Pesticide Exposure Controls

Environmental Health 557
Workplace exposure controls
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INTRODUCTION

The role of pest control in health and safety programs is often dominated by reliance on pesticides as a first and ultimate control method. Additionally the use of pesticides in public and workplace settings can be controversial and result in conflictual dialogues between stakeholders that fail to address the original choices for the pest treatment strategy. Efforts to control pest may result in excessive and unnecessary exposure to both pests (by failing to adequately control pests) and pesticides (by improperly releasing toxic compounds into an environment). These excessive exposures may be the result of poor choice of control measures, timing of the pest treatment and improper application techniques. Administration of pest control programs involves meeting certain regulatory requirements, above which improvements to programs may be viewed as "thought leadership". The ideal pest control program is modeled after voluntary consensus standards (VCS), of which many exist for pest control, and all involve some form of integrated pest management (IPM). The term integrated refers to the use of multiple tactics combined over space and time to control pests (Pedigo and Rice, 2006). The role of health and safety professionals in pest control is one of balancing the risk of injury from pests with the risk of injury from the pesticides themselves. This paper discusses aspects of pesticide exposure controls; the regulations and standards, evaluation methods and control methods for pest control programs. A case study of structural pest control at the University of Washington (UW) is used to illustrate how various methods can be used to draw conclusions about pest control programs and ends with some recommendations on how to improve upon UW's IPM.

REGULATIONS AND STANDARDS

Regulations

A myriad of pesticide regulations have been promulgated at the federal, state and local level with the intent of controlling pesticide pollution in order to protect the health of people and the environment. Given the level of pesticide regulation and the hazards posed by pesticide use, certain obligations and precautions should be considered for any organization with operations that include pesticides. In this vein the following information will highlight regulations and policies that are relevant for an effective pesticide health and safety program for colleges in the Washington state system, especially the University of Washington. Table 1 in appendix A provides a summary of the regulations discussed herein as well as other important regulations for preventing pesticide exposures.

The US EPA administers the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) under the authority of the Code of Federal Regulations (CFR) Title 7, Chapter 6. FIFRA regulates pesticides by requiring registration of pesticides for manufacturers and restricting pesticide application. FIFRA also requires manufacturers to provide labeling of products to inform the end user of the active ingredients and the proper application of the pesticide. US EPA also administers pesticide worker protection standards for agricultural workers (CFR 170). The OSHA pesticide standard covers all workplaces that use either of the following: fumigants, pesticides, insecticides or hazardous preservatives (CFR 29: OSHA Standard 1917.25).

At the state level general pesticide rules are in Washington Administrative Code (WAC) 16-288, with such laws as WAC 16-228-1200 that places restrictions on pesticide distribution, transportation, application, storage and disposal. Chapter 15.58 of Revised Code of Washington

(RCW) is the Washington pesticide control act wherein laws pertaining to licensing of pesticide applicators, registration of pesticides, and civil penalties for pesticide violations are provided.

For occupational health and safety Washington's worker protection standards regarding pesticides are found in WAC 16-233. These worker protection standards for WAC 16-233 essentially mirror portions of the federal agricultural worker protection standards. The pesticide worker protection standards include agricultural employer responsibilities and pesticide handling safety requirements and other important pesticide exposure controls. WAC 296-800-22020 requires all work places to control pests, thus any workplace in Washington with pest problems are required to carry out an effective pest control program.

For each Washington state institution of higher education RCW 17.15 is applicable with regard to pesticide health and safety. This regulation requires "all state agencies that have pest control responsibilities to follow the principles of integrated pest management". This chapter defines a "Pest" as follows:

"any insect, rodent, nematode, snail, slug, weed, and any form of plant or animal life or virus, except virus, bacteria, or other microorganisms on or in a living person or other animal or in or on processed food or beverages or pharmaceuticals, which is normally considered to be a pest, or which the director of the department of agriculture may declare to be a pest."

According to RCW 17.15.010, IPM is a decision-making and action process that takes advantage of environmentally and economically practical methods to control pests. An IPM program under these regulations is comprised of prevention techniques, monitoring for damage and pest population presence and density. Tolerance levels for damage or action levels for pest density should be set as these levels relate to protection of public health or aesthetics. Methods used to treat the pest problems, whether they are biological, cultural or chemical methods, should consider human health and ecological impact as well as the feasibility and cost-effectiveness of the control method used. Evaluation of treatment efficacy is required to determine if the pests were indeed controlled to below the set threshold level. The administration for each agency or institution is also required to designate a coordinator with specific IPM responsibilities such as ensuring IPM training for pest control personnel and to represent the organization at interagency IPM committee meetings. Table 2 in Appendix A shows the pest control requirements for the UW outlined in RCW 17.15.

The regulatory framework for pest control at the UW is codified in the Revised legal code of Washington and represents the minimum legal requirement for pest control programs. Additional regulations determine the appropriate pesticide use with regard to workers protection and healthy workplace establishment. Voluntary consensus standards (VCS) may provide guidance for site health and safety professional that wish to apply higher standards to their pest control programs.

Voluntary Consensus Standards

VCS are source for guidance on technical questions where the scope is outside of regulatory authority, and when a level of performance above the minimum legal requirement is desired. The great diversity in definitions and programmatic components for IPM has brought about the need to state the optimum acceptable approach to using pesticides in public places. The general components and definitions of IPM programs advocated by the US EPA, The IPM Institute of North America (IPMINA) and the General Service Administration (GSA) of the United States federal government are discussed in this section

The EPA provides guidance on the use of pesticides and has funded development of materials used to establish, manage and improve IPM programs at schools and public places. The EPA's concept of IPM involves four key components: action thresholds, monitoring, correct identification of pest and preventative measures [US EPA, 2008]. This approach is further expanded in *IPM for Schools: A How-to Manual*, (Daar et al. 1997) which was partially funded by the EPA.

In this manual, IPM is defined by key components that relate to risk communication, transparency and technical proficiency. These include an IPM policy statement, informed selection, evaluation of treatment strategies, record keeping, notification and the notion of using the least toxic approach. This comprehensive approach to pest control is aimed to provide the highest level of safety and targeted pest control, with continual improvement through evaluation of outcomes.

IPMINA was founded in 1988 as a non-profit to recognize advancements in the marketplace by goods and service providers who practice IPM. Their IPM Star program is meant to recognize and reward IPM practitioners involved in school districts, day-care centers and school age programs by providing incentive to reduce pesticide use [IPM Institute of North America, 2008]. Inspection and monitoring are used to detect pests and prescribe repairs and preventative maintenance to structures. Action is taken only when necessary, and with the least risk to human health and the environment. A written policy determines the requirements and an IPM committee and IPM coordinator are responsible for implementation and oversight of the IPM program. Record keeping with full public access and notification of treatments are required for the IPM Star designation. Under no circumstance is it acceptable to use calendar applications. This guidance comes with extensive documentation and resources such as model contracts for vendors and a model policy. These VCS's provide state of the art guidance to schools, community members, and pest control operators.

The GSA is the agency that is responsible for structural IPM guidance in federal properties, serving more than 70 federal agencies. Since 1989 the GSA has dispensed structural IPM guidance, and has been awarded the White House Closing the Circle Award (1999) in the category for IPM [US GSA, 2008]. On their website, the GSA states, "just because a pesticide product is used legally does not necessarily mean it is appropriate for a public building". The primary objective is to protect indoor air quality and health and safety of child occupied spaces and the potential for pesticide exposures on individuals with respect to the Americans with Disabilities Act.

According to the GSA the use of calendar applications is inappropriate and contrary to the principles of IPM, and pesticides should only be used if no other alternative exists. The least toxic material should be used and only containerized or crack and crevice treatments are allowed. MSDS sheets should be made available at each site. The use of fogs, space spraying or surface treatments should never be used indoors (unless no alternative for emergency applications exist), treatments should be applied as baits, formulated as solids and gels or pastes. Sanitation and exclusion techniques are emphasized before chemical controls are considered. For the control of rodents, traps, sanitation and exclusion techniques are favored over chemical controls. Additionally, coordination among individual departments with pest control responsibilities is critical to maintain the comprehensive protections and efficiencies provided by the IPM model. These guidelines have been used in many different situations to provide a high degree of pest control and protection of human health and the environment, resulting in overwhelming customer satisfaction.

The three sources for VCS's have shown a great degree of concordance in their principles and practices and have provided guidance for attaining the highest degree of IPM efficiency, protection and transparency to the public. Table 3 in Appendix A shows the three sources of VCS's representing stringent and comprehensive approaches to pest control in public spaces, where they are in close agreement over definition of IPM and recommended programmatic components.

EVALUATION OF PEST CONTROL PROGRAM

In the regulations and VCS, the role of evaluation in IPM programs is emphasized as being a necessary program requirement. This is largely to foster an analytic approach to solving pest problems, which iteratively improves upon itself through a monitoring and record keeping process. The results of evaluating an IPM program are dependent on the choice of an evaluation method that answers questions about specific aspects of an IPM program. Also, the choice of approach to evaluate an IPM program should be driven by how the resulting information will be used, such as for regulatory compliance, to establish "thought leadership" or to demonstrate operational proficiency. The wide variety of IPM programs suggests that presenting a range of evaluation options will provide accesses to the most appropriate method for the widest range of end-users. The range of evaluation methods includes methods used by professional associations as well as a precautionary approach and the use of industrial hygiene exposure control practices.

Program Evaluation

The approach of the program evaluation and audit has been developed by the American Industrial Hygiene Association to support any decision making process where it is important to evaluate actions and their results against some criteria or normal conditions. This process is critical in order to determine if progress toward advancement of institutional goals is being achieved. This method directly compares accomplishments with goals and is used continuously to update procedures and protocol, which is needed for attaining constant improvement in the process. An audit may be used to methodically examine and verify if a program meets legal requirements, internal policies and if essential program components are in place. Health and safety programs are evaluated and audited under identical criteria, (Garret et al. 1988) Sates "program evaluation and audits are Complimentary". These two methods are inextricably linked, and employed in tandem. This suggests that before a program is auditable, it must be evaluated. This conclusion is reasonable under the assumption that for a transparent and focused health and safety program, there must be documentation of the general goal and specific practices, with continuous evaluation of outcomes that generates a performance record, which can be audited. Many directly valuable results are returned with this approach, such as compliance status and information leading to the ability to detect when a health and safety priority has been inappropriately lowered, ignored or dismissed. This evaluation format also has the benefit of providing data that can be used to expedite development of needed exposure controls, resulting in reduced risk, liability and efficient use of resources. This method of program management is most adapted to well formulated programs that involve many levels of decision making and that have the support of staff, management and administration (Garret et al. 1988).

Precautionary Approach

Another approach to evaluate programs is a precautionary approach that has evolved out of concern about taking actions that involve potential risk, which comes with considerable uncertainty about the outcomes. This concept has been codified as the Precautionary Principle or Precautionary Approach by many nation states, states, and local governments where the role of precaution has been central to public health efforts. The role of the precautionary approach in this capacity is to drive "alternatives analysis" which addresses specific actions and treatment alternatives taken in pest control operations.

In this approach we are interested in asking if any less damaging and/or toxic alternatives exist to replace current treatment options or if the current treatment option is even needed. We are interested in the "best way" to achieve our objectives, where protecting human health and the environment is a performance criteria. This approach focuses on selecting a treatment from a menu of options that may include more effective and/or more protective measures. Also included in alternative analysis is the need to ascertain that some actor may be the sole beneficiary of an alternative, and this approach acknowledges this notion by asking where the benefits and harm from a treatment choice may reside, or if there is any harm at all. This approach allows us to re-evaluate our actions in light of existing alternatives or new science, or to update our understanding of a particular decision making process. The alternative analysis is best applied to questions surrounding specific treatment options and is not appropriate for determining regulatory compliance, or programmatic completeness.

Replicated Field Trials

Another method for evaluation of pest control programs is the replicated field trial (Flint et al., 2001), the most reliable method to determine the efficacy of different treatments. These trials are replicated to allow variability across experimental units, receiving the same treatment. Results from these experiments are used to compare specific treatments (most generalizable) or for observational studies (not generalizable). These experiments can be used to judge effectiveness of a treatment, understand treatment timing and for establishing action levels and thresholds. Replicated field trials cannot be used to assess regulatory compliance, BMPs or qualitative aspects of a pest control program. The role of replicated field trials in an IPM program is that of driving treatment strategies, and monitoring procedures.

These approaches to evaluation of pest control programs provide formulated methods that can answer specific questions and inform site health and safety professionals where deficiencies exist or if alternatives provide similar or improved results. These approaches involve the managers of a pest control program to make formal determinations, however often no such administrative oversight exists. In these situations a pesticide or treatment specific method of evaluation is needed.

EXPOSURE CONTROLS

The Hierarchy of Controls and Control Banding methods will be discussed in this section and are drawn from techniques used in industrial hygiene. These methods are considered here because of their adaptation potential as an IPM program evaluation strategy that can be utilized as a tool which site health and safety workers can easily apply to existing pest control operations.

Hierarchy of Controls

The hierarchy of controls approach provides guidance on how effective a particular control is based on whether it is an engineered control, administrative control, or personal protective equipment requirement. The hierarchy of controls approach considers all possible controls for a hazard. The priority is placed on the most effective, permanent and appropriate means of providing protection to workers and the community from a particular hazard. This model arose out of response to failures in behavioral approaches to workplace safety that placed ultimate responsibility for worker safety on the individual.

The hierarchy of controls includes four main components: engineered and administrative controls, personal protective equipment, elimination and substitution. The most effective and permanent control is to eliminate the hazard whenever possible, or provide a substitution with another material. Second, engineering controls constitutes an opportunity to engineer the problem out of the system or process. Third, administrative controls involve policies and procedures that contribute to a safe work environment. These types of controls are limited in their effectiveness so require full support by management and staff to experience protection because they can be disabled, subverted or overtly ignored. Finally, PPE includes all items used to protect workers individually from a hazard. These items are important for Pest Control Operator; however, their use for community level protection may be inappropriate. The hierarchy of controls provides site health and safety professionals with an ability to prioritize resources to provide optimum protection to human health and the environment.

The application of hierarchy of controls to treatment techniques is shown in Table 4 of Appendix A, where controls options are given for the four common treatment triggers. This approach demonstrates the versatility and range of options that are revealed when a pest treatment is evaluated. The person authorized to make pest control decisions can be informed about a range of options and proceed with most effective and least harmful. This approach may however lead to choices that don't reflect the least toxic option because of omissions and failure to consider all available options.

IPM Control Chart

The purpose of IPM is to control unwanted organisms and avoid damage above a predetermined threshold. A successful pest management program chooses and applies the right tools and/or a combination of control methods. The use of a control chart is one method for assessing the risk produced from IPM strategies employed by the UW's structural department. A control chart displays a matrix of hazard rating and exposure rating which can be used as a tool for decision making of IPM (Table 5 in Appendix A). In this matrix the cost of human and environmental health hazards must be taken into account.

These are steps to apply control chart for pest control. The greatest concern is human health effects. The best source of information to assess the potential health hazard from a pesticide is to consult the epidemiological and toxicological literature; however, this may be beyond the abilities of some managers. In the absence of a comprehensive literature review the Material Safety Data Sheet (MSDS) can furnish information. The labels have important information on health hazards, where signal words are used such as danger (high toxic), warning (moderate toxic), and caution (slight toxic or nontoxic). Control charts considers a combination of health effects and exposure levels. Hazard rating reflects health effects and consequences of hazard exposure levels in humans. For example, exposure to some pesticides may produce chronic health effects such as cancer, sterility, etc. Hazard rating is classified into 5 ranks as follow: 1) slight health effects and not affecting work performance or causing disability, e.g. habitat modification and sanitation, 2) minor health effects reversible, for example, symptoms that are not very specific to a particular chemical (e.g., nausea, headache, eye irritation), 3) major health effects such as capable chemicals that produce irreversible health damage without loss of life or symptoms that are very specific to a particular chemical, 4) fatalities or permanent total disability, and 5) multiple fatalities or known human carcinogen [US EPA, 2008; PAN Pesticide database, 2008]. Each symptom is assigned a number of points from 10-50 based on its specificity to the chemicals. Symptoms that are not very specific to a particular chemical (e.g., nausea, headache, eye irritation) are rated at 10 points. Symptoms that are very specific to a particular chemical are given more points (50 points). For example, neuronal effects such as altered or loss of consciousness, sluggishness, drowsiness, weakness or depression (20), loss of consciousness (30), and encephalopathy (50), respectively. This is an example of hazard rating of MaxForce gel bait (hydramethylnon) that is used to control cockroaches. This pesticide causes irritation of eyes and mucous membranes of the respiratory tract and accounts for toxic effects on human health, which totals 30 points [PAN Pesticide database, 2008]. (Table 2).

Exposure rating is divided into 5 categories, including “no chemical treatment” (very low or exposure negligible), “crack and crevice treatment-gel” (low or exposure are controlled well below occupational exposure limit-OEL), “Crack and crevice-powder” (low or exposure are controlled well below OEL, but higher than gel), “perimeter treatment” (medium), and “fog and space spraying” (high). “No chemical treatments” include clean and clear area, traps, seal leak, vacuum cleaner, etc. For example, flies are controlled by using traps and ants are controlled by seal leak. Crack and crevice are a procedure where insecticide sprays, dusts, aerosols and baits are injected to or placed in areas where conventional methods are not possible. For example, cockroaches are managed by using gel baits. They are non-volatile, long lasting, and are effective against many species of cockroaches at low concentrations of active ingredient [Reierdon et al, 2005]. Perimeter treatment is applied for a specific control area or assigned area. Fog and space spraying are applied sprays, aerosols or dusts techniques. For example, flies are treated by the pesticide pyrethrin. Applicators and exposed person are highest risk in this method as shown in Table 6 in Appendix A.

CASE STUDY

UW IPM Principles and Guidelines

The UW’s IPM strategies have been developing and improving for over twenty years. Today IPM responsibilities are organized between four departments: ornamental, agricultural, activities and structural. Ornamental IPM is restricted to pest control issues pertaining to indoor and outdoor plants on the University campus. The goals within this department are to protect plant health, maintain an attractive landscape and a stable plant research environment. The activities department handles the maintenance of sport fields on campus and the agricultural department focuses on forest and crops either adjacent to campus or in distant locations.

Structurally damaging pests are considered as isolated cases, thus are maintained by a separate department whose aims are to protect human health, comfort and UW property. The focus of this work is on structural IPM at the UW.
In general, the core UW IPM principles are to:

- Identify each pest, then understand its life cycle and natural enemies
- Determine aesthetic, economic, plant and human health damage thresholds of each pest species
- Prevent infestation by having remedial controls available
- Substitute less toxic chemicals for the more toxic ones with the objective of protecting the health of human occupants
- Develop long-term strategies to reduce persistent pest problems
- Question scheduled applications; thereby, making certain that chemical applications are necessary before applying
- Continuously monitor pest levels
- Consider the consequence of no pest control action unless a human health risk is present
- Write IPM policy into the campus pest control manual

In support of these principles UW has established a number of guidelines, which are considered for each pest. Before taking action, the pest management team will assess the pest problem to determine the degree, and assign it to one or more of the following categories: health, structural, economic and/or esthetic. The impact to human health is regarded with the highest priority. Action thresholds and individual sensitivities/ tolerances to the reported pest are also considered. Action thresholds are assigned based on the pest and are defined as a point at which its population is deemed unacceptable. For example, one bee may be considered as acceptable whereas a swarm can present a higher risk, and therefore, unacceptable. To keep in line with IPM philosophies, and the Universities' continual interest to keep cost down, there is an emphasis on prevention. This may be addressed by considering cultural behavior throughout campus, by encouraging sanitation or perhaps include construction design of new buildings to eliminate potential niches.

Section V, Part F of UW Biosafety Manual contains a description of the UW program for pest control. The pest control program at the UW is meant to control or eliminate crawling and flying insects, wild rodents, or similar pests. The UW program places an emphasis on eliminating breeding sites of pests. In order to reduce the risk of exposure to toxic pesticides the pesticides are only supposed to be applied by a licensed professional (EH&S, 2003). Environmental Health and Safety personnel for the UW are required to supervise any purchases of pesticides made by the campus. Environmental Health and Safety also provide guidelines on their website for employees disposing of pesticide containers (EH&S, 2008).

DISUCSSION

University of Washington Pests

The primary types of pest encountered in structures on campus are rodents and cockroaches. Secondary pest include cluster flies, fruit flies, gnats, ladybugs, lice, moths, silverfish, spiders, springtails, termites, vespids, ants, bats, fleas, and flies. This discussion highlights the two most persistent structural pest-- rodents and cockroaches.

Rats are commensal rodents who have learned to live in the shadows of human activities. They have co-exited with us for many centuries now so it's accepted that these pest are not going to be completely exterminated. Thus rat control is necessary to keep their populations from rapidly increasing and introducing heath and safety hazards. Rats are carriers are of *Yersinia pestis*, murine typhus, leptospirosis and salmonellosis (Gratz, 2006). These are all diseases that spread to humans and cause illness when rats are able to contaminate human food sources or enter living spaces. Some species are sewer dwellers and potential carriers of many additional enteric diseases. They are also have the potential to create severe damage to property such as building structures, furniture and computer wires. Keeping a cap on rat population growth is therefore important for public heath and economical reasons.

Controlling rodents indoors is accomplished on campus by the use of snap traps, glue boards, and tin cats, which generally do not require the use of harmful chemicals. Outdoor elimination strategies begin with a focus on eliminating potential niches such as burrows in buildings, brush or ground cover, and strict guidelines for garbage and food sanitation. Further, baiting stations are frequently used throughout campus to poison rats. Paralleling with UW's IPM principles, less harmful measures are also considered. Owls are natural predators of rodents, thus their population is encouraged with nest boxes.

Cockroaches are disgusting little creatures whose lives are unjustified so should be eliminated at all cost! This is the prevailing sentiment amongst sanitarians, and the general public as well. There are three main types of cockroaches present on our campus: German, American and brownbanded. The German cockroach (*Blattella germanica*) is a fast populating species whose preferred niche is near warm areas with a nearby food and water source. Both the American cockroach (*Periplaneta americana*) and brown-banded cockroach (*Supella longipalpa*) also enjoy warm regions but are less abundant than the German roach. Female cockroaches produce an ootheca (egg capsule), which they carry for varying times during incubation periods, then drop them just before germination. This ootheca can carry upwards of 35 eggs. The small body size of this pest allows them to sneak between the smallest cracks, making it more difficult to see them.

Cockroaches are nocturnal so a daytime spotting is an indication of a hardy population and warrants immediate action. Sanitation is a key step in preventing and encouraging cockroach populations. UW's strives to locate their harborage and baiting both American and brown banded roaches. German roaches are handled by applying MaxForce gel bait in areas where roaches were seen. An action threshold of zero has been established for each of these known roaches primarily because they are capable of fast replication and generally because their presence is extremely undesirable to humans due to their known odors and disease carrying capacity (Gratz, 2006).

RECOMMENDATIONS

In regard to EPA standards:
Evaluation of the pest control (especially for rodents) efficacy is lacking in the opinion of the authors. For example, currently the UW has their Pest Control contractor (Eden) conduct evaluation of rodent treatment via records indicating whether or not the bait was consumed. While this evaluation system shows some type of activity it does not necessarily determine whether or not eating the pesticide bait killed the rodent or to what extent the population density of the target pest was decreased. The pest controller simply assumes that activity is equivalent to killing a rodent. There is no quality assurance in terms of whether or not the bait was actually consumed by the target pest or a non-target pest. We recommend a form of pest control (such as a Tin Cat trap) that allows the pest controller to at least count the bodies to ensure that the target pest is being controlled. For determining the reduction in population density of the target pest the UW pest controller investigates for evidence of rodents. This approach combined with trapping is acceptable since this is the typical way of determining population density. A detailed statistical method for rodent density determination has been discussed in Parmenter et al (Parmenter et al, 1999).

Education and outreach of stakeholders on the UW campus appears to be lacking. For instance each department at the UW with pest control responsibilities does not adhere to a single and unified IPM policy. The Urban Horticulture department does not necessarily coordinate with the UW IPM coordinator as far as setting action thresholds or pest control techniques. Training of pest control guidelines across departments does not appear to be centralized but rather dependent upon the manager of each particular department. We recommend, where feasible, that IPM guidelines (such as action levels) and training be coordinated between the IPM coordinator and the department manager in charge of pest control for each department.

Continuous improvement outlined in the IPM Star program can improve on the UW campus. While it is important to recognize the UW's adherence to IPM principles in the past and the improvements made in reducing dependence on chemical pesticides, it is also important to recognize that continuous improvement in the IPM program is preferable. In an interview with the UW IPM coordinator it was stated, "I see no way how we could possibly do better than we are doing." This statement perhaps shows a certain level of reluctance to admit the possibility of improvement, which is likely based on an absence of rigorous evaluation of the efficacy of treatments. Lastly, we recommend the use of hierarchy of controls and the control chart to evaluate options for pest treatment strategies.

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APPENDIX A (Tables)

Table 1. List of WA state and county pesticide regulations.

Regulatory Authority	Title of Regulation
RCW 17.15	Integrated pest management http://apps.leg.wa.gov/RCW/default.aspx?cite=17.15
King County	IPM Tri-County Model Policy http://www.govlink.org/hazwaste/interagency/ipm/ipmeo.html
King County Executive Order	Ron Sims Executive Order on IPM http://www.govlink.org/hazwaste/interagency/ipm/ipmeo.html
RCW 17.21	Washington pesticide application act (in schools) http://apps.leg.wa.gov/RCW/default.aspx?cite=17.21
WAC 296-800-22020	Control pests in your workplace http://apps.leg.wa.gov/WAC/default.aspx?cite=296-800-22020
WAC 16-233	Worker Protection Standards for Pesticides http://apps.leg.wa.gov/WAC/default.aspx?cite=16-233
WA HB 1806*	Limiting the use of high hazard pesticides on school facilities. Revised for 4th Substitue: Developing a model integrated pest management program http://apps.leg.wa.gov/billinfo/summary.aspx?year=2007&bill=1806

*Legislation currently under consideration
Un-shaded columns focus on Integrated Pest Management

Table 2. Legal requirements for IPM at UW.

Legislative Declaration 17.15.005	Follow principles of IPM
Definitions 17.15.010	Prevention, monitoring, thresholds, evaluation
Implementation of IPM practices 17.15.020	Each state institution of higher education, for the institution's own building and grounds maintenance
IPM training and designation of coordinator 17.15.030	Provide IPM training for employees if they have pest control responsibilities, designate an IPM coordinator
Interagency IPM coordinating committee 17.15.040	Meet twice a year, public notice of each meeting

Table 3. IPM program components of state of the art voluntary consensus standards.

EPA	IPM Star	GSA
Monitoring	Monitoring and Inspection	Inclusions and exclusions
Pest ID	Action only when necessary	Initial building inspection
Injury Threshold	Documented performance	Pest control plan
Action levels	Least-toxic	Record keeping
Timing t_x	Continuous improvement	Service conduct
Targeted Application	Communication and out reach	Least hazardous
Least disruptive approach	Reduction in health and environmental risks	Program evaluation
Evaluation of effectiveness	Long term, preventative solutions	Quality control
Education of stakeholders		
Record keeping		

Table 4. The four main treatment triggers and hierarchy of controls.

Treatment Trigger	Pest	Elimination/ Substitution	Engineering Control	Administrative Control
Structural	Ants	Remove harborage, water and food source	Boric acid baits and gels, caulking cracks (entry restrictions), stickey traps	Good housekeeping, monitoring
Health and Safety	Rodents	Remove harborage, water and food source and cover Exclusion techniques	Snap traps and live capture bait stations. barriers	Good housekeeping, monitoring, everything 18” off the ground
Nuisance	Wasps	Remove all old nests, use hot soapy water applied with a super soaker, @ 25’ vacuming	Traps are very effective at local control, but require maintenence. Silica aerogel	Routine monitoring during the season
Aesthetic	Weeds	Replace weeds with suitable plant material, reprioritize bias against weeds, eliminate the obsession, Acetic acid, flame and mechanical methods	Weed block, corn gluten, mechanical and flame	Timeing, tolerance and informed management

Table 5. IPM control chart for structural pest control.

Hazard rating (points)	**Exposure rating**				
	No treatment	Crack and crevice treatment (gel)	Crack and crevice treatment (powder)	Parameter treatment	Fog and space spraying treatment
slight health effects/ not affecting work performance/ causing disability	No action	Immediate required	Third priority		
minor health effects reversible				Second priority	
major health effects					
1-3 fatalities or permanent total disability				First priority	
Multiple fatalities					

Table 6. Examples of IPM control methods, health hazard rating, and exposure rating.

Pest	**Control methods/ Chemical uses**	**Health hazard rating[(a)] (points)**	**Exposure rating[(b)]**
Cockroaches (American, Brown-banded, German)	-Locate harborage; MaxForce gel bait (hydramethylnon)	Irritation of eyes and mucous membranes of the respiratory tract	crack and crevice treatment or gel
	Gencor (pyriproxifen) insect growth regulator (liquid and aerosol formulation)	Harmful if inhaled or swallowed. Dust, mist or vapor irritating to eyes and respiratory tract. May cause skin irritation. Exposure to high vapor levels may cause headache, dizziness, numbness, nausea, and other central nervous system effects	Fog & space spraying
Flies (Blow, bottle, cluster, fruit, house, lesser house, phroid, sewer)	Pyrethrin spray	Irritation of skin, eyes and respiratory tract, sensitizer, may cause allergic reactions	Fog & space spraying
	Traps	No	No treatment
	Seal opening	No	No treatment
	Clean & clear area	No	No treatment
Ants (Argentine, Carpenter, Moisture, Odorous, Thief, Pharaoh)	Niban bait (boric acid)	Inhalation, cough, and sore throat. Eyes- Redness, pain, ingestion- abdominal pain, convulsions, diarrhea, nausea, vomiting, and skin rash	Fog & space spraying
	TERRO Ant Killer II Liquid Baits (Sodium tetraborate decahydrate)	Cough, shortness of breath, sore throat, nose bleeds, redness, abdominal pain, convulsions, diarrhea, headache, nausea, vomiting, and weakness	Fog & space spraying
	Seal leak	No	No treatment
	Vacuum cleaner	No	No treatment

a. Each symptom is assigned a number of points from 10-50 based on its specificity to the chemical in question. Symptoms that are not very specific to a particular chemical (e.g., nausea, headache, eye irritation) are rated at 10 points. Symptoms that are very specific to a particular chemical are given more points (***MSDS,*** *PAN* ***Pesticides Database).***

b. Exposure rating is divided into 5 categories based on human exposure levels, including no treatment, crack and crevice treatment or gel, crack & crevice powder, parameter treatment, and fog & space spraying.

Table 7.

EPA	IPM Star	GSA
Monitoring	Monitoring and Inspection	Inclusions and exclusions
Pest ID	Action only when necessary	Initial building inspection
Injury Threshold	Documented performance	Pest control plan
Action levels	Least-toxic	Record keeping
Timing t_x	Continuous improvement	Service conduct
Targeted Application	Communication and out reach	Least hazardous
Least disruptive approach	Reduction in health and environmental risks	Program evaluation
Evaluation of effectiveness	Long term, preventative solutions	Quality control
Education of stakeholders		
Record keeping		