Integrated Pest Management Intervention in Child Care Centers Improves Knowledge, Pest Control, and Practices

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ABSTRACT

Introduction: To reduce young children's exposure to pests and pesticides, an integrated pest management (IPM) intervention was provided for child care center staff.

Methods: The 7-month IPM education and consultation intervention was conducted by trained nurse child care health consultants in 44 child care centers in California. IPM knowledge surveys were completed by child care staff, objective IPM assessments were completed by research assistants pre- and postintervention, and activity logs were completed by the nurses.

Results: There were significant increases in IPM knowledge for the child care staff who attended workshops. There were reductions in the prevalence of pests and increases in IPM practices at the postintervention compared with the preintervention time point. The nurses consulted an average of 5.4 hours per center.

Discussion: A nurse-led IPM intervention in child care centers can reduce exposure to harmful substances for young children attending child care centers. J Pediatr Health Care. (2016) *30*, e27-e41.

KEY WORDS

Child care, child care health consultation, integrated pest management, pediatric nurse, pesticides, public health

INTRODUCTION

Children exposed to pesticides early in life are at risk for long-term cognitive, neurologic, respiratory, and developmental problems (Bouchard et al., 2011; Lanphear, Vorhees, & Bellinger, 2005; Liu & Schelar, 2012; Makri,

Goveia, Balbus, & Parkin, 2004). Chronic exposure to indoor residential pesticides in early childhood is associated with an increased risk of developing childhood leukemia and lymphoma (Chen, Change, Tao, & Lu, 2015). Young children are more vulnerable to the harmful health effects of pesticides than adults because of their body size, behavior, physiologic development (Moya, Bearer, & Etzel, 2004), and exposure through multiple routes and pathways (Bearer, 1995; Roberts, Karr, & Council on Environmental Health, 2012). Young children may have dermal contact and/or may inhale pesticides in the air and/or suspended dust because they spend a lot of time on the floor, where pesticides accumulate (Fenske et al., 1990; U.S. Environmental Protection Agency, 2007). Young children engage in frequent hand-to-mouth activity, increasing their ingestion of contaminated dust or residues on hands or objects (Roberts et al., 2012). Compared with adults, young children absorb chemicals at proportionately higher rates because they have a higher intake of air, water, and food per unit body weight, resulting in proportionately higher exposures (American Academy of Pediatrics, 2012; Bearer, 1995; Landrigan, Kimmel, Correa, & Eskenazi, 2004). Children's organs and bodily systems are growing and rapidly changing, and chemical exposure during critical ages may disrupt their development and lead to long-term health and neurodevelopmental problems (Bearer, 2000; Lanphear et al., 2005; Moya et al., 2004).

California accounts for over 20% of all agricultural pesticide use in the United States (California Environmental Health Tracking Program, 2014) and has 2.5 million children under 5 years of age (Child Care Aware of America, 2015). California also has more licensed child care centers than any other state; there are 11,302 licensed child care centers and approximately 1.5 million children under 6 years whose parents work outside the home. Children spend an average of 35 hours per week in out-of-home child care settings (National Center on Child Care Quality Improvement, 2013). Because 62% of children in California under 6 years of age spend a portion of their day in regular child care arrangements (Laughlin, 2013), interventions should be targeted to address harmful chemical exposures in child care programs.

Studies show that young children attending child care centers are exposed to pests and pesticides (Bradman et al., 2012; Mir, Finkelstein, & Tulipano, 2010; Morgan et al., 2005; Starr, Graham, Stout, Andrews, & Nishioka, 2008; Tulve et al., 2006; Wilson, Chuang, Morgan, Lordo, & Sheldon, 2007). In a survey of 481 child care centers in California, 85% of respondents reported pest problems, and 39% reported applying high-exposure pesticides, which include sprays, foggers, powders, or uncontained pellets (Messenger, Livingstone, & Kerschner, 2015). In another survey of 637 child care centers in California, 90% of the directors reported problems with at least one indoor or outdoor pest (Bradman, Dobson, Leonard, & Messenger, 2010). The most common pests included cockroaches, fleas, ants, stinging insects, spiders, and rodents. The presence of pests increases the risk of health problems for young and vulnerable children. Mosquitoes and rodents can spread diseases, and rodents (Torjusen et al., 2013; Wang, Abou El-Nour, & Bennett, 2008) and cockroaches can trigger asthma and allergy symptoms (Gruchalla et al., 2005; Morgan et al., 2004; Sheehan et al., 2010). Indoor environments in homes and child care facilities have moderate temperatures and humidity throughout the year, which contributes to conditions conducive for most, if not all, of these pests to multiply. In addition to health problems, some pests can damage the building's structural integrity and infest stored foods.

Most of the 637 child care facilities in the California survey used pesticides, such as sprays and total release foggers, to manage cockroaches, ants, or spiders (Bradman et al., 2010). The routine application of pesticides amplifies the toxicity of the environment by increasing children's exposure to harmful substances. Additionally, 20% of the centers applied pesticides weekly or monthly, even if there were no pests present. Another study of 194 child care centers in California found that 33% of the center directors reported applying pesticide sprays once a month, and another 33% reported making such applications a few times per year (Messenger et al., 2015). An observational study investigating the presence of pesticide residues in 40 California child care centers found that pyrethroid insecticides were detected in all of the centers and organophosphate insecticides were detected in the dust samples of over 90% of the centers (Bradman et al., 2012). Young children in child care centers may be exposed to harmful chemicals because of the use of these high-exposure pesticides in these environments.

To reduce young children's exposure to pests and pesticides, the California legislature expanded the California Healthy Schools Act in 2007 to include licensed child care centers. This expansion of the California Healthy Schools Act encouraged licensed child care centers to incorporate the use of integrated pest management (IPM). IPM is a preventive approach to managing pests designed to reduce or replace the use of pesticides by providing more effective long-term solutions than can be achieved by reactive pesticide use. IPM simultaneously minimizes the health risks to people and harm to the environment (American Academy of Pediatrics, 2012; Geiger & Tootelian, 2005; State of Illinois, 2009; University of California Agriculture and Natural Resources & Statewide Integrated Pest Management Program, 2014). The benefits of IPM programs in school environments have been recognized by U.S. government agencies (U.S. Environmental Protection Agency, 1993; U.S. General Accounting Office, 1999) and demonstrated by

research (Gouge, Lame, & Snyder, 2005; Green, Gouge, Braband, Foss, & Graham, 2007; Williams, Linker, Waldvogel, Leidy, & Schal, 2005), leading five states to adopt IPM laws or regulations for child care facilities (Environmental Law Institute & Children's Environmental Health Network, 2015). IPM programs reduce their dependency on pesticides by focusing on prevention and are more cost-effective than conventional pest management programs that rely on routine applications of pesticides (State of Illinois & Illinois Department of Public Health, 2009; Williams et al., 2005).

> IPM is a preventive approach to managing pests designed to reduce or replace the use of pesticides by providing more effective long-term solutions than can be achieved by reactive pesticide use.

School-based IPM programs have been successful throughout the United States. A school-based IPM program implemented by IPM specialists in seven states led to a 78% reduction in pest complaints and a 71% reduction in pesticide applications (Gouge et al., 2005). An IPM Star Certification for School Systems was developed by the IPM Institute of North America, Inc., and was successfully implemented in 17 school districts in several states (Green et al., 2007). The certification program increased the adoption of IPM policies, record-keeping and notification practices, and safe pesticide use.

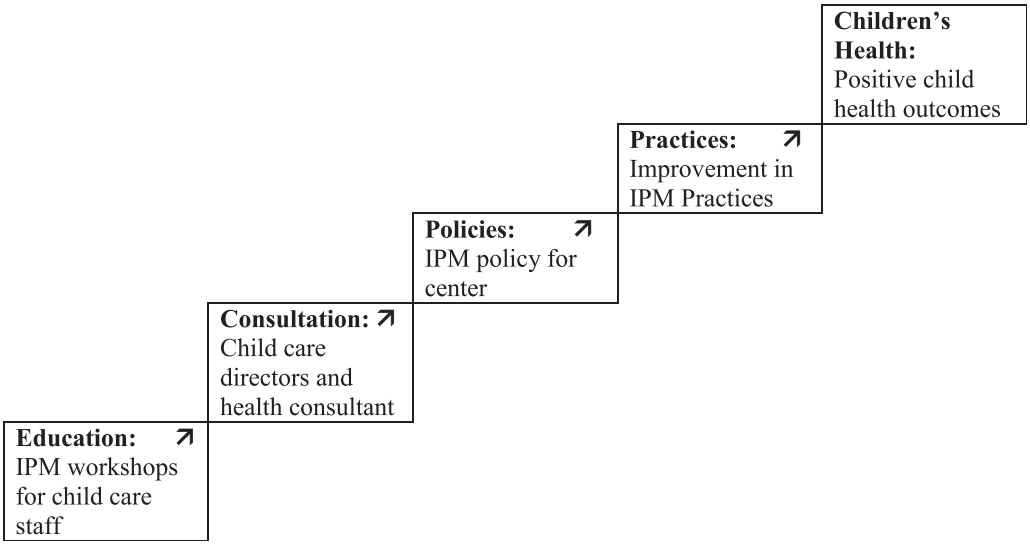
Compared with schools, child care centers have higher staff turnover rates (40%; Alkon, Ramler, & MacLennan, 2003; Bureau of Labor Statistics & U.S. Department of Labor, 2015; Fournier & Johnson, 2003; Mir et al., 2010; National Association of Child Care Resource & Referral Agencies, 2011), lower educational requirements for staff, (Bureau of Labor Statistics & U.S. Department of Labor, 2011; Institute of Medicine & National Research Council of the National Academies, 2012) and less financial stability (Institute of Medicine & National Research Council of the National Academies, 2012). In a recent report by the Institutes of Medicine, it was recommended that the education provided for child care staff be increased to improve the quality of care in child care programs (Institute of Medicine, 2015). Despite the challenges confronting child care staff and programs, intervention studies conducted in child care programs have shown positive changes in health and safety policies and practices (i.e., handwashing and IPM practices; Alkon, Bernzweig, To, Wolff, & Mackie, 2009; Anderson, Glynn, Enache, & EPA Region2 Pesticides Program, 2010; Fournier & Johnson, 2003; Isbell et al., 2013; Mir et al., 2010).

A study of an IPM train-the-trainer intervention in 892 child care programs over a 3-year period showed that IPM training increased the use of IPM practices, reduced pest problems, and increased staff knowledge (Mir et al., 2010). One third of the child care centers involved implemented IPM practices. The most common IPM preventive practices adopted were patching holes around pipes (60%), controlling clutter (60%), and cleaning behind appliances (56%). The pesticide practices that improved were using bait stations instead of sprays (41%) and stopping spraying (27%). Another IPM study in 45 child care centers in New York found that 84% of the directors were unfamiliar with IPM, but at the end of the study 80% adopted IPM practices (Anderson et al., 2010). The percentage of centers applying pesticides declined from 80% to 36%. A pilot IPM program in Indiana schools and child care facilities also showed adoption of IPM practices, such as clutter reduction, pest-proofing, and pesticide reduction (Fournier & Johnson, 2003).

Child care health consultation interventions have shown that addressing knowledge, attitudes, and behaviors are the first steps to improving health practices in child care centers (Figure) (Alkon et al., 2009; Isbell et al., 2013). Child care health consultants are health professionals trained to provide health workshops, write health and safety policies, conduct health and safety assessments, and provide consultation in child care programs (Isbell et al., 2013; Ramler, Nakatsukasa-Ono, Loe, & Harris, 2006). Nurse-led child care health consultation interventions have improved health and safety policies, nutrition practices, handwashing routines, and emergency preparedness in child care centers (Alkon et al., 2009; Crowley & Kulikowich, 2009; Dellert, Gasalberti, Sternas, Lucarelli, & Hall, 2006; Hanna et al., 2012; Isbell et al., 2013).

We conducted a pilot study in nine child care centers by nurse child care health consultants to evaluate an IPM intervention based on the IPM Toolkit (University of California, San Francisco School of Nursing's California Childcare Health Program, University of California, Berkeley's Center for Environmental Research and Children's Health, University of California Statewide IPM Program, & California Department of Pesticide Regulation, 2011) developed for early care and education programs in California to inform them of the California Healthy Schools Act. The pilot study showed that the first step of IPM implementation was the education workshop provided for the staff (Alkon et al., 2012). The staff improved their knowledge of IPM, and after 4 to 6 months of child care health consultation, they implemented IPM practices, eliminated the presence of pests, and reduced their exposure to pesticides. Additionally, qualitative interviews with the center directors, as part of the pilot

FIGURE. California Childcare Health Program's Stepwise Model of How Health Consultation Improves Children's Health.



study, helped explain the process of implementing IPM and the facilitators and barriers to including a new program in the center (Kalmar, Ivey, Bradman, Leonard, & Alkon, 2014).

The theoretical framework for this intervention project was the California Childcare Health Program's Stepwise Model of How Health Consultation Improves Children's Health (the Stepwise Model; Figure; Isbell et al., 2013). This Stepwise Model has been shown to be effective in general child care health consultation interventions (Alkon et al., 2008; Isbell et al., 2013; Ramler et al., 2006). Few studies have measured changes in child health, yet child care health consultation has been shown to increase staff knowledge on health and safety issues, increase the number of health and safety policies, and improve health and safety practices (Alkon et al., 2009; Crowley & Kulikowich, 2009). The Stepwise Model supports the approach to changing IPM practices by starting with IPM training and then working with child care directors to develop IPM policies that lead to changes in practice and ultimately positive changes in children's health.

Using the Stepwise Model as our framework, a 7-month nurse consultation IPM intervention program was designed for child care providers in centers to address the following research question: Does a nurse-led IPM intervention increase child care staff knowledge of IPM, reduce the number of pests present, and increase the number of IPM practices implemented in the child care centers?

In this study, the operational definition of IPM *is a process you can use to solve pest problems while minimizing risks to people and the environment* (University of California Agriculture and Natural Resources, & Statewide Integrated Pest Management Program, 2014). Pests were defined as *any living organism that causes damage or discomfort, or that transmits or produces disease* (University of California, San Francisco School of Nursing's California Childcare Health Program, University of California, Berkeley's Center for Environmental Research and Children's Health, University of California Statewide IPM Program, & California Department of Pesticide Regulation, 2011, p. 7). Pests can be animals, plants, fungi, or bacteria that pose a nuisance or health risk to those in the child care center. Pesticides are defined as *any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Any substance or mixture or substances for use as a plant regulator, defoliant, or desiccant* (U.S. Environmental Protection Agency, 2015). Low-exposure pesticides, such as self-contained baits or traps, minimize contamination and human exposure (Messenger et al., 2015). High-exposure pesticides are liquids or dusts applied directly, such as aerosol sprays or foggers.

METHODS

Study Design and Sample

This 7-month, quasiexperimental, pre-/postintervention study was conducted by trained nurse consultants in 44 child care centers in five counties of California located in the San Francisco Bay Area, Central Valley, and Central Coast regions from 2012 through 2014. The study design methodology and instruments were pilot tested in 2009 (Alkon et al., 2012; Kalmar et al., 2014).

The study protocol and child care director consent form were approved by the University of California,

San Francisco Committee on Human Research. The convenience sample of child care centers was recruited by the nurse consultants in collaboration with their local resource and referral child care agencies, local community colleges, or other child care planning councils. The centers met the following inclusion criteria: state-licensed child care center with a director available to complete two interviews, provide space and time for their staff to attend an IPM workshop, and plan to work at the center for at least the next 9 months.

Data Collection Procedures

After the nurse consultants recruited the child care center directors, a research assistant completed the preintervention IPM Checklist assessments. The nurse consultants conducted the preintervention director interviews. Next, the nurse consultants conducted IPM Workshops for the child care staff. Knowledge surveys were completed before and after the workshops. At the postintervention time point, 7 months after the workshop, the nurse consultant conducted the director interviews, and the research assistant completed the postintervention IPM Checklists.

The research assistants were trained and completed interrater reliability assessments with an experienced staff member before data collection started. The research assistants were not blinded to the study design because they tracked the timing of assessments, workshops, and intervention activities.

Intervention

The three nurse consultants were public health nurses with experience working in child care centers. They were trained on the IPM intervention format and content in person by a child care health consultant with IPM experience.

The child care staff, including directors, providers, janitorial staff, and kitchen staff were invited to the IPM workshops. The workshop included a slide presentation and discussion about the health effects of harmful chemicals on children, alternatives to using pesticides, and IPM practices useful in child care centers. The workshops were provided in English and Spanish. The nurse consultant also gave each child care director an IPM Toolkit, including the IPM curriculum covered in the workshop, pest information sheets, IPM posters, and the IPM Checklist. The director also received an IPM toolbox containing ant baits, a yellowjacket trap, a caulking gun, and an extension-pole spider web duster to use immediately in their centers. Each staff person who attended the workshop received a Certificate of Completion of IPM Training. Next, the research assistants completed the preintervention IPM Checklist assessments and summarized the findings with photographs and notes to identify gaps in IPM practices and/or pest problems. The nurse consultants reviewed the IPM Checklist summary with each director and provided monthly in-person, phone, or e-mail consultation specific to the center's needs.

Measures

Characteristics: Staff, director, children, center

The demographic characteristics of the director, staff, and children enrolled in the child care centers were collected during the preintervention director interviews. The child care staff demographic characteristics were completed by the participants at each IPM workshop. The demographic data included educational backgrounds, ethnic and racial backgrounds, sex, employment status, and years of work experience. The children's demographics included age, ethnic/racial background, and enrollment in government subsidy programs. The site characteristics included geographic location, building type, type of adjacent properties, and location.

IPM knowledge survey

A 10-item, multiple-choice knowledge survey was completed by the child care staff who attended the IPM workshops. Each item had one correct response, and the results were summarized as the total number of correct responses. The survey was modified based on the results of the pilot study to include only three responses per question and simpler language (Alkon et al., 2012). The revised knowledge survey had moderate reliability (Cronbach's alpha, $r = .72$) and validity (positive, significant changes postworkshop).

Director interview

The interview included 54 questions about the center's IPM practices, presence of pests, general characteristics, facilities, and maintenance issues. The questions were answered with categoric responses such as *yes, no, don't know, not applicable,* or narrative responses.

Pest prevalence and IPM

The numbers of pests seen in each room (i.e., kitchen, storage area, classroom) were identified as part of the IPM Checklist (eight items). The checklist included 65 objective, observational items about the environment's vulnerability to pests and IPM practices in place with the following responses: *yes, no,* or *not applicable*. The IPM Checklist was divided into outdoor and indoor sections with nine subscales. Cronbach's alpha coefficients for the preintervention items in the subscales showed a range of moderate reliability ($r = .38–.61$).

Given that California has a Mediterranean climate with a rainy season from approximately October through March, the season during which the IPM Checklist was completed was identified and recorded as either the wet or dry season. The wet season was

TABLE 1. Child care staff, director, and child demographics and site characteristics

Child care staff characteristics (*n* = 338)		
Child care staff demographics	Mean (*SD*)	Range
Years in child care field	11.90 (8.90)	0–44
Years at current center	5.63 (6.43)	0.01–21.33
Age in years	39.17 (12.05)	19–70
Child care staff education	*n*	%
High school	23	7
Community college	70	20
Some college	120	35
Bachelor's degree	116	34
Master's degree	16	5
Child care staff employment	*n*	%
Part time	20	6
Full time	324	94
Child care staff sex	*n*	%
Male	17	5
Female	331	95
Child care staff race/ethnicity	*n*	%
White	79	23
African American	47	14
Latino	129	38
Asian	55	16
Mixed	20	6
Other	14	4
Director characteristics (*n* = 44)		
Director demographics	Mean (*SD*)	Range
Years at center	8 (9.47)	0.25–35.00
Years in industry	19 (9.41)	3–40
Director education	*n*	%
Community college	6	14
Some college education	3	7
Bachelor's degree	30	68
Master's degree or higher	5	11
Child characteristics (*n* = 2,212)		
Children's demographics	*n*	%
Children receiving government subsidy	1,358	61
Children's race/ethnicity	*n*	%
Latino	820	41
White	640	31
African American	217	8
Mixed	257	11
Asian	221	7
Other	34	2
Native American	8	<1
Ages	*n*	%
0–12 months	13	30
13–35 months	27	61
3–5 years	39	89
>5 years	8	18
Site characteristics (*n* = 44)		
Geographic Region	*n*	%
Central Valley	6	14
Central Coast	19	43
San Francisco Bay Area	19	43
Building type	*n*	%
Commercial	18	41
Public (church or school)	10	23
Residential	8	18
Detached	8	18
Adjacent property	*n*	%
House	46	26
Open field	31	18
Apartment	26	15

(*Continued on page e33*)

TABLE 1. Continued.

Public park	10	6
Restaurant	4	2
Other	63	36
Location	*n*	%
Urban	18	41
Suburban	20	50
Rural	4	9

Note. *Abbreviation:* SD, *standard deviation.*

from October 1 through March 31, and the dry season was from April 1 through September 30 (California Natural Resources Agency, 2014).

Nurse consultant Activity Log

The Activity Log tracked the frequency and content of the nurse consultants' intervention. The Activity Log included the date of the contact, type of consultation activity, people receiving the activity, follow-up activity, travel time, and time spent preparing or providing consultation. The Activity Log was completed by all three nurse consultants for 39 out of the 44 centers.

Statistical analyses

The data were analyzed using STATA 12.0 (StataCorp LP, College Station, TX). Descriptive statistics were conducted on all measures, items, and subscales with means ± standard deviations (*SD*s) for continuous variables and frequencies for categoric or nominal variables. Bivariate relations between potential covariates and dependent variables (changes in pest prevalence and IPM Checklist scores) were examined using Pearson correlations, Spearman rank correlations, analysis of variance, or Kruskal–Wallis tests. Spearman correlations were conducted between the intensity of the nurse consultant intervention, changes in pest prevalence, and changes in the IPM Checklist. The changes between the pre- and postintervention periods were compared for individual items and observations with paired *t* tests for continuous data and McNemar tests for categoric data (Conover, 1999). Statistical significance was set a priori at $p < .05$.

RESULTS

Sample and Participation Rates

Forty-seven child care center directors signed consent forms, and 44 of them completed the IPM intervention project (94% completion rate). The 44 centers served 2,212 children (Table 1). The key demographic variables, director education, director's years working in child care, setting (i.e., urban, suburban, rural), and percentage of children receiving subsidies did not differ by region, so all subsequent analyses were conducted with the 44 centers together.

Most of the child care staff who attended the workshops attended some college, worked full-time, and were female (Table 1). The child care directors were very experienced in the child care field, and most of them had a bachelor's degree. The staff and children were from a range of racial or ethnic backgrounds representing the ethnic diversity of northern California.

Intervention Activity and Intensity

Each center received a mean ± *SD* of 5.4 ± 1 hours of nurse consulting time during the IPM intervention or a mean ± *SD* of 46 ± 43 minutes (range = 5–320 minutes) per contact. The nurse consultants' interventions were conducted for a mean ± *SD* of 7 ± 1 months. The IPM workshops lasted an average of 2 hours. The time spent on different activities varied; director interviews took an average of 50 minutes, and reviewing the assessments and other materials took an average of 20 to 30 minutes per activity. The other activities included recruitment, developing materials, scheduling interviews and visits, preparation time, and data entry.

There was a weak negative correlation between nurse consulting time and change in pest prevalence ($r = -.01$, $n = 39$) and a positive moderate correlation between nurse consulting time and change in IPM checklist scores ($r = .42$, $n = 39$).

IPM Knowledge

There was an overall statistically significant improvement in staff knowledge between the pre- and postworkshop surveys (paired *t* test statistic = 20.1, degrees of freedom = 337, $p = < .05$). There was a mean ± *SD* increase in knowledge from 6.13 ± 2.20 to 8.82 ± 1.24 items correct on the survey. There was a statistically significant increase in the percentage of correct answers for 9 out of the 10 questions. There was no statistically significant improvement in understanding the purpose of the U.S. Environmental Protection Agency registration number on a pesticide label.

IPM Policy

There was a significant increase in the number of IPM policies (Table 2). At the preintervention director interviews, only 18% of the directors had a written policy addressing pest management and pesticides, but 64% of the directors had these policies at the postintervention interview.

TABLE 2. IPM practices and policies: Director interview (*n* = 44 centers)

Question	Response	Preintervention, *n* (%)	Postintervention, *n* (%)	*p*[a]
IPM policy				
Does your child center have a written policy for use of bug killers, weed killers, rat killers, or other pesticides, stating when and how to apply pesticides?	Yes	8 (18)	27 (61)	< .001
	No	29 (66)	10 (23)	
	Don't know	7 (16)	27 (61)	
Building maintenance and cleaning				
Are gutters cleaned two times per year?	Yes	9 (20)	22 (50)	.007
	No	6 (14)	3 (7)	
	Don't know	24 (55)	16 (36)	
	Not applicable	5 (11)	3 (7)	
Does water drain away from building?	Yes	27 (61)	37 (84)	.004
	No	5 (11)	6 (14)	
	Don't know	12 (27)	1 (2)	
Is the foundation at least 12 inches above soil level?	Yes	10 (23)	20 (47)	.018
	No	7 (16)	6 (14)	
	Don't know	27 (61)	17 (40)	
Do you notice puddles outdoors after rainstorms or watering?	Yes	21 (48)	20 (47)	.006
	No	13 (30)	23 (53)	
	Don't know	10 (23)	—	
Is the refrigerator drip pan cleaned every 6 months?	Yes	8 (18)	21 (49)	.010
	No	20 (45)	12 (28)	
	Don't know	16 (36)	10 (23)	
Is food waste taken outside at the end of each day?	Yes	43 (98)	43 (98)	1.00
	No	1 (2)	1 (2)	
Is water poured down floor drains once per week?	Yes	5 (11)	10 (24)	.192
	No	23 (52)	18 (43)	
	Don't know	16 (36)	14 (33)	
Do you have an outside cleaning service?	Yes	24 (55)	24 (54)	1.00
	No	20 (45)	20 (45)	
IPM knowledge and practices				
Do you know what integrated pest management (IPM) is?	Yes	10 (23)	43 (98)	< .001
	No	34 (77)	1 (2)	
Do you have a designated IPM Coordinator?	Yes	1 (2)	27 (61)	< .001
	No	43 (98)	14 (32)	
	Don't know	—	3 (7)	
Have you tried to use IPM?	Yes	10 (24)	42 (95)	< .001
	No	29 (69)	2 (5)	
	Don't know	4 (7)	—	
If yes, what did you do?				
Fix leaks		14 (32)	24 (55)	
Monitor pest activity		12 (27)	34 (72)	
Seal cracks and crevices		9 (20)	24 (55)	
Remove access		10 (23	23 (52)	
Install door sweeps		4 (9)	6 (14)	
Clean thoroughly		10 (23)	36 (82)	
Hire IPM pest control company		1 (3)	10 (23)	
Other		5 (11)	12 (27)	
Did IPM work?	Yes	6 (21)	35 (83)	< .001
	No	10 (34)	4 (10)	
	Don't know	13 (45)	3 (7)	
Do you work with a pest management company?	Yes	22 (50)	20 (48)	> .99
	No	21 (48)	21 (50)	
	Don't know	1 (2)	1 (2)	
If yes, do they routinely spray pesticides?	Yes	11 (30)	7 (17)	.017
	No	15 (41)	29 (71)	
	Don't know	11 (30)	5 (12)	
Have pesticides been applied outside this facility?	12 months	4 (9)	—	< .001
	6 months	15 (34)	9 (22)	
	No	12 (27)	25 (58)	
	Don't know	13 (30)	9 (21)	

(*Continued on page e35*)

TABLE 2. Continued.

Question	Response	Preintervention, *n* (%)	Postintervention, *n* (%)	*p*[a]
Have pesticides been applied inside this facility?	12 months	2 (5)	—	< .001
	6 months	3 (7)	2 (5)	
	No	30 (70)	40 (91)	
	Don't know	8 (19)	2 (5)	

Note. *Abbreviation: IPM, integrated pest management.*
[a]*McNemars test.*

Pest Prevalence

Director interviews

The directors identified a total of 25 different types of pests during the pre- and postintervention interviews. The directors reported decreases in the number of ants, spiders, mice, rats, and gophers (Table 3).

IPM Checklist

There was a statistically significant decrease in the overall number of pests found during the IPM Checklist assessments when comparing the pre- (n = 147) and the postintervention periods (n = 82; Table 4). When considering the type of pest, there were statistically significant decreases in spiders and mold.

There were no significant bivariate relations between the recorded decrease in the number of pests present at the post- versus preintervention time points and the director's level of education, director's prior IPM knowledge, regional location of center, building type, adjacent property, funding, season, or nurse consultation intervention time.

There was a moderate, negative correlation between the change in pest prevalence and the change in total IPM checklist scores (r = −.37, n = 44).

IPM Practices

Director interviews

Some of the specific pests identified during the director interviews were bed bugs, fleas, mosquitoes, fruit flies, ants, cats, and mold. The IPM practices reviewed with the directors included green cleaning, installing screens and door sweeps, repairing leaks, and cleaning sandboxes.

The directors reported a significant positive change in pest management awareness and implementation of IPM practices during the postintervention interview compared with the preintervention interview (Table 2). At the preintervention interview, 23% of directors reported knowing what IPM was, compared with 98% at the postintervention period. Self-reported use of IPM practices increased from 24% at the preintervention interview to 95% at the postintervention interview. The most common IPM practices used, as reported at the postintervention interview, included cleaning thoroughly, monitoring pest activity, fixing leaks, and sealing cracks and crevices. There was an increase in the number of directors who reported IPM was working: 21% versus 83% of the directors at the pre- versus postintervention periods, respectively. The directors also reported fewer pesticide application outside and inside in the last 6 months.

IPM Checklist

Seventy-seven percent of the preintervention IPM Checklist assessments were completed during the dry season. Overall, there was a statistically significant increase in the use of IPM practices from the pre- to postintervention time points (Table 5). The mean ± *SD* IPM Checklist score (n = 44 centers) increased from 44.4 ± 4.7 to 49.8 ± 4.2. Six of the nine subscales significantly improved, although three subscales (i.e., building exterior, garbage storage, and staff area) did not significantly improve from the pre- to the postintervention periods.

TABLE 3. Child care directors: Change in the top 5 pest problem in the last 2 years (preintervention) and last 6 months (postintervention)

Pest	Preintervention *n* (%)	Postintervention *n* (%)	% Change
Ants	22 (50)	14 (32)	−18
Mice	16 (36)	6 (14)	−22
Rats	13 (30)	6 (14)	−16
Spiders	8 (18)	4 (9)	−9
Gophers	8 (18)	3 (7)	−11

TABLE 4. IPM checklist: Change in the top five observed pests and overall number of pests from the preintervention to postintervention time points

Pest	Preintervention Total pest, *n*	Postintervention Total pest, *n*	Significance[a] *z* score, *p* value
Flies	39	26	1.93, .050
Spiders	36	16	3.33, < .001
Mold	21	9	2.68, .007
Yellowjackets	9	3	1.19, .240
Weeds	7	4	0.91, .370
Total pests present	147	82	2.84, .004

[a]*Wilcoxon sign rank test.*

The bivariate relations between potential confounding variables and changes in the IPM Checklist scores from pre- to postintervention time points were analyzed. The centers that had the preintervention IPM Checklist completed during the wet season had more positive scores (mean ± *SD* = 10.3 ± 6.32) at the postintervention period compared with the centers who had the preintervention IPM Checklist completed during the dry season (mean ± *SD* = 4.0 ± 4.59, *t* test = 2.94, degrees of freedom with unequal variances = 12, $p < .05$). There were no significant relations between the director's level of education, director's prior IPM knowledge, regional location of the center, building type, adjacent property, funding, and the change in IPM Checklist scores.

DISCUSSION

This 7-month nurse-led IPM intervention in 44 child care centers increased child care staff knowledge of IPM, reduced the number of pests present, and increased the number of IPM practices implemented in the child care centers. The centers that received more hours of nurse consultation implemented more IPM practices than centers that received fewer hours of consultation. Also, centers that had higher IPM Checklist scores at the post- versus preintervention assessment had fewer pests present at the postintervention assessment.

These results support the Stepwise Model of health consultation: nurse child care health consultants provided IPM workshops for the child care staff, and the staff showed an increase in knowledge of IPM, which led to the implementation of IPM policy and changes in practices, as evidenced by director reports and objective assessments by research assistants.

Previous health and safety interventions in child care centers have also shown that addressing knowledge, attitudes, and behaviors is the first step to improving practices (Isbell et al., 2013; Kotch et al., 2007). To increase knowledge, the standardized interactive workshops provided a comfortable environment for staff to learn new pest management practices. These workshops support the Institute of Medicine's recommendation for increasing the education provided for child care providers to improve the overall quality of child care (Institute of Medicine, 2015).

This study also reaffirms other health consultant intervention studies conducted in child care centers that show it takes at least 7 months to change environmental policies and practices (Alkon, Sokal-Gutierrez, & Wolff, 2002; Benjamin et al., 2007; Kotch et al., 2007). It takes time to develop a trusting relationship with child care directors, a key element of a successful program. The nurse consultants fostered

TABLE 5. IPM Checklist: Subscale and total means by pre- and postintervention (*n* = 44 centers)

Subscale	Preintervention	Postintervention	Paired *t* test (*df*), *p*
IPM Checklist: Outdoor Areas			
Garbage storage (5 items)	3.84 (1.12)	4.04 (1.18)	−0.94 (43), .35
Building exterior (10 items)	7.89 (1.24)	8.18 (1.22)	−1.73 (43), .09
Landscape and play areas (12 items)	7.64 (1.53)	8.77 (1.25)	−3.89 (43), < .001
IPM Checklist: Indoor Areas			
Kitchen (13 items)	8.43 (1.93)	9.68 (1.55)	−4.05 (43), < .001
Bathrooms (5 items)	4.09 (1.14)	4.5 (0.63)	−2.61 (43), .01
Common space, play area, eating area (10 items)	6.11 (1.24)	7.34 (0.71)	−6.13 (43), < .001
Storage area(s) (5 items)	2.86 (1.29)	3.45 (1.34)	−2.53 (43), .02
Staff area (5 items)	3.57 (1.32)	3.86 (1.27)	−1.32 (43), .20
Total checklist score			
Total score (65 items)	44.43 (4.71)	49.84 (4.20)	−6.37 (43), < .001

open communication with the directors and a hands-on approach to help center directors incorporate IPM practices into their center's policies and daily practices. The IPM Checklist assessment provided an opportunity to focus the discussion between the nurse consultants and directors on center-specific gaps and interventions needed. The time spent on individual consultation activities provided over the 7 months varied from 60 minutes for on-site visits to 5 minutes for sending an e-mail with a pest information sheet.

There was an overall decrease in the number of pests observed in the centers over the intervention period. The numbers of flies, spiders, mold, yellowjackets, and weeds decreased more than those of other pests. The discrepancy between what center directors reported as their biggest pest problems and what the research assistant observed could be explained by different levels of accuracy in identifying pests and time and day of the observation. Only spiders were observed by both the directors and research assistants, possibly because of their visibility in webs versus other pests that travel around. There was a reduction in all of the five most serious pest problems identified by the center directors with a wide range of change (from 9% to 23%).

California has pronounced wet and dry seasons, and different pests (e.g., termites, ants) are known to increase in abundance or be more likely to invade structures during either one season or the other (Gordon, Moses, Falkovitz-Halpern, & Wong, 2001; Haverty, Getty, Copren, & Lewis, 1999). The centers where the preintervention IPM Checklists were completed in the dry season had more pests present than centers where the Checklist was completed in the wet season. On the other hand, there was no difference by season in the number of pests at the postintervention period. Thus, the IPM intervention was effective in decreasing the number of pests present in the child care centers regardless of the season in which the interventions were conducted. We found no differences in the adoption of IPM practices or presence of pests by building types or adjacent property types.

Participating directors reported using more IPM practices by the end of the intervention period. The subjective self-reports were supported by objective IPM Checklist assessments conducted by research assistants. At the postintervention period, 98% of the center directors reported that they knew what IPM was, and 95% of the center directors had implemented some IPM practices. The most commonly reported IPM practices implemented during the program included cleaning (such as mopping), monitoring for pests, fixing leaks, and sealing cracks and crevices.

Other studies also found an increase in IPM knowledge and practices postintervention (Anderson et al., 2010; Fournier & Johnson, 2003; Mir et al., 2010), but they did not include a nurse child care health consultant or IPM Toolkits. These IPM interventions showed similar changes in IPM practices such as sealing crevices, improved cleaning practices, and the use of bait stations rather than sprays. Our intervention showed larger increases in the use of IPM (95% vs. 80%; Anderson et al., 2010), with similar decreases in the use of routine pesticide applications (17% vs. 36%; Anderson et al., 2010). None of the IPM intervention studies included objective measures of pesticides or control centers.

Other nurse-led interventions in child care centers have shown similar improvements in health and safety knowledge and practices (Alkon et al., 2014; Isbell et al., 2013). Nurses are skilled in conducting assessments, working with families, communication, and building trusting relationships. The professional development of child care providers is supported by relationships (Whitebook, Phillips, & Howes, 2014), and the nurse consultants in this study recruited child care directors in their local communities where they had trusted relationships. In addition to the strong team of nurse consultants and research assistants, the multidisciplinary team in this study included experts in entomology, environmental science, public policy, and child care.

The strength of this intervention was its multifaceted and multilevel model. It involved different types of learning opportunities, including interviews, objective assessments, knowledge surveys, workshops, electronic communication, hands-on demonstrations, mailings, and one-on-one meetings, along with follow-up and reinforcement of the key center-specific messages over 7 months.

Although this study had important positive findings, there were some limitations. This quasiexperimental study included a convenience sample of child care centers with child care directors and staff who were motivated and organized, which limits the generalizability of the findings. Recruitment of child care centers can be challenging because of the child care staff's limited time for professional development, high staff turnover, and low wages (Whitebook et al., 2014). It was also challenging to recruit nurses to conduct research part time when they had competing clinical jobs. One of the three nurse consultants was not able to fully participate for 3 years. She conducted several workshops during which the participants showed increases in IPM knowledge, and she recruited seven centers that improved their IPM practices. In addition, incomplete or missing Activity Logs underrepresented her time spent on the intervention. Finally, there may be measurement bias in the identification of pests present because the research staff did not establish interrater reliability on the identification of pests. The pests identified were not aggregated by classification or density. Pest problems may vary by season and year, which subsequently affects how directors

and pest management professionals manage the problems. Although this study found a reduction in pest problems after the intervention, these changes may be due to structural changes, weather, or annual precipitation.

Although the study found a significant increase in IPM knowledge after the staff attended the nurse-led workshop, many staff members marked multiple answers for the questions; therefore, the instructions should have been more clear and consistent. Even though the survey was simplified after the pilot study, the literacy level of the items may still have been too high. There was no improvement in knowledge about the purpose of the U.S. Environmental Protection Agency registration number on a pesticide label, which may reflect the complexity of the issue or the lack of clear content during the workshops.

Although this study shows the nurse consultation model as a successful intervention model, there is a lack of support for the certification and training of child care health consultants. Future studies may investigate the effects of other types of professionals providing the IPM intervention in child care, such as community health educators, child care health advocates, Head Start health service managers, and environmental education professionals (e.g., Eco Healthy Child Care, Healthy Homes). Ongoing professional development for child care staff should be recognized with certificates and financial reimbursement for their time.

Only three of the eight subscales on the IPM Checklist (building exterior, garbage storage, and staff area) did not significantly improve from the pre- to the postintervention assessments. This may be due to existing practices of custodial staff not included in the intervention, the cost of improvements, or the recommended changes were not a priority or under the control of the directors. According to the directors, there were fewer pesticide applications after the intervention, even in centers that contracted with pest management companies. By encouraging pest management professionals to learn more about IPM for child care environments, children will ultimately have less exposure to pests and pesticides. Free online IPM training and certification for pest management professionals working in child care centers is available (www.ipm.ucdavis.edu/training/school-and-child-care-ipm.html), but increased awareness about these resources is needed.

CONCLUSIONS

The dissemination of the IPM Toolkit for Early Care and Education Programs in English and Spanish is needed in child care centers, because most child care directors and staff do not know about IPM. The IPM Toolkit's resources could be incorporated into statewide and regional Quality Rating and Improvement Systems to improve the quality of the environment in child care programs and ultimately improve health. In addition, parent groups should be targeted for dissemination of the IPM Toolkit to create consumer demand for child care centers that practice IPM. Incentives for programs to implement IPM, such as a certification system, could provide a new market for eco-friendly child care centers. Future IPM interventions in child care centers could include funding and/or stipends for materials and repairs to implement IPM; especially for centers located in low-income neighborhoods. Finally, future studies of IPM interventions in child care programs should include measures of child care providers' self-efficacy and objective measures of pesticide residues in the child care facility.

When young children attend child care centers where they can safely explore and play without encountering pests or pesticides, they will have a foundation for healthy development and lifelong learning.

This project shows the impact of a nurse-led center-based intervention on creating healthy environments for children attending child care centers. When young children attend child care centers where they can safely explore and play without encountering pests or pesticides, they will have a foundation for healthy development and lifelong learning. Thus, healthy and safe child care benefits children, families, and society.

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