

Bed Bugs Infestations and College Student Social Behavior in Berkeley, California

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ABSTRACT

The common bed bug, *Cimex lectularius*, has made a resurgence in the past decade with rapidly increasing rates of infestation in urban housing units. Bed bugs are especially problematic in areas of high population densities, such as college campuses. This study examined the relationship between previously-identified risky behaviors for bed bug infestation and rates of infestation. I distributed a survey to current and past students of the University of California, Berkeley with the goal of assessing these behaviors and sampling the rates of bed bug infestation at UC Berkeley. I also looked at the relationship between the type of housing and their correlations with the likelihood of infestation. Out of 214 survey respondents, 29 had experienced bed bugs in the past. People who lived in cooperative housing and campus dormitories were significantly more likely to have had bed bug infestations than people who lived in apartments, houses, and Greek housing. The survey also established a connection between certain risky behaviors, including introducing second-hand furniture into the household and acquiring bed bug infestations. These findings show that communal and high-density residences should be a priority for researching bed bug infestations.

KEYWORDS

Bed bugs, epidemiology, environmental health, UC Berkeley, infestation

INTRODUCTION

The common bed bug, *Cimex lectularius*, has become a household pest on every inhabited continent. As synanthropic ectoparasites, bed bugs live near the habitats of humans and prey on the surface of human hosts (Johnson 1941). Being nocturnal organisms, they feed on human blood during the nighttime and inhabit common human areas such as bed crevasses and room corners. Because of the skin rashes and allergic reactions that they inflict, they are considered a major epidemiological problem (Doggett et al. 2012, Gangloff-Kaufmann et al. 2006, Goddard and deShazo 2009). A study on the rates of bed bug infestation reports have shown a worldwide increase in their incidence over the past several decades (Doggett et al. 2004). Researchers have hypothesized that increases in international and domestic travel and interpersonal contact are factors in their resurgence; bed bugs are often transmitted in international cargo, often from countries with low export regulations (Doggett et al. 2004). Dwellings with high rates of turnover, such as hotels, military barracks, and college dormitories, tend to have high rates of bed bug infestations as well (Wang and Wen 2011). As such, researchers, administrators, and government officials have all recognized the need for more research addressing the control of bed bug spread and incidence.

Most research on bed bugs so far has focused on methods of detecting and eliminating the pests. The elimination of bed bugs, however, has had mixed results. Bed bugs are susceptible to extreme cold, heat, dehydration, and predator stress, but have been developing resistance to common pesticides such as chlorfenapyr, permethrin, and pyrethroid (Benoit et al. 2009, Benoit 2011, How and Lee 2010, Moore and Miller 2006, Romero et al. 2007, Steelman et al. 2008). The problem with the detection and elimination approaches are that they only work once a tenant realizes that there could be a bed bug problem. Because of this increasing resistance to pesticides, as well as the human risks of pesticide use, it is often unwise to use chemical treatments for extended periods of time (Leiss and Savitz 1995). Furthermore, biocontrol, a method of pest control that utilizes natural predators to eliminate a pest, is virtually impossible because bed bugs have few natural predators (Schuh and Slater 1995). As bed bug pest control methods can cost a few thousand dollars and last up to two or three years, it is important for risk of infestation to be minimized, instead of solely focusing on control. Thus, it is important for

researchers, homeowners, and tenants to learn how to prevent the infestation of bed bugs before it happens.

One of the largest risk factors in the spread of bed bugs is the turnover of personal belongings. As bed bugs commonly nest in furniture, exchanging furniture between households exposes recipients to potential bed bugs (Hwang et al. 2005). Areas with high population densities and high turnover rates of individuals are most at risk for the accidental spread of bed bugs within furniture, luggage, or clothing (Heukelbach and Hengge 2009). A combination of the public's lack of knowledge of how to detect bed bugs, and the difficulty in regulating risky behavior for bed bug infestation make control of bed bug transmission difficult (Reinhardt et al. 2008). As there is little research on the role of human behavior on the spread of bed bugs, it is necessary to have such information to understand patterns of bed bug infestation.

In this study, I used a survey to assess the spread of risk factors for bed bug infestation across different types of housing arrangements in Berkeley, California. I analyzed trends in social behaviors that contribute to infestation, as well as the types of housing that are most prone to bed bug infestations. The question assessed the relationship between housing types and risk behaviors, such as furniture acquisition and methods of cleaning. The results of this study will add significant information to the current body of research regarding the relationship between human behavior and bed bug infestation.

METHODS

Study Population

In order to get the largest number of respondents possible, I made the survey available to any person who had attended UC Berkeley in the past 4 years and were living in the city of Berkeley, California. There are an estimated 36,000 students, both undergraduate and graduate, who attend UC Berkeley. The undergraduate gender ratio is 53% male and 47% female, while the graduate gender ration is 55% male and 45% female. Ten percent of all students are from out of state. The average age of all undergraduate students is 21 years. Around 10% of both men and women join fraternities and sororities. Twenty-six percent of students live in campus-owned, -

operated, or –affiliated housing, while 74% of students live off campus (University of California, Berkeley, 2012).

Data Collection

To distribute the survey, I used the Internet to reach out to as many potential survey takers as possible. I found various forums related to students at UC Berkeley and posted the survey on the forum. Such forums included the Berkeley sub-reddit (<http://www.reddit.com/r/berkeley>), which is frequented by students of Berkeley, former students of UC Berkeley, and residents of Berkeley. This sub-reddit has 4,806 subscribers as of March 8th, 2013. Although demographics for the sub-reddit could not be found, surveys of Reddit’s general demographics revealed a 6:1 male-to-female ratio and an average age group in the 18-25 range (http://www.reddit.com/r/reddit.com/comments/gzb2w/i_made_a_basic_reddit_demographic_survey_lets/) Another forum used was the UC Berkeley forum on College Confidential (<http://talk.collegeconfidential.com/university-california-berkeley/>), which is frequented by prospective and current students of UC Berkeley.

I promoted the survey through Facebook messages, groups, events, and asked my contacts to forward it to people who might be interested in taking it. I created an event titled “Help Reduce Bed Bug Infestations in Berkeley with the Chance to Win an Amazon Gift Card” and invited those I knew at UC Berkeley to the event. I then asked my contacts to invite those they knew as well, resulting in over 2,000 people invited to the event. In the description, I briefly described my project and stated that the responses could help understand how to minimize risk for bed bug infestations at Berkeley.

To reach out to the fraternities and sororities, I talked to personal contacts that are either currently living in fraternity and sorority housing, or are part of the Greek system at UC Berkeley. There was generally a mailing list, sign board, or online group to which they would post the survey. I also requested my contacts to personally assist in spreading the word about the survey. Finally, I publicly-available mailing lists to reach out to student groups and organizations affiliated with the Greek community.

At UC Berkeley, cooperative housing is a system that provides opportunities for residents to put in labor for the general maintenance of the house and contribute to housing management in

a democratic manner. To reach out to those living in cooperative housing (known as co-ops), I talked to personal contacts who are part of the co-op community. They both posted the survey to the co-op mailing lists, as well as made announcements during house meetings about the survey. I also requested that my contacts personally assist in spreading the word about the survey. To gauge the key co-ops that I could focus on, I inquired contacts who live in co-ops about which co-ops have been reported to have bed bug infestation problems, either currently or in the past. I made a spreadsheet of all the co-ops at Berkeley with the information that I have collected about them and the number of residents in each co-op. From that data, I assessed the individual co-ops' priorities in my survey distribution.

I ended up with 159 responses from people living in various housing arrangements. The survey was distributed from February 2nd to April 28th.

Survey Design

To create the survey that I used for the project, I used a Google form, as it compiled my data in an accessible and readable manner. Most of the questions were multiple-choice or on a scale, but I left a few questions open-ended to account for gaps in the survey content. To provide an incentive for potential survey-takers to complete the survey, I advertised the potential to win one of three \$25 Amazon gift cards. I accepted responses to the survey from February 2nd until April 28th.

The first page of the survey introduced the respondent to the purpose of the survey, the estimated length, and the incentive (See Appendix A). It was important for the respondent to be informed of the topic and contents of the survey before they actually completed the questions. The overview of the project and the research question served as context for the respondent to understand the purpose of the questions and why they were needed. The initial text also contained privacy information regarding the identity of the respondent, any personal information would not identify respondents on an individual basis, and it would remain confidential.

The second page of the survey was dedicated to the respondents' demographic data, such as age, race, income, neighborhood, housing arrangement, and year in school. The information here was both used for data analysis and data collection. While the survey was active, I looked at the demographic data of the responses collected to see if I was critically lacking in any important

factors. For example, if there were many respondents from fraternities but much fewer in dormitories, I made a greater effort to distribute the survey to those living in dormitories. I did this so that I would have enough responses for each category to perform strong statistical analyses.

The third page of the survey asked the respondent about their experiences with the specific risk factors for bed bug infestation. Questions that I asked included: what was the source of the furniture in your housing arrangement, (how) did you clean or inspect the furniture, and do you know what bed bugs look like? The questions on this page were designed to assess the common behaviors of people in different housing arrangements with regard to their risk of bed bug infestation. An important question in this section was, has your housing been subject to bed bug infestation while you have attended UC Berkeley? Finally, I included a “snowball question” that asked if the survey respondent would be willing to pass on my survey to other students at Berkeley. As an incentive for this, I stated that for every person they passed the survey on to who completed the survey, the original respondent would have one more entry into the raffle.

The last page of the survey thanked the respondent for completing the survey. It also briefly explained the methods of choosing the reward - that the recipients of the gift cards would be chosen randomly from all the people who completed the survey. I stated that the recipients would be chosen by May 4th, and that they would be contacted by email and sent a code once they confirm.

Data Analysis

To analyze the data collected from my survey, I used the statistical software “R”. For the relationships that were between binary data (yes or no responses) and ordinal responses (for example, between likelihood of cleaning furniture and infestation of bed bugs), I used a paired t-test. I performed chi-square analysis to compare the rates of infestation of the different housing units.

RESULTS

Between January 13th, 2013 and April 10th, 2013, I received 213 responses to my survey. Of the responses, fifteen were from individuals who did not live in the campus area in Berkeley, so I did not use their responses in my analysis. Subtracting those who did not live in the area, I used a total of 198 survey responses counted in the analysis. For those who live in the UC Berkeley campus area, the distribution of housing in which the respondents live in is: 64 (32%) in cooperative housing, 56 (28%) living in apartments, 39 (20%) in Greek housing, 20 (10%) in campus-sponsored dormitories, 15 (8%) in houses, and 4 (2%) in private dormitories. The respondents accounted for approximately .5% of the entire UC Berkeley student population. Because of the low number of respondents who live in private dormitories, and the similar arrangement of housing, I grouped private dormitories and university-sponsored dormitories in one group.

The survey showed that there is a significantly higher rate of bed bug infestation in cooperative housing and apartment housing, compared to the other choices. Of the total 198 survey responses, 27 had admitted to having had a bed bug infestation, either currently or in the past. When asked what sort of housing they had lived in when there was an infestation, 14 indicated that they had lived in a co-op, 11 indicated that they had lived in an apartment, and one respondent each indicated that had lived in a house and in Greek housing.

Table 1. Distribution of respondents with and without bed bugs in relation to the residence type

	Dormitory	Co-op	Apartment	Greek Housing	House
Bed Bugs	14	11	3	5	0
No Bed Bugs	35	31	53	18	9

I measured rates of bed bug infestations from five different housing types. When comparing the expected number of respondents who had bed bugs with the observed using chi-squared test for independence, there was a significant difference between the results. ($X^2 = 11.090$, $P < .05$)

Among all the respondents, the most common bed bug infestation risk factors were: travel out of Berkeley (96%), contact with a person who had had bed bugs (55%), purchasing second-hand furniture into the housing (41%), and taking items off the street (21%). When comparing the difference between the risk factors of those who have had bed bug infestations and those who have not, none of the relationships showed to be statistically significant.

Table 2: Examining the relationship between bed bug infestation and predetermined risky behaviors that increase susceptibility to infestation.

Relationship	p-value
Contact with a person who has had bed bugs	0.728
Travel to a place with bed bugs	0.613
Taken furniture from the street	0.126
Obtained used furniture from a third-party vendor	0.393

The survey asked respondents to indicate the frequency of specific risky behaviors on a scale of 1-5. I used a two-sided t-test to assess whether those who have had bed bugs follow a significantly different set of behaviors from those who have not had bed bugs. The findings show that there is no significant difference of behaviors between the two groups ($P > .05$).

DISCUSSION

It has been difficult for pest control researchers and professionals to find ways to alleviate the impact of bed bug infestations. Many of the causes of infestations are due to human factors, which are nearly impossible to duplicate in controlled settings. Some of the human behaviors that have been identified as significantly contributing to the dispersal of bed bugs have been: frequent travel; lack of inspection of second-hand furniture; and exposure to other locations that have had bed bugs (Kells 2006). These behaviors, coupled with the bed bugs' natural ability to

hide in closed spaces makes it easy for the bugs to infest a residence. Previously, I identified housing types and risky behaviors as two factors in the transmission of bed bugs into a residence. This study has shown that there is a clear relationship between types of residences and the rate of bed bug infestation. Those who lived in co-ops and dormitories had significantly higher rates of infestation than did those living in other residences. However, our findings did not show as clear of a relationship between certain social behaviors that are considered to be factors for infestations, and the occurrence of infestations in the residences of people who exhibit such behaviors.

Housing Types, Culture, and Bed Bug Infestations

I found that co-ops and dormitories had a markedly higher rate of infestation than the other types of residences examined. One large factor may be the group living aspect; there are large numbers of people living in a single residence in the co-ops who can transfer bed bugs to another nearby person. The average number of inhabitants in each of the large communal residences that were sampled in the survey was 56.2 for the co-ops, 71.0 for the dormitories, and 31.8 for Greek housing. In contrast, houses and apartments had much lower average inhabitant numbers, with 5.5 and 3.1 per residence, respectively. Past studies have suggested a positive correlation between inhabitant density and rate of bed bug infestation (Hwang 2005). As those studies had been done with homeless shelters, showing that the correlation exists with other types of housing (dormitories and co-ops) further signifies the importance of population density in bed bug infestations.

Co-ops, dormitories, and apartments have similar qualities that may make them more susceptible to bed bug infestations than residences with lower numbers of people. The risks of bed bug infestations in cooperative housing systems have not been studied at all in academic literature, likely because this housing arrangement is not common to most areas of the United States. However, we can think of the cooperative housing units are similar to the dormitories in terms of function, housing large groups of people. Co-ops are also similar to dormitories and apartments in that they are both regulated internally, generally by individual housing managers. All three systems also have large numbers of inhabitants who live in close proximity to one another. Researchers have studied apartments as a major area of concern and study for the

pathways of bed bug infestations. Because of the close proximity of the housing units to one another, it is easy for bed bugs to spread through the exchange of items and the usage of equipment such as wheelchairs throughout the complex (Wang et al. 2010). Because of the similarities qualities of these types of housing, we can deduce that the communal living may have a role in increased bed bug infestations.

There is also a lack of studies on Greek housing and inhabitant health on college campuses. Literature in bed bug research has focused primarily on single-family households; although this is understandable, as most of the U.S. population lives in a single-family household, it does ignore a major population (college students) that have unique social interactions and living behaviors (Eddy and Jones 2011). In the study, I did not find significant correlation between risky social behaviors and bed bug infestation for Greek housing. While Greek housing is generally conceived as being less fastidious in housing upkeep than other residences, the stereotype does not hold in this study. One possible reason for this is that people living in Greek housing acquire and move less furniture than do people living in the other residences. Many of the staple furnishings, such as tables, bookcases, and drawers, remain in the Greek houses for long periods of time. In contrast, student apartments and residential houses often acquire new furnishings every year. One survey respondent indicated that they a certain portion of the house funds were set aside for a professional cleaner to come in a few times a semester (Zhou, personal communication). I had a lower sample of Greek housing survey respondents than I did for the co-ops and apartments, however, so these findings may not necessarily be conclusive.

Considering the amount of pest regulation that is present in the campus housing system, the high rate of infestation in the dormitories is extremely concerning. The campus dormitories are directly managed and regulated by the Residential & Student Service Programs (RSSP), a subsidiary of the University of California, Berkeley. Because of a history of bed bugs at universities in the 20th century, housing specialists have taken active steps to prevent bed bugs (Doggett et al. 2011). Even so, infestations have repeatedly occurred, with the most recent infestation in April of 2013 (Tyler 2013). Residential assistants, program assistants, and residential directors are trained to respond to bed bug infestations, aiming to catch infestations before they spread throughout a building. The residential staff first confirms the presence of the bed bugs by looking for the organisms or the blood stains from feeding. If there is a confirmed

infestation, the staff uses a set of defined procedures to address it. The university also has the advantage of having a direct connection with a pest control research center, the Urban Pest Management Center in Richmond. As such, they are equipped with knowledge of the most recent bed bug management techniques and detection measures (Lewis, personal communication). As the university is already equipped with a great deal of resources for dealing with bed bug infestations, the repeated infestations brings to light the need for further research on the effectiveness of specific bed bug control methods.

Although this study did not involve in-depth questions about the specific ways the respondents received bed bugs, the survey provided an optional text box for the respondents to comment on their infestations. Eight respondents (twenty-two percent of those who had bed bugs) indicated that the cultures of the co-ops or Greek system housing could have contributed to the infestation. Many people in those residences are accustomed to a culture of sharing, especially in the co-ops; instead of purchasing items, co-op residents often turn to friends and acquaintances to acquire second-hand items. One unique aspect that is shared between the co-ops is the presence of a free pile: a collection of discarded and second-hand items that are available for any resident to take (The LoopCycle 2013). While the purpose of such free piles is to promote sustainability and discourage resource consumption, the exchange of items without a system of monitoring of cleanliness potentially allows for greater spread of bed bugs within the co-ops.

Relationships between Risk Behaviors and Infestations

Items that have been discarded on the streets or in other public areas are often likely to carry bed bugs or their eggs (Heymann 2009). However, my findings show that respondents who have picked up items on the street, especially mattresses, and brought them into their residences, did not have significantly higher rates of bed bug infestations in this study (Table 2). However, the sample size for those who have had bed bugs was relatively low, so it may be difficult to draw strong conclusions. In addition, even though bringing street items into a residence was not associated with a higher rate of bed bug infestation, it is possible that those who took in items from streets were unaware of having bed bugs. Reinhardt et al. (2007) showed that only ten percent of individuals surveyed were able to identify a bed bug on sight. Also, people in the

younger age groups were less likely to be able to identify bed bugs, compared to those in the older groups. As such, it is possible that those who engaged in risky behaviors could have had bed bugs, but were unaware of them.

Of all the survey responses, the items most commonly obtained from either the street or third-party vendors were desks (41%), followed by mattresses and/or bed frames (36%). This is notable because one of the most common hiding places of bed bugs is in bed linings and mattresses. Bed bugs are also found in furniture with seams and cracks, such as desks and tables. College students may be more likely to buy used mattresses, desks, and other furniture possibly due to a cost-saving culture, and to the accessibility of second-hand furniture sources such as Facebook and Craigslist (Gregson and Crewe 2003).

I found no significant relationship between exposure to travel lodging establishments and rates of bed bug infestation, or between exposure to people who have had bed bugs and infestation rate. Ryan and Miller (2004) showed that establishments such as hotels are a main source of bed bugs for travelers, as they have a high flow rate of short-term residence, and most people are not knowledgeable about how to look for bed bugs. The lack of a relationship in my study between travel and bed bug infestation may be explained by the wide variation in hotel lodging – while there are some hotels that have a great deal of bed bugs, there are also many others that do not have any at all. As my study did not look at just hotels, it was more difficult to replicate results from the previous study. Regarding personal contact, the difficulty in accurately assessing the level of contact may affected the significance of the results.

Limitations

Although some of the relationships measured in the study were statistically significant, there could have been some data skewing due to survey methods. As my method of survey distribution was largely snowball sampling, many of the respondents may have had similar characteristics, behaviors, and responses. It is possible that those who choose to live with one another are likely to share similar qualities, such as level of cleanliness, and willingness to take in secondhand furniture. This may have affected the gradients of my responses and the variance in the data. This unexpected lack of variability in the responses was surprising, and may have

accounted to the lack of significance between rate of infestation and many of the assessed risky behaviors.

Another difficulty of the study was discerning whether the survey respondent actually had bed bugs or not. One of my survey questions was designed specifically for this purpose; I asked the respondent whether they had seen small red spots on their mattress, have had bites, or had seen the bugs themselves. However, even with this question, the survey relied on whether the respondents believed that they had had bed bugs. So, we need to acknowledge the possible bias in the data regarding number of respondents who have had bed bugs.

Future Research

The findings of this study suggest that sources of bed bug infestations should be researched further. Bed bug pest control is expensive, and people need to learn how to prevent bed bug infestation before they are introduced to a residence. Given my findings that densely populated residences are at high risk to bed bug infestations, researchers should do more research on residents who have had bed bugs to see what particular behaviors, circumstances or traits may have led to the infestations. To get a better holistic account for how the infestation may have occurred, interviews would be particularly effective in discerning unique factors leading to the infestations, such as specific hotels that one had stayed in, or past contact with other people with bed bugs. This could also address the issue of unreliable survey respondents. If the study could go more in-depth with asking the respondents about their infestations, the researchers could evaluate whether the interviewee actually had bed bugs.

Conclusion

I found that specific human behaviors, such as taking in second-hand furniture and neglecting to inspect it, increased the likelihood of bed bug infestations. Furthermore, I found that group housing environments were more susceptible to infestations, potentially due to a culture of sharing and the proximity of inhabitants. This study provides knowledge into the particular details behind factors of bed bug infestations that had been lacking in research in the past. There is much research to be done in all areas that affect bed bug infestations, including

preventative methods, educational materials, and housing policy. This study can prove useful in identifying unique aspects of human behavior and types of housing that affect rates of infestation.

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