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Why Is the Control of Bed Bugs' (Cimex spp.) Infestations as an Urban Environmental Health Pest Difficult? Reasons & Control Strategies

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The bed bug (*Cimex* spp.; Hemiptera: Cimicidae) is a public health nuisance and urban pest that can cause significant economic loss. It is a cryptic, wingless, and nocturnal hematophagous ectoparasite insect that requires blood meal from humans, other mammals, or birds to survive [1-3].

There was a resurgence of bed bug, as an important public health pest in the past decade [4.] Bed bug infestation is a neglected and unreported health and medical concern in comparison with other vector-borne diseases such as Leishmaniosis, Malaria, and Crimean-Congo hemorrhagic fever, which is increasing worldwide [2].

Bed bugs infestation can produce psychological distress with nightmares, insomnia, anxiety, avoidance behaviors, anemia, and personal dysfunction. So far, bed bugs have not been able to vector human pathogens. Their bites are painless and cause itching skin in individuals, but different complications can arise in individuals. Bed bug bites are mainly on the arms, forearms, legs, neck, and face [5, 6, 2].

Bed bugs are a severe public health issues with difficult and costly eradication methods. They are ordinarily nocturnal and hide in protected places [7] such as floor areas under beds and couches, mattresses, desks, walls, chairs, crevices and corners of wooden bed boards, sofas and wooden furniture, door and window frames, behind loose wallpaper, and behind pictures. Therefore, it is difficult to find and control the infestation [8]. Today, integrated pest management (IPM) approach is mainly used to control bed bugs, but the majority of bed bug infestation control methods are treated with conventional synthetic insecticides, such as Pyrethroids, Carbamates, Neonicotinoid, and other classes of insecticides [9, 10].

Bed bug infestation has been reported dramatically from different countries all over the world [11], such as United States, Australia, United Kingdom, Italy, Switzerland, France, Spain, Denmark, Sweden, Norway, Scandinavia, Brazil, Nigeria, Iran, Singapore, Malaysia, Thailand, and Kuwait [12-21]. The reason of this recent reemergence

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is unclear, but the following reasons are possible: I. High levels of bed bugs' resistance to domestic insecticides, II. Increased number of human travel (international travels and migrations), III. Decreased public awareness about bed bug biology, IV. Poor or lack of pest management practices, and V. Global warming [2, 12-21].

Bed bug resistant

In general, bed bugs' resistant to DDT has been determined since 1960s. The first case of bed bugs resistance to DDT was reported and confirmed in 1947s in Hawaii. Researchers reported bed bugs' resistant to other groups of insecticides such as organophosphates, carbamates, and pyrethroids all over the world [10, 22, 23]. Bed bugs' populations can become resistant by biochemical resistance [24], molecular resistance [22] and cuticular resistance [25]. The findings of Doggett *et al.* demonstrated that cuticle thickness is present within a pyrethroid-resistant strain of *C. lectularius* [22]. Moreover, Moussian *et al.* demonstrated that the bed bug (*C. lectularius*) cuticle acted as a protective coat against the penetration of insecticides [25].

Lack of identification, knowledge, and awareness against bed bug

The general lack of public awareness about bed bug is one of the most important factors that increased its infestation. In addition, people are usually not aware about the existence of bed bugs. So, at the time of infestation, bed bugs are often quickly picked by other individuals and transported into other houses [26]. Despite the increasing incidence of infestation, relatively few people can identify a bed bug. Hence, public awareness and knowledge are the key factors to reduce the bed bug infestation [2, 27].

Poor bed bug management practices

Implementation of controlling programs using just one strategy is rarely efficient and only causes immediate effects in eliminating the bed bugs' infestation. Most of the residents of houses, apartments, hotels, dormitories, and other human dwellings have no effective technical knowledge to prevent and control the bed bug infestation [28].

Integrated pest management (IPM) methods to control bed bug

Recently, IPM method has been applied as the main tool to control bed bug. Research carried out in the recent eight years showed that IPM was the best approach to eliminate bed bug infestation in contaminated houses [9, 28]. It refers to a logical combination of physical, environmental, mechanical, biological, and chemical controlling methods to minimize the risk of exposure to chemical insecticides and control the pests. According to the definition, IPM is a promising and safe strategy for humans and the environment and includes active surveillance and simultaneous use of both chemical and non-chemical control strategies, implementation of follow-ups and preventive measures [29].

In order to control bed bugs, IPM strategy includes survey for infestation, identification of its severity, cleaning all contaminated areas in order to eliminate the bed bug habitats (sanitation), physical removal (mechanical) of bed bugs, effective and careful use of insecticides according to the instructions, following the inspections daily, weekly, and monthly [29, 30].

Based on the latest research on the control of bed bugs by Wang *et al.*, IPM programs were more effective in reducing and exterminating the bed bugs' infestations than the traditional pest control services [31]. The findings of Wang *et al.* demonstrated two methods of pest control: (a) Non-chemical tools including steam, vacuuming, mattress encasement, de-cluttering, discarding severely infested items, and frequent laundering as well as (b) Chemical methods including insecticide sprays and dusts, which are named as IPM approach [31]. They indicated that these two methods were necessary for eliminating bed bug infestations rapidly from human's dwellings (Figure 1) [31].

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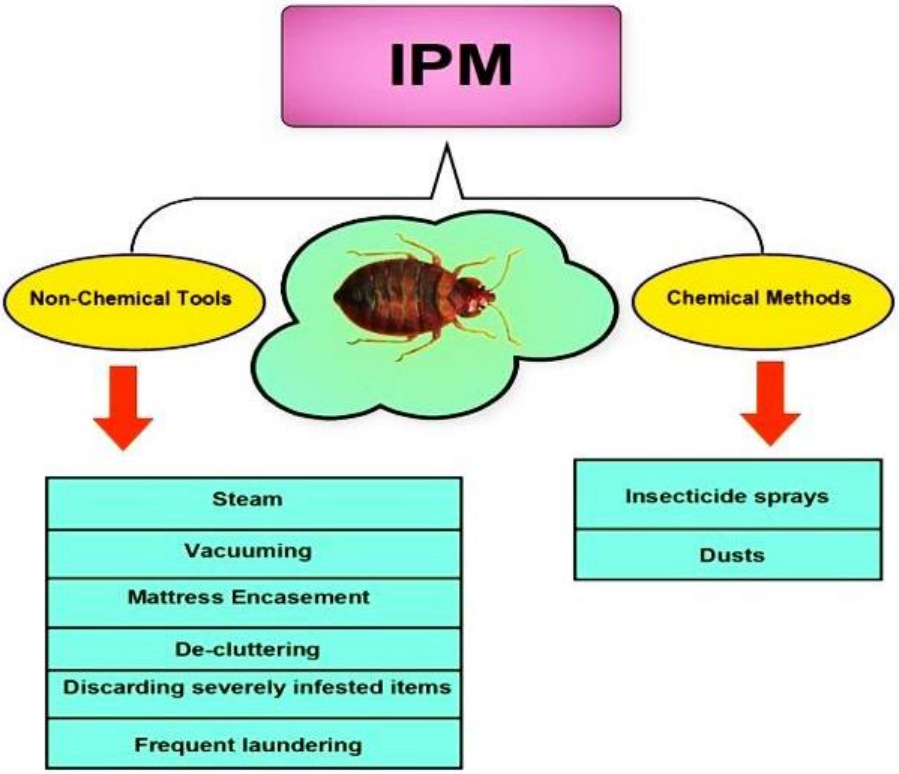

Figure 1: Methods to control integrated bed bug [31]

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