

Bed Bug Control

April 2018

Every region of Québec is affected by the problem of insect pest infestations. According to the most recent data, bed bugs are present in most of the province's large cities. Knowledge about bed bugs continues to evolve, as do the strategies available to fight them. All favour the use of integrated pest management. This approach combines multiple techniques for controlling insect pests without endangering human health or the environment, and does not view pesticides as the only tool for this purpose. The goal of the present training guide is to offer the most up-to-date information about the various methods of controlling bed bugs and the recommended preventive approaches.

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1. Biology

1.1 Description and life cycle

The bed bug is an insect belonging to the family *Cimicidae*. This family includes over 100 species that feed on the blood of birds or mammals. Two species live almost exclusively at the expense of humans: *Cimex lectularius*, which is primarily found in the temperate zone, and *Cimex hemipterus*, which is essentially limited to the tropical zone. This training guide deals with the former, *Cimex lectularius*.



Source: Piotr Naskrecki, Centers for Disease Control and Prevention, 2006

Figure 1. Adult bed bug feeding on blood

The adult bed bug (*Cimex lectularius*) is a few millimetres long (about 4 to 7 mm), oval in shape and reddish brown in colour. Dorsally flat, it becomes swollen with blood as it feeds. It has biting/sucking mouth parts, long antennae and vestigial wings that do not enable it to fly.

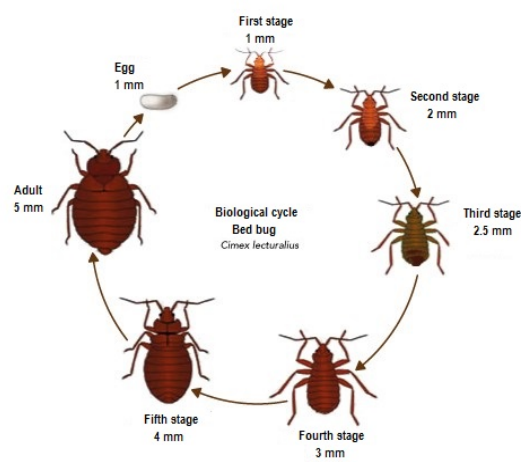
Bed bug eggs are a millimetre long and white in colour. They are difficult to see without magnification, particularly on light-coloured surfaces.

The bed bug is a heterometabolic insect, meaning that it undergoes incomplete metamorphosis. In immature stages (as a nymph) it resembles the adult, but with a different size and colour. After hatching, the young nymph is yellowish, no bigger than the head of a pin, then grows and becomes darker over the course of its development.

The adult female must feed after being fertilized in order to lay eggs. She can lay 300 to 500 eggs over the course of her life. When eggs are laid they are covered with a substance that sticks firmly to most surfaces. On average it takes 10 to 14 days for them to hatch, but occasionally an egg can hatch in as little as a week.

The nymph moults five times before becoming an adult, and must feed at least once between each moult. It does not feed every day, but every five to ten days.

The time required for a complete life cycle, from egg to adult, depends on the frequency of meals and the temperature of the environment, ideally between 21 and 26 °C. If conditions are particularly favourable, the bed bug becomes fully mature in a month, allowing multiple generations to develop in a single year. The life cycle can take longer when conditions are less favourable. The life span of an adult bed bug, from 10 to 12 months on average, can also vary depending on conditions. Bed bugs are highly resilient and can survive for months without feeding.



Adapted from the Centers for Disease Control and Prevention (CDC)

Figure 2. Life cycle of the bed bug

1.2 Habitat and dispersion

Bed bugs prefer to live in groups and can hide in any object or dark, narrow location. A crack no wider than a credit card is all they need. They hide primarily around mattresses and box springs, but can also be found in the cracks of walls, floors and furniture, in bedside tables and bed frames, behind pictures, behind wall trim, in electrical outlets, etc. The magnitude of an infestation will influence the multiplicity of places where they are found.

Bed bugs in all stages are primarily found in bedrooms, whence their common name; they feed on sleeping humans during the night. They can also travel for several metres along floors, walls, ceilings or any type of surface, and can invade adjacent rooms or apartments by crawling through the empty spaces in walls, along plumbing, electrical wiring and other elements that offer a bridge between apartments. Their dispersion from place to place tends to occur when they happen to be concealed in something that a human subsequently moves, such as luggage, clothing, a mattress or furniture.

Whether in a single-family dwelling, commercial establishment, apartment building or public facility, infestations can be of considerable scope. However, bed bugs are most likely to propagate in places with numerous inhabitants, such as hotels and motels, multiplex housing, halfway houses, student residences, seniors residences, hospitals, etc. In such places the number of people potentially affected by a pest control intervention is also greater.

2. Effects on Health

2.1 Bites

The appearance of cutaneous lesions due to bites is the most obvious manifestation of bed bugs having an effect on physical health. Such lesions are most often observed on body parts that are exposed during sleep, primarily the arms, shoulders, neck, face and legs. When a bed bug bites, it injects analgesic compounds to reduce any pain, anticoagulants to delay blood coagulation, and vasodilators to increase the diameter of blood vessels. These compounds, all present in the insect's saliva, facilitate the drawing of blood. They can cause allergic reactions leading to itching. Bites can also cause other lesions at the injection site.

Usually after a bed bug has bitten there are small, pinkish bumps on the skin like those caused by mosquito bites; they are often clustered in the same area of skin. Sometimes the victims say they were bitten a few days ago but not at all since, which may mean that there are only a few bed bugs and the infestation has just begun. Normally the pinkish bumps disappear on their own after a week or two, unless new bites occur as the infestation progresses.



Source: wikimedia.org

Figure 3. Common bites of bed bugs

Skin infections (e.g. cellulitis, impetigo) can develop when a person scratches because of the itching. Less common lesions include hives and blistering, and sometimes more serious allergic reactions can occur. Anyone with such lesions or reactions should consult a doctor.

The skin lesions resulting from bed bug bites are highly variable from person to person. Some people do not react at all to bites. It is generally agreed among specialists that the variability of reactions is so great, with such similarity to the bites of other insects, that bites alone are not enough to diagnose a bed bug infestation.

Cutaneous lesions may be due to any number of causes (mosquitoes, fleas, spiders, etc.), and some people do not react at all to bed bug bites. Never assume that the presence or absence of bites is enough to determine whether or not there is an infestation.

2.2 Mental health and sleep problems

Repeated episodes of infestation, or one that is not controlled, can have significant effects on mental health. For example, itching due to repeated bites can cause sleep disorders, fatigue and anxiety, greatly reducing the victim's quality of life. Anyone whose mental health is already fragile could experience worsening symptoms if they also have to endure a bed bug infestation.

There is still a taboo around bed bugs, so people faced with an infestation may feel ashamed, tell no one about it or become socially isolated. Consequently, it sometimes happens that the very people who could help right away are not informed until weeks or months have passed. **Such behaviour delays intervention and gives bed bugs time to multiply and spread.**

3. Integrated Management of Bed Bugs

The principal steps of integrated pest management are the following:

1. Prevention
2. Identification
3. Detection
4. Deployment of control methods
5. Assessment

Interventions to eradicate bed bugs should include all five of these steps. The pest control specialist should also be aware that people confronted with a bed bug infestation may be vulnerable, stressed, even psychologically disturbed. A relationship of trust must be developed, to reassure them, enable them to open their door and give access to their home with complete confidence. The pest control specialist has to adapt to the situation, creating a climate of confidence as quickly as possible, with a view to obtaining the client's engagement in preparing the home before the intervention, an important and necessary step.

3.1 Involvement of clients

3.1.1 Adapting interventions

Bed bugs can infest all kinds of places, regardless of the occupant's income, origin or social class. In some circumstances however, some people can be more vulnerable, including:

1. Those with a physical disability, or loss of autonomy
2. Those with a mental health problem
3. Individuals or families who are financially disadvantaged
4. Households with numerous children or composed of elderly persons

In 2015, a survey published in a report by the director of public health for Montréal revealed that with the exception of rodents, pest infestations were more common in the homes of tenants than in those of owners. Nearly one in ten households in Montréal were infested by rodents, bed bugs or cockroaches. Significant differences were noted depending on household income and the percentage of income devoted to housing.

Sometimes, municipality and health authorities can get involved. This may be needed for suitable preparation of the places, which requires a significant investment of time, energy and effort in a very few days. When this is the case, the pest control specialist must notify the owner or manager of the building, who can then contact local health authorities. In such situations it is important that intervention plans be shared with everyone involved and that their actions be synchronized.

Sometimes additional effort is necessary to adapt the intervention, and to make the clients fully aware of how important it is that they be involved for the intervention to be successful. This includes the owner or manager and especially the occupants.

3.1.2 Roles of the owner, manager and occupants

Besides explaining the steps to be carried out, the pest control specialist must detail the specific actions required on the part of the owner or manager and especially the occupants. They must all understand that they need to be active participants for the intervention to be successful, due to the difficulty of detecting and eliminating bed bugs.

Among other things, the owner or manager and the occupants must get involved in the following manner:

1. Provide access to the places for inspection and treatments by the pest control specialist
2. Do the necessary preparatory work before treatments are carried out
3. Leave the place, for their own safety, when pesticides are applied
4. Allow follow-up visits until the bed bug infestation is completely eliminated

In the case of commercial establishments and apartment buildings, the owners or managers must also contact the occupants of adjacent dwellings, to notify them about interventions underway. Their collaboration is essential due to the risks of propagation.

3.2 Prevention

Pest control specialists are always called in to deal with an infestation. But their responsibility goes beyond simply eradicating bed bugs. They must be able to inform the owner or manager, along with the occupants, about what they can do to prevent future infestations.

In many cases, treatments using heat or steam are sufficient to eliminate a bed bug infestation, and do not necessarily require technical expertise. However, **if the use of pesticides is necessary, this work must be carried out by a pest control specialist.**

There are concrete measures that can be taken to limit the risks of introducing bed bugs into living quarters. Here are some tips that the pest control specialist can give to clients:

Used clothing. Inspect used clothing carefully, transport it in a tightly sealed bag or container, and do not remove until it has been heat-treated (see section 3.5.2). Only then should used clothing be worn or put in the closet.

Used furniture. Pay attention before bringing home used furniture or other items, especially if they were left by the sidewalk, such as mattresses, box springs, upholstered or wooden furniture. There is a considerable risk of bringing bed bugs home. Inspect each item carefully and apply a mechanical or physical method of pest control (see section 3.5.2). For example, using a suitable mattress cover will eliminate the need to treat a mattress with pesticides. If the mattress is still good, vacuum cleaning and/or steam cleaning, combined with an anti-bed bug mattress cover, should suffice.

Travel. In accommodation facilities (hotels, motels, B&Bs, etc.), avoid putting clothes and personal effects in places where there might be bed bugs: in drawers, on the floor, on upholstered furniture or the bed.

Put your luggage on luggage racks or in the bath.

When bed bugs are detected in a room or on clothing, place personal effects in a plastic bag or other tightly sealed container, and keep them there until they have been treated by either a mechanical or physical control method (see section 3.5.2).

Inspect luggage immediately when you return from travels. If you suspect the presence of bed bugs, treat both the luggage and the contents quickly, using a mechanical or physical control method (see section 3.5.2).

Certain measures can also be taken to reduce the risk of bed bugs places, as discussed next:

Decluttering and housekeeping. Avoid accumulating useless stuff that will just become clutter. This alone will reduce the number of places where bed bugs can hide. Vacuum your home and inspect beds regularly.

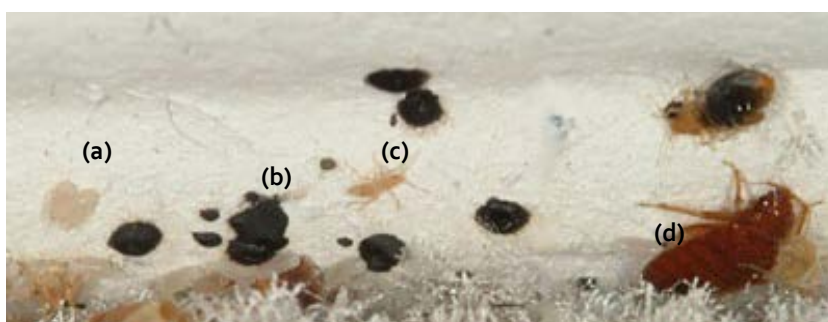
Cracks and crevices. Seal up any cracks and crevices that could shelter bed bugs: behind wall trim and molding, cracks in floors, empty screw holes in furniture, etc. All of these are choice habitat for bed bugs.

Rental housing. Seal electrical receptacles, power outlets, the electrical wiring around appliances and baseboard heaters, plumbing, and electrical boxes for ceiling lights, to prevent bed bugs from spreading from apartment to apartment.

3.3 Identification

Before applying pest-control measures, and to determine which ones would be most appropriate, the presence of bed bugs must first be confirmed. This is done by detecting the insect itself or by observing signs of its presence. Review section 1.1 for a full description of the insect. The present section will focus on the various signs by which you can be sure that bed bugs are present.

Finding a bed bug in one location does not necessarily mean that there is an infestation. However, finding several living bed bugs, hatched and unhatched eggs (Figure 4-a), nymphs (Figure 4-c) and the brownish skins (*exuviae*) left behind after moulting (Figure 4-d), all constitute incontestable proof of an infestation. Detection can be trickier however in cases of low-level infestation.



Source: M. Potter, University of Kentucky, 2004

Figure 4. Bed bugs and signs of their presence

(a) Eggs (b) Dried excrement (c) Nymph (d) Adult

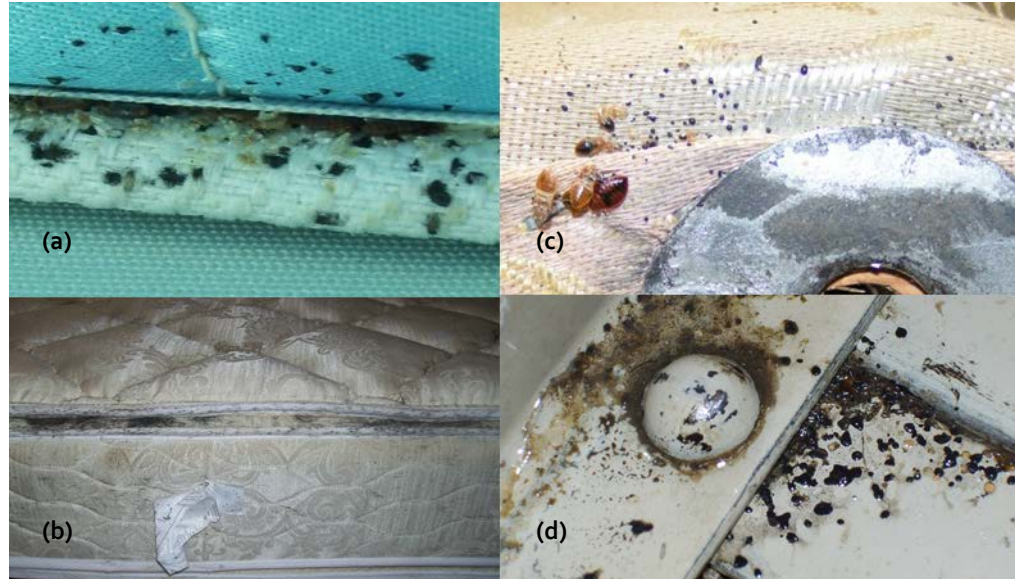
Indirect signs that bed bugs are present include the following:

1. Dried excrement, appearing as dark spots (Figure 4-b). Lightly wetted, they turn a rusty or reddish colour, indicating the presence of digested blood (clear proof that a biting insect is present).
2. Blood, appearing as reddish marks, from people scratching bites in their sleep; also from crushed bed bugs.

The following illustration shows typical examples of the presence of bed bugs: along the seams of a mattress (Figures 5-a and 5-b), near the leg mounting plate of a box spring (Figure 5 -c) and on a bed frame (Figure 5-d).

Figure 5. Typical examples of signs that bed bugs are present

- (a) Bed bugs at various stages, with excrement stains along the seam of a mattress
- (b) Signs of the presence of bed bugs on a mattress
- (c) Bed bugs at various stages, plus excrement near the leg mounting plate of a box spring
- (d) Bed bug excrement on a bed frame



Source: Maheu et Maheu

3.4 Detection

Various methods and systems can be used to detect bed bugs during an inspection. They can take a variety of forms depending on the location, the extent of the infestation and the purpose of the inspection.

3.4.1 Detection methods

Basic tools. The most common tools for detecting bed bugs and signs of their presence are: a powerful flashlight, a telescopic inspection mirror, and a magnifying glass or similar device. Since you will need to gain access to hidden or partially covered recesses, a screwdriver, pliers or crowbar will also be frequently used. Lastly, insects can be collected with insect tweezers and placed in small containers filled with 70% isopropyl alcohol, for later identification.

Active and passive detection systems. In complex cases, such as when only indirect signs are found, or when a dwelling is infested repeatedly, there are devices available to optimize detection. They may be active, attractive or passive, capturing bed bugs as they move around a home. Table 1 presents a few examples.

Table 1. Examples of Devices for Detecting Bed Bugs

Active Systems	Passive Systems
<ul style="list-style-type: none"> - Devices generating heat and carbon dioxide (CO₂) - Devices generating heat alone - Devices combining heat, CO₂ and attractants (pheromones) 	<ul style="list-style-type: none"> - Bed bug interceptors for the legs of beds or other furniture - Thin interceptors between mattresses - Sticky interceptors - Pitfall traps

Active and passive detection systems are usually placed under the legs of beds or furniture where an infestation is suspected. Such systems allow bed bug activity to be detected over a period of a few days or weeks. **They should be checked periodically to assess the growth of the insect population.**

Apart from the systems listed above, the use of a certified detection dog might facilitate the inspection.

3.4.2 Inspecting the places

Inspection of the places should begin where the infestation was first suspected, to confirm whether or not bed bugs are actually present: usually bedrooms, or more precisely bedding, mattress seams, box springs, headboards, etc.

Further inspection should then determine whether bed bugs are hiding nearby: in crevices, nooks and crannies, other hiding places like curtains, rug ends, baseboards, inside dresser drawers, the underside and crevices of upholstered furniture, electronic appliances, behind pictures and wall decorations, etc. The work continues with the inspection of hallways, closets, storage boxes, the beds or cages of pets, desks and all other locations where bed bugs could hide. Inspection then widens to include places where the occupants relax, such as the living room or family room, and finally any other parts of the dwelling that have not yet been examined.

In commercial environments, the inspection should include equipment like carts, and locations like laundry rooms, maintenance closets, storage rooms and gathering places like break rooms and recreation rooms, waiting rooms, etc.

One or more adjacent apartments may also be infested, or be the source of an infestation. **Unless all are inspected, there is a high risk of new infestations in the first apartment, and of propagation to the entire building.**

With apartment buildings, condominiums, hotels and other multi-accommodation buildings, the inspection of surrounding dwellings **should be an integral part** of the service offered when an infestation is confirmed. **The pest control specialist must then obtain authorization from the occupants to inspect all the places.**

Beyond inspection of the places, some additional information could also be useful. For example, checking the previous pest management file, if any, could reveal the intervention history and provide information on the living habits of the occupants, to determine potential infestation sources.

3.5 Control methods

Multiple control techniques can be combined to eradicate an infestation, since each has advantages and limitations. Interventions should be planned so that the techniques applied are not only effective but known to be the least harmful to the health and safety of the person applying them, the occupants and the environment.

3.5.1 Preparing the places

This step is crucial. It is essential to begin by preparing the places, so that if pesticides must be applied the pest control specialist will be able to do so effectively. Most pesticides approved for bed bug control must be applied in cracks and crevices, so the latter must be accessible. If preparation is not done properly, there is a high probability that the intervention will be ineffective.

Information about preparation must be given to the owner or manager, and especially the occupants, before interventions are carried out. It is also necessary to inform all concerned about how they can prepare the places to prevent bed bugs from moving further.

Basic preparation of the places should include at least the following tasks:

1. Move furniture to facilitate access to places where interventions are planned.
2. Empty closets, dressers and bedside tables.
3. Clean areas that are conducive to the growth of bed bug populations.
4. Place clothing and bedding that has been heat-treated in the dryer into tightly sealed plastic bags, bins or other containers.

This preparation can be done by the occupants or any other person involved, including health care or social service workers, volunteers, municipal employees and housekeeping companies.

3.5.2 Physical/mechanical control methods

Physical/mechanical control methods have proven their effectiveness against bed bugs. They should therefore be included in interventions. They will often control an infestation more quickly, while limiting pesticide use and the associated risks of exposure.

Vacuum cleaner. Vacuuming can quickly reduce the number of bed bugs, while also revealing the scope of an infestation. All surfaces where traces of bed bugs are found should be vacuumed thoroughly, using the appropriate accessory (brush, crevice nozzle, etc.). Pest control specialists should use a machine equipped with an absolute high-efficiency (HEPA) filter. Figure 6 shows an example of a professional vacuum cleaner. Highly effective in pest control, it is designed to capture particles of extremely small size, including fibres, mold spores, dust mites, pollen grains and other allergens. For occupants preparing their home prior to a treatment, a household vacuum cleaner can be used. Though essential to preparing the places, the vacuum cleaner alone will not eliminate all bed bugs, since they



Source: Atrix
Figure 6. Professional vacuum cleaner

are often hiding in inaccessible places. Nor will it eliminate the eggs, which are covered with a sticky substance that resists even powerful suction.

To avoid moving bed bugs to other sites, after the vacuum bag has been used it should be tightly sealed with a knot or twist-tie, then placed in the garbage outside the house. In the case of a bagless machine, the contents should be emptied into a plastic bag, which must then be tightly sealed. The interior of the machine as well as brushes and filters should be checked and cleaned following the manufacturer's instructions. It is critical that these procedures be done after every use, regardless of the type of vacuum cleaner.

Steam treatment. Steam treatment is highly effective, since it can kill bed bugs in every phase of the life cycle (from egg to adult). It is best to use a steamer that provides constant pressure and temperature. The temperature must be over 50 °C to kill bed bugs: generally a temperature of 70 to 80 °C is sufficient. Pest control specialists should use a commercial quality steam machine, as illustrated in Figure 7. It is not required for occupants preparing their home before a treatment.

Steam treatment can be applied to every potential hiding place of bed bugs: places where eggs, nymphs and adults have been found, and wherever infestation is suspected.

The nozzle should be held at a certain distance from the surface being treated, and moved slowly, allowing 10 to 15 seconds per 30 cm of travel. Steam must not be applied to delicate items such as leather, acrylic, vinyl or linen, painted surfaces, wood finishes, laminated wood, simulated wood trim, plastic, wallpaper or other glued surfaces, nor electronic appliances. If in doubt, test the effect of the steam on a small hidden area of the item concerned, then check for any damage by heat or moisture.



Source: VPR Impex

Figure 7. Commercial steam machine

To avoid the development of mold on treated mattresses and furniture due to residual moisture, **the occupants should leave steam-treated items plenty of time to dry, particularly before covering with bedding or anti-bed bug mattress covers.**

Heat treatment. This type of treatment requires very hot temperatures to eliminate bed bugs in every stage of the life cycle (from egg to adult). It can be done using the clothes dryer, washer or various types of equipment that allow objects or an entire room to be treated. Heat treatment can be applied to clothing, bedding, beds and furniture, even objects like toys and shoes. However, special attention must be paid to certain textiles that are not heat-resistant. In such cases cold treatment should be used instead.

Heat treatment using the dryer. This consists of putting textiles directly into the dryer. It should run for at least 30 minutes at its highest temperature (minimum 50 °C).

Heat treatment in the washer. Note that it is better to use the dryer than the washer, since the volume of water in front-loading or high-efficiency washers may be insufficient to eliminate bed bugs. However, if textiles are dirty or the occupants do not have access to a dryer, textiles can be run through the washer. To ensure the elimination of both adult bed bugs and their eggs, the following conditions must be met:

- The water must reach a temperature of at least 60 °C (140 °F).
- Water must cover items completely.
- A complete wash cycle is necessary.

To limit the risk of places an infestation, a laundromat or laundry service should only be considered when the occupants are not equipped at home.

Heat treatment of an entire room. This consists of exposing a room and all its contents to high temperatures. For this kind of treatment, it is important to ensure that the equipment can achieve and maintain a temperature that is high enough to kill all bed bugs: 71.5 minutes at 48 °C or when the temperature of the room reaches 50 °C. The room temperature must be monitored carefully to avoid damaging items vulnerable to heat. Figure 8 shows an example of heat treatment machines.



Source: Maheu et Maheu

Figure 8. Heat treatment machines

Only heat treatment equipment that has been designed and tested for use in pest control should be used. It should be carefully inspected before each use, to ensure that it is working properly and to avoid any risk of fire. Additionally, the Fire Code, municipal regulations on the use of portable heaters, precautions to avoid setting off sprinkler systems, and all other risks associated with heat treatment, must be known and taken into account.

Heat treatment in a portable heat chamber. This treatment allows items of smaller size to be heated. There are many types and models of portable heat chamber on the market, and most can completely kill all bed bug stages in under six hours.

As an example, the portable heat chamber presented in Figure 9 can be assembled in about 40 minutes and is easy to transport and store. A temperature of 49 °C is reached in the centre of treated objects within 2 to 3 hours. The heating system for this chamber can use two to four heating elements, depending on the circuits available. It has a fan that distributes heat in a uniform manner, and four sensors to measure the temperature at different points in the chamber.



Source: AmCan Products

Figure 9. Example of a portable heat chamber

Table 2 presents the recommended temperatures and exposure times for heat treatment.

Table 2. Recommended Temperatures and Exposure Times		
Treatment Method	Temperature	Exposure Times
Drying	50 °C	30 minutes
Washing	60 °C	Complete cycle
Heat treatment of an entire room ¹	48 °C	71.5 minutes
	≥ 50 °C	Until the room reaches this temperature
Heat treatment in a portable heat chamber	49 °C ²	2 to 3 hours

¹Pay attention to where thermometers are placed.

²At the centre of treated objects.

Cold treatment. This type of treatment requires very cold temperatures to eliminate bed bugs in every phase of the life cycle (from egg to adult). Cold treatment can be applied to most surfaces, including toys, plastics, books, electrical appliances, clothing and textiles (especially if they are not resistant to water or heat).

Items being treated must be left in the freezer at a temperature of -18 °C or colder for at least 84 hours (3.5 days). Avoid compressing them, and leave enough space between items for the recommended internal temperature to be reached quickly. Quickly reaching a temperature lethal to bed bugs, and allowing the minimum exposure time indicated, are essential for the intervention to be effective. If the freezer does not reach the recommended temperature (i.e. remains warmer than -18 °C), a longer freezing time is needed and the treatment's effectiveness must be carefully checked afterwards.

Anti-bed bug mattress covers. Anti-bed bug covers for mattresses and box springs create a physical barrier that prevents bed bugs from coming and going, trapping them inside where they will eventually die of hunger. Bed bugs do not have mouth parts that would allow them to pierce or cut tightly-woven textiles in order to get through. Any bed bugs in a mattress will therefore be trapped inside by the mattress cover, unable to bite. Anti-bed bug mattress covers can be used to prevent infestation from a used mattress or box spring, or can be installed after an intervention instead of discarding a mattress that might still be infested. Using mattress covers will also facilitate later inspection, since they render a customary habitat inaccessible. Bed bugs can survive a long time without feeding, so mattress covers should be left on permanently to be effective. If damaged, they should be replaced immediately. Figure 10 shows an example.



Figure 10. Mattress in an anti-bed bug mattress cover

Only approved anti-bed bug mattress covers provide an effective barrier. Before installing, vacuum or steam-treat mattresses or box springs to eliminate as many insects as possible. Attention must also be paid to the mattress cover's zipper, to ensure that bed bugs cannot slip through.

Disposing of furniture and other items. When infested items must be discarded, measures should be taken to minimize the risk of propagation within the building and to other locations. To protect the building interior, dis-

carded objects should be wrapped in plastic before being removed from the infested room. When put out for garbage collection, they should be identified as containing bed bugs, or be altered to discourage others from recovering them (e.g. by slashing the surface of a mattress with a sharp knife). Ideally, the disposal of infested items should be synchronized with garbage collection, or be carried out by taking items directly to the landfill site, in compliance with the laws and regulations in force.

Furniture should be inspected before being brought into the home. Also, no furniture should be brought inside until pest control measures are fully complete. Otherwise there is a risk of reinfestation, compromising the success of interventions.

3.5.3 Chemical control methods

In the spirit of integrated management, preference should always be given to alternative methods, to reduce the use of pesticides and thereby reduce the risks associated with them. For example, physical techniques like steam treatment are effective and pose no risk to the occupants of a home, whereas pesticides do present health risks. Information on toxicity is provided in section 4.2.

Pest control interventions should not systematically include pesticides. With an integrated pest management approach, physical control techniques reduce the need for pesticides along with the associated risks.

Combining chemical methods with other, physical methods can increase the success rate of interventions, while also reducing risks to health and the environment. **Moreover, pesticides are less effective on adults than on nymphs, and not effective at all on eggs.** When pesticides cannot be avoided, the recommended approach is to use the smallest amount possible and the least toxic products. The instructions for use on the product label must be carefully followed.

Pesticides used. The pesticides used for bed bug control are categorized as insecticides.

When the use of insecticides is necessary, only those approved for bed bug control by the Pest Management Regulatory Agency (PMRA) should be used. Under the *Pest Control Products Act*, the instructions for use on the product label must be respected at all times. Among other things, the instructions for use specify the dose and application rate, the method of application, and safety rules such as wearing personal protection equipment, proper storage and the safe disposal of containers. The label also specifies ventilation needs for treated rooms, and in some cases the waiting period for safe re-entry into the room.

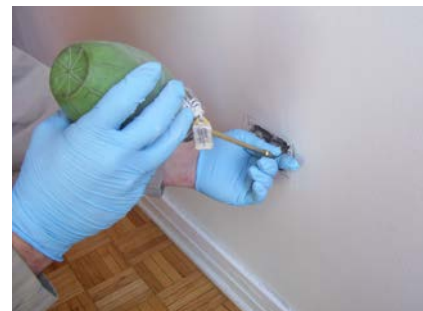
The registration and marketing of pesticides are constantly changing. For the complete list of insecticides approved for bed bug control, go to Health Canada's Pesticide Label Search web page at the following address:

<http://www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php>.

For information, in early 2016 the pesticides used for bed bug control primarily contained the following active ingredients: boric acid, cyfluthrin, d-phenothrin, d-trans allethrin, lambda-cyhalothrin, permethrin, prallethrin, pyrethrins and tetramethrin.

Application techniques. The insecticides approved for bed bug control are available in the form of powder, liquid, wettable powder, and aerosol spray. The equipment used for applying them includes bulb dusters, manual sprayers and aerosol cans.

Powder applicator, bulb duster. Powder applicators are used to blow powdered products into cracks, crevices, holes in walls and hollow places. Powders can easily disperse through the air, so they should only be applied to inaccessible places, out of reach of children and pets. Any visible traces of powder must be cleaned up before the occupants return. Figure 11 shows the application of pesticide powder into a wall.



Source: Maheu et Maheu

Figure 11. Application of pesticides using a bulb duster

Manual sprayers. Manual sprayers are used for applying liquids and wettable powders along walls, under bed frames, behind the bed headboard, under and behind chests of drawers and inside their drawers, under couches, sofas and easy chairs, etc. Ideally, such applications should be limited to places that are inaccessible to children.

Pressurized cylinders, aerosol cans. Aerosol cans are used for applying a product that is in liquid form. Since they vaporize fine droplets into the air they should be used sparingly, for they pose a higher risk of accidental exposure. Figure 12 shows the application of pesticides using an aerosol can.



Source: Maheu et Maheu

Figure 12. Application of pesticides using an aerosol can



Section 42 of the *Pesticide Management Code* stipulates that **it is prohibited to carry out pesticide spraying in a building used as a dwelling except with an aerosol can.** This means that other types of applicators that are used for spraying, such as misters and foggers, are prohibited in dwellings, including attic and basement areas.

3.6 Assessment

It often happens that an infestation of bed bugs is not entirely eliminated on the first visit. This makes it essential to do an assessment afterwards, to confirm the success of the treatment or the need for further intervention. The assessment must examine all elements in the intervention report and be completed by one or more follow-up visits. If necessary, new treatments should be applied that are appropriate to the situation. This stage must be pursued until the bed bugs are completely eradicated.

3.6.1 Intervention report

The intervention report documents every action taken, from the first visit to the final treatment. It makes it easier to determine the most appropriate measures to take. For this reason, it should consider every factor that could affect the effectiveness of those measures. The report should detail the following:

Results of inspections and the scope of the infestation. Most insecticides are not effective on bed bug eggs, and nymphs are more sensitive than adults to all types of treatment. This means that it is easier to treat a new infestation than a well-established population of adult bed bugs, due to the number of insects and their stage of development.

Collaboration of clients. Recommendations made to the owner or manager and to the occupants should be included in the report. The ability of clients to carry out these recommendations, and the degree to which they are performed satisfactorily, should also be noted, particularly with regard to preparation of the places.

Treatments achieved. The choice of treatments, the places where they are applied and the details of their execution should all be presented in the report. The pesticide application record, including locations, quantities and surface areas, can also be attached. When reviewed later, this information can reveal an incomplete treatment of rooms or other infested places in the building, thus explaining a resurgent infestation.



To learn more about the pesticide application record, which permit holders must keep up to date, please consult the reference leaflet *Registre d'achat, de vente et d'utilisation de pesticides*, which is available (in French only) at the following address:

<http://www.mddelcc.gouv.qc.ca/pesticides/permis/feuillet5-reference/feuillet5-registres.pdf>.

Other observations or particular situations. Such information could include any structural problems noted, conditions conducive to infestation that have not been corrected, and so on.

3.6.2 Follow-up visits

Follow-up visits include inspection to determine whether or not there are still bed bugs present (as would be indicated by newly hatched eggs, for example), and thus an assessment of the treatment performed. Such visits could also involve the application of new treatments, if necessary. A follow-up visit should be made two to four weeks after each treatment.

Installation and verification of detection devices. First, the occupants should be interviewed to see if there is any evidence of the presence of insects: new bites, stains on mattresses or sheets, live bed bugs noticed, etc. The interview should be followed by an inspection of the rooms and apartments treated, and of those that are adjacent, to confirm whether all places where bed bugs had been observed are now free of them. New signs of their presence would indicate that further intervention is required.

The appearance of new signs of bed bugs after a series of interventions does not necessarily mean that the treatments have failed. Bed bugs could have been reintroduced by visitors or objects brought into the home, or by the occupants visiting infested sites elsewhere.

Achievement of new treatments. In the event that new interventions are necessary, they should be chosen on the basis of the observations documented in the report. In complex cases, participation by the municipality and health authorities is always welcome.

4. Health Risks of Pesticides

Despite being approved, the insecticides used for bed bug control are toxic to various degrees and can pose health risks. When occupants or owners apply such products themselves, the risks of damage to health become even more worrisome. Problems can even arise when pesticides are used by pest control specialists.

4.1 Studies and incident reports

In Québec, from time to time health professionals learn of exposure situations that have caused health problems due to the improper use of pesticides, both by private individuals and by professionals. The incident reports submitted to Health Canada include problems related to the use of insecticides to control bed bugs:

Of the 72 cases reported from 2008 to 2015, 36 concerned the improper use of pesticides to control these insects, and in most cases effects on health were observed.

There is no Québec study giving numbers on cases of poisoning from the use of pesticides for bed bug control. However, data produced by researchers with the Centers for Disease Control and Prevention (CDC) in the United States shed light on the risks:

The study examined reported cases of pesticide poisoning in 7 American states from 2003 et 2010. The authors identified 111 cases of illness associated with exposure to insecticides used specifically for bed bug control. Though one death occurred during the period studied, most of the cases identified by the poison control centres were of low to moderate severity. In the majority of cases, the insecticides used were pyrethroids, pyrethrins, or both (89%), which are generally considered to be of low toxicity. Although some of the cases involved children under 15 (13%) or youth aged 15 to 24 (10%), the majority occurred among persons over 25 (67%). Various adverse effects were observed, including neurological symptoms (40%), respiratory symptoms (40%) and gastrointestinal symptoms (33%). The majority of cases (93%) occurred in private residences, including a number in multi-unit housing (40%). Several categories of workers were also affected, including pest control operators, hotel workers and emergency medical technicians.

Excessive application of insecticides and failure to wash or change pesticide-treated bedding were identified as the **risk factors** that mostly frequently contributed to insecticide-related illness. **Inadequate notification of pesticide application**, notably with regard to the wait time required for safe return afterwards, was also noted as a contributing factor. Due to the risks of exposure, even pesticide uses that comply with the directions on the label can have an impact on health.

4.2 Toxicological characteristics of pesticides, symptoms of poisoning

Pesticides carry a significant risk of acute or chronic toxicity. Exposure to these products can therefore have adverse effects on health.

Acute toxicity. The effects of acute poisoning from exposure to pesticides are relatively well known: migraines, digestive disorders, skin irritation, respiratory difficulties, generalized fatigue, headaches, nausea, etc. Appendix 1 presents the acute symptoms most often observed after exposure to the principal insecticides approved for bed bug control. These symptoms vary depending on the degree of exposure. In some cases, they may only occur after high exposure. However, the potential effects of these products richly justify using every means to reduce exposure, both to pest control workers and to the occupants of treated dwellings.

Chronic toxicity. Some products have toxicological characteristics that can potentially have chronic effects: allergies, chronic diseases like cancer, neurological disorders, endocrine disturbances, and effects on reproduction and child development.

Appendix 2 presents further details on the toxicological characteristics (acute and chronic) of the active ingredients in insecticides used for bed bug control.

At all times, if you or an occupant feel ill and you suspect poisoning due to pesticide exposure, **consult a doctor.**

4.3 Measures to reduce the risks of poisoning

Beyond the toxicity of pesticides, poisoning is usually the result of improper uses, methods or work techniques. To limit exposure levels and the risks of exposure as much as possible, prevention measures must be respected.

4.3.1 Protection of occupants

Some of the precautions taken by pest control specialists are aimed specifically at protecting the people concerned, who must be notified before a treatment is carried out:

1. Only use insecticides that are approved for bed bug control; never use a "homemade" mix, and follow the instructions on the product label.
2. Do not apply insecticide directly to mattresses, skin or clothing, even if approved for that purpose, to limit contact with the skin and mucous membranes.
3. As much as possible, restrict the use of insecticides to cracks, crevices and inaccessible places.

4. Do not allow people or pets to be present during the application of insecticide.
5. Follow the recommendations regarding room ventilation.

The pest control specialist should give clear recommendations to the occupants before they return to the places, notably as to how long they must wait before re-entering. The minimum standard is to respect the wait times specified on the label, but health professionals have their own recommendations, and these should be respected even if the time on the label is shorter. Table 4 presents the recommended wait times for different people.

Type of Person	Wait Time
Healthy adult	6 hours
Adult with respiratory problems or allergies Child that is walking	12 hours
Infant from 0 to 12 months Young child not yet walking Pregnant woman	24 hours

*If the wait time indicated on the label is longer, respect this longer time.

4.3.2 Protection for the pest control specialist

Certain precautions should be taken by pest control specialists to protect their health and safety at work:

1. Use the smallest quantities possible, and only when necessary, giving preference to less toxic products and following the instructions for use on the product label.



Under section 42 of the *Regulation respecting occupational health and safety* (ROHS), employers must minimize the exposure of workers to pesticides that contain carcinogenic substances.

2. Store pesticides in their original container, or in containers that are properly labeled and tightly sealed, on non-porous shelves (plastic or metal), in a place with adequate ventilation.
3. Wear the personal protective equipment (PPE) required for handling pesticides (safety visor, gloves, work clothing, respiratory protective device (RPD), etc.).



The legally required minimum PPE is indicated on the product label.

If the exposure level cannot be determined or there is a risk of exposure beyond the values in Schedule 1 of the ROHS, the employer must:

- Provide the pest control specialist with a RPD, free of charge

- Prepare and apply a respiratory protection program (including measures regarding the choice of appropriate RPDs, their maintenance, verification and storage, and the training of users)

For the full text of the ROHS including Schedule 1, go to:

<http://www.canlii.org/en/qc/laws/regu/cqlr-c-s-2.1-r-13/latest/cqlr-c-s-2.1-r-13.html>.

4. After applying a pesticide, remove the PPE or change clothes, and store in a clean and safe place.
 5. After use, decontaminate PPE, work clothes or outer workwear (never wash with the family laundry).
 6. Do not eat, drink, or smoke when using pesticides or in a place that has been treated with pesticides.
 7. Clean the tools used for preparing and applying pesticides (measuring containers, scale, sprayer, etc.) and store in a clean and safe place.
 8. Be especially careful to avoid contaminating the work vehicle. Never enter with contaminated clothing, and store the latter in an airtight compartment outside the driver/passenger compartment.
 9. Wash hands and face after the pest control treatment and take a shower at the end of the working day.
- It is vital that workers receive proper training in the use of pesticides, due to the health risks they present.

5. Conclusion

Knowledge about bed bugs and the limitations and possibilities of the modes of intervention available continues to evolve. At present, integrated pest management is considered the optimal approach. Integrated pest control does not view pesticides as the only or best tool, but as one of a variety of tools available. This approach is a response to the concerns of pest control professionals as well as the public with regard to protecting their health.

Putting to use the best practices set out in this document will reduce health risks to both the user and the public, while ensuring effective treatment.

6. Additional Information

Association québécoise de la gestion parasitaire

<http://www.aggp.ca/> (French)

Ministère de la Santé et des Services sociaux

Portail santé mieux-être:

<http://sante.gouv.qc.ca/en/problemes-de-sante/punaises-de-lit/> (English)

Directeur de santé publique de Montréal:

<https://www.santemontreal.qc.ca/en/public/health-a-z/bedbugs/> (English)

http://www.dsp.santemontreal.qc.ca/dossiers_thematiques/environnement_urbain/thematiques/logement/punaises_de_lit.html (French)

Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques

Information sheets on unwanted organisms:

<http://www.mddelcc.gouv.qc.ca/pesticides/permis/code-gestion/cpe-indesirable/punaise-lit.pdf> (French)

Health Canada

Healthy Living:

<https://www.canada.ca/en/health-canada/services/pest-control-tips/bedbugs-what-are-they.html> (English)

Report a Pesticide Incident:

<http://www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/incident/index-eng.php> (English)

Ville de Montréal

Let's Fight Bed Bugs:

<http://ville.montreal.qc.ca/bedbugs/> (English)

The leaflet on the website is available in nearly twenty languages, in the Documentation section.

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Appendix 1

Common Symptoms of Acute Poisoning by the Principal Insecticides Approved for Bed Bug Control (partial list)¹

Active ingredients ²	Convulsions	Paresthesia	Skin irritation	Respiratory difficulties	Abdominal pain	Generalized fatigue	Hyper salivation	Eye irritation	Watery eyes	Headaches	Nausea	Tachycardia	Excessive sweating	Trembling	Difficulty speaking	Dizziness	Blurred vision	Vomiting
Boric acid	• ³		•	• ³				•		•	•							•
Piperonyl butoxide								•			• ³							• ³
Cyfluthrin		•				•	•	•		•	•							•
N-octyl bicycloheptene dicarboximide ⁴								•										
d-Phenothrin		•						•		• ³	• ³							• ³
d-Trans allethrin			•			•				•	•							•
Lambda-cyhalothrin		•	•			• ³		•		• ³	• ³							• ³
Permethrin		•	•			• ³					• ³			• ³				• ³
Prallethrin								•		• ³	• ³							• ³
Pyrethrins			•	• ³				•				• ³	• ³					

Source: J. R. Roberts and J. Routt Reigart, 2013; CDC, 2011; Gorse, *et al.*, 2002; SOFAD, 2014.

¹ Symptoms other than those listed may occur.

² Active ingredients may no longer be approved for bed bug control. Always check product labels.

³ Only in cases of high exposure.

⁴ Generally of low toxicity alone, used as a synergist (increases the effect of other products with which it is combined).

Appendix 2

Toxicity of the Principal Active Ingredients Used to Control Bed Bugs (partial list)

Active Ingredients ¹	Acute Toxicity ²					Potential Chronic Effects
	DL ₅₀ oral (mg/kg)	DL ₅₀ dermal (mg/kg)	CL ₅₀ inhalation (mg/L)	Skin irritation	Eye irritation	
Boric acid	2950	> 2000	> 0.16	Slightly irritating	Slightly irritating	Possible effects on reproduction and development
Piperonyl butoxide	4570	> 2000	> 5.9	Very slightly or not irritating	Very slightly or not irritating	Possibly carcinogenic in humans
Cyfluthrin	> 16.2	> 5000	> 0.468	Very slightly or not irritating	Slightly irritating	Possible effects on reproduction
N-octyl bicycloheptene dicarboximide	> 5000	> 2000	> 1.98	Very slightly or not irritating	Slightly irritating	Possibly carcinogenic in humans
d-Phenothrin	> 5000	> 5000	> 2.1	Very slightly or not irritating	Slightly irritating	Possible effects on development
d-Trans allethrin	709	> 3000	2.51	Very slightly or not irritating	Slightly irritating	Possibly carcinogenic Possible effects on reproduction
Lambda-cyhalothrin	54	632	0.065	Very slightly or not irritating	Moderately irritating	No specific toxicity
Permethrin	2280	> 2000	> 5.32	Very slightly or not irritating	Very slightly or not irritating	Probably carcinogenic in humans
Prallethrin	640	> 5000	0.855	Very slightly or not irritating	Slightly irritating	No specific toxicity
Pyrethrins	700	> 2000	2.5	Very slightly or not irritating	Slightly irritating	Possibly carcinogenic in humans
Tetramethrin	4600	> 2000	> 2.73	Very slightly or not irritating	Very slightly or not irritating	Possibly carcinogenic in humans

Source: SAgE pesticides; BCPC, 2006; J. R. Roberts and J. Routh Reigart, 2013.

¹ Active ingredients may no longer be approved for bed bug control. Always check product labels.

² The severity of toxicity is presented in the table below.

Meaning of Acute Toxicity Indicators				
Acute Toxicity	Severity of Effect			
	Severely to extremely	Moderately	Slightly	Very slightly or not
	Value of Indicator			
DL ₅₀ oral (mg/kg)	≤ 50	> 50-300	> 300-2000	> 2000
DL ₅₀ dermal (mg/kg)	≤ 200	> 200-1000	> 1000-2000	> 2000
CL ₅₀ inhalation (mg/l)	≤ 0.5	> 0.5-1	> 1-5	> 5

Source: SAgE pesticides.

Bed Bug Control

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