Original Article

Public Awareness, Perception, and Knowledge of Bed Bug Infestation Prevalence in Iraq

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Abstract

Background: Bed bugs are blood-feeding insects and are an important urban pest. Bed bugs are nocturnal insects and hide in cracks in walls and beds during the day. The study aims to: (1) determine the bed bugs species that infest Iraq, their infestation source, and their distribution; (2) determine the level of awareness and concern regarding bed bugs among the Iraqi community.

Methods: Between 2020 and 2021, a survey of bed bug infestation dynamics was conducted in 18 infested sites located in major cities across eight governorates. The 23-item online survey was distributed over social media to Iraqi citizens between June and July 2022 to survey on their familiarity with bed bug habitat, medical significance, transmission, prevention, control measures, and concerns.

Results: There were a total of 1104 bed bugs collected. Based on the morphological characteristics, bed bugs collected from eight Iraqi governorates are identified as Cimex hemipterus. Besides, a high rate of bed bug infestation was observed in workers' dormitories. The online questionnaire was answered by 1843 respondents and based on the feedback, most respondents (55.3%) have no awareness of bed bug infestations, while around 43.8% are somewhat concerned about bed bug infestations in Iraq.

Conclusion: Only tropical bed bugs, *C. hemipterus* were found in all sampled sites. Bed bug infestations are mainly caused by migrant workers and the reuse of second-hand furniture and clothing. The results suggest that the Iraqi government should organize more proper demonstrations on bed bug awareness for the public.

Keywords: Bed bug; *Cimex hemipterus*; Infestation dynamics; Public health; Iraq

Introduction

Bed bugs are hematophagous arthropods belonging to the family of Cimicidae, under the order of Hemiptera Around 90 species are recognized in the family Cimicidae (1). Bed bugs feed only on the blood of living hosts, including humans, birds, bats and even domestic animals. Humans have been linked to psychological, physical and medical issues caused by this bug (2). As a result, the Environmental Protection Agency of the United States (EPA) has considered bed bugs a real threat to public health; they are classified as "a pest of significant health importance." Numerous studies have demonstrated that bed bugs might harbor more than 40 microorganisms in their stomachs, exoskeletons, feces, and saliva. Some investiga-

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tions have linked *Bartonella quintana*, which causes trench fever, and *Trypanosoma cruzi*, which causes Chagas disease, to bed bugs (3). Bed bugs have been suspected of transmitting human infections since the 1940s, although few studies support this (4). The common bed bug is prevalent across the temperate zones of the world, whereas tropical bed bugs are most commonly found in tropical and subtropical zones (5).

Bed bugs species, including *Cimex lectularius* and *C. hemipterus* have had a significant population resurgence worldwide since the late 1990s (4). It is anticipated that every infestation costs between $2500 and $3000 to completely eradicate bed bugs from houses and replace all infected items, such as furniture, clothing, and bedding (6).

Both *C. lectularius* and *C. hemipterus* also have been reported to be found in Iraq (7–9). However, these studies were conducted using the morphological characterization of bed bugs. In addition, pest management practices and the spread of bed bugs through human activities have led to variations in species, infestation levels, and distribution in Iraq could differ from those previously recorded.

In addition, a lack of public awareness among the people has also contributed to the resurgence of bed bugs (10). Over the past century, increased public awareness and widespread utilization of insecticides such as DDT and Malathion were attributed to the mitigated bed bug prevalence worldwide (11). In recent years, it has been reported that public awareness about bed bugs is still low, even among educated people (12). Many people do not realize the seriousness of the problem, the underlying causes, how to identify an infestation, and the appropriate measures to be taken when facing one of them. The lack of public awareness regarding bed bug infestations escalated the problem to catastrophic levels (13).

Knowledge, attitudes, and practices (KAP) are valuable indicators that can be used to assess and address the community knowledge gaps and understand the level of awareness of the public about bed bugs (14). In addition, knowledge and practice studies are commonly employed as an educational assessment tool for at-risk populations. The information obtained from these studies is subsequently utilized to develop targeted strategies specifically tailored to the at-risk communities' local social, cultural, and political contexts (15). A KAP study conducted in Ethiopia (16) demonstrated that community awareness campaigns, implementing continuous monitoring of bed bug infestations, educational interventions through the media, and implementing preventive strategies play a vital role in effectively educating individuals and translating their knowledge into implementable practices. These collective efforts play a significant role in achieving sustainable eradication of bed bugs.

Another study conducted in Iran (17) pointed out that assessing the public's ability to identify typical signs of bed bugs, stool spots, and allergic skin reactions is crucial for early detection, prevention of re-infestation, and controlling the growth of the population of these insects. In addition, it is suggested that presenting a live bed bug to the public could assist individuals in recognizing bed bugs if they have encountered them before or come across them in their homes (18).

Public awareness dispels misconceptions and reduces the stigma associated with bed bugs (19). By raising awareness, people gain a better understanding of the causes of infestations and the importance of reporting them promptly. This helps create an environment where individuals feel comfortable asking for help without fear of judgment or discrimination. It is suggested that public awareness campaigns promote cooperation between residents and pest management professionals, by promoting a collaborative approach, and thus communities can effectively address bed bug infestations (12).

Therefore, this study aims to: (1) determine bed bug infestation, species identification, and distribution in Iraq; (2) determine the level of

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awareness among the Iraqi community regarding bed bugs in Iraq. In addition, the study also demonstrates the level of concern regarding bed bugs.

Materials and Methods

Sampling sites

Between 2020 and 2021, a survey of bed bug infestations was conducted involving certain houses, hotels, and corporate worker dormitories. Information regarding the locations of bed bug infestations was provided by pest control companies and based on social media pages. Local regulations, ethical considerations, and the guidance of pest control professionals were all considered during the survey. A total of 18 surveyed sites were thoroughly inspected in eight governorates in Iraq, including Karbala, Baghdad, Basra, Erbil, Duhok, Thi Qar, Maysan, and Sulaymaniyah. Bed frames, bunk beds, mattresses, pillows, chairs, carpets, bed sheets, and clothing were all inspected. Figure 1 displays the bed bug sampling locations. Each site required 60–90 minutes to collect all discovered bed bugs. After being captured, live bed bugs were immediately preserved in a 10 mL plastic tube. All bed bug samples were labeled and stored according to their respective sites before being placed in frozen packs (Table 1). The labeling determined the source of bed bug infestation in each site. Source 1 refers to bed bugs collected from local hotels, followed by Source 2, which indicates bed bugs collected from family housing, while Source 3 refers to bed bugs collected from worker dormitories.

From observations, domestic hygiene can be grouped into Levels 1, 2, and 3. Hygiene Level 1 includes all the work done by people, like cleanliness, ventilation, and sanitary preparation of food. These activities involve washing bedding and clothes, sweeping and cleaning floors and toilets, and washing dishes after meals. The chairs, pillows, mattresses, and curtains were clean. On the other hand, hygiene Level 2 arises when people practice cleanliness, ventilation, and sanitary food preparation, but not continuously or periodically. In addition, chairs, pillows, mattresses, and curtains appeared somewhat dirty. Finally, hygiene Level 3 arises when people intentionally or unintentionally do not practice cleanliness, ventilation, and sanitary food preparation, thus creating a suitable environment for germs and diseases. As a result, the chairs, pillows, mattresses, and curtains are filthy. Harborage sites within the worker dormitory, hotel, and family housing were divided into bedding, mattresses, bedsheets, bed frames, pillows, wooden furniture, cracks, crevices, carpets, and electrical boxes and luggage.

Bed bugs identification

Bed bugs samples were delivered to the Iraqi Natural History Museum. They were identified morphologically under a stereomicroscope (Mariobrunorma, SRL, Italy) according to an identification key published by Usinger (1), which is the width-to-length ratios of the pronotum can be used to differentiate between bed bug species (1). The bed bug samples were reexamined for more accurate morphological identification using higher-resolution SEM at Universiti Sains Malaysia.

Online questionnaire Data collection, and sample size

In the current study, the survey conducted on the prevalence of bed bugs in Iraq revealed many cases of bed bug infestations across several governorates of the country. In addition, residents are unaware of bed bug infestation. After reviewing several references to determining bed bugs' public awareness and concern, an online questionnaire was designed to determine the public awareness and concern level. The questionnaire was initially based on earlier studies (16, 18, 20) from June to July 2022. A 23-item questionnaire was distributed as an online questionnaire among the residents of Iraq via social media platforms.

Since the target population is unknown, the sample size was calculated using Cochran’s

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formal (21): Sample size = Z^2p (1- p) e^2, where Z= 1.96 at a confidence level of 95%. Since similar studies in Iraq on community awareness about bed bugs are lacking, we assumed that 50% of the population has awareness about bed bugs. Therefore, we set the value of "P" to 50% (0.50) and the margin of error (e)= 0.05 (5%). This calculation resulted in a minimum sample size of 384. One thousand eight hundred forty-three respondents completed questionnaires beyond the minimum sample size of 384. This high response rate is important as it increases the chances of generalizing the results and enhances the reliability of the study.

The functional criteria for the online survey system were that any device with a web browser could respond. Display systems and functionality were optimized for desktops, cellphones, and tablets. The structured online questionnaire was prepared in English before being translated into Arabic to facilitate respondents' understanding. The respondents were randomly selected from three resident groups: employees, students, and the general population. The online questionnaire was restricted to adults aged 18 years and above who had Internet access and could respond accurately and confidently. The questionnaire underwent a pilot test, during which it was administered to two eligible pilot testers, their observations and comments were carefully considered, and the necessary modifications were made to the questionnaire based on their inputs. For data collection, data was obtained from respondents who completed the Google Forms platform via an online questionnaire, the collected data was then entered into an Excel database. The information collected through the questionnaire encompassed various socio-demographic factors of respondents, including age, gender, occupation, and educational level. Additionally, the questionnaire aimed to obtain information regarding the respondents' knowledge and awareness about bed bugs, attitudes towards bed bug infestation, and pest management practices. Furthermore, the questionnaire also assessed the level of concern among respondents regarding the spread of bed bugs.

Statistical analysis

The descriptive analysis involved examining the range and mean and presenting tables, graphs, and percentage details where applicable. The data collected were statistically analyzed using the chi-square test, while the significance level evaluation utilized the p-value and 95 percent confidence intervals. The association between the numbers of bed bugs/ visited sites and their sources was identified with Pearson's linear regression analysis using SPSS software version 16.

Results

Bed bug infestation dynamic and identification

Based on (Fig. 2), Erbil exhibited the highest number of collected bed bugs per visited sites after adjusted, which is 205 (49.48%), while Sulaymaniyah, Basra and Duhok had 73 (17.45 %), 40 (9.86%) and 37 (8.95%), the two governorates, Thi Qar and Maysan had the lowest numbers of bed bugs: 18 (4.35%) and 10 (2.42 %). Baghdad and Karbala showed only a slight difference in the numbers of bed bugs, which reached 13 (3.03%), and 19 (4.46%), respectively.

Based on (Fig. 3), the worker dormitories (71.12%) were the most common places with bed bugs infestation, followed by family housing (25.07%) and local hotels (3.81%). Moreover, the results showed a considerable and significant difference between the source and the number of bed bugs. The worker dormitories showed the highest significant difference compared to other bed bug sources, including family housing and local hotels (p= 0.0001; Chi-Square test= 263.31). In addition, the relationship between the source and the number of bed bugs was positively correlated (r= 0.125*) (Fig. 3).

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Bed bugs identification

In this study, all collected bed bugs have an average length-to-width ratio of less than 2; thus, all samples were morphologically identified as *C. hemipterus*.

The hygiene condition has been categorized into three levels based on public and private living hygiene. Thus, the results of the current study showed that most worker dormitories in Erbil, Sulaymaniyah, and Duhok had a domestic hygiene level of 3, similar to two local hotels in Baghdad. In contrast, family housing in Kerbala, Baghdad, Thi Qar, Basra, and Maysan had Level 1 of domestic hygiene, while the local hotel in Erbil had Level 2, as shown in Table 1.

From all the collection sites, bed bugs have dominantly infested the bedding area (87.5%), including box spring beds, fitted sheets, pillow flat sheets, and headboards. The signs of bed bugs have been considered, including bed bug eggs, nymphs, adults, bed bug exoskeleton after molting, and fecal spots near the harborage places. Wooden furniture was identified as the second most common source (91.6%), followed by infested cracks and crevices (83%). About 70% of them were in the carpets, while 50% infested boxes and luggage. Small populations of bed bugs preferred electric boxes and luggage as hiding areas, as shown in (Table 2).

Respondents' Socio-demographics

The following age groups of respondents were found to be represented: 18–24 years: 23% (n= 424); 25–34 years: 29% (n= 535); 35–44 years: 22% (n= 406); and 45–54 years: 18.9% (n= 349). A small number, 129 (n= 7%) of respondents, were found to be above the 55-year age range, while the 25–34 age group had the most respondents. No significant correlation was observed between respondents' knowledge and age (X^2= 2.869, P= 0.198). Most of the 1843 respondents were male (57.2%; n= 1055), while the remaining were female (42.8%; n= 788), as shown in (Table 4). The level of education among respondents was 0.4% primary school (n= 7), 1.8% middle school (n= 34), 6.9% secondary school (n= 127), 47.8% bachelor's degree (n= 881), 22% master's degree (n= 405), and 21.1% doctorate (n= 389). No significant correlation was observed between respondents' knowledge and education (X^2= 3.847, P= 0.496). In addition, the majority of respondents were government employees (58%; n= 1069), followed by private-sector employees (5.9 %; n= 108), businessmen (8%; n= 147), retirees (2.3%; n= 42), students (24.5%; n= 451), and others (1.4%; n= 26). No significant correlation was also found between the respondents' occupation and their level of knowledge (X^2= 1.391, P= 0.185) (Table 3).

Respondents' bed bug-related knowledge and awareness

The respondents' knowledge of five topics, including bed bug transmission, medical value, awareness, control, and prevention, were evaluated. Based on the findings, 65% of respondents (n= 1198) agreed that bed bugs were more common than in previous years. In addition, 55% (n= 1014) revealed that tourists and migrant workers brought bed bugs into Iraq, while 70.5% (n= 1299) agreed that bed bugs came from neighboring countries. Furthermore, 55.3% of respondents (n= 1020) were unaware of bed bug infestation and control, while 44.7% (n= 823) were aware. At the same time, 85.1% of respondents (n= 1568) revealed that the Ministry of Health Iraq was not conducting awareness-raising campaigns surrounding the risks of bed bug infestation. Additionally, 92.8% of respondents (n= 1711) agreed that increasing awareness about bed bugs could help prevent bed bug infestations. Among the 1843 respondents, 73.7% (n= 1358) responded that they had been bitten by bed bugs, while 26.3% (n= 485) of respondents answered no, as shown in (Table 4).

Bed Bug, prevention, detection, and control

The results showed that 52.8% of respondents (n= 974) mentioned bed bugs' habitat in bedrooms, followed by toilets (14.9%; n= 274), living rooms (7.9%; n= 146), and

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kitchens (2.9%; n= 54), while 21.4% (n= 395) claimed other places as bed bugs' habitat. The findings also established that most respondents (53.8%; n= 991) responded that bed bugs could transfer to their homes after visiting infested houses. In comparison, 20.7% (n= 381) and 25.6% (n= 471) of respondents believed that bed bugs could transfer to their homes after visiting hotels and public accommodations, respectively. Most respondents (46.2%; n= 852) believed that all items, including contact with an infected person, animals such as bats and birds, and infected equipment, transmitted bed bugs. However, 33% (n= 608) claimed that bed bugs were transmissible through infected equipment, followed by animals such as bats and birds (14.9%; n= 274), and contact with an infected person (5.9%; n=109), as shown in (Table 5).

Regarding preventing bed bug infestation, 63% of respondents (n= 1161) believed that public and personal hygiene is one of the prevention methods. Whereas 18.7% (n= 345), 16.5% (n= 305), and 1.7% (n= 32), respectively, believed that refusing to buy second-hand furniture and clothes, checking beds and mattresses, and other methods can help prevent bed bug infestation.

When asked about control practices for bed bug infestations, 83% of respondents (n= 1534) believed that controlling bed bugs by washing, sanitation, vacuuming, spraying, and steaming was a combination of methods for controlling bed bug infestations. While 13.4% of respondents (n= 247) claimed that they did not purchase used instruments or furniture, 2% (n= 36) did not need to control bed bugs, and 1.4% (n= 26) used other methods to control bed bug infestations. Meanwhile, if the respondents thought there were infestations in their houses, 33.33% of respondents (n= 613) applied pesticides themselves to control bed bug infestations. In comparison, 28.9% of respondents (n= 533) controlled bed bugs by seeking advice from professional pest control. Other respondents claimed that they used alcohol to kill bed bugs (14.7%; n= 270), discarded all infested furniture (13.7%; n= 253), and used hot water to kill bed bugs inside the infested items (9.4%; n= 174). Regarding the number of treatments required to eradicate bed bug infestations in their houses, the proportion of respondents that believed three to four treatments and two treatments could eliminate bed bug infestations in their houses were 39% (n= 719) and 34.6 (n= 638), respectively.

In contrast, the proportion of respondents who claimed one treatment could eliminate bed bugs in their houses was 14.5% (n= 267). Only a small proportion of respondents (11.95%; n= 219) believed five to six treatments were required to eliminate bed bug infestations in their houses. Table 5 summarizes these results.

Level of concern, sources of information, and methods of identifying bed bugs

Almost half of the respondents (43.4%; n= 799) believed that bed bugs were common in Iraq, while a further 10.6% (n= 195) were convinced that bed bugs were very common. In addition, the study revealed that 34.2% of respondents (n= 631) claimed that bed bugs were rarely present, whereas 7.2% (n= 133) responded that bed bugs were very rare in Iraq. Finally, only a few respondents (4.6%; n= 85) believed that bed bugs were not present in Iraq, as shown in (Table 6).

Respondents provided various methods upon being asked how they identified bed bugs. 29% of respondents (n= 548) could identify bed bugs through specimens, and another 29% (n= 541) could identify them through photographs. Fewer respondents could identify bed bugs by visual inspections (20.6%; n= 379) and workshops (20.3%; n= 375). Details are given in (Table 6).

Most respondents (31.2%; n= 575) obtained information on bed bugs from print media and the internet. Apart from that, other sources that the respondents used to gain knowledge on bed bugs were friends or relatives (21.5%; n= 396), school or education courses (19.9%; n= 367), television (15.7%; n= 289), and from previous experience (contact) (8.7%; n= 160). A large

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portion of the respondents (43.8%; n= 808) claimed they were somewhat concerned about bed bugs, as opposed to only 27.1% (n= 499), who were not concerned. However, only a few respondents (11.4%; n= 210) were very concerned, while the remaining 17.7% (n= 326) had no concerns about bed bugs. There was no significant correlation between the age of respondents and the level of concern (X^2= 2.534, P= 0.085). Moreover, there was no significant correlation between the level of concern and the level of education (X^2= 3.507, P= 0.627), as shown in (Table 6).

Regarding the level of concern among respondents from different governorates in Iraq, the results revealed that 50.8% of respondents expressed somewhat concern about bed bugs (Fig.4). The remaining respondents stated that they were no answers, were not all concerned, and were very concerned about bed bug infestation.

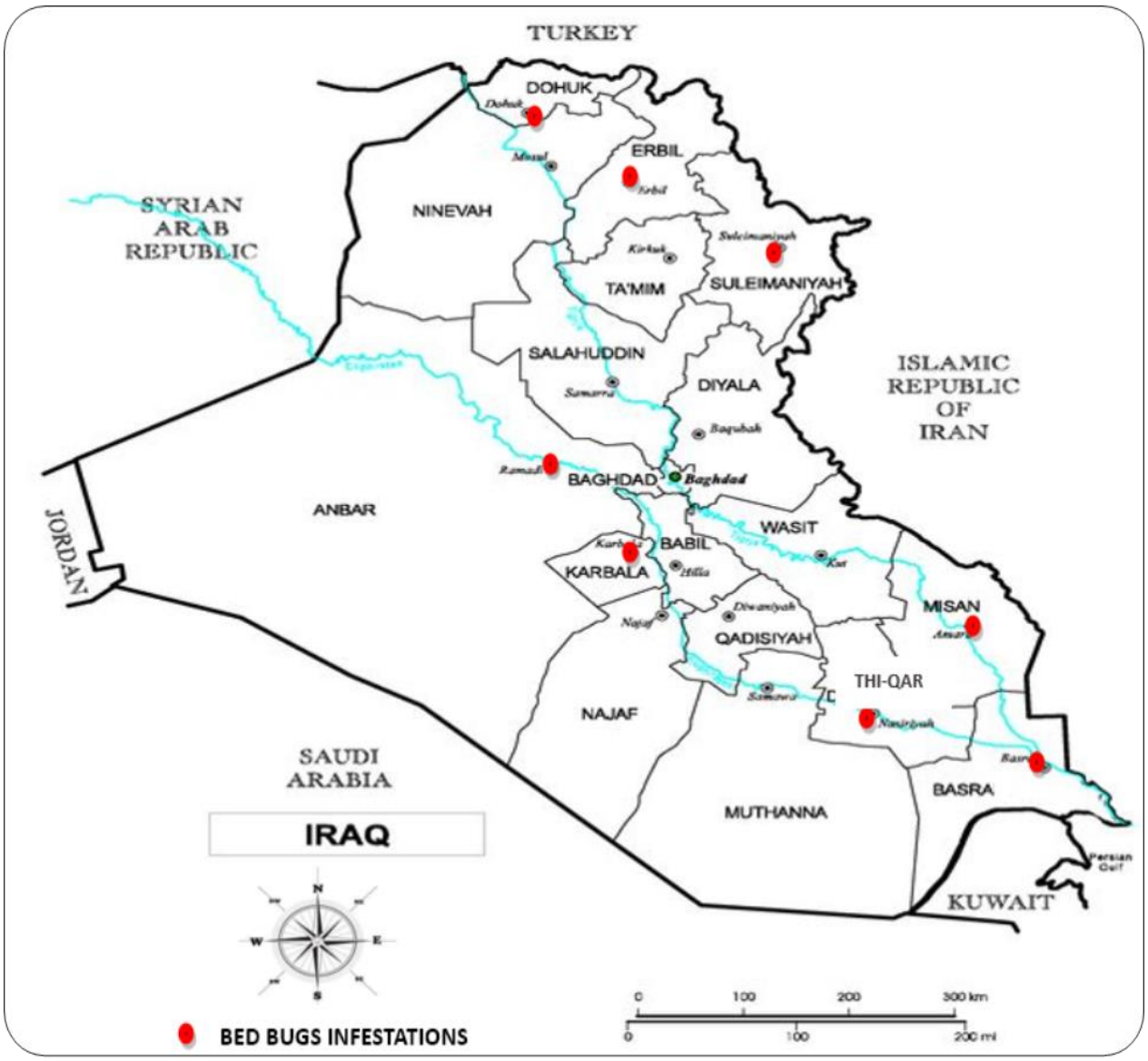

Fig. 1. Map of Iraq showing sampling locations of bed bugs collected for the present study, 2020–2021

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Table 1. Total bed bugs collected from all sites in eight Iraqi governorates during 2020–2021

#	Governorate	City	*Source	Number of bed bugs	Year of sampling	Group	*Status level of domestic hygiene
1	Erbil	Karizan	3	225	2020	Expats workers	3
2	Erbil	City center	3	350	2020	Expats workers	3
3	Erbil	City center	3	70	2020	Expats workers	3
4	Erbil	City center	3	55	2021	Expats workers	3
5	Erbil	Hotel Qelat	1	30	2021	local residents	2
6	Baghdad	Al-Hurriya	2	8	2021	local residents	1
7	Baghdad	Sadr City	2	9	2021	local residents	1
8	Baghdad	Al-Kadhimiya	1	13	2021	local residents	3
9	Baghdad	Al-Kadhimiya	1	20	2021	local residents	3
10	Sulaymaniyah	City center	3	55	2021	Expats workers	3
11	Sulaymaniyah	City center	3	90		Expats workers	3
12	Karbala	Al - Hassainya sub district	2	15	2021	local residents	1
13	Karbala	Al - Hassainya district	2	22	2021	local residents	1
14	Duhok	City center	3	44	2021	Expats workers	3
15	Duhok	City center	3	30	2021	Expats workers	3
16	Thi Qar	City center	2	18	2021	local residents	1
17	Basra	City center	2	40	2021	local residents	1
18	Maysan	City center	2	10	2021	local residents	1
				1104			

*Source 1 refers to bed bugs that have been collected from local hotels, followed by source 2 which refers to bed bugs collected from the family housing, and source 3 refers to bed bugs that have been collected from worker dormitory.
*Status level of domestic hygiene: Level 1= Good; Level 2= Average; Level 3= Poor (16).

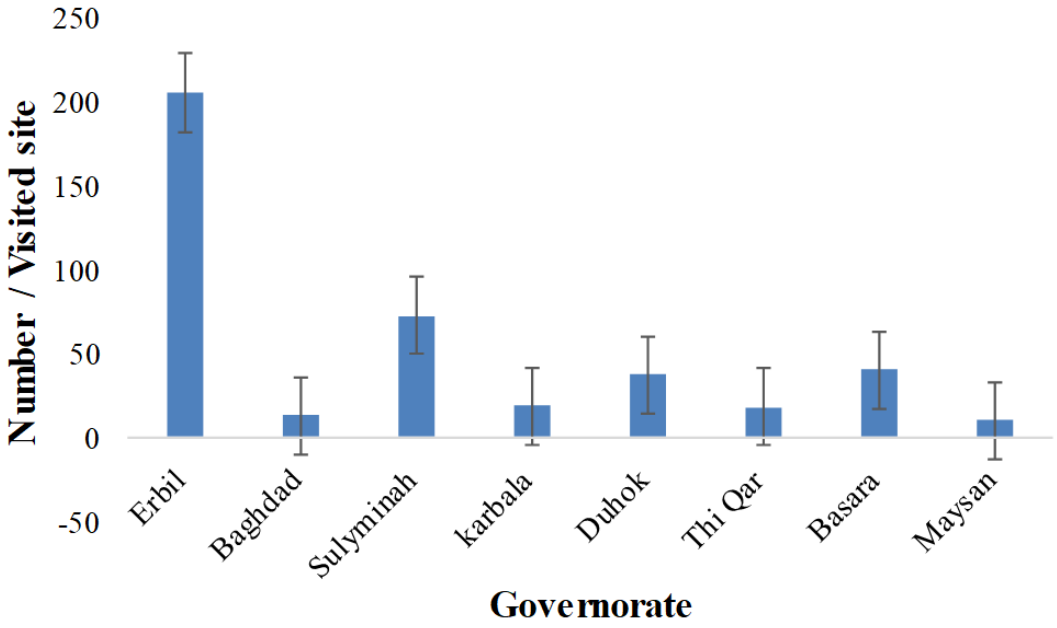

Fig. 2. The infestation of different governorates to bed bugs, Iraq, 2020–2021. The bars represent the standard deviation (SD) of the mean

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Table 2. Distribution of bed bugs harborages of the current study for 18 infestation sites in Iraq, 2021–2022

Harborage Site	No. of harborages	No. of harborages with bed bugs (%)	No. of bed bugs
Bedding (including box spring bed, fitted sheet, pillow flat sheet, and headboard)	400	350 (87.5)	800
Wooden furniture	60	55 (91.6)	150
Crakes and crevices	12	10 (83)	40
Carpets	50	35 (70)	29
Other (electric box, luggage)	40	20 (50)	85
Total	562	470(83.63)	1104

Table 3. Demographic characteristics of the respondents toward bed bugs, Iraq, 2021–2022

Socio-demographic variables		Number	Proportion%
Gender			
	Male	1055	57.2
	Female	788	42.8
Age category			
	18–24	424	23.0
	25–34	535	29.0
	35–44	406	22.0
	45–54	349	18.9
	55+	129	7
Education level			
	Primary school	7	0.4
	Middle school	34	1.8
	Secondary school	127	6.9
	Bachelor degree	881	47.8
	Master degree	405	22.0
	Doctorate	389	21.1
Occupation			
	Government employee	1069	58.0
	Private employee	108	5.9
	Businessmen	147	8.0
	Retiree	42	2.3
	Student	451	24.5
	Others	26	1.4

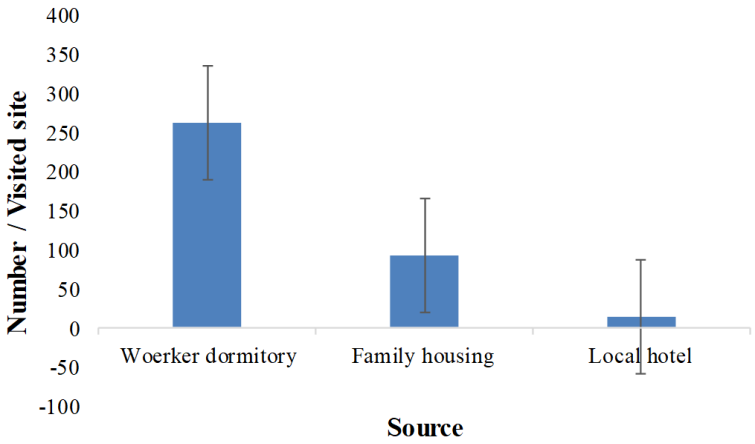

Fig. 3. Number of bed bugs per visited sites infestations collected from different sources in Iraqi governorates during 2020–2021. The bars represent standard error (SE) of mean

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Table 4. Knowledge, attitudes of respondents toward bed bugs, Iraq, 2021–2022

Items	Yes	No
Do you think that there are more common today than in previous years?	1198 (65%)	645 (35%)
Do you believe bed bugs are brought into Iraq by tourists and migrant workers?	1014 (55%)	829 (45%)
Do you think bed bugs come into Iraq from neighboring countries?	1299 (70.5%)	544 (29.5%)
Do you have an awareness of bed bug infestation and control in Iraq?	823 (44.7%)	1020 (55.3%)
Does the Ministry of Health Iraq conduct awareness-raising campaigns surrounding the risks of bed bug infestation?	275 (14.9%)	1568 (85.1%)
Can increasing awareness about bed bugs help prevent a bed bug infestation?	1711 (92.8%)	132 (7.2%)
Do you ever been bitten by bed bugs	485% (n=26.3)	1358 (73.7%)

Table 5. Respondents' reactions toward various practices for bed bug prevention, detection, and control, in Iraq, 2021–2022

Variables	Number	Proportion%
Bed bug habitat		
Kitchen	54	2.9
Living rooms	146	7.9
Bedrooms	974	52.8
Toilets	274	14.9
Others	395	21.4
Can bed bugs move to your house due to your visit to one of these places		
Hotels	381	20.7
Infested houses	991	53.8
Public accommodations	471	25.6
Transmission of bed bugs		
Contact with an infected person	109	5.9
By infected equipment	608	33.0
By animals such as bats and birds	274	14.9
All items	852	46.2
Prevention of bed bug infestation		
Checking bed and mattress	305	16.5
Public and personal hygiene	1161	63.0
Do not buy second-hand furniture, clothes, and other items	345	18.7
Others	32	1.7
Control practices for bed bug infestation		
No need to control	36	2.0
By washing, sanitation, vacuuming, spraying, and steaming	1534	83.2
Do not buy second-hand instruments /furniture	247	13.4
Others	26	1.4
What would you do if you thought you had bed bugs in your home		
Call a professional pest control	533	28.9
Use pesticides to control bed bugs by myself.	613	33.3
I discarded all my infested furniture.	253	13.7
Use hot water to kill bed bugs inside the infested items.	174	9.4
I would use alcohol to kill bed bugs.	270	14.7
How many treatments are typically required to eradicate a bed bug infestation in a house		
One treatment	267	14.5
Two treatments	638	34.6
Three or four treatments	719	39.0
Five or six treatments	219	11.9

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Table 6. Respondents' Respondent's knowledge of bed bug presence, Iraqis' sources of information about bed bugs, and identifying respondents' methods towards bed bugs and level of concern, 2021–2022

Variables	Number	Proportion%
Did you know that bed bugs can be present in Iraq?		
Very rarely	133	7.2
Rarely	631	34.2
NO	85	4.6
Common	799	43.4
Very common	195	10.6
Which of these methods do you think to help you to aid in identifying bed bugs?		
Bed bugs specimens	548	29.7
Visual inspections	379	20.6
Workshop	375	20.3
Photograph of bed bugs	541	29.4
Sources of information respondents know bed bugs		
Friends or relatives	367	19.9
Television	289	15.7
School or education courses	396	21.5
Print media and the internet	575	31.2
Previous experience (contact)	160	8.7
Level of concern do you have about bed bugs		
Very concerned	210	11.4
Somewhat concerned	808	43.8
Not at all concerned	499	27.1
No Answer	326	17.7

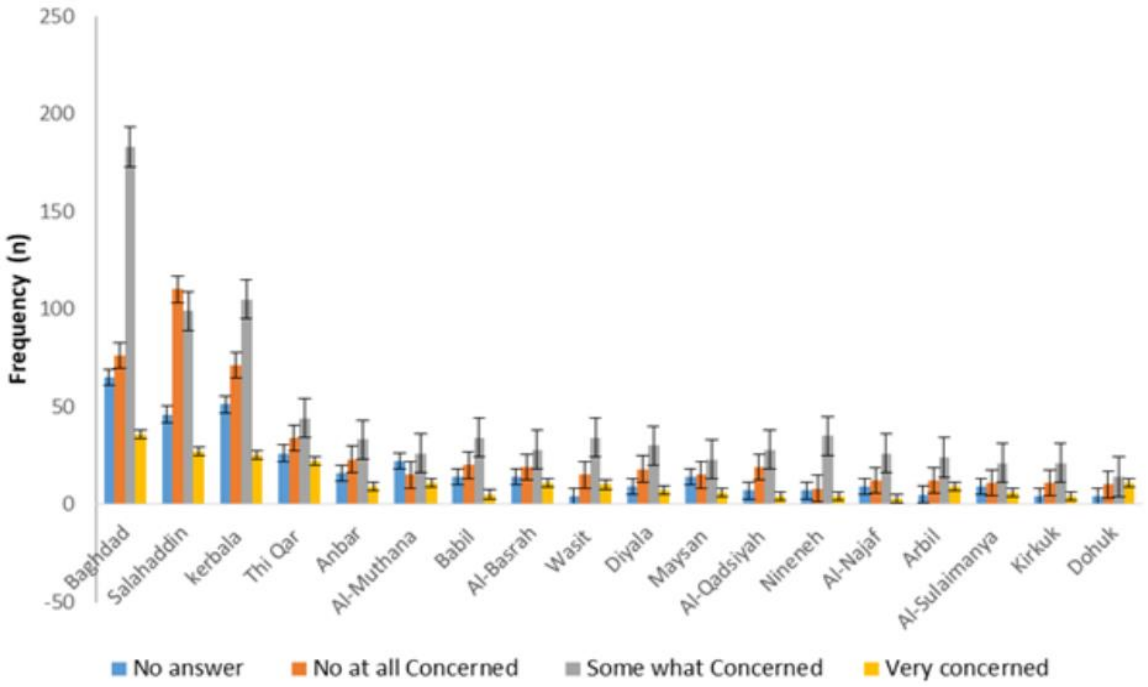

Fig. 4. The level of concern about bed bugs expressed by respondents based on governorates of Iraq, 2021–2022. The bars represent the standard deviation (SD) of the mean``tgggtgz3

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Discussion

One of the aims of this study is to examine bed bug infestation sites and determine their sources in Iraq. The current findings show that 71.12% of bed bugs are found in workers' sleeping areas (Fig. 3). This can be attributed to the high population density in these dormitories, which offer abundant food sources for bed bugs. Additionally, the lack of hygiene in these areas facilitates the breeding of bed bugs without encountering any obstacles. The results of the current study are consistent with a previous survey in 2019 (8), which showed a high incidence of bed bugs in workers' dormitories, particularly in the northern regions. Ameen relied on traditional methods in his study and speculated that the bed bugs originated from the same countries as the migrant workers, such as Nepal, Bangladesh, and India. Since bed bugs are small, flattened insects, they can easily be transported. Therefore, this study lacked a comprehensive diagnosis of bed bugs. According to the Iraqi parliament's Labor and Social Affairs Committee an estimated 1.5 million laborers, including illegal employees, were presented in March 2022 (22). Furthermore, two studies conducted in Malaysia (23) and Malaysia and Singapore (24) indicated that most bed bugs infestation were found in workers' sleeping areas.

The high infestation rate in worker dormitories could be related to the level of hygiene (Table 1). All the worker dormitories were a level of hygiene3 shows that these places are uncleanliness due to the unhygienic lifestyle of worker dormitories. The migrant workers tend to neglect these bugs, and the situation could be worse as dirty clothes near the bed sleeping attract bed bugs (25–26). On the other hand, the level of hygiene in Karbala, Baghdad, Thi Qar, Basra, and Maysan family homes was noticeably different, under the bed, furniture, and chairs, their living rooms were clean. The survey of the infestation dynamics results shows these houses infested with bed bugs could be due to bed bug entrances and habits, poor awareness of an infestation, traveling to infested areas, and reusing second-hand garments and furniture. The survey of the infestation dynamics also shows a moderate bed bug infestation in three local hotels: two in Baghdad and one in Erbil have level 2 hygiene; in these places, all parts of the premises and appurtenances have appeared somewhat dirty.

As for the source of bed bugs, the survey revealed that bed bugs mostly hide in wooden furniture cracks and bolt and screw slots (Table 2). About 83% of bed bugs hide in cracks and crevices in low-cost hotels and worker dormitories. The current study establishes that Low-cost hotels and housing had 70% bed bug-infested carpets as bed bugs can easily hide in carpet fibers. Bed bugs frequently inhabit the carpet, especially on the edges (10). We found bed bugs infested 50% of electric boxes in low-cost hotels and houses. This observation concurs with a research (12), claiming that power boxes and vacuum cleaners may be sources for bed bug infestations. Bed bugs like to hide, because these harborage sites protect them from contact with insecticides, even with control measures that use different insecticides. In terms of inspection, bed bugs hide in cracks and baseboards, also making them hard to find (2).

Previous studies have indicated the presence of both bed bug species *C. lectularius* and *C. hemipterus* bed in Iraq (7–9, 27). However, the survey conducted specifically in the Kurdistan North region in Iraq demonstrated that only *C. lectularius* was found (8). On the other hand, our findings reveal that the morphological characteristic of all the bed bug specimens was consistent with *C. hemipterus.* Since all previous studies in Iraq have merely relied on traditional methods for bed bugs' identification, it is necessary to employ molecular identification along with morphological identification to distinguish between the two similar species of bed bugs. Numerous studies have indicated that it is possible to achieve high accu-

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racy in distinguishing between the two species of bed bugs by relying on molecular identification and morphological identification (28–29).

A survey was also conducted to examine how well people know about bed bugs. The study assesses community knowledge, concerns, and control practices about bed bugs to determine the Iraqi community's awareness of bed bugs in Iraq. Based on (Table 4), 55.3% of respondents are unaware of bed bugs because they have never seen them in their homes or elsewhere. This can be true that these respondents have never seen a bed bug in their whole life, or they are immune to bed bug bites, and no symptoms showed, hence leading to unawareness. Moreover, most (73.7%) of respondents believed that bed bugs had not bitten them (Table 4). Due to a lack of information, most respondents may not discriminate between bed bug bites and other insect pest bites, including mosquitoes, fleas, lice, and mites, which can cause skin irritation. Durand et al. (30) also mentioned that bed bug bites could have been confused with other bites, such as mosquitoes or fleas, on some occasions.

Most respondents (85.1%) believed the Iraqi Ministry of Health does not raise bed bug awareness (Table 4). This may be due to bed bug infestation and management in Iraq has never been prioritized by the ministry. Instead, priority was given to other disease vectors, such as sand flies and mosquitoes (31). However, since the number of bed bug infestations has increased and caused lots of problems, the Iraqi government should make strategies to raise awareness among the Iraqi community through workshops, posters, and education on preventing bed bugs. Government agencies could also form coalitions, working parties, and task force advisory groups to formulate guidelines and best practices to stop the spread of bed bugs and effectively manage infestations (25).

The global population of bed bugs began to increase again after 1990 for understandable reasons but is likely related to increased global connectivity, pesticide resistance, and a general lack of responsiveness to infestation (10). According to the World Population Review, Iraq's population is increasing at 2.32% annually, adding under 1 million people annually (22). As a result, 65% of respondents claimed that Iraq has more bed bugs now than before. Population growth and rural-to-urban migration in Iraq cause urbanization. Hence, urbanization contributes to bed bug infestations socially.

Most respondents (46.2%) believed bed bugs could be transmitted by contact with an infected person, equipment, and animals like bats and birds (Table 5), and this is an obvious clue that these respondents did not understand the biology of bed bugs. Therefore, educational institutes have the responsibility of increasing awareness among citizens. Healthcare and educational institutions and national, regional, and local responsible entities must understand infestation risks and the necessity for developing protocols to avoid, identify, and raise awareness of the infestation and eradicate it effectively (32).

The increased concern surrounding the resurgence of bed bugs can motivate people to become more aware of this insect (33). Additionally, educating individuals on identifying and eliminating bed bugs is crucial, and individuals must differentiate bed bugs from other insects such as fleas, lice, ticks, or other similar pests (34). One of the ways to help identify bed bugs is through photographs. Government should use the internet to spread photos and information about bed bugs to increase awareness. It is noted that most people couldn't recognize bed bugs despite their visibility (16). However, 29.4% of respondents claim that a bed bug photo can help in identify bed bugs, even showing its life cycle.

Indeed, public awareness of bed bugs is vital in mitigating the prevalence of bed bug infestations (16). Numerous studies indicated that the effectiveness of bed bug control relies not solely on insecticide but also on public awareness and cooperation regarding bed bugs (26, 35). Public awareness about bed bugs can

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be enhanced through well-appropriate awareness campaigns that offer guidance on the safe use of insecticides due to the toxic nature of insecticides (36). In addition, governments at the local level should organize education campaigns about bed bugs, as they can significantly contribute to increasing public awareness about these insects (37).

Bed bugs can be controlled through non-chemical methods (38). According to this survey, 83.2% of respondents claimed they used washing, sanitation, vacuuming, spraying, and steaming to control bed bugs effectively. This may be because most Iraqis cannot afford effective bed bug pesticides; hence most responders used non-chemical techniques.

According to this survey, reused furniture, chairs, loveseats, desks, and tables cause most bed bug infestations in houses in some Iraqi governorates (Fig. 4). Bed bugs are epidemic in dwellings. Under optimum conditions, bed bugs can live for a year without a blood meal, while nymphs in the second through fifth stages can survive for 3 to 4 months (26). By reusing infested furniture, bed bugs may be more easily spread from one infested unit to another. Buying or renting used furniture is relatively common, especially in low-income communities, contributing to the spread of bed bugs to the new site (38).

Our study is not without its limitations. One of the constraints is the exclusion of individuals who do not have access to social media, such as people with low literacy levels and elderly individuals, which may render sampling bias. In addition, technical difficulties limited the analysis of response times to the online questionnaire. Furthermore, some respondents may be reluctant to disclose specific details about bed bugs due to embarrassment or privacy concerns, which also significantly affects the accuracy of the data.

Conclusion

In this study, *C. hemipterus* was the only bed bug species in Iraq. The main reasons for the bed bug resurgence are migrant workers and reusing second-hand furniture and clothing. Moreover, the lack of awareness and understanding about bed bugs could contribute to this bed bug resurgence in Iraq. Therefore, the government and non-governmental organizations should take critical steps to increase public awareness about bed bugs through workshops and awareness-raising campaigns surrounding the risk of bed bug infestation, focusing on the use of pesticides, prevention, monitoring, and identification of bed bugs. Thus, increased public awareness about bed bugs would prevent their spread and eliminate them early.

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Ethical consideration

Approval from the Human Ethics Committee at Universiti Sains Malaysia (USM/ JEPeM /19120868) was obtained.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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