically undertaken in traditional pest control (Assured Environments, Inc. Personal communication).

Discussion

The data from this two-armed prospective assessment of an IPM intervention in East Harlem indicate that IPM, individually tailored at the household level, can significantly and cost-effectively reduce cockroach infestation in urban households for at least a 6-month period. The frequency of cockroach infestation in the IPM intervention households declined by more than 50% over the 6 months of the study, whereas cockroach levels in control group households remained unchanged. Although there was loss to follow-up, 82% of this loss stemmed from families' moving out of the East Harlem community. We found no significant differences in sociodemographic characteristics between those households that remained in the study and those that were not followed.

Only a few previous studies have rigorously evaluated the effectiveness of IPM interventions to determine whether they can reduce indoor cockroach levels in urban households. These investigations have reported mixed results (Campbell et al. 1999) and have noted that introduction of IPM in inner-city communities may encounter multiple challenges (Kinney et al. 2002). Some researchers have argued that IPM will be effective in multiple-unit apartment buildings only if it takes place in the context of a buildingwide program of repair and pest control (Kass and Outwater 2002; Kinney, et al. 2002). We found otherwise: In the present study, we observed that individual tenants can successfully control cockroach infestation in their own apartments without using chemical pesticide sprays. The critical element in successful implementation of IPM by low-income, urban households appears to be the simultaneous application of multiple nonchemical approaches to pest control, including education, repair, least-toxic extermination, reinforcement, and repetition, all in the context of a community partnership and in a culturally sensitive environment.

A previous effort that produced findings similar to ours was reported from Chicago, Illinois, by the Residents' Committee of the Henry Horner Homes Public Housing Development and the Chicago Pest Control Project (Surgan et al. 2002). The IPM plan in that project consisted of cleaning out all vacant units; cleaning by residents in occupied units; replacing aerosol pesticides with less toxic gels, pastes, and nontoxic baits; and preventive measures such as caulking, screening, and better trash disposal. In addition, residents received educational material. A private pest control company was hired to inspect and treat apartments with gel bait where needed. During the course of the project, pest control operators reported a sharp decline in cockroach activity, resulting in an 83% drop in the amount of insecticidal gel bait applied (Viehweg J. Personal communication). A common factor in both our investigation and the Chicago project was strong community involvement at every stage from initial planning, through implementation, to final evaluation.

In the present project, the IPM intervention was individually tailored and systematically applied. All study personnel were employees of the local community health centers and were bicultural and bilingual in Spanish, the primary language of many participants. Most lived within the community. A key ingredient in the effectiveness of our educational program was the in-home "hands-on" demonstration that focused on how to identify sources of cockroach infestation and how to control the conditions that nurture them, such as leaks, clutter, food sources, and garbage. Also important was that a handyman, a resident of the community, was assigned to the intervention. He plugged cracks and crevices that are entry points for the cockroaches and fixed water leaks and refrigerator gaskets. All of these factors were important in enrollment and retention and in

Table 4. Presence of cockroaches at baseline and at 6-month follow-up in control and intervention households. Pesticide intervention project, New York City, 1999–2002.

	Study population followed				Population lost to follow-up	
	Intervention[a]		Control[b]		Intervention[c]	Control[d]
	Baseline	Follow-up	Baseline	Follow-up	baseline	baseline
Households with any cockroaches (%)	80.5*	39.0*,**	78.1	81.3**	66.7	66.7
Median no. of cockroach monitors placed	8	8	8	8	8	14.5
Median no. of positive cockroach monitors	3	0	5	4	2.5	3
Median of positive cockroach monitors (%)	25.0	0.0	54.0	40.0	33.5	20.0

[a]n = 41. [b]n = 32. [c]n = 12. [d]n = 6. *At the 6-month follow-up, intervention households reported a significant decrease in the percentage of households with any cockroaches (p < 0.0001, McNemar's test). **At the 6-month follow-up, there are significantly fewer households with cockroaches in the intervention group than in the control group (p < 0.001).

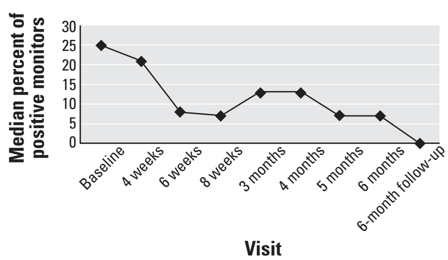

Figure 1. Percentage of positive cockroach monitors in intervention households (median and interquartile range) during a 6-month period: pesticide intervention project, New York City, 1999–2002. There is a significant decrease in the number of households with any cockroaches in the intervention group at the 6-month follow-up compared with baseline (p < 0.0001, trend test; n = 41, except for 3 months, n = 40).

the degree to which participants were receptive to having study personnel inspect and monitor their homes.

Although the dropout rate at 6 months among both intervention and control group participants was high (46% for the intervention group and 42% for the control group), the reason for dropout was primarily (82%) that participants had moved out of the East Harlem community. Moreover, we observed no significant differences between intervention and control groups in age, marital status, education, type of housing, ownership of housing, or age of housing. Among the population lost to follow-up, more of the intervention group than the control group had an insect problem at baseline.

Reported pesticide use during pregnancy in this population, although high (55–65% of homes), is somewhat lower than that reported in two other recent studies of urban households. In a cohort of 386 pregnant women receiving prenatal care at Mount Sinai Hospital, 72.3% reported indoor pesticide use during pregnancy (Berkowitz et al. 2003). This multiethnic cohort was 20% Caucasian, 27% African American, 51% Hispanic (primarily Puerto Rican), and 2% other of mixed race and ethnicity. In a cohort of pregnant African-American and Dominican women residing in northern Manhattan and the South Bronx, 85% reported indoor pesticide use (Whyatt et al. 2002).

We conclude on the basis of these data that IPM techniques are effective and relatively economical in controlling cockroach infestation in urban apartment dwellings at the household level, if community residents are directly involved in the development and implementation of the project at every stage and are provided with systematic education and "hands-on" guidance by pest control experts skilled in IPM techniques. These efforts must be supported by an infrastructure of knowledgeable building managers, superintendents, and other staff who provide services to urban apartments. The approach is exportable to apartment dwellings in similar urban communities.

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