

# A Case Study of Bedbug Infestation in the Student Dormitories of Iran-2018

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## ABSTRACT

**Introduction:** The bedbug bites is one of the most important health problems in human places, especially college dormitories. Risks related to bedbugs include insomnia, itchy bites, skin oedema, anaemia, stress and economic losses. The potential for severe contact to pesticides was used for bedbug control.

**Aim:** To identify college dormitories that were infested by bedbug, prevent them from spreading to other dormitories and minimise the bite of the pest, which was possible by designing a comprehensive guideline.

**Materials and Methods:** This research was a descriptive and analytic study, done in 2018 year (Apr to Jun) in student dormitories infested with bedbugs in Iran. Bedbugs alive were caught from 25 rooms of 100 rooms in dormitories by applying the sticky traps, vacuum cleaner, and forceps. The rooms were leveled according to the severity infested to bedbug, including high (>5 bedbugs), medium (3-4 bedbugs) and low levels (1-2 bedbugs). A questionnaire was designed on student demographic questions and information about behavioural bedbug to manage the control bedbug in the dormitory (MCBBD-Q). For validation of the questionnaire, Cronbach's alpha was used with a coefficient of 0.7. To determine the consistency of the questionnaire, a test-retest method was used. The questionnaire was completed for 100 students and returned to them after 14 days. Three methods were used

(I,II,III): applying only Insecticides, applying Insecticides and changing mattress and Integrated Pest Management (IPM) including: Replace mattress, Heat up, washing dress, checking suitcase, apply Naphthalene, Vacuum cleaner and Use glass wool) methods. Data was analysed by using SPSS 20 software and statistical Chi-Square test and one-way ANOVA.

**Results:** Eighty bedbugs were caught from 25 rooms of 100 rooms. A total of 52% students were male and 48% were female. In total more than 80% of students didn't have information about the biology of bedbug. A significant difference was found by comparing three methods (I-III) in bedbug eradication after 7 days ( $F=2.60$ ;  $df=4, 20$ ;  $p=0.06$ ), 14 days ( $F=6.27$ ;  $df=2, 22$ ;  $p\text{-value}=0.07$ ) and 24 days ( $F=7.65$ ,  $df=1, 23$ ;  $p\text{-value}=0.01$ ). There was also a significant difference in the effectiveness of the used control methods ( $p<0.05$ ). The eradication rate of the bedbugs through the three methods (I-III) was 25, 75 and 100%, 24 days after using control methods, respectively.

**Conclusion:** According to the results of this study, it is recommended 1) To prevent the entry of the bedbug into the dormitory, it is necessary to check student's suitcase out of rooms, cover the mattress, use of standard bed for students, cleaning the room twice a week with a vacuum cleaner.

2) It is better to use the IPM method to control the bedbug in college dormitories.

**Keywords:** *Cimex hemipterus*, Chemical method, Non-chemical method, Pest

## INTRODUCTION

Since thousands of years ago, *Cimex lectularius* has been recognised as a parasite found on the human body [1]. The word *Cimex lectularius* is originated from Latin *ci-mex* meaning "bug" and *lectulārius* meaning "bed". Except for *Cimex lectularius* and *Cimex hemipterus*, other species (Batbugs; *Cimex pipistrelli*) rarely feed on human body [2]. This family includes 91 obligate haematophagous species that are wingless ectoparasites feeding on mammals, birds and bats. The adult bedbug (*Cimex lectularius* L.: Heteroptera: Cimicidae) has a length of nearly 2.5 mm, a flattened oval body, and a reddish-brown colour. However, it is difficult to see an immature bedbug, as it has a lighter colour and smaller size. The pyramid-shaped head of a bedbug consists of slender antennae and prominent compound eyes, and there is a long proboscis placed beneath the thorax and head [3].

The length and weight of bedbugs can be increased by feeding off blood, reaching about 30-50% and 150-200%, respectively. Being recognised as night feeders, bedbugs do not normally appear in light during the day. They can be hidden in tiny fissures and cracks due to their very small, flattened body. The average life span in the adult bugs varies between 6 and 12 months. Even though they cannot find a host for feeding, they may live up to one year [4].

In the developed countries, bedbug has recently been emerged again as a result of the changed practices for controlling the pests, as well as immigration, international trips, and resistance to insecticides [3]. The increasing infestation of dwellings, hotels, dormitories and hospitals with bedbug has been reported. At first, beds and surrounding areas are susceptible to infestation, but the bugs spread in any location over time and occupy the whole space [3].

Bedbugs can be found in any fissures and cracks inside the home such as furniture, picture frames, bed frames, mattress seams, baseboards, and around headboards and box springs [5].

Bedbugs can be scattered by human as the host and transported to other places. They can also be transported by the clothes, furniture, suitcases, mattresses and any other personal belongings. These insects may pass through the pipes and holes and migrate to other rooms and spaces. Bugs can transfer from one place room to another through wall cracks, water pipes, or plumb radiant [3].

Changes in the human lifestyle, which include migrating from places infested with bedbugs to healthy places, having foreign travels, changing home furniture and continuing use of insecticides, has increased the number of bedbug in developing countries [6]. Bedbug feeds nocturnally, taking an obligatory blood meal from a sleeping human or other parasitised host. Immunological reactions

to bedbug saliva vary, but characteristically, bites yield erythematous and pruritic papules [7].

Previous studies reported that yellow fever, relapsing fever, tuberculosis, leprosy, smallpox, filariasis, kala azar (leishmaniasis), Chagas disease (*Trypanosoma cruzi*), plague, and cancer may be transmitted by bedbug. Currently, the studies are focused on bedbug as a possible vector of HIV (human immunodeficiency virus) and HBV (hepatitis B virus) [8].

Since ancient times, humans have sought to control the bedbug in human places. In Greek and Roman writings, hanging a rabbit's foot, deer and bear's skin, or putting a bowl of water under the bed, it was used as a repellants for bedbug, but these methods were not effective [9]. In the year 1690, Son and Tiffan they started the first control company bedbug in London. They believed that it was effective in controlling the insect by accurately checking the environment and preventing contamination of human habitats [9]. In other studies, the use of kerosene oil, boiling water, sulfur, arsenic and grease has been suggested as an effective ingredient in controlling bedbug. The flame getting inside the walls of the cracks and filling the cracks with gypsum will remove the bedbug breeding place [10].

The greatest human achievement in controlling bedbug was the discovery of DDT (Dichloro-diphenyl-trichloroethane) in 1940 [9].

In recent studies, beta-cyfluthrin, deltamethrin, hydroprone, bifenthrin, cyfluthrin have been used as suitable insecticides for controlling bed cushions, which have been shown beta-cyfluthrin, deltamethrin and hydroprone to have a significant impact on the reduction of the population of the pest. Approx 1% currently has the highest consumption at commercial, industrial, hospitals, nursing homes, hotels, restaurants and food supply centers [11].

Today, most researchers believe that the use of IPM (Integrated Pest Management) technique in addition to chemical methods has a better effect on the control of bed cushions and reduces insecticide use, which prevents resistance in the insect [12].

Potter MF et al., believes that pest control in the United States is a major challenge, and even pest control companies are struggling to find this insect. In a survey conducted by their industry, found the greatest place to find bugs was edges of beds. The methods Customer Cooperation, Vacuums and Steamers, Bed Encasement, Insecticide Treatment were used in their study that were similar to our study [13].

Due to the resistance of the bedbug to the parathyroid insecticides, should be used as heat treatment method, which will be eliminated at temperatures  $>41^{\circ}\text{C}$ , as the temperature increases, less time is needed for control [14].

Recently, pest control companies used IPM method that includes heating, cooling, floor vacuuming, bed changing, bed covering and seaming and wall chambers, which reduces consumption, insecticides and environmental hazards. These companies suggest that, once bedding is viewed, insecticides are not used, but physical control methods must be first used [15].

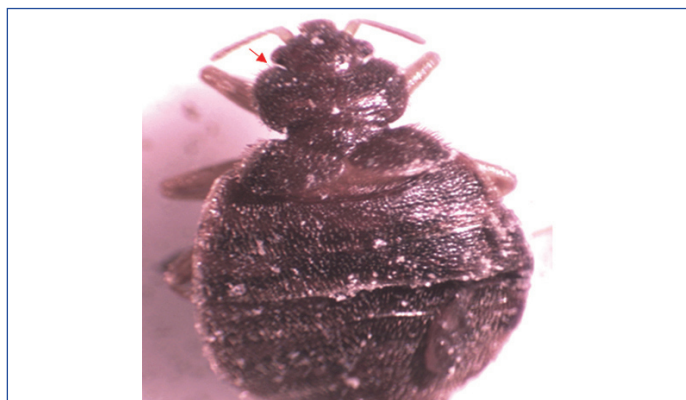
In this study IPM was used to compare with applying only insecticide that had different effectiveness (washing dress, use glass wool, apply naphthalene, checking suitcase) from other previous studies. Due to the fact that the bedbug hides in places that are far to think for human and their bites can cause human harassment. The purpose of this study was to identify the college dormitories that were infested by bedbug, prevent them from spreading to other dormitories and minimise the bite of the pest, which was possible by designing a comprehensive guideline.

## MATERIALS AND METHODS

This research was a descriptive and analytic study, done in 2018 year (Apr to Jun) in student dormitories (males and females) infested with bedbugs in Iran. This study was accepted in ethic committee in medical of Iran by coding. IR. GMU. REC. 2019. 0016.

## 1. Study Site

On 22 Apr 2018, following a report on the infestation of student dormitories to the bedbug, a thorough examination of the rooms was carried out by the medical entomologist of one center for disease control of Iran for one week on the probable spastic spawning places. Examined places included bed metal, Mattress, under the carpet of the room, behind the refrigerator of the room, behind the closets, behind the radiators and suitcases of the students' clothes. All species were *Cimex hemipterus*. Two bedbugs male and female were reared in laboratory to study their life cycle [Table/Fig-1].



[Table/Fig-1]: *Cimex hemipterus* pronotum with anterior margin moderate (Original photo).

## 2. Questionnaire Design

After conducting library studies and consulting with experts in epidemiology and entomology (Reliability), a questionnaire was designed to manage the control of bedbug in the dormitory (MCBBD-Q). For validation of the questionnaire, Cronbach's alpha was used with a coefficient of 0.7. To determine the consistency of the questionnaire, a test-retest method was used. The questionnaire was completed for 100 students and returned to them after 14 days. The questionnaire was designed in two sections: 1) Demographic information of students; and 2) Questions. Questions were designed in three topics: a) Behavioural Bedbug (X1); b) Individual Management of Bedbug Control (X2, X3); and c) Cumulative Management of Bedbug Control (X4-X10) [Table/Fig-2].

## 3. Sampling and Identification of Species of Bedbug

Bedbugs captured from dormitory rooms were transferred to the laboratory's medical entomology laboratory with laboratory tubes and the genus and species were detected by using the Pratt and Stojanovich identification key [16].

## 4. Room Leveling Based on the Type of Control Method

Hundred rooms in two dormitories were surveyed for catching the bedbug and it was found that 25 rooms were infested.

In order to determine the proper method for controlling the bedbug, one room as control and 8 rooms in 3 levels (The rooms were leveled according to the severity infested to bedbug, including high ( $>5$  bedbugs) and medium (4-3 bedbugs), and low levels (1-2 bedbugs) were selected randomly as items). In the first eight rooms were used only Insecticide (I),

In the second eight rooms were used Insecticides with a changing mattress (II), and finally, in the remaining 8 rooms, first, the equipments inside the rooms were moved to out of the rooms then, was used of method IPM (III: Insecticides and physically control).

### 3-1-Insecticides

The eight rooms were sprayed by applying a backpack sprayers Hudson in the morning. The insecticide ICON<sup>®</sup> mixed with cypermethrin was used at one turn, and one month later, cypermethrin was used mixed with Fouman's insecticide.

Demographic information	Gender: Male <input type="checkbox"/> Female <input type="checkbox"/> Nationality Age Academic fields Academic degree Family socioeconomic status: Low <input type="checkbox"/> Middle <input type="checkbox"/> High <input type="checkbox"/>			
Questions	Answer			
	Low	Middle	More	Uninformed
A: Behavioural bedbug				
X1: I have information about bedbug biology				
B: Individual management of bedbug control				
X2: I always check my suitcase after leaving my home and before going to the dormitory, so as not to be infected with a bedbug.				
X3: I clean my room twice a week with a vacuum cleaner				
C: Cumulative management of bedbug control	Yes	No		Uninformed
X4: Does the student's bed have the standard required?				
X5: Is the sleeping mattress covered?				
X6: Is the student room recently sprayed?				
X7: Do students report bedbugs bite at night?				
X8: Are all rooms equipped with a radiator heating system?				
X9: Are the rooms open to each other?				
X10: Is there a light source to prevent bedbug bites while students are sleeping at the night?				

**[Table/Fig-2]:** Demographic of college students and management control bedbug questionnaire (MCBBD-Q).  
Instructions for completing the questionnaire: In question 1, the word Low means is the student only knows that the bedbug canopy is bloodthirsty, the word Middle means the student knows that the bedbug is blood feeding and laying but it does not know how to transfer it, the word More means is the student knows that the bedbug is blood feeding and laying and transfer with furniture. The word uninformed means is the student don't have knowledge about the bedbug biology.

### 3-2-Replace Mattress

The mattresses of most rooms were zipped, and without a cover, which was a good place to lay the bed bucket. These mattresses were replaced with padding mattresses. To remove eggs and nymphs on mats, mattress covers were opened and boiled in water.

### 3-3-Washing Dress of Students

The student's clothes were washed with 1% permethrin shampoo in the large plastic tub individually. Then the clothes spread out in the sun, and after drying it was ironed.

### 3-4-Heating the Beds

The beds were removed from the rooms and disinfected in the dorm area with flamethrower, so that the eggs and nymphs in the seamed beds disappeared. To prevent the re-laying of the insect, the seams of the beds were filled with silicone glue. The floors, the back of the radiators, and the walls of the rooms were also heated [Table/Fig-3].

### 3-5-Heating Inside Suitcase

To check the contamination of the suitcases, the bedside cushion was heated with a hair dryer in the luggage of the clothes, and, if left, the bucket was repaired with a vacuum cleaner.

### 3-6-Repellent Mattress

In order to prevent the possible exit of the bagbed linen from the luggage, the naphthalene was placed inside a plastic bag and placed in the luggage. After this stage, luggage was placed in a garbage bag, and kept away from the student's bed. It was also



**[Table/Fig-3]:** Using of homemade flamethrower for eradication of egg, nymph and adult bedbugs (Original photo).

recommended that the clothes, bed linen and pillows be sprayed with repellent Dermin (permethrin 5%).

### 3-7-Using a Light Source

It was recommended to use yellow light for at least five months during sleep at night for the prevention of bedbug bites that are likely to survive.

### 3-8-Vacuum Cleaner

After completing the mentioned control procedures, it was recommended that the rooms be vacuumed daily for one month.

### 3-9-Use Glass Wool

Another useful initiative was to use glass wool under the mattress pad, which was used in the three level rooms.

## STATISTICAL ANALYSIS

After entering the data into the software SPSS ver-20, the correlation coefficient was calculated using one-way ANOVA (analysis of variance), the mean count of bedbugs was compared. Total Insecticides levels and total bedbugs were converted to the logarithmic mode and the amount of insecticide dust was converted to square root before using the ANOVA. Using the Tukey's HSD test ( $p=0.05$ ), the mean values were divided. Before removing the bedbugs, the median retreatment counts were compared using the Kruskal-Wallis test, and before removing the infestation, the median visit counts were compared.

## RESULTS

Hundred students participated in the completion of the questionnaire, 52 were male and 48 were females. A total of 79 were in age group 18-23 year and 21 were in 24-30 year. More than 80% of the students had no information about bedbug biology, that there were no significant difference between age groups ( $p$ -value=0.28) and sex ( $p$ -value=0.62). More than 80% students of age 18-23 years and more than 70% of age 24-30 years didn't check their suitcase. There was a significant difference between age groups 18-30 years ( $p$ -value=0.02) and no significant in genders ( $p$ -value=0.5). Less than 60% of students in different ages (18-30 years) had cleaned their room for two weeks, no significant difference were found between age groups ( $p$ -value=0.60) and genders ( $p$ -value=0.72). In others student's answers weren't significant difference between age groups and genders ( $p$ -value <0.05) [Table/Fig-4]. The percentage of medical students were more followed by nursing, health and paramedicine who participated and completed the questionnaire. Around 56% among them were undergraduates. Approximately, 50% of these students belonged to middle socio-economic groups (monthly income is \$ 200-400) as compared to 31% low socio-economic (monthly income is \$<200) as 19% high socio-economic group (monthly income is \$>400), respectively.



Demographic		%No. students												Mean (±SEM)	Median (Max, Min)								SD
Age (years)	18-23	79												21.5(0.27)	21(18-30)								2.73
	24-30	21																					
	30>	0																					
Gender	Male	52												p-value	% Gender								p-value
	Female	48													M				F				
Questions	% Age												p-value	% Gender								p-value	
	18-23				24-30				30>					M				F					
	L <sup>a</sup>	M <sup>b</sup>	M <sup>c</sup>	U <sup>d</sup>	L	M	M	U	L	M	M	U		L	M	M	U	L	M	M	U		
A: Behavioural bedbug														0.28									0.62
X1	7	3	1	89	19	0	0	81	0	0	0	0	9		3	0	88	10	2	2	86		
B: Individual management of bedbug control														p-value									p-value
X2	84	8	8	0	71	28	0	0	0	0	0	0	0.02		84	9	7	0	78	16	6	0	
X3	13	63	16	8	9	59	28	4	0	0	0	0	0.60	13	57	23	7	12	66	14	8		
C: Cumulative management of bedbug control		Y <sup>†</sup>	N <sup>†</sup>	U <sup>†</sup>	Y	N	U	Y	N	U		p-value	Y	N	U	Y	N	U		p-value			
X4	100	0	0	100	0	0	0	0	0	0	0	0	0	100	0	0	100	0	0	0	0		
X5	100	0	0	100	0	0	0	0	0	0	0	0	0	100	0	0	100	0	0	0	0		
X6	52	27	21	42	33	23	0	0	0	0	0	0.81	45	34	21	43	22	22	0	0.42			
X7	22	72	6	9	90	0	0	0	0	0	0	0.08	25	70	5	82	8	10	0	0.37			
X8	100	0	0	100	0	0	0	0	0	0	0	0	100	0	0	100	0	0	0	0			
X9	100	0	0	100	0	0	0	0	0	0	0	0.84	64	36	0	57	43	0	0	0.46			
X10	0	100	0	0	100	0	0	0	0	0	0	0	0	100	0	0	100	0	0	0			

[Table/Fig-4]: Analyse the demographics of college students and bedbug management control Questions.

<sup>a</sup>Low, <sup>b</sup>Middle, <sup>c</sup>More, <sup>d</sup>Uninformed, <sup>†</sup>Yes, <sup>†</sup>No

Eighty live bedbugs were captured from 25 infested rooms by using sticky traps, vacuum cleaner, and forceps. Sixty and 20 bedbugs were captured from the male and female students' dormitories, respectively. The rooms were leveled according to the infested severity, High: 7 rooms had 5> bedbugs, Middle: 10 rooms had 3-4 bedbugs, and Low: 8 rooms had 1-2 bedbugs. Twenty students had a red itchy bump of bedbug bites on their arms.

According to [Table/Fig-5], a significant difference was found by comparing the used methods, in the number of bedbugs after seven days (F=2.60; df=4, 20; p=0.06), 14 days (F=6.27; df=2, 22; p-value=0.07) and 24 days (F=7.65, df=1, 23; p-value=0.01) [Table/Fig-6]. In comparing twin control methods, there were a significant difference in group A (applying Insecticides only in rooms, comparing with Insecticides and changing mattress) (p-value=0.02) and C (IPM with Insecticides and changing mattress) (p-value=0.04) [Table/Fig-7]. There was also a significant difference in the effectiveness of the used control methods (p<0.05), [Table/Fig-8]. The eradication rate of the bedbugs through the three methods (I-III) was 25, 75 and 100%, 24 days after using control methods, respectively. On average, the most effective control method to reduce the number of bedbugs was observed in level 3 rooms (98.9%), whereas the less effective control method was observed in level 1 room (36.25%) [Table/Fig-9].

## DISCUSSION

One of the challenges and worries in student dormitories is the release of a bedbug in the student's rest room, which bites the insect causing the persecution and allergies of these people. Usually, due to the lack of knowledge of students about how to transfer the bedbug from outside to the rooms and the disorderly arrangement of their room equipment, this insect can be easily reproduced. In this study, field studies were carried out following the expansion of the bedbug in students' rooms and reported bedbug bites, were used of new and old methods that were published in previous studies [13-15].

The results of this study showed that student information about the life cycle of bedbug are low, which requires a training course on familiarisation with bedbug, planned annually by entomologists. Also, checking the suitcases before entering the rooms and vacuuming rooms more than twice a week will prevent the spreading of this insect. Approximately, 50% of these students belonged to middle socio-economic groups (monthly income is \$ 200-400, due to the high budgets of controlling the bedbug in human places, do not give much attention to this problem and as a result, the bedbug was entered to the dormitory through student's suitcase. The use of IPM method along with the use of insecticides reduces the amount of pesticide use and minimises the environmental risks. Another benefit of the IPM method is to prevent the insect's resistance to pesticides.

Methods treatment	No. room infested	Initial treatment time per room									
		*0	†p	7	p	14	p	24	p		
I. Insecticides only	8	3.5 (1-5) <sup>a</sup> , 3.2±0.5 <sup>b</sup>	0.09	2 (1-3), 2±0.2	0.48	1 (0-2), 0.8±0.2	0.2	1 (0-1), 0.7±0.1	0.05		
II. Insecticides and changing mattress	8	3 (1-5), 3±0.4	0.7	2 (1-4), 2±0.3	0.02	1 (0-2), 0.7±0.2	0.22	0 (0-1), 0.2±0.1	0.1		
III. IPM	9	3 (1-5), 3.3±0.5	0.06	1 (0-2), 0.6±0.2	0.34	0	0.17	0	0.01		

[Table/Fig-5]: Comparison of efficiency of three methods (I, II, III) on bedbug eradication according Initial treatment time per room.

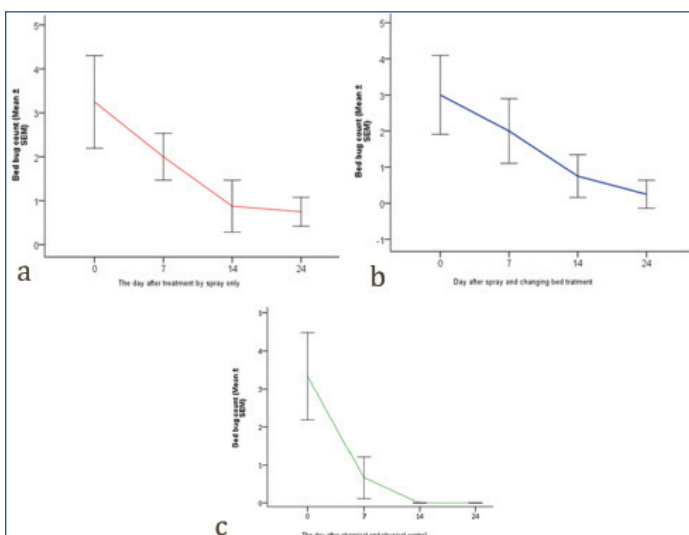
\*day, Median (Max, Min) a, Mean (±SEM) b, †p-value

Groups methods treatment	Time (day)	df	Mean square	F	p-value
Between groups	0	4	1.63	0.76	0.01
	7	4	4.36	2.60	0.06
	14	2	9.25	6.27	0.07
	24	1	12.72	7.65	0.01
Within groups	0	20	1.66	-	-
	7	20	1.67	-	-
	14	22	1.47	-	-
	24	23	1.66	-	-

**[Table/Fig-6]:** Analysis of variance of three methods treatment in 4 time intervals.

Methods group comparison	Methods treatment	$\chi^2$	df	p-value
A	Insecticides only	40	25	0.028
	Insecticides and changing mattress			
B	Insecticides only	35	25	0.086
	IPM			
C	Insecticides and changing mattress	37	25	0.049
	IPM			

**[Table/Fig-7]:** Group comparison of the effectiveness of bedbug control methods that were used in the rooms.



**[Table/Fig-8]:** Comparison between the effectiveness of three methods of bedbug control according eradication time.

Accordingly, bedbug control should be particularly considered, especially in student dormitories, where bedbug bite can lead to distress, difficulty in sleeping, and anaemia among the students [6]. Use of only Insecticides to control bedbugs cannot be effective, since they oviposit in places, where the residual insecticides cannot affect them. In addition, their resistance to the insecticides can result in unnecessary Insecticides and the loss of financial resources, as well. Therefore, physical control methods along with Insecticides (IPM) with phosphorus and pyrethroids insecticide are more effective to control bedbugs in living environments and can lead to the reduced use of insecticides [17].

In the mid-1990s, one of the most important methods to control bedbugs was to use chemical insecticides. The initial solution for the bug control was the burnt sulfur fumigation [3], which was known as the fire and brimstone method. Producing sulfur dioxide and sulfur trioxide, this method effectively controlled all stages of the bedbug life cycle. However, due to the low rate of penetration, it was necessary for some cases of infestation to apply the substance several times. The efficiency of using hydrogen cyanide (solution of hydrocyanic acid in water) as the fumigation was found to be very effective for controlling the insect. Other bedbug controlling chemicals included naphthalene, benzene, kerosene, gasoline, phenol, rotenone, cresol, Lethane 384, turpentine, and alcohol [1,3].

The effect of fumigation and chemicals was not lasting for a long time and as a result, the infestation with bedbug could happen again.

In the late 1980s, there was a major transformation of using pesticides [3,18]. DDVP [4,5,3], organophosphates fenthion [3,19] and several types of pyrethroid Insecticides including cyphenothrin, cypermethrin, deltamethrin and permethrin were among the widely used chemicals [20-22]. Also, to control bedbug, there existed a liquid mixture containing 0.75% deltamethrin, 0.75% propoxur and 0.3% cypermethrin [23].

In this method, to obtain better results, the level of infestation of the rooms, affected sites, how long pesticides can last in the environment, the level of toxicity for humans, the non-resistance of the bedbugs to the selected insecticide, and the cost should be considered. Spraying by residual insecticides of the walls around the rooms by Lambda-cyhalothrin, Cypermethrin, Permethrin was used by the Pest Control Company regardless of the mentioned factors, which based on the results, had no effect on reducing the number of bedbugs. It can be due to the oviposition in hiding places, where spraying by residual insecticides cannot affect the seeds. Bedbugs oviposited more on the students' beds and mattresses, so the insecticides and spraying type did not affect the number of bedbugs [24].

According to Hwang SW study, insecticides alone can cause some disadvantages and difficulties [25]. According to the studies by Koganemaru R et al., herbal poisoning is more used to control bedbugs currently, which is not effective on the resistant bedbugs; whereas powdered and fumigant insecticides are more effective [26].

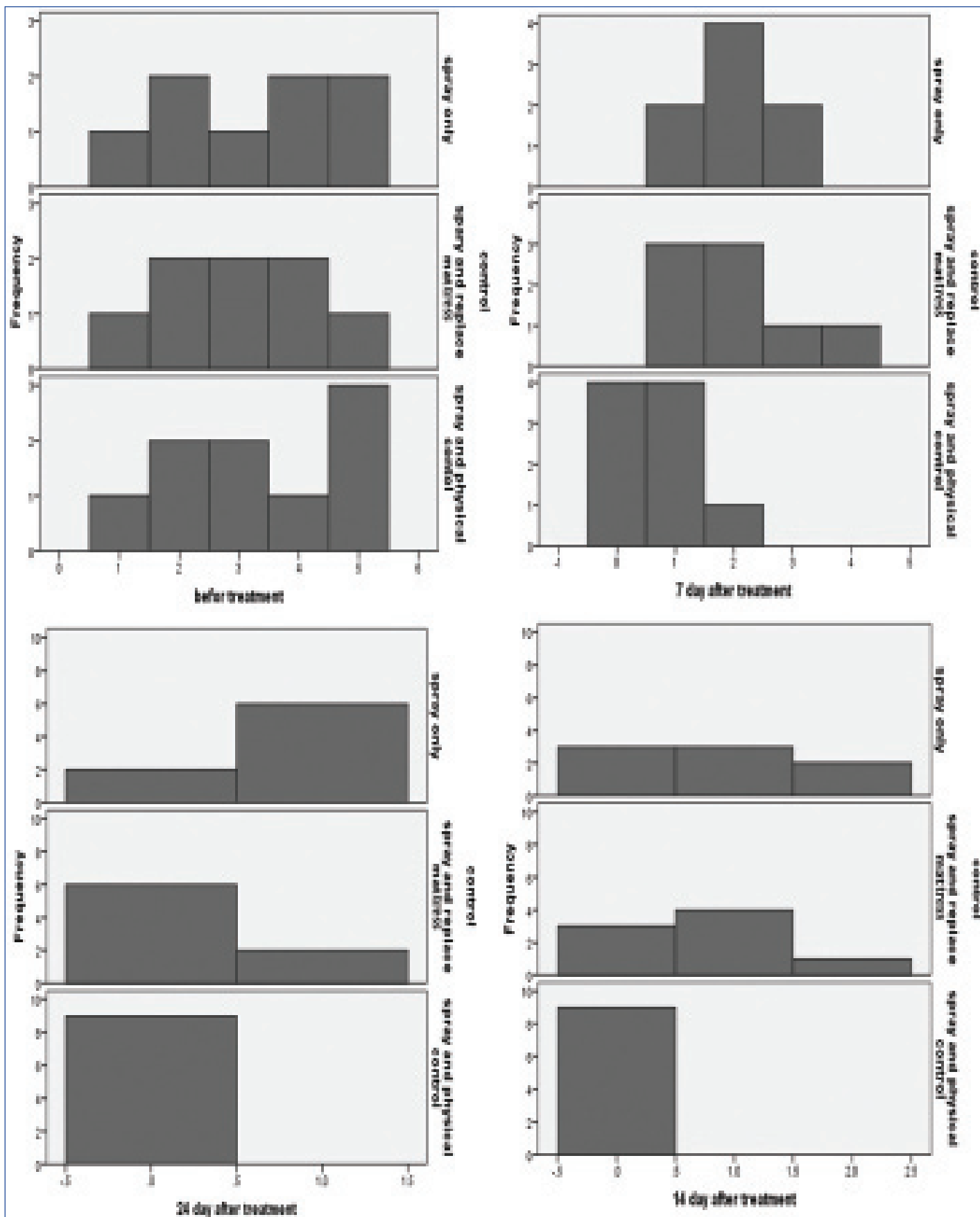
In replace mattress method, given that the cloud mattresses used in the rooms lacked a cover, and most of them were zippered mattresses, the bedbug easily laid in the zipper parts, which inevitably replaced the mattresses with covered mattresses. The previous mattresses were kept in the sun for 48 hours, and then stored in an unused storage room until the young ones disappeared. Kells SA studies also point to the important use of mattress cover as a barrier between human skin and sealed mattresses, and the next advantage is to avoid hiding the bug [24].

The students' clothes were washed individually in a large tub using permethrin shampoo 1% for 1 hour, and were sun-dried for 48 hour, in order to get rid of the hidden bedbugs, since the bedbugs were found more in the students' baggage in the dormitory rooms. Dried clothes were ironed to remove the live eggs. They were placed inside the cover to avoid recontamination, and placed inside the baggage which was checked with a hair dryer for bedbugs, next to the Naphthalene balls. The baggage containing clothes was placed inside the cover so that the bedbugs inside the room could not enter. Naphthalene, as an insect repellent prevented the live bedbugs to enter or exit the baggage [24].

The gaps inside the metal beds were one of the major hiding places of the bedbugs, which were controlled using flamethrowers. All beds were heated for 5 minutes outside the rooms. Moreover, the gaps inside the rooms are the appropriate hiding places for the nymphs, were heated following transferring the equipment outside, which was effective in reducing the number of bedbugs.

One of the captured (unfed) engorged bedbugs was rearing at entomology laboratory to check its biology without feeding. Ovipositor was done and the nymphs were alive for 20 days without feeding. The adult bedbug was alive for 2 months without feeding. In order to prevent the feeding of the bedbugs, students were recommended to have a light source inside the room for two months to prevent the bug bites.

The visible bedbugs inside the room were captured by vacuum cleaner; however, all bedbugs cannot be captured using a vacuum cleaner alone, because some of them were in the hiding places through the day [24].



**[Table/Fig-9]:** Comparison of the efficacy of three methods treatment on reducing the bedbug population in rooms after 24 days. Y-axis: frequency rooms; X-axis: frequency bedbug

Putting glass wool below the board under the mattress was another innovative technique. It captured the surviving bedbugs and made them unable to move, which they could easily be captured using forceps.

In a study, Wang C used the non-chemical control methods along with the treatment with insecticide. The operations included the exposure of infested beds and other items to summer sunlight,

washing the mattress by hot water poured into the holes and fissures, dropping the bed from a height on the ground to remove bedbugs, using cold water to immerse items for 50 hours, the application of hot steam, using needle to remove the insects, and filling the holes and fissures of floors and walls [3].

In addition, to eliminate some types of bedbug, it is required to wash the clothes and beds and dry them at the temperatures higher than

120°F to vacuum the carpets. Moreover, the soapy water and brush can be used to make the holes and fissures free from bedbug and its eggs.

The infested mattress can simply be controlled by a mattress bag, which is a commercially available large plastic bag known as “encasement”. The bag allows the mattress to be used for sleeping while preventing any bedbug possibly existing in the mattress from leaving. The encasement should also be used to cover the box spring. As bedbug cannot live in the high temperatures, they could be killed by being exposed for 1 hour to the 113°F temperature. It is recommended to assign this pest-control treatment to the experienced and equipped companies [27].

Thirty-two apartments infested with bedbug were detected in a similar study conducted from May to December 2014 in Irvington. Four treatment apartments groups were used: 1) the non-chemical treatment alone; 2) the chemical control treatment alone; 3) the non-chemical and chemical control treatment; and 4) the chemical control treatment alone. The elimination rate in treatments I to IV was 100, 86, 89, and 88%, respectively, at 28 weeks and the need of the insecticides was 58% less than the chemical only treatment [28]. In our study, the eradication rate of the bedbugs through the three methods (I-III) was 25, 75 and 100%.

## LIMITATION

Impossibility of entering female students’ dormitories, which was a challenge to bedbug control. Another constraint, the control of the bedbug was synchronised with the final examinations of the students’ course, which lost the best time of controlling the bedbug. To overcome these two main problems, students whose rooms were infected by the bedbugs, were transferred to temporary dormitories and female trained staff were used to control bedbug in female dormitories.

## CONCLUSION

According to the results of this study, it is recommended that, for dormitory students there should be planned training sessions, learning about the bedbug biology and its control methods. Also to prevent the entry of the bedbug into the dormitory, it is necessary to check the student’s suitcase out of rooms, covered the mattress, use of standard bed for students, cleaning the rooms more than twice a week with a vacuum cleaner and it is better to use the IPM (Integrated Pest Management) method to control the bedbug in the dormitory, in time.

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