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REVIEW ARTICLE

Bed Bugs in Healthcare Settings

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Infestations caused by bed bugs have resurfaced during the past decade across all continents. Even though bed bugs primarily cause skin manifestations in humans, a major stigma is placed upon people or institutions found to carry them. It is important for healthcare facilities to be prepared for this pest by implementing policies, carefully selecting materials used for hospital furniture, and educating providers on early identification and control.

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Bed bugs are insects that have reemerged worldwide after a relatively quiescent phase between 1950 and the late 1990s. Many factors are believed to have played a role in this resurgence, including resistance to the most commonly used pesticides and an increase in international travel. Nevertheless, peer-reviewed literature on the frequency and management of bed bug infestations within hospital facilities is currently lacking. Therefore, we aim here to summarize the main concepts with regard to the epidemiology and clinical implications of bed bugs and provide guidance on the management of these insects, with a major emphasis on infestations within healthcare settings.

EPIDEMIOLOGY

The Hemiptera order is composed of two clinically relevant insect groups: the Cimicidae (which includes bed bugs) and the Reduviidae (which includes triatomine bugs, which transmit *Trypanosoma cruzi*, the agent of Chagas disease). The two species of Cimicidae associated with humans are *Cimex lectularius* (temperate climates, such as the United States) and *Cimex hemipterus* (largely tropical climates). Bed bugs are hematophagous, are flat when not blood engorged, and have 5 juvenile stages. The youngest stage is off-white in color and approximately 1 mm in length, and as the insect grows it becomes darker. Adults are a brownish red and 4–6 mm in length (Figure 1). Even though blood meals are required for progression of the nymphal stages, adults can live for several months without any blood meals. It has been stated that an adult bed bug can live for up to 2 years; however, in temperature-regulated environments they live for only up to approximately 5 months at 22°C. Females produce an average of 5–8 eggs per week for a total of 18 weeks.¹ Bed bugs are

attracted mainly to carbon dioxide, body heat, and other ill-defined olfactory cues, feeding primarily at night from any mammal but preferentially from humans. Furthermore, their bites are painless because of the extremely fine needlelike stylets that penetrate the skin.

An important characteristic of bed bugs is that they are wingless; therefore, they do not fly or jump, but rather they depend on physical contact to move from one surface to another. Active transmission is accomplished by the crawling of bugs across contiguous areas (ie, from room A to room B). To the contrary, passive transmission occurs by the inadvertent transfer of these bugs from place to place via objects (eg, clothes, bags, and infested furniture). It is important to underscore that bed bugs do not live in or on humans but solely feed on them, largely at night. These insects prefer to live in dark, hidden cracks in close proximity to people. Therefore, typical spots for finding them include the seams, piping, and straps of mattresses; pillowcases; and bed frames.² Other frequent hiding spots include furniture pieces, especially those made of wood, paper, or fabric.¹

There is scant medical literature describing bed bug infestations within healthcare facilities. This paucity of literature might in part be explained by underreporting due to the negative publicity that these kinds of reports generate. This is evident by a search of Google Scholar, which revealed numerous news articles about reports of bed bugs in many US hospitals. Delaunay et al³ described the case of a patient who arrived with her own mattress to a French nursing home. Two months after admission, the index patient was noted to have insect bites; 200 bed bugs were subsequently discovered underneath her mattress. Within a couple of weeks, bed bugs were also detected in 4 nearby patient rooms (probably due to active transmission). Four months later, a fifth case was

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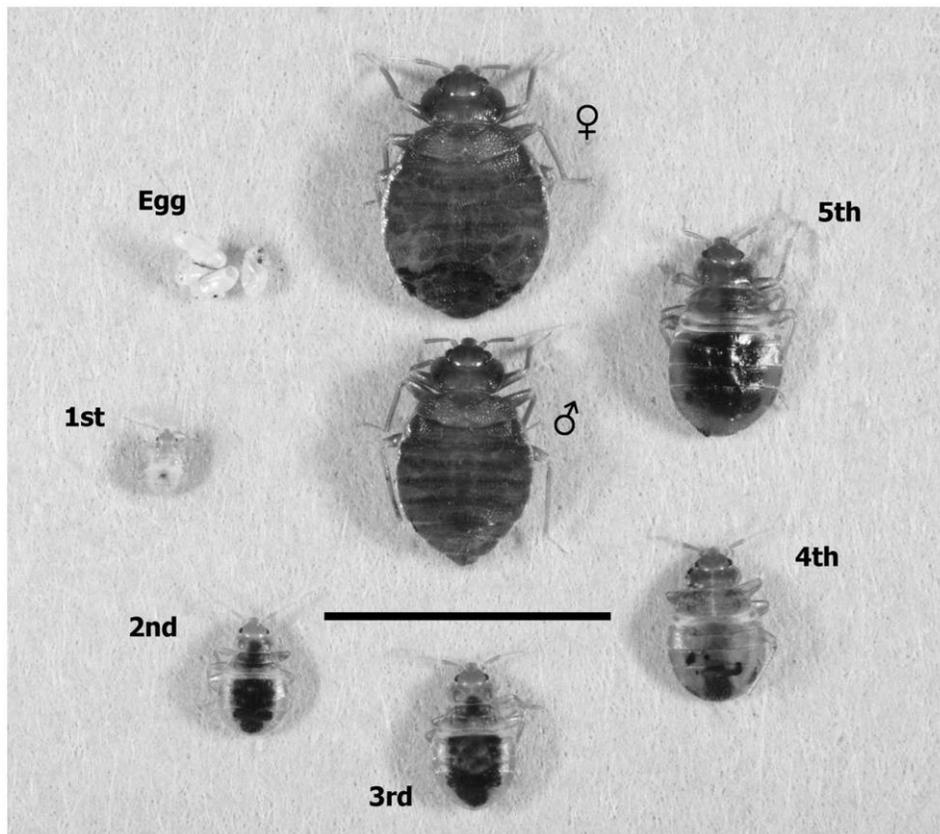


FIGURE 1. *Cimex lectularis* life stages. Shown are eggs, 5 nymphal stages, and adults. Bar measures 5 mm. A color version of this figure is available in the online edition of the journal. ©2009, Stephen Doggett, Department of Medical Entomology, Westmead Hospital, Westmead, New South Wales, Australia.

detected several rooms away from the index case (likely due to passive transmission). Three pest-control interventions were required to eliminate this infestation.³ A second report by Erdogan and collaborators described the identification and management of a patient with bed bugs at a Brooklyn emergency department.⁴ Other reports that have appeared in the popular press have been reviewed by Doggett et al.¹ These authors discuss how some patients have been refused treatment, while whole hospital wards have closed down because of bed bugs, threatening the provision of health care services.

CLINICAL IMPLICATIONS

Skin reactions constitute the main clinical impact of bed bugs. These reactions occur as a consequence of proteins with anticoagulant and vasodilator properties present in the saliva of these insects.^{1,5} Bites usually follow a linear pattern if numerous bed bugs are present, and they are more frequent on the extremities but can occur anywhere on the body (Figure 2). Pruriginous macules or papules follow the bites, usually within 48 hours, although the timing and degree of reaction is dependent on prior exposure. In some instances, a second

round of bites is required before a skin reaction occurs. Systemic symptoms (eg, fever and anemia) associated with bed bug bites are unusual.¹

Another concern associated with bed bug bites is the potential for these insects to transmit infectious diseases. Even though bed bugs have been found to carry infectious organisms, such as hepatitis B virus, in the field, it has never been proven (experimentally or in clinical practice) that any organism can be transmitted by bed bugs.^{1,6,7} Furthermore, there is experimental evidence that even with presence of high human immunodeficiency virus loads in blood, bed bugs fail to transmit the virus.⁷⁻⁹

Nevertheless, Lowe and Romney¹⁰ tested 5 bed bugs for bacterial organisms. The authors recovered methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococci from 2 and 3 bed bugs, respectively.¹⁰ These insects were collected at the time of hospital admission from 3 residents of a single Vancouver shelter. However, questions have been raised about these findings.¹

An overlooked consequence of bed bugs is the significant psychological distress that it can cause among victims.¹¹ Insomnia, fatigue, distress, social isolation, anxiety, stigma, and



FIGURE 2. Skin lesions caused by bed bugs bites. Shown are papular erythematous lesions on the back. A color version of this figure is available in the online edition of the journal. ©2009, Stephen Doggett, Department of Medical Entomology, Westmead Hospital, Westmead, New South Wales, Australia.

persistent crawling sensations on the skin (even after elimination of bed bugs) have been described.^{1,11} Even though infestations are nowadays a common occurrence even in high-end hotels, laypeople still associate bed bugs with poor and unsanitary conditions; this misconception results in further alienation of victims.¹

As mentioned above, patients suffering from bed bugs have been refused medical care by hospitals. As will be discussed in the following sections, this is an unnecessary and unfair measure. Infestations with bed bugs constitute major losses of productivity and revenue at different levels, such as individuals, families, businesses, and society.¹¹

PEST CONTROL

Infestations by *C. lectularius* are difficult to control because of the insects' resistance to commonly used pesticides and

their furtive behavior, which usually conceals their presence within the environment. Therefore, control of bed bugs requires a bundle of interventions known as "integrated pest management," which encompasses the use of nonchemical means of control as well as the judicious use of insecticides. Otherwise, inadequate response often leads to a spreading of the infestation, with subsequent escalation of costs. Therefore, interventions aimed at controlling this pest should be orchestrated by an experienced and certified pest control management service.

Upon receiving the first notification of a possible infestation, the steps to follow should include positive identification of the insects, determination of the area affected, consideration of nonchemical and chemical interventions, and risk assessment of nonaffected areas to minimize the risk of future infestations (Table 1).

TABLE 1. Actions to Be Taken upon Identification of a Bed Bug

Item	Action	Other
Index case: skin (very rare)	Exchange old clothes with new hospital gown. Inspect the skin. No need to apply any products to the patient. Inspect room in case it was previously infested (the bed bug may have come off the bed and not from the patient).	
Index case: clothes and belongings	Remove from the patient and promptly place in sealed bags. These items can be hot laundered or frozen. Inspect room for bed bugs.	Provide fact sheet to patient and family about bed bugs.
Index case: inpatient or ED exam room ^a	Notify a certified pest management service company. Close the room until pest management determines it safe to use. Options for management include insecticides, vacuuming, steam, etc. Inspect adjoining rooms.	Leave all the furniture exposed to the index case in the room. Do not add any furniture to the room. Place a sign indicating that the room is not to be entered. All adjoining rooms should be inspected by an experienced pest manager to rule out the presence of bed bugs.
Index case: bed linens	Seal in alginate bags within the room, then hot launder. Inspect adjoining rooms.	
Index case: mattress/pillows	Hospitals usually use plastic encasements for their mattresses and pillows. As a precaution, pillows can be hot laundered, frozen, or steam treated. Mattresses can be vacuumed and steamed or treated with various insecticides. Inspect adjoining rooms.	
HCWs in contact with index case	Not a major route of transmission unless direct contact is made with index case's belongings. However, as an extra precaution, consider hot laundering the clothes of exposed HCWs if staff have any concerns. Inspect room for bed bugs.	Provide fact sheet about bed bugs. Notify staff present during the shift of this potential exposure.
Other patients exposed to index case	Their clothing and belongings should be disinfected. These items can be either hot laundered, frozen, or fumigated.	Provide fact sheet to patient and family about bed bugs.

NOTE. This table represents the opinion and experience of the authors. ED, emergency department; HCW, healthcare worker.

^a Including furniture.

Nonchemical Control

Given the materials used for furniture in the hospital settings (metal and plastic), disposing of furniture pieces is usually not necessary. Moreover, hospitals use plastic-encased mattresses and pillows, which should reduce potential hiding places for bed bugs. Plastic rather than fabric should also be used in all other furniture pieces, such as chairs, sofas, and curtains, with special attention to limit potential hiding places within seams. As an adjunctive measure, vacuuming can markedly reduce the load of insects; however, care should be undertaken to quickly seal and dispose of the vacuuming bag. Heat has also been shown to kill bed bugs. Temperatures at harborage areas (crevices) need to reach 48°C (118°F) for 90 minutes or 45°C (113°F) for 7 hours to be effective.² Nevertheless, improperly applied heat (with insufficient temperatures within crevices) could cause dissemination of the infestation to cooler areas. Similarly, freezing temperatures are

effective against bed bugs. Placing infested items, such as clothes and bags, in the freezer for a few days will successfully kill all insects, as long as the clothing is loosely placed. Bed bugs can survive without feeding for several months; therefore, leaving patient rooms unoccupied is not a practical way to stop an infestation. Use of canine detection teams can be an effective means of early bed bug detection, although there have been reported issues with the lack of standardization of training, making some of these dogs less effective.¹²

Chemical Control

Use of insecticides corresponds to one of the main means of controlling bed bugs. Commercially available insecticides include pyrethroids; however, resistance to these compounds has been described among the *Cimex*, especially against older formulations, such as permethrin. Therefore, permethrin-impregnated mattresses or fabrics are largely ineffective in

preventing *Cimex* infestations. Nevertheless, newer pyrethroids generations seem to be more active against bed bugs, particularly when synergized and applied as a topical control agent (ie, direct at the bugs), but they provide little residual protection. Foggers (insecticide bombs) tend to be ineffective against bed bugs, as they are made with pyrethroids. Furthermore, the generated mist fails to reach hiding places of the bed bugs, such as crevices. This is in contrast to fumigation, in which the gaseous vapors penetrate to all areas within a structure. However, fumigation is costly and highly toxic to humans. Moreover, fumigation requires treatment of the whole infrastructure (eg, house) rather than only isolated rooms (eg, patients' rooms) to seal the gas within the target area.^{1,5}

Other chemical options available for the control of bed bugs include silicates, insect growth regulators, and some new chemical groups, including the neonicotinoid and arylpyrrole insecticides. Silicates are compounds of low toxicity to humans and act at the level of the bug's shell by absorbing lipids and subsequently causing the death of the insect by dehydration. These substances have long residual activity on surfaces; however, their action is slow, taking up to a couple of weeks for all insects to die, which in most cases is an unacceptable amount of time. Insect growth regulators are substances that depend on the active growth of the nymphal stages. To be active, therefore, insect growth regulators require nymphs to have blood meals (bite) and mature to adults. This prerequisite makes these products unattractive. Although still active against bed bugs, organophosphates, because of their toxicity, are no longer available in Europe or the United States for control of these insects. The neonicotinoids are highly effective at controlling insecticide-resistant bed bugs when applied directly to the insect but provide poor residual control. In experimental studies, the arylpyrrole insecticides have demonstrated variable results, making it difficult to justify such products in a bed bug management program.^{1,5}

The final choice of which insecticide to use will depend on the setting and extent of the infestation, geographical location of the institution, local resistance patterns, and degree of experience of the pest control management service.

PEST PREVENTION

While it is impossible to prevent bed bugs, risk minimization procedures should be implemented to reduce the possibility of developing an infestation within the hospital setting. This entails strategies at 4 levels: (1) introduction of the insects, (2) establishment of the infestation, (3) growth of the insect population, and (4) spread of insects to subsequent areas.¹ To prevent introduction of the insects to the facility, personnel at the points of entry (emergency or outpatient clinics) should be trained on how to recognize these insects and their bites. Prevention of establishment within the hospital is minimized by avoiding wood furniture and using plastic encasements for pillows and mattresses. Fabrics should also be avoided for

chairs, especially in high-traffic areas, such as the emergency department. Regular preventive spraying of insecticides to hospital areas should be discouraged. Prevention of expansion of the pest population can be achieved by early detection within patient rooms by trained environmental services personnel.¹ Prevention of the spread of the insects can be accomplished by responding quickly as soon as a bed bug is identified, closing infested rooms, and placing all contaminated clothes and fabrics within sealed bags before removal.¹

To ensure an orderly and systematic response to any identification of bed bugs, institutional policies should be developed. These policies should outline how to recognize bed bugs and their bites, who to notify, and how to treat the room and patient belongings to eradicate the infestation.

CONCLUSION

Bed bugs have reemerged during the past decade all over the world. The clinical consequences of these insects are mainly dermatologic. However, a major stigma is still present among individuals or facilities found to harbor bed bugs. Therefore, there is a need to educate healthcare workers on how to screen for and respond to bed bugs. Hospitals need to be prepared for this pest by implementing policies before infestations arise. Additionally, further research is needed to determine the role played by bed bugs and other arthropods in the horizontal transmission of pathogenic bacteria, as well as the role that various types of materials used for hospital furniture play in increasing the propensity of infestations.

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