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COMPARISON OF THE COST EFFICIENCY OF ELECTRONIC BED BUG MONITORS WITH PASSIVE BED BUG MONITORS IN APARTMENTS

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Abstract. Proactive monitoring is consistently being recommended as a method of rapid bed bug detection in multi-unit housing. The purpose of this study was to compare the cost and maintenance time required to implement either a passive or electronic bed bug monitoring system in multi-unit facilities. While the material costs of implementing a passive system was found to be more affordable than those of an electronic system, the maintenance time needed to check passive monitors (on a regular basis) greatly exceeded that of the electronic system. Overall, it was determined that although the electronic system implementation would require some technological advances before they could be widely used in apartment complexes, their efficiency for use in large multi-unit facilities would greatly exceed that of the passive monitoring systems, simply because they did not require regular (monthly) visual inspections.

Key words *Cimex lectularius*, pro-active monitoring, passive, electronic, detection

INTRODUCTION

The bed bug resurgence in the United States has been a continuous and increasing problem over the last two decades. While the media still tends to focus on bed bugs in hotels and other high visibility name-brand locations, the majority of infestations have been consistently found in multi-unit housing facilities. The demographic that has been particularly plagued by bed bug infestations is the elderly/disabled. Unfortunately, these vulnerable citizens make up a large percentage of the residents living in low-income multi-unit housing.

It is fairly well known that elderly/disabled residents often do not detect bed bugs in their homes as quickly as younger residents. This is because in many cases, elderly people do not react to the bed bug bites. In addition, many of the elderly residents have poor vision and may not be able to see the bed bugs, or bed bug evidence until the bed bug population has become well established. The consequence of not recognizing bed bug introductions early on, is that the bed bugs then have time to reproduce and spread within the housing facilities.

While there is still no viable way to keep residents from accidentally bringing bed bugs in to their homes, there are documented methods for detecting bed bugs soon after they are introduced. These methods include proactive monitoring and inspection. Inspections can be conducted by pest management professionals, or by bed bug sniffing canines. While regular bed bug inspections (human or canine) should be conducted in apartment facilities on a monthly or quarterly basis, the cost can quickly become prohibitive for the apartment owner.

Recent studies have shown that passive bed bug monitors can also be used to detect bed bug introductions if the monitors are inspected on a regular basis (Wang et al. 2011). Since 2010, passive monitoring has become well known as a way of detecting incipient bed bug infestations. Passive bed bug monitors are basically plastic bowls with textured exterior surfaces so that bed bugs can climb into the monitor. The bugs then fall into the slick interior of the monitor from which they cannot escape. These monitors can be placed in multiple locations around the home and then checked regularly to see if a bed bug is trapped inside. Cooper et al. (2015) conducted monitoring studies in government subsidized housing in New Jersey, USA and determined that passive monitoring could detect low level infestations, and even eliminate those infestations if multiple monitors were placed into the apartment units. Vail and Chandler (2017) determined that if the monitors were to be used simply as bed bug detection devices, only two monitors were needed to detect low-level populations within a four-week period.

In 2014, an electronic bed bug monitoring system was been developed. This electronic system alerts the designated monitor inspector on their telephone when a bed bug is captured in the device (Delta Five Bed Bug Monitor, Delta Five LLC. Raleigh, NC USA). The Delta Five electronic monitor is a small, inconspicuous device that has been marketed to hotels and other businesses where the managers must be very conscious of bed bug introductions. The electronic monitor is plugged into an electrical outlet which heats the monitor and turns on an interior camera. The electronic monitor contains an attractant lure, and two capture chambers. When an insect that enters one of the capture chambers and internal camera photographs the insect. Upon installation, each monitoring device is connected to the wireless internet (wifi) system, the wifi will then record any insect entry onto a central computer dashboard. The dashboard will alert the connected recipient on their cell phone when an insect is captured. The recipient will receive the monitor number and the photograph of the captured insect. The advantage of this electronic monitor is that, rather than having to pay someone to visually check all passive monitors at given time intervals (e.g. once a month), the Delta Five system will alert the desired recipient when there is a reason to check the monitor.

Although the use of the electronic monitoring systems would seem ideal for most all situations, the price of the electronic monitors is greater ($50 US each plus a $5.00 US connection fee for the wifi) than that of the passive monitors (~$5.00 US). However, it needs to be taken into consideration that the amount of time (cost per minute) for a human to check each passive monitor in a multi-unit housing facility may be somewhat prohibitive. It is interesting to note that at this time, there is no widespread use of any bed bug monitors in multi-unit housing, even though the passive monitors are relatively inexpensive. Is it possible that the electronic monitors be more cost effective than the less expensive passive monitors when large numbers of apartment units are in need of a proactive program? This study presents the preliminary data obtained from the first month of a year-long bed bug monitoring study. The overall purpose of this study is to compare the costs (product and maintenance time spent) of passive monitors with that of electronic monitors installed for bed bug detection in the field. We took the material costs and the time to inspect the monitors and multiplied them by different numbers of apartment units to project the cost and amount of inspection time required to monitor housing facilities of different sizes (50 units, 100 units, 1000 units, and 4000 units).

MATERIALS AND METHODS

Study site. M.S. Hayworth apartments is a government subsidized housing community for low-income elderly and disabled residents (Rocky Mount, N.C. USA). The residents pay up to 30% of their monthly income for their rent (minimum $25 US), or they can choose to pay a flat rate of $280 (US) per month. The M.S. Hayworth apartments are contained in a single two story-building of slab-on ground construction. The building consists of forty single-bedroom apartments, that are each ~65m^2. Although the exact number of bed bug infestations in this building has not been consistently recorded, the facility has been treated for multiple bed bug introductions and infestations over the last decade. In each case, the current pest management contractor (multiple contractors over the last 10 years) for the Rocky Mount Housing Authority was called in to treat the unit. Professional treatments have included two-week follow-up inspections, and additional pesticide treatment if live bed bugs are found. However, there has been any proactive inspections conducted or any monitoring to determine if there are bed bugs in units that residents have failed to report.

Monitor preparation. ***Passive monitors*****.** Prior to installation, all of the passive monitors were labelled with apartment number and the letter "A" if the monitor was to be placed in the living room, or "B" if it was to be located in the bedroom. The time taken to label each monitor was recorded (40 monitors total). ***Electronic monitors***. Prior to installation, all electronic monitors had to be configured to communicate with a wireless internet system (wifi) system. Because the M.S. Hayword building had no central wifi, a local "hotspot" was created and all of the electronic monitors were configured to communicate with the "hotspot". The time taken to configure the monitors to communicate with the "hotspot" was recorded (20 monitors total).

Monitor installation. Our study began in October of 2017. Twenty apartment units were randomly selected to receive either two of the passive monitors or one electronic monitor. In each of the units selected to receive the passive monitors, one monitor was placed in the bedroom, as close to the head of the bed as possible. The second monitor was placed in the living room, either under or near the couch or chair that had the best view of the television.

In units that were selected for testing the electronic monitors, each monitor was plugged in near the head of the bed, or in the wall outlet next to the bed. Each monitor had an adhesive strip on the back so that it could be "stuck" to the wall surface. Because of the small size of the bedrooms in the facility, the electrical outlet locations in the bedrooms allowed for all of the electronic monitors to be adhered to the wall right next to the mattress or box springs.

The time it took to knock on the door and gain access to each apartment unit was recorded. Once inside the apartment the time it took to install either both passive monitors, or the single electronic monitor was also recorded. Communication with the resident (all residents had questions) was also included as part of the monitor installation time.

Passive monitor inspections. All of the passive monitors were inspected every month. Residents were provided with monthly notices that inspector were coming to check the monitors. A timer was started when inspector began knocking on the door. Inspectors knocked on the door a total of 3 times, if there was no response to the initial knock. Inspector waited ~ $\leq$10 seconds between knocks, if there was no response. If there was no answer, the housing maintenance person unlocked the door for inspectors to enter. Entry time was recorded.

After gaining entry into the unit, the timer was restarted to record the amount of time it took to locate the individual monitors, inspect them, clean them (if necessary), and replace them. If bed bugs were found in a monitor, the time it took to count the bed bug numbers at each monitor location ("A or B") was recorded.

Response to electronic monitor alerts. Electronic monitor alerts from the Delta Five dashboard were sent directly to Mr. Timothy Pierce, who served as the field facilities supervisor for this study. Mr. Pierce had been familiarized with the Delta Five system and trained in how to inspect the monitors as well as to record the monitor inspection time. Upon notification from the Delta Five dashboard, Mr. Pierce would travel to the M.S. Haywood facility and record the amount of time it took him to gain access to the apartment unit, inspect the monitor catch chambers, and record what was found. Included in this time was the removal of the insect(s) from the chamber, time spent replacing the monitor, and explaining to the residents what was found.

Costs, Installation, and Maintenance Time. The data presented in this study includes the material cost of the passive monitors and the electronic monitors for their respective (20) test units. This included the $5.00 "wifi" configuration fee for each of the electronic monitors. The monitor installation data includes the average amount of time that it took to label the passive monitors and to configure each of the electronic monitors to communicate with the "hotspot". The average time that it took to gain access to the apartment (knocking on the door etc.) was recorded across all 40 test units.

The total amount of time that it took to place both of the passive monitors in their pre-determined locations in all 20 test units was compared with the total amount of time it took to plug in and adhere each electronic monitor to the wall surface. Electronic monitors were also checked to make sure that they recognized the "hotspot" installation (an LED light on the monitor would blink upon installation but then turn off once it recognized the "hot spot").

Passive monitor inspection and maintenance. The passive monitors had to be checked visually every month. Therefore, the total amount of time required to locate and check both monitors (and clean them if necessary) was recorded for all 20 apartment units.

Electronic monitor inspection and maintenance. During the first month of the study, four alerts were received, indicating that an insect had been captured in the electronic monitor. The total amount of time that it took to check the four monitors (and talk to the alarmed residents) was recorded.

Projection of costs and inspection time for both monitoring programs.

Cost and maintenance data were compared for both monitoring systems. This data was also used to project the potential cost and time needed to implement and maintain these monitoring systems in larger multi-unit housing facilities, that would contain more housing units. In other words, the actual material cost for placing electronic or passive monitors in 20 units was used to project the material cost of placing the monitors in 100, 500, 1000, and 4000 apartment units.

Similar to the cost projection data, the total amount of time spent inspecting and maintaining the passive monitors in the 20 test units was used to project the amount of time it would take to conduct the inspection and maintenance of the passive monitors in apartment facilities that had 100, 500, 1000, or 4000 units. This data projection of the amount of time it would take to inspect passive monitors in large multi-unit housing facilities was then compared with that of the electronic monitors that did not require all units to be checked at regular intervals.

Because only four units out of the 20 (0.2) electronic monitor apartments required inspection during the first month of the study, the total time needed to inspect one-fifth of the apartments in a facility was used to project inspection times for facilities that would have larger numbers of units. The inspection time was calculated to determine the time need to inspect monitors in one-fifth of apartments in facilities that had 100, 500 1000 and 4000 units.

RESULTS AND DISCUSSION

This study was intended to quantify the material costs and time required to install and maintain a proactive bed bug monitoring program. Overall, we were able to quantify the costs of the passive monitoring program and compare it with the costs of the electronic monitoring program. In addition, we were able to use these actual costs to predict the potential costs of implementing these programs in facilities of different sizes (large numbers of units).

Overall, the average amount of time needed to gain access into an apartment unit in the elderly housing facility (knocking on the door etc.) was 38 seconds. The average amount of time that it took to install two of the passive monitors (2 min 14 sec) was less than the amount of time that it took to install an electronic monitor (2 min 38 sec).

Table 1. Actual costs of purchasing and implementing the Delta Five electronic monitoring system (20 units) and the Black Out passive monitoring system (20 units) in the M. S. Hayworth multi-unit housing facility. The actual costs were used to project the costs and time needed to implement and maintain these same monitoring systems in multi-unit housing facilities of different sizes (100, 500, 1000, and 4000 housing units).

Delta Five Electronic Monitor ($55.00 USD)	Black Out Passive Monitors (2@ $5.00 each USD)
Actual Cost and Time (Field Data) ***20 apartment units- Total material cost $1100*** ***(20 units) 52 min 40 sec: Total time to install*** ***(4 alerts) 17 min 24 sec: Total time to check***	**Actual Cost and Time (Field Data)** ***20 units-$200*** ***(20) 44 min 40 sec*** ***(20) 55 min 40 sec (1 h)***
Projected Cost and Time 100 apartment units- $5500 (100 units) 263 min 20 sec (20 units) 87 min 4 sec **(~1.5 h)**	**Projected Cost and Time** 100 apartment units-$1000 (100 units) 223 min 20 sec (100 units) 278 min 20 sec (**5 h**)
Projected Cost and Time 500 apartment units-$27,500 (500 units) 1316 min 40 sec (100 units) 435 min 0 sec (**7.3 h)**	**Projected Cost and Time** 500 apartment units-$5,000 (500 units) 1,116 min 40 sec (500 units) 1391 min 40 sec (**23 h**)
Projected Cost and Time 1000 apartment units- $55,000 (1000 units) 2633 min 20 sec (200 units) 870 min 0 sec (**14.5 h**)	**Projected Cost and Time** 1000 apartment units-$10,000 (1000 units) 2233 min 20 sec (1000 units) 2783 min 20 sec (**46 h**)
Projected Cost and Time 4000 apartment units-$220,000 (4000 units) 10,533 min 20 sec (800 units) 3,480 min 0 sec **(58 h or 1.5 work weeks)**	**Projected Cost and Time** 4000 apartment units- $40,000 (4000 units) 8,933 min 20 sec (4000 units) 11,133 min 20 sec **(186 h or 4.6 work weeks**)

During the first month of the study, there were a total of four positive alerts in different apartment units using the electronic monitors. One of the alerts indicated that a bed bug had been captured. The other three alerts indicated that the monitors had captured an ant and a cockroach. Upon inspection of the capture chambers, one monitor did contain a bed bug. The other three monitors captured an odorous house ant, a carpenter ant, and a German cockroach nymph. The average amount of time that it took to inspect the electronic monitor capture chambers, record trap catch, and replace the monitor, was 4 minutes and 21 sec. Although only 4 monitors had to be checked during the month, this process of checking one monitor took longer than that required to check two of the passive monitors at 2 min 27 sec. This relatively lengthy inspection time for the electronic monitors did not have to do with checking the monitor itself. Instead the inspection time was increased because the residents were surprised by the unexpected arrival of the

inspector, and concerned about a bed bug being detected in their monitor. The residents had many questions, thus increasing the amount of time needed to conduct the inspection.

One of the final objectives of this preliminary study was to determine the costs of implementing the proactive monitoring programs in housing facilities of different sizes, with larger numbers of units. Table 1 presents the actual costs of purchasing, installing, and maintaining the two types of monitoring systems in 20 units. Table 1 also lists the projected material costs and maintenance time in housing facilities that have 100, 500, 1000, or 4000 units.

While the material costs of implementing a passive monitoring system in large housing developments ranged between $100-$40,000 US (100-4000 units), this was still much less expensive than the material cost of the electronic system being placed in the same number of units ($5,500-$220,000 US). Yet, these material expenses would be considered a one-time cost.

In contrast, the amount of time needed to check the passive monitors in a large housing facility (e.g. 4000 units) would require that more than a month to check all units a single time. This is because every monitor would have to be checked individually (8000 monitors). This would be a constant recurring labor cost. Alternatively, if (as predicted by the first month number of alerts) only one-fifth of the electronic monitors had alerts each month, the inspection time for the same number of monitored units would only amount to 60 hours. Thus, the costs in time for the electronic monitoring system becomes more economical as the number of apartment units increases.

Summary. Currently, hotels are the primary market for electronic bed bug monitoring systems. This is because hotels have centralized wifi that serves the entire facility. As of 2020, most apartment building do not have centralized wifi. Instead, internet service is purchased individually by apartment residents. However, as the technology advances, we can fully expect to see more centralized internet systems being developed for use in apartment facilities. These systems could then be used to connect electronic bed bug monitoring devices. While the projected costs of electronic monitoring may look prohibitive at this point in time, these electronic systems (that do not require regular human inspection) will no doubt become more widely used as the need for early bed bug detection, and labor costs continue to increase.

REFERENCES CITED

Cooper, R., C. Wang and N. Singh. 2016. Effects of various interventions including mass trapping with passive pitfall traps on low-level bed bug populations in apartments. J. Econ. Entomol. 109:762-769. Doi:10.1093/jee/tov337.

Vail, K. M. and J. G. Chandler. 2017. Bed Bug (Hemiptera: Cimicidae) detection in low-income, high-rise apartments using four or fewer passive monitors. J. Econ. Entomol. 110: 1187-1194. Doi: 10.1093/jee/tox053

Wang, C., W. Tsai, R. Cooper and J. White. 2011. Effectiveness of bed bug monitors for detecting and trapping bed bugs in apartments. J. Econ. Entomol. 104: 274-278. DOI: 10.1603/EC1014.