National Center for Healthy Housing

What's Working for Bed Bug Control in Multifamily Housing:

Reconciling best practices with research and the realities of implementation

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Executive Summary

There is no silver bullet for eliminating bed bugs. They present a challenge to modern pest control that the industry is still struggling to meet. To make up for the lack of chemical power we have for battling this insect, additional people and tools must be involved. Bed bug success stories usually involve people who live and work in a building (including a pest management professional) coming together as a team to battle this pest. Throughout this paper you will see how communication and cooperation among residents, staff, and the pest control service provider are keys to success.

This report is designed for health professionals, housing professionals, and pest management professionals seeking to plan for or respond to a bed bug infestation in multi-family housing. It is not a best management practices document and does not comprehensively address the biology, behavior, or health implications of this pest. For information on these topics, contact your local cooperative extension program, university entomology department, or department of health.

It is a summary and evaluation of the methods used to control bed bugs based on published research, trade magazine articles, and interviews with practitioners and researchers. See the Acknowledgements and References sections for the lists of people and works consulted. This document covers what they have found actually works. The body of the document covers the Pros, Cons, and Recommendations for each management method. References to peer reviewed and non-peer reviewed research are included as footnotes.

Bed bugs at various stages of growth.

The following table is a summary of considerations for IPM methods for bed bugs. Each method is discussed in more detail in this paper.

Summary of Bed Bug Management Methods

Management Method	Primary Responsibility	Retail Cost per System	Commentary	Compatibility with other methods
Laundering	Resident	Dissolvable Bag: $22 for 10	Laundered fabrics will be free of bed bugs as long as they are kept isolated from infested areas.	Include in every control effort.
Unit Preparation	Resident	Varies	Poor housekeeping, sanitation, etc., are not necessarily conducive to bed bug infestations, but bed bugs are more likely to remain undetected and pest control efforts are more likely to fail in a cluttered home.	Include in every area so that the Pest Management Professional (PMP) can properly inspect the property.

Management Method	Primary Responsibility	Retail Cost per System	Commentary	Compatibility with other methods
Encasements	Resident	$80 for mattress and $50 for box spring	Bed bugs that are trapped in an encasement designed for use in bed bug control will not be able to feed or escape and will eventually die. Encasements keep bed bugs from infesting mattresses and box springs.	Use encasements either after treatment or before an infestation is found.
Monitors	PMP, resident, or staff	4 interceptors for $8. Carbon dioxide attractant attractant devices $15–$950 initial cost.	Monitors will catch bed bugs, but are not meant to control infestations.	Monitors can be used alone or in combination with other detection and control methods to confirm active bed bug infestations.
Vacuuming	PMP, trained staff, or trained resident	HEPA Vacuum for $250–$500	Vacuuming is not reliable as an exclusive control method.	PMPs, staff, and residents should use a vacuum to remove bed bugs during inspections and unit preparation.
Steam	PMP or trained staff	$500–$1500	Steam wand must be moved at a rate that heats the area to a lethal temperature.	Use with other methods such as insecticidal dust for voids that steam cannot penetrate. Mattresses and box springs must be dry prior to encasement.
Thermal Remediation Using Ambient Heat	PMP or trained staff	$330 for luggage-sized container. $90,000 for whole unit heater. $800–$2,000 to treat an apartment.	Lethal temperatures must penetrate all items for the treatment to kill all stages of bed bugs.	Heat treatment is a good option for cluttered homes where preparation is a struggle.
Bed Bug Detecting Canine	PMP	$10,000 to purchase. $1,300 per team per day.	Dogs are effective and effecient for large-scale (multi-unit) inspections.	Use with visual inspection. Treat in areas where the dog alerts.
Pesticides	PMP	Varies by product.	See analysis in the following report. Consider the residual and ovicidal properties of each product before selecting it.	Pesticides are used as needed in combination with other treatment methods.
Freezing Using Dry Ice	PMP	$6,900 for a machine	Not widely used in the US, but widely used in Europe. Insufficient information to assess at this time.	More research is needed comparing the penetration of both heat and cold.

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What's Working for Bed Bug Control?
An Evaluation of Methods

1. Inspections

1.1 Visual Inspections

Pros

All pest control is about site-specific problem solving. The pest management professional (PMP) doesn't need to locate every bed bug to treat successfully, but the PMP needs to look for bed bugs in various locations to determine the extent of the infestation. In addition, a visual inspection is essential for understanding site-specific limitations and preparation needs. Conversations with the residents during inspection may also identify where the bed bugs came from and is an opportunity for educating the residents about preventing further introduction. Both of these are important to property-wide control efforts. Early detection and prompt professional treatment is the most time- and cost-effective solution for bed bugs, and knowing the scope helps the PMP plan for effective treatment. Checking hot spots for signs of bed bugs (e.g., the bugs themselves, eggs, and blood spots) does not take a long time, and a quick inspection for signs of all household pests is already part of many pest control companies' routine service.

Cons

Visual inspections may miss bed bugs in an infested area and often severely underestimate the actual number of bed bugs in apartments (Wang et al., 2009a†). Clutter in homes is a significant impediment to finding all bed bug harborages.

Recommendations

Regardless of how the PMP plans to control bed bugs, whoever is responding to a bed bug report should start with visual inspection to understand the extent of the infestation. PMPs, cleaning contractors, landlords, and residents alike should look for all life stages of bed bugs in the hot spots. Research shows that the locations where bed bugs are most often found (in order of most to least often infested) are beds, bedding, baseboard/carpet edges, furniture such as nightstands and dressers, upholstered furniture such as couches and chairs, walls and ceilings, clothing, and appliances (Potter et al., 2008a‡; Gangloff-Kaufmann et al., 2006a‡). These areas should be inspected monthly in a building that has a history or high risk of infestation (e.g., buildings with frequent turnover or high visitor traffic). If monthly inspection is not feasible, quarterly inspection may be substituted, with residents taking a higher responsibility for detecting and reporting bed bugs. Management's commitment to educating residents about pests and fronting the costs of all components of preparation and treatment helps ensure resident cooperation.

Bed bug crawling into a screwhole to hide.

When the PMP finds bed bugs, he should perform a thorough inspection[1]. At a minimum, the PMP must have access and

[1] *Inspecting the infested residence is a must, but inspection should go beyond the infested unit (Wang et al., 2010†). Adult bed bugs can travel over 16 feet in five minutes (Haynes et al., 2008‡), and adult female bed bugs tend to disperse from clusters (Pfiester et al., 2009†). Early instar nymphs often cluster (Benoit et al., 2007†), increasing the likelihood of detection. These nymphs also tend to stay close to food sources, which increases the likelihood of detection.*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

inspect all units—above, below, and on all sides (including across the hall)—adjoining infested units. An adjacent unit is often an unreported reservoir of bed bugs[2].

If the inspection finds bed bugs only in or around a bed, the infestation is most likely light to moderate. In this case, an infested bed can be isolated from the rest of the room by pulling it away from walls and other furniture, keeping any bedding from touching the floor, and putting all bed frame legs in an interceptor (See Section 2.1). PMPs call this process making the bed into an island. If the resident can make the bed into an island, a PMP can potentially resolve a light infestation with two professional treatments and minimal preparation of the area.

When a resident reports bed bugs in a building with no history of bed bugs, management should call a PMP to perform a building-wide bed bug inspection. In response, the PMP will briefly inspect each unit within the building to determine the scope of the infestation and plan treatment accordingly. See Section 4: Unit Preparation. Even if bed bugs are only found in the reported unit, the immediate building-wide response can be used to educate other residents about inspection and prevention.

1.2 Inspections Using Bed Bug Detection Canine

Pros

Well-trained dogs are useful for the following tasks:

- Building-wide inspections to identify the scope of the infestation (with the intention of treating every site where the dog finds bed bugs);
- Initial inspections to confirm whether an infestation is present when visual inspection cannot find a bed bug;
- Post-treatment verification that no live bed bugs or viable eggs are present; and
- At trainings or door-to-door talks as a motivator for residents to find out more about bed bug control.

The last of these is worth highlighting since lack of adherence to the PMP's instructions on the part of either management or residents is often the cause for treatment failures. If a trainer brings a dog to a meeting, it can serve as an icebreaker for discussing the responsibilities of residents and management vis-à-vis bed bug control.

Cons

While bed bug detection canine providers report 98% accuracy, some PMPs remain concerned with false positives (e.g., the dog alerting to an area where bed bugs are not found). The dogs stay most effective with daily tuning and routine check-ups from the original trainer. Controlled training minimizes the chance of false positives. Options for check-ups from the original trainer include in-person visits, video conferencing, and blind test kits that are completed and mailed back to the trainer for scoring.

Dogs have bad days, just like people. If the handler or the dog is having a bad day, the dogs may not perform at their highest levels. An uncomfortable or stressful environment also can affect the dog's performance (Cooper, 2007a‡). Like other service dogs, bed bug detection canines are not pets. They are living tools of the trade. PMPs serving as canine handlers must not forget this distinction at all times.

Recommendations

Inspections using a bed bug detection canine are especially useful in two scenarios. The first is when a person reports bed bugs but the PMP can't find any with visual inspection. The second is when a PMP wants to confirm that the area is bed bug-free, for example post-treatment. Canine inspections for bed bugs can identify emerging infestations in their earliest stages, helping property managers gain building-wide control before an infestation spreads to other units, saving considerable time and money.

Inspection with canines is useful for detection, but as with inspection by humans, there is potential for error. The dog's effectiveness depends upon the quality of its

[2‡] *PMPs report migration resulting from dense bed bug infestations and the use of foggers. Building-wide policies against the use of foggers can prevent both migration and the risk of an explosion. At minimum, property management should offer information on proper label use and product selection.*

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‡ = *source is not peer reviewed*

training, the ability and consistency of its trainer, and the conditions in the area of inspection. In addition, companies should know exactly what their dog can and cannot be expected to do. For instance, not every dog is trained to detect viable versus unviable eggs. If trained and handled properly, bed bug-sniffing dogs can inspect much more effectively and in a much shorter time than a human[3].

The National Pest Management Association (NPMA) is starting a canine scent detection division to bring together stakeholders such as the National Entomology Scent Detection Canine Association (NESDCA) to develop national standards and procedures. Properties looking to use a canine for inspection should consult recommendations put forth by this group.

2. Monitors

Monitors are an important tool for bed bug control, which pest control companies may offer as a detection option in place of a visual inspection[4]. Currently, PMPs use two types of bed bug-specific monitors: moat-style interceptors (Climbup® Insect Interceptors); and portable devices that use heat, carbon dioxide, and kairomones as lures (CDC 3000 and NightWatch™). Unpublished research from Dr. Wang's lab at Rutgers University showed their homemade portable monitor was more effective than those commercially available.

Many PMPs also use common sticky traps for bed bug monitoring[5]. Research has not been published on the efficacy of sticky traps as bed bug monitors, but professionals report that the monitors do catch bed bugs if they place enough around hot spots. A heat lure in the center of a sticky trap or placement of several traps may improve performance.

Monitors are without a doubt a valuable addition to the options available for bed bug control. Monitors using carbon dioxide, heat, and a chemical lure have great potential, but are not yet widely used in multifamily housing because they are expensive and have not been on the market for very long. Until more research emerges, the different types of monitors should not be considered as equivalents to each other (or canine inspection) for indentifying a bed bug infestation[6].

[3] *Research indicates that dogs are able to discriminate bed bugs from* Camponotus floridanus, Blattella germanica, *and* Reticulitermes flavipes, *with a 97.5% positive indication rate (correct indication of bed bugs when present) and 0% false positives (incorrect indication of bed bugs when not present). Dogs also were able to discriminate live bed bugs and viable bed bug eggs from dead bed bugs, cast skins, and feces with a 95% positive indication rate and a 3% false positive rate on bed bug feces. In a controlled experiment in hotel rooms, dogs were 98% accurate in locating live bed bugs (Pfiester et al., 2008*[†]).

[4] *The only peer-reviewed study on a bed bug monitor reported on the effectiveness of the moat-style interceptor for monitoring bed bugs. This study found interceptors are more effective than visual inspection for estimating numbers and detecting infestations (Wang et al., 2009a*[†]).

[†] = *source has undergone peer review*

[‡] = *source is not peer reviewed*

[5] *A survey of PMPs found that fewer than 50% use glue boards, steamers, fumigation, or freezing for bed bug treatment, and 53% routinely use sticky traps to monitor and detect bed bug activity. Pest control companies also report using double-sided sticky tape around the legs of bed frames (Potter et al., 2008a*[‡]*).*

[6] *The only peer-reviewed study on a bed bug monitor reported on the effectiveness of the moat-style interceptor for monitoring bed bugs. This study found interceptors are more effective than visual inspection for estimating numbers and detecting infestations (Wang et al., 2009a*[†]*).*

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[‡] = *source is not peer reviewed*

2.1 Moat-Style Interceptors

Pros

When users place a bed frame leg in the center of the interceptor, the device makes a moat around the leg. Talcum powder applied to the walls of the moats causes bed bugs to slip and fall in, where they remain trapped. These devices are cost effective and PMPs can use them to help confirm complete elimination, show where bed bugs are coming from (an inner and outer moat shows whether the bed bugs came from the floor or the bed), detect an infestation early on, and give residents some reassurance that bed bugs won't get on their bed. While moat-style interceptors are not a complete control tool, they do trap bed bugs in addition to monitoring. Most PMPs consider interceptors worthwhile.

Interceptors are an effective tool for determining the presence of bed bugs and the need for action. Residents often contact experts (e.g., cooperative extension staff) when they suspect they have bed bugs. Experts can save time by giving monitors to residents who suspect they have bed bugs but lack evidence. Asking the resident to use the interceptors to catch a bed bug before asking for a full consultation can save valuable time and help put the person at ease.

Cons

Moat-style interceptors use a sleeping human as the lure and catch bed bugs when they try to crawl up (or down) the bed legs. Their effectiveness can be compromised in several ways:

1. Bed bugs can crawl in and out of the device if the talcum powder that coats the inner-sides of the moat is not kept fresh. Residents or maintenance staff need to maintain the devices.
2. Alternative "bridges" from the floor to the mattress (such as a blanket, bed skirt, or headboard touching the wall) will reduce effectiveness.
3. They cannot be used where furniture does not have legs or the legs cannot fit into the device.
4. The device should be placed on a solid surface to prevent cracking. If there is doubt, a square of 1/4" plywood should be put under the interceptor.

Recommendations

Interceptors are recommended for bed bug monitoring. As passive monitors, interceptors don't share some of the faults associated with canine and visual inspection because their success isn't contingent upon training or thoroughness. PMPs or property managers should use interceptors to monitor for bed bugs. When published research becomes available comparing interceptors to sticky traps for bed bug monitoring, the latter may also be a defensible option.

2.2 Portable Monitoring Devices[7]

Portable monitors attract bed bugs using heat, carbon dioxide, and a pheromone lure and then trap the insects in a compartment where they die. While effective, use of these interceptors is limited by their cost and availability. The monitors commercially available use the same concepts, but differ in design. For a comparison of the monitors on the market and how to make a low-cost alternative watch for published research by Wan-Tien Tsai in the Wang lab at Rutgers University.

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[7] *Existing monitors marketed specifically for bed bugs take advantage of the bed bugs' attraction to heat, carbon dioxide, and a chemical lure to mimic their communication pheromone, usually in some combination. The research supporting these bed bug behavioral triggers is as follows:*

- *Heat above ambient was found to be overwhelmingly attractive when compared with humidity, blood, carbon dioxide, muscle and subcutaneous tissue, liver, bile, skin, hair, perspiration, sebum, and cerumen (Rivnay, 1930; Marx, 1955; Aboul-Nasr and Erakey, 1967, in Siljander, 2006‡). These studies also show that the upper limit of heat attractiveness is 110º F. Higher temperatures are repellent (Rivnay, 1930, in Siljander, 2006‡). These finding should be kept in mind when setting the temperature of monitoring devices, monitoring, and conducting heat treatments.*
- *The results reported by Siljander are in conflict with two studies that found carbon dioxide to be more attractive than heat and chemical lure (Anderson et al., 2009†; and Wang et al., 2009c†). All studies show that bed bugs are attracted to carbon dioxide and heat, regardless of which is more attractive.*
- *Traps baited with chemical lure attract more bed bugs than the control, but not at a statistically significant level (Wang et al., 2009c†).*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

Pros

This alternative monitoring and inspection option should work better than interceptors in the following situations:

1. To help confirm that the unit does not have bed bugs when it is vacant. This can also be achieved by canine inspection.
2. To keep bed bugs from migrating from a vacant unit to find an alternative host until the PMP does a bed bug service.
3. To confirm the presence of bed bugs in areas not inhabited by humans at night (such as a laundry room or office space). Canine inspection can also achieve this.
4. To monitor when there is a bed frame without legs such as a captain's bed (platform bed with drawers under the mattress) or a mattress directly on the floor.

Cons

Commercially available portable devices that use heat, carbon dioxide, and kairomones as lures can are expensive (over $500). Researchers are experimenting to determine their effectiveness. This will help justify their cost and give guidance to operators (PMPs) on how often they need to replace carbon dioxide canisters and lures.

Recommendations

PMPs who have done their own field tests on portable devices report good results, especially in vacant areas. Peer-reviewed research is needed to confirm the efficacy of portable devices and identify the situations in which they are most effectively used. Until then, the only situation for which it appears that portable devices are uniquely qualified is for use in vacant, infested units awaiting treatment. A portable device used in such a situation may minimize the chance of bed bug migration to adjoining units.

3. Non-Chemical Treatment Methods

3.1 Clutter Removal

Pros

The bed bug's ability to hide is one of the main reasons why it is such a formidable opponent. Reducing the harborage available to bed bugs increases the chance that a PMP will find (and thus be able to kill) the insects[8].

Cons

It is important to be sensitive to the time and financial limitations of residents and property staff. PMPs also need to accommodate residents' desire to keep sentimental belongings as well as handicaps that may impede residents' ability to control clutter. If the PMP asks more than is necessary of the residents and/or management or if those doing prep work do not understand the rationale behind the preparation requirements, then the task may seem daunting and they may be less likely to attempt to prepare the unit. In addition, any disruption to the area may cause bed bugs to spread.

Recommendations

Experts often tout clutter removal as an essential part of bed bug elimination. When an effort to eradicate an infestation fails, it is almost always due to clutter and lack of cooperation with the pest control company's preparation and follow-up instructions. The most complex environment for bed bug eradication is in multifamily housing, especially in low-income housing. The complexity comes from the number of people involved and limited resources for costly preparation materials, such as mattress encasements.

Before the initial visit, the pest control company should only request that residents do a basic clean up of the bedroom and other suspect locations. Residents should pick up items strewn on the floor and vacuum as they ideally would for a landlord inspection. The property

[8] *No unit preparation was required of the residents in Moore and Miller's study which evaluated pesticides commonly used for bed bug control. Their traditional treatment (pyrethroid and insect growth regulator [IGR]) reduced bed bugs by 95% by the end of eight weeks (having been treated four times) and isolated the bed bug infestation to the mattress and bed area. The novel treatment (pyrrole, alcohol, dust, and IGR) reduced bed bugs by 86%, but did not isolate the infestation to the bed (Moore and Miller, 2008[†]). In this study, bed bug infestations were reduced, but not eliminated. The researchers state that this is due in part to the fact that no cleaning or preparation was done.*

[†] = *source has undergone peer review*

[‡] = *source is not peer reviewed*

manager should include instructions for this basic clean up with the notice of service. Minimal preparation avoids disrupting the bed bugs and limits the burden on staff and residents. To expedite inspection and minimize the chance of PMPs chipping paint, maintenance personnel are sometimes asked to loosen the screws and plates on any switch or outlet plates in the vicinity of the bed.

If the infestation is light and the bed can be isolated as an island, the PMP may treat during the initial visit and schedule the follow-up treatment. Alternatively, the PMP should leave detailed preparation instructions for the resident and schedule his next visit (at which time he will treat). Regardless of the level of preparation needed, any time a PMP finds a bed bug, he should kill and remove it.

If correct room preparation is essential to the effective and efficient elimination of a bed bug infestation, then PMPs should plan this aspect of control as carefully as they do chemical choices. At first, property management will not have the knowledge to determine the level of preparation necessary and must rely on the PMP for education and instructions. Once management and the PMP work together on a few successful eliminations, management may be able to begin to predict the level of preparation necessary in a given situation and advise the residents accordingly before the PMP's first visit.

3.2 Disposal of Infested Items

Pros

Although it seems logical to get rid of bed bugs by getting rid of the things they hide in, the number of items thrown away does not seem to correlate with the success of the control effort. In most cases, infested items do not have to be thrown away. In fact, in multifamily settings, the risk of spreading the infestation (by bed bugs falling off the furniture during transport and by others scavenging the items) is often greater than the benefit to the control effort. Two scenarios that may warrant removal are the following:

1. Disposal may be the most sanitary option when a well-established infestation exists on a piece of furniture.
2. Disposal may be the most practical option if the PMP finds a heavily infested, complex piece of furniture (one that offers lots of harborage to bed bugs) for which encasements are not available.

Cons

PMPs must be sensitive to the potential for disrupting the bed bugs when asking residents to dispose of items. Also, PMPs must take the limited resources of the residents into consideration when recommending disposal. The mattress and box spring are usually the most heavily infested items. Replacing them can be a significant financial burden on the resident. If a company delivers the new mattress and takes away the old one in the same truck, there is potential for spread. Residents may also unintentionally re-introduce bed bugs with replacement mattresses because the cheapest mattresses are often from the curb or refurbished. Residents bringing home infested items they find outside the building are often blamed for building-wide infestations.

Recommendations

Disposal of items should never be part of a control effort before the PMP visits the home unless the building staff members have experience with successful bed bug control and think it is necessary. The PMP should identify what needs to be thrown away and give specific instructions for disposal. If the budget allows, treating the infested item (at least to significantly reduce the population) before removing it is recommended as a part of reinfestation prevention. Staff or PMPs should wrap identified items (so that bed bugs don't fall off and migrate to new locations during transport and storage) and immediately bring them to a secure location where others cannot pick them up and bring them home. Inspection and treatment of vehicles and locations involved in disposal can be included as part of the bed bug service. If there is any chance of passers by seeing the item, whoever is responsible for disposal should make it unusable by breaking it or cutting open the fabric on all sides. Marking the item with a picture of a bed bug or writing "Bed Bugs Chinches" may also deter passers by from bringing the item back in the building.

In low-income housing settings, management should give residents bed bug-proof encasements for mattresses and box springs when the PMP finds bed bugs. Encasements eliminate the need to apply pesticides on bedding, make inspection easier, and trap bed bugs inside where they eventually die.

3.3 Isolation in Plastic Containers or Bags

Pros

Containing items in containers or bags simplifies the habitat for treatment, keeps items that do not have bed bugs from becoming infested, and contains infested items for later treatment. Knowing that items sealed in bags are protected from future infestation may comfort residents.

Cons

Containment efforts kill bed bugs only if the insects have no chance for escape and the items are either left enclosed for a long enough time to starve the bed bugs[9] or if the PMP uses a chemical in the bag or sealed container[10].

Recommendations

As discussed previously, PMPs should determine the extent of the infestation and take resident time and financial limitations into consideration before requiring this type of preparation. If plastic containers are used, the PMP or resident should treat items in containers so that the bed bugs die. Laundry, carbon dioxide, heat, and fumigation are all options for treatment. Freezing the container and its contents in a freezer is unreliable[11].

3.4 Petroleum Jelly as a Barrier

Pros

Residents can use a barrier of petroleum jelly for a variety of situations. Building a barrier on a table around a television may be an effective way of protecting hard-to-treat items from infestation[12].

Cons

Petroleum jelly is messy and could damage surfaces on which it is left. In addition, any break in the barrier would significantly reduce the chance of it working. We do not know the specifications for the width and height of an effective barrier. One staff member at a shelter in Pennsylvania (see Case Studies) said that when they used this strategy (around bed legs) bed bugs were found stuck in the petroleum jelly (see Case Studies section). It is unclear whether the barrier discourages the bed bugs, traps them, or simply catches an unlucky few that don't make it across.

Recommendations

This practice is popular on discussion boards, but professionals do not include it in their control programs. When possible, residents should use more vetted barriers such as interceptors.

3.5 Metal Furniture

Pros

Bed bugs can travel on metal and plastic, but not as well as on wood, cloth, or other rough surfaces. Loudon at the University of California-Irvine analyzed(the movement of bed bugs on different surfaces and found that bed bugs slip often and struggle to move forward on plastic and glass, even on a horizontal surface. The links between metal and bed bug behavior need research. The greatest benefit of metal furniture is that it often has fewer locations where bed bugs can hide compared to wood or wicker. If a piece of metal furniture does have gaps through which a bed bug could crawl to find harborage, the resident should seal up the gaps. Smooth surfaces and lack of hiding places makes inspection and treatment easier.

Cons

If residents do not keep the metal clean, rust-free, with holes sealed, bed bugs will be able to travel on the surface as easily as they would on wood.

Recommendations

Because early detection is the goal of a proactive bed bug program, management could advise residents purchase metal furniture. Plastic furniture may also help prevent

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[9‡] *Unpublished research by Andrea Polanco out of the Miller lab at Virginia Tech has shown that starved bed bugs die faster than previously thought. Whereas existing recommendations (based on old research) tout that bed bugs can live over a year without a meal, bed bugs used for this research died within three months.*

[10] *The latter option will be more available in the near future (see discussion of dichlorvos).*

[11] *Specifications for temperature and time have not been confirmed by research.*

[12] *Research has not been performed on this strategy.*

[†] = *source has undergone peer review*

[‡] = *source is not peer reviewed*

bed bug movement on to furniture because of the slippery surfaces. Regardless of construction material, residents should avoid purchasing complex platform beds (such as captains' beds). The staff at a homeless shelter that successfully eliminated bed bugs stated that replacing all of their existing furniture with metal furniture was one of the most essential parts of the process. See the Case Studies section for the shelter's procedure.

3.6 Cleaners

Pros

By cleaning up blood spots on infested furniture, PMPs can help provide the most sanitary living conditions possible and detect new evidence of bed bugs. In the process of removing blood spots, the PMP can also distinguish between cockroach frass and bed bug blood spots. The latter will smear reddish-brown before washing away. Although PMPs do not consider it a control method per se, keeping objects clean will help with early detection and treatment.

Cons

A solution of isopropyl alcohol will kill bed bugs (Harrison and Lawrence, 2009() and sanitize the area, but no research has been done on its efficacy. Since isopropyl alcohol does not have an EPA pesticide label listing bed bugs, users should check with their state's pesticide program before recommending its use.

Recommendations

Cleaning with soap and water should be used as a supplement to control methods when an infested item requires special care. This cleaning will remove bed bugs and eggs, but not necessarily kill them. The key to this control is detail-oriented cleaning; simply dousing an area with soapy water will not control bed bugs. Soap and water should only be used where electrical shock is not an issue and where water damage cannot occur to cleaned surfaces including electrical and electronic equipment.

3.7 Laundry

Pros

Laundering is probably the best bed bug control method when evaluating options in terms of both practicality and effectiveness. The heat in a clothes dryer is extremely effective at killing bed bugs and eggs. Clothes dryers are accessible to almost everyone. Dissolvable laundry bags are recommended for transporting infested items to the laundry room.

Cons

Laundering takes time and (unless the machines are in the home) can be expensive. Some items cannot be laundered. There is also potential for disrupting the bed bugs if residents launder everything before consulting a PMP. When management recommends laundry, the resident needs to understand they cannot transport the laundry to and from the infested area in the same container.

Recommendations

Ideally the resident, PMP, or preparation contractor will:

1. Take all fabrics to the laundry room (or facility) in dissolvable bags (bags that dissolve in the wash such as Green Clean Dissolvable Laundry Bags).
1. Wash them using the hottest setting the fabric can stand.
2. Dry them for a full cycle on the hottest setting that the fabric can stand.
3. Place them in a new clean plastic sealed bag to prevent re-infestation of the items. To optimize effectiveness of treatment, residents should keep all but essential items in the sealed bags for as long as practical or at least during the treatment period.

While this is an ideal plan (because it almost guarantees that bed bugs will not be in or on fabric), laundering every fabric item in a home is rarely a practical recommendation. In most cases, this extensive work is not even necessary for bed bug control. After doing an initial inspection and treatment, the PMP should make

site-specific recommendations for what residents need to launder[13]. Residents can avoid the possibility of re-infestation by using dissolvable bags, transporting clothes in cloth bags that get washed with the clothes, or using two sets of bags (preferably different colors) for infested and clean items[14].

What is the most practical recommendation for using laundering to kill bed bugs? Residents should take fabrics the PMP determines need laundering to the facility in one bag, place items directly into a dryer, run the dryer on the hottest cycle for 30 minutes (or a full cycle at a lower heat setting if high heat will damage the fabric), and bring items home in a bed bug-free bag. Note that this recommendation does not involve washing and that fabric put into the dryer is already dry. This is effective for killing bed bugs, minimizes cost and time, and can usually be done with dry clean-only items[15].

3.8 Steam

Pros

Steam kills bed bugs and eggs with a short period of exposure and leaves no chemical residue. The user moves the nozzle over the bed bugs at a rate of 20 seconds per linear foot. Where PMPs can't use pesticides, steam is invaluable. Steam is less costly than dry heat or fumigation that achieve the same results, but are generally used on a larger scale.

Cons

Faults with steam are that it does not penetrate materials very deeply and if applied with too much pressure may blow bed bugs away. Steam treatment leaves moisture behind that may damage treated surfaces that must dry. Steam may damage materials and can conduct electricity[16]. One PMP indicated that it is best to use a "dry" steam unit (one that produces 5% or less moisture). Steaming has no residual effect.

Recommendations

PMPs have found that an upholstery nozzle wrapped in a piece of fabric diffuses the pressurized air so that bed bugs are not blown from the treatment area. Although lack of residual is a downside of steaming, most professionals admit they don't rely on the action of residual products much anyway. In an ideal world, the PMP would use steam to kill each bed bug seen during inspection and a thorough steam treatment would be the source of initial population knock down[17]. This is not the common practice because steaming takes a long time. Many companies make steam units available to their PMPs, but few PMPs routinely use them as part of their standard bed bug service[18].

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[13] *In the article, "The Business of Bed Bugs," Michael Potter reports on a survey conducted with PMPs from across the country. He asked, "Which of the following methods do you routinely use to control bed bugs?" and 86% had their clients launder clothes (Potter, 2008a‡).*

[14] *One PMP alleviated some worry about infested laundromats. He believes lack of infestation at these sites (in his experience, with his clients) is due in part to the fact that they are so well lit and he applies insecticide dust to the underside of the tables. He does warn laundromat owners about allowing people to store bags of clothes in the facility overnight.*

[15] *If using a dry cleaner, residents need to take precautions to avoid spreading bed bugs to the facility (Kells, 2006 b‡ & c‡).*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

[16] *Experts advise PMPs steam items with low moisture, "dry" steam using a commercial unit and a floor/upholstery attachment (Harrison and Lawrence, 2009‡; Kells, 2006 b‡ & c‡; and Miller, 2009‡).*

[17] *The only study with steam as a variable was not peer-reviewed, but the observed results were promising. PMPs treated one hotel with conventional techniques using dust material under the carpet at the floor/wall junction and in the wall voids. PMPs treated the mattresses per the pesticide label directions with a liquid residual and encased them. PMPs treated the second hotel with residual dust materials in the same fashion as the first, but they treated the mattress and box spring with steam instead of pesticide. The PMP monitored for recurrences. In both hotels, the bed bug population crashed after 60 days. Within 90 days, the company received call-backs from the first hotel. The second hotel remained controlled for the duration of the monitored time (12-plus months) (Meek, 2003‡).*

[18] *In the article "The Business of Bed Bugs," Michael Potter reports on a survey done with PMPs from across the country. He asked, "Which of the following methods do you routinely use to control bed bugs?" Of PMPs surveyed, 25% used steamers (Potter, 2008a‡).*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

3.9 Mattresses and Box Spring Encasements

Pros

Mattress and box spring encasements simplify the habitat around the bed. From the perspective of a bed bug, a mattress and (even more so) a box spring offers endless locations to hide and wait until the next meal, especially if there is a hole in the fabric. Encasements eliminate hiding spots and make it easier to detect an infestation early on. They make the daunting task of eliminating a bed bug infestation a little bit easier. When encasements are used, the PMP does not need to use pesticides on the bedding. Since there are many concerns with using pesticides on bedding, encasements are an invaluable control tool. An added benefit comes to residents with asthma from using encasements because encasements limit exposure to dust mites.

Cons

Mattress and box spring encasements generally cost more than $50. This cost is prohibitive for many low-income residents[19]. To be used for control, the encasement must remain on and intact for over a year to ensure starvation of all trapped bed bugs[20]. Cheaper mattress covers, such as those made of vinyl, can be uncomfortable and usually rip before a year.

Recommendations

Both mattress and box spring encasements purchased for use in a bed bug program (including the early detection part of a program) should be both escape-proof and rip-resistant. Where most products fail is in their being escape-proof. The zipper area is the common site of

escape. At this time, two encasements recommended by experts are Protect-A-Bed and ActiveGuard™. Before purchasing mattress encasements, consumers should make sure the product has been tested with bed bugs. Based on observation and opinion, quality mattress encasements on both the box spring and mattress are an essential part of bed bug control.

Ideally, when a bed bug infestation is discovered, encasements would be put on the box spring and mattress immediately after the first visit by the PMP. Shelters, hotels, and multifamily housing with high turnover rates should consider encasements before a problem arises to help with early detection. The reality is, the majority of residents in low-income housing will not be able to afford encasements. Managers may need to be creative and find supplemental funding for the purchase of encasements for low-income residents. Box springs are structurally more complex and more difficult to treat than are mattresses, so if only one encasement can be purchased, the box springs should be encased.

Experts rarely mention pesticide-impregnated mattress encasements. The main concern with these is that, in theory, they will expedite the already-evolving problem of resistance in bed bug populations. Secondly, residents would be in close contact with pesticides as they sleep which raises health concerns. Because of the resistance concerns, if the PMP recommends a pesticide-impregnated encasement for a control effort, someone should remove and replace it with an untreated encasement after the bed bugs die. Without overlooking the risks of exposure implicit any time a person is near pesticides, PMPs should consider pesticide-impregnated mattress encasements where the bed bug population is susceptible and either the resident wants to keep a heavily

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[19] *Wang et al. used mattress encasements as part of their IPM treatment, but as part of every IPM treatment, not a variable (Wang et al., 2009a†). The mattress encasements, along with time spent steaming, were the costliest components of their control program.*

[20‡] *Personal communication regarding unpublished research by Andrea Polaneo out of the Miller lab at Virginia Tech has shown that starved bed bugs die faster than previously thought. Whereas existing recommendations (based on old research) tout that bed bugs can live over a year without a meal, it seems modern bed bugs die within three months.*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

infested mattress or management wants to treat the mattress (or box spring) before transporting it to the garbage[21]. Before recommending the latter, industry needs research on how long these encasements need to be in place in order to kill bed bugs.

3.10 Freezing

Pros

The two options for freezing are: place items in a freezer or use solid carbon dioxide (which is exempt from FIFRA registration requirements) to flash-freeze the bed bugs and eggs. Solid carbon dioxide is more commonly known as dry ice. One company that mainly offers non-chemical treatment options uses dry ice in a container for infested items that are sensitive to heat. Due to the lack of research and the variability of home freezer temperatures, this method cannot be recommended at this time.

Cons

The lack of penetration achieved with the frozen carbon dioxide method, along with the time and its expense, often dissuades companies from using it. Those who have tried the application marketed specifically for bed bugs also report that the solid carbon dioxide comes out at such a high rate that it often blows the bed bugs away rather than killing them. Steam is thought to be more effective, practical, and can be used in most of the same situations.

Using a freezer may fail for a number of reasons. The freezer will not be effective at killing the bugs if the item is not frozen to a sufficiently cold temperature for a long enough period of time. Current research has not been done to determine these thresholds.

Recommendations

Time and temperature varies between freezing recommendations, but no peer-reviewed research exists that defines the correct temperature. One recommendation maintained by all is that the cooling has to be quick. If given time to adjust, bed bugs can survive extremely cold temperatures. Simply putting items outside in the winter won't work because an item may not cool to a killing temperature or a passer-by might pick up and bring it home.

If a prevention program uses public freezers, management needs to develop a communication and coordination system so that residents transport belongings in a way that minimizes the chance of spreading bed bugs. There is no guarantee for control using this method. A chest freezer was used in the prevention efforts of a shelter described in the Case Studies section.

3.11 Vacuums

Pros

When trying to minimize pesticide exposure, vacuuming is preferable to contact pesticides as a way of eliminating bed bugs that the inspector spots. When the PMP removes bed bugs, the findings of his follow-up inspections are more relevant because the evidence is new.

Cons

"Normal vacuuming by clients is generally of little benefit in bed bug management because the bugs reside in places where housecleaning efforts normally do not reach" (Potter, 2006‡). Experts' main concern with vacuuming is that it does not reliably get the eggs. Whoever is vacuuming must take precautions to avoid re-infestation from live bed bugs in the vacuum. There is also the possibility of re-infestation (or spreading an infestation) from the vacuum.

Recommendations

Where vacuums may realistically play a role in bed bug control is during a PMP's inspection. As with cockroach control, use of a HEPA vacuum to suck up any insects found upon inspection is recommended from the perspective of pesticide use reduction. Steam will have a greater impact on eggs (than vacuuming or most pesticides), but steam doesn't remove the evidence.

[21‡] *One PMP reported second-hand on a field study on pesticide-impregnated encasements. The PMP who did the study replicated the results twice. For each, in the control infested unit he put mattress encasements on both the mattress and the box spring; in the treatment unit he put a pesticide encasement on the box spring and an untreated encasement on the mattress. The encasements were the only treatment used. One week later, in both trials, the units with the pesticide encasements had a few crawling bed bugs, but most were dead. The other units had bed bugs crawling all over the encasements.*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

Cleaning contractors who use the same vacuum throughout a building should know to look for bed bugs. They can help detect infestations early and the knowledge will help them prevent spreading bed bugs. Experts recommend using a vacuum with a removable bag and putting talcum powder or insecticidal dust in the bag according to the label instructions. See Section 5.3 for a discussion of insecticidal dusts.

3.12 Ambient Heat Treatments

Pros

Ambient heat treatments use fans and a heat source to heat a space to 130°F to 140°F and hold that temperature for a sufficient enough time to heat all areas within the space to 120°F. These treatments are popular for scenarios where unit preparation cannot (or will not) be done. Clients who do not want the PMP to use pesticides will usually opt for a heat treatment. This chemical-free control method can either provide complete control, or significant knock down depending on the quality of preparation and treatment.

Cons

Although the process of heating a space sounds simple, companies are learning the hard way that ambient heat treatments can fail in a number of ways. Most failures come from an area not reaching 120°F. PMPs must open drawers and peel carpet away from baseboards, as they are two areas that often fail to reach 120°F. Someone must prepare the unit to minimize areas of insulation (such as piles of fabric) and heat sinks where the heat can escape. Because the PMPs need to be in the unit rearranging fans and heaters anyway, they can do the necessary preparation with a resident's permission. Southern companies who have been using heat treatments for termites and cockroaches can be mentors for Northern companies who are new to the technology and don't know about building variables associated with heat treatments.

Recommendations

Ambient heat treatments heat a space to 130°F to 140°F and hold that temperature for a sufficient enough time to heat all areas within the space to 120°F[22]. PMPs may choose to heat up a whole room or heat items contained in an insulated compartment (see Pereira et al. 2009† for a description of a compartment for heating). Containing items in an insulated area has great potential because it may be more cost effective than heating an entire unit. In this treatment, a group of items is isolated in the unit with an insulated five-sided box[23]. Heaters raise the temperature in the box while the PMP treats the surrounding unit.

Propane, infrared, and electric (usually from a generator) are all options for heat sources. Each has its limitations, especially for use in a multifamily building. Propane-powered heaters generate large volumes of heated air blown in through flexible ducts from outside the building. While propane heaters are efficient, they are not always able to force hot air to the upper levels of multi-story buildings (Potter et al., 2008a‡) and may not be allowed by local housing codes. All have potential to work, but the PMP has to regulate heat throughout the space using thermometers and fans. A PMP must be on hand during the entire course of the heat treatment to monitor temperatures and make adjustments, as necessary. As with all bed bug control efforts, a system must be in place for preventing re-infestation after treatment.

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[22] *Heaters have been shown to work to heat a home to 130°F, killing all bed bugs and eggs exposed to the heat for three hours (Getty et al., 2008‡).*

[23] *Among all heat-treatment trials where an insulated box was placed over objects on the unit floor and the contents heated, those in rooms with carpeted floors produced lethal temperatures for the bed bugs in the shortest times (2.4-3.1 hours), compared with treatment times between 4.9 and 7.3 hours for rooms with tile floors. Temperatures at different locations within the treatment envelope varied depending on the position of the heaters and fans, amount of furniture and other materials within the envelope being heat-treated, and level of insulation between the temperature monitor and the heated air inside the treatment envelope. In order for heat to penetrate all objects in the compartment in the shortest amount of time, heaters must be placed at opposite corners of the treatment envelope and fans placed so that the circulation of heated air is maximized (Pereira et al., 2009†).*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

If the landlord is responsible for re-housing residents displaced for treatment, the total treatment time is an important consideration[24]. One housing authority switched from infrared heaters to heaters that are wired into the electrical panel because infrared heating took too long to heat up the entire unit. Heat works, if done correctly, but management should consider the factors tied to each method of heat treatment (such as expense for personnel, carbon monoxide poisoning, and local codes pertaining to propane) before investing.

3.13 Ineffective Non-Chemical Alternatives

3.13.1 Increasing Heat in the Infested Area with a Thermostat

Pest control companies that supply preparation instructions before determining the extent of the infestation sometimes have this as part of the protocol. They rationalize that increased heat will increase the activity of bed bugs and thus have them walk over pesticide residuals. No research exists that determines whether this increases treatment success, but research has shown that dry residuals of most liquid pesticides are not effective at killing bed bugs. Increased heat will dry the liquid pesticide products faster. This recommendation should not be used in the preparation instructions for a bed bug treatment.

3.13.2 Putting Items in Black Plastic Bags and Leaving Them in the Sun for a Day

In one study, the maximum-recorded temperature on the upper (sun-exposed) sides of mattresses placed in black plastic in the sun was 185°F, whereas lower side temperatures for the thick mattress never exceeded 95°F. Since bed bugs need to be exposed to temperatures above 100°F for an extended period of time to be killed, and because areas of sub-lethal temperature exist within the bed at any given time, this technique seems to be not suitable for bed bug management (Doggett et al., 2006†).

[24] *PMPs need to consider the rate of heating since some items (such as wood laminates) run a greater risk of damage if heated too quickly. No faster than 15°F per hour is recommended (Potter et al., 2008a‡).*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

4. Unit Preparation

Proper preparation makes a treatment successful. Even with the best preparation, bed bug treatments will fail if management doesn't hire an experienced company. Property management can use the following process to minimize inconvenience for the resident and property staff while maximizing the chance that the PMP's efforts will be effective:

1. A pest control company receives a call to do a bed bug treatment.
2. The company gives instructions to the property manager requesting the residents of the reportedly infested unit and units adjacent to the infested unit to clean and organize the room as they would for a housekeeping inspection. No further preparation is required so that the infestation is not disrupted before the PMP has a chance to evaluate the situation. This also minimizes the burden of unnecessary preparation. With this plan of action the PMP does not depend on management to pass on crucial information about extensive unit preparation to the resident. The manager then delivers the instructions by hand.
3. One or two PMPs (accompanied by property management or maintenance) visit the unit equipped to do a treatment (whether that be with pesticides, steam, vacuum, monitors, or a combination thereof).
    a. First, they perform a thorough inspection of the infested unit and adjacent units to identify the extent of the infestation. If a bed bug is found, they use the least toxic option to kill and remove the bed bug. As the inspection is done, every effort should be made to educate both the resident and the accompanying staff person.
    b. Once the thorough inspection is complete, the PMP has two options:
        i. Not treat, give site-specific preparation instructions, and schedule the next treatment. PMPs should choose this option when there is extensive clutter or a widespread infestation. Preparation instructions will include laundering, installing mattress encasements, and organizing

clutter. Resident cooperation is key to clutter reduction. For a discussion of this, see the Solutions for Compliance section.

ii. Perform an initial treatment, give site-specific follow-up instructions (which may be as simple as installing a mattress encasement and keeping the bed isolated from the rest of the room), and schedule the next visit. PMPs should choose this option when the infestation is light or if the room does not have much clutter.

4. The PMP returns for a follow-up inspection and possible treatment in the units where he found bed bugs. This treatment may be more extensive (in terms of PMP time and tools used) than the first if he left site-specific preparation instructions. Alternatively, it may simply be an inspection if the initial inspection and treatment was thorough. The timing will depend on what the PMP did during the first visit. If the first visit was a full treatment, the follow-up should be two to three weeks later.

5. Pesticides

Pros

In general, the message coming from pest control experts is that if you can find bed bugs, you can kill them with a pesticide. Although nontoxic options exist that are equally or more effective than pesticides, PMPs usually use pesticides because they can be a quicker and cheaper way to eliminate bed bugs. All of the active ingredients below are either labeled for bed bugs or are in the process of having the label revised (by EPA) to include bed bugs.

Cons

Bed bug resistance to pesticides is well documented, and the levels of resistance vary between populations. Despite resistance concerns, none of the PMPs interviewed thought it factored in to why their control efforts failed. PMPs plan their chemical treatments so that they don't rely too heavily on residuals and they are constantly on the lookout for bed bugs that are so resistant that a direct spray does not kill them. "Despite the fact that many of the registered products have residual properties, few if any of the current residual liquids appear to be very effective against bed bugs once they have dried" (Pinto et al., 2007†).

Total release foggers are detrimental to bed bug control. Setting off one of these "bug bombs" does not kill most bed bugs, and significantly increases their migration. PMPs attribute bed bugs moving into adjacent rooms to the use of foggers. In a number of cases, residents' use of foggers disrupts the bed bugs before the PMP gets involved and they (like any pesticide) can be unsafe if the residents don't follow the label instructions.

Recommendations

The key is to involve an experienced PMP who will find as many bed bugs as possible before he treats. Pesticides should only be used for bed bug treatment by a licensed applicator. Pest control companies need continuing education and special certification options to help ensure that their PMPs do a thorough job.

Before trying an all-pesticide control plan, managers should seriously weigh all options in terms of probability of success given the conditions and people in the area. When there is lack of cooperation from people involved, resistance to products, or a PMP with limited experience, multiple pesticide treatments may be unsuccessful. An alternative control plan may be faster and cheaper in the long run.

The vast majority of PMPs chooses pesticides carefully and applies them judiciously based on the factors present in each infestation. Some residents and landlords use pesticides ineffectively—and even illegally. The impact of the use of over-the-counter products on bed bug control success has not been documented, but one can deduce the effectiveness of the active ingredients in the products available to both consumers and professionals from research. Experts warn against pesticide application by unlicensed and inexperienced individuals because of the potential for disrupting the bed bugs and making the problem worse. There is no silver bullet for bed bug control. For more general pesticide questions not addressed in this paper, contact the National Pesticide Information Center at http://npic.orst.edu/ or by calling 1–800–858–7378.

5.1 Pyrethroids

Pyrethroids are the principal category of chemical pesticides used for bed bug control, despite research that regularly finds bed bug resistance to pyrethroids[25]. PMPs are using pyrethroids for the majority of their treatments because only a few other chemistries exist that can be legally used for bed bugs and PMPs report that pyrethroid products do quickly kill bed bugs coming in contact with the pesticide while it is still wet[26]. Once the liquid pesticide is dry, it usually won't be effective for control and may contribute to resistance. Most companies are not depending on pyrethroids for ovicidal properties, but unpublished tests show that some of the contact products labeled for use on mattresses will kill eggs. PMPs reported no major differences between pyrethroid products in the field[27].

5.1.1 D-Phenothrin with an Alcohol

This product provided control when used to reduce a population of bed bugs on a mattress. There is no residue, so efficacy is based on thoroughness of application (Moore and Miller, 2008†, Romero et al., 2007b‡). These products also kill eggs on contact (Pinto et al., 2007†).

5.1.2 Permethrin

An agricultural study showed insecticide with permethrin worked as a contact insecticide at low concentrations but exhibited residual activity only on metal and wood (not cardboard, cotton cloth, or cotton-polyester blend) (Fletcher and Axtell, 1993†). These findings are at odds with the reported efficacy of permethrin-impregnated mattress encasements marketed for residual control.

These insecticidal liners are tested (see Ballard, 2008‡; Snell, 2008‡), but peer-reviewed, published research does not exist. A study using Olyset net (a polyethylene net used mainly for mosquito control with two percent permethrin incorporated within fibers) found only 25 percent mortality after 24 hours when the bed bugs crawled on the net for 30 minutes (Sharma et al., 2006†).

5.1.3 Beta-Cyfluthrin

Research by Miller found resistance to beta-cyfluthrin, but the researchers used a product with cyfluthrin along with deltamethrin and hydroprene to reduce a bed bug infestation successfully by 95 percent. Although the control was not 100 percent, in situations where clutter and lack of resident cooperation severely hinders treatment, 95 percent is a considerable improvement. Moore and Miller attribute the success to the thoroughness of the applicators more than the residual toxicity of the product (Miller, 2009‡; Moore and Miller, 2008†).

5.1.4 Deltamethrin

As with other pyrethroids, researchers find resistance in field-collected populations to deltamethrin, particularly the dry residues. Two studies found that bed bugs avoided areas treated with deltamethrin. When there was an attractant on the other side of a treated strip or the treated area had bed bug eggs and feces, bed bugs readily traveled through the product (Haynes et al., 2008‡; Romero et al., 2009a†). In the study done by Romero et al., deltamethrin caused low mortality and increased activity, which could lead to increased exposure or migration to a new location (Romero et al., 2009a†). In contrast, Moore and Miller found that deltamethrin was not repellant (Moore and Miller, 2006†).

5.1.5 Lambda-Cyhalothrin

On susceptible populations lambda-cyhalothrin is the fastest acting of the pyrethroid active ingredients (Moore and Miller, 2006†). An agricultural product containing lambda-cyhalothrin was active at low concentrations on all surfaces and exhibited relatively long-lasting residual activity (12 weeks) on wood, cardboard, metal, cotton cloth, and cotton-polyester blend, with the shortest residual life on metal (Fletcher and Axtell, 1993†). Researchers find resistance in the lab, but the products still perform in the field.

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[25] *In addition to the usual process of resistant population development due to selection, cross-resistance may be at play (Romero et al., 2007a† & b‡; Yoon et al., 2008†).*

[26] *Pyrethroid-based products gave good (>60 percent) residual control, but mortality was not 100 percent in a study done by Todd. No contact pyrethroid products tested by Todd exhibited significant flushing action, but did give fair knockdown and good kill (Todd, 2006‡).*

[27] *In their 2006 study, Moore and Miller found that pyrethroids work faster than chlorfenapyr. In terms of LT50, the order (fastest to slowest) was: lambda-cyhalothrin, bifenthrin, deltamethrin, and then permethrin (Moore and Miller, 2006†).*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

5.2 Chlorfenapyr

This pyrrole is the main alternative chemistry to pyrethroids. PMPs use it as a nonrepellant residual and are reporting success, but it may take more than a week[28,29,30]. As with pyrethroids, PMPs are not relying heavily on the residual provided by chlorfenapyr-containing products. The experience with pyrethroids shook the industry's trust in all liquid residual products for bed bugs. In addition to its residual potential, this pesticide also kills eggs. As with any treatment, a professional follow-up inspection and possible retreatment is necessary.

5.3 Dusts

Sometimes boric acid is mistakenly used for bed bug control. Boric acid is commonly used for cockroaches. The powder is abrasive to the insect's cuticle, but the main mode of action is as a stomach poison. Bed bugs would have to ingest this stomach poison for it to be effective, and since they only suck blood, this will not happen. Residents and PMPs should not use boric acid for bed bug control.

There are three active ingredients in insecticidal dusts available for bed bug control. These are pyrethroids, diatomaceous earth, and limestone. Diatomaceous earth and pyrethroid dusts have the best reputation. PMPs use both as dependable residuals. When the user applies it according to label directions pyrethroid dust remains effective as a residual (whereas liquid pyrethroid sprays don't). The pyrethroid in the dust does not break down readily in dark hidden areas where it isn't exposed to UV light or cleaning products and remains effective for many weeks.

As with any bed bug control method, the key to success is in the user. Of all treatment options, dusts are most often incorrectly employed. This jeopardizes the success of the overall treatment. As always, experts advise all users to read the labels and to adhere strictly to the manufacturer's instructions for each product.

5.3.1 Silica with Pyrethrins

Benoit et al. found pyrethroid-containing silica dusts to be more effective (higher water loss after 10 minutes of exposure) than diatomaceous earth. One study showed that an addition of pheromone to the dust increased activity over silica dust, enhancing its efficacy (Benoit et al., 2009†). No dusts with an attractant are commercially available, but the topic deserves further research.

5.3.2 Diatomaceous Earth (DE)

Diatomaceous earth takes up to two weeks to kill bed bugs. This is too long for most residents to wait to see the effects of the PMP's visit. PMPs use it as a backup to other faster products. Because of its mode of action, DE does kill resistant bed bugs, but it (and other dusts) can't be applied as widely as other products, and it takes some time to kill (Romero et al., 2007b‡; Benoit et al., 2009†).

5.3.3 Limestone

Most PMPs report that limestone dust is not very effective in the field; however, a few PMPs do think it works. Dust with limestone as the active ingredient killed only 20 percent of continuously exposed bed bugs after five days (Todd, 2006‡). Moore and Miller found that it took eight weeks to get high mortality using limestone dusts (Moore and Miller, 2008†).

5.4 Insect Growth Regulators (IGRs)

PMPs almost always use insect growth regulators in combination with other products when treating bed bugs. Although no obvious positive results of using IGRs have

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[28] *Chlorfenapyr can take more than a week to kill bed bugs (Moore and Miller, 2006†; Haynes et al., 2008‡; Romero et al., 2007b‡) making it one of the slower-acting products. In one contrasting study, live bed bugs were treated directly with liquid and many died within three days (Moore and Miller, 2008†). Another study found that bed bugs exposed to chlorfenapyr mated and laid viable eggs (Moore and Miller, 2006†). Chlorfenapyr is not repellant (Haynes et al., 2008‡; Romero et al., 2009a†; Moore and Miller, 2006†).*

[29] *Wang et al. used it as the primary pesticide in an IPM study and found that it successfully reduced (but did not eliminate) populations (Wang et al., 2009a†).*

[30] *Using it along with other non-pyrethroids as the pesticides in a control effort may require the application of more active ingredient than if the PMP relied on pyrethroids (Moore and Miller, 2008†).*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

been seen in the field, PMPs still use them because the risks are low and companies often want to try everything available. Two pest control companies went from using IGRs to not using IGRs without noticeable change in treatment efficacy. Researchers find that IGRs kill older nymphs, but not adults, and may significantly affect the mortality of nymphs hatched from the eggs of treated females.

No published research or observations report on IGRs being used alone to eliminate a bed bug infestation. Based on their actions on other insects, IGRs should cause water stress in bed bugs, prolong the juvenile stage, and affect the cuticle. Although IGRs have delayed effects, they could play a role in killing the few remaining bed bugs in treated locations.

5.4.1 Pyriproxifen

Boase found very substantial reduction in reproduction by female bed bugs exposed to the IGR pyriproxifen (Boase, 2001‡), but PMPs are not using it for bed bug control.

5.4.2 Hydroprene

Hydroprene does not work on bed bugs with the same efficacy that it does with other insects. It does not delay molting, but once nymphs reached adulthood, many die. Some adults that survive produce offspring (Todd, 2006‡; Miller, 2009‡). Since PMPs apply hydroprene in combination with other products for bed bug control, it is hard to determine how much of a successful eradication is due to its effect. Despite its unconfirmed efficacy, 65 percent of PMPs questioned by Potter reported incorporating IGR into their spray treatments (Potter, 2008a‡).

5.5 Fumigation

5.5.1 Sulfuryl Fluoride

Fumigation is almost always prohibitively expensive, but it kills all life stages of bed bugs and can be a last-resort solution to a bed bug infestation[31]. In multifamily settings, property managers usually have PMPs perform offsite container fumigation (as opposed to whole-building). Compartment treatments can be cost effective when combined with other treatments for the items not fumigated. Whole-building fumigation is rarely an option for multifamily housing because, in addition to the expense of the treatment, management may be left with the expense of finding alternative housing for their residents during treatment.

Hiring a qualified and experienced PMP to perform the fumigation is important. It is a risky treatment. Procedures for minimizing resident exposure to residual chemicals and preventing re-infestation of bed bugs must be in place before undertaking fumigation. See the Case Studies section to read how a shelter used fumigation as part of their control effort.

5.5.2 Dichlorvos

Small-scale fumigation using the organophosphate dichlorvos is currently in limited use, but it has great potential for effectiveness (and misuse). These treatments are effective for items that can be contained for two or three days in a plastic bag or container. Ideally this chemical would be used only as a last resort, when other less toxic options cannot do the job.

Potential for misuse of this highly toxic chemical includes using more than necessary in a given area, and using it as an area-wide treatment (such as using the product under a bed). PMPs observe this misuse in the field. When these products become available, reformulated and labeled for bed bugs, retailers must stress that the user follow the label directions.

5.6 Essential Oils

There is no published peer-reviewed research on the effectiveness of these chemistries on bed bugs. Many of them are exempt from FIFRA registration under Section 25b. PMPs who use the botanical-based EcoSmart line of pesticides report that they are effective at killing on contact.

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[31] *Fumigation with sulfuryl fluoride can be done either for a whole structure or within a compartment. It is expensive, but does provide 100 percent kill of both adults and eggs (Miller and Fisher, 2008‡; Walker et al., 2008‡).*

† = *source has undergone peer review*

‡ = *source is not peer reviewed*

5.7 Chemistries Being Registered for Bed Bugs

In addition to the dichlorvos mentioned above, EPA is in the process of re-registering a few products for bed bugs. These chemistries are welcome additions to the limited options available now. None will be a silver bullet, but having alternatives to pyrethroids will better arm PMPs to battle bed bugs.

5.7.1 Acetamiprid (with Bifenthrin)

Data from preliminary university testing shows that this neonicotinoid insecticide is effective as a residual. It comes in various formulations, but the wettable powder seems to be the most effective. It may also be a repellant. PMPs use repellant products on the outer perimeter of an infestation to drive the bed bugs into an area treated with a non-repellant residual.

5.7.2 Imidacloprid (with Beta-Cyfluthrin)

Data from preliminary university testing shows that this neonicotinoid insecticide is effective as a residual.

5.7.3 Indoxacarb

PMPs expect products with this oxadiazine active ingredient to have bed bugs added to their label.

5.7.4 Dinotefuran

Expect to see more research on and use of this guanidine insecticide in the upcoming year.

5.7.5 Propoxur

At the request of more than 12 states, EPA is considering adding bed bugs to the label of this carbamate. University of Kentucky tests show propoxur residual kills bed bugs more consistently than other pesticides currently available, so it could potentially be a useful option for battling bad infestations.

Case Studies

1. Pennsylvania Homeless Shelter: Procedure for Complete Elimination

A homeless shelter in Pennsylvania had two options-solve their bed bug problem or have the program shut down by the health department. To avoid losing the community resource and having bed bugs spread to other low-income housing when the residents moved, the shelter staff (in cooperation with the residents and a pest control contractor) took on the challenge of eliminating bed bugs on the property. The shelter consists of three townhouses connected by shared walls. Thirty-nine people lived in 12 bedrooms within the townhouses at the time of treatment. To prevent re-infestation, property management developed protocols for admitting new residents. Their bed bug elimination program was successful.

1.1 What Didn't Work

Prior to embarking on the program that eventually succeeded in eliminating bed bugs, the shelter tried to eliminate bed bugs using their PMPs and partial resident cooperation. The PMPs inspected, applied pesticides, and vacuumed and steamed each unit's mattresses, curtains, dressers, and bed frames. Management asked residents to keep all clothes and personal belongings in plastic totes (which management provided) and do laundry as much as possible. Management also provided mattress encasements and made a chest freezer available for all resident belongings that a dryer would damage.

Although the PMPs did their part, resident cooperation was not sufficient to knock down the population of bed bugs property-wide. Residents did not keep their belongings in the totes, they tore mattress covers and never replaced them, and the freezer had a limited capacity. Management spent significant time and money and the PMP applied a large quantity of pesticides during these unsuccessful efforts.

1.2 What Worked

Management weighed the options available for complete elimination. Tenting and fumigating the entire building would have cost $80,000. The alternative plan, described below, cost $32,000 (including expenses for all control methods employed).

The effort began with a series of five daily meetings that management required all 39 residents to attend. Representatives presented specific aspects of bed bug control from the perspectives of the health department, shelter staff, pest control company, and shelter management. The fifth meeting was a question-and-answer session. Inevitably, not all residents made all five meetings, but by the end of the week every person knew the plan of action for the treatment and his or her responsibilities.

On the day of elimination, all residents received boxes into which they put all of their belongings. The PMP took the boxes and put them into an 18' truck for offsite fumigation. Only wooden and upholstered furniture remained in the townhouses. Shelter staff wrapped all the furniture (including mattresses) in plastic and immediately took items to an incinerator. Meanwhile, the PMPs inspected and thoroughly treated the now-empty rooms during a four-hour window. After treatment, staff brought in new furniture to re-furnish the rooms and applied petroleum jelly around the bottom of each of the bed and couch legs. All new furniture was metal or plastic-coated fabric. Although the new furniture looked institutional, shelter staff attributes much of the success of the program to the furniture's metal construction. Immediately after the 24-hour control program, staff found bed bugs stuck in the petroleum jelly, but by the time of the PMP's follow-up, no live bed bugs were detected.

During this four-hour period of time, residents brought one bag with clothes they would need for the day to a laundromat that the shelter had rented for the day. Residents washed and dried their clothes, put them in news bags, and returned to the shelter. After the 24-hour fumigation, the PMPs returned all belongings and the residents restocked their homes.

To maintain this level of control, procedures are strictly followed for the coming and going of people and their belongings. Every person who comes to stay at the property must wash and dry all items that can be laundered (in the shelter's machines) and place non-washables in the chest freezer for 48 hours. The shelter still provides plastic totes to the residents, but this is more of a precaution than an essential part of control. Since the turnover of people is only about one person per day, a single freezer and one washer and dryer set are sufficient. The PMP comes regularly and thoroughly inspects (including the undersides of drawers and behind electrical outlet plates).

2. Massachusetts Housing Authority: Preventing Spread during Renovation

Since a significant amount of economic stimulus funding has been directed towards renovation projects in low-income housing, it is worth mentioning the procedure used by one housing authority for residents who have to be relocated during renovation.

The housing authority has a contract that includes pest control with a relocation company. Four weeks before a resident move-out, the relocation company inspects the resident's home. If t bed bugs are found, the relocation company hires a PMP to treat. If the PMP requests that the residents launder potentially infested clothing,, the housing authority provides tenants with dissolvable bags.

Each temporary housing location has an onsite dryer dedicated to bed bug prevention. Incoming residents must put fabrics in the dryer for 30 minutes before they are allowed to move into their temporary home. In addition, interceptor monitors are in place at the temporary site so that staff can detect infestations and deal with them early. Each temporary unit has a seven day vacancy in between occupancies during which time the contractor cleans, inspects, and uses portable monitoring devices for bed bugs.

3. Oregon Section 8 Property: Reducing Incidences of Bed Bugs with Building-Wide Policies

In Oregon, property staff noticed a trend in a project-based Section 8 property with elderly/disabled residents: bed bug infestations. One staff member estimates that one-third of the building's units had bed bugs. Tenants and management were not cooperating with instructions from the PMP. Management did not understand why they couldn't rely on the PMP for the entirety of a bed bug control effort. Residents did not report bed bugs because they knew that they would be responsible for buying costly mattress encasements and possibly the PMP's services. This approach of PMP-only bed bug control did not work and the building-wide infestation level grew. With the goal of early detection and intervention based on a zero-tolerance for bed bugs, property management and the pest control company developed a new protocol.

The process for each bed bug infestation at the property is now:

1. The resident reports bed bugs to management.
2. A housing staff employee who has experience with bed bugs inspects and verifies the infestation visually.
3. The housing staff member develops a trusting relationship with the resident to determine what outside help the resident will need in order to do his or her part in pest control. The staff member prescribes individualized preparation instructions for the unit. (This is not left to the PMP because staff has become very experienced with the process and rationale of unit preparation.)

4. Property management, social services, and residents work together to prepare the unit (all paid for by management). When residents can't or (sometimes) won't prepare, a contracted preparation team services the unit. The prep team does the physical work for preparation and reassembly of the room. The prep team personnel are educated about bed bugs and communicate well with the residents.
5. The PMP treats the unit when (and only when) the resident or preparation team has fully prepared it.

Education of staff and residents helped them understand the pest and how to prevent it. Two of management's goals for education were to remove the stigma associated with bed bugs, and inform everyone of the procedure in place for bed bug control. Management encouraged education with written materials, group education (with translators if needed), and one-on-one interventions. Education increased communication and invested everyone in the program.

Because early detection by residents and prompt intervention by the PMP is the ultimate goal of this program, management carries the financial burden associated with bed bug control (including preparation contractors and mattress encasements). This asset management is feasible from a business sense. Before, management was continuously paying for service that never fully eliminated the problem; now the costs associated with bed bug control are mostly upfront and do not occur very frequently. Under this strategy, in six months, number of treatments per week was reduced from an average of ten to less than one. What was once a building-wide infestation has been reduced to a few sites in need of treatment and surveillance.

Compliance Solutions

1. Options for Education

Three educational approaches used by management in affordable housing are:

- Community-wide distribution of educational materials;
- Training in group settings; and
- One-on-one communication.

The goal of education campaigns is to educate everyone working and living in a particular facility about both bed bugs and building-specific procedures for controlling them.

Trying to resolve isolated bed bug infestations reactively is neither sustainable nor effective. Management must motivate staff, residents, and contractors to do their part in the process—and they must be patient in enlisting this support. Management should base the building-wide plan on national models but keep site-specific factors in mind. As soon as there is a suspected bed bug infestation, management should act quickly and consider the control effort an urgent need.

Achieving a sustainable solution may require going outside of the building to the community, especially if re-infestation is occurring from a known reservoir in another building. Some experts suspect that housing complexes run by property management companies without a zero-tolerance policy for bed bugs are reservoirs for bed bugs that can lead to community-wide infestations.. Communication, prevention, early intervention, and the integration of multiple control methods are the cornerstones of an effective bed bug control strategy.

1.1 Written Materials

Written materials can be distributed through monthly rent bill mailings, newsletters, move-in materials, postings in public places, and door-to-door delivery. Property managers should review leases, tenant handbooks, housekeeping standards, and pest control policies to endure these documents contain language articulating tenant and property management roles and responsibilities for pest control. Management should use unambiguous language to describe pests of concern and what constitutes an “infestation” that must be reported to management.. Documents should contain clear language about pest prevention and the requirement for tenant cooperation with PMPs. In addition to helping residents understand their responsibilities regarding pest management, such clear written language in leases and other key documents can be useful should enforcement action be required in the face of tenant non-compliance.

It is important that written materials be easily accessible to property managers, tenants and any other parties who may need them. Currently, many property managers develop their own materials based on what they read online. There is a need for professionally developed written materials about bed bugs that communicate the major messages at a third-grade reading level or lower. Educational materials should be translated into a variety of languages as well as Braille. As new documents are developed, they should be noted to indicate the importance of the information and need for translation for local audiences. All-visual materials for illiterate populations should also be developed. Materials should communicate what residents should do if they think they or someone they know in the building has bed bugs. This may help in early detection.

1.2 Group Training

Training led by a bed bug expert in a group setting is the most time- and cost-effective way of educating, but only if the people whose participation is necessary to ensure program success are willing and able to attend the training. Unfortunately, it is often the residents that don’t attend such training session who are housing

the reservoirs of bed bugs in a building. Nevertheless, group education is an excellent means for informing tenant advocates, social service workers, maintenance staff, and management, and serves as a starting point for collaborative efforts to identify and resolve bed bug infestations. Moreover, holding group meetings is a clear demonstration of landlord support of the issue and may be a more comfortable environment than one-on-one interventions for people who are squeamish or ashamed.

Trainers use a combination of written materials, samples, and inspection exercises (using either a real or mock unit). Content should include where and how bed bugs live, nontoxic control measures, what to expect from a PMP, and what the procedures are for the building that hosts the training. If the attendees understand where and how bed bugs live, they are more likely to see the importance of recommendations for preparation made by the PMP. Almost all pest control companies are willing to lead group training at no additional charge. Management should schedule these sessions at various times (including the evening) to accommodate everyone's schedules. A bed bug-themed tenant council meeting is often effective as well. An excellent one-day training program for IPM in affordable housing, which includes a module on bed bugs, was developed jointly by EPA, CDC, HUD, USDA, the Northeast Regional IPM Center, the National Center for Healthy Housing, NPMA, and Penn State University. This training can be viewed on-line at www.stoppests.org/ or www.healthyhomestraining.org/ipm/training.htm. For further information on this course, contact Allison Taisey at aat25@cornell.edu or Tom Neltner at tneltner@nchh.org.

1.3 One-on-One Education

One-on-one education is time intensive, but is the best for residents who have severe bed bug infestations in their homes. This form of education is more personal and involves a meaningful, personalized investment of time from both the trainer and the trainee. Trainers should attempt to determine how bed bugs began so that steps can be taken to avoid reinfestation during and after the treatments.

The person administering the one-on-one education must know about bed bug control and building-specific procedures for pest control. Attending one of the group education sessions should be a minimum standard for those working one-on-one with residents. Management, maintenance, resident support services, the PMP, or outside agencies all have opportunities to educate residents when they visit a unit (whether it be for pest control or not). There is a great need for multilingual educators. Every door that opens should be seen as an opportunity for pest control education. The personnel *and* resources needed for one-on-one training should be available to communicate effectively with whoever is behind the door.

2. Solutions for Difficult Residents

2.1 Residents Who Can't

Those who provider input on this report suggested the following options for accommodating residents who can't prepare their homes for bed bug treatment. People in the pest control profession need to network with social service groups to identify other options available.

- Early in a bed bug control effort, identify residents who cannot do unit preparation so that support services can be employed.
- Contact the families of residents who are unable to prepare their homes to ask if they can dedicate time or money to the effort.
- Utilize social service agencies to help residents who do not have family to help.
- Have the PMP, building maintenance, or hired preparation contractor prepare the physical unit.
- When residents are hoarding, PMPs should try to make the bed an island and make as much of an impact as possible with contact treatments. Sustainable control will not be achieved without the help of a therapist.

2.2 Residents Who Won't

Those who gave input on this report suggested the following options for dealing with residents who refuse to prepare their homes for bed bug treatment. People in the pest control business may need to network with social services and law enforcement groups to identify other options available.

- Management gives notices requesting cooperation and detailing consequences.
- Management charges the resident for lack of compliance with PMP's instructions.
- Management proceeds to lease enforcement. (Management should try to avoid eviction since the resident will likely both take the problem to the next residence and cause migration due to disruption during the moving process.)

Questions for Further Research

Researchers should strive to test every tool and active ingredient available for bed bug control as an independent variable. Ideally, studies would follow comparing efficacy of tools and products that can be used together in various types of infestations (e.g., different buildings and levels of infestation). In this way, peer-reviewed research can support PMPs' plans that involve multiple control methods. Questions posed for research are:

Inspections

- Which is more effective at identifying a light bed bug infestation in vacant units: dogs, sticky traps, moat-style interceptors, or portable monitors? In occupied units?
- What visual inspection procedure is most effective at detecting a light infestation when done by a non-professional?

Monitors

- Are interceptors more effective at monitoring for bed bugs than sticky traps?
- Which chemicals are most attractive as lures?

Unit Preparation

- What are design specifications for the furnishing and organization of a bedroom that is least conducive to bed bug infestations?
- What is the best way to work with residents who can't cooperate with pest control efforts?
- What is the best way to work with residents who won't cooperate with pest control efforts?
- What impact does metal furniture have on bed bug control efforts?
- What impact does the use of dissolvable bags have on the success of building-wide bed bug control efforts?
- What specific impact did laundering have on a successful bed bug control program?

Non-Chemical Treatment Methods

- What impact do mattress encasements have on a building-wide bed bug control program? (This research may also consider the fact that encasements help control dust mites.)
- How much of an impact can steam have on a population when compared to other non-residual treatments?
- What triggers the dispersal behavior of adult female bed bugs and how far do the (potentially fertilized) females travel?
- Which is more effective at killing bed bugs and eggs on upholstered furniture: steam or frozen carbon dioxide? (What is the penetrating ability of each of these?)
- What is the temperature of the freezer (household, deep, and container truck) and for how long must the item stay in the freezer to kill adult bed bugs and eggs if they are in the center of a bag full of fabric?
- Does petroleum jelly work as a barrier? If so, what is the width of the barrier needed to guarantee that bed bugs won't make it across?
- Does double-sided tape work as a barrier?

Pesticides

- At what threshold of clutter and infestation level should a PMP refuse to apply a chemical treatment?
- Do pheromone lures make insecticidal dusts more effective?

- Do foggers or pesticide sprays interfere with the ability of bed bug detection canines to detect bed bugs?
- Why is there a difference between pyrethroid efficacies in the lab versus the field?
- How long do pesticide-impregnated encasements need to be in place in order to kill bed bugs and eggs trapped inside?

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Final Thoughts

The best-case scenario for dealing with bed bugs effectively and efficiently (complete elimination using minimum time and money) is when a resident reports an infestation early and management acts promptly based on established procedures that support a zero-tolerance policy for cockroaches, mice, rats, *and* bed bugs. All people living and working in the building must know of the zero-tolerance policy and everyone must understand his or her part. Bed bug infestations get out of hand when staff doesn't know about them, does not take action, does not communicate preparation instructions to residents, or residents do not comply either because they can't or won't.

Integrated pest management (IPM) is a reduced-risk approach to pest control that looks at pest problems as building-wide issues, rather than isolated incidents. An IPM program establishes procedures for preventing pest entry and limiting food, water, and shelter available to pests. When all members of the IPM Team (management, staff, contractors, and residents) know their role in pest management *before* a problem arises, a reported infestation (regardless of pest type) can be dealt with quickly. When residents understand that they will not be charged or penalized for reporting a pest infestation and that the building management and staff have committed to providing a pest-free home, they are more likely to report infestations before they get out of hand. An effective IPM program addresses all the reasons bed bug control efforts fail.

As part of their role in pest control, all members of the IPM Team should know to report cockroaches, mice, rats, or bed bugs as soon as one, or evidence of one, is seen through a pre-determined system. Communication is a large part of an effective IPM program. All members of the IPM team should be in communication about pest control issues and resolutions. Management will be able to hold everyone accountable for their part in pest control by using a building-specific work order system or IPM log to track problems from start to finish.

Resident compliance is not a bed bug-specific issue. Residents who don't comply with bed bug control efforts are probably the same residents who would not be doing their part in any IPM effort. It is worth repeating that these residents fall into two (very different) categories of *can't do their part in pest control* and *won't do their part in pest control*. Solutions need to be found for both of these groups. Solutions will come from experts outside of pest control. The IPM team must include legal and social service experts. Getting residents the support or motivation they need to do their part in pest control is an ongoing battle that must be fought with undiminished enthusiasm. A pest-free home is part of what makes a healthy home and *every* person deserves a healthy home.

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