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Bed Bugs Epidemic in the United States

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Abstract

Studies and reports suggested that bed bug infestation has been increasing rapidly in the United States since 2004. Scientists suggested that the reason for this resurgence of bed bugs is the less use of pesticides and the international immigration where foreign people carry bed bugs with them into the country. The main purpose of this review is to study the causes of the rapid bed bugs' infestation and its effect on human health. It will also discuss the best ways to control this epidemic. This review article was written and designed based on reviewing many research articles, scientific books, and science based websites that had done researches on the epidemiology of bed bugs and its effect on human health. In addition, this review also discussed the best strategies and solutions that can be used to eradicate bed bugs including, collecting of data, understanding the reasons of the problem, and intervening of government. In conclusion, bed bugs' infestation is still increasing and spreading in the United States. Developing a new effective insecticide and new government legislations are essential to eradicate this epidemic.

Keywords: Bed Bugs; pesticides; pathogenic diseases; Epidemiology

Case Definition

Bed bugs have been almost completely eradicated in the U.S. since 1940. From 1980 to 2014 bed bugs have comeback with limited extent. In 2004, the bed bug infestation has increased rapidly. It is clear to many scientists that bed bugs are rising again [1]. The reason for this resurgence is the less use of pesticides; however, some scientists mentioned that international immigration from developing to developed countries might be one of the reasons. Goddard and deShazo stated that this resurgence is due to the fact that bed bugs have developed a resistance to insecticides [2].

Bed bugs feed on human bodies and bite their skin to get their blood meal. Frequent bites of human skin can cause many physical problems and psychological distress. Bed bugs also carry many pathogenic diseases such as Hepatitis C, Hepatitis B, and HIV [1]. It is a serious health issue that needs to be addressed.

Agent

Bed bugs are small parasitic insects that depend on either human or animal blood for their food [1]. There are many species of bed bugs. Some of them depend on animals and birds for their food, while others rely specifically on humans for their food. The most common bed bug that infects humans is called Cimex lectularius [1]. After feeding they can increase in length (30-50%) and weight 150-200% [3]. The normal life span of bedbugs is about 6-12 months. Bed bugs are obligate blood feeders and they can survive up to a year without feeding. Bed bugs are oval, flat, and they become engorged after feeding on blood.

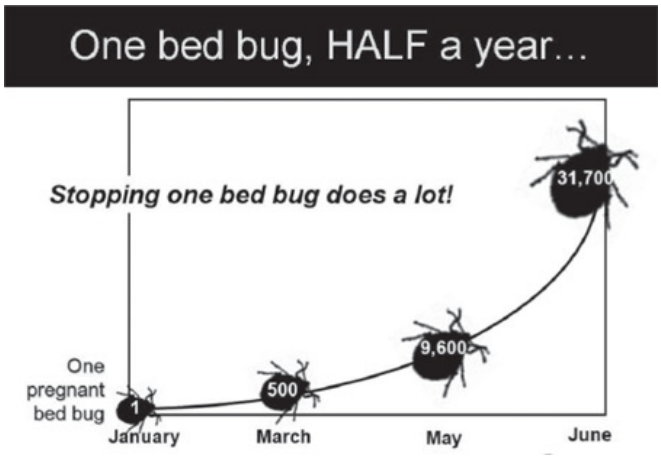
Bonnefoy, Kampen and Sweeney included that bed bugs usually hide in many places and appear only when they need to feed on the host. They can survive without food for an entire year. They can also survive in high temperatures up to 40°C and low temperatures -10°C. The reproduction cycle of bedbugs is quick. Females lay 200-500 eggs within 2 months [4] (Figure 1).

Life Cycle and Chain of Infection

The Bed Bugs Handbook reported that the Bedbug life cycle starts with an egg. After birth the bed bug will move through 5 instars or stages, ending with adulthood. While they are moving through the 5 stages they are referred to as a nymph. In order to move from stage to stage during the lifecycle of a bed bug, a bed bug needs to feed on a mammal. They prefer human blood, but will feed on other available animals such as a pet or bat. They can feed several times during each stage and as much as 1x per day. As the bed bug moves from each stage or instar they will molt as they grow. (para. 2 and 3) [5]. In general, bed bugs depend on humans in all stages of their lives. It is a direct relationship between a bed bug and a person.

Health Effect on Human

Bed bugs always bite the host in order to get their food which is



(Johnson Pest Control, Inc., 2011)

Figure 1: The multiplication of one bed bud in six months.

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blood. Bed bugs' bites can cause many health effects including physical symptoms, psychological distress, secondary infection and disease transmission, and physiological effects in the host [6].

Physical symptoms are usually allergic reactions, skin rashes, pruritic papules, and nodules. Psychological distress includes nervousness and sleeplessness as a result from frequent bites of bed bugs [1].

Hill and MacDonald found that bed bugs carry many pathogens including bacteria, viruses, protozoa, and parasitic worms [2]. Some scientists suggested that the risk is still present and more studies needed to be done on the other diseases that bed bugs can transmit to human [1,2,7].

Reinhardt and Siva-Jothy stated that physiological changes usually occur as a result of frequent bed bugs bites. It includes disturbances of lymphatic system and spleen functions including enlargements of the spleen and disturbance in the production of lymphocyte and peripheral leukocytes. Extended exposure can also lead to major blood loss, especially in children, and anemia eventually [6,7].

Morbidity and Mortality

Morbidity

The prevalence of the bed bugs' infestation has been increasing rapidly in the United States since 2001. For instance, neha.org mentioned that the number of newspaper articles that was written on bed bugs from 2001 to 2006 has increased significantly from around 25 up to 155 articles. Some pest control companies have reported 50 times more bed bug calls than the normal rate in the past few years [8]. In addition, the New York department of Housing Preservation and Development (HPD) mentioned that the number of bed bugs' bites violation has been increasing steadily from 2004 to 2010 with no decline. See Figure 2 for more details.

Furthermore, a national bed-bug organization mentioned that bed bugs infestation is no longer limited to some states which reported bed bug infestation like New York, Florida, and California, but it has been rising in all states. For more details, see Figure 3. Based on the above information, it is clear that the morbidity of bed bugs infestation in the U.S. is very high and it is still increasing. The Bed-Bug Organization also provided that bed bugs infestations has reached epidemic levels in some states such as New York, Ohio, Florida, and California. See the Prevalence of bed dugs infestation on Figure 3 [9].

Mortality

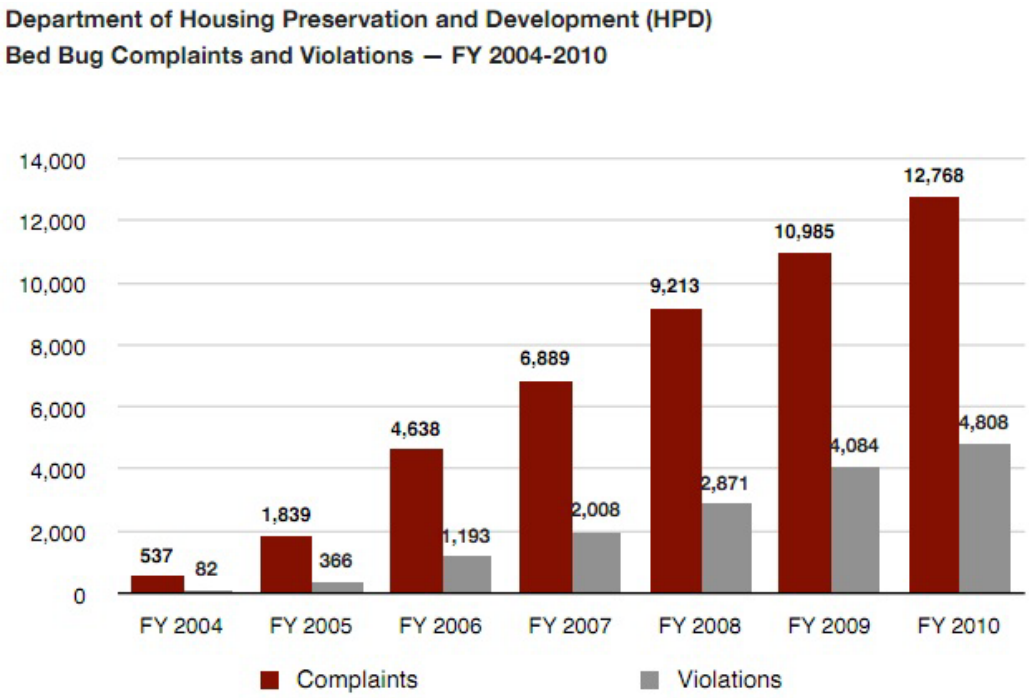
The Center for Disease Control and Prevention mentioned that the mortality rate of bed bugs infestation is zero. Bed bugs' bites do not cause death. However, insecticides, used to control bed bugs such as DDT, can cause some acute illnesses to human [9,10]. In addition, some scientists stated that bed bugs carry some fatal pathogens including hepatitis B virus and HIV. Until now, there is no evidence that bed bugs can transmit these pathogens to human, but people are still at risk of these viruses [7].

Descriptive Epidemiology

Host characteristics (Person)

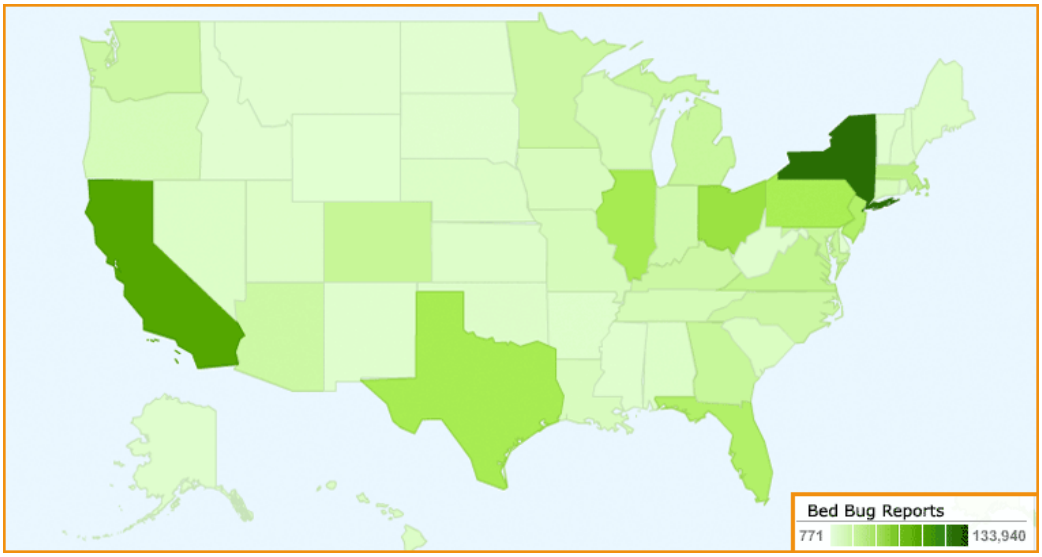
It is believed that the original hosts of bed bugs were bats, pet animals, and domestic birds. However, bed bugs have the ability to shift from one host to another. Cimex lectularius, the common bed bugs, is able to locate humans from 1.5 cm away by sensing the temperature and detecting the CO_2 [6].

Bonnefoy, Kampen and Sweeney also mentioned that bed bugs,



(NYC Department of Housing Preservation and Development (HPD), 2010).

Figure 2: Increase of Bed Bug Complaints and Violations from 2004 to 2010.



(The Bed-Bug Organization, 2011)

Figure 3: Prevalence of Bed Bugs in the U.S.

especially Cimex lectularius species, target all humans regardless of their age, gender, or ethnicity. Bed bugs do not prefer to infest a specific host, but they usually try to find any available person whenever they need a blood meal. For this reason, all people are at the same risk whether they are young or adults, males or females [1].

Despite of these findings, some studies indicate that incidence of bed bug infestation occurs more frequently in lower socioeconomic classes [1]. For instance, the infestation rates are higher in immigrants, guest workers, and homeless people since they tend to move from one place to another and carry the bugs with them passively [6]. This is not because of the socioeconomic factor itself, but because of other related factors such as housing, dwelling, immigration, and transportation which I will explain in details in the following section.

Environmental attributes (place)

Geographic location, housing, and socioeconomic factors: Reinhardt and Siva-Jothy also mentioned that the infestation rate of bed bugs is very high in warm areas, and it can reach 100% in some local places. However, the rate varies in tropical and subtropical areas and it can be high in some areas and low in others [6].

Bonnefoy, Kampen and Sweeney stated that: Bedbugs will infest human dwellings in all social and economic groups. A number of factors more commonly associated with poverty, however, are ideal for bedbugs. Buildings and other dwellings that are crowded, cluttered and in need of repair offer bedbugs many places to hide very near their food source (p. 140) [1]. These places provide an ideal condition for bed bugs to hide and survive for long time.

Immigration and transportation: Potter said that immigrants and guest workers play a significant role in transmitting bed bugs. This is clear especially in some large cities where people translocate frequently and occupy a place briefly such as hotels or motels. New York, California, and Florida have the highest rates of bed bugs' infestation. These states have also higher rates of immigrants and frequent transportation rates [11] (Figure 3).

Bed bugs can spread into other places either by active or passive dispersal ways. Active dispersal occurs when the bed bugs walk from one place to another. This is very common when the bug moves from one room to another within the same house. Bed bugs are primarily feed at night when the host is asleep and stationary for long periods. They rarely travel more than 8 feet to feed (CDC AND EPA, 2010) [6]. In general, active dispersal of bed bugs is usually limited and it is not the important way of bed bugs to spread and reach new hosts.

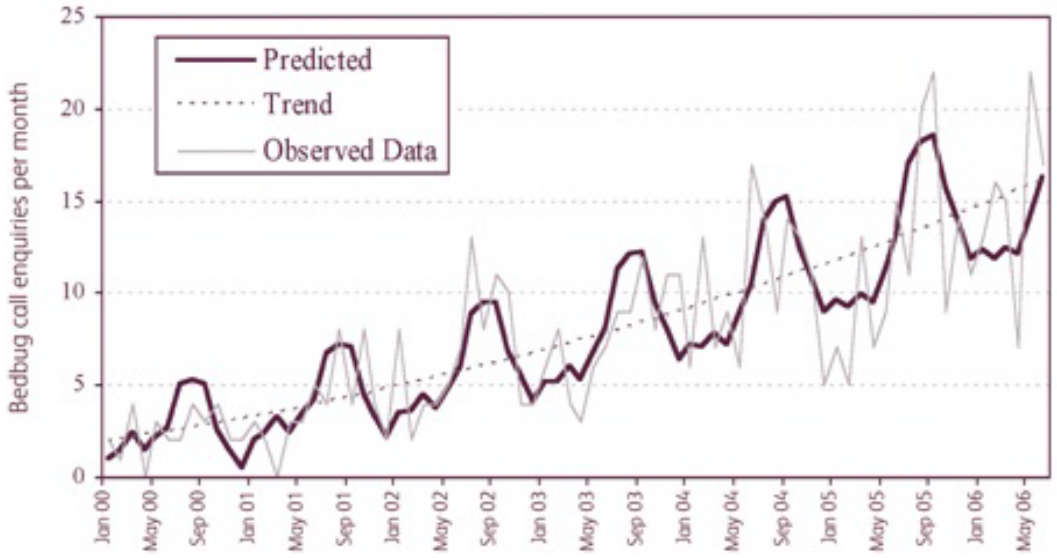
Passive dispersal is the most significant way to spread to new locations. It is also one of the main reasons of bed bugs infestation in the U.S. In this case, bed bugs can be transported in clothes, shoes, or furniture. People can transport bed bugs when they travel by cars, trains, ships, or airplanes. Bed bugs infestation is increasing not only in the U.S., but also in Europe.

Bonnefoy, Kampen and Sweeney reported that Observational reports from Germany and the United Kingdom claim a sharp increase in the frequency of infestations during the last decade. In the city of Berlin, Germany, more than a tenfold increase in the frequency of bedbug infestations has been reported, rising from five cases reported in the 1992 to 62 cases in 2002 and to 76 cases in 2004 [1].

Time variation (TIME)

Secular trend: The long term trend of bed bugs infestation has been declining since 1940 [1]. In 2004, however, the trend has shifted with a new resurgence and comeback of bed bugs [8]. According to the latest available data, the infestation peaked in 2010 (Figure 2). Although, Romero et al. (2007) mentioned that bed bug infestation has not reach its peak yet. It will record new peaks in the coming few years, and the escalation of this infestation seems to be inevitable [12].

Cyclic trend: Bed Bugs infestation occurs in any time. But, because of the cyclic nature of bed bugs, the intensity of infestation differs from one season to another. Bed bugs become very active in the summer season, especially in August and September when the infestation reaches its peak. In the winter, January and February, the lowest infestation rate of bed bugs is recorded in the year [13]. See Figure 4 for more details. This cycle is almost the same every year.



(Richards et al., 2009).

Figure 4: Cyclic nature of bed bugs infestation.

Current Epidemic Hypothesis

Bonnefoy, Kampen and Sweeney wrote that bed bugs have been eradicated in the U.S. from 1940. From 1980 to 2000, bed bugs have made resurgence with limited extent. Bed bugs infestation has been increasing rapidly since 2004. Pest control companies were not able to eradicate bed bugs efficiently because of the fact that bed bugs have developed a resistance to the current pest chemicals. Resistance is one of the main reasons for bed bugs resurgence [1].

The other main reason of bed bugs resurgence is related to the immigration and transportation. Scientists stated that people's clothes, furniture, and other items can carry the bugs easily. This problem occurs particularly in places like hotels, motels, and apartments. Once the bed bugs enter a new place, they spread directly and hide in many places [10].

Strategies and Solutions to Deal with Bed Bugs Infestation

Collect data and observe the prevalence in all states

There are lot of health agencies and organizations that provide the latest updated data about the prevalence of bed bugs in each state of the U.S. For instance, the bed bug organization has provided these data on their websites. See Figure 3 for more details.

Another source of data is the New York department of housing. They provide some important data about bed bugs infestation, especially in New York (Figure 2).

Pest control companies are also an important source of information since they deal with the problem on a daily basis. For example, Johnson Pest Control Inc. has long term experience about bed bugs infestation. They have also some valuable data on the locations and rates of infestation. They can contribute by providing more reliable data on bed buds [8].

Television, newspapers, and news articles are also another source of information. They provide the latest reports and data about bed bugs frequently. Anderson and Leffler have completed a study that provides lots of health data related to bed bugs infestation by states and location. This study depends on news articles basically to collect all the information [14].

Based on the above sources, bed bug infestation is present in all states. There are 5 states that show high prevalence and reach an epidemic level. These 5 states are New York, Ohio, Florida, California, and Illinois. After research and investigation, now we have a general idea about bed bug infestation in the U.S.

Understand the reasons for this epidemic and infestation

Based on the data mentioned above, bed bugs infestation is present in all states. In this section, we need to understand the reasons of this resurgence of bed bugs. There are 2 main reasons for this infestation. One is a general reason and the other is a specific reason.

The general reason is the resistance. Bed bugs have developed a resistance against most pesticides. Traditional pesticides (DDTs) are no longer effective and were banned by the authority in the U.S. And this reason has helped bed bugs spread throughout the U.S.

The specific reason is related to the 5 states that show high prevalence rates of bed bugs' infestation. Immigration and travel occur more frequently in these states. Some immigrants and strangers carry bed bugs in their clothes or items.

It is important to understand these reasons in order to solve the problem. In the next section, I will talk about how we can deal with this health issue.

Intervention and control bed bugs' infestation

Bed bugs infestation is a public health issue. In order to deal with this health problem, policy regulators, health organization, media, and the public should be working together. Bed Bug epidemic can be divided into 3 main levels based on the degree of bed bug infestation. Some solutions will be suggested on each level. The solutions are derived basically from the literature review.

Places with high infestation rates: I mentioned above that the 5 states that show high prevalence rates of bed bugs are New York, Ohio, Florida, California, and Illinois. The main reasons of this high infestation are immigrants and strangers who came from other places and carry the buds with them.

In these states, the governors and health departments should issue new legislations for hotels, motels, and temporary resident apartments to make sure that they inspect and check the presence of bed bugs on a regular basis. The new rules will be held by a special authority. These places must do inspection for bed bugs periodically. Authorities, who are responsible for bed bugs inspection in hotels, motels, and apartments, should follow-up withy the mentioned places to make sure that the new rules are applied. The places that do not apply the new inspection rules will pay a specific fine.

In addition, all pest control companies must provide a monthly report of all bed bugs calls to the special authority. This will provide a follow-up to evaluate the success of the intervention. This process is important for further developments in the future.

Places with low infestation rates: Most states show low prevalence rates of bed bugs infestation. In these places, the local governments are responsible to design some campaigns to urge people to take an action against bed bugs infestation. For infected place, people should eradicate bed bugs as soon as possible.

Controlling bed bugs is a big challenge since the use of DDT was banned by the U.S. regulators. But, there are many ways to eradicate bed bugs. Pest control companies have some other techniques that are very effective in controlling bed bugs. One of these techniques is the heating process of the infected places (such as mattresses, furniture, carpets) by providing hot air 55 C for 20 minutes [10]. This process can kill all bed bugs easily.

Further research is also needed to provide new ways of treatment, and to develop new effective pesticides.

Places with no infestation: Prevention is very important in these places since it is easier to prevent than eradicate bed bugs [15]. This group represents a large percent of the country. If we succeed to prevent the infestation from these places with no infestation, we will stop the spread of this health issue.

Local government must provide an adequate budget to create public health service announcements about bed bugs. These campaigns will target children in schools, people in work places, and families at homes. It is important to increase people's awareness about this new emerging health issue.

The main goal is to stop the infestation of bed bugs first, then try to decrease the prevalence in the coming few years. Once people start to be aware of this problem and take some actions, the spreading of this infestation will stop and decrease gradually within the coming years.

Principal Gaps in Knowledge about Bed Bugs

Goddard and deShazo stated that: Transmission of more than 40 human diseases has been attributed to bed bugs, but there is little evidence that such transmission has ever occurred. Seminal researches postulated that bed bugs may be vectors of plague, yellow fever, tuberculosis, relapsing fever, leprosy, filariasis, kala azar (leishmaniasis), cancer, smallpox, yellow fever, and Chagas disease (Trypanasoma cruzi). Recently, the possibility of human immunodeficiency virus and hepatitis B virus (HBV) transmission by bed bugs has been investigated. (p. 1361) [2].

On the other hand, Eddy and Jones (2011) mentioned in their study that: The results as a whole indicate that no biological multiplication of virus occurs in C. lectularius but that mechanical transmission from insects to man could occur by (i) contamination of a person when crushing infective bugs; (ii) contamination from infected feces; and (iii) infection by bite due to regurgitation or interrupted feeding." Therefore, mechanical transmission of disease organisms through infected feces remains the most plausible scenario since bed bugs have been observed to defecate on their host following a meal. (p. 9) [16].

Disease transmission from bed bugs is still equivocal. The risk of transmitting some serious diseases to human is present. Scientists must focus on this area specifically and do more studies researches in order to develop deep scientific knowledge about this issue. Bed bugs infestation is increasing. If they are able to transmit diseases to human, we might face other health problem and consequences as well.

Conclusion

Based on the above data, the bed bugs' infestation is still increasing and spreading. CDC reported that bed bugs "Although largely eradicated in the Western countries in the 1940s with the aggressive use of pesticides, notably DDT, they began to re-emerge in the mid-1990s" [17]. Romero et al. reported that without developing a new effective insecticide, the escalation of this problem will continue. Now, we knew the reasons for this infestation. The two main reasons are immigration and bed bugs' resistance to insecticides. I believe that we can stop the spread of this health problem. We need to collaborate with policy makers, health agencies, and pest control companies together and take action as soon as possible. I think that if the decision makers took the professionals' recommendations and my suggestions that I mentioned above, they will be able to develop new intervention to stop the infestation, and solve the problem eventually [11].

Future Research

There are two main areas that need more researches and studies. First, the current insecticides are not effective and new researches need to be done to develop new insecticides [11]. Second, a research by Barbarin et al., reported that Beauveria bassiana spores, an organic fungal pesticide, can be used as a spray on all kinds of furniture and it is effective in eliminating bed bugs infestation. Scientists need to do more researches on this area particular area. It could be an alternative organic pesticide for controlling bed bug infestation [18,19].

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