

Worldwide Status of Insecticide Resistance in Bed Bug (*Cimex Lectularius*)

Faranak Firoozfar^{1,2}, Tahereh Sadat Asgarian¹, Saeede Ebrahimi¹, Fatemeh Kouhestani³ and Hassan Vatandoost^{2,4*}

¹Department of Public Health, Faculty of Health, North Khorasan University of Medical Sciences (NKUMS), Iran

²Department of Medical Entomology & Vector Control, School of Public Health, Tehran University of Medical Sciences (TUMS), Iran

³Vector-borne Diseases Research Center, North Khorasan University of Medical Sciences, Iran

⁴Department of Chemical Pollutants and Pesticides, Institute for Environmental Research, Tehran University of Medical Sciences, Iran

***Corresponding author:** Hassan Vatandoost, Department of Chemical Pollutants and Pesticides, Institute for Environmental Research, Tehran University of Medical Sciences, Department of Medical Entomology & Vector Control, School of Public Health, Tehran University of Medical Sciences (TUMS), Tehran, Iran

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ABSTRACT

The common bed bug, *Cimex lectularius* L., is an obligate blood-feeding ectoparasite that preferentially feeds on humans. In recent decades, it has become a prominent indoor pest on a near global scale. Although bed bugs are not known to transmit any diseases to humans, their presence in homes is a repeated bites by these hematophagous insects cause allergic reactions, including itching and erythematous or popular urticaria-like dermatitis, which favors secondary bacterial infections, cellulitis, impetigo, ecthyma, and lymphangitis. Infestation of these pests also gives rise to anxiety, insomnia, and worsening of an existing mental health condition. In this review, papers found in scientific databases were used after removing old ones as well as duplicate content. The information obtained from Iran and other countries of the world was categorized and presented in the fields of identification, level of infection, ways to control bed bugs and prevent their spread. *Cimex lectularius* L. populations have been documented worldwide to be resistant to pyrethroids and neonicotinoids, insecticides and permethrin that have been widely used to control bed bugs. In controlling this pest, in resistant populations, an 'integrated pest management program' is essential.

Keywords: Bed Bugs; *Cimex Lectularius*; Insecticide Resistance

Background

100 species of blood feeding parasitic pests are in the family Cimicidae [1]. The common bed bug, *Cimex lectularius* L., is an obligate blood-feeding ectoparasite that preferentially feeds on humans [2-5] that has reemerged in recent decades to become a prominent indoor pest on a near global scale [6]. Over the past two decades, the common bed bug, *Cimex lectularius* L. (Hemiptera: Cimicidae), has re-established as a perennial indoor pest, causing global public health concerns [7-10]. This resurgence has been aided by an increase in travel, exchange of secondhand furniture, ineffective pest control, and the evolution of mechanisms conferring insecticide resistance [6,8,11]. Bed bugs can exert adverse effects on health and quality of

life [12]. and these insects, are cryptic and nocturnal ectoparasites adapted to blood-feeding on humans [13] but are most commonly encountered in sleeping areas [14]. And bed bug is most prevalent in temperate regions [13,15]. Although bed bugs are not known to transmit any diseases to humans [2], their presence in homes is a repeated bites by these hematophagous insects cause allergic reactions [16,17], including itching and erythematous or popular urticaria-like dermatitis, which favors secondary bacterial infections [7], cellulitis, impetigo, ecthyma, and lymphangitis. Infestation of these pests also gives rise to anxiety, insomnia, and worsening of an existing mental health condition [15,18,19] and Some Bed bug infested patients are associated with anemia [20]. Eradication of bed bug infestations is

particularly difficult and costly because they are cryptic, shelter on surfaces that often cannot be treated with insecticides, and multiple insecticide treatments may be required to eradicate bed bug populations [7]. However, insecticides are the most effective means of bed bug control [21, 22], a continual application of chemical insecticides has resulted in bed bug resistance and have created widespread worries among pest control professionals [8].

The resistance spectrum of bed-bugs towards this group of compounds resembles those of *Anopheles gambiae* and *Musca domestica*, indicating similarity in the defence mechanism [23]. Several hypotheses have been proposed to explain the resurgence of common bed bugs, including increased travel by the public and the evolution of pyrethroid insecticide resistance in field populations [24,25]. More recently, some bed bug populations were shown to be highly resistant to various neonicotinoids and possess reduced susceptibility to pyrrole compounds [26]. And bed bugs were determined to be resistant to pyrethroids and carbamates, deltamethrin and λ -cyhalothrin [21,27]. Comprehensive approaches to controlling bed bugs include mattress encasements, trapping, vacuuming, spot and spatial heat treatments, inorganic dusts, and chemical treatments with pyrethroids, neonicotinoids, and pyrroles [7]. The purpose of this study was to assess bed bug infestation levels, and the efficacy of locally available insecticides. The information derived can then be used to better inform the community on the most appropriate bed bug management strategies.

Materials and Methods

The search was carried out in databases including: Pub Med, Google Scholar, Science Direct, Scopus, Web of Science, from 1958 to 2021. Duplicates were excluded. A literature search was performed by using the following terms: "bed bugs", "*Cimex lectularius*", "insecticide resistance" alone or in combination, both in Persian and English languages in world wide. We inclusively searched all databases. Finally, 185 papers with epidemiological parameters of interest were selected and 31 articles fulfilled the inclusion criteria. Those articles reporting to status of insecticide resistance in bed bug included to the study.

Results

Some factors such as increased travel of people as well as bed bug resistance to pesticides can be effective in the outbreak of this insect. Many methods have been proposed to control and limit the growth and expansion of the population of this insect. Control of this pest in small populations will be very easy and fast, therefore, detection of bed bugs in the early stages of infection is very important [16]. In the control plan for three decades. In Iran, pyrethroid insecticides have been introduced to control programs of bed bugs since 2000 and in the past decade of new millennium. In virtue of the enhanced contamination and resurgence of bed bugs, the application of these insecticides, along with OPs, CMs, phenylpyrazoles, and neonicotinoids, was escalated. Studies on the Middle East are scarce and limited to a few

reports of the common bed bug from Iran, Israel, and Kuwait and of the tropical bed bug from Israel and Iraq [15,28]. Multiple resistance mechanisms have been identified in bed bugs including penetration resistance through cuticle thickening or remodeling, metabolic resistance by increasing the activities of detoxification enzymes (e.g. cytochrome P450 monooxygenases and esterases), and knockdown resistance by *kdr* mutations. Other potential resistance mechanisms such as behavioural and physiological changes (e.g. increasing esterase activities by point mutations, glutathione S-transferase, target site insensitivity including altered AChEs, GABA receptor insensitivity, and altered nAChRs), and symbiont-mediated mechanisms are yet to be discovered [8,19].

Cimex lectularius L. populations have been documented worldwide to be resistant to pyrethroids and neonicotinoids, insecticides and permethrin that have been widely used to control bed bugs [4,15]. Molecular techniques could provide an early warning of the development of insecticide resistance and could determine the specific resistance mechanism. Even though molecular assays such as PCR and direct DNA sequencing have been employed to detect *kdr* mutations in bed bug samples, these methods are impracticable for studying large-scale populations [15,29]. In addition, regular monitoring of this insect in areas prone to infection can be very effective in preventing the spread and recurrence of bed bugs [16]. And there is an urgent need to discover new active ingredients with different modes of action to control bed bug populations [7].

Discussion

Bed bug infestations have been reported to be increasing globally, including from Africa [14]. Insecticide resistance, lack of effective insecticides, and poor community bed bug management practices have been reported as contributing factors to the bed bug resurgence [14]. The commonly used commercial formulations are largely ineffective [14]. Numerous cases, the incorrect dose of insecticides are often applied, thereby exposing the household to insecticide health risks as noted above [14]. Meanwhile, a survey conducted among pest control companies in Malaysia reported that 25% of them found that the insect became resistant [30]. The United States and Europe had a wide range of resistance levels to fipronil [7]. The severity of bed bugs as a nuisance often depends on the extent and size of the infestation [14]. Therefore, one way to overcome insecticide resistance could be the formulation of insecticides with synergists that counteract metabolic resistance [12]. Management of the common bed bug (*Cimex lectularius* L.) necessitates the use of multiple control techniques [26]. Little studies have been documented the usefulness of IPM strategy for control bed bugs [18]. Non-chemical techniques include heat treatment, vacuuming, mattress encasements, laundering, freezing and heat steam [18,31]. Financial support is needed to assist residents that are bed bug affected and needs to include the provision of effective and safe pest management procedures for the control of bed bug infestations [14].

Conclusion

This study revealed an occurrence of insecticide resistance in bed bug populations. We recommend that persons who involve in controlling this pest should be trained to use combination of effective insecticides against susceptible bed bugs. Also, in resistant populations, an 'integrated pest management program' is essential.

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Conflicts of Interest

The authors have no conflict of interest.

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Hassan Vatandoost. Biomed J Sci & Tech Res



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