National Assessment of Bed Bug Impacts and Demonstration of IPM in High-risk Elder/Disabled Housing Facility

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PROJECT IMPACT STATEMENT

Objective 1: Identify constraints to greater adoption of IPM strategies and determine appropriate IPM approaches via national assessment of bed bug impacts on society, acquisition risk factors, and pesticide use (Research).

Impacts: Provided baseline data for the development and implementation of sustainable IPM strategies in elder/disabled housing facilities. The bed bug survey tools and data were made available to stakeholders nationally, laying a foundation for future program expansion based on documented quality-of-life impacts.

Objective 2: Develop and provide bed bug and German cockroach IPM outreach and training to individuals involved with the elder/disabled housing facilities (Extension).

Impacts: Improved stakeholder awareness and knowledge regarding pests and IPM practices. Improved awareness and knowledge of bed bug and German cockroach management, chemical risks and pesticide safety for target audiences (indicated using pre and post event surveys and changes in pest management practices). Increased the communication and efficiency in IPM practices through information exchanges among IPM practitioners and service providers.

Objective 3: Develop educational materials and information delivery systems for effective IPM outreach efforts (Extension).

Impacts: Improved stakeholder awareness regarding pests and IPM practices in their environments. Increased the communication and sharing of resources and provide benefits to more than one state/territory via regional and national collaborations. Promoted cooperative efforts across appropriate disciplines. Networks improved information flow among IPM components, stakeholders, and IPM research, education, and Extension communities.

Objective 4: Enhance the development and implementation of sustainable bed bug and German cockroach IPM strategies in elderly/disabled housing facilities (Extension) and measure the impacts of IPM adoption in the same facilities (Research).

Impacts: Increased awareness and knowledge of IPM among residents, facility management teams, pest management personnel as housing facility adopters highlight program activities and outcomes among other communities.

Reduced risk of negative health impacts related to pest infestation and pesticide use.

Improved quality of life of residents living in elderly/disabled housing, and staff working in the facilities.

Objectives:

1) Identify constraints to greater adoption of IPM strategies and determine appropriate IPM approaches via national assessment of bed bug impacts on society, acquisition risk factors, and pesticide use (Research).

1) Major activities completed / experiments conducted

Residents (mostly based in the continental U.S.) visiting .edu and .org websites conducting online searches for information on bed bugs, accessed solicitations to complete an online survey about bed bug impacts. People who have never experienced bed bugs, people with a history but no current infestation, and people with current infestations were asked to answer a series of questions (see Appendix 1: https://cals.arizona.edu/apmc/docs/Appendix-1_VF-012914-Survey_23105095.pdf and Appendix 2: https://cals.arizona.edu/apmc/docs/Appendix-2_VF-Spanish-Survey_37331487.pdf). Solicitations were placed on university resource sites, and a number of public health resource sites (e.g., National Pesticide Information Center) in English and Spanish.

2) Data collected

Between 01/08/2013 and 11/19/2017 only 38 responses in Spanish were obtained despite the fact that links were placed on Spanish language websites. We concluded that online surveys were not a useful method to gather bed bug impact from Spanish speaking only residents. During the same time interval 762 responses to the English survey were received. Based on the responses the English survey was modified and refined 3 times. The final version can be seen in Appendix 3: https://cals.arizona.edu/apmc/docs/Appendix-3_BedBug-Survey-V6.pdf.

3) Summary statistics and discussion of results

38% of respondents were currently living with bed bugs, 16% of respondents had experienced bed bugs in the past, and 46% of people had never experienced bed bugs. The majority of respondents identified as female.

Current or historical bed bug infestation vs no bed bug history

Stratified (blocked) contingency tables (Cochran-Mantel-Haenszel test of general association); effects based on a priori hypotheses permitted by sample sizes are as follows:

- Income (poverty vs no poverty) based on Federal Register 2016 poverty guidelines
- Children (present vs absent)
- Living arrangements (renting vs alternate vs owning)
- Mobility (moved, traveled, hosted visitors ≥ 4 times, acquired 2nd hand furnishings ≥ 2 times/year vs none of these)

Poverty stratified over children present, living arrangements, and mobility showed that poverty was associated with bed bug infestations across other effects (General Association = 29.40, df = 1, P < 0.01, n = 537; Figure 1).

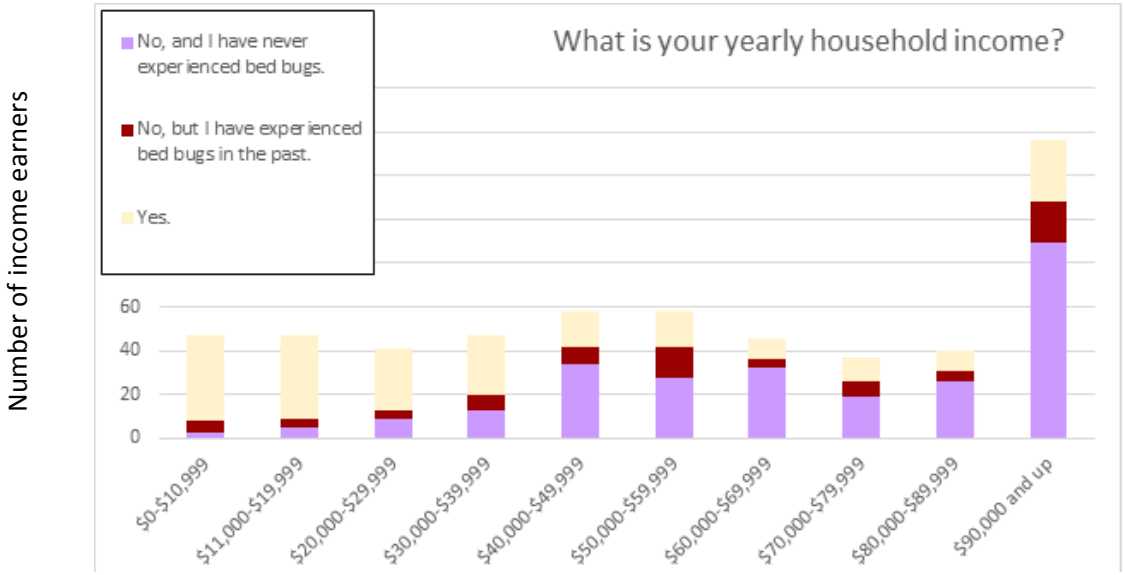
Living stratified over children present, poverty, and mobility showed that owning (including buying a home) is associated with lower incidence of bed bugs compared with renting or alternative housing arrangements (General Association = 35.14, df = 2, P < 0.01, n = 537).

Mobility stratified over children present, living arrangements, and poverty showed that increased mobility is associated with a lower incidence of bed bug infestation (General Association = 4.43, df = 1, P < 0.035, n = 537).

Children stratified over living arrangements, poverty, and mobility showed that the presence of children is weakly associated with bed bug infestation (General Association = 2.95, df = 1, P < 0.086, n = 537).

The most commonly reported impacts caused by bed bugs (current and past) are 1) sleep loss; 2) anxiety; 3) depression; 4) concerns about transferring bed bugs elsewhere; 5) financial losses.

Figure 1. People with lower annual income reported more infestations



Residents reported the following:

About 41% of residents determined that they had bed bugs based on pest management professional advice. Another 40% determined the presence of bed bugs on their own, leaving 19% to rely on advice from others. Only 2.4% of respondents had used university Extension professionals to identify the pest.

35% of respondents had been living with bed bugs for more than 6 months. 20% had no obvious bite reaction, but over 60% reported bite reactions including 7% that sought medical attention because of the severity of their reactions.

More than 60% of residents living with bed bugs reported feeling of isolation, with 5% expressing thoughts of self-harming and 2% reporting that they had harmed themselves. A shockingly alarming 13% of residents living with bed bugs and with a history of bed bugs reported suicidal ideation as a result of the stress.

Most people attempted to resolve infestations using retail products, 36% of people used a pest management company using pesticidal remediation alone, 9% used companies that included heat or cold treatments, 6% of residents used canine detection as part of the process, 5% of residents received pro bono treatments, and 10% of property owners completed treatments of rental properties.

Residents reported using a variety of strategies themselves summarized in Table 1.

Table 1. Percentage of residents taking control actions who had an active or historical bed bug infestation

Powders	64%
Aerosols	60%
Mothballs	7%
Encasements	58%
Gasoline	7%
Kerosene	4%
Alcohol	40%
DEET or other insect repellents	16%
Windex	11%
Vaseline	9%
Heating or cooling your home using in-home air-conditioners or home heating system	20%
Steam	33%
Vacuuming	91%
Laundering	100%
Interceptor traps (placed under bed legs)	29%
Sticky insect traps	33%
Volcano traps	7%
Other kinds of commercially available bed bug traps	11%
Homemade bed bug traps	11%

Additionally, 36% of residents with infestations report applying pesticides more than 8 times, and only 3% report success. 84% of residents said they would contract with a professional company if they could afford to do so.

More than 75% of residents who had experienced a bed bug infestation in the past reported modifying their behavior as a result of the experience. More than 60% of residents who had no experience of bed bugs at all report modifying their behavior as a result of bed bug reports in general.

A change in knowledge

Survey findings have been presented to fellow entomologists during International Congress of Entomology 2016.

A change in action N/A

A change in condition N/A

2) Develop and provide bed bug and German cockroach IPM outreach and training to individuals involved with the elder/disabled housing facilities (Extension).

Educated residents, pest management professionals, and facility managers about bed bugs, German cockroaches, pesticide safety and IPM via stakeholder dialog sessions, needs assessments, informal discussion groups, one-on-one consultations, meetings with facility management teams, etc. Delivered 887 (220 in Y1, 456 in Y2, and 211 in Y3) Arizona Office of Pest Management (AZ OPM, for urban pest management) continuing education units (CEUs) to the pest management professionals, 50 National Environmental Health Association (NEHA) CEUs in Y2 and 9 Arizona Department of Agriculture (AZ ADA) CEUs in Y2. We conducted trainings, workshops, and outreach events for Phoenix Housing Maintenance staff, residents, facility managers and general public regarding IPM strategies for bed bugs and German cockroaches.

1) Major activities completed / experiments conducted

Integrated Pest Management training occurred in multiple formats throughout the grant period (July 2015 – November 2017).

- All 5 sites received multiple whole-building assessments that were used not only to determine active infestation levels, but as hands-on practicums for facility management teams (Table 2).
- Four of the five sites received resident outreach events specifically focused on the topic of bed bugs (Table 2 and Appendix 4: https://cals.arizona.edu/apmc/docs/Appendix-4_Resident-outreach-event-Flyer.pdf).
- Facility management teams received constant updates and pest management recommendations, along with the explanations of why the changes would elicit improvements.
- Facility maintenance staff received annual training on how to work around bed bugs and avoid taking them home as part of their regular training days.

2) Data collected

Maintenance and management staff participated in experiential learning during each site visit, as well as classroom style annual continuing education safety education events. Several became bed bug and German cockroach experts, surpassing the expertise of their contracted pest management service providers.

Regular communication, and timely response to calls for assistance played a critically important part of convincing on-site staff that IPM was an effective approach, and upper administration teams that IPM was necessary and ultimately cost effective (Table 3). Initially two of the five locations were under threat of closure because of HUD assessments, and severe pest infestations. Significant increases in pest management costs occurred throughout, but no closures occurred and although the exact

economics continue to be baffling, City housing leads confirm that closures would have resulted in the highest expenses.

Table 2. Whole-building site assessments

Site	Number of units	Initial assessment	Interim assessments	Final assessment	Resident outreach	Other spot assessments
1	156	07/27/2015 08/13/2015	01/07/2016 02/01/2016	07/20/2016 09/09/2016 11/03/2017	4/15/2016	Bimonthly 07/27/2015- 11/03/2017
2	108	08/02/2016 09/14/2016		04/04/2017 05/20/2017	11/02/2016 (see Appendix 4)	
3	120	06/02/2016 07/13/2016	03/28/2017 04/25/2017	09/01/2017 09/11/2017 11/03/2017	08/05/2016	Bimonthly 08/02/2016- 11/03/2017
4	112	11/09/2016 12/20/2016	04/13/2017 5/19/2017	09/11/2017 09/18/2017 11/03/2017		Bimonthly 11/09/2016- 11/03/2017
5	116	11/10/2016 12/21/2016		5/26/2017 06/27/2017	04/07/2017	

Table 3. Site visits and communication

Site	Site visits	Communications (phone, email)	Reports to site manager
1	**21**	**>112**	**20**
2	**5**	**>13**	**5**
3	**19**	**>52**	**19**
4	**7**	**>17**	**7**
5	**5**	**>10**	**5**

3) Summary statistics and discussion of results N/A

4) Key outcomes or other accomplishments realized

Extensive input was made regarding redrafting of the pest management service contract. Discussions and meetings began in July 2015 and a revised service contract finally went out for bids November 1st 2017.

A change in knowledge

Awareness of pest issues has dramatically improved, maintenance staff, facility managers, social workers, middle and upper housing administration teams, contracted pest management professionals and residents have improved awareness and greater knowledge.

A change in action

Pest management practices have changed extensively, management protocols for German cockroaches, bed bugs and house mice have improved greatly (see objective 4).

A change in condition

Described fully under objective 4.

Reduced risk of negative health impacts related to pest infestation and pesticide use.

Improved quality of life of residents living in elderly/disabled housing, and staff working in the facilities.

3) Develop educational materials and information delivery systems for effective IPM outreach efforts (Extension).

Reached about 29,000 participants in meetings, workshops and conferences, demonstrations and outreach events, including pest management professionals, health care staff, environmental health professionals, facility managers, nurses, school personnel, industry representatives, pesticide applicators, homeowners, residents, representatives from numerous tribes and tribal organizations, racial and ethnic minorities that work in urban sectors. The monthly newsletter reached more than 5,000 readers nationwide each month. Outputs are summarized in Table 4.

Table 4. Summary of outputs

Conference Papers and Presentations Abstracts	7	
Conference Papers and Presentations	10	
Community Presentations	85	
Journal Articles	11	
Monthly newsletters	21	
Other (Extension publications, Reports, Popular Press and Trade)	17	
Websites	https://cals.arizona.edu/apmc/public-health-IPM.html	Public Health IPM in Community Environments http://cals.arizona.edu/apmc/public-health-IPM. This website hosts the ARDP project - Gouge 2014 "National Assessment of Bed Bug Impacts and Demonstration of IPM in High-risk Elder/Disabled Housing Facility", including the purpose and background, team members, bed bug impact assessment survey and survey reports, and project-related outputs and materials. The website is maintained constantly and updated regularly. Some examples of outputs are as follows: • 2016 NEHA EEK: Vectors and Public Health Pests Virtual

		Conference Presentation: Bed bugs in Elderly and Disabled, Low-income Housing - Getting Real! http://neha.org/sites/default/files/news-events/workshop/Dawn_Gouge.pdf • 2016 NEHA EEK: Vectors and Public Health Pests Virtual Conference Presentation: Bed Bug (*Cimex lectularius* L.) Infestations Impact Quality of Life. http://neha.org/sites/default/files/news-events/workshop/Lucy_Li_Bedbugs.pdf • Bed bug survey report in November 2015 http://cals.arizona.edu/apmc/docs/Bed-bug-survey-reports-Nov2015.pdf • Poster for general public – Bed Bugs Integrated Pest Management http://cals.arizona.edu/apmc/docs/Bed-Bugs-IPM.pdf • Bed bug adventure game http://cals.arizona.edu/apmc/docs/Bed-bug-adventure-game.pdf • Bed bug journey learning objectives: http://cals.arizona.edu/apmc/docs/Bed-Bug-Journey-Learning-Objectives.pdf
Audio or Video	3	Newly created videos: • Bed bug infested units at site 1 in Phoenix http://cals.arizona.edu/apmc/docs/Phoenix-Bedbugs.mp4. This video has been produced to visually explain the bed bugs infestation level at site 1 in Phoenix. • Cockroach infested units at site 1 in Phoenix http://cals.arizona.edu/apmc/docs/Phoenix-Cockroach.mp4. This video has been produced to visually explain the cockroaches infestation level at site 1 in Phoenix. • Over the counter (OTC) pesticides used by residents at site 1 in Phoenix http://cals.arizona.edu/apmc/docs/Phoenix-Site1-Pesticides.mp4. This video has been produced to visually explain the over-the-counter pesticides used by residents at site 1 in Phoenix.
Educational Aids or Curricula	Bed bug adventure game and the associated bed bug journey learning objectives; poster	We have developed this bed bug adventure game and the associated bed bug journey learning objectives specifically for trainings and outreach events at the elder/disabled housing facilities. • Bed bug adventure game http://cals.arizona.edu/apmc/docs/Bed-bug-adventure-game.pdf • Bed bug journey learning objectives: http://cals.arizona.edu/apmc/docs/Bed-Bug-Journey-Learning-Objectives.pdf We have created this poster targeting the general public to learn more about bed bugs and bed bugs IPM. http://cals.arizona.edu/apmc/docs/Bed-Bugs-IPM.pdf

Survey Instruments	A national online bed bug survey	A national online bed bug survey was launched in 2014 (1) to identify risk factors most associated with bed bug infestations; (2) to document specific stresses attributed to dealing with bed bugs by people who have experienced infestations; and (3) to examine and compare pest management practices, including pesticide use, of people who have and have not experienced bed bug infestations. The anonymous online survey was implemented on SurveyMonkey following Institutional Review Board (IRB) approval of the survey instrument and methods. Information and documentation can be found at http://cals.arizona.edu/apmc/public-health-IPM. As a result of suicidal ideation entries and feedback from EPA bed bug IPM specialists the survey questions were modified upon the approval of IRB in August 2016. View the most recent survey http://cals.arizona.edu/apmc/docs/Bed-bug-Survey-new-2016Sep.pdf

4) Enhance the development and implementation of sustainable bed bug and German cockroach IPM strategies in elderly/disabled housing facilities (Extension) and measure the impacts of IPM adoption in the same facilities (Research).

1) Major activities completed / experiments conducted

The three most severely infested sites were assessed most extensively, and received the most face-to-face visits and assessments. All sites went through an initial and final whole-building assessment during which German cockroaches, bed bugs, other pests were monitored for in each apartment, common area and office. As the action threshold for bed bugs and German cockroaches was set at one, the percent of units infested was the most carefully tracked data point (not the continuous counting of insects per unit). Both visual assessments and sticky monitoring traps, and Activ Volcano traps were used to determine which units were infested. Although the level of infestation was tracked, the aim was to reduce the number of units infested to as close to zero as possible. Only one site had units with mice in several apartments.

Clutter, and sanitation scores were all assessed by Dr. Shujuan Li. Sanitation and clutter was assessed as a 1-5 score system, with one being the best and five being the most cluttered, and the poorest sanitation standard.

Residents and facility staff associated with the first site were surveyed regarding their satisfaction with pests and pest management before IPM recommendations were put in place and after.

Resident pesticide use was documented, as well as the existing contracted pest management practices.

2) Data collected

Whole-building assessments established the percentage of units infested with German cockroaches and bed bugs. Severity of infestation was assessed initially, but proved to be too difficult to be an adoptable assessment protocol for housing staff. An inspection protocol useful for staff was adopted, and put into use to determine if this was an effective approach (Table 5).

Table 5. Initial and final pest infestation levels, sanitation and clutter scores.

		Initial assessment				Final assessment			
	Site	% German cockroaches	% Bed bugs	Clutter	Sanitation	% German cockroaches	% Bed bugs	Clutter	Sanitation
1	1	39.1	13.5	2.3	1.9	1.3	2.6	1.5	1.1
2	2	29.4	2.8	2.3	1.3	8.3	0	1.5	1.1
3	3	100	15	3.3	1.6	14.2	1.7	1.2	0.9
4	4	38	3.6	2.2	1.5	1.8	0.1	1.5	1.1
5	5	1.7	1.7	1.9	1.1	1.7	0	1.2	1

Retail (OTC & internet), illicit, and legacy pesticides were used by residents and between 32-60% of units had one or more pesticide products being used. The highest incidence of pesticide use by residents occurred in site 1 (60%). Site 1 had the youngest average resident age at the time the pesticide use was assessed, and the highest percentage of units infested with bed bugs. Site 3 had 100% of units infested with German cockroaches, and almost 30% of them had severely high populations (observation of >20 nymphs and adults during daytime hours, or more than 20 caught on a monitoring trap), but had the oldest average age of residents. Only 32% of site 3 apartments had resident owned pesticide products present.

Pesticide classes used by residents included those listed below, and we observed many instances of off-label use, excessive use, no PPE, one clear case of dangerous use requiring hazardous material cleanup (Figure 2), and none of the residents reported that they reported the label.

- Pyrethrins/pyrethroid
- Phenylpyrazole
- Borates
- Diatomaceous earth/silica
- Amidinohydrazone
- Organophosphates
- Carbamates
- Second generation anticoagulant

Figure 2. Apartment in which Demon WP 40% cypermethrin had been sprayed so excessively the floor, walls, all surfaces were white, and kitchen cabinets and crockery were covered in the pesticide residue.

3) Summary statistics and discussion of results

It took over a year to get infestation levels under control in the most severely infested buildings, and site 2 and 3 still have an unacceptable number of units with German cockroaches, although only 1 unit in site 3 still has what would be described as a moderate infestation in one apartment (5-20 nymphs or adults observed during daytime hours, or 5-20 caught on a monitoring trap).

Pest infestation was drastically reduced (Figures 3 and 4).

Interestingly at all sites the clutter and the sanitation scores improved (Figures 5 and 6), despite the fact that we did not ask residents to alter the way they live. Our aim was to reduce pests without requiring residents to prepare for service, or help manage pests in their homes. We did discourage residents from risky behaviors known to increase the chances of bed bug acquisition. We believe that the regular visits to the locations, and personal relationships forged in the process greatly facilitated cooperation of the residents even though it was not required.

Analysis of the original pest management service contract revealed the following:

- No effective bed bug remediation measures in place.
- Baiting for cockroaches was stipulated, but was not actually being done.
- Many units were being passed by due to “insufficient prep”.
- Products used were being incorrectly reported on service slips.
- The pest management costs charged were less than $0.80 per month, per unit.

The following recommendations were made:

- **No** resident preparation of the unit was required.
- Details of an effective bed bug remediation plan using an IPM approach. Including unit transition requirements, and ongoing monitoring plan.
- Details of an effective German cockroach remediation plan using an IPM approach. Including an ongoing monitoring plan.
- IPM recommendations for house mice, pigeon remediation and Indian meal moth control.

Residents and staff were asked to indicate their satisfaction with pest infestation and pest management practices on a scale of 1 to 5, with 1 being extremely unsatisfied, and 5 being extremely satisfied. Both groups reported significant improvement in satisfaction (Table 6).

Table 6. Resident and staff pest infestation and pest management satisfaction scores (1 = extremely unsatisfied/needs immediate improvement; 2 = needs improvement; 3 = satisfied, but some pests occasionally; 4 = good, pests seen rarely; and 5 = extremely satisfied, no pests present.

Site 1	Initial scores averaged	Final scores averaged
Staff	1.7	4.2
Residents	1.5	4.2

Figure 3. German cockroach reductions

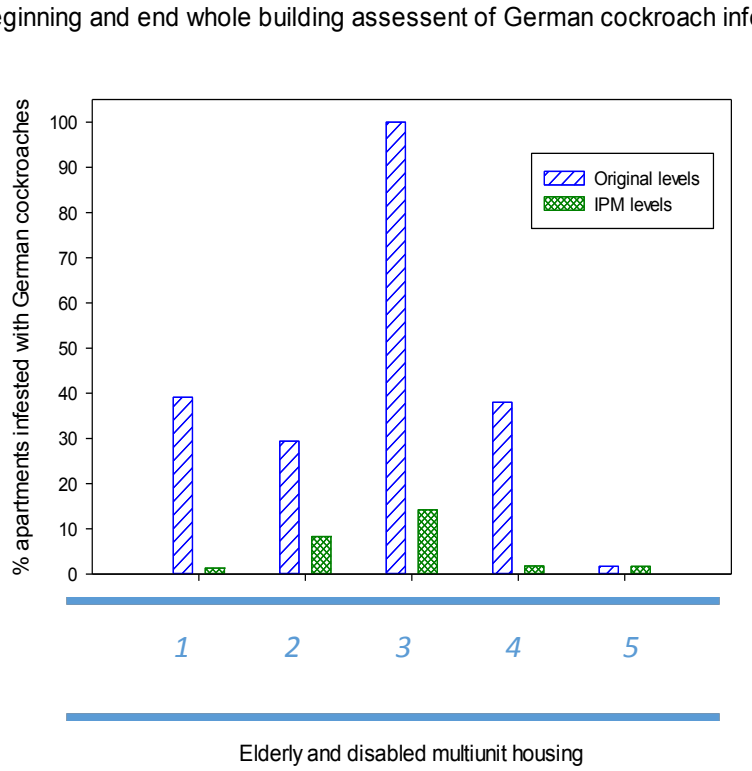


Figure 4. Bed bug reductions

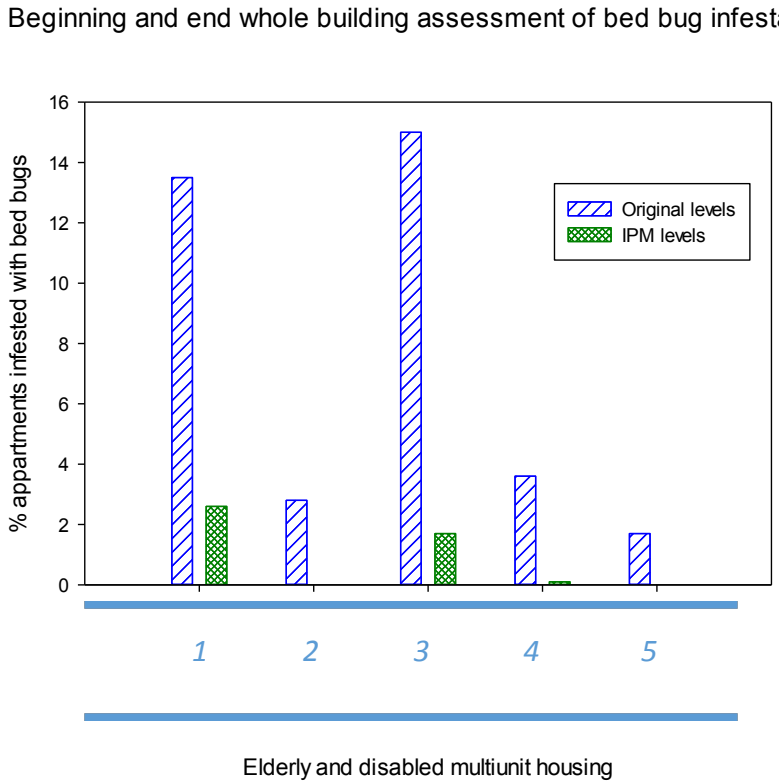


Figure 5. Clutter score improvements

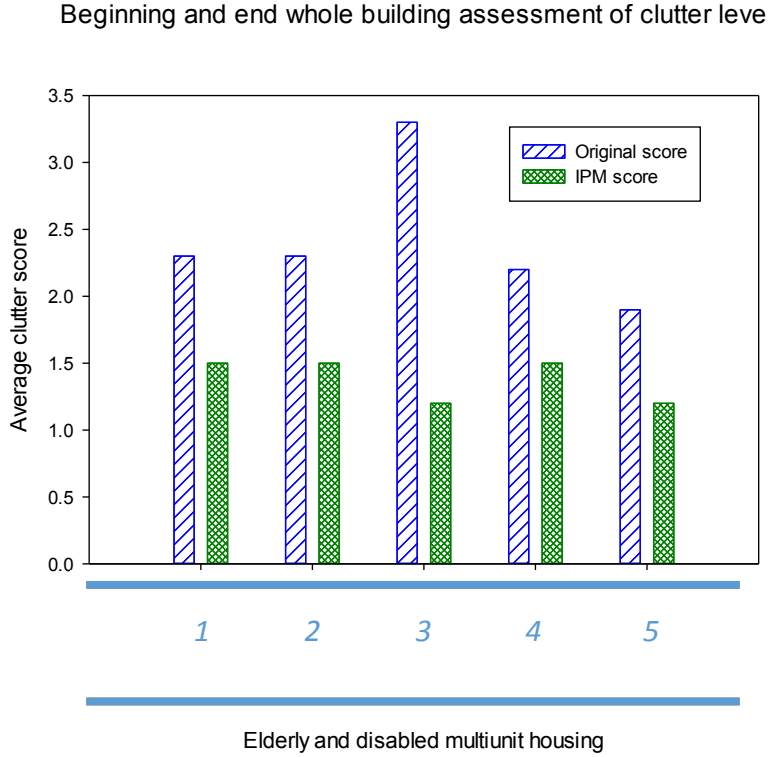
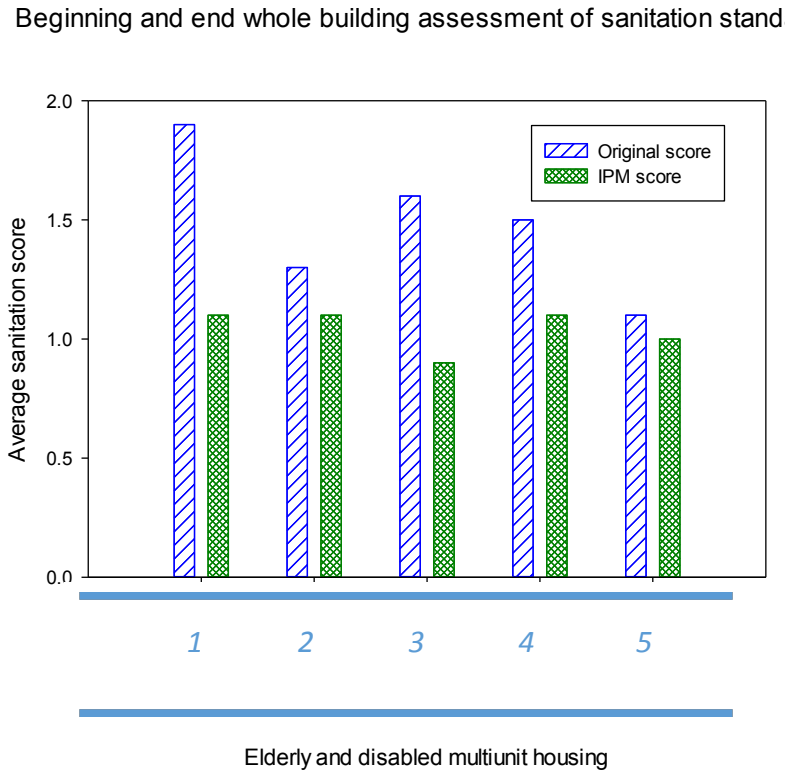


Figure 6. Sanitation score improvements



4) Key outcomes or other accomplishments realized.

A change in knowledge

Increased awareness and knowledge of IPM among residents, facility management teams, pest management personnel as housing facility adopters highlight program activities and outcomes among other communities.

A change in action

Pest management practices.

A change in condition

Reduced risk of negative health impacts related to pest infestation and pesticide use.

Improved quality of life of residents living in elderly/disabled housing, and staff working in the facilities.