Integrated pest management in child care:
A mixed methods examination of the implementation process

By
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Abstract

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Background: Pesticide use is a potential health threat to children and staff in child care centers. Child care providers receive little-to-no training on non-toxic pest management practices thus implementation rates of integrated pest management (IPM) are low, despite legislative efforts to increase its use.
Objective: The objective of this convergent mixed methods study is to: (1) develop a more complete understanding of the process of IPM implementation in child care programs, (2) describe the facilitators and barriers to implementing IPM in child care programs, and (3) examine congruence between IPM practices identified on an IPM Checklist with practices reported in manager interviews.
Methods: A seven-month pilot study was conducted with nine California child care centers, serving 854 low-income children. The intervention included an educational workshop and IPM assessment with feedback on the IPM practices and building structure. We employed a convergent parallel design for data collection and analysis, using qualitative interviews with center managers and quantitative pre- and post-intervention observational IPM Checklists and self-report survey interviews.
Results: The qualitative analyses of the implementation process revealed a four-stage progression, from awareness, recognizing the importance of IPM and learning how to practice it, motivation and the decision to adopt IPM, to implementation of IPM. A wide range of facilitators and barriers were identified. There was general congruence between the manager interviews and IPM Checklist findings on IPM policies, practices, and management.
Conclusion: Understanding a model of how IPM was implemented in these child care centers, and the facilitators and barriers involved in the process, can inform planning efforts for future health interventions in child care programs.

Paper One. Literature Review

1. Introduction

Sixty-three percent of United States child care centers reported using pesticides in 2001 (Tulve et al., 2006). In California, 90% of child care centers reported pest problems; 55% of the centers reported using pesticides to control pests; and 75% of respondents reported not knowing what integrated pest management (IPM) was (Bradman, Dobson, & Leonard, 2010). Nationwide, 63% of children ages 0-5 attend out of home child care (US Census Bureau, 2009).

Pesticide use in child care is a problem that has not been well studied. In this paper, I review information about pesticide use in child care centers, state-level policies focused on pest management, and approaches to implement these policies. I also examine the efficacy of current interventions, particularly in California. Finally, I discuss strategies to engage child care staff in creating change, and propose innovative-decision theory as a relevant model for successfully changing pest management practices in child care centers.

2. Protecting Children's Health

2.1 Pesticide Levels in Child Care

Many child care centers use pesticides to manage pests inside and outside their facilities. Pest management professionals (PMPs) are often contracted to routinely spray facilities with pesticides and follow up in the case of any pest infestations (Fournier, Gibb, & Oseto, 2010). This traditional model can be thought of as an "out of sight, out of mind" approach to pest control (Fournier et al., 2010). Recent research indicates that pesticide use is common in United States (U.S.) child care centers (Bradman et al., 2010; Lu, Knutson, Fisker-Anderson, & Fenske, 2001; Tulve et al., 2006). For example, the U.S. Department of Housing and Urban Development (HUD), the U.S. Consumer Product Safety Commission (CPSC), and EPA conducted a national study in 2001 of 168 child care centers to characterize pesticide use and levels. Sixty three percent of centers reported using between one and ten types of pesticides, in some cases up to 100 times per year. Pesticides were detected in surface and soil samples from 89% of centers. Furthermore, the discrepancy between pesticide reporting and the presence of pesticide residues suggests that child care centers underreport, or perhaps are unaware, of pesticide applications (Tulve et al., 2006).

Particularly common indoors in child care centers are organophosphates and pyrethroid pesticides detections (Tulve et al., 2006). In some cases, unregistered or illegal pesticide use has been documented in and around school sites (Environmental Protection Agency, 2009; Lu et al., 2001). Similar practices may occur in child care centers.

The combination of pervasive pesticide presence in school sites and the long hours that children spend there, make child care centers a dangerous site for pesticide exposure.

2.2 Health Effects of Pesticides

Pesticide exposures have been associated with both acute and chronic illnesses in children. For example, there were 2593 cases of acute pesticide related illnesses associated with pesticide exposure at schools between 1998 to 2002 (Alarcon et al., 2005). Pesticide exposure can lead to adverse health effects, including nausea, dizziness, respiratory problems, headaches, rashes and mental disorientation (Feldman & Owens, 2009). For example, each year in New York City over one thousand accidental pesticide exposures are called in to the regional poison control center, the majority concerning children (Evans et al., 2009). Acute exposures can lead to problems such as skin irritation, lesions in the respiratory tract and mild to severe adverse neurological effects (Jurewicz et al., 2006).

While the short-term health effects of acute pesticide poisoning are well known, less is known about the long-term effects of accumulative exposure (Baldi, Mohammed-Brahim, Brochard, Dartigues, & Salamon, 1998). Much of what is known about long-term effects comes from retrospective studies, which lack accurate exposure data. A meta-review of retrospective epidemiologic studies on pesticides shows three categories of long-term health effects: 1) cancer (especially hematological cancer), 2) neurotoxicity (Parkinson's disease, polyneuropathy and behavioral hazards) and 3) reproductive disorders (infertility, endocrine disruption, birth defects and perinatal mortality) (Baldi et al., 1998). There is increasing concern about the health effects of pesticides on children under the age of five. Of particular concern for children is the effect on the nervous and respiratory systems, as these are not fully developed at birth (Makri, Goveia, Balbus, & Parkin, 2004).

Table A presents known health effects of the four most common pesticides present in surface samples from the First National Environmental Health Survey of Child Care Centers (Beyond Pesticides, 2006; Tulve et al., 2006).

Table A. Common School Site Pesticides and Their Health Effects

Active Ingredient	% Detection	Cancer	Endocrine Disruption	Reproductive Effects	Neurotoxicity	Kidney/ Liver Damage	Sensitizer/ Irritant	Birth/ Developmental Effects
chlorpyrifos	93%			Y	Y	Y	Y	Y
trans-permethrin	72%	Possible	Suspect	Y	Y	Y	Y	Y
cis-permethrin	72%	Possible	Suspect	Y	Y	Y	Y	Y
diazinon	67%			Y	Y	Y	Y	Y

There are 40 pesticides that are commonly used in schools. Among these, 28 may cause cancer, 14 are linked to endocrine disruption, 26 can adversely affect reproduction, 26 are neurotoxic, and 13 can cause birth defects (Feldman & Owens, 2009).

2.3 Why Children are More Vulnerable

Children are more vulnerable to pesticides than adults and experience higher exposures because they (1) eat, drink and breathe more per kg, (2) exhibit more exposure-prone behaviors, (3) are physiologically immature, and (4) metabolically immature.

In order to understand why children have higher exposures, it's important to understand possible routes of pesticide exposure. Exposure may come from interactions with various sources, such as air, diet, dust and soil. The pathways of exposure may be dietary and non-dietary ingestion, inhalation and dermal absorption (Hubal, Egeghy, Leovic, & Akland, 2006;

Wilson, Chuang, & Lyu, 2001). In addition to direct dermal transfer, pesticides can transfer to toys that then are played with and mouthed by children (Bradman et al., 2010).

Children are more prone to higher exposures due to frequent contact with the ground or floor, where pesticides collect; hand-to-mouth activity; less varied diet; eating, drinking and breathing more per kg than adults; and spending most of their time indoors (Makri et al., 2004).

Children's undeveloped bodies make them more susceptible to increased pesticide absorption and also less able to deal with high levels of exposures than adults. For instance, in children ages 2 to 6, there is an increase in gastric emptying as compared to adults, possibly resulting in faster absorption and higher peak serum concentrations. Also, their surface area to body mass ratio is higher than adults, leading to the possibility of larger absorption due to dermal exposure to pesticides. Physiologically, children's respiratory and metabolic systems are still immature at this age, making it difficult to metabolize pesticide toxins (Makri et al., 2004).

In addition to their behavioral and physiological differences, children ages 0-5 are more vulnerable to pesticide exposure based on their inability to recognize warning signs or hazards.

2.4 U.S. Child Care Statistics

Children spend as much as 10 hours a day, five days a week at child care centers. Nationwide, 63% of all U.S. children (13 million) ages 0-5 are placed in out of home child care for some portion of the work day (Tulve et al., 2006; US Census Bureau, 2009).

In addition to children, there is one staff member for roughly every 5-10 children in child care. Child care providers are also at risk for pesticide exposure. Many of them are women of child-bearing age, and may be pregnant while working.

2.5 Director Statistics

The director is critical to the organizational structure of the child care center. The job is busy, fast-paced and dynamic. Compared to the high turnover rate of most child care staff, director turn-over rates are lower (Bureau of Labor Statistics, 2004). For example, among 484 licensed child care centers in Alameda County, CA director turnover was 13.7%, substantially lower than teaching staff (26.5%). Sixty one percent of directors had worked at their job for more than five years and 84.5% of centers reported no director turnover in the past year (Whitebrook et al., 2006). It follows logically that directors are fundamental in creating lasting change in child care, but that a committed team is also necessary in order to carry it out.

The remainder of this paper will examine different policies and techniques that have been employed to help protect children and prevent pesticide exposures.

3. Pest Management Policies in Child Care

3.1 State Pest Management Policies

Legislation is one way to create a solution that would reduce pesticide use in child care centers and school sites[1]. According to the authors of "The New Spectrum of Prevention: A Model for Public Health," "Legislation and other policy initiatives have proven to be among the most effective strategies for achieving broad public health goals. Both formal and informal policies have the ability to affect large numbers of people by improving the environments in which they live and work, encouraging people to lead healthy lifestyles, and providing for consumer protections" (Rattray, Brunner, & Freestone, 2002).

Currently, the state of legislation and policy surrounding pest management in child care is disparate. While federals laws exist concerning pesticide use, there are no current national requirements regulating pesticide use specifically in child care centers. For instance, the Federal Insecticide, Fungicide and Rodenticide Act mandates that pesticides must be registered with the United States Environmental Protection Agency (US EPA or EPA) before being sold or distributed, and includes an amendment known as the Food Quality Protection Act that requires that pesticides used on foods must produce no harm (EPA, 1996). However, these laws do not include specific requirements about use of pesticides on school sites.

Many states and school districts have responded to this need by creating state- or school-specific laws to protect children from pesticides while in school or child care. Beyond Pesticides, formerly the National Coalition Against the Misuse of Pesticides, identified 33 states that have created their own, more stringent regulations as of 2008 (Green, Gouge, & Lame, 2009; Piper & Owens, 2002). These regulations vary in their components, with a mixture of restrictions on pesticide application versus pesticide notification.

3.2 Components of Policies

This regulatory mixture contains an assortment of six main components: 1) Posting Notification Signs for Indoor Pesticide Applications 2) Posting Notification Signs for Outdoor Pesticide Applications 3) Prior Written Notification 4) Minimal training for pesticide applicators 5) Integrated Pest Management (IPM) (law or rule) 6) Product restrictions (Beyond Pesticides, 2002).

Table B presents current pest management regulations in schools in twelve western states:

Table B. Inventory of Western Region School Site IPM Laws and Regulations

	Indoor posting	**Outdoor posting**	**Prior-notification**	**Minimal training for applicators**	**IPM law or rule**	**Product restrictions or green list**
Arizona	Y	Y	Y	Y	V*	Y
California	Y	Y	Y		V	
Colorado		Y		Y		
Idaho						
Hawaii						
Montana	Y		Y	Y	V	

[1] The existing state level policies on pest management are targeted at schools, with some policies extending to child care. This section will therefore not be specific to child care centers.

Nevada						
New Mexico	Y	Y	Y	Y		
Oregon						
Utah				Y		
Washington	Y	Y	Y	Y		
Wyoming	Y	Y	Y			

*V means that IPM is voluntary.

Though this table represents only a quarter of the states in the US, it is representative in illuminating state-to-state discrepancies. In addition to having non-uniform policies, only 33 of 50 states (66%) currently have any sort of pest management or pesticide use regulation. The laws of these 33 states are supplemented by around 400 school district policies nationwide (mostly in Indiana), but the coverage is not exhaustive and many children are still vulnerable to pesticide exposure while at school (Beyond Pesticides, 2002).

3.3 IPM

Of the various components of pest management policies, integrated pest management (IPM) is recognized as the most comprehensive and sustainable approach to pest management.

3.4 IPM History

According to the IPM Institute of North America, Inc.:

> "IPM is an approach to solving pest problems by applying our knowledge about pests to prevent them from damaging crops, harming animals, infesting buildings or otherwise interfering with our livelihood or enjoyment of life. IPM means responding to pest problems with the most effective, least-risk option. Under IPM, actions are taken to control pests only when their numbers are likely to exceed acceptable levels. Any action taken is designed to target the troublesome pest, and limit the impact on other organisms and the environment." (IPM Institute of North America, 2004)

Initially developed for agriculture, integrated pest management (IPM) is a prevention-based pest management strategy. It has existed in many permutations and has been practiced for centuries, but has gained increasing attention since the middle of the 20th century (Tweedy, 1976). The concept and catalyst for IPM stemmed from the discontent of using a solely chemical approach to pest management in the 1950's (Texas IPM, 2007). Despite their success at killing insects and other unwanted pests, detrimental side effects of pesticides were not withstanding. These effects included pest resistance to certain pesticides, destruction of natural predators, residue, environmental health and public health problems (Huffaker & Croft, 1976).

What started as purely agricultural management practices of IPM such as crop rotation and planting resistant crop varieties, has expanded to a more widely-applicable set of strategies (Texas IPM, 2007). IPM is now practiced in urban environments, both in and around buildings. Specific IPM categories of practices involve: 1) prevention, 2) monitoring, 3) identification and

4) management. In all cases, pesticides are used as a last resort, and only in accordance with a center's established IPM policy. A large component of IPM is the goal to have a minimal impact on human health, environmental health and non-target organisms (Flint, Daar, & Molinar, 2003).

3.5 IPM Efficacy

IPM has been proven to be effective both in agricultural and urban settings. In urban settings, several studies have shown that education about and implementation of IPM reduced the number of cockroaches, cockroach allergen levels, pesticide use and asthma symptoms (Brenner et al., 2003; Levy, Brugge, Peters, Clougherty, & Saddler, 2006; McConnel et al., 2005). A 2009 study by Evans, et al., compared the use of traditional, pesticide-based pest management and IPM over the course of 6 months in 280 apartments in New York City. They found that the IPM intervention reduced pest populations and allergens relative to traditional pest control, and that it was successful in reducing the resident's use of pesticides (Evans et al., 2009).

3.6 IPM and Policy

IPM has become integrated in a number of federal policies that aim to reduce pesticide use, and thus reduce health and environmental risks, in both agricultural and urban settings. As early as the 1970s, President Nixon, the USDA, the Council on Environmental Quality and President Carter recommended IPM be incorporated into national policies and practices (Fournier et al., 2010). This trend of incorporating IPM into public policy has continued to the present day, with the Environmental Protection Agency (EPA) beginning to advocate for use of IPM in schools since the early 1990s (Environmental Protection Agency, 1993). However, as stated above, none of the numerous attempts to create national legislation around IPM in schools have been successful (Harrington, 2002).

3.7 IPM in Schools

Of the 33 states that have school and child care pest management policies, 21 of the policies, or 66%, include use of IPM (Green et al., 2009). Fifteen of the 33 states have policies that require the use of IPM, while six states have policies that recommend its use.

IPM programs in schools follow a systematic approach to pest control, with minimal risk to children, staff or the environment (Environmental Protection Agency, 1993). The goal is to use mechanical, cultural, biological and behavioral tools to reduce pest populations, without relying on chemicals (Daar, Drlik, Olkowski, & Olkowski, 1997). The programs do so by focusing on eliminating the three factors that favor pest infestation and survival: access, shelter and food.

On a practical level, implementing an IPM program starts with establishment of an IPM policy and, in some cases, creation of an IPM Advisory Committee (Lame, 1999; Owens, 2003). This step is critical, and many experienced IPM implementers feel that it is impossible to implement IPM programs in schools without proper administrative support (Lame, 1999; Lame et al., 2001). It has been said that IPM in schools relies on communication and education, and needs to be supported by an engaged administration (Lame et al., 2001).

3.8 Statistics Based on IPM Policy

As mentioned above, some state policies mandate the use of IPM while others only recommend it. Not only is the number of states including IPM in their state policies increasing, the awareness about IPM in schools and child care centers is also increasing. For example, the number of states mandating school IPM increased from 5 to 15 between 1998 and 2008 (Green et al., 2009; Owens & Feldman, 1998, 2002). Very little longitudinal research has been conducted to demonstrate any correlated change in pest management practices after the passing of state policies. One study conducted by Scherer in Florida showed that the percentage of schools that routinely apply pesticides decreased from 78% in 1996 to 28% in 1999. It also recorded an increase from 45% to 75% in the number of schools that self-reported use of IPM (Scherer, 2000). In a similar positive trend, the Safer Pest Control Project in Illinois found that, as of 1996, only 17% of school administrators had heard of IPM. This number rose to 97% of the same sample of schools claiming to use IPM, two years after a state law was passed to require schools to use IPM. Despite the seemingly positive results based on the institution of an IPM policy, further analysis showed that only 73% of these school programs included non-chemical methods and excluded routine pesticide spraying (Safer Pest Control Project, 2001). A study by Gooch in 2004 showed similar results: though Massachusetts's school pest management policy requires IPM in school, less than 30% of schools were actually in compliance (Gooch, 2004). These longitudinal studies focus on self-report and outcome measures only, which makes it difficult to assess if the passage of IPM-related policies is effective at reducing pesticide use.

The following two examples go further to demonstrate that policy alone, without supplementary educational interventions, does not create promising uptake of IPM or reduction of pesticide use:

3.8.1 California

In 2008, the Department of Pesticide Regulation (DPR) funded a survey of 637 California (CA) child care centers to determine adherence with the Healthy Schools Act (HSA). The results show that, even after creation of a policy in 2000: a) 90% of child care centers reported at least one problem with indoor and/or outdoor pests b) 55% of centers reported using pesticides to control pests c) fewer than half of the child care centers complied with the notification and warning sign requirements of the HSA when applying pesticides and d) three quarters of respondents reported not knowing what the term IPM meant (Bradman et al., 2010). Though there are no pre-policy data, it is clear that the current pest management practices are not up to the caliber expected by the Healthy Schools Act. This is an example of a state where creation of a policy without education or intervention was not sufficient at improving pest management.

3.8.2 Indiana

In 2001, the Indiana School Board Association adopted a pesticide policy and encouraged other school districts throughout the state to do the same. Subsequent reviews by the state chemist's office determined that up to 255 school districts had followed the recommendation and adopted a pest management policy that emphasized IPM. However, only half of the schools that adopted a policy were actually following it. In 2004, Purdue University conducted a survey with written questionnaires sent to 294 Indiana school corporations to assess policy adoption and implementation. Of the 184 responses they received, they learned that: 1) greater than 95% of the schools had adopted a pest management policy, or had plans to, 2) 31% of the policies recommended the use of IPM and 27% required it, and 3) 60% of schools used routine preventive applications of pesticides. Note that routine application of pesticides is against IPM policies. This means that even though 60% of centers adopted a policy that included the use of IPM, not all of them were following it (Moore, 2010).

These two examples underscore the fact that passage, or even adoption, of IPM policies alone does not translate to implementation of IPM in school sites.

4. Creating Pest Management Change in Child Care

4.1 Pest Management Interventions

An assortment of techniques specifically related to pest management has been used to educate school and child care staff and pest management professionals about statewide policies and IPM. These educational interventions can be categorized as (1) IPM resource development, (2) workshops and other trainings, (3) pilot IPM programs, (4) IPM curriculum development and student-run IPM programs, and (5) certification programs and awards for schools and IPM implementers (Fournier et al., 2010). Each approach has unique benefits and drawbacks, and they are often used in combination for this reason.

Very few studies to determine the efficacy of various IPM interventions have been conducted and published. This section will highlight success from (i) one school district in Indiana, (ii) the state of Illinois, and then go on to discuss (iii) an IPM intervention currently underway in California.

4.1.1 Indiana

Despite Indiana's lackluster adherence as a state to district-wide pest management policies, there is one exemplar school district: the Metropolitan School District in Indianapolis. Over the course of two years, by adhering to IPM strategies, the district practically eliminated all pesticide use with a simultaneous decrease in the number of pest complaints. During this time, not only were there no increases in the schools' pest management expenses, there were actually up to $10,000 worth of pest management savings for the district (Moore, 2010). This example shows that IPM is implementable and can actually save money, and that adopting IPM-centered pest management policies is feasible and sustainable.

4.1.2 Illinois

In 2007, an amendment was made to the 1999 Illinois Structural Pest Control Act to require the adoption of IPM. From 2006-2008, the Safer Pest Control Project (SPCP), the Illinois Department of Children and Family Services (DCFS) and Department of Health – Resource and Referral (R&R) network collaborated to promote IPM in licensed child care facilities. After three years of training sessions, a study was done by Mir et al. to evaluate the impact of these sessions. The results showed that: a) 27% of centers stopped spraying pesticides, b) 13% stopped using all pesticides, c) 41% switched to using baits instead of spraying (this is an IPM technique) (Mir, Finkelstein, & Tulipano, 2010). Though these data were collected by survey and are based on self-report, the study shows promise that educational campaigns surrounding policy can improve policy uptake and adherence.

4.1.3 California

From 2009-2011, the California Department of Pesticide Regulation (DPR) funded the UCSF California Childcare Health Program (CCHP) and the UC Berkeley Center for Environmental Research for Children's Health (CERCH) to collaborate on an integrated pest management intervention in California child care centers. This study was titled "An Integrated Pest Management Toolkit for California Child Care Programs." It began with the development of a Child Care IPM Toolkit targeted to child care providers, child care administrators and custodians. The Toolkit included an IPM curriculum, Health and Safety Notes, Fact Sheets for Families, Posters and an IPM Checklist. The IPM Checklist is an objective tool to (1) assess pest control practices and compliance with the Healthy Schools Act and (2) identify the IPM practices being utilized, pests present, pesticide use and health hazards identified in child care programs. The IPM curriculum and IPM Checklist was pilot tested in two child care centers and accordingly revised based on feedback. The Toolkit was disseminated to California child care centers.

In 2010, a quasi-experimental study was designed to evaluate the IPM Toolkit, which included an intervention and evaluation component. This IPM in California Child Care study was carried out at nine child care centers located throughout California. The intervention comprised of distribution of the IPM Toolkit as well as a one and a half hour IPM educational workshop at each child care center. The evaluation included pre- and post-workshop tests at all workshops, a survey director interview and the IPM Checklist, which was to be done at the beginning of the intervention and 4-6 months after the intervention (A. Alkon, 2010).

In Indiana, Moore showed a decrease in pest numbers (in addition to cost savings) while using IPM and in Illinois, Mir et al. showed a decrease in the number of centers spraying pesticides after an IPM intervention (Mir et al., 2010; Moore, 2010). These outcome variables are promising, but a more rigorous study of whether or not a school site is using IPM would need a more thorough examination of the process of implementation.

5. Understanding Change

5.1 Innovative-Decisions Process

Despite high rates of adoption of IPM in multiple states and school districts that require or recommend it in their policy, it is clear that implementation rates are not as high. In order for IPM to be fully implemented in child care centers, it is important to understand this discrepancy between adoption and implementation. Though it has been around in agriculture for decades, the idea of using IPM as a form of pest management in child care centers is a form of innovation. As such, this discrepancy can best be understood through the diffusion of innovations theory. Rogers describes diffusion as "the process by which innovations spread through social systems over time." Innovation is defined as "any idea, practice or technology that is perceived as new by a potential adopter" (Rogers, 1995).

Within the diffusion of innovations theory, there is a model known as the Innovation-Decision Process (IDP) that outlines the decision-making process involved in potential adoption of an innovation. The main idea behind this model is that there is a similar five-step process that individuals or groups go through to determine whether or not they will integrate the innovation into their social system. IDP is defined as “the process through which as individual (or other unit of adoption) pass (1) from first knowledge of an innovation, (2) to forming an attitude about the innovation, (3) to a decision to adopt or reject, (4) to implementation of the new idea and (5) to confirmation of this decision” (Rogers, 1995).

The timeframe for these five steps is dynamic and varies highly based on the child care center and director. The adoption of an innovation plots as an S-shaped curve, corresponding to the adopters at each stage. These adopters of an innovation can be classified in one of five categories, depending on their attitude and timeframe towards uptake. Roger defines these categories as: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards (Rogers, 1995).

The IDP model is important for understanding why some child care centers adopt and implement IPM policies, and why others merely adopt them. It will help construct a guideline to purposefully explore the various facilitators and barriers in the implementation process.

5.2 Importance of Qualitative Studies

Greene and Breisch suggested that there are two approaches to evaluate IPM implementation in public buildings. Past studies of IPM have focused either on one part of an IPM program (such as limiting chemical management) or on the efficacy of IPM at reducing pest numbers, as compared to traditional pest control methods (Greene & Breisch, 2002). In order to better understand how IDP works in the context of IPM, it’s necessary to conduct research that does not solely focus on outcome variables. To this point in this paper, all research cited has been quantitative, and survey- or observation-based. These methods are not able to adequately appreciate the process of IPM adoption to implementation, and what factors are involved this progression. Patton explains that qualitative methods are best suited for appreciating process, whereas quantitative methods are best suited for documenting outcome measures (Patton, 1990). In addition to the dearth (if not complete absence) of published qualitative research on implementing IPM, there are no published qualitative studies looking at IPM in child care settings. Formative work is needed to understand the process of implementing integrated pest management, as it relates to the child care setting. A collection of process measures will help examine the implementation process in a way that outcome measures cannot.

6. Conclusions

In sum, there is a clear relationship between pesticide exposure and health. Children are especially vulnerable, which is concerning given the documented levels of pesticide use and residue in child care centers. State policies have been created to address this problem, but are not successful in creating change on their own. Educational interventions have proven to make a positive impact on outcome measures, but further research needs to be done to understand the process. This research should include child care directors as a target population, since director buy-in is a critical component of IPM implementation and directors have the lowest turnover rate. Understanding the process, particularly as it relates to child care directors, will help to identify facilitators and barriers of IPM and allow recommendations to be made at how to direct future intervention efforts.

The qualitative study, “Documenting and Understanding Success at Implementing Integrated Pest Management in Child Care”, will assess the effects of the CCHP training program on child care center pest management practices at 9 California child care centers. The qualitative analysis will complement the quantitative analysis from Abbey Alkon’s study, “An Integrated Pest Management Toolkit for California Child Care Programs.” Using a qualitative methodology based on grounded theory, nine key informant interviews will be conducted with child care directors and providers whose centers underwent this training.

The objectives of the qualitative study are to:

(1) employ a convergent mixed methods design to develop a more complete understanding of the process of IPM implementation in child care programs,

(2) describe the facilitators and barriers to implementing IPM in child care programs, and

(3) examine congruence between IPM practices identified on an IPM Checklist with practices reported in manager interviews.

Paper 2. Integrated pest management in child care: A mixed methods examination of the implementation process

1. Introduction

Pesticide use is a common problem in United States (U.S.) child care center. In 2001, the U.S. Department of Housing and Urban Development (HUD), the U.S. Consumer Product Safety Commission (CPSC), and the Environmental Protection Agency (EPA) conducted a national study of 168 child care centers to characterize pesticide use and levels (Tulve et al., 2006). Sixty three percent of centers reported using between one and ten types of pesticides, in some cases up to 100 times per year. Pesticides were detected in surface and soil samples from 89% of centers (Tulve et al., 2006). A study by Bradman et al. found that over 50% of 637 California (CA) child care centers reported pesticide use (Bradman et al., 2010).

Pesticide use in child care is a potential health threat to children, as well as to staff. Pesticide exposure has been associated with both acute and chronic illnesses in children, such as skin irritation, respiratory and reproductive disorders, cancer, and mild-to-severe adverse neurological effects (Baldi et al., 1998; Bradman et al., 2011; Evans et al., 2009; Horton et al., 2011; Jurewicz et al., 2006; Makri et al., 2004; M. Morgan et al., 2007; M. K. Morgan et al., 2004). Young children are more vulnerable to pesticides than adults and experience higher pesticide exposures because they eat, drink, and breathe more per kilogram; exhibit more exposure-prone behaviors; and are physiologically and metabolically immature (Bradman et al., 2010; Hubal et al., 2006; Makri et al., 2004; Wilson et al., 2001). Pesticide exposure is also of concern for the 1.3 million US child care center staff, 94.5% of whom are women often of child-bearing age, which increases risk for *in utero* and pregnancy-related pesticide exposure (Bureau of Labor Statistics, 2004).

A 2005 study by Alarcon analyzed national surveillance data and found that there were 2593 cases of acute pesticide related illnesses associated with pesticide exposure in schools between 1998 and 2002 (Alarcon et al., 2005). This is particularly concerning in child care settings, where children are younger than they are in the K-12 school system, and even more concerning given the numbers of U.S. children in child care. Nationwide, 63% of all U.S. children ages 0-5 are placed in out of home child care for some portion of the workday (Tulve et al., 2006; US Census Bureau, 2009).

In an effort to reduce pesticide use in schools, 35 states out of 50 states have developed statewide school pest management legislation (Green et al., 2009; Owens, 2009). Legislation and specific guidelines vary by state, and integrated pest management (IPM), a prevention-based approach to pest management, is a component of two thirds of these policies (Green et al., 2009). IPM programs in schools follow a systematic approach to pest control that uses pesticides only as a last resort, and focuses on prevention, monitoring, identification of pests, and management. The goal is to minimize the risk of exposure of pesticides to children, staff, and the environment (Daar et al., 1997; Environmental Protection Agency, 1993; UCSF California Childcare Health Program, 2011).

While 15 states have policies that require the use of IPM in school and 6 states have policies that recommend it, studies show a discrepancy between creation of a state policy, adoption of it in schools, and implementation of it (Brajkovich, Hanger, Messenger, & Simmons, 2010; Fournier et al., 2010). A 2004 study by Gooch showed that, though Massachusetts's school pest management policy requires IPM in school, less than 30% of schools were actually in compliance (Gooch, 2004). Similar to the phenomenon in schools, a survey of CA child care centers found that only 25% of 637 center respondents were familiar with the term IPM, despite a statewide policy that recommends its use (Bradman et al., 2010). A 2010 study in Indiana showed that 1) greater than 95% of the schools had adopted a pest management policy, or had plans to, 2) 31% of the policies recommended the use of IPM and 27% required it, and 3) 60% of schools used routine preventive applications of pesticides, which is non-compliant with practicing IPM (Moore, 2010). These studies highlight that rates of IPM implementation are not always in accordance with the policies that require or recommend it.

Though young children are at an increased risk, few state laws extend to child care centers. In the 13 western states, nine states have pest management laws; only five include child care in the legislation (Western Region School IPM Implementation and Assessment Work Group, 2011). Similar to the trend of school-centric pest management policies, pest management education and research have also primarily targeted schools (Brajkovich et al., 2010).

Various factors have been identified that influence school IPM implementation, including state legislation, trainings and educational materials about IPM, and school-specific "champions" of IPM (Fournier et al., 2010; Piper & Owens, 2002). Despite increasing educational outreach research about IPM in schools, little is known about IPM in child care. Compared to K-12 schools, child care centers are less stable and more stressed financially (Institute of Medicine and National Research Council of the National Academies, 2011). Child care centers suffer from high annual staff turnover rates, sometimes as high as 40% (A. Alkon, Ramler, M, MacLennan, K, 2003; Bureau of Labor Statistics, 2011; Mir et al., 2010; The National Association of Child Care Resource and Referral Agencies, 2006), and low staff education levels (Bureau of Labor Statistics, 2011; Institute of Medicine and National Research Council of the National Academies, 2011; National Child Care Information Center, 2004). There is no explicit regulation requiring child care providers to receive training about pesticide use and pest management (American Academy of Pediatrics, 2011).

Due to the unique stresses and characteristics of the child care system, it is likely that implementation of IPM in child care centers is different from implementation in schools. More research is needed to understand how IPM is adopted and implemented in child care centers. Other studies of child care have shown positive changes in policies and practices based on general health interventions (A. Alkon, Bernzweig, To, Wolff, & Mackie, 2009). One study conducted by Mir et al. over a three year period showed that IPM training in child care centers increased their use of IPM strategies, reduced pest problems, and increased staff knowledge and understanding of IPM (Mir et al., 2010). A literature review did not yield any other research pertaining to implementation of IPM in child care. This field of pest management in child care is an important, yet under-studied area.

This study attempts to address this gap. It employs mixed methods to document the process of implementation of IPM in 9 CA child care centers. It is innovative both in the focus on IPM in child care and in the use of mixed methods to intentionally integrate qualitative and quantitative methods to draw on the strengths of each one. Used together, qualitative and quantitative methods can help develop a more complete understanding of IPM implementation in child care by describing both process, facilitators, barriers, and outcomes (Creswell, 2011). Previous research has focused more on quantitative results, and this study strives to explain both the processes that explain changes in IPM polices and practices along with quantitative outcomes.

The objectives of this pilot study conducted in nine CA child care centers were to:

(1) employ a convergent mixed methods design to develop a more complete understanding of the process of IPM implementation in child care programs,

(2) describe the facilitators and barriers to implementing IPM in child care programs, and

(3) examine congruence between IPM practices identified on an IPM Checklist with practices reported in manager interviews.

2. Methods

This study was a seven-month intervention study with a convergent mixed methods design.

2.1 Participants

Nine child care centers were recruited between September 2010 and December 2010 via purposive sampling. The number of centers was chosen based on the budget and available personnel time. Recruitment was conducted using a list of licensed child care centers and of staff contacts located in five California counties, and phone calls were made to screen centers for eligibility. Inclusion criteria were that a center: 1) provided out-of-home care, 2) served low-income children, 3) took care of their own garbage, 4) was interested in the IPM project, and 5) would be in operation in 7 months.

Managers were chosen for interviews due to their lower turnover rate and higher level of influence (The National Association of Child Care Resource and Referral Agencies, 2006; Whitebrook et al., 2006). The non-director managers who participated in this study were appointed by center directors based on their capacity to oversee IPM implementation. Managers had worked at their centers for 2 to 32 years (M=14.94 years), had worked in child care for 8.5 to 35 years (M=20.72), and the majority (n=7) had an education level of at least a Masters degree. (See Table 1)

2.2 Intervention

The intervention was comprised of distribution of the IPM Toolkit, a one and a half hour IPM educational workshop at each child care center, and written and photographic feedback on the IPM Checklist inspection. The evaluation included a manager interview and an observational inspection using an IPM Checklist, completed at baseline before the intervention (pre-intervention) and 4-6 months after the intervention (post-intervention).

2.3 Instruments

Instruments were created with input from an interdisciplinary team (n=6), which consisted of experts in the fields of environmental health, health care, child care, and IPM. The interview and Checklist were pilot tested at two child care centers not included in this study. Feedback on clarity and instrument-usability was incorporated into the final versions of the instruments.

2.3.1 Manager Interview

2.3.1.1 Survey Interview

The survey interview was a 58-item, objective assessment tool developed to assess pest control practices and compliance with AB 2865 (California's school and child care pest management law). It contained questions regarding pets, earthquake supplies, building maintenance and policies, cleaning and sanitizing, and pesticide use or IPM practices. Centers demographics were also collected as part of the survey interview.

2.3.1.2 Semi-structured Interview

The qualitative protocol was developed to aid in creating a conversation via open-ended questions (Patton, 1990; Spradley, 1979). This component was not in the original protocol, but grew out of conducting the pre-intervention assessment. The purpose of its inclusion was to create a more appropriate means to better understand the process of implementing IPM, and why there is often disconnect between adoption of IPM and its actual implementation.

The qualitative questions covered the following themes: manager responsibilities, center and statewide policy, workshop take-aways, process of IPM implementation, and current pest management practices. The range of topics was designed to give child care managers the opportunity to discuss their experiences with implementing IPM, and the facilitators and barriers involved in the process. The interviews were audio-recorded.

2.3.2 IPM Checklist

The IPM Checklist was a 72-item objective, observational tool to identify IPM prevention and management practices, and pest problems in child care programs. It included observation of the garbage storage area, building exterior, landscape and play area, kitchen, bathrooms, common space, classrooms, storage area, and staff area. Options on the checklist included: yes, no, not applicable, and a comments field. Prior to conducting the IPM Checklist, the study staff was trained by an expert in the field of IPM.

2.4 Data Collection Procedures

All study procedures were approved by the Institutional Review Boards of University of California, San Francisco and University of California, Berkeley. Data were collected via a convergent model, with separate but concurrent quantitative and qualitative data collection and analysis (Creswell, 2011). (Figure 1) Each center was visited two times during the 2010-2011 school year, once before the educational IPM workshop and again 4-6 months after the workshop. At each visit, a survey manager interview and IPM checklist were administered.

Photographs were taken to document the problems identified on the Checklist and to compare the problems pre- and post-intervention. The pre-intervention Checklist results and photographs were shared with center managers after the IPM workshops were completed. The average time to complete the Checklist was about one hour. In addition to the survey manager interview, a semi-structured qualitative interview was administered at each post-intervention visit. Interview length ranged from 25 to 45 minutes. The average pre-intervention interview lasted 31.4 minutes and the average post-intervention interview lasted 34 minutes. Field notes and contact summary sheets were recorded after each visit.

2.5 Data Analysis

Per the convergent design, qualitative and quantitative data were analyzed separately and were then merged for model development and validation (Creswell, 2011).

2.5.1 Qualitative Analysis

Data were analyzed using principles derived from grounded theory, notably the stepwise creation of a theory based on successive analyses of data (Miles, 1994). Interviews were transcribed, printed, read through, and descriptive codes were assigned to units of text. A sentence or thought was considered a unit of coding (Miles, 1994). During early coding, annotations and memos were written to record themes, questions, and highlight areas for further discussion with other co-authors. These memos and discussion helped form inferential codes. This coding scheme was developed inductively, as themes emerged from the transcripts (Miles, 1994). Coding was iterative, and validated by two co-authors, and two independent researchers with qualitative experience.

Descriptive and inferential codes were compiled and organized into a comprehensive codebook, with domains and subcodes. The codebook was organized according to study objectives, with the following major domains: barriers, facilitators, changes since IPM intervention, pest management practices, center relationship with policy, and manager responsibilities. Transcripts and the codebook were imported into Hyperresearch, a qualitative research software, to facilitate organization and ease of analysis. Using the software, all nine transcripts were re-coded according to the final codebook. Each domain was read, and data displays and matrices were created to capture frequency and relationships between codes. After construction of data displays, memos were written to capture trends and pull out major themes from interviews.

From this preliminary analysis, a model of IPM implementation began to emerge. This model was constructed based on the different themes that were discussed by child care managers, such as lack of awareness of IPM (prior to the intervention), learning about IPM and the hazards associated with pesticide use, motivation for adopting IPM, and the process of implementation of IPM. Themes were clustered and then organized into a stepwise process to create an implementation model. This process was mapped against Rogers' Innovation-Decision Process (IDP) to compare and contrast a more global model of diffusion (Rogers, 1995). This comparison helped to support the IPM implementation model, but was not part of its initial creation. Cross-case analysis was performed to compare individual centers to the overall model, and to refine and verify the implementation model (Miles, 1994). Each step of the four-step process was analyzed individually. The four steps were derived from the semi-structured (qualitative data) and survey interviews (quantitative data). The last section describes the quantitative results from Checklist and survey interview data, and helps to validate the outcome of the intervention. Facilitators and barriers were identified through the coding process, and grouped into subthemes, such as outsider identification of pest problems or lack of money.

2.5.2 Quantitative

Data from the survey director interview and IPM Checklist were summarized using descriptive statistics in Stata 11.0. The frequency of the items observed in the IPM Checklist, IPM policies, and prevention practices were summarized with numbers and percentages. Pre- and post-intervention data were analyzed using either paired samples t-tests or Wilcoxan matched pairs signed ranks tests. These data were used to develop and examine congruence with qualitative findings, as per the convergence design (Creswell, 2011).

3. Results

The qualitative themes emerged to form a set of steps that child care center staff progressed through to successfully implement IPM: 1) awareness of IPM, 2) recognition of the importance of IPM and learning how to practice IPM, 3) motivation and decision to adopt IPM, and 4) implementation of IPM, including facilitators and barriers. Evidence of change was established by examining congruence between qualitative and quantitative results. (Figure 2) Each section highlights managers' experiences in each of the steps.

3.1 Awareness of IPM

Managers reported that this was the first official center-wide training on any type of pest management at 100% of the child care centers. One prominent theme that surfaced was not being aware of alternatives to pesticide-based pest management, or of the danger that pesticides pose to children, staff, and the environment.

> In the past we used to just buy the cans of spray and we didn't realize how harmful that was. That's why it's very important to learn more about the different materials that are available, and try to use what is least harmful, especially for the children.

This lack of awareness about IPM was shared at many centers. Before the intervention, only 22% of the managers knew what IPM was, compared to 100% at the end of the project. ($t(df) = -5.29$ (16), $p<.05$) Without awareness of an alternative or their potential harmful effects, pesticides had been applied outdoors in 44% of the participating centers, and indoors in 33% of the centers in the 6 months prior to the study. By the post-intervention interview, there was a decrease in the use of pesticides so that only 11% of centers had applied pesticides outdoors or indoors.

3.2 Recognizing the importance of IPM and learning how to practice IPM

More than just being aware that IPM exists, child care managers and staff gained knowledge about how to practice IPM and follow the state pest management legislation. Managers reported a new understanding of the adverse health effects that may come from pesticide exposure, state laws about usage and parent notification, and how to handle a pest infestation internally or when to call for outside support. One hundred percent of managers mentioned feeling more capable of dealing with a pest infestation after the intervention. In particular, there was a shift in emphasis from managing infestations to preventing them.

> Using IPM rather than how we looked at things in the past, it's changed how we view rodents and cleanliness and all that stuff. So if we have things getting in our classrooms, how are they getting in? That hasn't always been the focus, the focus has been on how do we get rid of them.

Managers attributed this new knowledge to IPM workshops, the individualized feedback and conversation through the interview and Checklist, and other accompanying educational materials. Prior to the intervention, centers got their information on pest management from pest management professionals (PMPs) (44%), fliers or research on the internet (22%), or “we don’t” (33%).

Many managers also reported feeling empowered knowing how to handle a pest infestation, and having the option to handle the situation internally. Managers noted the importance of viewing pest management as “everyone’s business.”

> IPM seems much safer and much more effective when you focus [on cleanliness and building structure] rather than just calling our pest man to come out and solve our issues. It gets the team involved in a different way, not being an outside person's job to come in and solve this. It gets the team involved in thinking what they can do, how they're handling their site.

3.3 Motivation and decision to adopt IPM

When asked why they believe IPM is important, the majority of managers discussed children’s health and well-being. Managers told stories of previous experiences with foggers or indoor spraying, noting the residual smell and effect on air quality. The health of the children and staff were frequently acknowledged as the motivation to not spray pesticides. Some managers explained that children at their centers suffer from asthma, and that this was exacerbated by fumes or aerosolized pesticides.

> Well, it's important for the health of the children. A healthy environment…If you are not going to provide a healthy environment to the children, it will affect their growth and development.

Providing quality care and complying with national standards and state licensing were also listed as reasons to adopt IPM. While only 44% of the centers formally incorporated IPM into their written policies, managers from the remaining 56% of centers mentioned current informal policies and changes in practice, and intent to formalize policies in the future. Thirty-three percent of managers were so compelled by the notion of preventive pest management that they held workshops with or shared information with parents and began practicing IPM in their own homes after the intervention.

3.4 Implementation of IPM

Following a change in awareness and knowledge, and the decision to adopt IPM, child care centers began to implement changes in their pest management approaches. In the post-intervention interview, managers described the changes that had been implemented. For example, they explained changes in how they handled pest infestations, viewed sanitation and building integrity, or contracted PMP or applied pesticides.

> I've been keeping an eye on my facility and maintenance staff, just to make sure they're doing a proper, thorough cleaning and they're doing proper inspections of items, for example, like any gaps, any webbing, any traces of rat dropping or mice droppings, anything that needs to be cleaned up and not left behind.

In order to understand the process of implementation and why some centers adopt an IPM policy but fail to implement it, managers were asked about the facilitators and barriers that they encountered.

3.4.1 Facilitators

Despite differences in center characteristics, a coherent set of facilitators emerged from the interviews with managers. Facilitators were grouped into categories such as identifying problem areas (outsider identification of pest problems), knowing how to solve the problems (reliable information source, IPM training workshop and Toolkit), having support from staff and assistants (everyone one same page, many resources available to work on projects), and having people to fix problems (existing staff who can help implement IPM, PMP or contractor who can help implement IPM). (Table 2)

3.4.2 Barriers

Common barriers included lack of control, lack of money, division of labor and lack of communication between staff involved in pest management. (Table 2) The barriers were more disparate than the facilitators, with less consistency across centers regarding common barriers in the implementation process. This may be due to differences in center organization, and the unique factors that inhibit the implementation process. For instance, division of labor was more common at centers where there were more than fifteen staff, or there were outside contractors. However, it was not an issue at smaller centers.

3.5 Evidence of change

In addition to using qualitative data to document the adoption and implementation of IPM, quantitative measures were used to document traditional outcome measures, such as physical or structural and process or behavioral changes. Quantitative results are outlined in Development and Evaluation of an Integrated Pest Management Toolkit for Child Care Providers (A. Alkon, Kalmar, E, Leonard, V, Flint, ML, Kuo, D, Davidson, N, Bradman, A, 2012). The qualitative self-report measures from manager interviews were supported by findings from objective checklists. The combination of these methods validates change through the process of triangulation.

3.5.1 Process/Behavioral Changes

There was an increase post-intervention in the number of centers with tracking systems for building maintenance (33%), cleaning and sanitizing (25%). There was also a 31% increase in the number of centers with written policies for use of pesticides, as well as an 80% increase in IPM practices (37 out of 46 items). Forty four percent more centers had a designated IPM coordinator, and 33% fewer centers had sprayed pesticides in the last 6 months. The number of centers where pesticides were applied by a non-manager, custodial staff, or PMP went from 100% (n=8) at pre-intervention to 0% post-intervention. (z statistic=2.83, p<.05) (Table 3)

3.5.2 Physical/Structural Changes

In addition to process and behavioral changes, many observable sanitation changes and physical repairs were made between the pre-intervention and post-intervention Checklist. Physical changes included a decrease in the number of damaged window screens; the number of cracks, crevices or holes around cabinets, or in the walls, roof, or foundation; and the amount of spilled liquids or garbage around garbage cans and dumpsters. There was an increase in exterior doors with sweeps or weatherstripping on the post-intervention Checklist. Observable sanitation changes included more instances of food being stored in tightly sealed containers and recyclables being rinsed or cleaned (A. Alkon, Kalmar, E, Leonard, V, Flint, ML, Kuo, D, Davidson, N, Bradman, A, 2012).

As well as changes made, there was a decrease in the instances of pest infestations on the post-intervention Checklist. There were 10 instances of pests noted on the pre-intervention observation, compared to zero instances of pests noted post-intervention. (see Table 4)

4. Discussion

This multi-faceted intervention study increased IPM awareness and implementation and reduced pesticide use and observed pest infestations in child care centers. Overall, it yielded positive outcomes and an ability to overcome the challenges between creation of legislation and implementation of IPM. Through the use of mixed methods, this study helped to document what motivates child care managers to invest in the process IPM, and the facilitators and barriers that help lead to IPM implementation. Several key messages can be gleaned from these findings and can be extrapolated to future health and safety interventions in child care:

4.1.1 Awareness

Lack of awareness is the first problem that prevents child care centers from implementing IPM. This study adds to a growing body of research that documents a lack of awareness about IPM in child care centers, despite legislation that encourages or requires its implementation (Bradman et al., 2010; Mir et al., 2010). On a more positive note, it demonstrates the impact of education in increasing awareness and beginning the process of pest management change in child care. With education about IPM, there was an 88% increase in the number of managers who knew about IPM, and 100% of managers felt they were more capable of dealing with pest problems after participation in the intervention. It should not be assumed that creation of statewide policies or legislation will translate to awareness in child care centers.

4.1.2 Information

The second message that emerged from this study is the importance of noteworthy information source. Though child care standards are changing, they have traditionally focused on having a pest-free center, rather than a pesticide-free center, which may inadvertently compel centers to routinely spray pesticides to keep pests out (National Association for the Education of Young Children, 2007). Additionally, since IPM is not often incorporated into child care training, child care staff often are not informed about the potential dangers associated with pesticide use. In a 2008 survey of child care staff, 30% of respondents considered pesticide use to be safer than alternative pest management methods (Bradman et al., 2010). In this study, managers reported a wide variety of information sources on pest management, with 30% of managers mentioning that they don't have an information source. Incorporating IPM education into child care staff training may alleviate this problem and not only dispel any myths about pest management but also compel staff to use more non-pesticide-based, preventative approaches.

4.1.3 Protecting Children

Many managers talked about the importance of "putting the children first." Understanding the potential adverse health effects associated with pesticide exposure motivated child care managers to change their centers' pesticide use and pest management. This interest in the health effects of pesticide exposure was also found in the study by Mir et al (Mir et al., 2010).This helped to personalize the importance of IPM, and change the focus from following a set of regulations, to protecting children's heath. During pilot presentations, participants requested more information on health effects noting that it was something that they were not familiar with. Clear delineation of the importance and relevance of IPM helped bridge the disconnect between awareness and implementation, and inspired managers to promote IPM implementation in their centers. In general, this illustrates the usefulness of educating child care staff about the significance of new policies and innovations.

4.1.4 Inclusion of all staff and managers

The majority of managers recounted their satisfaction that the educational IPM workshop was targeted at the complete staff. By attending the workshop together, managers expressed that everyone was "on the same page" regarding pest management. It set the stage for future implementation and, in some cases, managers followed up with staff meetings, IPM workdays, and parent workshops. IPM implementation may involve various staff depending on the type of child care center, staffing, and organization, but getting everyone involved is important for success in all cases. This study showed a significant decrease in pesticide application in general, but also in the number of "other" individual applicators. The fewer people who apply pesticides, the better control over pesticide spraying. This type of change is dependent upon center-wide understanding of IPM and new practices. We found that smaller centers, where staff worked more closely together and met frequently, were more likely to report a sense of "everyone being on the same page," and consequent ease in carrying out an implementation plan.

4.1.5 Management Support

Similar to other studies, we found that working directly with managers facilitated the implementation of an innovative educational intervention program (A. Alkon et al., 2009; Crowley, 2009). The manager's capacity to oversee and make decisions gave them the power to lead the implementation of IPM, or appoint a more appropriate person to do so. Managers are an especially suitable target for interventions given that they have a lower turnover rate than staff, and therefore can sustain change, transfer knowledge, and train new staff for longer (Whitebrook et al., 2006).

4.1.6 Length of Intervention

It is difficult to change health practices and behavior (Farrer, 2007). Child care intervention studies show a range of time before positive changes were observed (A. Alkon et al., 2008; A. Alkon, Ramler, M, MacLennan, K, 2003; Mir et al., 2010). This study found positive results after 7 months. This may be due to the sense of accountability that was fostered through the intervention process, and awareness of a post-intervention inspection. Having an outside person visit the center and identify problem areas helped facilitate the implementation process and may have shifted the priority to make IPM-related changes.

4.2 Limitations

Although this study was unique in combining manager's thoughts about the IPM program in addition to objective IPM assessments, this study had many limitations. This pilot project included a small sample size which introduces selection bias related to the convenience sample of child care centers. The IPM Checklist was completed by an objective, non-center employee which supports a strong scientific design, but is not easily replicated in child care centers with limited resources. It is not known if the changes observed over this study period will be sustained or improved over a longer period of time. Future studies with a larger, more representative sample of child care centers is needed to test this model of IPM implementation.

4.3 Conclusion

While this pilot study was conducted with a small sample, the observed changes in pest management may help create a healthier, pesticide-free environment for children and staff. By continuing to disseminate IPM Toolkits and our findings, more child care staff will learn about IPM. In fact, the most recent edition of Caring for our Children, a national guide of health and safety performance standards for out-of-home child care programs, includes a section on IPM, compared to the previous versions which did not include pest management (American Academy of Pediatrics, 2011). The most recent standards and guidelines for child care and environmental health are similarly beginning to encourage use of IPM (American Academy of Pediatrics Council on Environmental Health, 2012; National Association for the Education of Young Children, 2007). These changes in child care-specific health standards, combined with increased educational efforts targeted at the child care community, can help to reduce pesticide use and, ultimately, improve children's health.

References

Paper one. Literature Review

Alarcon, W., Calvert, G., Blondell, J., Mehler, L., Sievert, J., Propeck, M., . . . Stanbury, M. (2005). Acute Illness Associated With Pesticide Exposure at Schools. *JAMA, 294*(4), 455-465.

Alkon, A. (2010). *An Integrated Pest Management Curriculum for Urban Child Care Programs*. IRB application. California Childcare Health Program. Berkeley, CA.

Alkon, A., Bernzweig, J., To, K., Mackie, J., Wolff, M., & Elman, J. (2008). Child Care Health Consultation Programs in California: Models, Services, and Facilitators. *Public Health Nursing, 25*(2), 126-139.

Alkon, A., Bernzweig, J., To, K., Wolff, M., & Mackie, J. (2009). Child Care Health Consultation Improves Health and Safety Policies and Practices. *Academic Pediatrics, 9*(5), 366-370.

Alkon, A., Kalmar, E, Leonard, V, Flint, ML, Kuo, D, Davidson, N, Bradman, A. (2012). *Development and Evaluation of an Integrated Pest Management Toolkit for Child Care Providers*

Alkon, A., Ramler, M, MacLennan, K. (2003). Evaluation of Mental Health Consultation in Child Care Centers. *Early Childhood Education Journal, 31*(2).

American Academy of Pediatrics, A. P. H. A., National Resource Center for Health and Safety in Child Care and Early Education,. (2011). *Caring for our children: National health and safety performance standards; Guidelines for early care and education programs* (3rd edition ed.). Washington, DC.

American Academy of Pediatrics Council on Environmental Health. (2012). Pediatric Environmental health R. A. Etzel, Balk, S.J. (Ed.) Retrieved from http://ebooks.aap.org/product/pediatric-environmental-health-3rd-edition

Baldi, I., Mohammed-Brahim, B., Brochard, P., Dartigues, J., & Salamon, R. (1998). Delayed health effects of pesticides: review of current epidemiological knowledge. *Rev Epidemiol Sante Publique, 46*(2), 134-142.

Beyond Pesticides. (2002). State and Local School Pesticide Policies. Retrieved May 1, 2011, 2011, from http://www.beyondpesticides.org/schools/schoolpolicies/index.htm

Beyond Pesticides. (2006). Beyond Pesticides' Gateway on Pesticide Hazards and Safe Pest Management. http://www.beyondpesticides.org/gateway/about.htm

Bradman, A., Castorina, R., Boyd Barr, D., Chevrier, J., Harnly, M. E., Eisen, E. A., . . . Eskenazi, B. (2011). Determinants of Organophosphorus Pesticide Urinary Metabolite Levels in Young Children Living in an Agricultural Community. *International Journal of Environmental Research and Public Health, 8*(4), 1061-1083.

Bradman, A., Dobson, C., & Leonard, V. (2010). Pest Management and Pesticide Use in California Child Care Centers. In U. B. S. o. P. H. The Center for Environmental Research for Children's Health (Ed.).

Brajkovich, L., Hanger, A., Messenger, B., & Simmons, S. (2010). California's Use of IPM in Managing Pests in Schools. *Outlooks on Pest Management, 21*(1), 25-30.

Brenner, B. L., Markowitz, S., Rivera, M., Romero, H., Weeks, M., Sanchez, E., . . . Berkowitz, G. (2003). Integrated Pest Management in an Urban Community: A Successful Partnership for Prevention. *Environmental Health Perspectives, 111*(13), 1649-1653.

Bureau of Labor Statistics. (2004). Childcare Workers. from U.S. Department of Labor, http://www.policyalmanac.org/social_welfare/archive/child_care_workers.shtml
Bureau of Labor Statistics. (2011). Career Guide to Industries, 2010-2011 Edition. Retrieved November, 2 2011, from U.S. Department of Labor, http://www.bls.gov/oco/cg/cgs032.htm
Census, U. (2005-2009). United States -- Age and Sex. http://factfinder.census.gov/servlet/STTable?_bm=y&-geo_id=01000US&-qr_name=ACS_2009_5YR_G00_S0101&-ds_name=ACS_2009_5YR_G00_
Creswell, J. W., Plano Clark, Vicki L.,. (2011). *Designing and conducting mixed methods research* (2nd edition ed.). Thousand Oaks, CA: Sage.
Crowley, A. A., Kulikowich, Jonna M.,. (2009). Impact of Training on Child Care Health Consultant Knowledge and Practice. *Pediatric Nursing, 35*(2).
Daar, S., Drlik, T., Olkowski, H., & Olkowski, W. (1997). *Integrated pest management for schools: a how-to manual*. Washington, D.C.: EPA Retrieved from http://www.epa.gov/pesticides/ipm/schoolipm/index.html.
Environmental Protection Agency. (1993). Pest Control in the School Environment: Adopting Integrated Pest Management. Retrieved from http://www.epa.gov/pesticides/ipm/brochure/
Federal Insecticide, Fungicide, and Rodenticide Act (1996).
EPA. (2009). Illegal Pesticide Products. *http://www.epa.gov/pesticides/health/illegalproducts/*.
Evans, D., Espino, C., Tiven, J., Clarke, B., Garfinkel, R., Nagle, S., . . . Kass, D. (2009). Effectiveness of an Integrated Pest Management Intervention in Controlling Cockroaches, Mice and Allergens in New York City Public Housing. *Environmental Health Perspectives*.
Farrer, J., Alkon, A, To, K. (2007). Child Care Health Consultation Programs: Barriers and Recommendations. *Maternal Child Health Journal, 11*.
Feldman, J., & Owens, K. (2009). The School Environment Protection Act of 2009: Myths and Facts. *Pesticides and You: A quarterly publication of Beyond Pesticides, 29*(4), 12-18.
Flint, M., Daar, S., & Molinar, R. (2003). Establish Integrated Pest Management Policies and Programs: A Guide for Public Agencies. 13. Retrieved from
Fournier, A., Gibb, T., & Oseto, C. (2010). *Go to the Head of the Class: A Research-Based Approach to Understanding Adoption and Implementation of Integrated Pest Management in Schools.* West Lafayette, IN: IPM Technical Resource Center.
Gooch, H. (2004, July 2004.). School IPM's viscious cycle. *Pest Control Magazine,* 5.
Green, T., Gouge, D., & Lame, M. (2009). IPM Implementation by 2015, a Pest Management Strategic Plan. Retrieved from ag.arizona.edu/apmc/docs/PMSPInfomationsheet_June09.pdf
Greene, A., & Breisch, N. (2002). Measuring integrated pest management programs for public buildings. *Journal of Economic Entomology, 95*(1), 1-13.
Harrington, G. (2002, February 14, 2002). School pest management measure wins Senate approval, press release, *National Pest Management Association*.
Horton, M. K., Rundle, A., Camann, D. E., Boyd Barr, D., Rauh, V. A., & Whyatt, R. M. (2011). Impact of Prenatal Exposure to Piperonyl Butoxide and Permethrin on 36-Month Neurodevelopment. *Pediatrics, 127*(3), e699-e706.

Hubal, E. A. C., Egeghy, P. P., Leovic, K. W., & Akland, G. G. (2006). Measuring Potential Dermal Transfer of a Pesticide to Children in a Child Care Center. *Environmental Health Perspectives, 114*(2), 264-269.

Huffaker, C., & Croft, B. (1976). Integrated pest management in the U.S.: progress and promise. *Environmental Health Perspectives, 14*, 167-183.

Institute of Medicine and National Research Council of the National Academies. (2011). The Early Childhood Care and Education Workforce: Challenges and Opportunities -- A Workshop Report. Washington, D.C.

IPM Institute of North America. (2004). IPM Standards for Schools: A Program for Reducing Pest and Pesticide Risks in Schools and Other Sensitive Environments

IPM, T. (2007, March 2007). The History of IPM. Retrieved April 2, 2011, from http://ipm.tamu.edu/overview/history.html

Jurewicz, J., Hanke, W., Johansson, C., Lundqvist, C., Ceccatelli, S., Van Den Hazel, P., . . . Zetterström, R. (2006). Adverse health effects of children's exposure to pesticides: What do we really know and what can be done about it. *Acta Paediatrica, 95*(0), 71-80.

Lame, M. (1999). The national IPM in schools workshop 1999: efforts for coordination and implementation of IPM in child sensitive facilities. *Indiana University School of Public and Environmental Affairs*.

Lame, M., Andersen, E., Andriyevska, L., Beekman, C., Burns, R., Crowley, K., . . . Weston, D. (2001). Draft agency initiative and implementation plan for integrated pest management in schools. *Indiana University School of Public and Environmental Affairs*.

Levy, J. I., Brugge, D., Peters, J. L., Clougherty, J. E., & Saddler, S. S. (2006). A community-based participatory research study of multifaceted in-home environmental interventions for pediatric asthmatics in public housing. *Social Science & Medicine, 63*(8), 2191-2203.

Lu, C., Knutson, D., Fisker-Anderson, J., & Fenske, R. (2001). Biological Monitoring Survey of Organophosphorus Pesticide Exposure among Preschool Children in the Seattle Metropolitan Area. *Environmental Health Perspectives, 109*(3), 299-303.

Makri, A., Goveia, M., Balbus, J., & Parkin, R. (2004). Children's susceptibility to chemical: A review by developmental stage. *Journal of Toxicology and Environmental Health, Part B, 7*(6), 417-435.

McConnel, R., Milam, J., Richardson, J., Galvan, J., Jones, C., & Thorne, P. (2005). Educational intervention to control cockroach allergen exposure in the homes of Hispanic children in Los Angeles: results of the La Casa study. *Clin Exp Allergy, 35*, 426-433.

Miles, M. B. H., A.M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd edition ed.). Thousand Oaks: Sage Publications.

Mir, D. F., Finkelstein, Y., & Tulipano, G. D. (2010). Impact of integrated pest management (IPM) training on reducing pesticide exposure in Illinois childcare centers. *NeuroToxicology, 31*(5), 621-626.

Moore, J. (2010). From Pest Treatment to Pest Prevention: A Case Study of Integrated Pest Management at The Metropolitan School District of Pike Township.

Morgan, M., Sheldon, L., Croghan, C., Jones, P., Chuang, J., & Wilson, N. (2007). An observational study of 127 preschool children at their homes and daycare centers in Ohio: Environmental pathways to cis- and trans-permethrin exposure. *Environmental Research, 104*(2), 266-274.

Morgan, M. K., Sheldon, L. S., Croghan, C. W., Jones, P. A., Robertson, G. L., Chuang, J. C., . . . Lyu, C. W. (2004). Exposures of preschool children to chlorpyrifos and its degradation product 3,5,6-trichloro-2-pyridinol in their everyday environments. *Journal of Exposure Analysis and Environmental Epidemiology, 15*(4), 297-309.

National Association for the Education of Young Children. (2007). NAEYC Early Childhood Program Standards and Accreditation Criteria: The Mark of Quality.

National Child Care Information Center. (2004). Center Child Care Licensing Requirements.

Owens, K. (2003). An in-depth look at integrated pest management (IPM). In B. Pesticides (Ed.), *In Beyond Pesticides, Safer Schools: achieving a healthy learning environment through integrated pest management* (pp. 4-12). Washington D.C.

Owens, K. (2009). Schooling of State Pesticide Laws. *Pesticides and You: A quarterly publication of Beyond Pesticides, 29*(3).

Owens, K., & Feldman, J. (1998). The schooling of state pesticide laws. *Pesticides and You, 18,* 9-22.

Owens, K., & Feldman, J. (2002). The schooling of state pesticide laws - 2002 update. *Beyond Pesticides*. Retrieved from www.beyondpesticides.org/schools/publications/index.htm

Patton, M. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, California: Sage Publications.

Piper, C., & Owens, K. (2002). Are Schools Making the Grade? School disctricts nationwide adopt safer pest managment policies. *Beyond Pesticides/National Coalition Against the Misuse of Pesticides, 22*(3), 11-20.

Rattray, R., Brunner, W., & Freestone, J. (2002). The New Spectrum of Prevention: A Model for Public Health Practice. *Contra Costa Health Services, Public Health Division*.

Rogers, E. (1995). *Diffusions of innovations* (4th ed.). New York, New York: Free Press.

Safer Pest Control Project. (2001). Implementation of IPM and Pesticide Notification in Illinois Schools: Results from a Survey by Safer Pest Control Project. Retrieved from

Scherer, C. W. (2000). School Integrated Pest Management: Annual Report of the Florida School IPM Advisory Board. Gainsville, Florida: University of Floriday, Entomology and Nematology Department.

Spradley, J. P. (1979). *The ethnographic interview*. Forth Worth, TX: Harcourt Brace Jovanovich College Publishers.

The National Association of Child Care Resource and Referral Agencies. (2006). Child Care Workforce. Retrieved from http://www.naccrra.org/randd/data/childcareworkforce.pdf

Tulve, N., Jones, P., Nishioka, M., Fortmann, R., Croghan, C., Zhou, J., . . . Friedman, W. (2006). Pesticide Measurements from the First National Environmental Health Survey of Child Care Centers Using a Multi-Residue GC/MS Analysis Mehtod. *Environmental Science & Technology, 40*(20), 6269-6274.

Tweedy, B. (1976). Integrated Pest Management. *Environmental Health Perspectives, 14*, 165-166.

UCSF California Childcare Health Program. (2011). Integrated Pest Management: A Toolkit for Early Care and Education Programs   Retrieved from http://www.ucsfchildcarehealth.org/html/pandr/trainingcurrmain.htm

Western Region School IPM Implementation and Assessment Work Group. (2011). Inventory of School and Child Care Laws and Regulations. Retrieved October, 23rd 2011 http://ag.arizona.edu/apmc/docs/InventoryofSchoolandChildCareIPMLawsandRegulations2011.pdf

Whitebrook, M., Sakai, L., Kipnis, F., Lee, Y., Bellm, D., Almaraz, M., & Tra, P. (2006). *California Early Care and Education Workforce Study: Licensed child care centers*. Berkeley, CA: Center for the Study of Child Care Employment.

Wilson, N., Chuang, J., & Lyu, C. (2001). Levels of persistent organic pollutants in several child care centers. *Journal of Exposure Analysis and Environmental Epidemiology, 11*, 449-458.

Paper 2. Integrated pest management in child care: A mixed methods examination of the implementation process

Alarcon, W., Calvert, G., Blondell, J., Mehler, L., Sievert, J., Propeck, M., . . . Stanbury, M. (2005). Acute Illness Associated With Pesticide Exposure at Schools. *JAMA, 294*(4), 455-465.

Alkon, A. (2010). *An Integrated Pest Management Curriculum for Urban Child Care Programs*. IRB application. California Childcare Health Program. Berkeley, CA.

Alkon, A., Bernzweig, J., To, K., Mackie, J., Wolff, M., & Elman, J. (2008). Child Care Health Consultation Programs in California: Models, Services, and Facilitators. *Public Health Nursing, 25*(2), 126-139. doi: 10.1111/j.1525-1446.2008.00689.x

Alkon, A., Bernzweig, J., To, K., Wolff, M., & Mackie, J. (2009). Child Care Health Consultation Improves Health and Safety Policies and Practices. *Academic Pediatrics, 9*(5), 366-370.

Alkon, A., Kalmar, E, Leonard, V, Flint, ML, Kuo, D, Davidson, N, Bradman, A. (2012). *Development and Evaluation of an Integrated Pest Management Toolkit for Child Care Providers*

Alkon, A., Ramler, M, MacLennan, K. (2003). Evaluation of Mental Health Consultation in Child Care Centers. *Early Childhood Education Journal, 31*(2).

American Academy of Pediatrics, A. P. H. A., National Resource Center for Health and Safety in Child Care and Early Education,. (2011). *Caring for our children: National health and safety performance standards; Guidelines for early care and education programs* (3rd edition ed.). Washington, DC.

American Academy of Pediatrics Council on Environmental Health. (2012). Pediatric Environmental health R. A. Etzel, Balk, S.J. (Ed.) Retrieved from http://ebooks.aap.org/product/pediatric-environmental-health-3rd-edition

Baldi, I., Mohammed-Brahim, B., Brochard, P., Dartigues, J., & Salamon, R. (1998). Delayed health effects of pesticides: review of current epidemiological knowledge. *Rev Epidemiol Sante Publique, 46*(2), 134-142.

Beyond Pesticides. (2002). State and Local School Pesticide Policies. Retrieved May 1, 2011, 2011, from http://www.beyondpesticides.org/schools/schoolpolicies/index.htm

Beyond Pesticides. (2006). Beyond Pesticides' Gateway on Pesticide Hazards and Safe Pest Management. http://www.beyondpesticides.org/gateway/about.htm

Bradman, A., Castorina, R., Boyd Barr, D., Chevrier, J., Harnly, M. E., Eisen, E. A., . . . Eskenazi, B. (2011). Determinants of Organophosphorus Pesticide Urinary Metabolite Levels in Young Children Living in an Agricultural Community. *International Journal of Environmental Research and Public Health, 8*(4), 1061-1083. doi: 10.3390/ijerph8041061

Bradman, A., Dobson, C., & Leonard, V. (2010). Pest Management and Pesticide Use in California Child Care Centers. In U. B. S. o. P. H. The Center for Environmental Research for Children's Health (Ed.).

Brajkovich, L., Hanger, A., Messenger, B., & Simmons, S. (2010). California's Use of IPM in Managing Pests in Schools. *Outlooks on Pest Management, 21*(1), 25-30. doi: 10.1564/21feb07

Brenner, B. L., Markowitz, S., Rivera, M., Romero, H., Weeks, M., Sanchez, E., . . . Berkowitz, G. (2003). Integrated Pest Management in an Urban Community: A Successful Partnership for Prevention. *Environmental Health Perspectives, 111*(13), 1649-1653. doi: 10.1289/ehp.6069

Bureau of Labor Statistics. (2004). Childcare Workers. from U.S. Department of Labor, http://www.policyalmanac.org/social_welfare/archive/child_care_workers.shtml

Bureau of Labor Statistics. (2011). Career Guide to Industries, 2010-2011 Edition. Retrieved November, 2 2011, from U.S. Department of Labor, http://www.bls.gov/oco/cg/cgs032.htm

Creswell, J. W., Plano Clark, Vicki L.,. (2011). *Designing and conducting mixed methods research* (2nd edition ed.). Thousand Oaks, CA: Sage.

Crowley, A. A., Kulikowich, Jonna M.,. (2009). Impact of Training on Child Care Health Consultant Knowledge and Practice. *Pediatric Nursing, 35*(2).

Daar, S., Drlik, T., Olkowski, H., & Olkowski, W. (1997). *Integrated pest management for schools: a how-to manual*. Washington, D.C.: EPA Retrieved from http://www.epa.gov/pesticides/ipm/schoolipm/index.html.

Environmental Protection Agency. (1993). Pest Control in the School Environment: Adopting Integrated Pest Management. Retrieved from http://www.epa.gov/pesticides/ipm/brochure/

Environmental Protection Agency. (2009). Illegal Pesticide Products. *http://www.epa.gov/pesticides/health/illegalproducts/*.

Federal Insecticide, Fungicide, and Rodenticide Act (1996).

Evans, D., Espino, C., Tiven, J., Clarke, B., Garfinkel, R., Nagle, S., . . . Kass, D. (2009). Effectiveness of an Integrated Pest Management Intervention in Controlling Cockroaches, Mice and Allergens in New York City Public Housing. *Environmental Health Perspectives*. doi: 10.1289/ehp.0800149

Farrer, J., Alkon, A, To, K. (2007). Child Care Health Consultation Programs: Barriers and Recommendations. *Maternal Child Health Journal, 11*.

Feldman, J., & Owens, K. (2009). The School Environment Protection Act of 2009: Myths and Facts. *Pesticides and You: A quarterly publication of Beyond Pesticides, 29*(4), 12-18.

Flint, M., Daar, S., & Molinar, R. (2003). Establish Integrated Pest Management Policies and Programs: A Guide for Public Agencies. 13. Retrieved from

Fournier, A., Gibb, T., & Oseto, C. (2010). *Go to the Head of the Class: A Research-Based Approach to Understanding Adoption and Implementation of Integrated Pest Management in Schools.* West Lafayette, IN: IPM Technical Resource Center.

Gooch, H. (2004). School IPM's viscious cycle. *Pest Control Magazine,* 5.

Green, T., Gouge, D., & Lame, M. (2009). IPM Implementation by 2015, a Pest Management Strategic Plan. Retrieved from ag.arizona.edu/apmc/docs/PMSPInfomationsheet_June09.pdf

Greene, A., & Breisch, N. (2002). Measuring integrated pest management programs for public buildings. *Journal of Economic Entomology, 95*(1), 1-13.

Harrington, G. (2002). School pest management measure wins Senate approval, press release, *National Pest Management Association*.

Horton, M. K., Rundle, A., Camann, D. E., Boyd Barr, D., Rauh, V. A., & Whyatt, R. M. (2011). Impact of Prenatal Exposure to Piperonyl Butoxide and Permethrin on 36-Month Neurodevelopment. *Pediatrics, 127*(3), e699-e706. doi: 10.1542/peds.2010-0133

Hubal, E. A. C., Egeghy, P. P., Leovic, K. W., & Akland, G. G. (2006). Measuring Potential Dermal Transfer of a Pesticide to Children in a Child Care Center. *Environmental Health Perspectives, 114*(2), 264-269. doi: 10.1289/ehp.8283

Huffaker, C., & Croft, B. (1976). Integrated pest management in the U.S.: progress and promise. *Environmental Health Perspectives, 14*, 167-183.

Institute of Medicine and National Research Council of the National Academies. (2011). The Early Childhood Care and Education Workforce: Challenges and Opportunities -- A Workshop Report. Washington, D.C.

IPM Institute of North America. (2004). IPM Standards for Schools: A Program for Reducing Pest and Pesticide Risks in Schools and Other Sensitive Environments

Jurewicz, J., Hanke, W., Johansson, C., Lundqvist, C., Ceccatelli, S., Van Den Hazel, P., . . . Zetterström, R. (2006). Adverse health effects of children's exposure to pesticides: What do we really know and what can be done about it. *Acta Paediatrica, 95*(0), 71-80. doi: 10.1080/08035320600886489

Lame, M. (1999). The national IPM in schools workshop 1999: efforts for coordination and implementation of IPM in child sensitive facilities. *Indiana University School of Public and Environmental Affairs*.

Lame, M., Andersen, E., Andriyevska, L., Beekman, C., Burns, R., Crowley, K., . . . Weston, D. (2001). Draft agency initiative and implementation plan for integrated pest management in schools. *Indiana University School of Public and Environmental Affairs*.

Levy, J. I., Brugge, D., Peters, J. L., Clougherty, J. E., & Saddler, S. S. (2006). A community-based participatory research study of multifaceted in-home environmental interventions for pediatric asthmatics in public housing. *Social Science & Medicine, 63*(8), 2191-2203. doi: 10.1016/j.socscimed.2006.05.006

Lu, C., Knutson, D., Fisker-Anderson, J., & Fenske, R. (2001). Biological Monitoring Survey of Organophosphorus Pesticide Exposure among Preschool Children in the Seattle Metropolitan Area. *Environmental Health Perspectives, 109*(3), 299-303.

Makri, A., Goveia, M., Balbus, J., & Parkin, R. (2004). Children's susceptibility to chemical: A review by developmental stage. *Journal of Toxicology and Environmental Health, Part B, 7*(6), 417-435. doi: 10.1080/10937400490512465

McConnel, R., Milam, J., Richardson, J., Galvan, J., Jones, C., & Thorne, P. (2005). Educational intervention to control cockroach allergen exposure in the homes of Hispanic children in Los Angeles: results of the La Casa study. *Clin Exp Allergy, 35*, 426-433.

Miles, M. B., Huberman, A.M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd edition ed.). Thousand Oaks: Sage Publications.

Mir, D. F., Finkelstein, Y., & Tulipano, G. D. (2010). Impact of integrated pest management (IPM) training on reducing pesticide exposure in Illinois childcare centers. *NeuroToxicology, 31*(5), 621-626. doi: 10.1016/j.neuro.2010.05.013

Moore, J. (2010). From Pest Treatment to Pest Prevention: A Case Study of Integrated Pest Management at The Metropolitan School District of Pike Township.

Morgan, M., Sheldon, L., Croghan, C., Jones, P., Chuang, J., & Wilson, N. (2007). An observational study of 127 preschool children at their homes and daycare centers in Ohio: Environmental pathways to cis- and trans-permethrin exposure. *Environmental Research, 104*(2), 266-274. doi: 10.1016/j.envres.2006.11.011

Morgan, M. K., Sheldon, L. S., Croghan, C. W., Jones, P. A., Robertson, G. L., Chuang, J. C., . . . Lyu, C. W. (2004). Exposures of preschool children to chlorpyrifos and its degradation product 3,5,6-trichloro-2-pyridinol in their everyday environments. *Journal of Exposure Analysis and Environmental Epidemiology, 15*(4), 297-309. doi: 10.1038/sj.jea.7500406

National Association for the Education of Young Children. (2007). NAEYC Early Childhood Program Standards and Accreditation Criteria: The Mark of Quality.

National Child Care Information Center. (2004). Center Child Care Licensing Requirements.

Owens, K. (2003). An in-depth look at integrated pest management (IPM). In B. Pesticides (Ed.), *In Beyond Pesticides, Safer Schools: achieving a healthy learning environment through integrated pest management* (pp. 4-12). Washington D.C.

Owens, K. (2009). Schooling of State Pesticide Laws. *Pesticides and You: A quarterly publication of Beyond Pesticides, 29*(3).

Owens, K., & Feldman, J. (1998). The schooling of state pesticide laws. *Pesticides and You, 18,* 9-22.

Owens, K., & Feldman, J. (2002). The schooling of state pesticide laws - 2002 update. *Beyond Pesticides*. Retrieved from www.beyondpesticides.org/schools/publications/index.htm

Patton, M. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, California: Sage Publications.

Piper, C., & Owens, K. (2002). Are Schools Making the Grade? School disctricts nationwide adopt safer pest managment policies. *Beyond Pesticides/National Coalition Against the Misuse of Pesticides, 22*(3), 11-20.

Rattray, R., Brunner, W., & Freestone, J. (2002). The New Spectrum of Prevention: A Model for Public Health Practice. *Contra Costa Health Services, Public Health Division*.

Rogers, E. (1995). *Diffusions of innovations* (4th ed.). New York, New York: Free Press.

Safer Pest Control Project. (2001). Implementation of IPM and Pesticide Notification in Illinois Schools: Results from a Survey by Safer Pest Control Project. Retrieved from

Scherer, C. W. (2000). School Integrated Pest Management: Annual Report of the Florida School IPM Advisory Board. Gainsville, Florida: University of Floriday, Entomology and Nematology Department.

Spradley, J. P. (1979). *The ethnographic interview*. Forth Worth, TX: Harcourt Brace Jovanovich College Publishers.

Texas IPM. (2007). The History of IPM. Retrieved April 2, 2011, from http://ipm.tamu.edu/overview/history.html

The National Association of Child Care Resource and Referral Agencies. (2006). Child Care Workforce. Retrieved from http://www.naccrra.org/randd/data/childcareworkforce.pdf

Tulve, N., Jones, P., Nishioka, M., Fortmann, R., Croghan, C., Zhou, J., . . . Friedman, W. (2006). Pesticide Measurements from the First National Environmental Health Survey of Child Care Centers Using a Multi-Residue GC/MS Analysis Mehtod. *Environmental Science & Technology, 40*(20), 6269-6274.

Tweedy, B. (1976). Integrated Pest Management. *Environmental Health Perspectives, 14*, 165-166.
UCSF California Childcare Health Program. (2011). Integrated Pest Management: A Toolkit for Early Care and Education Programs Retrieved from http://www.ucsfchildcarehealth.org/html/pandr/trainingcurrmain.htm
US Census Bureau. (2009). United States: Age and Sex 2005-2009. http://factfinder2.census.gov/
Western Region School IPM Implementation and Assessment Work Group. (2011). Inventory of School and Child Care Laws and Regulations. Retrieved October, 23rd 2011 http://ag.arizona.edu/apmc/docs/InventoryofSchoolandChildCareIPMLawsandRegulations2011.pdf
Whitebrook, M., Sakai, L., Kipnis, F., Lee, Y., Bellm, D., Almaraz, M., & Tra, P. (2006). *California Early Care and Education Workforce Study: Licensed child care centers*. Berkeley, CA: Center for the Study of Child Care Employment.
Wilson, N., Chuang, J., & Lyu, C. (2001). Levels of persistent organic pollutants in several child care centers. *Journal of Exposure Analysis and Environmental Epidemiology, 11*, 449-458.

Tables and Figures

Table 1. Demographic Characteristics of Managers, Centers, and Children (n=9 centers, 854 children)

Demographic information	**Percent**	**N**
Manager type		
Director	55.6%	5
Site supervisor	22.2%	2
Maintenance manager	11.1%	1
Health and safety specialist	11.1%	1
Manager educational level		
Bachelor's degree	22.2%	2
Master's degree or more	77.8%	7
Center Type		
Head Start	33.3%	3
Private	33.3%	3
State-funded	33.3%	3
Children's ethnic background		
Asian/ Pacific Islander	8%	68
African American	5%	43
European American	20%	171
Hispanic, Latino	60%	512
Mixed Race	3%	26
Other groups	4%	34
Children receiving government subsidies	77%	657
Manager Experience	**Mean**	**N**
Years worked in childcare field	27	9
Years worked at this center	11	9

Figure 1. Convergent Parallel Mixed Methods Design

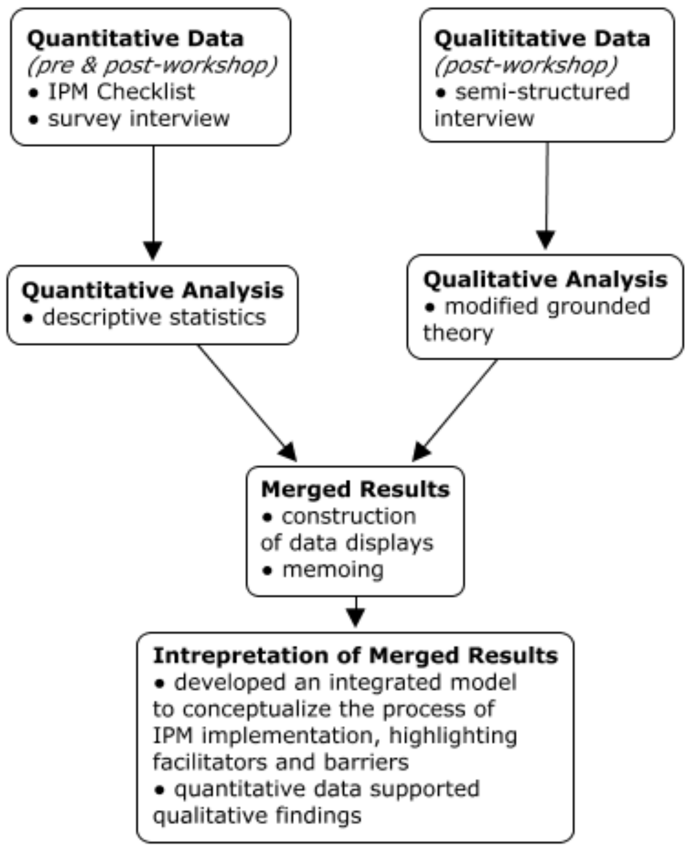

Figure 2. Child Care IPM Implementation Model

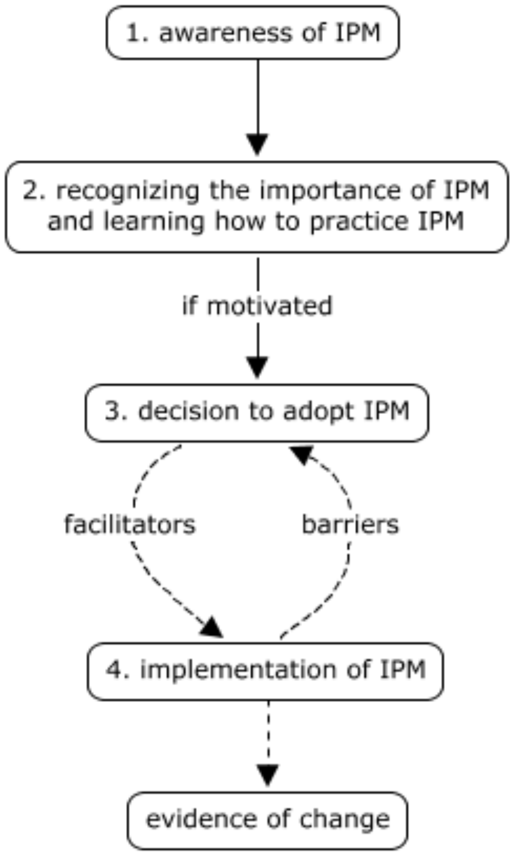

Table 2. Facilitators and Barriers to IPM Implementation

Item	N (9)	%	Manager Quote
Facilitators			
Outsider identification of pest problems	8	89%	We just weren't looking at the building that way. So I think it helped us look at things in a new way.
Reliable information source & IPM training workshop and Toolkit	8	89%	So that data [from IPM workshop] that they can definitely rely on us giving them the right information and whatever they might need to get the job on.
Everyone on same page	7	78%	As long as I have the support of the staff, it will work.
Many resources available to work on projects	5	56%	We have a lot of assistants, students, volunteers…
Existing staff who can help implement IPM	7	78%	I have a handyperson who can come in and handle all of the small things.
PMP or contractor who can help implement IPM	8	89%	[A pest management professional (PMP) that uses IPM strategies] comes every month and checks all of the classrooms inside and outside, all the playground. He changes the material that is needed to control pests accordingly.
Barriers			
Division of labor and lack of communication	4	44%	I am in charge of 15 staff, so I have to make sure that everyone is following our policies, and keeping the area safe and clean.
Lack of control	5	56%	The building belongs to us, but the land belongs to the city. So they used to come every three months and fumigate the whole site, but we had no control of the pesticides that they were using.
Lack of money	5	56%	I think initially we looked at some things and when [the office manager] was putting the work orders in, there were budget issues…

Table 3. Changes in IPM Policies and Prevention Practices Pre- & Post-intervention (n=9)

Item	Pre-intervention # Interviews (%)	Post-intervention # Interviews (%)
Policies		
Written policy for use of pesticides	1 (13%)	4 (44%)
Written policies include IPM	0 (0%)	4 (50%)
Tracking system		
Tracking system for building maintenance	5 (56%)	8 (89%)
Tracking system for cleaning and sanitizing	4 (50%)	6 (75%)
Know what IPM is[a]	2 (22%)	9 (100%)
Designated IPM coordinator	1 (13%)	5 (56%)
Tried to use IPM	4 (50%)	8 (89%)
Did it work?	4 (67%)	8 (100%)
Pesticides sprayed outside in the last 6 months	4 (44%)	1 (11%)
Pesticides applied by 'other'	8 (100%)	0 (0%)

[a] $t(df) = -5.29\ (16),\ p<.05$

Table 4. Summary of Convergent Parallel Design

Theme	Qualitative	Quantitative
Awareness of IPM	"In the past we used to just buy the cans of spray and we didn't realize how harmful that was. That's why it's very important to learn more about the different materials that are available, and try to use what is least harmful, especially for the children." • Unaware of alternatives to pesticides	• 1st IPM training for 100% of centers • 22% knew the term IPM • 44% of center applied pesticides outdoors and 33% applied pesticides indoors in last 6 months
Recognizing the importance of IPM and learning how to practice it	"Using IPM rather than how we looked at things in the past, it's changed how we view rodents and cleanliness and all that stuff. So if we have things getting in our classrooms, how are they getting in? That hasn't always been the focus, the focus has been on how do we get rid of them." • Learned about legislation, adverse effects of pesticide use, IPM and how to practice it	• Prior to the workshop, centers got their information on pest management from: PMPs (44%), fliers or research on the internet (22%), or "we don't" (33%). • 100% of managers mentioned feeling more capable of dealing with a pest infestation after the intervention
Motivation and decision to adopt IPM	"Well, it's important for the health of the children. A healthy environment…If you are not going to provide a healthy environment to the children, it will affect their growth and development." • Promotes children's health • Provides quality care	• 44% of the centers incorporated IPM into their written policies, • 56% of centers mentioned current informal policies and changes in practice • 33% shared information with parents and now practice IPM at home
Implementation of IPM	"I've been keeping an eye on my facility and maintenance staff, just to make sure they're doing a proper, thorough cleaning and they're doing proper inspections of items, for example, like any gaps, any webbing, any traces of rat dropping or mice droppings, anything that needs to be cleaned up and not left behind."	• *See Table 2. Facilitators & Barriers*
Evidence of change	**Practices** • 89% of centers tried to use IPM (100% reported that it worked) • 33% decrease in pesticide application over 6 months **Outdoors** • observed pest infestations decreased from 10 to 0 • 34% improvement in holes and cracks on building exterior • 40% installation of external doorsweeps and repair of damaged window screens **Indoors** • 29% increase in food being stored in sealable container • 29% improvement in cleaning of recyclables	